
ELECTR
DE

ONIC
SIGN

MAY 28, 1958

Two Watt Amplifier in a Size 8 Can (Cover) . . . . . p 32

In diameter, no larger than a size 8 servo motor, this new servo amplifier packs a lot of power for its size. To achieve an 85 per cent space factor, it uses a very novel packaging technique.

Graphical Method Simplifies Wien Bridge Oscillator Design . . . . p 20

Here is a reliable, effective, design procedure for Wien Bridge oscillators. It gives better and faster results than the more common trial-and-error approach.

Overlap Method Makes Fast Pulses In Transistor Circuits . . . . p 44

By taking a pulse as the overlap between a positive and negative step, displaced by the desired pulse width, Mr. Mark Smith has achieved unusually fast, flat-topped pulses in transistor circuits. His peculiar use of logical diagrams suggests many ways to obtain the overlap.

Optimum Design of Power Transformers and Saturable Reactors, Part 2 . . . p 48

Here's the concluding part of Mr. Nisbet's article on how to design the most efficient transformer. In this part, he presents some nomograms, solves some very messy equations

ELECTRONIC DESIGN

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CIRCLE 2 ON READER-SERVICE CARD ➤

G-V stands guard with Robertshaw to detect harmful vibration...

Abnormal and persistent vibration in rotating equipment usually means costly trouble. Robertshaw-Fulton's Vibraswitch Detectors and Model 651 control units detect vibration and shut down valuable equipment before damaging trouble develops.

Two G-V Red Line Thermal Time Delay Relays are used in each control unit. One blocks out the vibration detector while the protected equipment is starting up. The second times the duration of vibration and permits shut-down only if trouble persists.

Absolute reliability of every component is vital in a protective system of this sort. G-V Red Line Delay Relays meet this requirement for reliability ...at surprisingly low cost. Apply them in your equipment and be safe.

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G-V CONTROLS INC.
18 Hollywood Plaza, East Orange, New Jersey

G-V

ENGINEERING REVIEW

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

Open-Shut Case

Radome on Lockheed's prop-jet Electra swings open on top-mounted hinges for easy maintenance of C-band weather radar unit. Radome consists of a 1/2 in. honeycomb core covered with laminated plastic. Support braces on each side, at the mid-section, hold unit away from joint. It is fastened in place by four quick-disconnect latches.

Approximately 4 ft deep, the 76-in. diam radome is covered with a high-grade rubber foot to prevent rain erosion. Thoroughly checked in static tests, it withstood maximum aerodynamic strains anticipated in actual flight, Lockheed engineers said.

The radome was manufactured by H. I. Thompson Fiber Glass Co., to design specifications by Lockheed Aircraft Corp., 745 Chrysler Building, New York 17, N.Y.

Developmental high-temperature gallium arsenide microwave diodes are examined by Dr. D. A. Jenny of RCA who developed new semiconductor device.

Diode, Rectifier Point To Smaller Missile Controls

Two new RCA-developed high-temperature semi-conductor devices use gallium arsenide. They may pave the way to smaller, more compact radar equipment, electronic computers, and control systems for aircraft and missiles.

High temperature characteristics of gallium arsenide have made possible the construction of a number of microwave diodes and power rectifiers. These devices are capable of operating efficiently at temperatures substantially higher than those at which present germanium or silicon devices will function. The developmental rectifier will operate effectively at temperatures above 572 F, as compared to a maximum of about 392 F for silicon rectifiers.

The microwave diode, developed by Dr. D. A. Jenny has been operated at a frequency of 6000 mc and has been raised to temperatures of 200 C. This device, however, reportedly has an optimum temperature "way beyond this figure" but higher temperature operation has been restrained by the temperature

(Continued on following page)

limitation of supporting equipment. Diode application is forseen in ultra-high-speed switching operations and radar system hf detection.

According to RCA officials, these and other new semiconductor devices presently under development, will reduce substantially the problem of cooling in the design of many electronic systems, permitting close packaging of components or higher power level operation of present equipment. Substantial advances also are being made at RCA Laboratories in the application of gallium arsenide to transistors. In addition, new ground is being broken in the growth and processing of gallium arsenide in the pure crystal form.

Multi-Channel SSB System Operates at 900 Mc

A multi-channel single-sideband radio system operating in the 900 mc region has been successfully produced and tested by Federal Telecommunication Labs., Nutley, N.J. Although designed primarily for line-of-sight transmission, the single-sideband equipment is adaptable to over-the-horizon microwave radio through the use of bigger antennas and larger power amplifiers. Proposed development plans will push the operating frequency up to 2000 mc.

The system will accommodate up to 120 telephone channels within a 500 kc bandwidth, alloting just over 4 kc to each channel. Present systems using other types of modulation, such as frequency or pulse modulation, are characterized by bandwidths, of the order of 30 to 40 kc per channel.

The new equipment was loop-tested over a 4 mile experimental circuit with losses inserted to simulate a normal 30-mile line-of-sight circuit. Total power required to light all the filaments and operate both transmitter and receiver is about 65 w.

◄ CIRCLE 4 ON READER-SERVICE CARD

his **continuous seam** welding machine can turn out 00 parts in one hour when hand loaded.

Continuous Seam Welder Seals Transistors

A welding machine has been developed for ealing semi-conductor devices. The new tech- nique eliminates presoldering preparation and all leaning. It also stops high-temperature penetra- tion of the working parts and prevents glass breakage.

A specially constructed hollowed ring sur- ounds the glass stem of the transistor. One elec- trode is applied to the inner portion of the ring and one to the outer by means of which a con- tinuous seam weld is accomplished. The machine weighs 30 lbs and requires 1 kva. Power is sup- plied from any standard 110 v ac outlet. Produc- tion rates of 300 per hour are possible with hand loading of parts. The machine which has under- gone two years of successful tests at RCA was developed by Sidney S. Steriess, 1307 Edward L. Grand Highway, Bronx, N.Y.

Transformers Rated at 150 Kva Easy on the Ears

Dry-type transformers rated through 50 kva single-phase and 150 kva three-phase having low-noise sound levels of 45 db or below are being built by General Electric, Fort Wayne, Ind. Noise analyses are made by sealing the trans- formers in a laboratory which has an ambient noise level of less than 10 db measured on NEMA specified equipment. It is a five field chamber that exceeds NEMA's recommended specifica- tions. The sound level of a transformer is deter- mined by taking the arithmetic average of five measurements. One each is taken at intervals of approximately 90 deg around the transformers. One measurement is taken above the transformer on the vertical axis.

BuShips Picks Ungrounded Electrical Systems

Ungrounded neutral electrical systems are chosen over the grounded systems on naval ships where the voltage is 600 v or less and where continuity of power supply is vital. This policy was discussed in a paper delivered at the Middle Eastern District AIEE meeting by E. W. Lusby and C. L. Straub of the Bureau of Ships, U. S. Navy Department. Ground faults are the most common causes of power failure, they pointed out. The ungrounded system requires more maintenance, however, it was said, and additional facilities and personnel must be provided. The grounded system, which has less maintenance requirements, can be used "on those ships that do not depend on continuity of power supply." The grounded system is also better where there are abnormal voltages to ground, the authors said, but "test results and analytical investigations have indicated that abnormal voltage to ground occurs infrequently on Naval ships."

Heat Energy Converted Directly to Electricity

Heat is being converted directly to electricity with a new engine designed at the Massachusetts Institute of Technology.

The device, called the thermo-electron engine, consists of two plates, one hot and one cold. Electrons possessing sufficient energy to overcome a potential barrier stream from the hot plate which is at a temperature of perhaps 2000 F, to the cold plate.

The model built at MIT by Dr. Joseph Kaye and Dr. George N. Hatsopoulos is based on a report made by Dr. Hatsopoulos two years ago. It appears that an efficient power plant could be built to yield 5000 to 15,000 w in each cu ft of plant volume.

◄ CIRCLE 6 ON READER-SERVICE CARD

New Collision Avoidance System Unveiled

A new collision warning and anti-collision command computer for piloted aircraft has recently been devised. The operation of this equipment is based upon the principle that the relative velocity vector between two aircraft must coincide with the line-of-sight between them in order for a collision to occur. The relative velocity between two aircraft which are near enough the same altitude to collide potentially is computed from altitude, speed and heading information exchanged between airplanes. Line-of-sight between the two aircraft is determined by direction finding equipment. When the relative velocity is found to lie within a few degrees of the line-of-sight, warnings are given that a collision with the other airplane may be imminent. It is only necessary for the pilot to maneuver according to the steering command given to eliminate the collision threat. This device does not measure range since it is not required in the computation. Nor does it require an operator's attention. Designed by the Aerosystronics Corp., Los Angeles, Calif., the system is expected to weigh approximately 30 lbs and occupy about 1 cu ft.

Escape Velocity Exceeded

Upstream view of Hotshot II shows technicians preparing to fire the electric arc-driven wind tunnel in which escape velocity has been exceeded at the Arnold Engineering Development Center near Tullahoma, Tenn. Man in foreground sights high-speed camera on test object in 50-inch-diameter test section while another technician works on arc chamber. Unipolar generator, beyond and to left of arc chamber, builds up electrical energy in inductive coil (out of picture at right) until level required for test run is reached. Test flow at escape velocity lasts about 1/10th of a second. The arc which produces the airflow creates pressures of more than 15 tons per sq. in. Friction of air flow past the test object produces temperatures exceeding 40,000 F.

Nuclear Instrumentation System Built

Instrumentation for nuclear reactors has been shipped to the Atomic Energy Commission's Knolls Atomic Power Lab in Schenectady, N.Y. Designed to serve as control and safety equipment in either land or marine installations, the equipment is to be used in a land-based prototype of a nuclear powered submarine. The nuclear instrumentation system is capable of measuring from one to 10 billion units of neutron flux per sec. The reactor is constantly monitored by the system which gages and indicates the density and rate of change of neutron flux of the atomic reactor from "start up" to "full power."

The system basically consists of three channels of reactor monitoring equipment: source range channel; intermediate range channel; and a power range channel. All channels are provided in duplicate as an additional safety precaution. Each channel is built into a separate, interchangeable drawer, allowing quick replacement without plant shut down.

Device Prevents "Shorts" Up to 100,000 A

A current limiting fuse, which protects circuit components having available currents as high as 100,000 a, was described during the Great Lakes District Meeting of the AIEE.

In his paper, Norman Shackman of the Bulldog Electric Products Co., Detroit, Mich., explained that the current limiting fuses are used in fusible devices, in series with circuit breakers, or as a part of a circuit breaker to protect individual loads and groups of loads. The device, which increases short circuit energy by limiting the magnitude and duration of fault current, is constructed to be dependable and permanent.

Rectifier Operates At 1300 F

Silicon carbide rectifiers have been made to operate at temperatures up to 1300 F. This marks the highest temperature yet achieved at which solid state rectifiers will perform, according to scientists at Westinghouse, Pittsburgh, Pa. The grown junction silicon carbide crystals are prepared in a specially designed furnace operating at temperatures higher than 4500 F. The furnace contains an atmosphere of pure helium or argon to prevent contamination of the crystals as they grow inside the furnace. Once the crystals are prepared, they are cut, etched, and otherwise treated for fabrication.

Drone Guidance System Tests Air Defense

An electronic guidance system designed to help the Air Force test U. S. defenses against the most modern air weapons available to an enemy has been successfully demonstrated, the U. S. Air Force and Sperry Gyroscope Co. announced. The microwave command guidance system was specifically engineered for use with Q-4 and Q-5 supersonic drones. It now is being considered as a universal system for controlling other target drones for test purposes, pilotless aircraft, and missiles.

The system enables a control team anywhere on the ground—or in the air—to track a drone, command its engine and flight controls, and receive flight data. All three functions of the system are carried out on a single radar frequency band. The system also is the first to provide remote control of aircraft at low altitudes and great distances, because it incorporates use of an air director (control aircraft) which, like the master ground control station, is fitted out completely with radar range, tracking, command, plotting, and data receiving equipment.

◄ CIRCLE 8 ON READER-SERVICE CARD

WASHINGTON REPORT

Herbert H. Rosen

Cockpit Instrumentation Declassified

The Office of Naval Research has unwrapped more details on its Army-Navy Instrumentation Program—ANIP. Described were the functions of two black boxes—a central control computer and a contact analog generator. The pilot of a jet airplane will watch an instrumented TV screen. On display will be the averaged data from the ILS, Doppler radars, Tacan, Omni, Vortac, or any other navigation aids—or combination of aids, coming from the control computer. It will even operate on dead reckoning data and feed it into the analog display. Superimposed on the position data will be graphic information on fuel consumption, flight path or plan, present position, destination, and Tacan stations.

Cmdr. G. W. Hoover, ANIP project officer, predicted the whole system will be in production within two years. Although the first systems will use a standard CRT display, later models will incorporate an improved version of the Ross Aiken flat CRT.

Besides the flat tube, the ANIP program has been responsible for other significant developments. One member of an unique service-industry team, VARO Manufacturing, has come up with some very clever techniques called microcircuitry. This is microminiaturization carried another step. It utilizes an atmospheric evaporation technique to place circuits on dime-sized ceramic pallets.

The analog display system developed by Kaiser Electronics also represents a novel departure. A picture is presented to the pilot which gives him just the right feel to confidently guide his craft down the "highway" displayed before him.

Departure from convention is standard operating procedure for the ANIP. When Litton Industries needed a new kind of material to store its computer logic, it called on fellow team member, Servomechanisms, to find the material.

Rather than modify existing materials and possibly come up with a marginal answer—a staff of eight researchers decided to tear oxygen atoms apart. As a consequence, they have come up with insulating and semiconducting materials, such as $TiO_{1.95}$ and call them suboxides. Breaking into the atomic and molecular lattice is easy now. Servomechanisms has done so to all kinds of metallic oxides—zirconium, nickle, chromium, molybdenum, cesium, manganese, and others.

Prime contractor for the fixed wing part of the ANIP is Douglas Aircraft. They are now flying a Navy T2V with the system (and a flat CRT) installed. Douglas has also built a simulator on which tentative solutions to problems were tested before hardware was developed.

Teaming with Litton, DuMont, Bendix Pacific, and the Franklin Institute, is Bell Helicopter, which is dealing with helicopter instrumentation. Fortunately, ONR demands that all members of all the teams get together and crossfertilize. Thus in five years, a whole new concept of cockpit instrumentation has become a reality.

DOD To Monitor Missile Reliability

After a year of studying what could be done to improve reliability specifications in military contracts affecting guided missiles, the Department of Defense has come up with an interim plan. According to D. H. Patterson, of DOD's Guided Missiles Office, a reliability monitoring program will be attempted.

"The proposed reliability assurance program," as Patterson calls it, "begins when the contract is awarded and continues through the phases of design, development, production, and major product improvement in the life cycle of the missile weapon system." Stages at which reliability is to be predicted, assessed, or measured have been formulated to provide a basis for the monitoring program. These are: detailed design study; breadboard; prototype; preproduction demonstration; demonstrations of service readiness; service evaluation; full-scale production; and demonstration of major product improvement.

Obviously, reliability will have to be written into the very first guided missile system contract and progress with the system up to the point of "correcting for obsolescence" in a modification contract.

Patterson and his *ad hoc* committee have not set up this program unilaterally. More than 200 replies from industry association members have been received in answer to a request for comments on the first draft of the proposal. A final draft reflecting some of the replies will be submitted to the Military Services "for consideration and comment on how it may be incorporated into future guided missile weapons systems contracts."

Patterson cautions that the monitoring program is designed to "permit a minimum of interference with the contractor's work and to be compatible with the Military Services' specifications and practices in progress reporting."

And, as in the form of a prayerful hope, Patterson adds, "I hope the time will be short when we will think no more of specifying and achieving reliability than we do of specifying and achieving performance factors such as altitude or range."

Speech Worth Applauding

Dear Mr. Lippke:

Your editorial in the April 16, 1958 issue of ELECTRONIC DESIGN is much appreciated. For years my wife has been very emphatic on the poor quality of presentation made by engineers at technical meetings.

Our ISPE [Illinois Society of Professional Engineers] just completed their annual convention at Decatur where four out of five general meeting speeches were "read." It took a member of the faculty of the Business School from the University of Illinois to give the key speech in such a way that 200 men and 200 women were sitting on the edge of their chairs. His topic, "Inflation, Deflation, and Flation," included conversation on business statistics. His style of presentation was amazing and, even though he had reference sheets on the speakers stand, you never felt he was "reading."

Dr. Robert O. Harvey, Professor of Business Administration, could certainly be looked at as an example. He took a subject in which the usual "professor" would go down deeper, stay down longer, and come up drier than any other individual and held his combined audience in humorous stitches for more than 45 minutes. He was able to impress his points on economic changes and still leave you with a feeling that you would like to hear him continue.

Could you please send further information on the new Professional Group on Engineering Writing and Speech referred to in the last paragraph of your editorial.

Warner A. Johnson, P.E.
Micro Switch
Freeport, Ill.

► Information about the Professional Group on Engineering Writing and Speech may be ob-

LETTERS

tained from Eleanor McElwee, Secretary, PGEWS, Commercial Engineering, RCA Tube Div., Harrison, N.J. For membership, write to IRE headquarters at 1 E. 79th St., New York, N.Y.

Uniterm Filing System

Gentlemen:

Congratulations to an article which may help fill a crying need.

We've started a similar system on our own, but find it is beyond our resources of time and secretarial help. Perhaps by publishing this letter we may find a like-minded company in our own area which would like to join in a cooperative effort.

Stephen V. Hart, Vice-President
Electronic Control Corp.
Detroit, Mich.

Dear Sir:

I have read with interest Mr. Bell's article in the April 16 issue concerning the Uniterm system of filing.

There is no doubt that the article is a step in the right direction on a problem that has vexed us considerably in the past; a problem that is, no doubt, shared by most engineers.

My suggestion at first thought is that each article in a periodical has already been Unitermed by the author. This information can be printed in a box in the upper right hand corner of the title page of the article with a space reserved for the appropriate filing number as determined by the reader or filing clerk.

Joseph Salvatore
Control Systems Lab.
University of Illinois
Urbana, Ill.

MEETINGS

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, N.Y.

June 8-12: National Association of Electrical Distributors

San Francisco, Calif. For more information about the convention write to the National Association of Electrical Distributors, 290 Madison Ave., New York 17, 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 9-13: 4th International Automation Exposition and Congress

Coliseum and Barbizon-Plaza Hotel, New York, N.Y. Included in this exposition and congress will be over 100 clinic sessions, 15 technical sessions, plus the Military Automation Exposition. Conferences on "Human Factors in Systems Engineering," and "Plant Layout for Automation" will also be held in connection with the exposition and congress. For further information write to Harrison Gilmer, Director of Public Relations, 4th International Automation Exposition and Congress, 845 Ridge Ave., Pittsburgh 12, Pa.

June 15-19: Semi-Annual Meeting of the ASME

Detroit, Mich. Write to ASME, 29 W. 39th St., New York 18, N.Y., for further information about the meeting.

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.

June 18-20: Statistical Methods in Radio Wave Propagation

University of California, Los Angeles, Calif. Sponsored by the University of California Engineering Extension. Participants from England, France, India, and the United States will present papers in three major fields, statistical theory and techniques of use to scientists and engineers, phenomenological investigations with both statistical and physical structure, and instrumentation for the rapid reduction of large quantities of radio data. Inquiries should be addressed to Dr. W. C. Hoffman, Engineering Building, Room 3116, University of California, Los Angeles 24, Calif.

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, Narragansett Electric Co., 15 Westminster St., Providence, R.I.

July 24-25: 5th Annual Symposium on Computers and Data Processing
Albany Hotel, Denver, Colo. Sponsored by the Denver Research Institute, Electronics Div., University of Denver. Symposium will consist of technical papers on basic problems in the field of data processing, particularly in the areas of formalized analysis techniques, logical design techniques, automatic programming, systems organization, digital communications, and components and devices. Queries concerning the symposium may be addressed to C. A. Hedberg, Head, Electronics Div., Denver Research Institute, University of Denver, Denver 10, Colo.

Aug. 6-8: Special Technical Conference on Non-Linear Magnetics and Magnetic Amplifiers
Hotel Statler, Los Angeles, Calif. Sponsored by AIEE. The four technical sessions will include technological and theoretical aspects of non-linear magnetics and magnetic amplifiers, computer applications, special purpose devices and applications, and "new frontiers" in the field. Exhibits will be displayed by 40 manufacturers selected for their contributions to the industry. For more information about the conference write AIEE, 33 W. 39th St., New York 18, N.Y.

Aug. 13-15: Conference on Electronic Standards and Measurements
NBS Boulder Labs., Boulder, Colo. Sponsored

MEETINGS

by the Professional Group on Instrumentation of IRE, Electronic and High-Frequency Instruments Committee of AIEE, and the Radio Standards Lab. of the National Bureau of Standards. Six technical sessions will cover the following subjects: The Relationship of Standards to Physical Constants; Frequency and Time Interval Standards; Direct-Current and Low-Frequency Standards; Radio-Frequency Standards (Measurement of voltage, current, power, impedance, attenuation, phase shift, field strength); Microwave Standards (Measurement of power, impedance, attenuation, noise), and The Organization and Operation of Standards Laboratories. Write James F. Brockman, National Bureau of Standards, Boulder Labs., Boulder, Colo.

Aug. 19-22: Western Electronic Show and Convention

Los Angeles, Calif. Details will be announced later. For more information write Western Electronic Show and Convention, 1435 S. La Cienega Blvd., Los Angeles 35, Calif.

Paper Deadline

June 25: Deadline for papers to be presented at the **1958 National Simulation Conference.** The conference, sponsored by the IRE, is planned for October 23-25 in Dallas, Tex. One hundred words abstracts and 500 word summaries of technical papers in the general field of simulation should be transmitted in duplicate to *D. J. Simmons, Rt. 8, Box 447, Ft. Worth, Tex.*

Courses—Seminars

Aug. 4-15: Special Summer Program on Microwave Ferrites. Massachusetts Institute of Technology, Cambridge 39, Mass. Topics will include Electromagnetic Theory of Fields in the Presence of Ferrites, Measurements of Ferrite Characteristics, and Linear and Non-linear Ferrite Devices: Theory and Application. Write to Dr. Herman A. Haus, Assistant Professor, M.I.T. Department of Electrical Engineering for information.

Aug. 4-15: Summer Study Course in Microwave Theory and Technique. Case Institute of Technology, Cleveland, Ohio. The course will be directed toward the engineer in industry who has found a growing need for training in the methods of measuring and analyzing with microwaves. Requests for additional information on the course should be directed to the Director of Special Programs, Case Institute of Technology, 10900 Euclid Ave., Cleveland 6, Ohio.

EDITORIAL

ELECTRONIC DESIGN Breakthrough

Last month, after advertising lineage was counted, ELECTRONIC DESIGN moved into first position in display advertising among electronics technical publications. In 64 months, ELECTRONIC DESIGN has outpaced all electronics magazines—a record unparalleled among some 1200 business magazines. We're in first place because you, the reader, said we were the most helpful to you in giving you ideas to do your job better.

Being first in advertising makes our publishers and sales force jubilant. We editors don't deny we're pleased, but the fact is almost anticlimactic. We have for some time carried more engineering design information than other publications. It has been our goal to give you the best in helpful, practical design information. Whether we are first in advertising is immaterial except as it affects total space available for editorial.

As of last month, we were the only principal magazine, serving the electronics industry exclusively, with a square format. To you, the reader, this has meant attractively laid out articles, easy to read and to follow. The magazine lies flat on your desk. (Of course, we know the shape makes it more difficult to remove articles for filing, but we feel that quantity and quality are more important.) To the advertiser, the square format has meant editorial next to every page of advertising. If the editorial is interesting, his ad will be exposed to readers. Your response to his advertising has made him aware that ELECTRONIC DESIGN is read. He gives us more advertising, we have more room for editorial—a happy cycle.

What makes being first even more significant is that our audience, exclusively design engineers, is not as wide as that of other publications. This goes to prove that you, the design engineer, are the key man. In this time of general recession, ELECTRONIC DESIGN, which goes to design engineers with a design engineering message, is growing. Others are off.

Of course, much of the credit should go to our engineer-authors. It has been their desire to pass along helpful information that has enabled us to become so successful. It has not been easy for some authors—we have many times asked them to rewrite their material so that we could pass along only essential-to-know information in as short a space as possible. We trust the results of writing for us have been rewarding. One bit of satisfaction to the author comes from knowing that he is being exposed to the greatest number of design engineers.

As we toast the success of the magazine, we toast you, the reader, for the support and words of encouragement that you have given us as we were growing.

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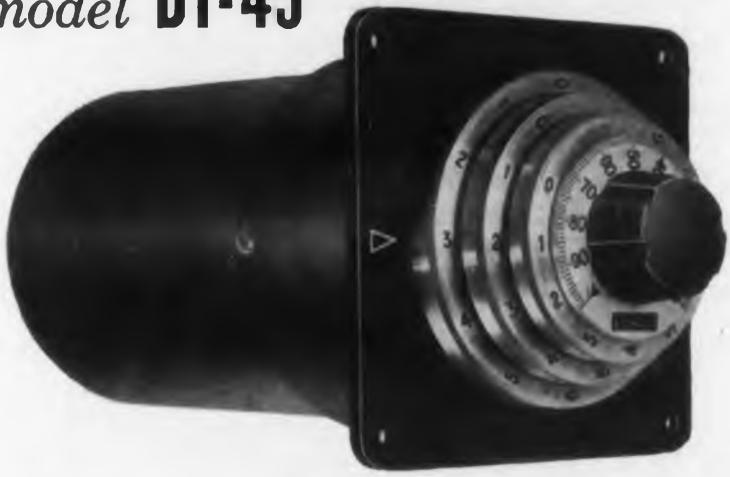

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Graphical Method Simplifies Wien Bridge Oscillator Design

Earl D. Grim
Radio Corporation of America
RCA Victor Div.
Camden, N.J.

Here's a simple graphical method for the analysis and design of Wien Bridge oscillators. It avoids the "dogwork" of the rigorous mathematical design and the sloppiness of the trial and error method.

TOO OFTEN, Wien Bridge oscillators have been designed by the "hit and miss and try again" method. This has resulted in oscillators with poor waveform or unstable operation. This article describes a reliable, effective design procedure. Curves are presented to enable the design engineer to outline the requirements for the feedback network and amplifier parameters to produce circuit oscillation at the desired frequency.

Basic Wien Bridge Oscillator

A simplified schematic of the oscillator is shown in Fig. 1. The gain of the amplifier is symbolized by $|G|$. The symbol A is defined as the ratio of R_1/R_2 and C_2/C_1, and T is defined as $R_1C_1 = R_2C_2$ where the R's and C's are defined in Fig. 1.

In Figs. 2 and 3, ϕH, the phase of H (the transfer function of the feedback network) is plotted against generalized frequency coordinates. Fig. 3 is an enlarged section of Fig. 2 in the region near $\omega = 1/T$.

Fig. 4 presents $|H|$, the gain factor of H, plotted against A, the feedback network parameter. This gain factor varies also with the phase shift through the network. Hence, three curves are plotted, with phase shifts corresponding to zero, ± 20 and ± 40 degrees.

There are two main points to note with these curves.

1. As A increases, the feedback network has a larger gain factor. As A gets very large, the gain factor approaches unity.
2. If the phase shift through the network is not zero, the gain factor is always smaller than the corresponding zero phase shift gain factor.

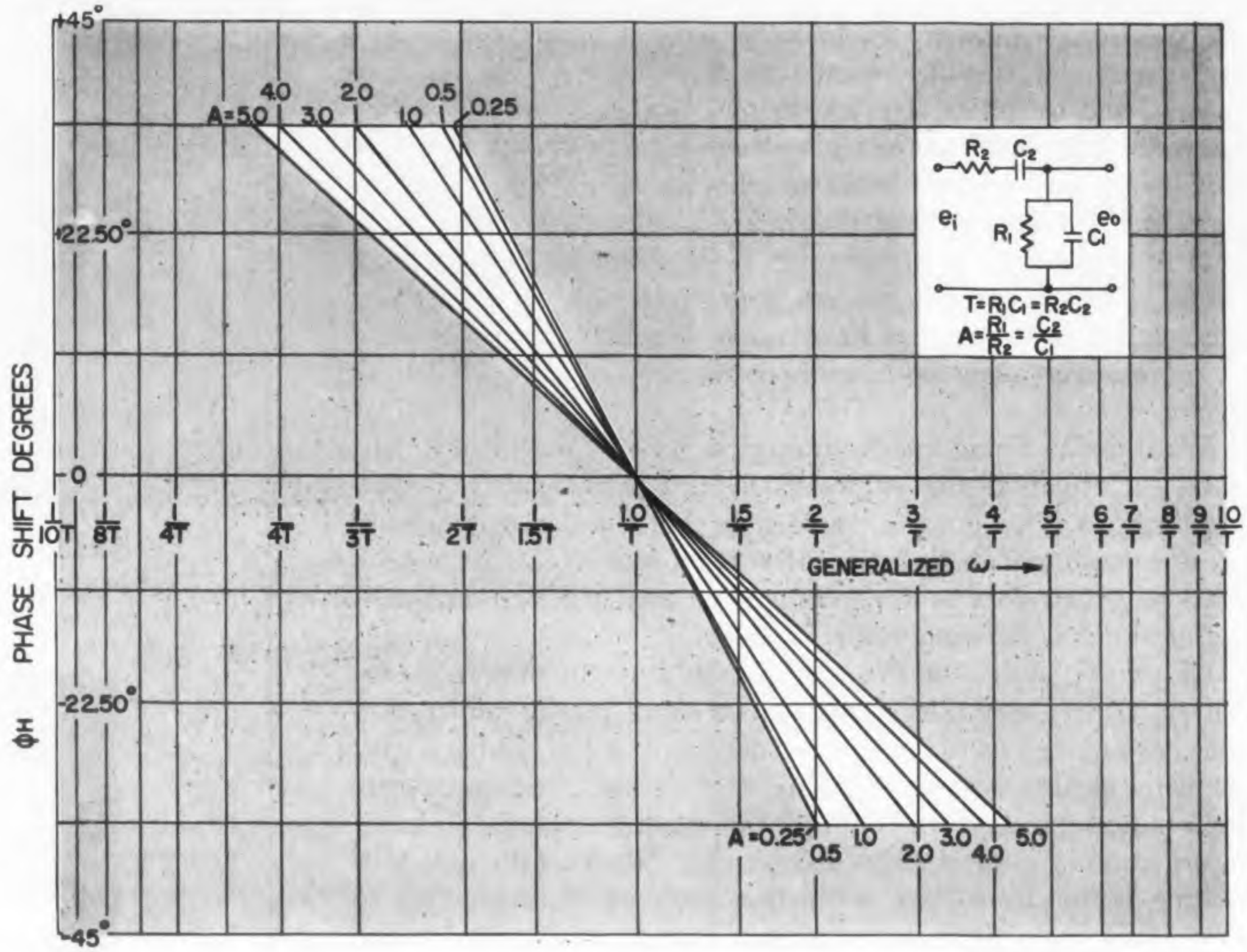

Fig. 2. The network phase shift is plotted here against generalized frequency (in radians per second) for various values of the parameter A.

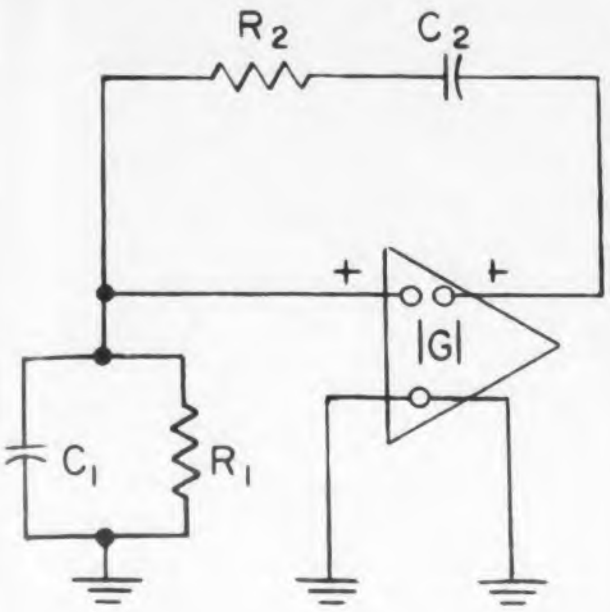

Fig. 1. Basic Wien Bridge oscillator. The ratios $R_1/R_2 = C_2/C_1$ are symbolized by A. The time constant $T = R_1C_1 = R_2C_2$. C_1 includes amplifier input and stray capacity and R_1 includes the amplifier grid resistor.

If the closed loop representing the amplifier and feedback network is broken at the input to the amplifier, and if a voltage is fed to that input, then the closed loop will oscillate if the voltage at the output of the feedback network has the same phase and equal or greater magnitude than the amplifier input voltage.

Expressed mathematically:

$$\phi G + \phi H = 0$$
$$|G|\,|H| \geq 1$$

where ϕG and ϕH are the phase relationships of the transfer functions of the amplifier and feedback network respectively. $|G|$ and $|H|$ are the absolute values of their magnitudes. With these criteria, one can design an oscillator.

5 kc Oscillator Design

Feedback Network: For a 5 kc oscillator

$$\omega = 2\pi \times 5 \times 10^3 = \pi 10^4$$
$$T = 1/\omega = R_1C_1 = R_2C_2 = 10^{-4}/\pi$$

In setting the impedance level of the feedback network, a compromise must be effected between the desirable high impedance which minimizes amplifier loading, and the equally desirable low impedance which minimizes the effects of changes in circuit capacity due to tube changes.

