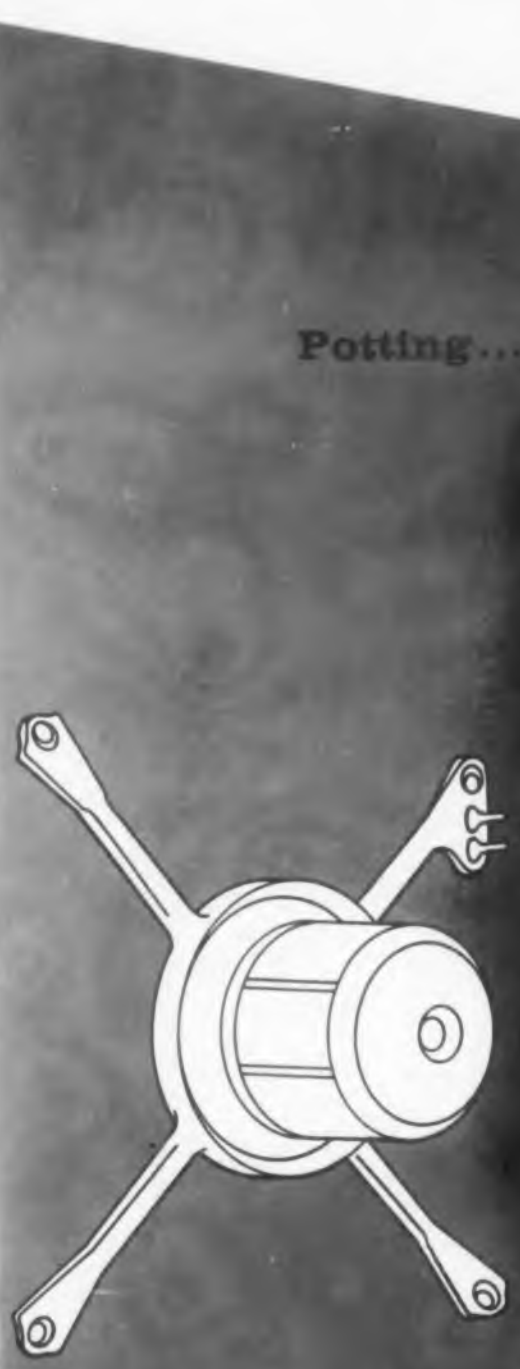
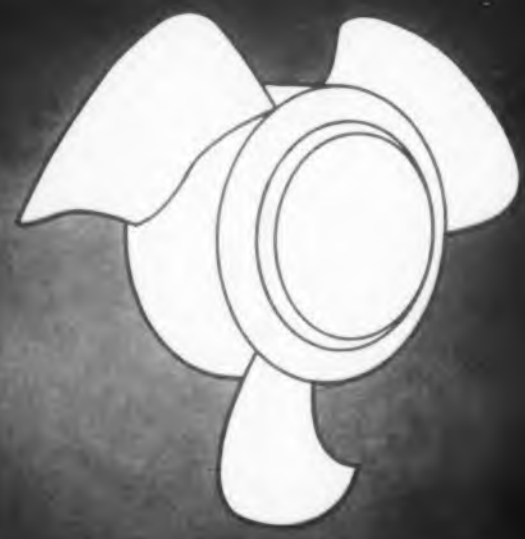
ELECTRONIC DESIGN