In this spirit of compromise, a value of 56 K is chosen for R_2. Then

$$C_2 = \frac{1}{5.6 \times 10^8 \pi} = 560\ \mu\mu f$$

Now a value for A must be chosen. Notice in Fig. 2 that for values of A less than 0.25, the curve would have substantially the same slope as for $A = 0.25$. Values of A greater than 5 are not

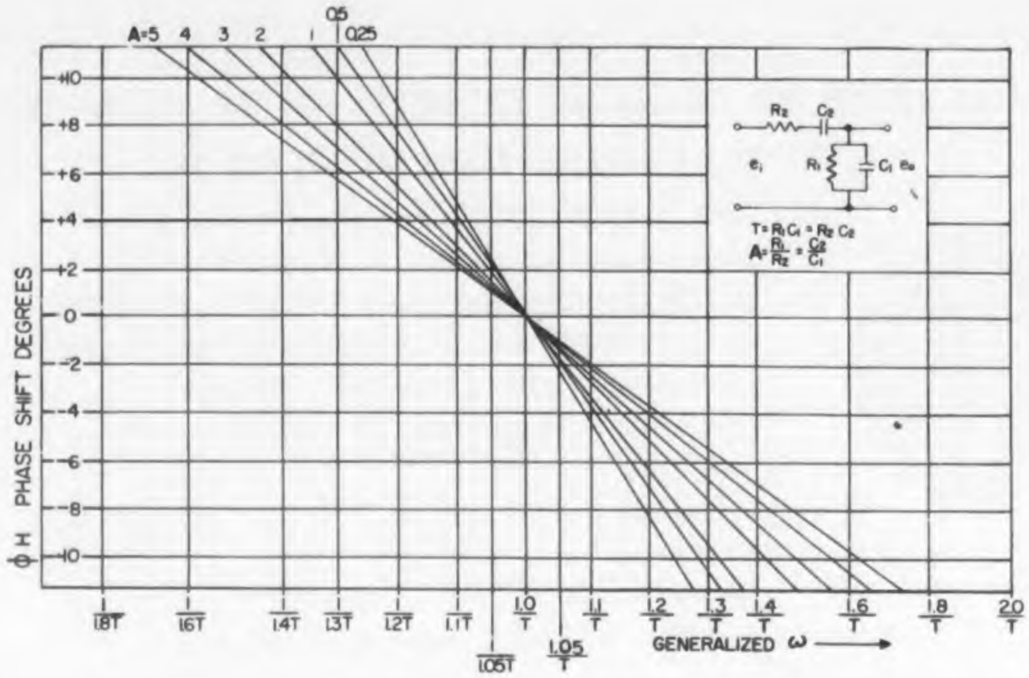

Fig. 3. This is an expansion of Fig. 2 in the vicinity of $\omega = 1/T$.

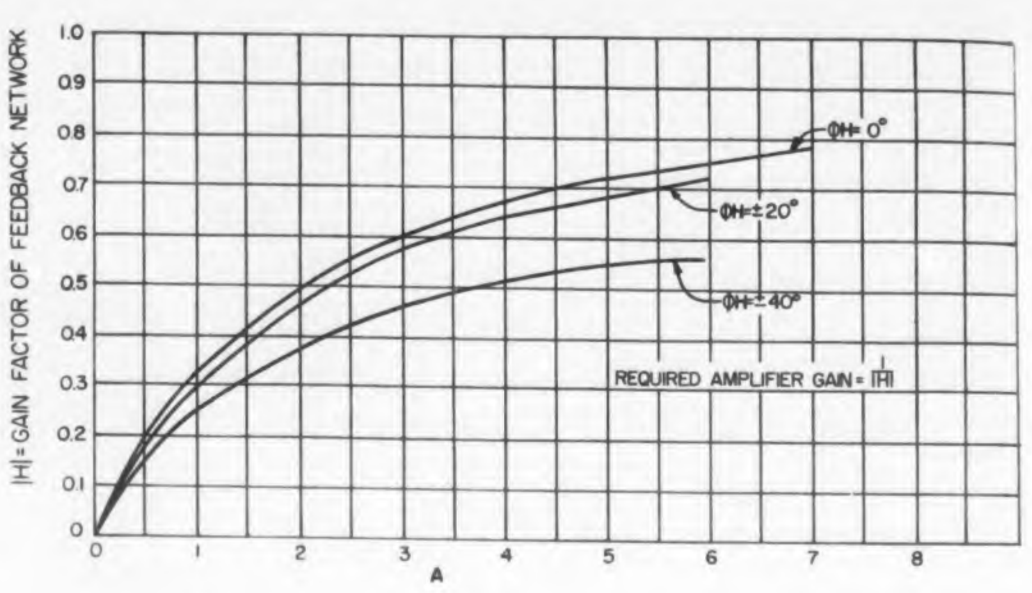

Fig. 4. These curves are used to determine the required amplifier gain and feedback network gain, knowing *A*. They are especially useful for high and low frequency design.

too practical since they result in severe frequency changes for small phase changes. Again, in a spirit of compromise, a value of $A = 2$ is chosen. Then

$R_1 = AR_2 = 112\ K$
$C_1 = C_2/A = 280\ \mu\mu f$ (which must include amplifier input capacity)

This completes the design of the feedback network. The required gain and phase shift characteristics of the amplifier must now be determined.

Amplifier Phase Shift and Gain: Referring to Fig. 3, and recalling that $\omega = 1/T$ and $A = 2$ were chosen as parameters to determine the feedback network characteristics, it can be seen that ϕH must be zero at the point defined by the values of ω and A.

Since $\phi G + \phi H = 0$ as an oscillation requirement, then ϕG must equal 0.

Thus one amplifier requirement is that its phase shift at 5 kc must be zero. Of course, this may be 360 deg or multiples of 360. Phase shift in the amplifier can often be found conveniently by plotting the break points in the amplifier frequency gain curve and computing the phase shift. (See the reference.)

The gain requirement of the amplifier can be found by referring to Fig. 4. This presents $|H|$ as a function of A with ϕH as a parameter. When ϕH is 0 and A is 2, then $|H| = 0.5$.

Since for oscillation the product of $|G|$ and $|H|$ is equal to or greater than 1, then $|G|$ must be equal to or greater than $1/0.5 = 2$.

Thus the amplifier must have a gain of two or slightly greater for oscillation. This gain should be measured with the feedback network and any other load impedance that might be present.

A 5 kc Oscillator

Fig. 5 shows a workable design for a 5 kc oscillator using a 12AT7. The actual amplifier design procedure will be covered in a forthcoming article.

Briefly, a few points in the schematic are worthy of note. C_1 had been calculated to be 280 μμf. In the schematic, however, C_1 consists of two capacitors having a total value of 259 μμf. The difference is accounted for by the input capacity of the amplifier. The first triode has a 100 *K* plate load to provide high gain, while the second triode has a total plate load of only 8.2 *K* to minimize the loading effect of the feedback network and reduce the gain to 2. The 7.5 *K*, 1.8 *K* combination provides negative feedback to reduce gain and minimize changes in the open loop gain. The tap in the second triode's plate load is to compensate for variations in the amplification factor from tube to tube. The values of the coupling capacitors are chosen to balance lagging and leading phase shifts and to provide zero phase shift at 5 kc.

Output is taken from the cathode of the second stage of amplification so as to maintain a low impedance to minimize loading. Where severe loading is anticipated, this output should drive another cathode follower.

High and Low Frequency Oscillators

In designing very high or very low frequency oscillators, it is difficult to obtain zero phase shift through the amplifier with any reasonable gain. In these cases, a design can be completed with phase shift.

Suppose an amplifier design has a gain of 3.5 with 20 degrees of lagging phase shift at the desired frequency of oscillation. Since the sum of the phase shifts of the amplifier and feedback network must be zero, and the amplifier has a phase shift of −20 deg, the feedback network must have a phase shift of +20 deg.

Also, since the product of the gain factors of the amplifier and feedback network must equal or be greater than 1, $|H|$ must equal or be greater than $1/3.5 = 0.286$.

Referring to the ϕH curve of Fig. 4, one can produce oscillation with a value of A of about 1 or greater. In general, the lowest value of A should be chosen to provide the most stable circuit operation. This can be observed in Fig. 2. The slope of the curves increases as A decreases, which indicates that a smaller frequency change in the closed loop will occur for a given change in amplifier phase shift with smaller values of A.

Therefore the value $A = 1$ is a good choice for a feedback network parameter. Now the two parameters, $A = 1$ and $\phi H = +20$ define a point on Fig. 2 from which ω can be found. This value is $\omega = 1/1.75\ T$. Then $T = 1/1.75\ (2\pi f) = R_1C_1 = R_2C_2$.

Since f is known, T is defined by this equation and R and C can be found. Again these values should be chosen as a compromise between stray capacity effects and amplifier loading. After R_1 and C_1 are known then R_2 must equal R_1 and C_1 should equal C_2 since A was chosen equal to 1.

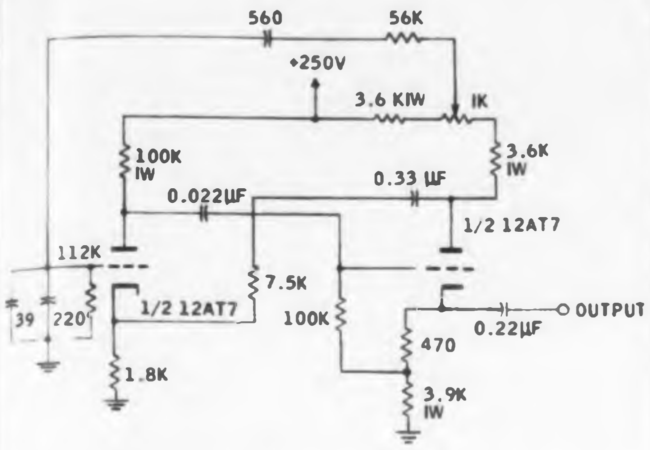

Fig. 5. A 5 kc Wien Bridge oscillator. Capacitor values are in µµf unless otherwise designated.

Knowing the expected variation in the phase shift and gain of the amplifier, one can predict the frequency variation and the capability of oscillation. With A known, a given variation in amplifier phase shift will cause a specific frequency shift which can be found from Fig. 2 or 3. The oscillation capability can be determined from Fig. 4. If the gain $|G|$ is less than $1/|H|$ at the chosen A value at any limit point, the circuit will not oscillate. If $|G|$ is much greater than $1/|H|$ the output waveform will be distorted.

Since zero or 360 degrees of phase shift is required, two stages are generally necessary if the common cathode connection is used. However, one can get gain and the required phase shift in one stage if the common grid connection is used, or in the transistor, the common base connection. An obvious difficulty with this type design is the very low input impedance of the cathode or emitter circuit. Nevertheless, if this is taken into account an oscillator can be built with only one amplifier stage.

Variable Frequency Design

A variable frequency oscillator can be designed if, for example, C_1 and C_2 are varied simultaneously. The frequency of oscillation is:

$$\omega = 1/T = 1/R_1C_1 = 1/R_2C_2$$

But this is true only if the phase shift through the amplifier is zero. If there is phase shift, then the actual frequency of oscillation can be found from Fig. 2 or 3. Thus the designer can predict deviations from linearity in the variable capacitor vs frequency relationship and establish specifications for the amplifier phase shift according to his design requirements.

Reference

Servomechanisms and Regulating System Design, Vol. I, Chestnut and Mayer. John Wiley, New York, N.Y., 1951, pp. 309-310.

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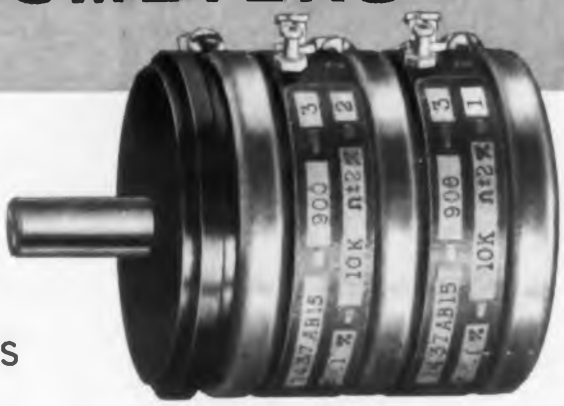

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Using Transistors in Demodulator Circuits

Albert N. DeSautels
Minneapolis-Honeywell Regulator Co.
Minneapolis, Minn.

Part 1

Phase discriminators with dc output are used extensively in control circuits. Transistorized discriminators have the advantage of small size and low power consumption. They provide amplification with good reliability over a wide temperature range.

This article discusses half-wave and full-wave phase discriminators using transistors and diodes to produce output capable of driving magnetic amplifiers, energizing relays, heating coils, and hydraulic valves.

Part 2 will analyze operating characteristics and discuss power considerations and limitations.

DEMODULATOR circuitry uses the switching characteristics of the junction transistor. A transistor demodulator (Fig. 1) can be combined with a magnetic amplifier or transistor amplifier to produce an effective unit in a synchro-controlled system.

In essence, when the base is positive with respect to both emitter and collector, the transistors will act as open switches with very low leakage. When the base becomes negative with respect to either, the transistors will act as closed switches with very little voltage drop.

When transistors are acting as switches rather than amplifiers, their characteristics are not critical and no need exists for matching. Low gain transistors can also be successfully used.

The demodulator (Fig. 1) is a stable device

Fig. 1.

Fig. 2.

capable of operating at as low as 20 millivolts of signal. However, a fairly large signal is required to achieve respectable values of current through a load. In an experimental setup, an E_s of 1/2 v produced 50 μamp of dc.

Phase Discriminators

A half-wave phase discriminator (Fig. 2) is capable of furnishing much higher levels of dc current to a load. Transistors and diodes are combined to provide amplification, demodulation and discrimination with reliability and stability over a wide temperature range. Power handling capabilities are extensive and are limited primarily by maximum voltage and current rating of the transistors.

The circuit shown in Fig. 2 will produce half-wave differential dc current into a three-terminal or split load such as is found in the activating coils for hydraulic valves in automatic flight control systems. Discriminator action is furnished by the diodes D_1 and D_2. Considering the NPN transistor shown, when the points A and B are becoming positive at the same time, T_1 will conduct and current will flow through D_1 and one-half of the load L_1. On the negative half-cycle, T_1 is cut off and no current will flow.

If the signal phase at A is reversed and points A and C are becoming positive simultaneously, T_1 will again conduct with current flowing through D_2 and the other half of the load L_2. Once again on the negative half-cycle, T_1 is cut off and no current will flow.

The resistance R_e may be added to improve transistor interchangeability and performance with temperature variation. The ratio R_1/R_2 would be independent upon the amplitude of the dc power supply and the amount of quiescent current acceptable in the load. It is necessary that the diodes D_1 and D_2 be matched for balanced phase response.

When one diode is conducting, a back voltage appears across the other equal to twice the peak reference minus the voltage drop in the load. Therefore, the nonconducting diode should have an inverse voltage rating in excess of $2\sqrt{2}V_R - V_L$.

When the transistor is nonconducting, the collector emitter junction is subjected to an inverse voltage equal to the peak reference voltage. Therefore, the maximum collector voltage rating should be greater than the peak reference voltage value.

Often it is advisable to use full-wave rather than half-wave discrimination. The large fundamental ripple on the half-wave dc output may necessitate use of shunting capacitors in hy-

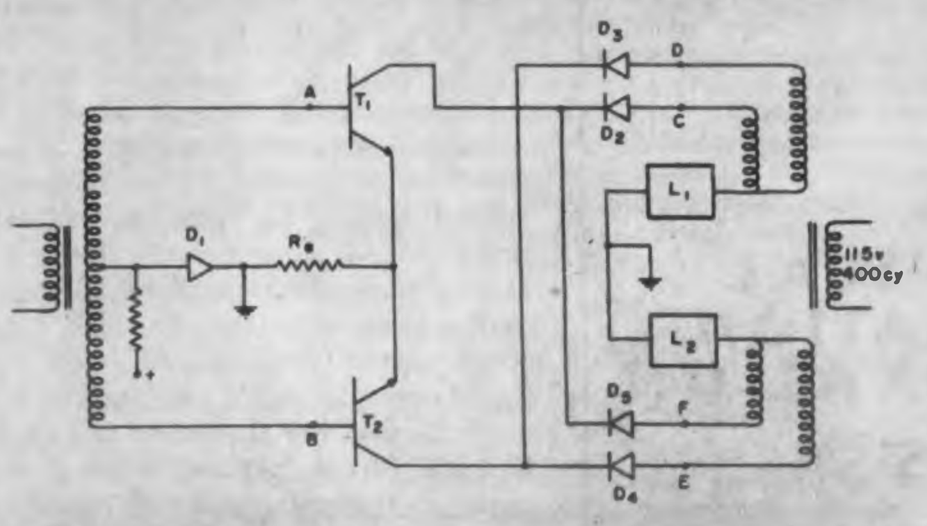

Fig. 3. Full-wave phase discriminator with three-terminal load.

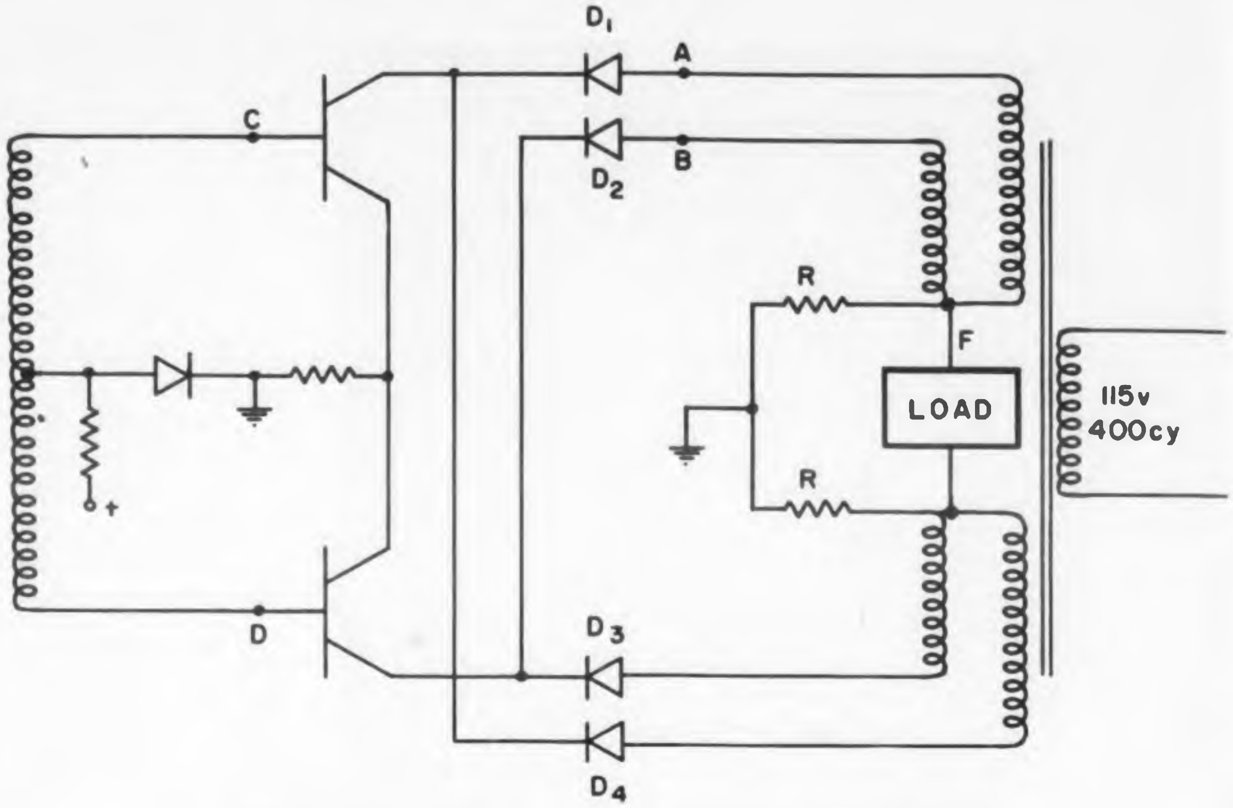

Fig. 4. Full-wave phase discriminator with two-terminal load.

draulic valve or relay drive applications. Full-wave discrimination would eliminate the need for any capacitor in most instances.

Half-wave magnetic amplifiers will present more stable performance with full-wave dc controls. More efficient control of the full-wave magnetic amplifier can be obtained with full-wave through the control windings.

Transistors can be used as well in full-wave discriminators as in half-wave.

The half-wave discriminator can be adopted to full-wave output into a three-terminal load (Fig. 3). Full-wave output is obtained through the summing of two half-wave actions.

When *A* and *C* become positive simultaneously, T_1 conducts through D_2 and the load L_1. During this half-cycle, T_2 is cut off because of the negative signal at *B*. On the second half of the cycle, *A* and *C* become negative cutting off T_1 while *B* and *D* become positive. T_2 then conducts through D_3 and the load L_1. Thus, the load experiences two half-wave current pulses during the cycle, or a full wave of current. For a 180-degree phase change in the signal, points *A* and *F* would become positive simultaneously, and conduction would occur through T_1, D_5, and the load L_2 for one half-cycle. For the second half-cycle, *A* and *F* would become negative while *B* and *E* become positive and T_2 would conduct through D_4 and L_2, completing the full wave of current.

Since both transistors conduct during the cycle to provide an average or effective current, the transistors need not be matched. The same inverse voltage considerations associated with the half-wave circuitry will apply to full-wave circuitry. For balanced phase response, the diodes may have to be matched.

Constant bias voltage for the transistors is provided by D_1. Control of forward current through D_1 establishes a desired transistor bias voltage related to the forward diode voltage drop. Bias voltage is selected in accordance with the amplitude of quiescent load current permissible for a particular application.

An additional function of D_1 is to provide some compensation for temperature changes. Transistor characteristics are such that with temperature decrease, an increase in bias voltage is required to maintain constant collector current conditions. Conversely, with temperature increase, a decrease in bias voltage is necessary to maintain constant collector current. The temperature characteristics of the bias diode are such that the forward resistance increases with decreased temperature and decreases with increased temperature. Therefore, with a constant current source to the diode, the forward voltage across the bias diode D_1 would increase with lower ambient and decrease with higher ambient. In this manner, the drop across the diode would

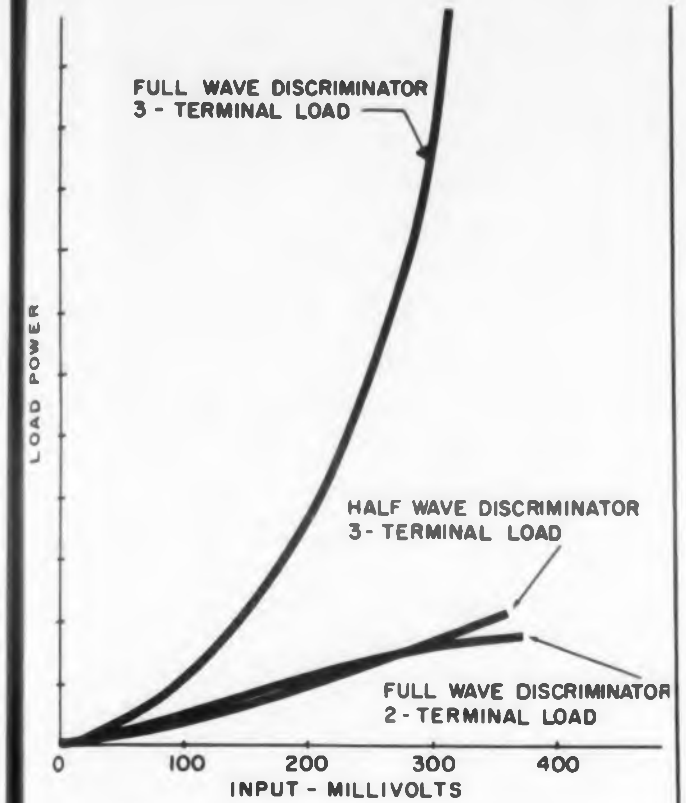

Fig. 5. Load power vs input voltage

tend to compensate for the changing bias requirements of the transistor. R_e may be added to improve transistor interchangeability.

A two-terminal, phase-sensitive dc output from the full-wave discriminator can be obtained by adding bleeder resistors and connecting the load as shown in Fig. 4.

For best power transfer to the load, R is approximately equal to the load resistance. One-sixth of the output power is dissipated in the load; the remainder is lost in the bleeder resistors. Thus, this configuration is considerably less efficient than the three-terminal usage.

Current through the load will be full-wave with direction related to signal phase. When point C becomes positive, T_1 conducts through D_1; and the current takes two paths, one through the load and the other through R. On the next half-cycle, points D and B become positive, and T_2 conducts through D_2 and completes the full wave of current through the load, With reversed signal phase, conduction would be through D_4 and D_3 with a reversal of current direction through the load.

Fig. 5 compares load power for half-wave, full-wave three-terminal, and full-wave two-terminal transistor phase discriminators as a function of input voltage. These curves show a favorable comparison between half-wave three-terminal output and full-wave two-terminal output.

High Voltage Semimetal Thermocouples

Robert W. Fritts
Assistant Director of Research
Baso Inc.
Milwaukee, Wis.

Editor's Note: The semimetals discussed in this article were originally developed by Dr. Fritts for use outside the electronic industry. A semimetal thermocouple heated by a gas pilot light, was designed to provide direct control of a safety valve. ELECTRONIC DESIGN feels that semimetals, which lie between metals and semiconductors in respect to electrical properties, have potential applications in electronics. The manufacture, properties, and new applications for the material are discussed.

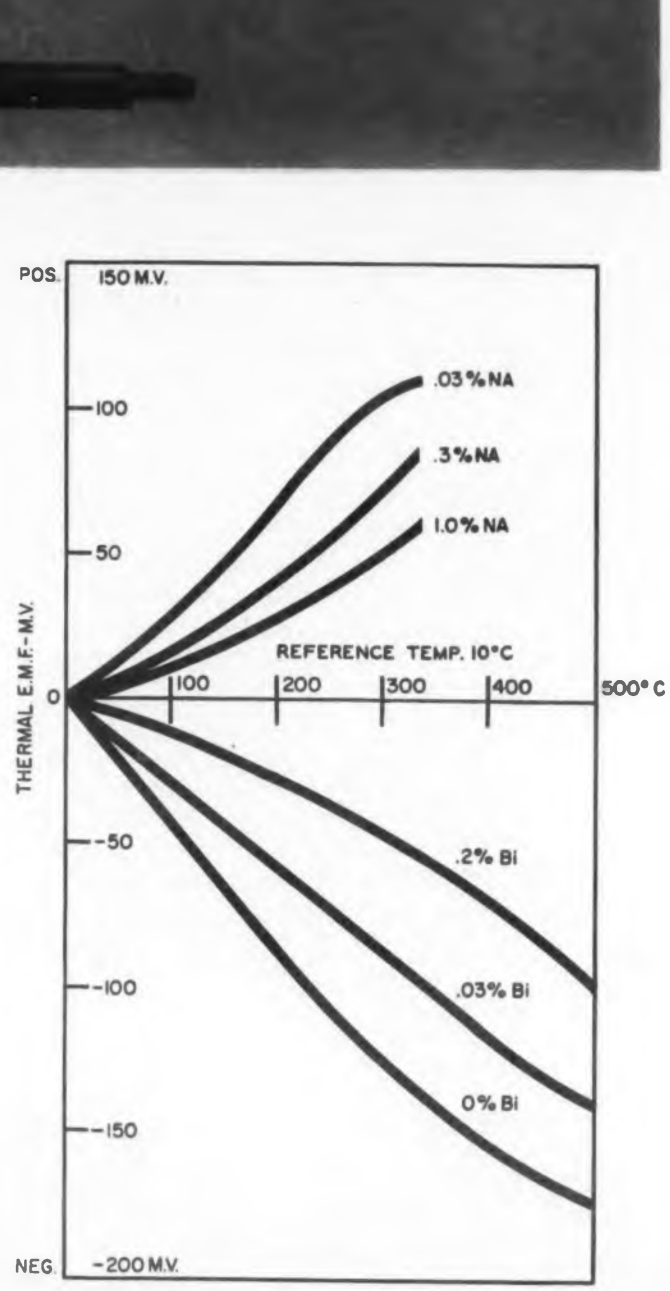

Fig. 1. Thermal emf for several specific pbTe alloys indicate the temperature and voltage ranges possible with various compositions.

THERMOELECTRIC materials, which generate enough power to operate relays, valves, and small motors, make possible the operation of equipment directly from a thermocouple junction. Composed of lead telluride (PbTe) modified by alloying agents, the new materials can generate power ten times more efficiently than conventional metallic thermocouples. They exhibit electrical properties between metals on the one hand and semiconductors on the other. The material used in the elements is called a semimetal to distinguish it from high resistance germanium and silicon devices.

Semimetal thermocouple elements are alloys composed principally of crystals of PbTe with minute concentrations of bismuth or sodium alloying agents to overcome the naturally high resistivity of the lead telluride. Desired electrical properties of the elements are obtained by varying the concentration of the alloying agent. The thermocouples can be manufactured at low cost since there is no need to prepare them in single crystal form, or with the high purity necessary for germanium and silicon. The elements are produced by casting ingots in carbon molds in a reducing atmosphere. They can be made with either positive or negative polarity depending on the kind of alloying agents used. Ready machinability is a further factor in low production and fabrication costs.

Positive and negative polarities in semimetals are obtained by varying the lead content in relation to the tellurium and by the addition of elements called positive promoters or negative promoters. In semimetals of positive polarity, *P*-type alloys, the amount of lead in the PbTe alloy ranges from 59 per cent to 61.8 per cent by weight, the positive promoter being less than 1 per cent. Semimetals of negative polarity, *N*-type alloys have a lead content of 61.95 per nt to 63 per cent with a negative promoter ain of less than 1 per cent. Conductivity of th materials can be varied over wide ranges changing the amounts of the promoters added. ariations of the lead content within the ranges ecified has negligible effect upon the conduc-ity.

Operating Conditions

Both *P* and *N* ingots can be used in open air up the melting point of tin (230 C). Above this mperature oxidation of the alloy becomes sig-ificant and hermetic sealing is necessary. The -type alloy is sufficiently stable for long time ervice up to 350 C when operated in a non-oxi-izing atmosphere. The *N*-type alloy can be used r extended service up to 600 C.

For lower temperature applications, both the and *N* alloys may be soldered with tin or lead-n eutectic solders. For higher temperatures, spe-ial electrode alloys have been developed to pro-ide physically bonded ohmic contacts with a egligible contact resistance.

New Applications

Sensitive relays have been operated directly om a single *P-N* thermocouple from a tempera-ure difference of only 85 C. Accurate control of ng time delay relays can be effected by ex-rnally heating the hot junction of the relay op-

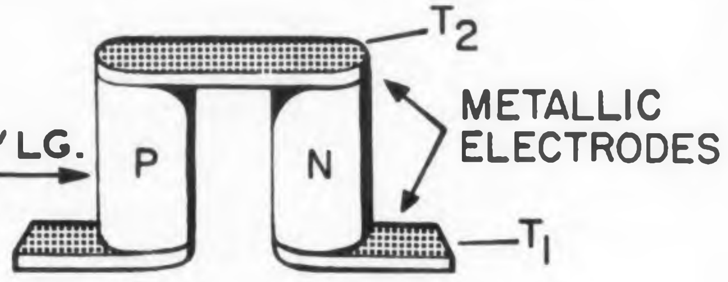

Table 1. Electrical properties possible for various alloys. Voltage sensitivity and maximum power into a matched load depend upon different choices of P and N alloys.

For High Voltage Sensitivity

T_2 °F	T_1 °F	E mv	R	I	Matched Load Power mw	N alloy	P alloy
550	50	197	0.12	0.82	81	.01 wt. % Bi	.002 wt. % Na
350	50	116	0.07	0.83	48	''	''

For Maximum Power To Matched Load

T_2 °F	T_1 °F	E mv	R	I	Matched Load Power mw	N alloy	P alloy
550	50	117	.0148	3.95	230	.10 wt. % Bi	.035 wt. % Na
350	50	65	.0106	3.06	99.7	''	.021 wt. % Na

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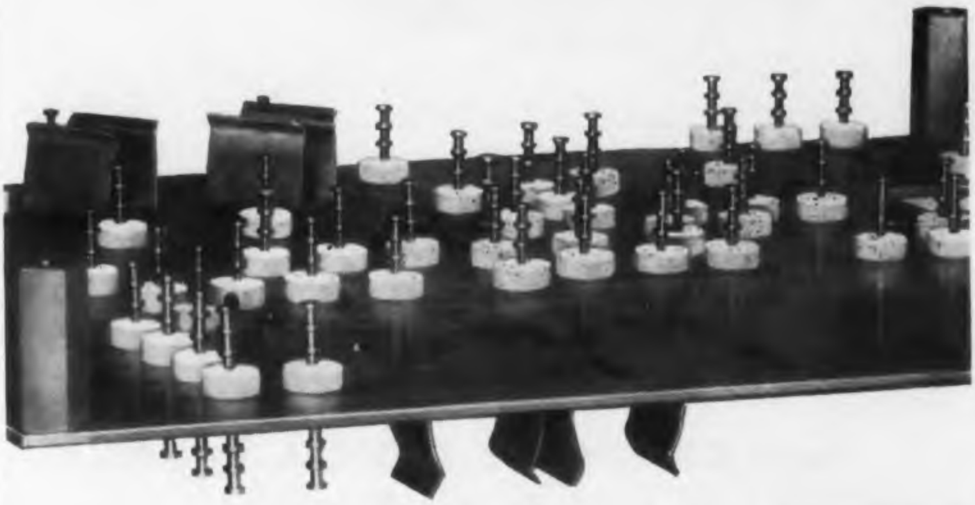
STAND-OFF & FEED-THRU INSULATORS



Withstanding shock, vibration, temperature extremes, Chemelec Insulators—made of du Pont TEFLON—are replacing components of brittle materials for *high reliability* in many critical electronic circuits.

Made in both compression-mounting and metal base, miniature and subminiature types, in standard R.M.A. colors and wide range of sizes and terminal designs.

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COMPRESSION MOUNTED TYPE

METAL BASE TYPE

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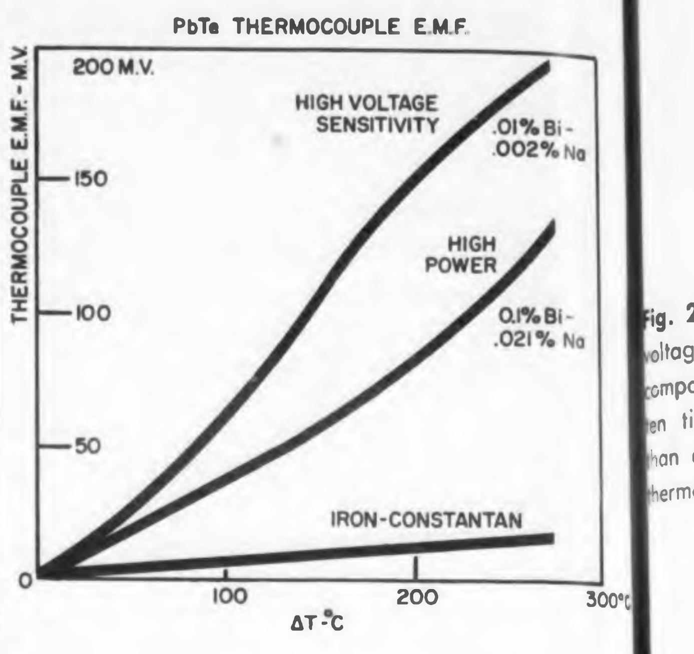
CIRCLE 23 ON READER-SERVICE CARD



erating thermocouple to raise its temperature slowly to the point where sufficient current is developed to actuate the relay.

One high temperature application of the *N*-type alloy has been the operation of valves and safety shutoff devices in the gas controls industry. The thermocouple, when heated by a small pilot flame, provides enough power to operate the safety valve. A thermopile of twelve such thermocouples has driven a small air-circulating fan from the heat of a laboratory Bunsen burner. The same thermopile operated a lamp-bank of six penlight bulbs at full brilliance. With focussing means, infrared radiation can be used as a source of electrical power.

Because of the ease with which these alloys can be fabricated, many other applications are contemplated.

Physical and Electrical Properties

When cast and hydrogen annealed, a semimetal has these physical properties:

Tensile strength	—greater than 1000 psi
Compressive strength	—greater than 10,000 psi
Young's modulus	—2×10^6 psi
Density	—8.15 g/cc
Thermal expansion coefficient	—18×10^{-6}/deg C
Thermal conductivity	—.02 watts/cm/deg C

Complex relationships exist between thermal emf, resistivity, and temperature in a semimetal thermocouple. The composition for positive and negative thermocouple elements is governed by the desired function of the thermocouple and the temperature range in service. The thermal emf for several specific PbTe alloys are shown in Fig. 1. These emf's are taken with respect to cop-

Fig. 2. Semimetal high voltage and high power compositions have up to ten times more output than an iron-constantan thermocouple.

per. When positive and negative PbTe elements are used in a single thermocouple, the thermal emf developed is the sum of emf's for the two components or the ordinate differential between the two curves. The electrical resistivity of these materials exhibits a large positive temperature coefficient at ordinary temperatures, but at elevated temperatures this coefficient becomes negative.

The shape of the resistivity-temperature curves of semimetal materials depends strongly upon the degree of alloying with negative or positive promotor. Some examples of composition and properties are shown in Table I.

A comparison of the data in Table I shows that high voltage sensitivity and maximum power delivery to a matched load cannot be obtained with a single choice of P and N compositions. High voltage sensitivity is obtained with P and N elements doped with small amounts of sodium and bismuth. High matched load power is obtained with elements doped with relatively higher amounts of these additives. The data for thermocouples designed for maximum power delivery to matched load illustrates how the selection of composition depends upon the temperature ranges to be encountered. A comparison of the voltage sensitivity of semimetal materials with conventional thermocouple alloys is shown in Fig. 2. Thermal emfs for two semimetal combinations are plotted with the voltage output of an iron constantan couple.

As is shown, semimetal high voltage sensitivity and high power compositions have up to ten times the output of the iron-constantan thermocouple.

Two Watt Amplifier In A Size 8 Can

IT'S HARD to believe that anybody could build a two watt amplifier in a size 8 shell. It's harder still to believe the amplifier could deliver two watts of 400 cycle power continuously in a 100 deg C ambient—and with no heat sink.

But it's been done. The new amplifier provides enough power, in push-pull, to drive the new size 8 servo motors. It has the same diameter, and is not much longer. Requiring only a 28 vdc power supply, it can deliver 40 v rms to an 812 ohm center-tapped load. The input impedance is 5000 ohms.

Its gain can be adjusted from 200 to 1000 with an external resistor. The entire assembly weighs only an ounce and occupies only 0.8 cubic inch.

The Precision Components Div., of Norden-Ketay Corp., of Commack, N.Y., wanted this miniature amplifier to resemble a servo motor as nearly as possible. To pack so much power capability in so small a space required a novel packaging technique.

The result was a sandwich type struc-

Size 8 motor and amplifier to drive it.

ure, easy to assemble, and very rugged.

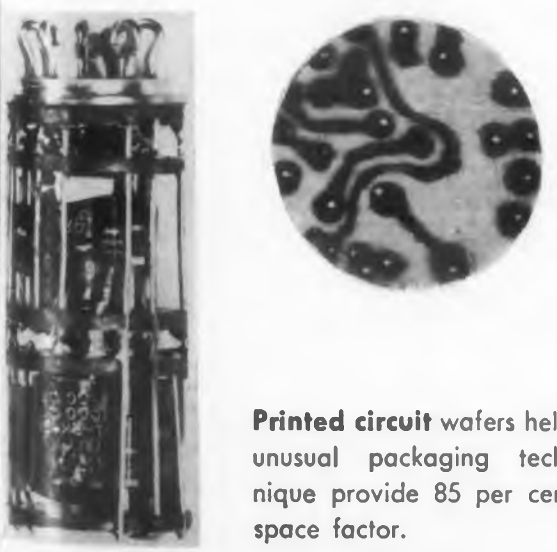
The construction uses five printed circuit boards, each 1/16 in. thick with a /4 in. diameter. A standard header and ase, and standard resistors, capacitors, nd transistors (four of them) are used.

The arrangement embodies parallel ets of printed circuit boards with circuit components between. The sandwich odules are assembled first. The fifth oard brings connections to the header ins. The amplifier assembly is then ompleted by feeding peripheral leads hrough outer holes at the edge of the oards for interconnection between oards and connections to the header.

The entire assembly is then resin dipped, evacuated and filled with a Monsanto liquid coolant. Finally, it is sealed n its case.

The cylindrical package lends itself ideally to the use of standard resistors nd capacitors, and to the use of the tandard JETEC-30 transistor case.

For more information turn to the Reader-Service card and circle 27.



Printed circuit wafers help unusual packaging technique provide 85 per cent space factor.

Radar Reflectors of Reinforced Plastic

Ralph L. Mondano
Raytheon Manufacturing Co.
Waltham, Mass.

The application of reinforced plastics in the fabrication of radar reflectors can be primarily traced to the facility with which glass-resin layups can be accurately shaped to a compound curvature. Radar reflector designers were immediately intrigued by the idea of being able to make an accurate male form upon which they could position some woven glass fabric, paint it with the new magic liquid thermosetting resins and obtain a good mechanical structure.

. . . . as they come from the mold

PROPERTIES not obtainable or economically unobtainable in metal radar reflectors are now available in reflectors made of reinforced plastic. At Raytheon Manufacturing Company's Plastic Research Division, practical plastic reflectors have been produced which resist corrosion, are easily reproduceable, can be molded with good surface finish and are dimensionally stable. But the one most important feature is *light weight*. Yet, the strength-weight ratio is comparable to or better than for metal reflectors.

Development of a reflector in reinforced plastics, which would have all the desirable properties indicated above plus reasonable cost (competitive position cost-wise will depend on quantity), required the solution of a number of formidable problems.

Problems Encountered

In the design of plastic radar reflectors, the following questions had to be answered:

- How would the necessary metallic reflecting surface be obtained?
- Would this structure have enough rigidity when mounted and gimballed at high accelerations?
- What are the aging characteristics as well as creep problems?
- How should metal attachments be made to these reflectors?
- Is a sandwich construction more desirable than a single laminate?
- How close could these reflectors be held to the mold?
- What would be the actual tolerances of reproducibility to the mold with respect to each reflector?

Design Evolution

To make a reasonably inexpensive mold having a compound curvature with a tolerance of plus or minus 0.003 in.—and able to withstand the handling and usage encountered in making a reinforced plastic part—phenolic tool resin was decided upon. This mold was hand worked and completed to required tolerances by the use of several sets of accurately finished metal templates. But, in trying to get a reinforced plastic piece reproduced from this mold resulted in disaster. An attempt was made to fabricate the reflector by laying up and curing the outside skin, the honeycomb, and the inside skin on the mold all in one step. The approach was to use a rubber blanket technique, put the sandwich construction assembly in an autoclave, subject it to the steam temperature and pressure and, presto, complete the part. This proved a costly venture. The large heat differential caused by the rapid introduction of heat to the outside surface of the mold caused it to shatter and to fracture into many pieces. Further afterthought suggested that more reinforcement should have been used in the fabrication of the plastic mold.

A second plastic mold was fabricated and a reflector made using the vacuum-bag technique. The assembly was laid up in steps and each layup was cured under heat lamps. Dimensions of the plastic mold changed from week to week, however, distorting under average atmospheric conditions. Changes were not on the order of thousandths but *tens* of thousandths of an inch.

By natural sequence, an all-metal mold was built. Most reinforced plastic manufacturers have concluded, and in some cases the hard way, that a good reinforced plastic part requires a well-designed metal mold. This holds true regardless of the process, whether it be press molded or vacuum-bag formed.

On this metal mold it was possible to successfully fabricate the first sandwich reinforced plastic reflector, but, unfortunately, not suitable to the radar people. Polyester resin, glass skins, and polyester glass-based honeycomb were used. Mechanical checks were run on the completed reflectors to compare them to the molds. It was found that the plastic reflectors were out as much as 0.030 in. This again was in no way uniform and resembled a distorted effect. Several polyester-glass honeycomb sandwich reflectors were fabricated, each of which exhibited poor performance when subjected to radar tests. At this time aluminum wire screening was being used, embedded in the face laminate of the reflector for the necessary radar reflecting surface. Every effort was made to avoid using epoxy resins to make radar reflectors—mainly because of the difficulties encountered in handling and releasing of the epoxy part from the mold.

But, eventually it proved necessary to fabricate an epoxy resin reflector using aluminum screening as the reflector face. This reflector performed better electrically than any of those previously made, apparently due to lower shrinkage and better stability of epoxy resins. Further work with epoxy resins made it clear that a need existed for accurately controlled curing temperature and time schedules in order to obtain a minimum of distortion.

Reinforcing Considerations

Up to this point no consideration was given to internal and external ribbing and reinforcing. A honeycomb sandwich was made with an epoxy front skin involving a special edge reinforcement, glass polyester honeycomb and a top skin of epoxy and glass, the reflector face being aluminum screening. In some reflectors, especially the airborne ones, the requirements of weight and space dictated that, if possible, no ribbing or build-up should be employed beyond reasonably thin honeycomb sandwiches. This led to consideration of internal ribbing (fig. 1). This consisted of adding stiffening members between the two skins, and was found to be extremely satisfactory. This produced the first suitable plastic reflector. External ribbing that would increase the thickness of the plastic reflector structure could also give added rigidity and resistance to distortion.

Fig. 3. Removing parabolic-reflector sections from the mold and checking for blemishes.

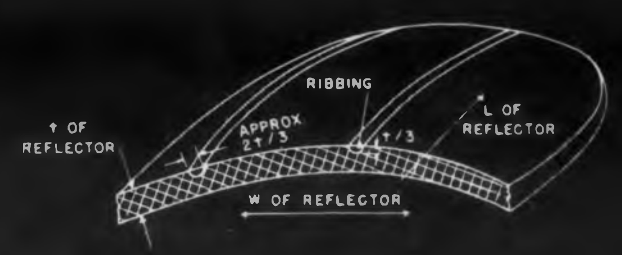


Fig. 1. How internal ribbing can be used to strengthen a reflector. The stiffening members are applied between the two skins. They are glass rovings which give unique unidirectional reinforcement.

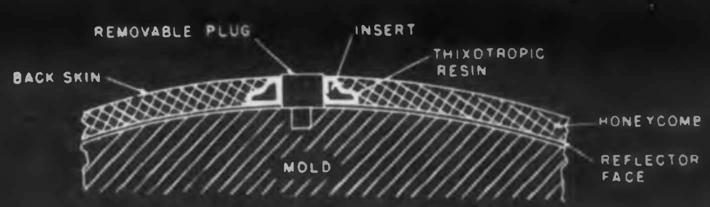


Fig. 2. How inserts are installed. Pins and plugs are designed to hold the inserts in place during lay-up.

Production Problems

One problem that would be faced in production would be the shaping and positioning of the aluminum screening. Therefore, consideration was given to the use of other types of conductive coating. Several techniques such as conductive lacquers, electrodeposition, electroless plating and metal spray appeared feasible. A recent development is a laminating resin sufficiently dc conductive to be suitable for a radar reflective surface.

Performance Tests

One glaring obstacle at present is the temperature performance limitation. Plastic reflectors have been built and tested which have suitably performed up to temperatures of 275 F. Higher

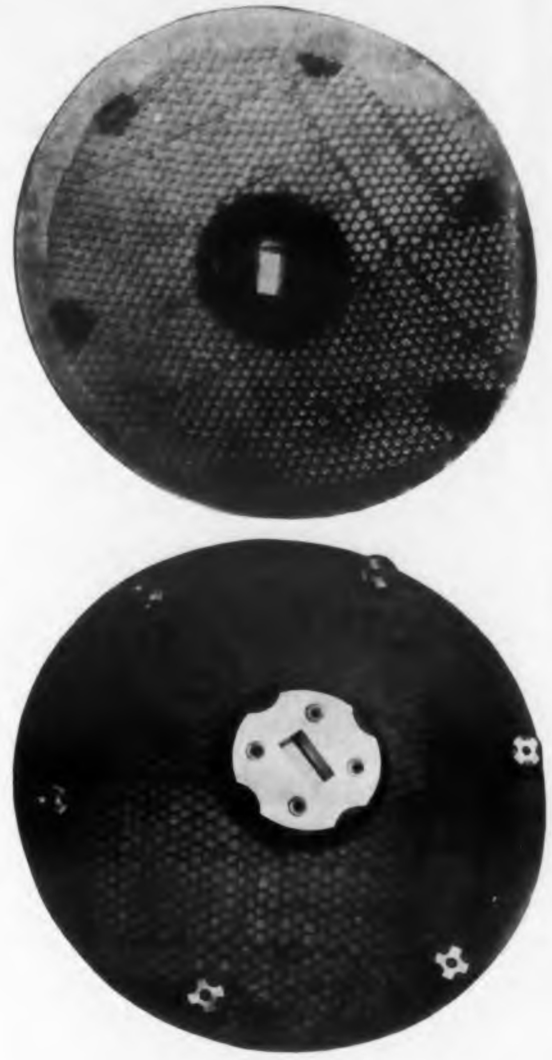


Fig. 4. Plastic-sandwich-type parabolic reflector. Front view, **above** and rear view, **below.**

temperature resins, stable at 500 F, offer promise of overcoming the present temperature performance limitation.

The structure proved to have enough rigidity at high accelerations when mounted and gimballed. In very rigid drop tests the equipment attached to the reflector was severely damaged, while the reflector showed no visible signs of damage. All indications are that the epoxy-glass reflectors are remaining within operational tolerances, on creep and distortion with aging which would indicate the retention of mechanical tolerances. Some of the reflectors have been on test for three years.

The reflectors have successfully passed all environmental tests to which they have been subjected. One of these tests consisted of keeping the reflector at a temperature of −62 C for 48 hours and then raising the temperature to −54 C for an additional 24 hours. After being brought to room temperature, mechanical inspection for delamination, appearance, fraying, color change, contour change and loosening of hardware revealed no effect of low temperature on the reflector. Another test required that the reflector be held at its resonant frequency for 6 hours. Again there was no mechanical damage. Drop testing at 8 g and 15 g did not damage the re-

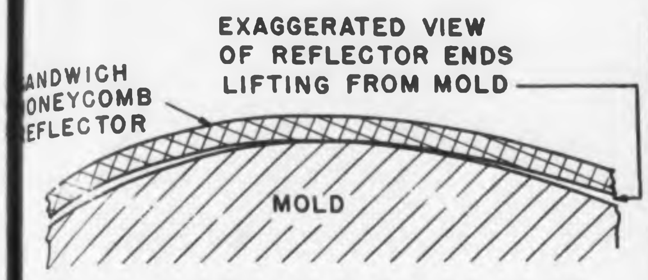


Fig. 5. How the edges of the sandwich honeycomb tend to lift away from the mold on curing. This tendency must be accounted for in mold design but is accurately reproduceable from reflector to reflector.

lector. Electrical pattern checks have shown that the plastic reflector compares favorably with an all-metal reflector in beam width and side lobe characteristics.

Metal Attachments

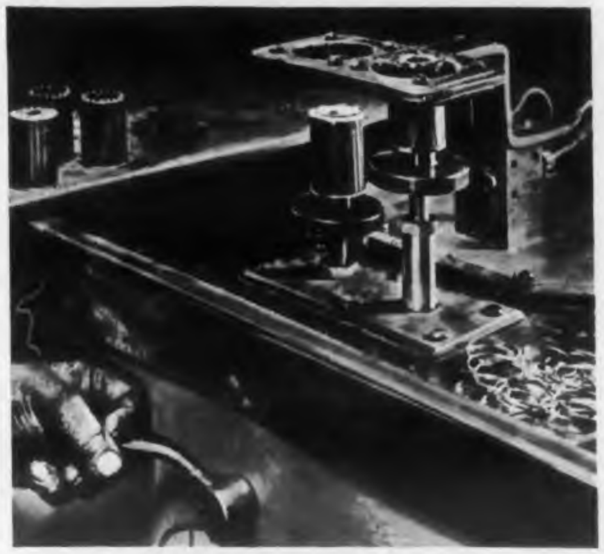
Metal attachments can be easily fastened to molded-in inserts. Including inserts in the mold decreased the time and effort of locating and positioning attachments and allowed through holes for wave-guide horn feeds—a valuable innovation to the manufacturing technique. Pins and plugs could be designed to hold inserts that would remain an integral part of the sandwich structure similar to that shown in fig. 2.

A sandwich construction was found to be much more desirable than a single laminate mainly because it proved to have the best weight-stability factor. Reflectors were fabricated up to a laminate thickness of 3/8 in., mainly, to study the dimensional stability possible. An attempt was made to obtain the best possible solid laminate reproduction of the mold by utilizing staggered orientation of glass fabric and a slow, low temperature cure technique. Even so, the laminate structure proved less satisfactory than the sandwich structure.

Tolerances

The actual degree to which the best sandwich structure reflectors can be held to the mold varies with reflector size, design, and shape. A simple parabolic reflector, fig. 4, displayed exceptionally good reproducibility, yet, it defied techniques to establish tolerances. Mold tolerance reproducibility of the parabolic section reflector in fig. 3 also proved a difficult job. With reflectors approximately five feet long, the tips of the reflector showed a slight tendency to lift off, as shown in fig. 5. However, the reproducibility of one reflector to the next proved excellent by actual performance tests.

Extensive work has been done with plastic and metal reflectors involving fiberglass, CTL honeycomb and magnesium skins, and aluminum honeycomb and magnesium skins, making use of high-temperature plastic interface bonding.



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Tri-Plate "Packages", designed for broad band operation within the frequency range of 100 to 12,400 mc, feature low radiation and cross talk, precise reproducibility, and reliability that meets military specifications.

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CIRCLE 31 ON READER-SERVICE CARD

New Delay Line

triples delay/rise-time ratio

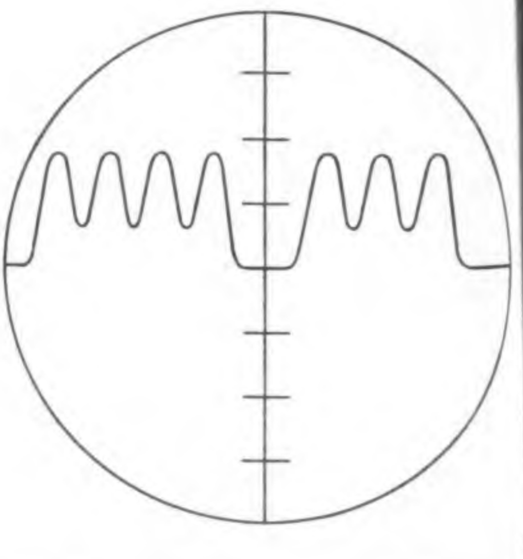
DESIGNERS of radar recognition systems can do a better job of encoding and decoding information, thanks to a new lumped constant delay line. With no sacrifice in reliability, this line performs three times better than older lines.

Its figure of merit, or delay to rise time ratio, is 145, compared with 50, formerly considered the practical upper limit. This enables computer engineers to design delay line memories with 72 bit storage capacity rather than 25.

Engineers at ESC Corp., in Palisades Park, N. J. feel their new family of delay lines with their faster rise times, better figures of merit, and greater bandwidth, can encompass applications previously beyond the scope of a delay line.

Radar engineers have been using delay lines for their high reliability, long term accuracy, thermal stability, and simple circuitry. But these lines limited the amount of information radar systems could handle.

The number of codes they can handle and their ability to distinguish code groups depend on system bandwidth.



Pulse train after transmission through a delay line with a delay-to-rise-time ratio of 50 to 1.

But former lines, with their relatively long rise times, narrowed the bandwidth. (Bandwidth is inversely proportional to rise time.)

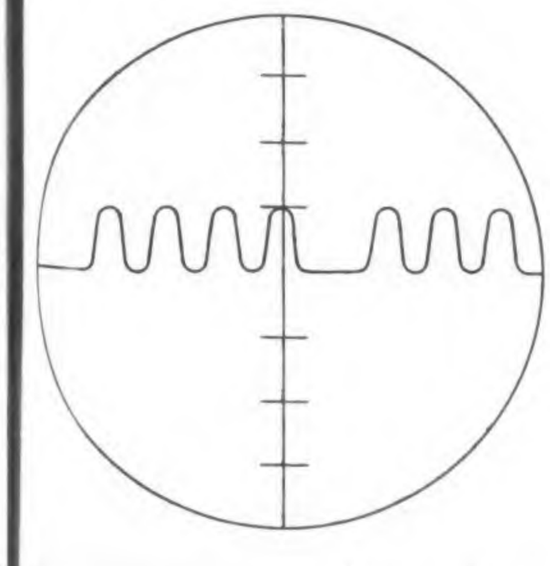
With older lines, engineers were forced to resort to additional circuitry to boost system performance. One approach used pulse shaping circuits at discrete time intervals along the delay line. This improved the situation, but at the expense of circuit simplicity—hence reliability.

It is theoretically possible to make delay lines with any delay to rise time ratio by cascading low pass filter sections with the desired phase and frequency characteristics. But practical delay lines cannot realize the ideal because of the limits imposed by their components, particularly inductors, with low Q's on the order of 50 or 100.

ESC's new lines use advanced design techniques and higher Q inductors to reach their unprecedented figure of merit. The only sacrifice they've made is size, and not much of that. Lines with the figure of merit of 145 measure 3 x 4-1/2 x 8-1/2 in. compared with the 2 x 4 x 8 dimensions for similar lines with a merit figure of 50.

Like former lines, their temperature coefficient of delay is less than 65 ppm per deg C, and can be improved considerably. They can be tapped to within 0.1 per cent of total delay, while former lines could be tapped only to 0.5 per cent.

For more information, turn to the Reader-Service card and circle 32.



Pulse train after transmission through a line with a 145 to 1 merit figure. Notice the steep edges of the pulses.

Pitfalls in Precision AC Measurements

Dr. H. A. Poehler
Section Head
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Pleasantville, N. Y.

Part 1

THE MOST common pitfalls in ac high precision measurements can be attributed to ground loops; loading effects; improper connections of shielded cables; harmonics in the null; calibration at an impedance different from that used in the measurement; and cancellation of errors in an overall measurement. Errors created by ground loops, loading effects, and harmonics in the null are examined and illustrative examples of typical circuit errors are presented.

A subsequent article will consider the remaining sources of error outlined above.

Ground Loops

Lack of attention to grounding connections can lead to appreciable errors in precision measurements. The errors lie in the difference in potential which may exist between different grounds. A circulation of current, therefore, takes place through the "ground loops" and results in unrecognized IR drops.

An example of a ground loop is given in Fig. 1 in the circuit used to measure the output voltage of a tachometer. The loop is set up by double grounding at points *A* and *B*. Since the power source is generally located at one ond of the equipment and the tachometer to be tested is located at the other, the existence of the double ground is not always as obvious as it appears in the figure. The error in this measurement is the potential drop produced by the ground current in flowing from *C* to *B*. Removal of the ground at *A* will free the circuit from this current.

Loading Effects

The input impedance of the null detector is also frequently neglected. Fig. 2 shows a typical circuit for the measurement of the voltage ratio of a transformer. The input capacity of the null detector, and the capacity of the ground terminal of the null detector with respect to ground are

(*Continued on page 43*)

The problems encounterd in high precision measurements are in some ways analogous to those encountered in high frequency measurements. It is, therefore, possible to draw from the techniques used in the h-f fields to analyze these problems. This article discusses the commonly incurred errors in precision ac measurements and some corrective techniques.

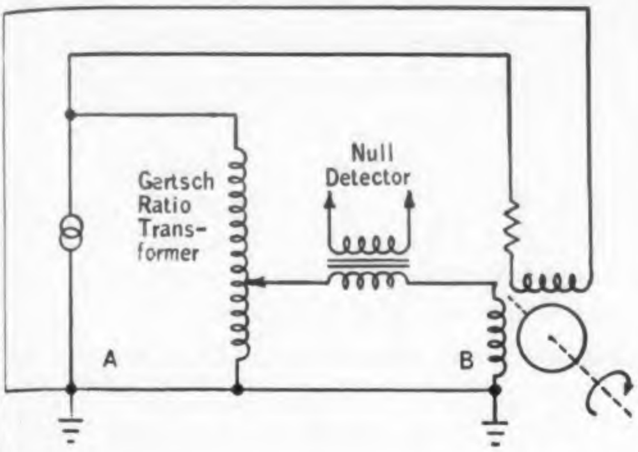


Fig. 1. Ground loop in the circuit for the measurement of the output of a tachometer.

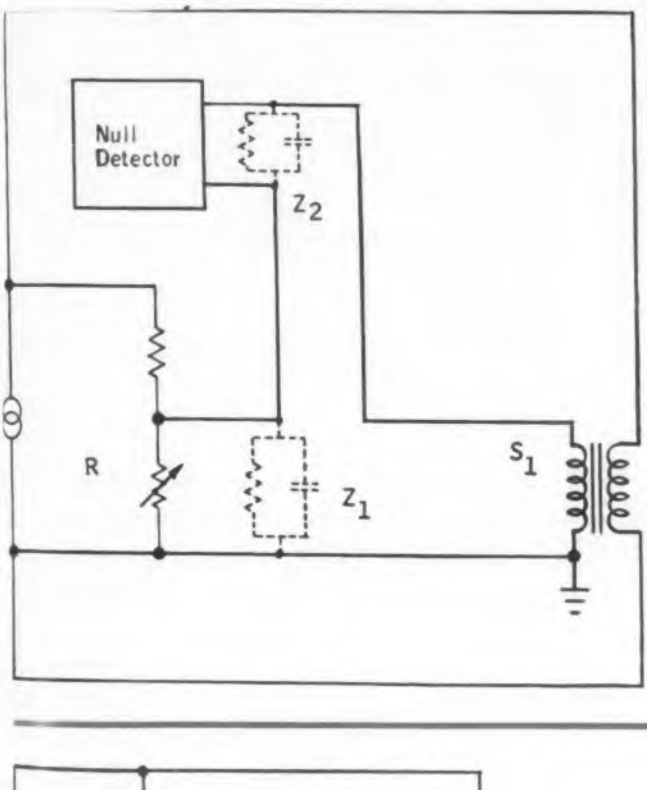


Fig. 2. Circuit for measuring the output ratio of a transformer. Error is introduced by the loading effect of the null detector.

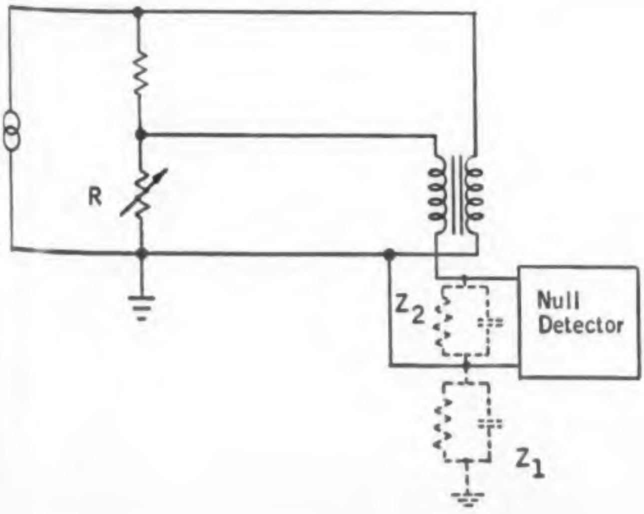


Fig. 3. The Null Detector is properly connected. There is no loading effect.

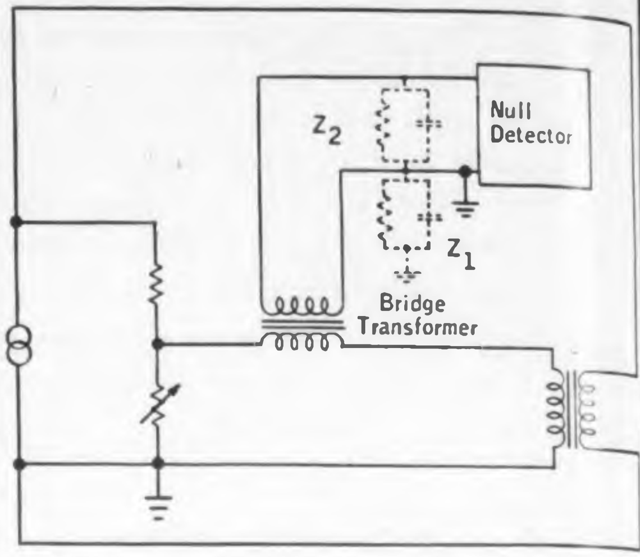


Fig. 4. The use of a bridge transformer permits the known and unknown voltage to have one side grounded. The null detector is properly connected and no loading error is introduced.

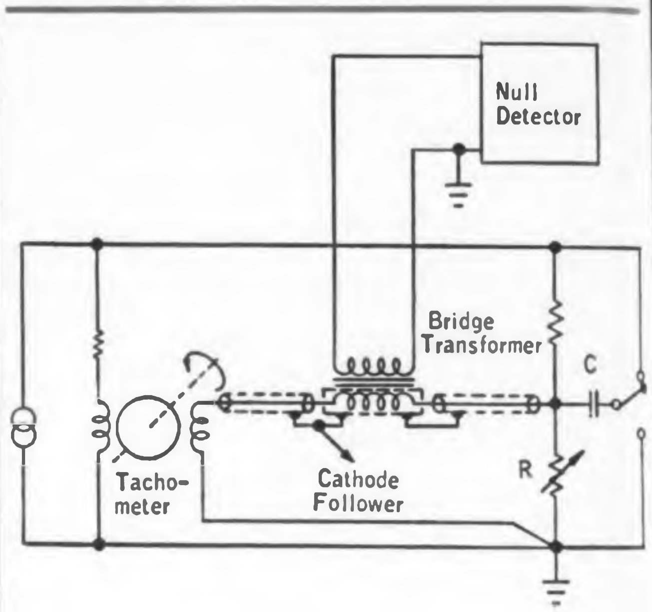


Fig. 5. Circuit for the measurement of the output voltage of a tachometer where errors arise from the presence of harmonics in the null.

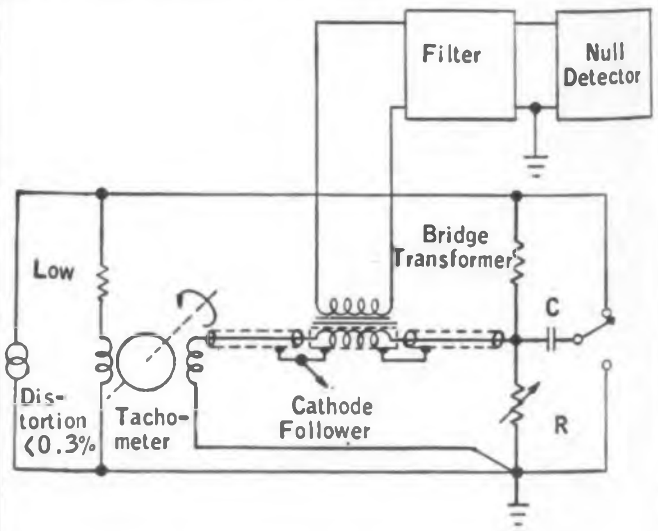


Fig. 6. Errors arising from the presence of harmonics in the null have been eliminated by a suitable filter and by reduction of the distortion in the power supply.

shown. The capacities of the null detector will cause appreciable errors unless the impedances Z_1 and Z_2 are negligible compared to the impedance R and the output impedance at S_1.

A circuit which avoids these pitfalls is shown in Fig. 3. Note that the impedance Z_1 is shorted out, and that Z_2 has zero voltage applied to it at null.

The latter principle can be applied quite generally. Whenever a disturbing impedance cannot be eliminated in a measurement circuit, the circuit may be arranged so that the voltage across this impedance is zero at the null.

In cases where it is necessary to ground both the resistance divider and the output winding of the transformer a bridge transformer may be used as in Fig. 4. The disturbing effects of Z_1 and Z_2 are here eliminated.

Harmonics In the Null

Considerable errors in measurement may result when the effect of the harmonics and pickup on the null detector are ignored.

A typical example is shown in Fig. 5 where the output voltage of a tachometer is measured. Suppose R and C are adjusted for a balance as indicated by a phase-sensitive voltmeter, such as a Phazor. In a practical case where the output of the tachometer is 6000 mv and measurements are desired to ± 0.5 mv, harmonic errors of as much as 6 mv have been observed. The difficulty arises since the phase-sensitive voltmeters are not insensitive to harmonics pickup in the null.

For precision measurement harmonics should be less than 10 times the desired minimum-detectable signal. In a case where it is desired to measure within 0.5 mv, the maximum permissible harmonic level in the null is 5 mv.

It is common practice, unfortunately, to attempt a measurement of a 1 mv in-phase signal in the presence of harmonic residuals of 200 mv.

At least two means of reducing the harmonic content of the null signal are available:

- The distortion in the supply voltage should be reduced by reducing the distortion at the output of the oscillator feeding the amplifier, or by reducing the distortion in the amplifier;
- The null signal at the null detector should be filtered.

For precision measurements, the distortion in the output voltage should not exceed 0.3 per cent total. Phase shift in the filter will not affect the accuracy of the measurement, provided that both the in-phase and the quadrature components of the null are adjusted to zero. It is inconvenient, however, to use filters with too large a phase shift, since an in-phase adjustment of the null causes changes in both the in-phase and the quadrature components.

The circuit of Fig. 6 indicates application of these principles to avoid harmonics in the null.

Overlap Method

Makes Fast Pulses

In Transistor Circuits

Mark Smith
Bogue Electric Mfg. Co.
Paterson, N.J.

Overlapping a pulse and a delayed pulse can provide very high pulse repetition rates with very steep rise and fall times. The technique employs delay lines to provide very high quality pulses.

CONVENTIONAL transistorized pulse generators usually cannot provide fast, flat-topped pulses. Where repetition rates and amplitudes must be very high, and rise and fall times must be very low, the overlap technique may be just what the doctor ordered.

This technique involves more elaborate circuitry. It consists in taking the pulse as the overlap between a positive and negative step, displaced by a time interval equal to the desired pulse width. Though this technique is not new (see Ref. 1), its description with logical diagrams suggests many circuits by which the overlap can be obtained.

Logic

In Fig. 1, the arrow-headed lines may have one of two possible values, "0" or "1." Electrically, these values are represented by a high and a low voltage respectively. The "*NOT*" block in Fig. 1a inverts its input, so that if its input, X_d, is a "0," its output, X_d', is a "1." A plate amplifier can perform this inversion nicely.

The "*AND*" block provides a "1" at its output only when both inputs are "1." The expression, XX_d', signifies X "*AND*" X_d'. One type of "*AND*" circuit has two plate amplifiers with a common load resistor, followed by a second plate amplifier. The second amplifier has a "*NOT*" function, and is needed because the first two plate ampli-

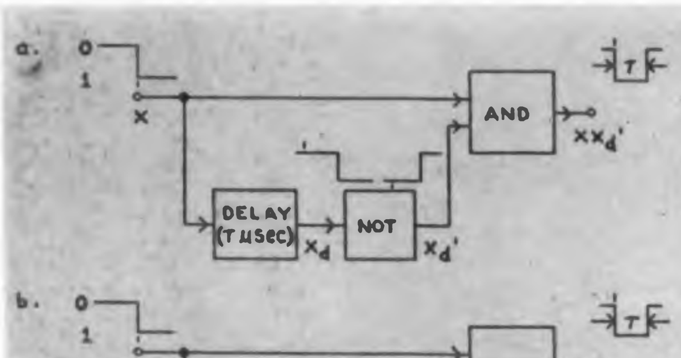


Fig. 1. Logical diagrams show many ways to produce overlapped pulses. Note the shift of the pulses with respect to the timing marks.

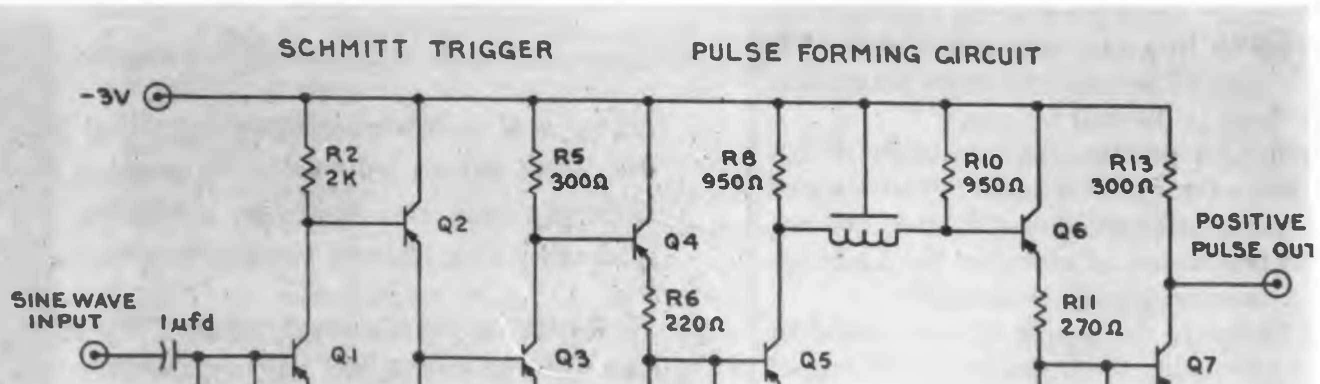


Fig. 2. This circuit, described in the text, provides unusually fast, high quality pulses.

rs invert the signal. The "*DELAY*" block reproices the input signal at a later time, as shown the shift in the pulse with reference to the ning mark.

Fig. 1 shows how logical building blocks may used to generate pulses. Many circuits are ailable to produce the simple logical funcons, "*AND*," "*OR*," "*NOT*," and "*INHIBIT*."

Fig. 1b shows an "*INHIBIT*" block which mply combines the functions of the "*NOT*" and e "*AND*" blocks. The level of its output is at " only when one of its inputs is a "1" and the her is a "0."

Fig. 1c shows the overlap method applied here both the positive and negative steps are ailable. Both steps are available from multiviators, Eccles-Jordan flip-flops, or Schmitt trigrs. The overlap method is suitable when these rcuits provide leading and trailing edges which e short enough for the desired pulse.

This technique is particularly useful as a subitute for *R-C* differentiators in circuits like inary counters. It has three main advantages:

. The counter output has pulses only of the pority selected;

. There is no trailoff;

. Nonlinearity of the edges of the flip-flop outut is not emphasized.

A Fast Pulse Generator

ow It Works. Fig. 2 shows a Schmitt trigger riving a pulse forming circuit which uses the verlap technique. The Schmitt trigger delivers negative going step across *R7*. This causes *Q5* swing from cutoff to saturation. Since a negave input provides a positive output, *Q5* has proided the "*NOT*" function.

At the time *Q5* is driven into saturation, curent is driven into the base of *Q8*. Since *Q7's* ase is also negative at this time, both *Q7* and *Q8* aturate, bringing *Q7's* collector to about zero olts.

After a time equal to the electrical length of e delay line, the collector voltage of *Q5* appears at the input of the emitter follower *Q6*. Its utput, taken across *R12*, cuts *Q7* off, so *Q7's* collector returns to —3 v.

The result of all this is a positive pulse at *Q7's* ollector as wide as the length of the delay line. he Schmitt trigger which drives this pulseormer must have a positive going edge which is aster than the electrical length of the delay line. *Q7*, *Q8*, and *R13* do not provide the "*AND*" unction referred to in Fig. 1a. "*AND*" may be erformed by applying the positive pulse to a rounded emitter amplifier. However, if a negaive pulse is needed, it may be obtained at the ollector of *Q10* when the connections indicated y the broken lines are made.

(Continued on page 47)

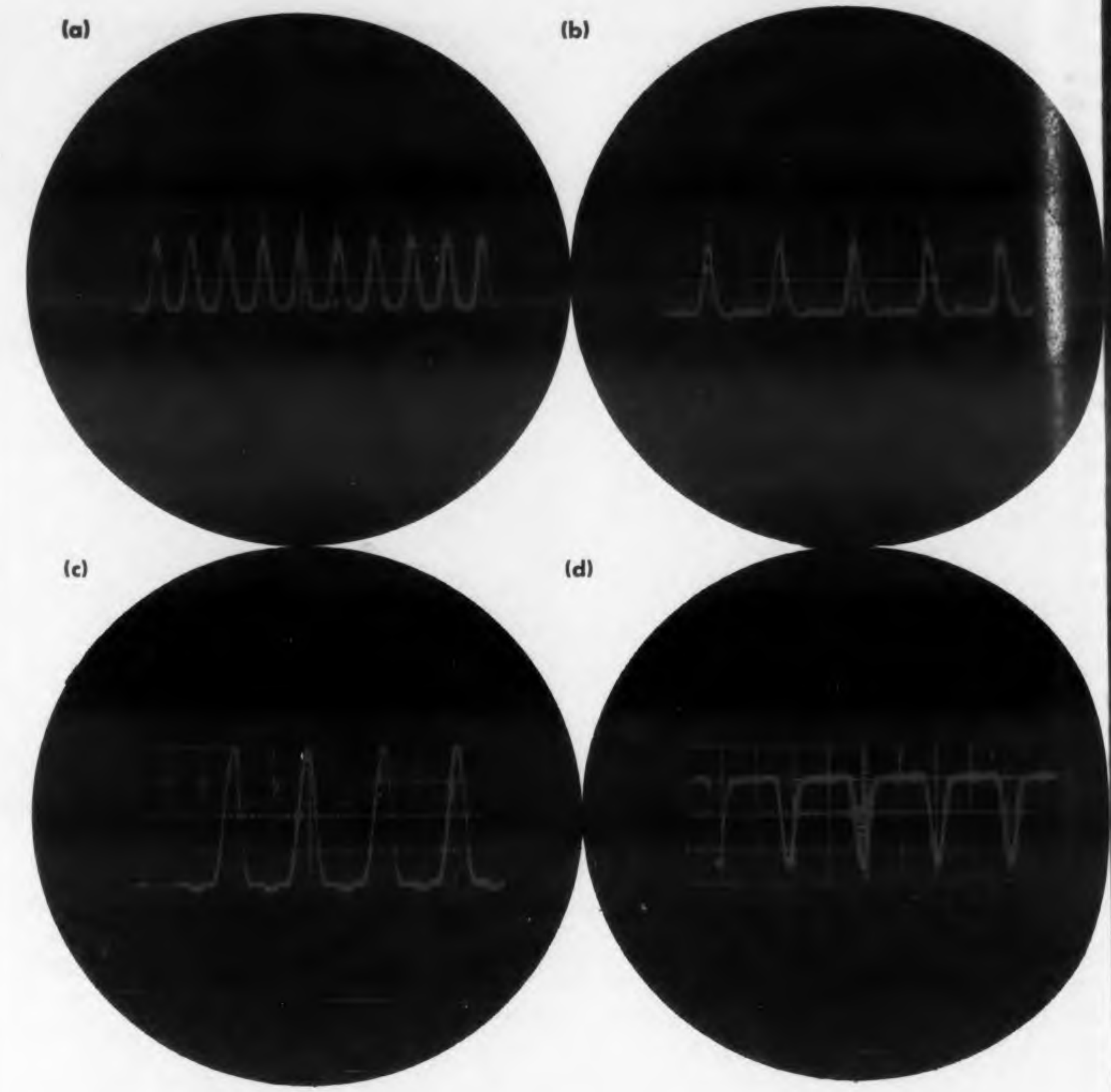


Fig. 3. Wave forms for the circuit of Fig. 2. The time base is set at 0.1 μsec per major division. The delay line i a, b, and d, was a 4 in. length of RG-65/U. A 12 in. length was used in Fig. 3c. **a.** Taken at Q7 collector. Si wave input was 3 v peak to peak at 10 mc. Amplitude is 0.5 v per major division. **b.** Same as Fig. 3a, but with mc input. **c.** Same as Fig. 3b, but with 4 v p-p input. **d.** At collector of Q10. Input is 3 v p-p at 5 mc. Amplitud is 1.0 v per major division.

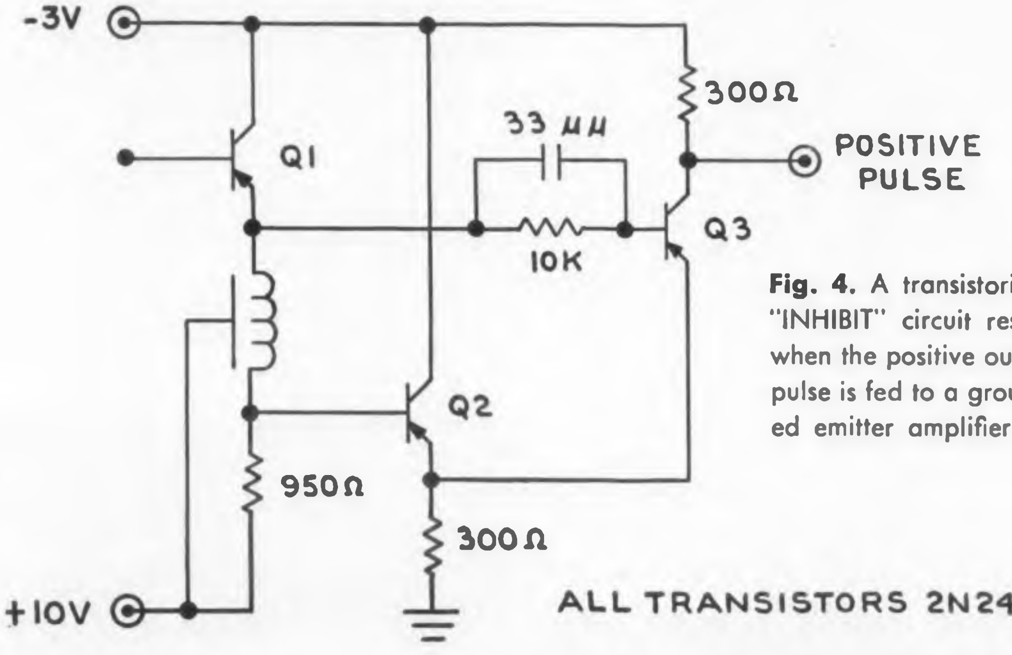


Fig. 4. A transistorized "INHIBIT" circuit results when the positive output pulse is fed to a grounded emitter amplifier.

ow Well It Works. Fig. 3 shows the wave-ms obtained from the circuit of Fig. 2. gh and low frequency limits could not be de-mined due to the limitations of the test equip-nt. The sine wave oscillator could not provide ine wave slower than 10 cps, and the scope, Tektronix 545 with a 53/54B pre-amp had a e time of 0.015 μsec.

Though this scope is one of the fastest avail-le, it was still not fast enough to pass the fre-encies available from this pulse generator thout distortion. The rise times shown in the cillograms are for the CRO, not the pulse cir-it.

Since the test equipment was the limitation, effort was made to improve circuit perform-ce with peaking coils, speed-up capacitors, int-to-point wiring without sockets, and spe-l delay lines or resistors. Nevertheless, the plitude vs time relationship was the same m 10 pulses per second to 5 million, with duty tios available to 40 per cent.

At the time the circuit was developed, in the ring of 1956, the 2N240 was considered the st suitable transistor. Since then the 2N393 s become available. It has higher power and rent ratings, so it should permit much higher tput voltage and current with no sacrifice in gh frequency performance.

The Inhibit Circuit

The *"INHIBIT"* function, which combines *OT"* and *"AND,"* lends itself to transistoriza-n. In Fig. 4, when the base of *Q1* is at 0 v, its itter voltage keeps *Q2* and *Q3* cut off. *Q3's* llector is then at —3 v. A negative step, fed to *1* causes *Q3* to saturate, so its collector goes to 1.5 v. After a time equal to the length of the ay line, Q2's base conducts heavily and back ses the emitter-base diode of *Q3*, cutting *Q3* f. Its collector swings back to —3 v, providing positive pulse. To complete the *"INHIBIT"* nction, this pulse can be applied to the base of grounded emitter amplifier.

Logic Conventions

The convention wherein "0" is represented by high voltage, and "1" by a low voltage, was lopted here because the circuits use pnp tran-tors. When npn's are used, the convention is ually reversed so a given logic circuit provides e same logic whether it uses pnp's or npn's.

References

. Radiation Laboratory Series, Massachusetts Institute of echnology, Vol. 19, pp 244-245.

. Transistor Switching Circuits, M. Smith, ELECTRONIC ESIGN, Oct. 1, 1957.

For a reprint of this article turn to Reader-ervice card and circle 41.

Optimum Design of Power Transformers and Saturable Reactors

Part 2

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

Here, in the concluding part of Mr. Nisbet's article, he presents useful nomograms and a procedure for optimizing transformer designs. The nomograms remove a great deal of the drudgery normally involved in transformer and saturable reactor designs.

MANY of the equations which arise in this work are of the form* $a\,e^6 + b\,e^4 - c\,e^2 - d = 0$. The conventional method of solving them is very time consuming. Since great accuracy is not normally required, a simple trial and error method was first attempted, but even this was quite laborious.

Cubic Equations

The nomogram of Fig. 6 enables good approximate solutions (to two or three significant digits) for a cubic equation of this form. In effect, the first two terms are considered as $(e')^4\,(ae^2 + b)$. The nomogram is used to find the value of e' which makes the equation true. Successive approximations are discarded until $e' = e$, that is, until the original value of e is reached.

Another type of cubic equation arises in the evaluation of v*. The coefficients in this case have similarities which enable the nomogram of Fig. 7 to be simpler to operate than Fig. 6.

Regulation

The calculated value of total wire loss can be visualized as a resistance in series with the secondary of a perfect transformer. The voltage drop which would be caused by the secondary current flowing through this value of resistance makes possible a quick check on the anticipated transformer regulation.

*e=side of core area=tape width=inches of build-up; v=ratio of window sides=g/f. See *ED*, Apr. 16, pp 27-28, figs. 3, 4.

Leakage Inductance

Regulation is affected by leakage inductance. By interleaving sections of the primary and secondary, the leakage inductance can generally be reduced significantly. For the type of transformer described, the leakage inductance effectively present in a winding of N turns is approximately

$$L_L = 5.3\,N^2\,(MLT)\,(2 - S_w)\,v^{-1}\,10^{-6}\ \text{mh} \quad (15)$$

where

$$MLT = \text{mean length of turn} = 4(e + f) \quad (15a)$$

Eq (15) is based on the assumption that half the primary and half the secondary are wound on each of the two bobbins. If the windings are further split, so that each bobbin contains a fraction of one winding sandwiched between fractions of the other winding, the leakage inductance is multiplied by approximately n^{-2}, where n is the number of boundaries of insulating material between sections of the windings.

It is important to note that it is possible, in most cases, by interleaving sections of the windings, to make the leakage inductance small enough to be represented by a 5 per cent increase in the calculated value of resistance.

Maximum VA Rating

The core loss is a function of the peak flux density. It is important, therefore, to have a method for determining the optimum value of flux density.

If published graphs of core loss vs peak induction are studied, it will be seen that in the majority of cases the "curve" is a straight line when ordinates and abscissas are plotted on logarithmic scales. From any such graph, a constant, n, can be derived, representing the differential logarithmic core loss, a property of the material. As B varies from B_1 to B_2 kilogauss, the core loss,

Table I. Differential Logarithmic Core Loss

Material	n	Frequency of Measurement
Ferrite	.438	100 kc
Grain Oriented Steel	.527	" "
Silicon Iron	.485	" "
Grain Oriented Steel, 2 mils	.5	10 "
Silicon Iron, 1 mil	.434	" "
Ferrite (Ferroxcube IIIB)	.41	" "
Grain Oriented Steel, 5 mils	.575	400 cps
Silicon Iron, 4 mils	.51	" "
High Perm 49, 6 mils, at 15 kilogauss	.64	" "
High Perm 49, 6 mils, at 1 kilogauss	.34	" "
Silicon Iron, 14 mils, at 14 kilogauss	.535	60 "
Silicon Iron, 14 mils, at 1 kilogauss	.38	" "
Grain Oriented Steel, 14 mils, to 15 kilogauss	.527	" "
Mumetal, 14 mils, at 2 kilogauss	.725	" "
Mumetal, 14 mils, at 8 kilogauss	.493	" "

(Source — graphs published in "Reference Handbook for Radio Engineers")

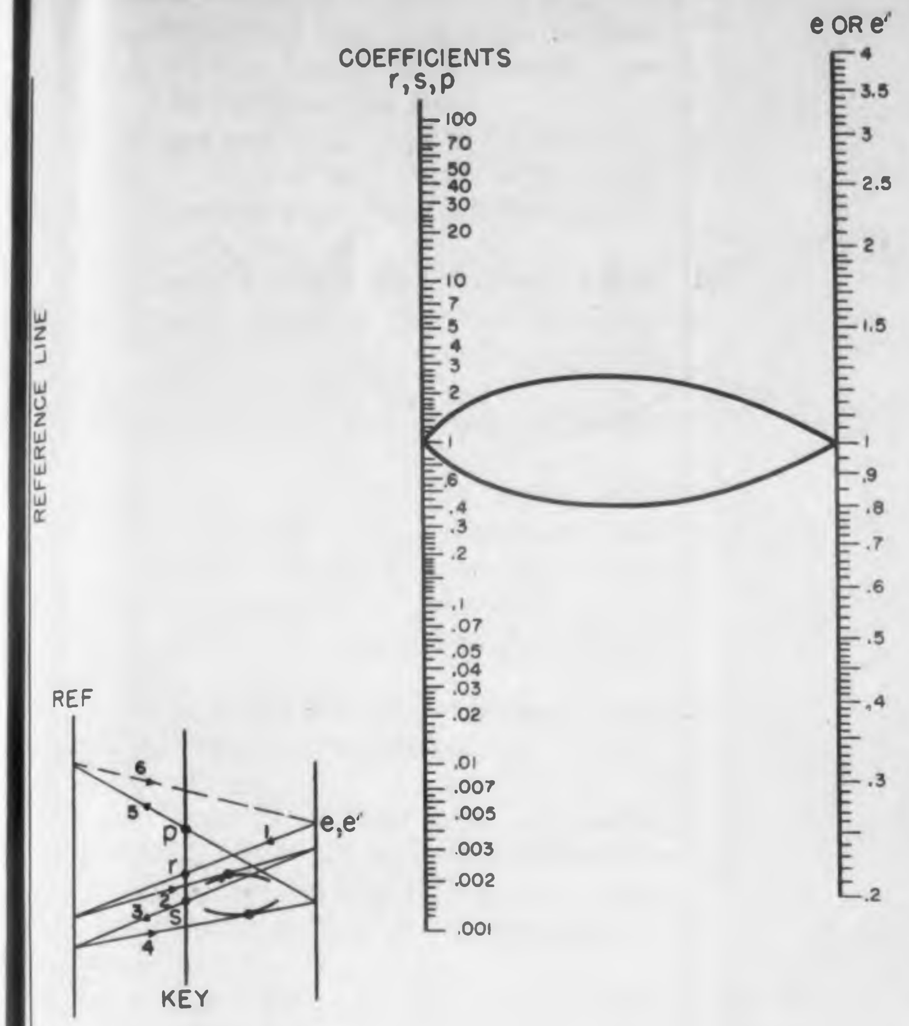
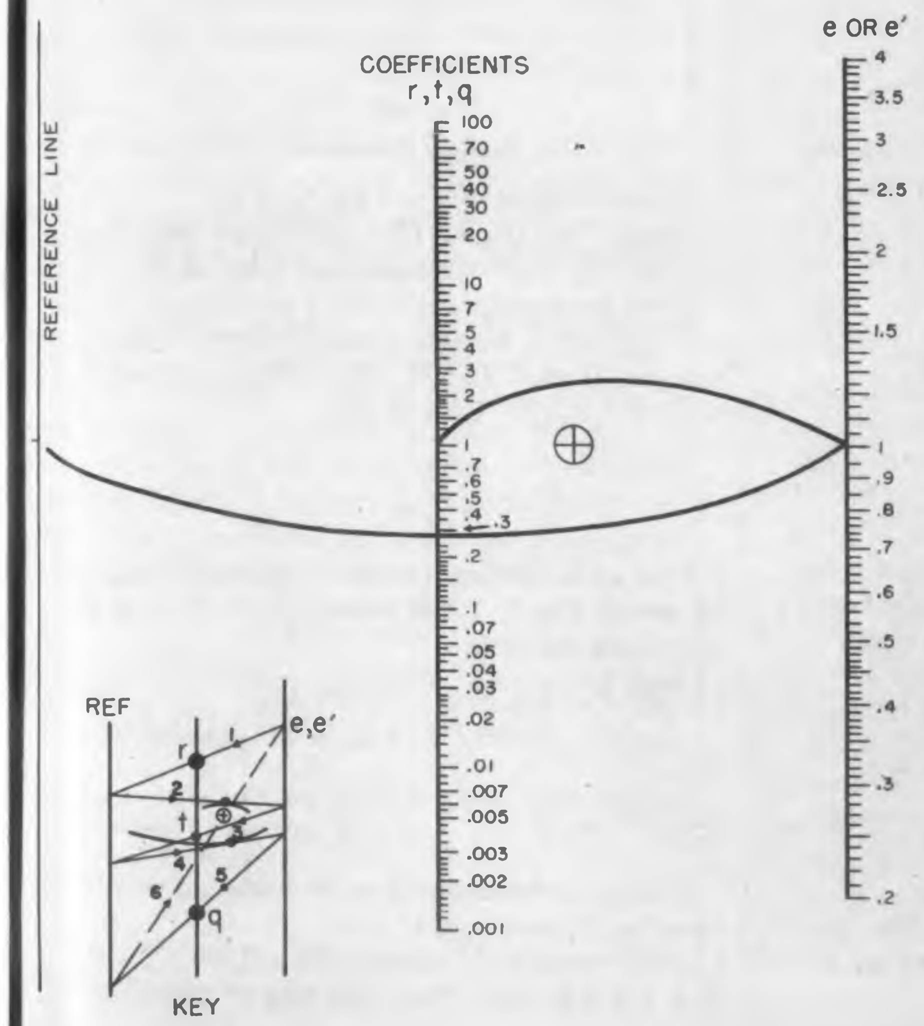


Fig. 6. Nomograms for cubic equations.

a. To find e from $ae^6+be^4-ce^2-d=0$. Calculate $r=b/a$; $s=(da/bc)-1$; $p=c/a$. Pick a point on the e scale and traverse the scales as shown in the key. In the sixth traversal, follow the sloping lines to plot a point on the right scale corresponding to one on the left. Note the point of intersection on the e scale after the sixth traversal. With this point, repeat from the start till the sixth traversals cut the e scale at the same point twice.



b. This solves for e also, but in this case, $r=b/a$; $t=1-(da/bc)$; $q=a/c$. Start with any point on the e scale. Follow the key, repeating the first traversal from the point on the e scale where the sixth traversal finishes. Repeat till the sixth traversal cuts the e scale twice at the same point.

P, varies from P_1 to P_2 watts per lb. Hence

$$\frac{\log B_2/B_1}{\log P_2/P_1} = n \qquad (16)$$

a constant for the core material.

For maximum volt-amperes

$$P_c/P_w = 2n \qquad (17)$$

This relationship should be observed in a design where the ultimate limiting factor is the temperature rise. Values of n for different core materials are shown in Table I. It should be noted that unlike the core loss itself, n is substantially independent of frequency.

By inserting the expanded formulas for core loss and wire loss in eq (17), an equation can be written for setting a maximum VA rating.

Optimum Design

For minimum weight

$$\frac{d}{de}(P_w) = -\frac{Q}{P\,\rho_w\,S_w}\,\frac{d}{de}(P_c) \qquad (18)$$

For maximum efficiency

$$\frac{d}{de}(P_w) = -\frac{d}{de}(P_c) \qquad (19)$$

For maximum efficiency and minimum weight

$$P = \frac{Q}{\rho_w\,S_w} \qquad (20)$$

This offers a useful starting point in design, provided that flux densities approaching saturation are not involved. From P, the manufacturer's data gives a value of peak induction B, which is necessary for the calculation of c in eq (1a).

Where saturation densities are involved, (when P becomes fixed at its maximum permissible value), it can be shown that

$$Q \approx \frac{P\,\rho_c\,S_c}{(6n-1)}\,\frac{e^2}{M}\,\frac{(v+1)}{v^{1/2}} \qquad (21)$$

and n is assumed at 0.5.

Window Shape

The window shape factor, v, has heretofore been assumed. It can now be evaluated.

If a design has been calculated for an assumed value of v, a value is obtained for the two sides, f and g. If f is multiplied by a correction factor z, and g is divided by the same amount, the window area remains the same but the distribution of weights and losses is changed.

To find the window shape which yields the lowest combined core and wire loss, the combined loss is evaluated. The window side g is retained as a separate entity, to enable it to be divided by z while f is multiplied by z. Equating the differential with respect to z to zero gives

$$v' = \frac{v}{z^2} = 1 + \frac{Q\,M^2}{P\,\rho_c\,S_c\,e^4} \qquad (22)$$

In this equation, v is the ratio g/f which was assumed in order to enable the first calculation to proceed. Since z has changed the ratio g/f, the new value v' is the old value divided by z^2. This new value is used as v in the next calculation.

Comparison of eq (21) and (22) shows that v depends on Q, and Q on v. The equations must therefore be solved simultaneously. The solution is a cubic equation for which the nomogram of Fig. 7 was constructed.

The presence of the variable M/e^2 in (21) and (22) requires that, after solving for v and Q, the design procedure must be continued, at least until e and M are evaluated. By a repetitive process (or by intelligent anticipation of a suitable value of M/e^2) a final design can be arrived at. Fortunately, stability is reached quickly, usually after two successive corrections to an assumed value of v.

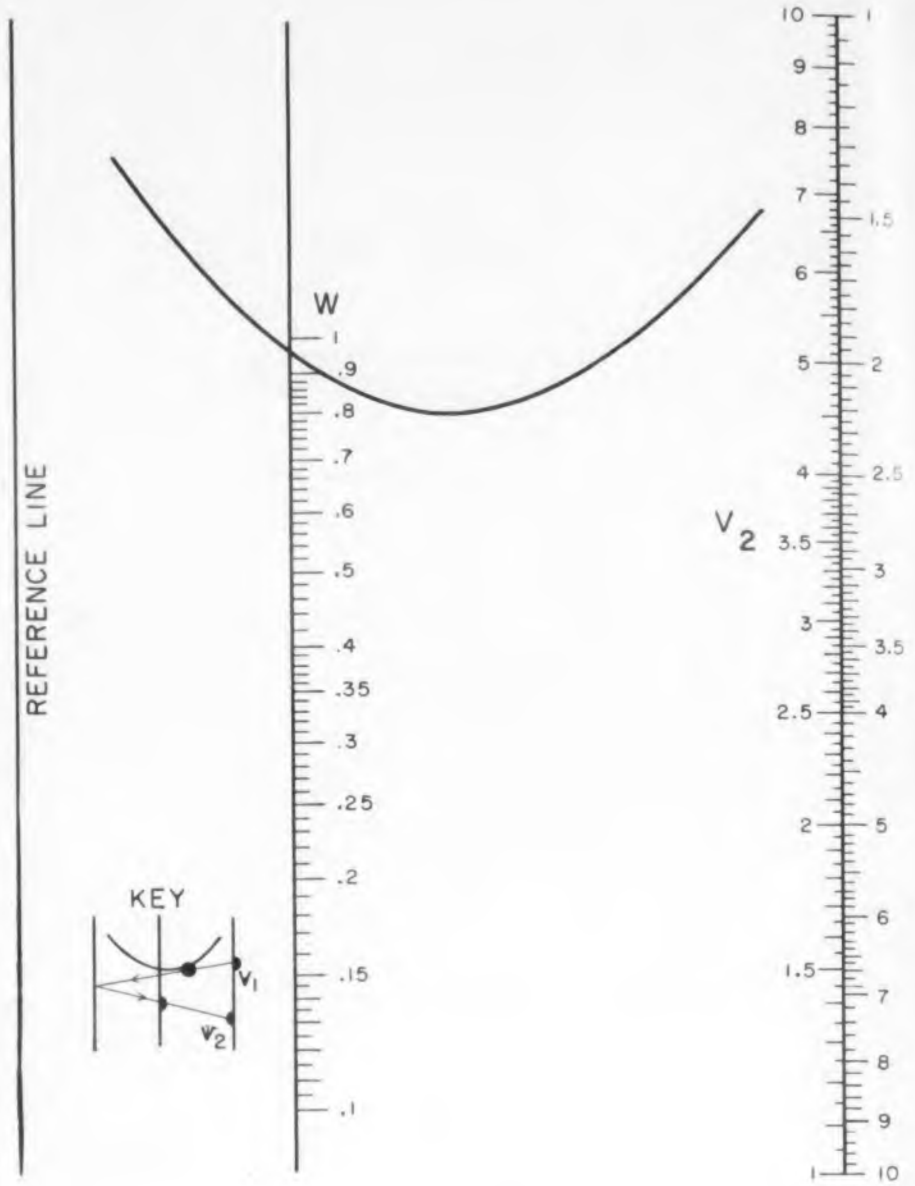


Fig. 7. To solve for v. Calculate $M/[e^2(6n-1)]$. With this point on scale w, find the number on the v_1 scale which, when the key is followed, gives the same number on the v_2 scale. This number is v.

Design Procedure

1. Assume values of $v = 2$ and $Q = 0.8$.
2. Find $P = Q/\rho_w S_w$ (20) and from manufacturer's data. Find corresponding value of B.
3. From the nomogram of Fig. 1 and from $V/N = c\,e^2$ (1a) find c. Assume a suitable high temperature and from Q find D. (Fig. 2) From D find T. ($D = T\,I/S_w$) (3). Find M from

$$M = \sqrt{\frac{V}{c\,k\,T}} = e\,f\,v^{1/2} \qquad (2)$$

4. Find e for minimum weight with eq (9) solved by use of Fig. 5. Write values of e^2, e^4, and e^6 and check solution.

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

5. Find $$v' = 1 + \frac{Q\,M^2}{P\,\rho_c\,S_c\,e^4} \qquad (22)$$

Use this as new value for v in minimum weight equation. Repeat until $v' = v$.

6. Find weight of core $= 2.9\,\rho_c\,S_c\,e^3 + 2\,\rho_c\,S_c\,(v+1)\,v^{-1/2}\,M\,e$ (6). Find core loss (P times core

weight). Find volume of windings $= 4M^2 e^{-1} + 2M^3 v^{-1/2} e^{-3}$ (7). Find wire weight ($\rho_w S_w$ times volume). Find wire loss (Q times volume). Core loss should be $2n$ times wire loss.

7. Find surface area $= 2f^2 (2 + 3v) + 6e\,f\,(2 + v) + 11.8\,e^2$ (13); $f = M/e\,v^{1/2}$ (2). If no special methods of cooling are to be used, estimate the temperature rise from (14).

8. If temperature rise is too low, use a higher value of Q and repeat from *Step 1*, provided that this does not require a peak flux density which is too close to saturation.

9. If temperature rise is correct, proceed to *Step 17*.

10. If temperature rise is too low, and if closeness to saturation flux density prevents Q from being raised in accordance with (20), assume $v = 2$ and $Q = 1$ to start the calculation, or proceed from the results obtained in the previous calculation.

11. Use the maximum permissible values of B and P which do not involve saturation.

12. Same as *Step 3*.

13. Find v' from Fig. 7. Find Q (21). Check values of v' and Q from (22). Use these values for v and Q and repeat from *Step 12*. Repeat or anticipate likely change in M/e^2 to hasten reaching of stability, where $v' = v$.

14. Same as *Step 6*.

15. Same as *Step 7*.

16. Estimate temperature of wire from the surface temperature and apply this if necessary as a correction to *Step 12*. If temperature is unreasonably high or low, repeat from *Step 10*, using a lower or higher value of Q and the value of v yielded by the last calculation.

17. Evaluate $MLT = 4\,(e + f)$, and from wire tables confirm total wire loss and the fact that the window will accommodate all the turns.

18. From wire tables, check on the value used for T.

19. Construct a diagram of the window, dimensioning the insulation thicknesses, wire diameters, unused portions of final layers of windings, etc., to confirm assumed values of S_w and k.

In the majority of applications involving 400 cps and higher frequencies, the conditions described in *Step 10* will apply and the design procedure can usually commence at that point.

References

Electronic Transformers and Circuits, Reuben Lee, John Wiley & Sons, Inc.

Radio Engineering, F. E. Terman, McGraw Hill Book Co., Inc.

Reference Handbook for Radio Engineers, International Telephone & Telegraph Corp.

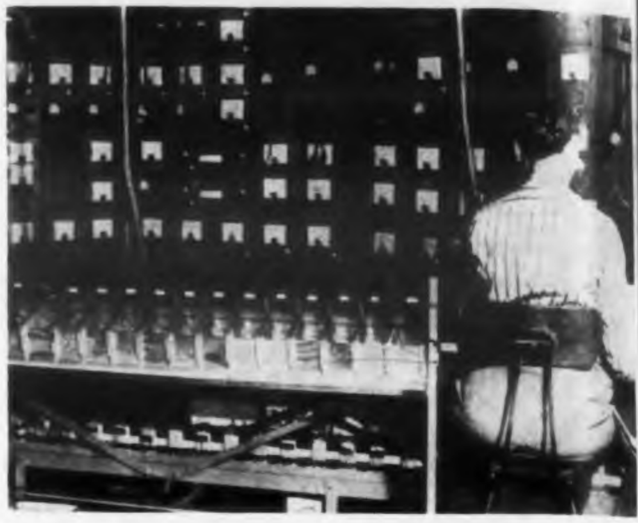
Arnold Engineering Co., *Bulletin SC-107.*

Sprague Engineering, *Bulletin No. 400A.*

For a reprint of both parts of this article turn to the Reader-Service card and circle 45.

Faster Tube Checker

Tests 1200 tubes an hour



More than 20 tubes can be checked each minute for 20 characteristics per tube with a new tube tester, recently installed by Tung-Sol Electric Inc. The machine uses 60 meter-relays furnished by Chesterland, Ohio's Assembly Products, Inc., and can test tubes four times faster than hitherto possible.

The meter relays monitor plate, screen, filament, and gas currents; leakage and cut-off currents; emission, voltage gain, and mutual conductance, as well as short circuits.

The tube tester can test almost any of a thousand vacuum tube type. In addition to testing, the meter-relays monitor all voltages and can automatically shut down the conveyor if improper test conditions develop.

In about a third of a second, each meter-relay can measure an electrical property and display the magnitude on a dial; reject a faulty tube; and reset itself so it is ready to test another tube.

When a tube is faulty, a moving pointer on the meter-relay meets either a high or a low fixed pointer. Contacts on the pointer touch and lock electro-magnetically, closing a circuit. This actuates a load relay, closing the contacts of a heavy duty power relay. The power relay actuates a counter that keeps track of the number of tubes rejected for a particular characteristics. The power relay also breaks the circuit to a reject solenoid, whose plunger is released, pushing the defective tube from its socket at the right time so it falls through a chute with other tubes rejected for the same test.

Though the meter-relays are slower than electronic devices, they are more reliable, easy to work with, and rarely need calibration.

Assembly Products, Inc., Dept. ED, Chesterland, Ohio.

CIRCLE 47 ON READER-SERVICE CARD

Ceramic Magnetic Wire

Insulation withstands up to 1000 F

Two types of high-temperature magnet wire have been announced. One of these has a bonded refractory insulation which is rated for continuous use at 700 F, and for intermittent use up to [illegible]00 F. The other wire has a ceramic insulation which is rated for continuous use at 1000 F. Both of these insulations are normally supplied on copper wire but other metals or alloys which have better temperature characteristics are available.

Secon Metals Corp., Dept. ED, 7 Intervale St., White Plains, N.Y.

CIRCLE 48 ON READER-SERVICE CARD

Damping Fluid

Low viscosity silicone

Available in 5, 10, and 20 centistoke grades, type 81743 silicone fluid has a lower viscosity-temperature coefficient and lower pour point than most methyl silicone fluids. Suggested uses for this compressible fluid are as a damping medium in vibration dampers, shock absorbers, dash pot relays and timing relays; and as a hydraulic fluid in servomechanisms, accelerometers, instruments and other control devices.

In common with other silicone fluids, type 81743 is highly resistant to shear breakdown and possesses unusual chemical resistance. Typical values for the three grades include a specific gravity of 0.92, 0.94, 0.96; weight per gallon of 7.7, 7.8, 8 lbs; refractive index of 1.3965, 1.3998, 1.4016; minimum boiling point (1.5 mm Hg) 275, 390, 480 F; flash point, 310, 415, 525 F; and pour point −100, −100, −76 F.

General Electric Co., Silicone Products Dept., Dept. ED, Waterford, N.Y.

CIRCLE 49 ON READER-SERVICE CARD

Tinning Process

Instantly coats printed circuits

Called Instant Tin, this solution is designed for the tinning of brass and copper articles at room temperature. The process provides protection and acts as a soldering aid for non-ferrous electrical components, printed circuits, solder lugs and others.

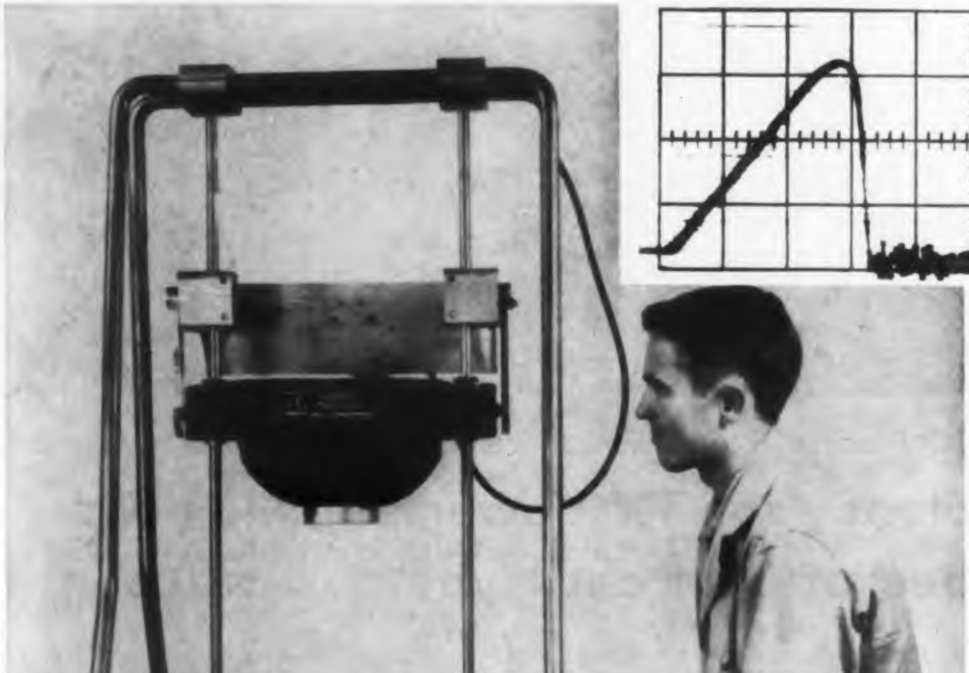
Desert Laboratory, Dept. ED, 17-312 N. Indian Ave., N. Palm Springs, Calif.

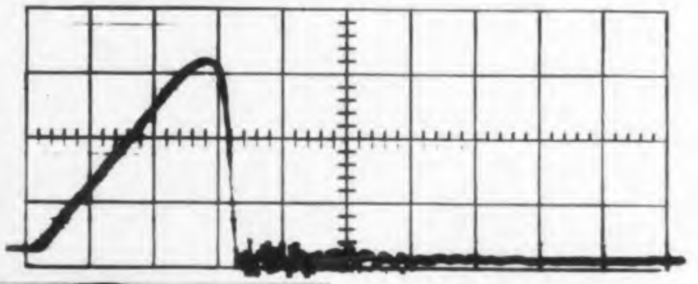
CIRCLE 50 ON READER-SERVICE CARD

CIRCLE 51 ON READER-SERVICE CARD

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 largest number of items, products which are best suited to a brief description have been noted at the end of the section.





SHOCK TESTER

Accurate shock patterns are reproduced on this machine through the use of differently shaped lead pellets placed on the impact anvil. Among other shock patterns, the shock tester provides a specified terminal-peak sawtooth pulse shape—similar to the one shown—rising to 100 g in 6 msec and then dropping abruptly to zero. The machine accommodates specimen weights to 40 lb, a cross-sectional area to 12-1/2 in. sq.

Avco Manufacturing Corp., Lycoming Div., Dept. ED, 550 Main St., Stratford, Conn.

CIRCLE 54 ON READER-SERVICE CARD

OSCILLOSCOPE CAMERA

Ten traces can be photographed by the Oscillotron camera on a single frame, or a one-to-one presentation can be given, whichever is desired. The camera has a large polaroid back that takes up to 80 finished pictures in a single loading. The versatility of the unit is provided by a feather-touch multiple exposure positioning bar. A 35 mm or 70 mm electrically pulsed camera is also available for attachment to the same periscope system used with the Oscillotron camera.

Beattie-Coleman, Inc., Dept. ED, 1000 N. Olive St., Anaheim, Calif.

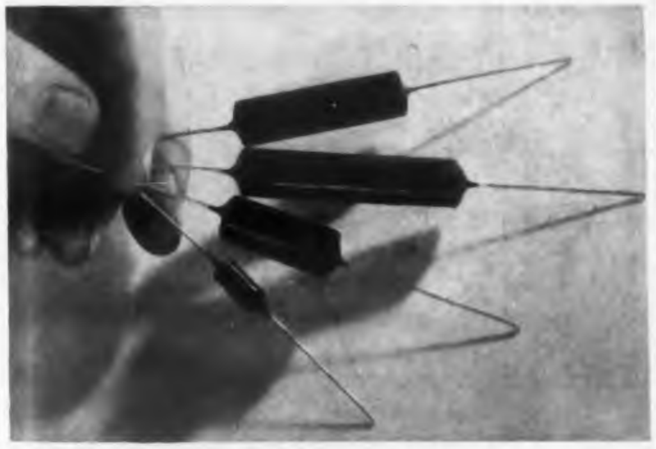
CIRCLE 55 ON READER-SERVICE CARD

GAUSSMETER

Magnetic flux densities up to 50,000 gauss, in static or ac fields, are measured to an accuracy of ±3 per cent by model 1295 gaussmeter. The transistorized instrument utilizes the Hall effect to make these measurements. Two standard magnets of 1000 and 5000 gauss, calibrated to ±1 per cent, are included.

Radio Frequency Labs., Inc., Dept. ED, Powerville Rd., Boonton, N.J.

CIRCLE 56 ON READER-SERVICE CARD



WIREWOUND RESISTORS

Temperature ratings over 250 C are featured in the Blu-Ohm series of wirewound resistors. Seven different sizes cover a power range from 2.5 w through 15 w. A typical 3 w unit, type B-2, will maintain its 3 w rating at 80 C, derated to 1 w at 275 C. Larger units, from 5 through 15 w, will derate at full load to 0 at 275 C. The series is constructed of ceramic materials together with alloy wires designed to withstand high temperatures.

Bradford Components, Inc., Dept. ED, Box 107, 65 South Avenue, Salamanca, N.Y.

CIRCLE 57 ON READER-SERVICE CARD

NEW PRODUCTS

Gear Train Analyzer

Measures gear play

This gear train analyzer accurately evaluates lost motion in precision gear trains. The instrument consists basically of controls and a two-phase torque actuator. Total lost motion is measured by applying constant torque to the input pinion of the locked gear train and reading clockwise and counterclockwise actuator shaft displacement.

Daco Instrument Co., Dept. ED, Tillary & Prince Sts., Brooklyn, N.Y.

CIRCLE 59 ON READER-SERVICE CARD

Sampling Switches

2400 samples per min

General specifications for the series 1300 sampling switches include up to four accurately synchronized poles, and as many as 24 non-shorting channels. Type 1300-a samples at the rate of 24,000 samples per minute per channel. The unit weighs 1 lb. and measures 2 x 2 x 3 in. Sizes in other models vary with the requirements of the switch.

General Devices, Inc., Dept. ED, Princeton, N.J.

CIRCLE 60 ON READER-SERVICE CARD

◄ CIRCLE 61 ON READER-SERVICE CARD

Microwave Attenuator

Cover 0.8 to 6 kmc bandwidths

These microwave attenuators measure 5 in. diam and cover bands of 0.8 to 2.5 kmc and 2.0 to 6.0 kmc. There are three units to each bandwidth. The minimum insertion loss is 0.2 db and full insertion loss is at least 30 db over the full band. High resettability and accurate calibration are also featured.

Antenna and Radome Research Associates, Dept. ED, 1 Bond St., Westbury, N.Y.

CIRCLE 62 ON READER-SERVICE CARD

True Airspeed Computer

Accuracy of ±2 knots

SMI Type AXC 529 true airspeed computer has an accuracy of ±2 knots in a range of 100 to 250 knots. The accuracies are possible through the utilization of a highly accurate and sensitive force balance Mach number transducer which generates a shaft position functionally proportional to Mach number.

The unit is designed to provide the necessary true airspeed input to airborne navigational systems.

Servomechanisms, Inc., Dept. ED, 12500 Aviation Blvd., Hawthorne, Calif.

CIRCLE 63 ON READER-SERVICE CARD

CIRCLE 64 ON READER-SERVICE CARD ➤

Power Converter

Missile-telemetering types

Measuring 5-1/2 in. in diam and 4-3/4 in. long, these telemetering converters provide 270 v at 22 ma, 150 v at 10 ma, and 30 v at 15 ma, all with 75 mv or better ripple.

Inputs are respectively 16 v dc and 7 v dc for the PS1008 and PS1009 models. Weight is 2 lb 8 oz. Units are capable of operation at temperatures up to 85 C.

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

CIRCLE 65 ON READER-SERVICE CARD

Decade Counter

Counts at rates of 150 kc

Model CT-101 transistorized decade counter is capable of counting at rates as high as 150 kc. The unit has an easy-to-read visual display featuring large 3/8 in. numerals. A 9-pin socket provides decimal or binary coded decimal electrical output for remote indication purposes. Power consumption is 120 mw, and only two supply voltages of −3 and −10 v are required.

Epsco Components, Dept. ED, 108 Cummington St., Boston, Mass.

CIRCLE 66 ON READER-SERVICE CARD

◄ **CIRCLE 67 ON READER-SERVICE CARD**

Commutation Switches

With printed circuit commutation plates

Each commutation switch, designated Mycalex PC, has 2-poles, 60 contact per pole, and operates on a duty cycle of either 54 ±4, or 87 to 95 ±4 per cent, at speeds up to 1800 rpm, 30 signals per revolution, break before make. Depending on circuit conditions, noise level performance is less than 1 mv with a 5 v input signal. The switch can be completely enclosed, and measures 2-3/16 x 2-3/16 x 3-9/16 in. weighing approximately 24 oz.

Mycalex Electronics Corp., Dept. ED, 125 Clifton Blvd., Clifton, N.J.

CIRCLE 69 ON READER-SERVICE CARD

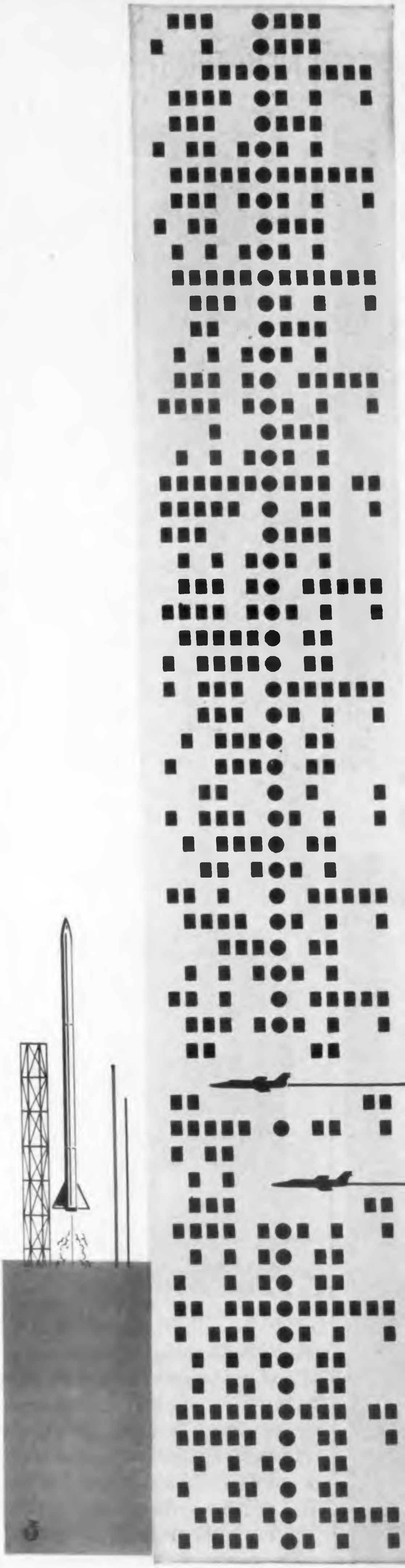
Quartz Crystals

Frequency range 3 to 15 kc

These vibration-resistant quartz crystals have a frequency range of 3 to 15 kc. Crystals will operate through vibration frequencies of 5 to 2000 cycles at 10 g over temperature range of −55 to 105 C and maintain a frequency stability of ±0.025 per cent under dynamic conditions stated. When smaller ambient temperature ranges are encountered frequency stability as close as ±.002 per cent can be achieved. Where greater frequency stability is required, temperature-controlling ovens are available.

Hill Electronic Engineering & Mfg. Co., Inc., Dept. ED, 400 E. Factory St., Mechanicsburg, Pa.

CIRCLE 70 ON READER-SERVICE CARD



maintain and control reliability

with new

PRE-PROGRAMMED INSTRUMENTATION

NEW ROBOTESTER — IMMEDIATE AID TO IMPROVE MAINTAINABILITY OF EQUIPMENT RELIABILITY

A bold imaginative concept has evolved from Lavoie Labs in the form of a Programmed Instrumentation Approach with Failure Prediction. Designed for the **active control** of maintainability and reliability of electronic equipment in aircraft, missile and weapon systems.

The universal-tape programmed performance checking Robotester is versatile and flexible and is the basis of this forward-thinking Lavoie program.

The Robotester itself expands checkout capabilities and slashes 80% of final test time. Operational testing and production line check out is accomplished through continuous, high-speed sampling and comparison . . . split-second recognition, isolation and identification of abnormal functions.

Nominal circuit values and specified tolerances are tape-punched in minutes to accommodate voltages (AC and DC) from 0.5 to 500 volts; Hi Pot to 500 volts; resistances from 1 ohm to 9.99 megohms; and tolerances of 1%, 5%, 10% and 20% of nominal. A total in excess of 60000 tests possible . . the Robotester will check any two circuit points at rates up to 100 tests per minute.

Write today for complete technical information and specifications on the New Robotester.

Write on company letterhead for "Lavoie Programmed Instrumentation" . . please specify application.

Lavoie Laboratories, Inc.

MORGANVILLE, NEW JERSEY

DESIGNERS AND MANUFACTURERS OF ELECTRONIC EQUIPMENT

CIRCLE 71 ON READER-SERVICE CARD

Electronic Timer

Ranges from 25 msec to 50 sec

Model T1 electronic timer can be used for single or repeat cycle timing, interval or delayed action timing. It features 25 msec to 50 sec range, regulated power supply, plug-in relays, 5 a isolated load contacts. Included are stabilized tubes, line transient suppression components, Mylar timing condensers.

Ferrara Inc., Dept. ED, 8106 W. Nine Mile Rd., Oak Park 37, Mich.

CIRCLE 73 ON READER-SERVICE CARD

Magnetic Clutches

16 and 32 oz-in. clutching torques

Model D-103 (shown) is a size 11, 1.062 in. diam single-ended, magnetically activated clutch. Clutching torque is rated at 16 oz-in., with three watts of dc applied to the control coil. Voltage ratings range from 1.5 to 300 v dc, with 24 v as standard. Size 18 magnetic clutch brake, designated D-102, has a clutching torque of 32 oz-in. The voltage ratings are the same as D-103. The unit has a diameter of 1.75 in.

Dynamic Instrument Corp., Dept. ED, 59 New York Ave., Westbury, N.Y.

CIRCLE 74 ON READER-SERVICE CARD

Transistor Tester

Gives direct I_{cbo} readings

Model 960 portable transistor and crystal diode tester can test for I_{cbo} gain, leakage, shorts, on low, medium and high-power transistors of both the pnp and npn types, as well as the new tetrode transistors. Operating specifications are: direct I_{cbo} readings, in terms of true collector current, on wide-angle 5-1/2 in., 100 ua meter; five I_{cbo} ranges; wide range of collector potentials from 0.5 v dc to 100 dc in 17 selected steps; direct reading gain ranges with five separate injection currents for low, medium and high power types; and leakage tests to check emitter to collector current at fixed collector bias.

Precision Apparatus Co., Inc., Dept. ED, 70-31 84th St., Glendale, Long Island, N.Y.

CIRCLE 77 ON READER-SERVICE CARD

Gyro Transducer

Senses motion about the roll, yaw and pitch axes

Consisting of three gyros mounted so as to sense motion about the roll, yaw and pitch axes of a vehicle, the free gyros provide an accurate reference in the form of an electrical signal which is proportional to displacement about the outer gimbal axis. The hermetically sealed unit weighs 19-1/4 lb, including caging mechanisms, inverter and radio-noise filters. Gyro motors may be operated directly from a 115 v, 400 cps source. If required, unit may be supplied with 27 v dc, and the 400 cps power generated internally. Altitude and humidity conditions have no effect and the unit will operate satisfactorily at temperatures from —65 to +160 F.

Clary Dynamics, Dept. ED, 408 Junipero St., San Gabriel, Calif.

CIRCLE 78 ON READER-SERVICE CARD

A stand out

THE 1802 HYDROGEN THYRATRON, WITH UNPRECEDENTED PERFORMANCE AND RUGGEDNESS, CERAMIC-ENVELOPED AND *FAR SMALLER*

The new EG&G Hydrogen Thyratron, Model 1802, delivers 30 megawatts peak power in a smaller package than any comparable unit. It supersedes many older types, and surpasses the performance of the Type 5948/1754 on all counts, in less than 1/7th the size. The new 1802 is air-cooled by convection and will tolerate ambient temperatures up to 100° C. Yet its warm-up time is only 5 minutes. Other comparisons with the 5948/1754:

	1802	5948/1754
Input trigger power	250 v at 400 ohms max.	650 v at 250 ohms max.
Delay time	0.5 μs rated (average is 0.25 μs)	1 μs
Jitter	.002 to .005 μs	.02 μs
Reservoir Range	±10%	± 5%
Filament Power	90 watts	200 watts
Ambient Temp. Max.	100° C	75° C

The hydrogen thyratron was invented by K. J. Germeshausen, President of EG&G. Advanced research continues to keep this company in the forefront of hydrogen thyratron development. For specific data on the 1802, and for the most authoritative information on gas-discharge tube types and MILLI-MIKE* CRT's, TW oscilloscopes and systems, write to us on your company letterhead.

*Trademark

EDGERTON, GERMESHAUSEN & GRIER, INC.

160 Brookline Avenue, Boston, Mass. 1622 South "A" Street, Las Vegas, Nev.

CIRCLE 80 ON READER-SERVICE CARD

NEW PRODUCTS

Attenuator

Measures rf power ratios

This instrument is intended for measuring rf power ratios in systems employing modulated rf power sources and square-law rf detectors. In such systems the audio voltage output from the detector is proportional to the rf power input, and it is therefore necessary to substitute audio attenuation corresponding to the change in rf attenuation. This audio attenuator reads, in decibels, this change in rf attenuation. The audio frequency attenuator has a characteristic impedance of 2000 ohms and is adjustable over a range of 104 db audio attenuation corresponding to 52 db rf attenuation.

Weinschel Engineering, Dept. ED, Kensington, Md.

CIRCLE 81 ON READER-SERVICE CARD

Power Supplies

For transistor use

The first of this series of power supplies is designed for both laboratory and production line use, and features three models with variable dc output. Model VM-120 has an output variable from 0-15 v dc, a maximum current of 2 and an internal impedance of 1.3 ohm. Model VM-300 has an output variable from 0.30 v dc, a maximum current of 1, and an internal impedance of 5 ohm. Model VM-500 has an output from 0-50 v dc, a maximum current of 1 and an internal impedance of 8 ohm.

The second series has an output variable from 0-28 v dc, a maximum current of 1 a, an internal impedance of 1.1 ohm; and a ripple factor of 0.065 per cent.

Ferrotran Electronics Co., Dept. ED, 693 Broadway, New York 12, N.Y.

CIRCLE 82 ON READER-SERVICE CARD

CIRCLE 83 ON READER-SERVICE CARD

Telemetering Noise Cutout

Permits recovery following noise bursts

Model MNC-1 noise cutout unit provides for the rapid recovery of telemetered signals following noise bursts which often cause data to be temporarily lost due to interference. During periods of signal drop-out, this unit stores control-loop voltage levels to provide wave form restoration with a minimum loss of data due to recovery time factors. Signal restoration accuracy after one-half minute of drop-out is within two per cent of full scale.

Applied Science Corporation of Princeton, Dept. ED, P.O. Box 44, Princeton, N.J.

CIRCLE 84 ON READER-SERVICE CARD

Power Pack

For electrostatic devices

Designed primarily for electrostatic devices, this encapsulated high voltage dc power pack will deliver voltages up to 12,000 v at currents ranging up to 0.5 ma. It is current limited to 5 ma under short circuit conditions and measures only 2-1/4 x 2-1/2 x 6-1/4 in.

Skysweeper, Inc., Dept. ED, McHenry, Ill.

CIRCLE 85 ON READER-SERVICE CARD

CIRCLE 86 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Transistor Enclosure

Hermetically sealed at 1000 C

This all-glass transistor enclosure is made possible by the development of a close-control electric sealing process. The base and envelope are hermetically sealed at 1000 C while temperature near the semiconductor, less than 1/4 in. away, is kept below 150 C. Sealing is done in approximately 10 sec. Both base and envelope of the 200 mil lead circle-enclosure are made of strong, thin-walled, precision glass tubing.

Corning Glass Works, Dept. ED, Corning, N.Y.

CIRCLE 88 ON READER-SERVICE CARD

Dual-Beam Scope

DC to 100 kc frequency response

Type 502 dual-beam oscilloscope has two high-gain vertical amplifiers with calibrated sensitivities in 16 steps from 200 μv/cm to 20 v/cm.

Frequency response is dc to 100 kc at maximum sensitivity, dc to 500 kc at sensitivities lower than 50 mv/cm. Both channels have differential input with high rejection, and a constant input impedance of 1 meg, 47 μμf.

Tektronix, Inc., Dept. ED, Portland 7, Ore.

CIRCLE 89 ON READER-SERVICE CARD

DC Potentiometer

Permits readings to three places

This dc potentiometer includes standard cell, working battery, null balance galvanometer, volt box, shunts and adjustable power supply for calibration of dc instruments in any ranges from 0.1 μa to 9.99 a and 0.1 mv to 999 v. Three decade switches provide readings to three places. Precision wire wound resistors are manganin with tolerance of 0.5 per cent.

Assembly Products, Inc., San Gorcinto Div., Dept. ED, P.O. Box XX, Palm Springs, Calif.

CIRCLE 92 ON READER-SERVICE CARD

Parabolic Antennas

Range between 200 and 5000 mc

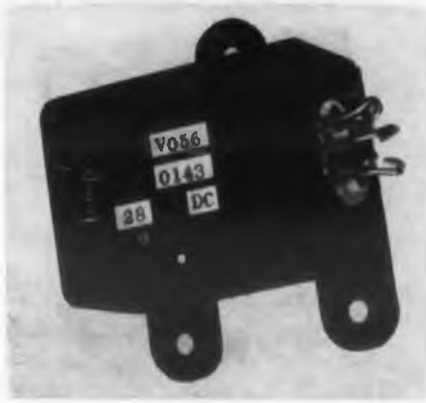
These 28 foot parabolic antennas with dual-polarized feed horns cover the range between 200 and 5000 mc. The reflector consists of a center section of four identical pie segments, and an outer section of six ring segments. Type 21 mount is for mounting on the face of a 10-foot tower, but is adaptable to other sizes. It provides for azimuth and elevation positioning through ±5 deg. Type 22 mount is for mounting on the corner of a tower, and may be used on triangular towers with leg spacings of 10 feet or less, providing azimuth and elevation position through ±4 deg. The antenna weighs 1800 lb net, including face mount.

Technical Appliance Corp., Dept. ED, 1 Taco St., Sherburne, N.Y.

CIRCLE 93 ON READER-SERVICE CARD

Time Delay Relays

10 a contact rating



Design and performance details of these transistorized time delay relays include: time delay periods from 0.01 to 60 sec; timing accuracy of ±10 per cent of nominal delay period; contact arrangements and ratings of 1-pole, double throw, 10 a resistive or 3-pole, double throw, 10 a resistive; ambient temperature from —55 to 125 C; vibration resistance of 10 to 80 cps., 0.12 in peak double amplitude, 80 to 2000 cps at 20 g; shock resistance of 50 g for 11 msec; input voltage of nominal 28 v dc. A typical model measures 1-1/4 x 1-11/16 x 2-1/4 in. and weighs 5-1/2 oz.

Tempo Instrument Inc., Dept. ED, 240 Old Country Rd., Hicksville, N.Y.

CIRCLE 96 ON READER-SERVICE CARD

Data/Log

Capable of 150 printing operations a minute

The Data/Log series MC 203 units are adapted to large scale data logging systems. As many as 14 digits can be entered on one printing cycle in any arrangement from 1 up to 14, or in any grouping within 14 digits. These machines are capable of a maximum of 150 printing operations a minute. Hence it is possible to obtain a speed of over 30 characters per second. With the 18 in. carriage, up to 136 characters and spaces may be printed on a single line.

Monroe Calculating Machine Co., Inc., Electronics Components Div., Dept. ED, 60 Main St., San Francisco, Calif.

CIRCLE 97 ON READER-SERVICE CARD

Antennas

For communication and telemetering in the 2,200 mc region

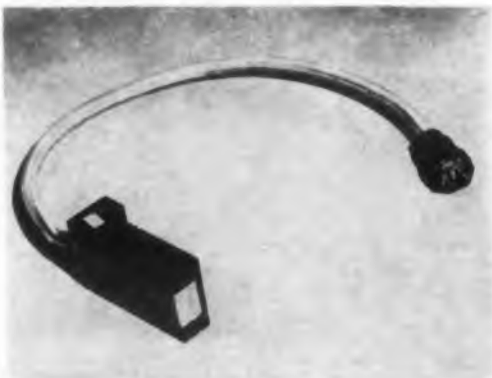
This 8 foot diameter horn-fed paraboloid antenna weighs only 82 lb and provides a 4 deg pencil beam for high gain requirements. Another type is a compact blade antenna which has been designed for missiles and supersonic aircraft. It is less than 1 in. high, has very low drag, and provides an omni-directional pattern. A conical scanner is available for installation in 6, 8, or 10 foot diameter paraboloids. Optimum reception of telemetering signals even at long range is obtained by automatic tracking with the narrow beam provided. Horizontal, vertical and circular polarization are available.

Canoga Corp., Dept. ED, 5955 Sepulveda Blvd., Van Nuys, Calif.

CIRCLE 99 ON READER-SERVICE CARD

Transducer

Accurate to 1 sec of arc



T833 transducer which is a differential transformer type pickoff consists of an E-core stator and one or more separate companion rotors. The transducer is accurate to 1 sec of arc and is used in position pickoff in servo rate or optical systems. The dimensions of the transducer in potted core are 1-1/8 x 5/8 x 1/2 in. while in potted housing the dimensions are 2 x 1-1/4 x 3/4 in. The rotor face is 0.250 in. diameter round or 0.250 in. square. Excitation: 5 to 100 ma/300 cps to 2 kc. Sensitivity of 0.1 ma per .001 in. per ma excitation at 400 cps.

Sterling Precision Corp., Instrument Div., Dept. ED, 17 Matinecock Ave., Port Washington, N.Y.

CIRCLE 100 ON READER-SERVICE CARD

ACEPOT®

SUB-MINIATURE, PRECISION, WIRE-WOUND

LINEAR POTENTIOMETERS

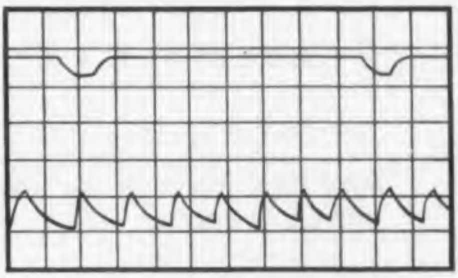
500 Series ACEPOT actual size

Small pot size — Big pot performance

Only ½" in diameter, the ACEPOT excels in a combination of all around top performance characteristics comparable to larger units. For example, these precision units feature ± 2% resistance tolerance and ± 0.3% independent linearity. Every potentiometer is completely sealed against sand, dust and foreign matter to avoid abrasive action between moving parts. All materials and metals are treated for maximum resistance to salt spray, corrosion, humidity and conform to shock and vibration tests. ACEPOTS are designed and assembled MIL-A-8625A, QQ-M-1512, JAN-T-152, MIL-E-5272A, MIL-R-19A, NAS-710 and MIL-R-19518 (ships).

ACEPOT LINEARITY TEST

Plot of voltage ratio error versus rotation illustrates linearity to better than ± 0.3%.



ACEPOT RESOLUTION TEST

Section of oscillograph trace of electrical resolution shows voltage change for each turn of wire.

ACE offers a wide variety of linear and nonlinear precision, wire-wound potentiometers in standard, special and AIA sizes. Custom designs to meet special requirements can be made available on short lead time. Call, write or teletype Dept. G, ACE ELECTRONICS ASSOCIATES, INC., 99 Dover Street, Somerville, Mass., SOmerset 6-5130, TWX SMVL 181.

ACEPOT®
ACETRIM®
ACESET®
ACEOHM®

ACE ELECTRONICS ASSOCIATES, INC.

CIRCLE 101 ON READER-SERVICE CARD

Telemetering Unit

For use with solid state commutators

The DKO-11 keyer subcarrier oscillator makes it possible to combine pw data channels with existing channels in fm/fm and fm/pm airborne telemetering systems. The DKO-11 is especially designed to operate from negative pedestal triggering pulses typical of those generated by solid state high level commutators. It is suited for use in airborne pw/fm/fm telemetering systems. When used in conjunction with a suitable pw commutator, the DKO-11 permits the multiplexing and pw encoding of a large number of data channels on a single 70 kc subcarrier oscillator frequency. This subcarrier can then be mixed with other subcarriers and applied to an rf carrier for radio transmission.

Applied Science Corp. of Princeton, Dept. ED, P.O. Box 44, Princeton, N.J.

CIRCLE 103 ON READER-SERVICE CARD

Terminals

Features 4 way crimp

These terminals used on both stranded and solid wire, are available in three sizes: 22 thru 16, 16 thru 14 and 12 thru 10. These one-piece terminals are all copper and feature small overall size for applicability in restricted spaces, wide bell-mouths for easy wire insertion, serrated barrels for joint efficiency, and open-end construction for easy visual inspection. The terminals may be installed with the C-241 hand pressure tool or with the D-241 dies which are adaptable for mounting in most common presses.

Buchanan Electrical Products Corp., Dept. ED, 234 Rt. 22, Hillside, N.J.

CIRCLE 104 ON READER-SERVICE CARD

Oscilloscope

DC to 15 mc

Type 533 is a dc-to-15 mc oscilloscope with the company's plug-in feature. All type 53/54 plug-in units can be used with this instrument for signal-handling versatility. Risetime of the main vertical amplifier is 0.022 μsec. The Type 533 has 22 calibrated direct-reading sweep rates from 0.1 μsec/cm to 5 sec/cm, with sweep magnifications of 2, 5, 10, 20, 50, and 100 times. Full sweep range is 0.02 μsec/cm to 15 sec/cm.

Sweep lockout-reset feature provides for one-shot recording. 10-kv accelerating potential assures bright trace for single sweeps. Writing rate is 250 cm/μsec. Viewing area is 6 by 10 cm. Amplitude calibrator has 18 fixed steps from 0.2 mv to 100 v peak to peak. Square-wave frequency is about 1 kc. Other features include automatic blanking for switching transients when dual-trace unit is used in its chopped mode, and warning lights for uncalibrated sweep rate and magnifier settings.

Tektronix, Inc., Dept. ED, P.O. Box 831, Portland 7, Ore.

CIRCLE 107 ON READER-SERVICE CARD

RF Amplifier

Extended range to 245 mc

The REL-09-HF is a further development of the REL-09 rf power amplifier extending the amplification range from 235 to 245 mc. The unit employs a type 6360 miniature dual-beam power-amplifier tube with a CCS rating of 15 w. With 1.4 w input drive, it will deliver an 8 w minimum output to a 52 ohm grid plate.

Rheem Electronics Div., Dept. ED, 7777 Industry Ave., Rivera, Calif.

CIRCLE 108 ON READER-SERVICE CARD

FXC presents a comprehensive line of

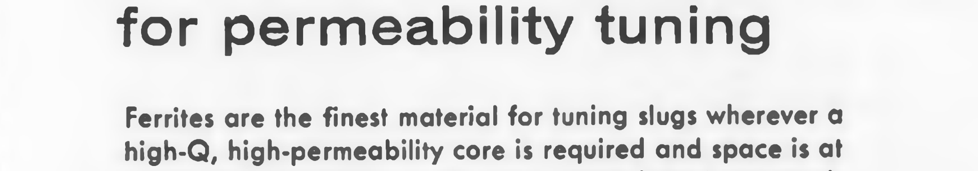
threaded ferrite slugs

for permeability tuning

Ferrites are the finest material for tuning slugs wherever a high-Q, high-permeability core is required and space is at a premium. These Ferroxcube tuning slugs have been specifically developed for the permeability tuning of inductors, filters and transformers in the 1 kc to 4 Mc frequency range. They come in a large variety of sizes and threads, and have been found particularly useful for final inductance adjustments on filters with ferrite pot cores. The screwdriver slot in the slugs runs all the way through the core for simpler coil assembly and easy adjustability at either end. All Ferroxcube threaded slugs are furnished complete with self-threading coil forms of phenolic-impregnated tubing.

For complete data, as well as information on the availability of specific types and sizes, write to:

FERROXCUBE CORPORATION OF AMERICA
55C East Bridge Street, Saugerties, New York



Manufacturers of ferrite cores for recording heads, magnetic memories, TV flyback transformers, pulse transformers, filters, inductors, high frequency shields and power transformers

CIRCLE 109 ON READER-SERVICE CARD

4PDT Relay

Sensitivity of 1 mw per contact

Type 104 4pdt relay features a sensitivity of 1 mw per contact. The unit can be used for very close differential applications where dropout is required as close as 85 per cent of pickup. The relay is designed for dc operation but is also made for ac, using selenium rectifiers contained within the enclosure. Standard coil resistance is up to 30,000 ohms with special windings to 100,000 ohms.

Contact capacity is 1 amp inductive or 3 amp resistive at 115 v ac or 29 v dc. Contacts are available in silver, palladium, silver cadmium oxide, or gold alloy. The relay has thorough wipe action on the contacts.

General Automatic Corp., Dept. ED, 12 Carlton Ave., Mountain View, N.J.

CIRCLE 110 ON READER-SERVICE CARD

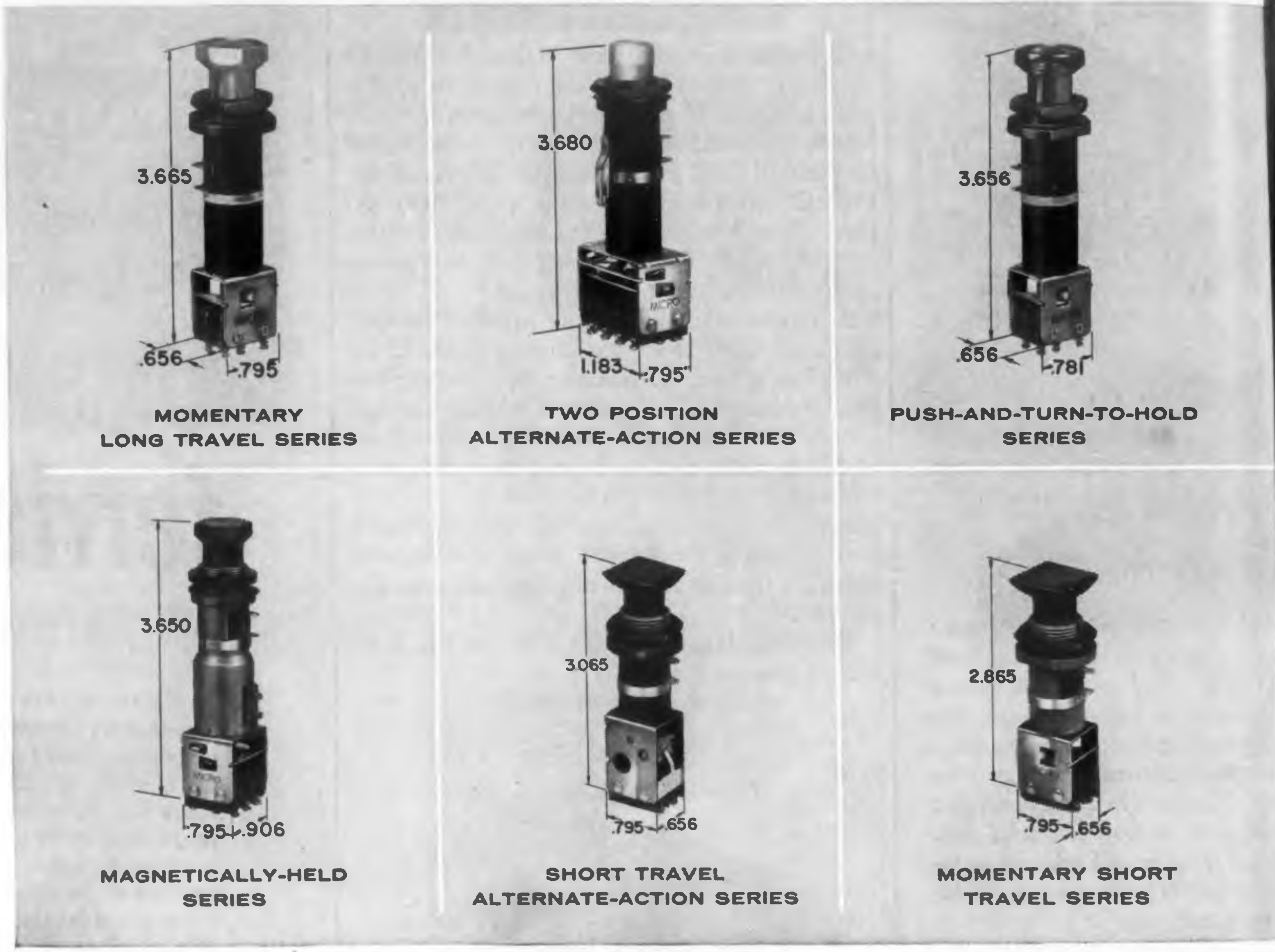
Temperature Control

Explosion-proof dual switch

Type D98A is a sensitive, remote bulb temperature control designed for use in hazardous locations where explosive vapors and gases are present. Two separate switches permit switch action above or below the set point, control of two independent circuits, and great flexibility of switching arrangement. The standard head compensation provided is effective from −65 to +160 F.

United Electric Controls Co., Dept. ED, 79 School St., Watertown, Mass.

CIRCLE 111 ON READER-SERVICE CARD



¾-inch Round. Available in red, yellow, blue, green and white.

⅝-inch Hex. Available in red, yellow, and green.

½-inch Round. Available in red, yellow, blue, green, white and clear.

¾-inch Square. Available in red, yellow, blue, green and white.

Control Panel Units

For transistorized circuitry

Included in this line of control panel components are: the Echo-lite, a push button with an NE-2 neon bulb enclosed; the Memo-lite, a subminiature thyratron indicator for transistor circuitry; and the Transistor-lite, a transistor controlled neon lamp circuit. Each is housed in an anodized aluminum tube of 1/2-in. diameter, 2-in. long. The gold plated terminal connections take A-MP series 53 taper pins. The lenses are molded from clear plastic, but are available in colors as well. The terminal header is nylon, and mylar insulation is used internally. Provisions are made internally for as many as four 1/2 w composition resistors.

Transistor Electronics Co., Dept. ED, 3357 Republic Ave., Minneapolis 26, Minn.

CIRCLE 113 ON READER-SERVICE CARD

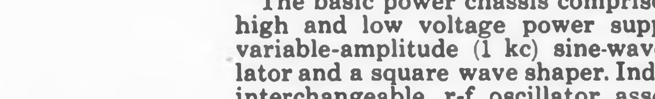
Digital Totalizer

Visual and electrical readout

Model 7106 Digitote accepts pulses at a rate of 60 per second and totalizes any input quantity for remote indication, control, or telemetry. Three and five digit visual and electrical readouts provide high accuracy and large capacity (up to 99999) totalizing. Number wheels are lighted for photographic and visual clarity.

Digitran Co., Dept. ED, 45 W. Union St., Pasadena, Calif.

CIRCLE 114 ON READER-SERVICE CARD



Pressure Transducer

Repeatability of 1 per cent

Model 451212 pressure transducer, a potentiometer output device, has a 2000 wire (0.05 per cent) resolution and accuracy within 1.0 per cent of reading. The instrument is available in pressure ranges from 0-10 through 0-50 psi absolute, differential, or gage.

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

CIRCLE 116 ON READER-SERVICE CARD

Tape Strobe

Checks type speeds of all tape records

Under 60 cps light sources, reference marks on the wheel disc appear to stand still if the tape is moving past the capstan at correct speeds: 7-1/2, 15, and 30 ips. Only a 60 cps light source is necessary.

Scott Instrument Labs., Dept. ED, 17 E. 48 St., New York 17, N.Y.

CIRCLE 117 ON READER-SERVICE CARD

Magnetic Shield

Eliminates ion fields

This small cylindrical netic co-netic magnetic shield fits over the gun portion of a crt and eliminates most of the indication caused by ion fields entering at the face of the tube. Construction is 1 layer of netic and 1 layer co-netic cladded together. The shield provides permanently effective shielding because it is non-shock sensitive, non-retentive and does not require periodic annealing.

Perfection Mica Co., Magnetic Shield Div., Dept. ED, 1322 No. Elston Ave., Chicago 22, Ill.

CIRCLE 120 ON READER-SERVICE CARD

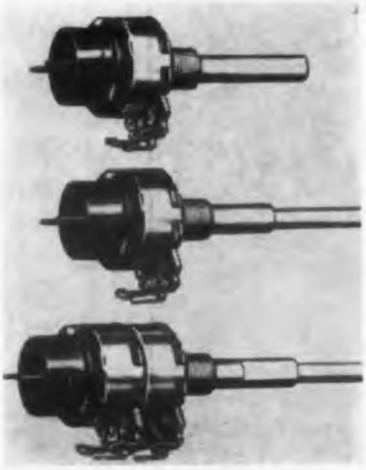
Digital Actuator Motor

Provides digital to analog conversion

Model 7105 Digistepper, a digital actuator motor, is capable of bidirectional digital stepping rates up to 60 steps per second. The large step travel of 180 deg increases available torque in exchange for angular travel by the addition of standard servo gear heads. Typical motor with 180:1 gear head produces 80 in.-oz. of torque for a 1 deg step.

The Digitran Co., Dept. ED, 45 West Union St., Pasadena, Calif.

CIRCLE 121 ON READER-SERVICE CARD



Potentiometers

Independent control and switch action

These variable resistors also operate as push-on, push-off line switches. Pushing the shaft once closes the switch. Pushing the shaft again, opens the switch. Thus the equipment may be turned on and off without disturbing the setting of volume, tone, contrast, or other function.

Stackpole Carbon Co., Electronic Components Div., Dept. ED, Stackpole St., St. Marys, Pa.

CIRCLE 122 ON READER-SERVICE CARD

NEW LITERATURE

Semiconductor Applications 12

"The Use of Silicon Junction Diodes to Protect Sensitive Current Devices" is the first of bulletin series on semiconductor applications. The 4-page text shows how silicon diode nonlinear characteristics, both in the forward and zener operating regions, improve the protection of ac and dc meters. Typical circuits are illustrated along with the test results obtained from these circuits. The applications presented include dc microammeter, dc and ac voltmeter, ac milliammeter, and microwatt and low current relay protection. Hoffman Electronics Corp., Semiconductor Div., 930 Pitner Ave., Evanston, Ill.

Rectifier Handbook

A silicone rectifier handbook explains the technicalities of these devices, how they are made, where they are used, and how they can be used in many applications. This booklet is available at a price of $1.00. *For further information write direct to Audio Devices Inc., Rectifier Div., Dept. ED, 620 E. Dyer Rd., Santa Ana, Calif.*

HF Transistor 12

High-frequency transistors are described in this 12-page brochure. The maximum ratings, cut-off and small signal characteristics, and charts showing the common emitter output static characteristics for 4 npn and 5 pnp transistors are included in Brochure G-150. General Transistor Corp., 91-27 138th Pl., Jamaica 35, N.Y.

Bobbin Cores 12

With pictures, Bulletin TB-103 describes a line of bobbin cores for digital data processing systems. The 4-page folder includes data on available magnetic materials—Orthonik and 4-79 molybdenum permalloy. It also covers the usea sizes, and protective covering of the bobbins. G-L Electronics, 2921 Admiral Wilson Blvd., Camden 5, N.J.

Permanent Magnets 128

Publication of a 20-page bulletin on permanent magnets is announced. Entitled "Permanent Magnet Design" or Bulletin 158, it covers such subjects as permanent magnet applications, fundamental properties, design problems, magnet testing, magnetic attraction, mechanical considerations, and stabilization and magnetization of finished magnets. The booklet is illustrated with pictures and curves. Thomas & Skinner Inc., 1151 E. 23rd St., Indianapolis 7, Ind.

oltage-Variable Capacitors 129

Two papers about a voltage-variable capacitor e offered free: "Report on Potential Applicans of the PSI Varicap" and "Varicap Research d Development." The papers are reprints of erdepartmental correspondence multilithed o 12-page and 8-page formats. Pacific Semiinductors, Inc., 10451 W. Jefferson Blvd., Culr City, Calif.

unched Card Reader 130

In Product Data Sheet 5705, a punched card ader for automatic control of blending, batchg, and proportioning operations is described. lustrated with photographs and a cutaway inallation drawing, the 2-page sheet shows how rmula changeovers are made. It also tells how e PCR control is used with IBM or other nched cards. Richardson Scale Co., Clifton, J.

olenoids and Switches 131

Four-page Bulletin 1157LS presents a line of tary solenoids, selector switches, hermetically aled selectors, and stepping motors. It has a imension and torque chart for all stock solenoid odels, a cutaway drawing of the stepping mor, dimensional data on selector switches, and a ief review of sealed selectors. G. H. Leland, c., 123 Webster St., Dayton 3, Ohio.

lectronic and Magnetic Alloys 132

The engineering properties and fabrication aracteristics of a complete range of special lloys for electronic, magnetic, and electrical aplications are detailed in a 64-page booklet. The formation covers physical constants, mechanal properties, working instructions, heat treatent, and corrosion resistance in all categories. he illustrated booklet also has a useful glossary f terms. The Carpenter Steel Co., 3116 W. Bern ., Reading, Pa.

erminal Catalog Directory 133

The "Selectalog" is a 20-page annotated direcry of catalogs on solderless terminals and aplication tooling. A reference index for those ncerned with electric circuitry, the 4-color ooklet is also a digest of solderless termination chniques. From it engineers can select the catag with the information they want. The catalogs t lists cover all company terminal and connector ypes, splices, Autostrip terminals, as well as apacitors, pulse forming networks, power suplies, patchcord programming systems, and aplication tooling. Amp Inc., Harrisburg 30, Pa.

NEW LITERATURE

Bellow Diaphragms 136

A 5-page brochure describing a precision built welded diaphragm type bellows has just been prepared. It gives facilities available, industries served and material used. Metal Bellow Corp., 31 Mica Lane, Wellesley Hills, Mass.

Testing Facilities 137

This brochure illustrates and describes facilities, equipments, and instrumentations used for testing components for missile, rocket, and aircraft applications. The laboratories are available to general industry for component reliability tests. Networks Electronic Corp., 14806 Oxnard St., Van Nuys, Calif.

Terminals 138

Subscriptions to "Terminalogy," a bimonthly news bulletin devoted to Teflon terminals and connectors, are offered free. The first issue, January-February, contains information on the latest press-fit types, installation procedures, applications, and tests. Sealectro Corp., 610 Fayette Ave., Mamaroneck, N.Y.

Servomotor 13

Details of an adjustable, size 11, ve locity-damped servomotor are covere in Data Sheet 912. The sheet includes cutaway drawing, electrical and me chanical specifications, dimensional an schematic drawings, and torque-spee curve of the 115-v, 400 cycle serv Beckman/Helipot Corp., Newport Beac Calif.

Electrolytic Capacitors 14

Bulletin TQ-10 covers subminiatur tantalum solid electrolyte capacitors th are metal cased and hermetically seale The 1-page sheet gives specifications, c pacitance ranges, and dimensions. Min tronics Corp., 328 Grand St., New Yor 2, N.Y.

Fasteners 14

A complete line of "quarter-turn" fas teners is illustrated and described i this 24-page catalog. Information on eac fastener includes dimensional data, com prehensive installation instructions, an where-to-use information. Illinois Too Works, Fastex Div., 195 Algonquin Rd Des Plaines, Ill.

Toggle Switches 143

Pull-to-unlock, sealed toggle switches are cataloged and described in Data Sheet 142. The 4-page brochure has photographs and dimensional drawings of 1-, 2-, and 4-pole types. It also has drawings showing 11 locking designs, and charts of electrical data. Micro Switch, Div. of Minneapolis-Honeywell Regulator Co., Freeport, Ill.

RF Filters 144

Hermetically sealed rf filters that will withstand extreme temperatures without loss of impregnant or degradation of performance are the subject of a 4-page brochure. The pamphlet contains general characteristics and frequency vs. attenuation curves. The Magnavox Co., Ft. Wayne, Ind.

Contacts 145

This revised and expanded 16-page general catalog describes properties and uses of a line of electrical contacts. The publication is designed to aid in selection and application of these electrical contacts throughout the broad original equipment field. One feature of the catalog is an outline showing the company's best contacts for various applications. The company's contact assembly service is also described. Gibson Electric Co., Delmont, Pa.

Microwave Test Units 146

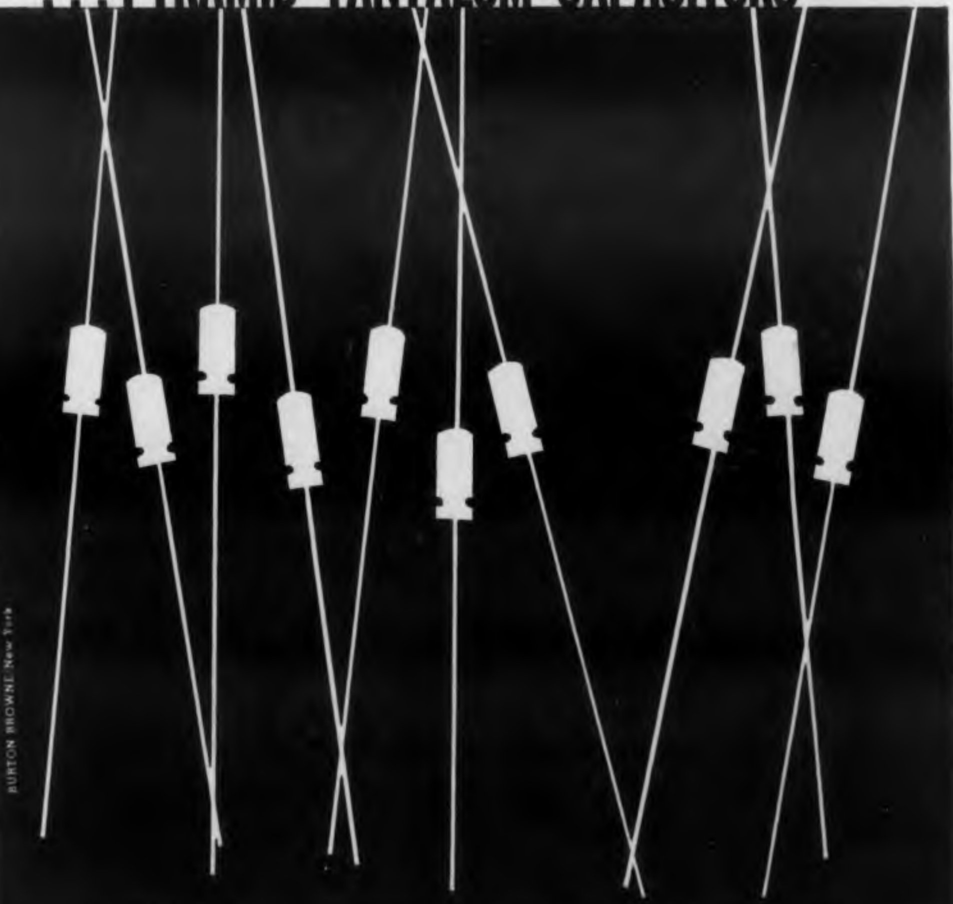
Detailed coverage is given to microwave test equipment in 32-page Catalog No. 58. Pictures, descriptions, and specifications cover coaxial attenuators, insertion loss test sets, modulated rf sources, bolometer preamplifiers, terminations, and other units. Weinschel Engineering, 10503 Metropolitan Ave., Kensington, Md.

Automation Controls 147

A catalog lists automatic controls most commonly used to design automatic systems. Called "Automation Controls," the booklet includes counting devices, switches, electric valves, actuators, relays, limit controls, time switches, and accessory equipment which can serve as building blocks. General Controls Co., 801 Allen Ave., Glendale 1, Calif.

UP TO 1000 MFD-VOLTS IN LESS THAN 2/100 OF A CUBIC INCH

...PYRAMID TANTALUM CAPACITORS



BURTON BROWNE New York

Pyramid Tantalum slug capacitors are miniaturized to provide maximum space economy.

New Pyramid Tantalum slug capacitors have cylindrical cases and contain a non-corrosive electrolyte. Due to the special construction of materials used in the manufacture of Pyramid Tantalum slug capacitors, these units are both seep and vibration proof. In addition, this type of capacitor assures long service life and corrosion resistance – made to meet MIL-C-3965 Specifications.

Commercially available immediately, these new Pyramid Tantalum capacitor units have an operating range between –55 C to 100 C for most units without any de-rating at the higher temperature.

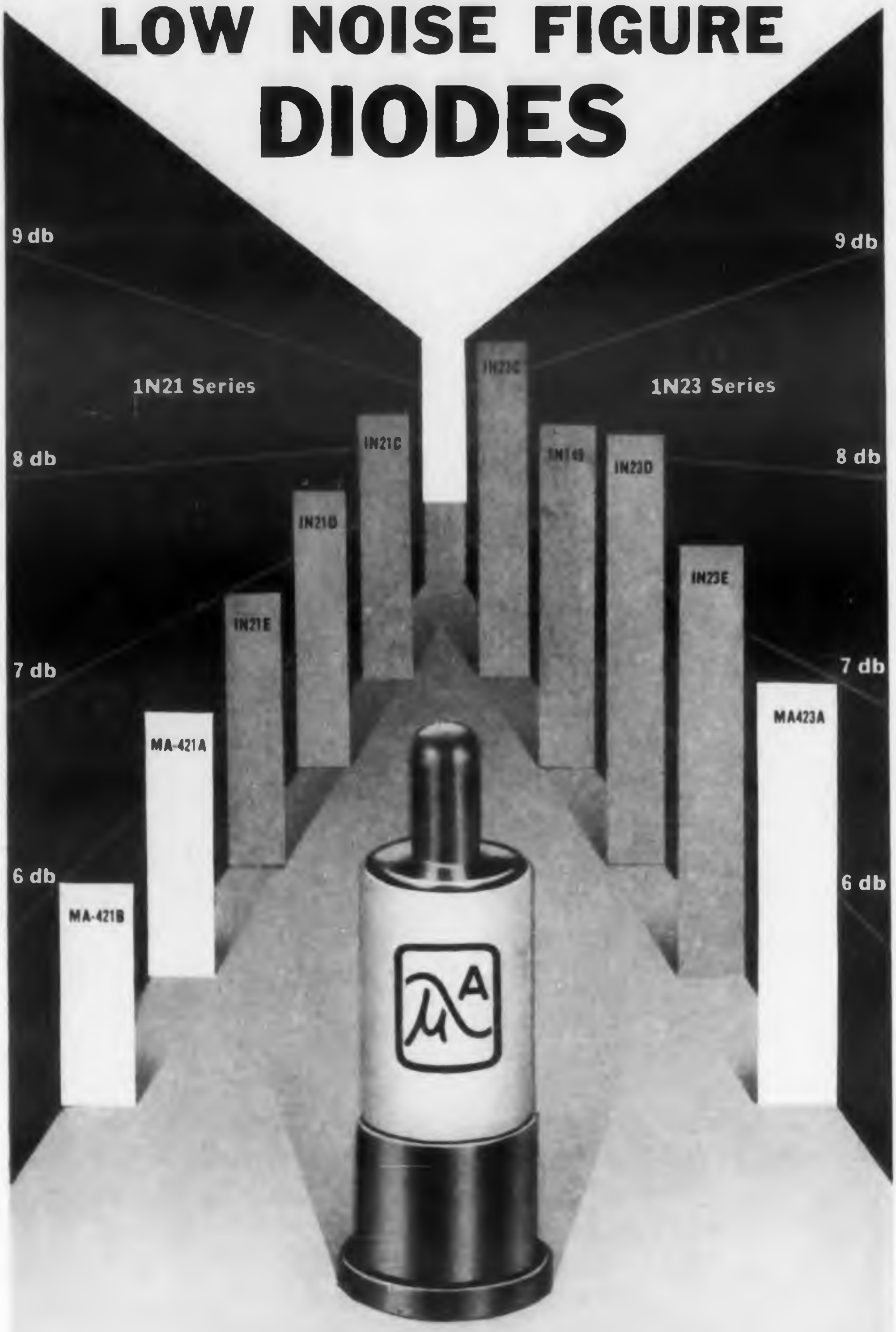
To obtain complete engineering data and prices for Pyramid Tantalum slug capacitors, write to: Pyramid Research and Development Dept., Pyramid Electric Company, 1445 Hudson Boulevard, North Bergen, New Jersey.

CAPACITORS – RECTIFIERS
FOR ORIGINAL EQUIPMENT –
FOR REPLACEMENT

PYRAMID
ELECTRIC COMPANY
NORTH BERGEN, N. J.

CIRCLE 185 ON READER-SERVICE CARD

NEW
LOW NOISE FIGURE
DIODES



Microwave Associates' new MA421A, 421B and 423A provide the lowest noise figures in the field to date.

Available in production quantities right now, these rugged, high-reliability diodes mark a new advance in the field.

Electrically these new diodes are similar to Microwave Associates' well known E series, but provide a significant advance in noise figure as shown in the above illustration.

Physically, they are fully interchangeable with the older 1N21 and 1N23 types which they can replace in existing systems to advantage.

SEND FOR THIS DESIGNERS HANDBOOK

Our new Handbook-Catalog is a valuable aid in application and measurement techniques. Ask for Brochure 58S

MICROWAVE ASSOCIATES, INC.

BURLINGTON, MASSACHUSETTS • BRowning 2-3000

CIRCLE 149 ON READER-SERVICE CARD

Zener Diode Uses—

1 In Series With Capacitor

When circuits require subminiature parts, an electrolytic capacitor with a low voltage rating can be used in series with a zener diode. This is illustrated in a dc restorer application.

The dc restorer illustrated was required for a 15 cps square wave signal. The resulting varying dc voltage was required to be insensitive within a temperature range of 0 to 100 deg C. The circuit was required to utilize subminiature components.

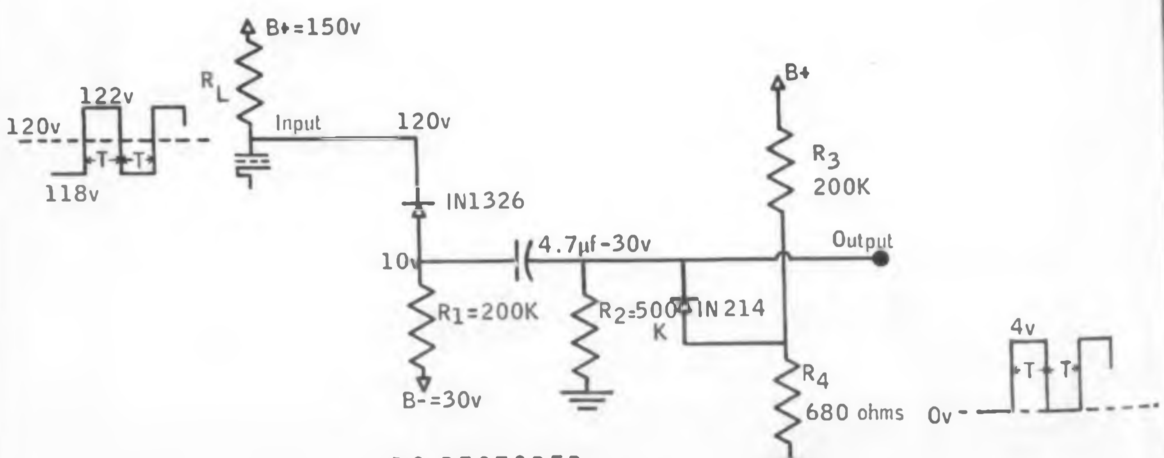
The output of an ac amplifier stage with a 150 to 300 v plate supply may well have 100 to 200 v dc level at the plate. The conventional dc restorer will require a series capacitor with a voltage rating equal or larger than the dc level at the plate. To hold the flat top of the square wave within 2 per cent, a capacitor of at least 3.33 μf is required in accordance with the equation $T/RC = P/100$ where P is the desired percentage, R_2, C and T as indicated on the diagram.

In the illustrated example, a 4.7 μf, 150 v capacitor would be required. Even an electrolytic capacitor would be of considerable size, besides an appreciable amount of leakage current would flow through the capacitor.

A zener diode in series with the capacitor overcomes both disadvantages. The diode D_1 drops the dc plate level to the vicinity of ground level. A small voltage rating for the capacitor is sufficient and a subminiature capacitor can be used.

Temperature changes will influence the zener breakdown voltage of D_1 but this is of no consequence since the charge of the capacitor will adjust to compensate for that change. For similar reasons B+ changes are not sensed at the output. R_1 provides for current flow through D_1 and its value should be chosen in accordance with allowable dissipation of D_1. Without the divider network of R_3 and R_4 the restorer will restore to −0.5 v rather than to ground because of the forward breakdown characteristic of D_2. At the expense of increasing the forward resistance of D_2 by R_4 the biasing network R_3 and R_4 provide precise restoration to ground potential.

Manfred Hilsenrath, Assoc. Engineer, Lockheed Aircraft Corp., Palo Alto, Calif.



DC RESTORER

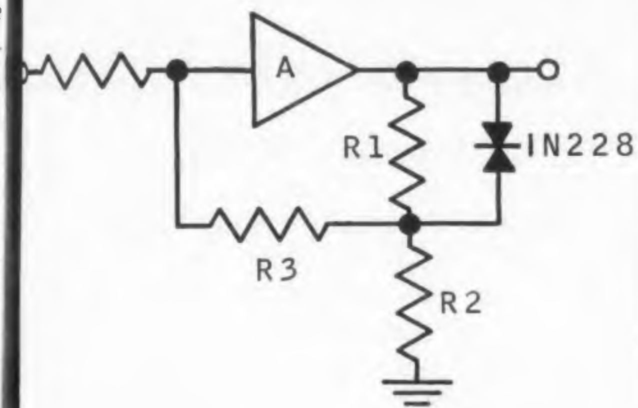
et $10.00 plus a by-line for the time takes you to jot down your clever esign idea. Payment is made when he idea is accepted for publication.

As Output Limiter

A zener diode at the output of an amplifier n replace input limiting devices which alter equency response. This solution worked well protecting a magnetic deflection amplifier om overloading. The output of the operanal amplifier which preceded the magnetic eflection amplifier was limited.

The maximum operating output of the operaonal amplifier was to be ±30 v; the maximum lowable without damaging the deflection amlifier was ±35 v. Amplifier saturation occurred t ±70 v, so a limiter was required which would perate in the range of 35 to 70 v, without afecting the amplifier characteristics.

A feedback divider (R1 and R2) of 1:1 was serted, and the feedback resistor (R3) was reuced by a factor of two to retain the same

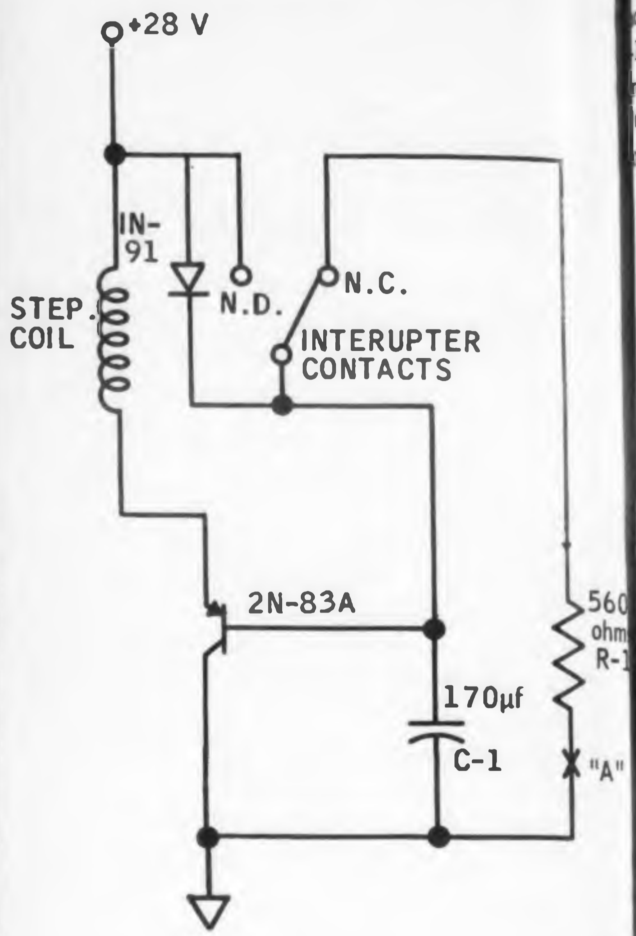


eedback factor as originally. R1 was bypassed y a 15 v (1N228) double anode zener diode.

These characteristics determine R1 and R2: R1 limits the current through the diode to revent burnout, hence it depends on the watage rating of the diode; *b*. the combination of R1 and R2 must be of high enough value not to oad the amplifier; *c*. R1 must be sufficiently low ot to be affected by the leakage resistance of he diode. The leakage current of the diode preents its use directly in the high impedance eedback loop in ordinary feedback systems.

Once the output signal exceeds thirty volts, he diode conducts heavily, effectively removing R1 from the circuit. The gain of the amplifier s cut in half, and the amplifier saturation level serves a limit for the new gain factor, and the outp it never exceeds ±35 v.

Hal C. Martin, Intermediate Engineer, Litton ndustries, Beverly Hills, Calif.



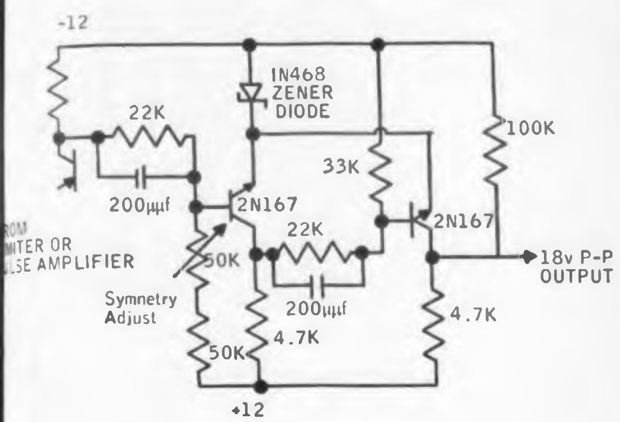
Transistor Driven Slow Speed Stepping Switch

Problems of radio noise and slow speed which occasionally arise in stepping switch circuits are eliminated in a circuit using a p-n-p power transistor to drive the switch. Radio noise is reduced from approximately 75 µv/meter/kc in a conventional circuit to 0.15 µv/meter/kc as measured at 50 mc in a screenroom. The high speed of selfdriven switches may be preserved if desirable, but can be reduced to any reasonable rate down to about 1 step per second without component values getting excessively large.

In the circuit shown, C-1 discharges through R-1 until its potential is within about a volt of ground. At this point, the transistor goes into conduction and pulls in the stepping switch coil, holding it closed. The interrupter contacts recharge C-1 to +28 v, cutting off the transistor and releasing the armature of the switch, which then steps forward. Holding the switch closed is an undesirable delay since the switch cycles only on the release. The 1N91 diode prevents arcing when the capacitors are charged. A small resistor can also be inserted in the N. O. contact to avoid the charging surge.

With the circuit constants shown, the switch cycles at about 2 steps per second. C-1 can be changed, or R-1 can be reduced to adjust the e constant. R-1 cannot be increased since the e current would then result in a bias high ough to prevent the transistor from conducting. l lead may be broken at "A" to control the cuit.

George S. F. Orsten, Engineer, The Martin ., Denver, Colo.



A Fast Square Amplifier

A squaring amplifier capable of constant out- t amplitude, fast rise and fall time, and mini- m distortion of symmetry, can be designed ith two high frequency transistors utilizing a dified Schmitt trigger configuration.

There are four design considerations to keep mind:

1. pnp transistors can be used equally effec- ely;

2. zener diode may be replaced with an ap- opriate emitter resistor and bypassing capaci- r. This will require the two transistors to have ilar saturation voltages;

3. keep collector current low and transistor t-off frequency high, rise and the fall time n be as low as 0.2 μsec;

4. excessive loading is to be avoided since it nerally detenates waveform and output am- itude. Output impedance is essentially 7/100 k.

Max Lang, Electronic Engineer, Consolidated lectrodynamics Co., Pasadena, Calif.

No More Lost Wires

Too often, when wiring electronic equipment, all pieces of cut wire fall into the chassis and e lost or hard to find.

A couple of small pieces of 1/16 in. neoprene, ued to the open side of diagonal pliers, can lve the problem. They will grip the wire as iers close.

Clarence J. Brown, SCP-11, Los Alamos Scien- fic Laboratory, Los Alamos, New Mexico.

CIRCLE 153 ON READER-SERVICE CARD

CIRCLE 154 ON READER-SERVICE CARD

REPORT BRIEFS

Alkaline Storage Batteries

This volume reports part of a continuing project aimed at better understanding, and possible utilization in naval applications, of the alkaline type of storage battery. Positive plate characteristics of the nickel oxides were studied in several different types of cells. It was found that a current efficiency of 95 to 100 per cent could be attained if oxygen evolution was avoided during charge. Under such conditions, however, the capacity of the positive plate nickel oxide was reduced one-third. A summary of earlier and present work on the electrode showed that the $NiNi(OH)_2$ and $NI_3O_2(OH)_4$-beta NIOOH couples are well defined, while two other possible nickel oxide couples are not. (Two other NRL studies were released earlier through OTS and are still available under the general title *Alkaline Storage Batteries: The Self-Discharge of the Positively Charged Nickel Oxide Electrode. The volumes are PB 121430 Part 1—The Role of Water in the Process, Oct. 1956, 7 pp, $0.50; and PB 121483 Part 2—Potential as a Function of Time on Open Circuit and as a Function of the Active Oxygen on the Nickel Oxide Plates, Oct. 1956, 17 pp, $0.50.)*

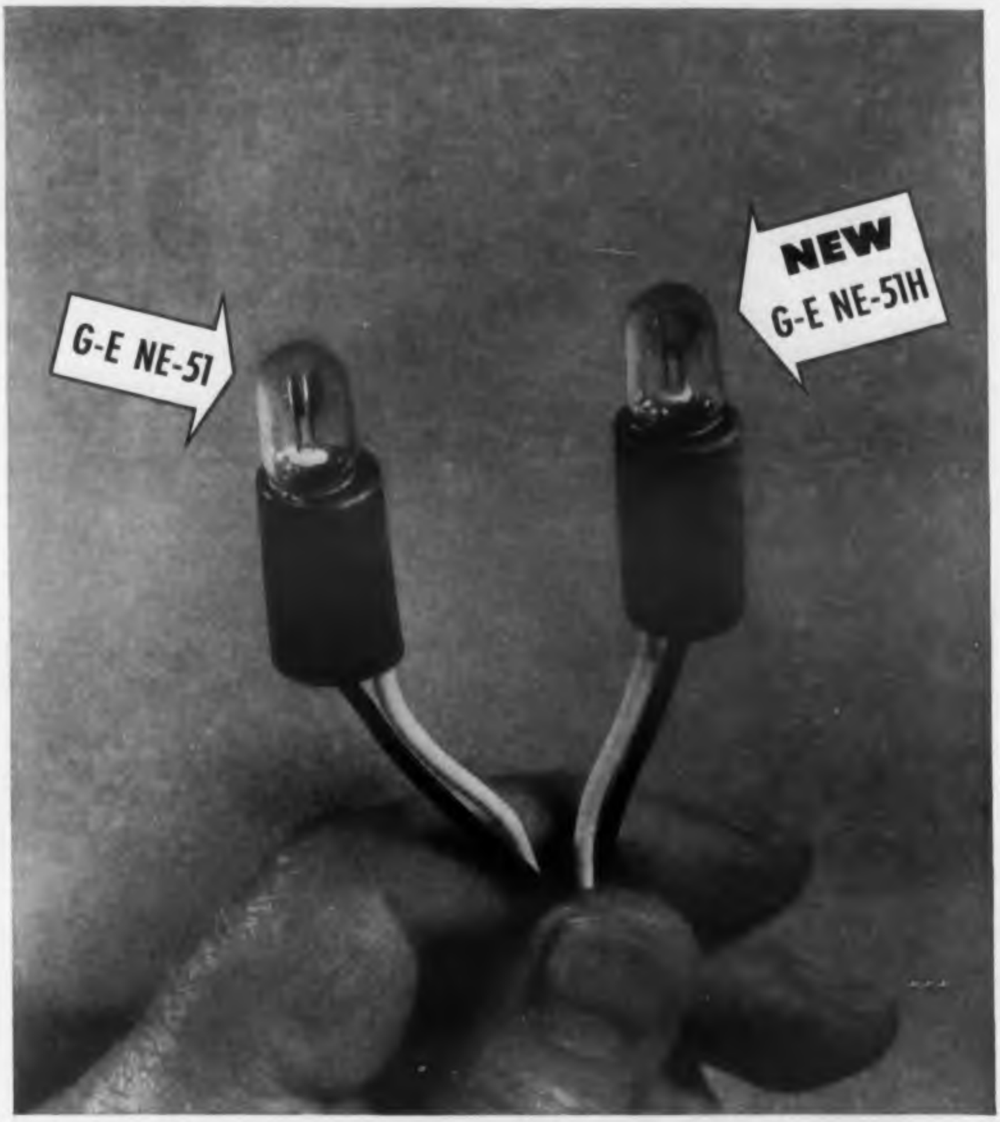
Alkaline Storage Batteries: An Investigation of Nickel Oxide Positive Plate Characteristics, A. L. Pitman and G. W. Work, Naval Research Lab., Dec., 1957, 23 pp, $0.75. Order PB 131329 from OTS, U.S. Department of Commerce, Washington 25, D.C.

Copper-Mandrel Potentiometers In A-C Operational Amplifiers

A simple method is described for phase error compensation for multiturn copper-mandrel potentiometers used as variable feedback resistance elements for gain setting of operational amplifiers in a-c analog computers. The potential of the copper mandrel is held close to one-third the potential of the potentiometer slider with respect to the beginning of the resistance winding. A figure of merit is established. The report discusses the stability of the operational amplifier with phase error compensation. Practical circuit configurations employing phase error compensation are presented. A study also is made of the envelope behavior of the compensated operational amplifier by means of modulation equivalent transfer matrices. *Performance of Copper-Mandred Potentiometers In A-C Operational Amplifiers, H. H. Hosenthien, Army Ballistic Missile Agency, Sept., 1956, 35 pp, $1.00. Order PB 131289 from OTS, U.S. Department of Commerce, Washington 25, D.C.*

Environmental Requirements

This volume provides a guide to the research and development requirements for environmental design of electronic parts, including related test procedures. The guide was intended for use by the three military services in current and future electronic planning. A chart provides environmental requirements for 10 groups of parts, including those for use in electronic hardware items; highly specialized components; general shipboard and ground components and those under nuclear radiation; high-performance aircraft and surface-to-air and air-to-air missiles; nuclear-powered aircraft and ballistic missiles; shipboard missiles; and nuclear-powered weapons. Data are given for such environmental characteristics as temperature, pressure, moisture, vibration, shock, acceleration, explosive atmosphere, sand and dust, salt atmosphere, flammability, nuclear radiation, and fungus resistance. Also described are test procedures to determine the resistance of electronic parts to harmful effects of natural elements and the conditions of use in military equipment. *Environmental Requirements Guide for Electronic Parts, Advisory Group on Electronic Parts, Office of the Assistant Secretary of Defense for Research and Engineering, Oct., 1957, 11 pp, $0.50. Order PB 131423 from OTS, U.S. Department of Commerce, Washington 25, D.C.*



New G-E NE-51H glow lamp gives 20 times more light!

. . . without changing bulb size or shape!

Do your customers complain that indicator lamps seem to fade out when general lighting goes on? Here's a tiny but powerful glow lamp that's built to make indicators more readable—even in today's better lighted plants and homes.

The new G-E NE-51H gives 20 times more light than the familiar NE-51 when operated with the recommended resistors. It has the same bayonet base, same rugged construction that stands up under shock and vibration—and it uses approximately ¼ of a watt! Rated at more than 5,000 hours, it's ideal for machine tools, electrical controls and household appliances—plus hundreds of other applications where a brighter indicator is called for. There are considerable advantages in size and space over larger lamps of equal brightness—and they fit standard holders —AC only.

If you'd like more information on this versatile new G-E Glow Lamp, and how it can solve your indicator problems, write: General Electric Co., Miniature Lamp Dept. ED-58, Nela Park, Cleveland 12, Ohio.

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GENERAL ELECTRIC

CIRCLE 159 ON READER-SERVICE CARD

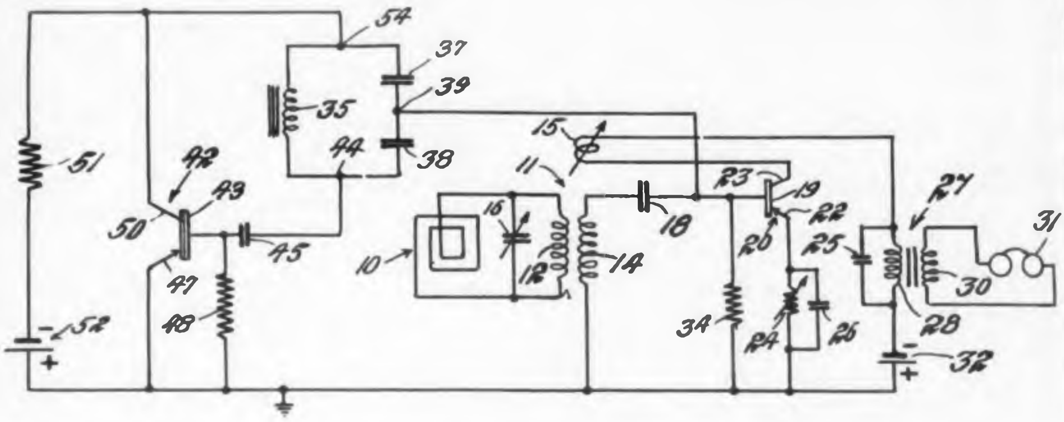
PATENTS

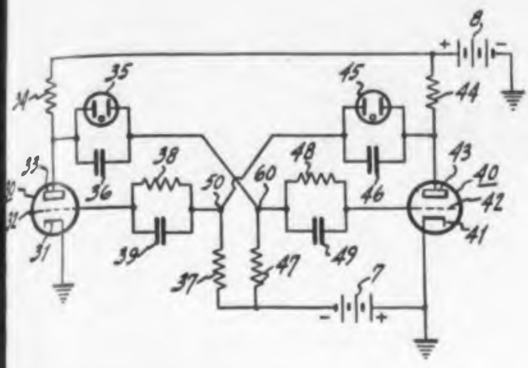
Miniature Super-Regenerative Radio Receiver Using Transistors

Patent No. 2,821,625. Harry L. Price.

A special super-regenerative circuit described in this patent permits the production of miniature transistorized receivers.

Transistor 20 is connected as a tuned regenerative detector. Tickler winding 15 adjusts the feedback and resistor 24 introduces volume control. The Colpitts quench oscillator includes pnp transistor 42 and the tank circuit of inductance 35 and condensers 37 and 38. At junction point 39, a tap point of relatively low impedance, the quench signal is conductively coupled to the low impedance base electrode input circuit of transistor 20. As a result there is a minimum of loading on the quench oscillator by the regenerative detector and vice versa. Good selectivity is obtained with transformer 11 operated in a high "Q" circuit.





istable Multivibrator

Patent No. 2,803,747. W. E. Woods. (Assigned to United States of America)

The multivibrator illustrated permits wider tolerances in component parts and hence becomes less expensive to manufacture. This circuit substitutes a gaseous discharge tube 35 and 45 for the shunting resistor in each of the connections from the anode of one tube to the control grid of the other. In addition a parallel combination of a resistor and condenser are included in each connection. The gaseous discharge tube provides constant voltage drop across its terminals and across its parallel condenser for all values of current. The grid current of each tube is limited by resistors 38 and 48. Capacitors in parallel with the gaseous discharge tubes result in a quick response of the circuit. Because of the gaseous discharge tubes the voltages at the junction points 50 and 60 change with the respective anode voltage, volt for volt. As a result resistor tolerances are much less critical and much less dependent upon each other.

Magnetic Pulse Generator

Patent No. 2,817,773. Henry F. McKenney. (Assigned to Sperry Rand Corporation)

The rectangular pulse generator comprises a source of alternating voltage having a pair of branch circuits across its terminals. Each of the circuits has a reactor winding disposed on one of the cores of a pair of saturable cores. The flux is controlled to consecutively saturate the cores. A transformer has a pair of input windings each of which is disposed in one of the circuits and poled to induce opposing fluxes in the transformer. The output is taken from an output winding of the transformer.

FOR EASIER MOUNTING

NEW FANSTEEL SILICON RECTIFIER STACKS

SINGLE-PHASE
FULL WAVE BRIDGE CIRCUIT

1 amp. (resistive or inductive load)
d-c output: up to 249 volts maximum

SINGLE-PHASE

1 amp. (resistive or inductive load)
d-c output: up to 249 volts maximum

SINGLE-PHASE
FULL WAVE CENTER TAP CIRCUIT

1 amp. (resistive or inductive load)
d-c output: up to 125 volts maximum

THREE-PHASE
FULL WAVE BRIDGE CIRCUIT

1.5 amp. (resistive or inductive load)
d-c output: up to 372 volts maximum

VOLTAGE DOUBLER CIRCUIT
ALSO AVAILABLE

- PEAK REVERSE VOLTAGE: 50-600 VOLTS
- Fansteel Type 1A Silicon Rectifiers used throughout
- For magnetic amplifier and d-c power applications with ambient temperatures ranging from −55°C to +150°C

CAPACITORS
FANSTEEL®
RECTIFIERS

FANSTEEL METALLURGICAL CORPORATION
North Chicago, Illinois, U.S.A.

DEPENDABLE RECTIFIERS SINCE 1924

CIRCLE 162 ON READER-SERVICE CARD

BOOKS

Logical Design of Digital Computers

Montgomery Phister, Jr., John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N.Y. 408 pp, $10.50.

Using synchronous circuit components almost entirely, this book describes and interprets the methods and techniques used in the digital computer field, and applies them to a wide variety of problems in logical design. The book provides the reader with the information, tools, and procedures needed to carry out the complete design of a general or special-purpose computer.

Featured in this volume are the detailed discussions of: (1) the Veitch Diagram method of simplification of Boolean equations; (2) the "difference-equation" approach to memory elements; (3) the Huffman-Moore model of digital systems; (4) the complete solutions to flip-flop input equations; and (5) a mathematical introduction to Boolean Algebra.

Permanent Magnet Handbook

Crucible Steel Co. of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa., 360 pp, $10.00.

A complete, authoritative reference on the nature, characteristics, and economic uses of permanent magnet materials is provided by this handbook. It includes sections on Permanent Magnet Design, Permanent Magnet Measurements, Theory of Ferromagnetism, Magnetization and Demagnetization, and Electromagnetic Theory. Sections on important permanent magnet materials commercially available or not are included.

Solid State Physical Electronics

Aldert van der Ziel, Prentice-Hall, Englewood Cliffs, N.J., 604 pp, $13.00.

Here is a comprehensive account of the application of solid state physics to modern solid-state devices used in, or developed for, the electronics industry. The author attempts to convey a clear understanding of the operation of cathodes, vacuum tubes, transistors, and other solid state devices in terms of the physical phenomena which make them possible. Circuit applications are elaborated only to the degree required for a better understanding of the operation and the usefulness of the devices.

The author has organized his book in four main sections. In the first five chapters he presents a lucid account of atomic physics, statistics, structure of the solid state, and the theory of semiconductors. Chapters 6 through 11 cover thermionic and field emission, cathodes, vacuum tube problems, secondary emission, and photo-emission. The third section, devoted to semiconductor devices, discusses metal semiconductor contacts, p-n junctions, transistors, semiconductor photo-devices, and luminescence and light amplification.

In his concluding section, the author takes up dielectrics, piezoelectrics, and ferroelectrics (with applications in each case), as well as ferro- and ferri-magnetic devices of various kinds.

Management for Engineers

Roger C. Heimer, McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N.Y., 453 pp, $6.75.

The book takes a practical basic look at the impact of costs, standards, materials, methods, taxes, insurance, power, equipment, labor, and ethics upon engineering considerations. It describes the fundamentals of business cost considerations and shows how both cash and credit are made to work in behalf of the overall business purpose.

The author analyzes the income contributions of engineers and the costs which are controllable by them in his discussion of a mythical business firm. A chapter "Money Flow in the Business Enterprise" explains basic record keeping for corporation financial transactions. Another chapter is on "Depreciation" and one acquaints the reader with "The Legal Forms of Business Organization."

What The Russians Are Writing

Y. George Adashko

MICROWAVES

Large-Amplitude Electromagnetic Waves in Ferrite with Alternating Magnetization by Ya. A. Monesov. REE 8/57, pp 951-959, 5 figs.

Examination of the propagation of a uhf electromagnetic wave in a ferrite medium, magnetized by an alternating magnetic field. The problem is solved by assuming the magnetizing and microwave fields are commensurate. If the frequency of the electromagnetic oscillations exceeds a certain critical value and the frequency of the magnetization field is less, the parameters of the medium for the electromagnetic oscillations vary with the magnetizing oscillations, but with a certain phase shift. This change in parameters is linearly related to the amplitude of the magnetizing field and is independent of the amplitude of the microwave field. Theoretical results are confirmed experimentally for 3-cm.

Quadratic Relationships for Media with Tensor Parameters by A. G. Gurovich. REE 8/57, pp 960-968, 3 figs.

General quadratic relationships (such as the Lorentz or the Poynting–Umov equations), which are very significant in electrodynamics, are obtained for complex amplitudes in the case of media with tensor parameters. These equations, together with the use of perturbation theory, lead to formulas for hollow systems (regular and irregular waveguides and resonators) containing media with tensor parameters.

Variational Method of Design of Waveguides with Periodic Irregularities, Part II by Sh. Ye. Tsimring. REE 8/57, pp 969-988, 6 figs.

The variational method, developed in the first port of this article (Radiotekhnika i Elektronika, January 1957, Page 3) (ED 9/1/57) is extended to odic waveguide (resonant cavity) permits the partial-region method. The author formulates and proves a theorem to determine a pair of dispersion curves (and corresponding natural frequencies), located on both sides of the true dispersion curve. This is important in the estimate of the accuracy of the results.

As an example, the procedure developed was used to obtain the dispersion equation for a decelerating system with rectangular corrugations of finite thickness. Various dispersion curves are calculated for several values of dimensions of this system. Reference is made to work by Chu and Hansen, Journal of Applied Physics, 1949, Volume 20, Page 280 and to J. R. Pierce's "Traveling Wave Tubes."

Calculation of the Critical Wave Lengths of the Lower Modes for Asymmetrical Pi, T, and Several Other Waveguide Shapes by A. Ya. Yashkin. REE 8/57, pp 989-1000, 7 figs.

The author derives equations relating the critical wave lengths with the cross sectional dimensions of asymmetrical pi and T waveguides, of waveguides having L and E cross sections, and of waveguides having two symmetrically located grooves. The calculated data are used to plot curves which illustrate the characteristics of these waveguides. Certain calculation data are compared with available experimental data.

Determination of Eigenvalues and Eigenfunctions of Gyrotropic Systems by Successive Approximations by V. V. Nikol'skiy. REE 8/57, pp 1074-1077, 3 figs.

Supplement to work performed by the author and published in the April 1956 (Page 447) and February 1957 (Page 157) issues of Radiotekhnika i Elektronika. See ED 11/15/56 and 9/15/57. In these articles the author derived an exact formula for the gyrotropic perturbation of a resonator waveguide. In this article he shows approximate solutions to these equations.

Nonlinear Theory of Traveling Wave Tube, Part II. Numerical Results by L. A. Vaynshteyn. REE 8/57, pp 1027-1047, 25 figs.

The first part of this article was published in the July issue of Radiotekhnika i Elektronika, Page 883. (See ED 3/19/58.) In this part the equations of the nonlinear theory of the traveling wave tube, operating as an amplifier for monochromatic signals, are numerically evaluated. The propagation and buildup of the electromagnetic field along the tube are studied, as well as the motion and bunching of the electrons. Dependence of the maximum power of the electromagnetic field on various factors and the connection between the input and output powers are investigated. Certain new nonlinear effects are obtained. Reference is made to work by Nordsieck (proceedings IRE, 1953, Vol. 41, Page 630) Tien, Walker and Wolontis (ibid. 1955, Vol. 43, Page 260), and to Pierce's "Traveling Wave Tubes."

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 Teknika 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 122 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.

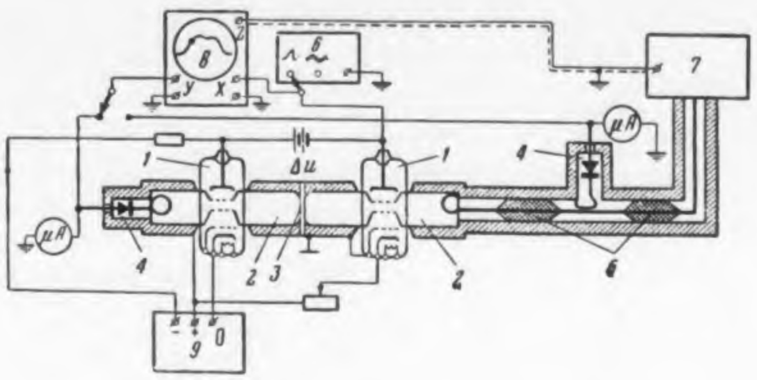


Fig. 1. Setup for investigating simultaneous operation of two reflex klystrons: 1—klystron; 2—cavity; 3—coupling element; 4—detector; 5—attenuator; 6—modulator; 7—wavemeter; 8—oscillograph; 9—power supply.

Mutual Synchronization of Reflex Klystrons Without Discontinuities in Amplitude and Frequency by R. B. Braginskiy, S. D. Grozdover, A. S. Gorshkov, and I. T. Trofimenko. REE 8/57, pp 1048-1052, 5 figs.

The purpose of this experimental investigation was to obtain a wide band of electronic frequency retuning. The authors have established the region of the values of fundamental parameters, in which klystrons operate in synchronism without discontinuities in amplitude and frequency of the generated oscillations. The resultant range over which electronic frequency detuning is possible is three times greater than obtained with a single klystron. Although the simultaneous operation of klystrons was already considered previously by Abdel Dayen (Synchronization of Reflex Oscillators, Zurich, 1953), the mutual synchronization studied there was under identical transit angles, and the purpose of that investigation was an increase in the general output power in the center of the oscillation region. The problem of extending the range of electronic retuning of the generated frequency was not touched upon there at all. Fig. 1 shows the experimental setup.

Contribution to the Design of Waveguides with Gradually Changing Cross Sections by A. L. Gutman. RE 9/57, pp 20-28, pp 20-28.

Expressions are derived for the elementary waves in a waveguide with gradually changing transverse cross sections. These expressions are used to obtain formulas for converting impedances and admittances in such a waveguide. The external parameters of the four-terminal equivalent of a gradually varying section are formulated.

An integral equation for the longitudinal profile of a waveguide junction with minimum distortion, namely a waveguide section with gradual change in transverse cross section is also obtained.

COMPONENTS

New Type of Broadband Transformers by Yu. M. Lebedev-Krasin. RE 9/57, pp 38-46, 9 figs.

Description of new broadband transformers operating effectively from 10^3 to 10^8 cps. They are used in apparatus designed for simultaneous transmission of signals with a wide frequency spectrum, as well as for tuned amplifiers with a tuned frequency that is smoothly adjustable over a wide range. In the latter case the special transformer developed for this purpose is used simultaneously for inductive variation of the resonant frequency of the tuned circuit with electronic control. Refers to "Very Wide Band Radio Frequency Transformers" by Maurice and Minns (Wireless Engineer, June 1947) and "A Wide Band High Frequency Transformer Using a Ferrite Core" by T. R. O'Meare (Proceedings of the National Electronic Conference, October, 1954).

High Sensitivity Vacuum Relay by K.P.Yegorov, V.G.Krasin'lov and L.V.Reyman. EC 9/57, pp 58-64, 9 figs.

Description of a relay design for operation at 0.01-0.05 microamperes, with a

winding resistance of 800 ±100 ohms, a current carrying capacity of 1-2 ma, and an operating time of 0.5 sec.

INFORMATION THEORY

Contribution to the Estimate of the Noise Rejection of Radio Reception Methods Based on Averaging the Functions of the Signal and Noise by N. L. Teplov. RE 9/57, pp 3-11, 8 figs.

Generalized statistical analysis and relative comparison of radio reception methods based on averaging the functions of a signal and a random noise (method of multiple repetition, integral reception method, method of storage, and method of discrete averaging). The deductions and equations derived can be directly used for calculating the noise rejection of actual radio receiving apparatus. Refers to "Mathematical Analysis of Random Noise" by S. O. Rice, Bell System Technical Journal, July 1944 and January 1945.

RECEPTION

Mechanism of Occurrence of Phase Distortions in Partial Suppression of One Sideband Frequency by A. B. Polonskiy. RE 9/57, pp 29-37, 11 figs.

Phase distortion in partial suppression of one sideband occurs, fundamentally, as a result of carrier phase shift, occurring in the single sideband receiver. This leads to a phase shift in all the modulating frequencies transmitted by the single sideband, by the same phase angle through which the carrier is shifted.

The transient characteristics of the single sideband receiver with phase distortion are calculated.

CIRCUITS

Analysis of Detection of Amplitude-Modulated Oscillations by Means of Low-Frequency Equivalent Method by L. S. Gutkin. REE 8/57, pp 1012-1026, 17 figs.

In the detection of am signals the loading produced by the detector on the circuit that feeds it should, in general, be taken into account not only by determining the input resistance of the detector for the carrier frequency, but also by determining the input impedance of the same detector for deviations of the envelopes of the detected signal. The difference in many cases of practical importance can be so great, that the bandwidth of the tank circuit for the sideband frequencies may differ by a factor of several times from the bandwidth of this tank circuit determined by taking only the impedance into account.

A general method is given for the analysis of the detection of am signals, based on the account of the difference between the input impedance and resistance and replacing the supply tuned circuit (or system of tuned circuits) by its low-frequency equivalent.

Lock-in of a Self Excited Oscillator by Means of an Amplitude Modulated External Signal by V. P. Martynenko and R. V. Khokhlov. REE 8/57, pp 1001-1011, 6 figs.

The article shows that if a detuned oscillator is synchronized by an amplitude modulated voltage, and if detuning does not exceed the lock-in band, phase modulation appears in the ouput signal, and the envelope waveform is distorted.

If the detuning exceeds the lock-in band, and the modulation frequency is less or slightly greater than the lock-in band, the beats are synchronized at the modulation frequency.

Frequency Dividers Employing Transistors by M. Z. Tseytlin. EC 9/57, pp 33-41, 11 figs.

Description of regenerative transistorized frequency dividers using junction and point-contact transistors. This circuit contains a frequency multiplier in the feedback loop and is similar to the vacuum-tube equivalent circuit. The application of the circuit is described and an experimental proof of the theoretical premises is given. The circuit gives reliable frequency division at a coefficient from three to ten and above. The divider operates reliably with supply voltages ranging from five to 40 volts. The tolerance in the circuit parameters increases from 2-2.5 per cent at $n = 0$ (n is the frequency division coefficient) to 4-10 per cent at $n = 3$.

Another circuit described is a regenerative frequency divider employing a ferrite peaking transformer, in accordance with the circuit proposed by V. M. Rozov (Elektrosvyaz', June 1956), (See ED 1/15/57), which can raise the frequency division coefficient to 14-16. A divider with a peaking transformer is cheaper and consumes less power than a circuit using two transistors. See Figs. 2, 3 and 4.

Coupling of Tank Circuits of Superheterodyne Receivers and Nonlinear Distortion Connected with Misalignment by I. M. Simontov and L. Ye. Yashchuk. EC 9/57, pp 30-32, 2 figs, 1 table.

The present method of aligning superheterodyne tuned circuits with trimmer capacitors produces a correct alignment only at two or three frequencies, depending on the number of additional elements in the heterodyne circuit. At the remaining circuits there is a certain detuning. This article tells how to determine how close the alignment is in mass-produced radio broadcast apparatus and to what extent the misalignment increases the nonlinear distortion in the receiver.

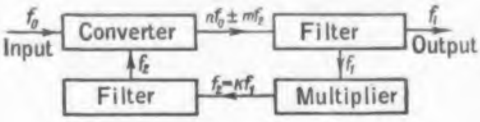


Fig. 2. Block diagram of frequency divider.

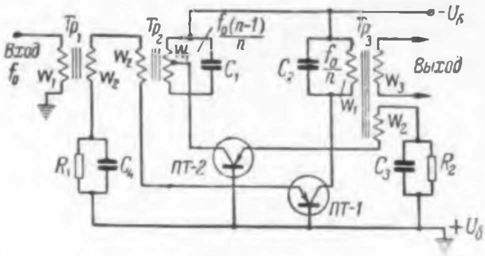


Fig. 3. Actual frequency divider circuit.

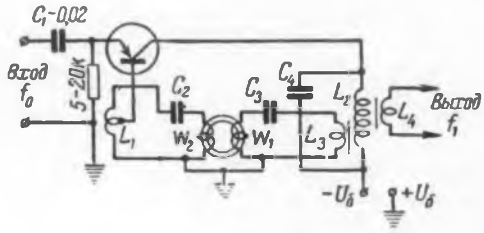


Fig. 4. Another version of the frequency divider.

RUSSIAN TRANSLATIONS

WORLD'S FAIR

World's Fair by M. Likhachev and A. Shokin, 1/58, pp 28-30, 5 figs.

Describes what the Russians planned to exhibit at the World's Fair in Brussels. A television studio installed at the Soviet pavilion is to produce local tv programs and demonstrate the on new model sets. They intend to broadcast in Belgium and surrounding countries.

They will telecast exhibits, commercial meetings, appearance of Soviet artists, scientists, and other guests. Telecasts of Soviet theatric groups, both from the pavilion and from theaters halls in Brussels are to be broadcast from mobile equipment.

Various tv cameras incorporate new transmitting tubes. A new truck-mounted three-camera mobile station with receiving equipment to insure reliable transmission of images with 600 line definition, and a frequency characteristic, uniform to within 2 or 3 db. A reporting setup is intended for on-the-spot transmission. It includes a portable transmitting camera with gun-like construction and a stationary receiving stand. With transmission regulated with change of illumination, high sharpness is insured, even at low illumination levels.

The Russians will also display underwater tv apparatus, with a special camera in a bathysphere. Many circuit novelties make it smaller, lighter, and reduce the power consumption. This equipment provides maximum image linearity and permits instantaneous change in viewing angle.

The exhibit will have many industrial tv installations as well as more than twenty types of tv receivers. These will have crt's measuring from 14 inches to 21. Some will include radio and phonographs. The article illustrates many of the new models.

In addition to tv apparatus, they will show some of their best radio receivers and sound systems, many of them pilot models of equipment they expect to sell in the USSR next year.

REE NOVEMBER 1957

This issue has no technical articles. It is entirely devoted to a survey of the history of electronics in the USSR since the November 1917 revolution.

Articles cover the history of Soviet developments in surface propagation; and meter, decimeter, and centimeter wave propagation in the ionosphere and troposphere. Also covered are antenna theory, interference immunity, nonlinear oscillations and the development of thermionics.

RUSSIAN BOOK REVIEW

Intermediate Frequency Amplifiers

M. L. Volin, 3rd edition, Soviet Radio Publishing Press, Moscow, 1956, 232 pages.

This was written for electronic engineers who design intermediate frequency amplifiers. It contains very practical information. This reviewer discussed the book with two Russian electronic engineers at the 1957 Wescon show; they said it was highly regarded by Soviet engineers. A German translation has also been published.

The first part of the book develops basic i-f amplifier theory. It develops methods of calculating selectivity, shape factor, gain, LC ratios, and maximum gain stability. Results of the analyses are tabulated.

The material illustrates the design of complete i-f amplifier sections to meet specific requirements. These include a 465 kc, 8 kc bandwidth amplifier; a 30 mc amplifier with an 8 mc bandwidth; and a 60 mc unit with 20 mc bandwidth.

The author then presents a detailed treatment of i-f amplifier transient response. He treats methods for computing rise time, overshoot, and decay time for pulse modulation signals as encountered in television, radar and data transmission systems. Here again, design examples illustrate the text.

One of the more difficult aspects of practical i-f amplifier design is the prevention of feedback loops that cause regeneration and distortion of the frequency response. The last two chapters depict the most common feedback problems and their correction. It covers shielding, decoupling, measurement technique, and physical placement of parts. For many engineers, this will be the most valuable part of the book, since published material dealing with i-f amplifier feedback problems is very rare.

Available in Russian from:

Imported Publications and Products, 4 West 16th Street, New York 11, New York;

Four Continent Book Corp., 822 Broadway, New York, New York; ;

Victor Kamkin, Inc., 2906-14th Street N.W., Washington, D.C.

Reviewed by Richard E. Daniel, Sr., Electronic Engineer, Hoffman Laboratories Div., Hoffman Electronics Corp., Los Angeles, California.

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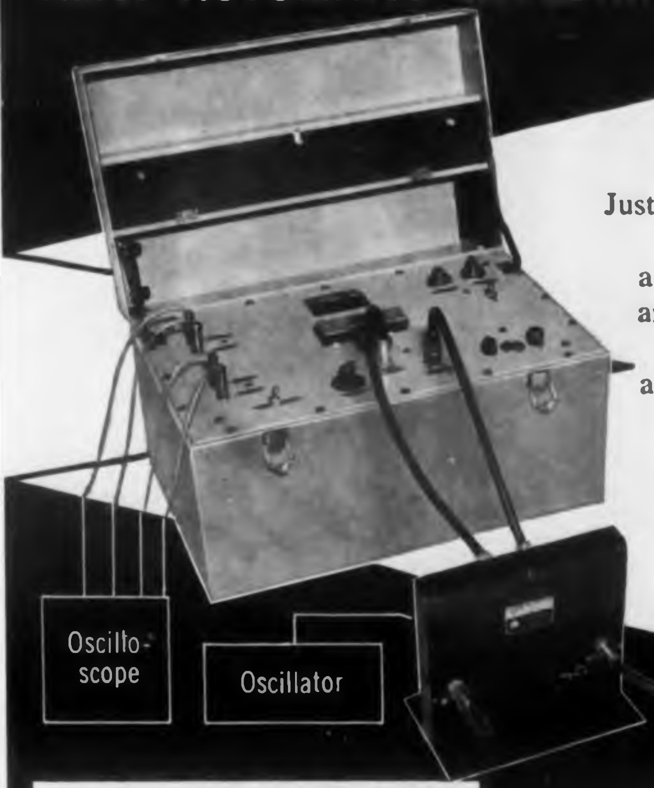

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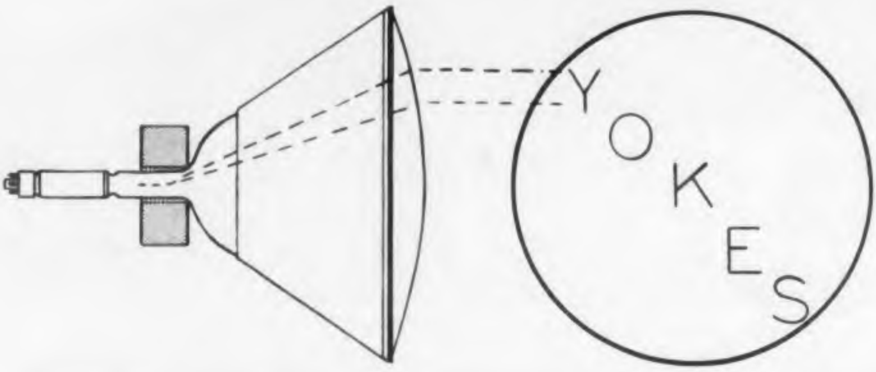

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Noise Voltage Measuremen[t]

in Low Impedance Element[s]

WHEN noise voltages generated in resistors are measured, a wide-band amplifier generally precedes the frequency selective voltmeter. The order of magnitude of the equivalent noise resistances of such preamplifiers increases with decreasing frequency in the audio frequency range. The order of magnitude of this equivalent resistance with typical first stage tubes is about 1 K at 5 kc. Consequently the noise voltage generated by resistors of the order of 10 ohms cannot be measured with such an arrangement.

In many practical applications such measurements must be made; i.e. the measurement of noise voltage generated by germanium or silicon diodes conducting in the forward direction. A suitably designed transformer, connected as in Fig. 1, can be used to step up the noise voltage of the test element so that the equivalent noise voltage at terminal pa[…] *a-a* can be made to exceed the noise ge[…] erated by the first stage of the wide-ba[…] amplifier.

The equivalent noise resistance, R_e, [...] a device whose complex impedance is [...] is defined from the basic resistor noi[se] equation

$$\overline{V_N}^2 = 4\,k\,T \int_{f_1}^{f_2} R_e\, Z\, d\,f$$

through the formula

$$\overline{V_N}^2 = 4\,k\,T\,R\,\Delta f$$

where T is temperature in °K.

The transformer introduces the extr[a] noise due to the losses in the transforme[r]. The equivalent circuit of the arrangement is shown in Fig. 2. All quantitie[s] are referred to the secondary, and th[e] "noise generator" associated with eac[h]

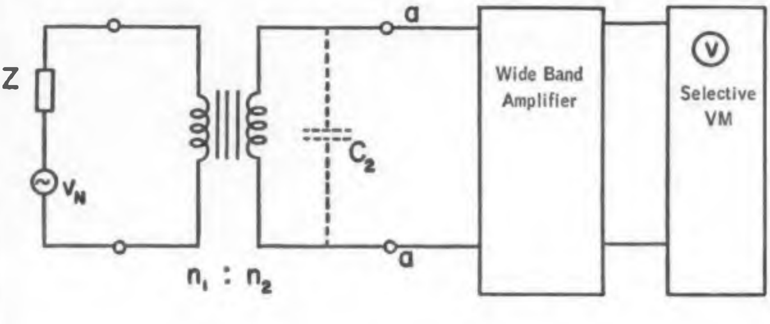


Fig. 1. Use of input transformer to step up noise voltage from the test element Z.

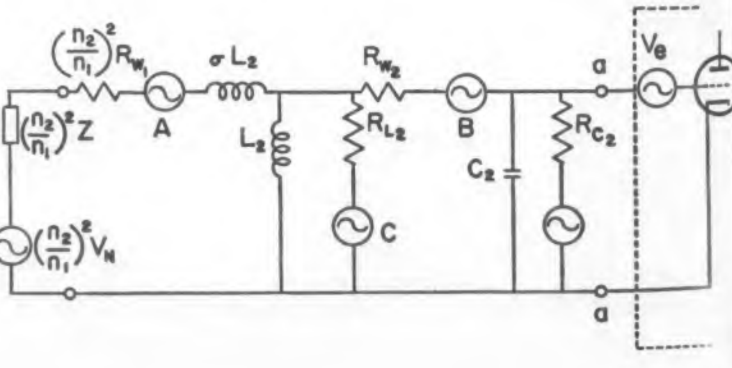


Fig. 2. Equivalent circuit for Fig. 1. Generators A, B, and C represent noise voltages due to transformer resistance. Generator V_e represents noise generated by first amplifier stage.

istance is shown in the diagram. It is sirable to have a large input impedce at the primary terminals of the nsformer compared to the resistance the test element since this element can ry within wide limits. Assuming the ment under test is principally resistive, e transformer is designed for a particufrequency f_o. It can be shown, hower, that a particular transformer can rve over a frequency range of about o decades.

The inductance L_2, given by $(n_2/n_1)^2$, is chosen to resonate with C_2. The pacitance C_2 includes the winding capacitance of the secondary, and the input pacitance of the amplifier. The order magnitude of C_2 is 10^{-10} fd. The turns tio of the transformer is chosen from e inequality

$$(n_1/n_1)^2 Z \geq 5\,[R_e + (n_2/n_1)^2 R_{w1} + R_{w2}]$$

here R_e is the noise resistance of the nplifier, and R_{w1}, R_{w2} are the winding sistances of the primary and secondary, spectively. If the winding resistances e negligible compared to R_e then the rns ratio is chosen to correspond to the inimum expected value of the test imdance by

$$(n_1/n_2)^2 = 5\,R_e/Z_{min}$$

addition, if the maximum value of the st element is Z_{max}, it can be shown that

$$Z_{max}/Z_{min} = R_{p2}/50\,R_e$$

here R_{p2}, the resonant resistance of the nk circuit is given by

$$R_{p2} = Q/\omega_o C_2$$

he transformer can be realized using a rrite core. A Mu metal magnetic shield r the transformer and the input circuit used to eliminate stray noises. Using a 0 c bandwidth, it is possible to measure e noise voltage of a 10 ohm resistor ith an accuracy of 10 per cent.

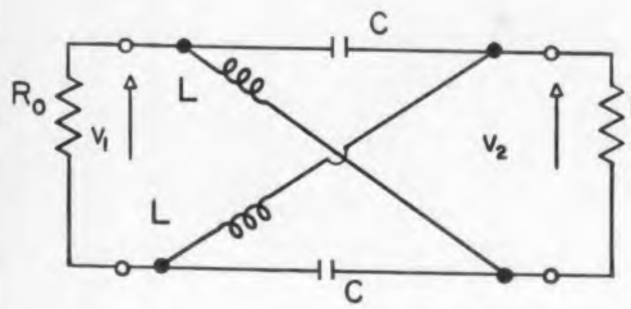
With this arrangement it was found ssible to measure the noise voltage enerated by crystal diodes in the high urrent region. It was found that while r low currents the diode acts as a reistor with half the value of the incremental resistance, for large currents the oise resistance ceases to decrease (with creasing currents) and actually increases in the ma range.

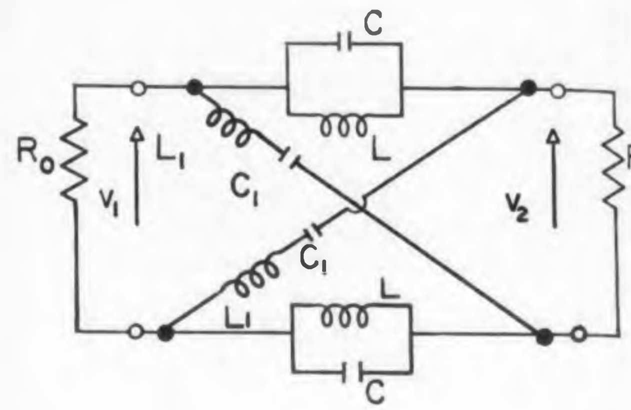
Abstracted from an article by W. Nonnmacher, Nachrichtentechnische Zeitchrift, *Vol. 10, No. 11, Nov. 1957, pp 69-563.*

All-Pass Filter Time and Frequency Response

THE lattice-type, all-pass filters shown in the accompanying table are used as phase equalizers. Various reference equations are provided for each. Such networks are popular for the linearization of the envelope delay time in single sideband transmission, as in TV. The original paper includes universal curves for the characteristic functions given in the accompanying table.

Abstracted from an article by H. Dobesch, Hochfrequenz und Elektroakustik, *Vol. 66, No. 3, Nov. 1957, pp 67-70.*





Parameters

$R_o = \sqrt{L/C} \qquad \omega_o = 1/\sqrt{LC}$

$R_o = \sqrt{L_1/C} = \sqrt{L/C_1};\ C = 1/2R_o a;$
$L = 2R_o a/(a^2 + b^2);\ L_1 = R_o/2a$
$a = 1/2R_o C;\ b^2 = 1/(LC) - a^2$

Complex Transfer Function

$$\frac{V_2}{V_1} = \frac{j(\omega/\omega_o) - 1}{j(\omega/\omega_o) + 1}$$

$$\frac{V_2}{V_1} = \frac{(j\omega - a - jb)\ (j\omega - a + jb)}{(j\omega + a + jb)\ (j\omega + a - jb)}$$

Phase Shift of the Transfer Function

$$\phi = Tan^{-1} \frac{Z\ \omega/\omega_o}{(\omega/\omega_o)^2 - 1}$$

$$\phi = Tan^{-1} \frac{2\alpha\ \mu\ (\mu^2 - 1)}{(1 - \mu)^2 - \alpha^2\ \mu^2}$$

$$\alpha = \frac{Z\ a}{\sqrt{a^2 + b^2}};\quad \mu = \frac{\omega}{\sqrt{a^2 + b^2}}$$

Envelope Delay: $\tau = d\ \phi/d\omega$

$$\tau = -\frac{1}{\omega_o} \cdot \frac{2}{(\omega/\omega_o)^2 + 1}$$

$$\frac{d\phi}{d\mu} = -\frac{2\ \alpha\ (\mu^2 + 1)}{(1 - \mu^2)^2 + \alpha^2\ \mu^2}$$

Step Response

$$v_2(t) = (2e^{-\omega_o t} - 1)$$

$$v_2(\tau) = 1 - \frac{4\ \alpha}{4 - \alpha^2}\ e^{-\frac{\alpha\tau}{2}}\ sin\sqrt{1 - \frac{\alpha^2}{4}}\ \tau,$$

$$(\tau = \sqrt{a^2 + b^2}\ t).$$

Approximation for Logarithmic Functions

TRANSCEDENTAL equations involving the natural logarithm can often be explicitly solved by approximating the logarithmic function with a function of the form Ax^c. Using this form, power series approximations may often be avoided.

It can be shown that in an interval x_1 to x_2, as illustrated, the function $\ln x$ may be approximated within a relative error value, Δ, by the form

$$\ln x \approx Ax^c = \frac{\ln x_m}{1+\Delta}\left(\frac{x}{x_m}\right)^{\frac{1+\Delta}{\ln x_m}} \approx \ln x_m \frac{(x)^{1/\ln x_m}}{e}$$

where the last approximation holds for very small values of Δ. The limits of the approximation, x_1 and x_2 are chosen so that the error is just equal to Δ at these extremes. It is shown that x_m is the geometric mean of x_1 and x_2 ($x_1 x_2 = x^2_m$). The ratio x_2/x_1 is related to x_m and Δ through

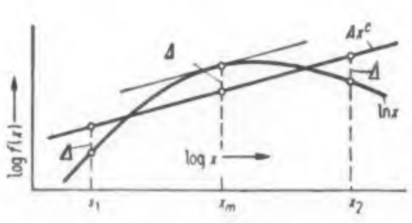
$$\frac{x_2}{x_1} = x_m^{\frac{4}{1+\Delta}\sqrt{\frac{\Delta}{1-\Delta}}} \approx x_m^{4\sqrt{\Delta}}$$

It can be shown that the approximation improves, i.e., includes a larger interval of the variable, as the value of the variable increases. For this reason a scale change is often indicated. If

$$\ln x = \frac{1}{m}\ln x^m = \frac{A}{m}(x^m)^c$$

is written then the choice of m as 10 or 100 results in the desired improvement.

Abstracted from an article by W. Rehwald and O. Zinke Archiv der Elektrischen Uebertragung *Vol. 11, No. 10, October 1957, pp 397-402.*



The function and curve which approximates the function.

ABSTRACT

The Intrinsic-Barrier Transistor

THE INTRINSIC-BARRIER transistor offers the following advantages over the familiar pnp or npn transistor structures:

- Feedback capacitance from collector to base is reduced;
- Maximum voltage sustainable between collector and base is greatly increased permitting operation at higher power levels;
- Transit time is reduced, hence, a smaller base current is necessary to control emitter-to-base current to much higher frequencies;
- Smaller input power is required for any given value of control current since base resistance is reduced.

Significant improvement in the design of familiar pnp and npn transistors can, of course, be obtained by reducing the thickness and the resistivity of the base region, and by reducing the area of the transistor in an effort to reduce und

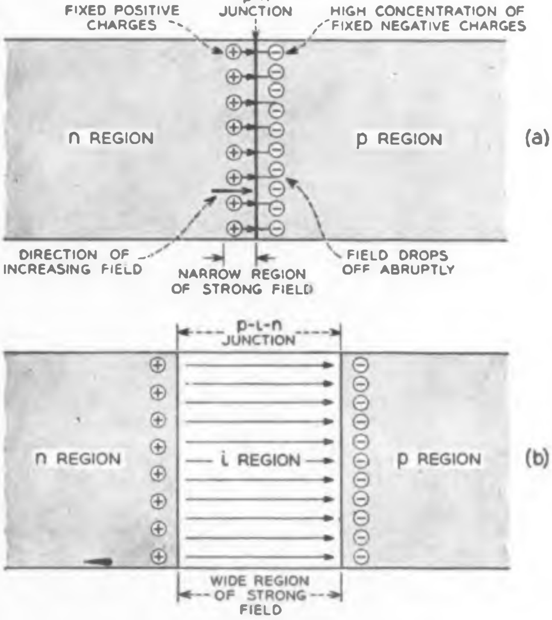


Fig. 1.(a) conventional pn junction has narrow strong-field region; (b) n-i-p junction has constant field through wide intrinsic layer.

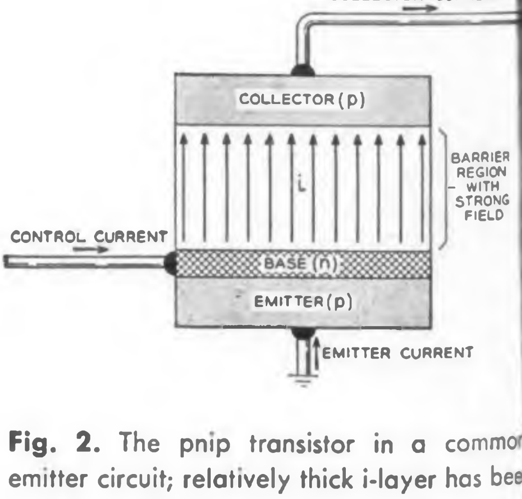


Fig. 2. The pnip transistor in a common emitter circuit; relatively thick i-layer has been introduced between base and collector.

able feedback capacitance. There are, however, very definite limits to such design modifications.

Since thinner base regions and lower base resistivities decrease the width of the strong-field region between collector and base there is an associated larger feedback capacitance and, hence, smaller permissible maximum voltage. A relatively wide strong-field region is necessary to permit application of high and useful voltages between collector and base. An examination of the factors affecting width of the strong field region leads to the concept of the intrinsic-barrier transistor.

P-N and P-I-N Junctions Compared

Consider the distribution of charges in an ordinary pn junction, as illustrated in Fig. 1(a). A very narrow region of strong field is developed. This region acts as a parallel plate capacitor and, therefore, capacitance is high. The maximum voltage which this field can sustain is small.

If now the n and p regions are separated by a wide region material, as in Fig. 1(b), which is neither n nor p type and which contains substantially no fixed-charge centers, this layer will act as a strong-field region. The base layer may now be made much thinner and at the same time its resistivity may be reduced. Moreover, the transit time is lowered without raising base resistance.

The intrinsic barrier is incorporated into the transistor structure illustrated in Fig. 2.

465 Mc Transistors Built

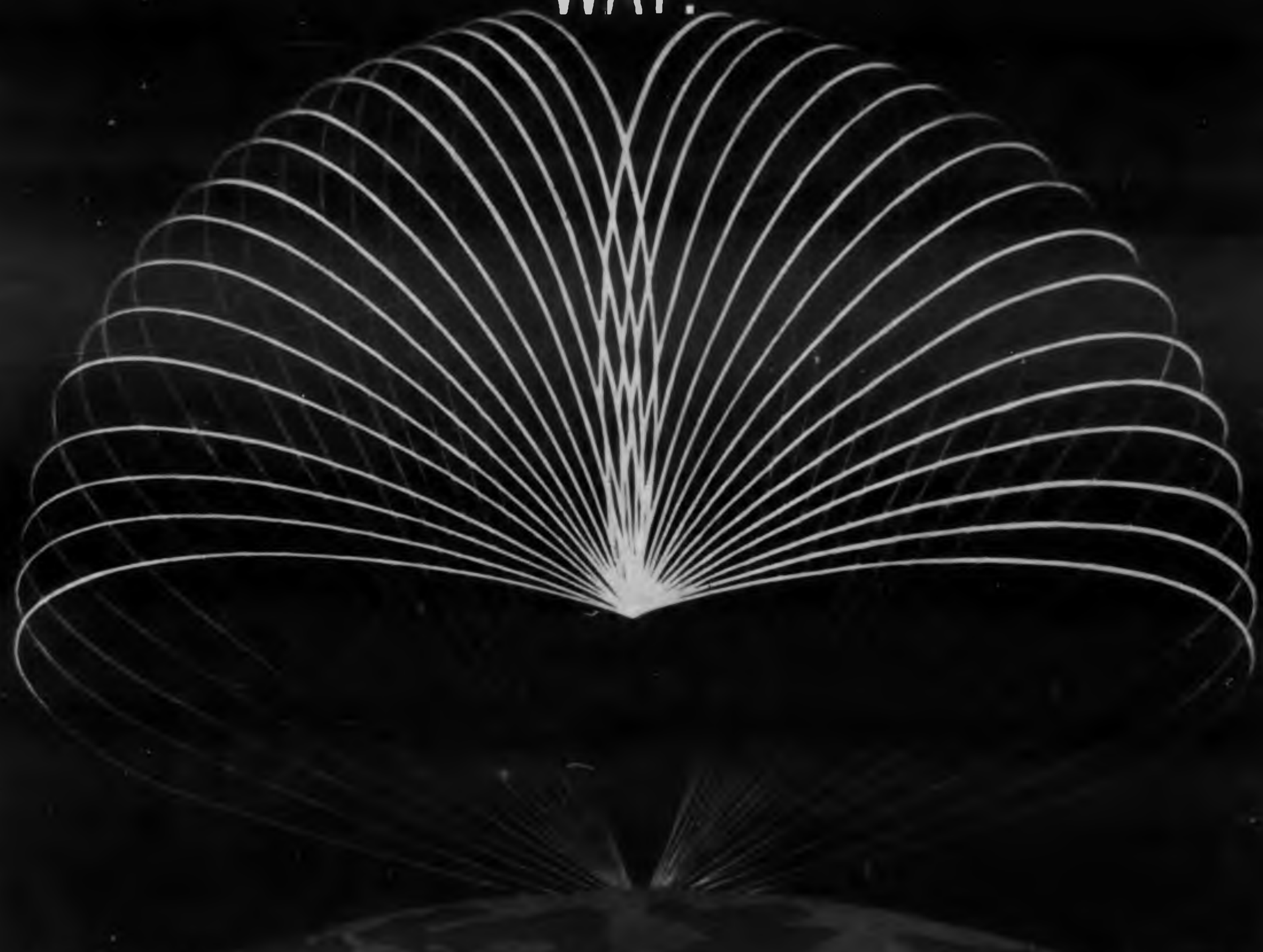
An oscillator circuit in which intrinsic-barrier transistors have been operated at a frequency of 465 mc has been built. The circuit employed is a common-base circuit in which a tuned circuit is placed between the collector and base electrodes, a feedback capacitor between collector and emitter, and a tuned circuit between emitter and base.

In circuits of this type, very substantial powers have been obtained at frequencies as high as 300 mc.

It should be emphasized that despite the reduced capacitance possible in intrinsic-barrier transistor structures, the high-frequency transistor remains a very small-area device. For example, all of the electronic action in the 465 mc oscillator takes place in a region which is only 0.010 in. in diam and 0.001 in. thick. A structure so exceedingly small is, of course, difficult to construct. Nonetheless, this tiny structure promises to help solve the problem of application of the transistors to broadband systems and to tuned high frequency systems like mobile radio.

Abstracted from the article, The Intrinsic-Barrier Transistor—How It Works by J. M. Early, Bell Laboratories Record, March, 1958.

WHICH WAY?



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The curious Trojans, neglecting to look this gift hearse in the mouth, dragged it inside the city — their last mistake of the war. That night the scientists managed to escape and open the gates of the sleeping city for the Greek Army.

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RCA-7086 DATA

Filament volts	2.5	
Filament Amperes	92	
Air Flow (cfm)	60	
Supply Frequency (cps)	25 to 60	
	Continuous Service	Intermittent Service
Peak Anode Volts:		
Forward	650 max.	650 max.
Inverse	650 max.	650 max.
Anode Amperes:		
Peak	160 max.	400 max.
Average	40 max.*	7 max.**

*Averaged over any period of 15 sec. max.
**Averaged over any period of 36 sec. max.

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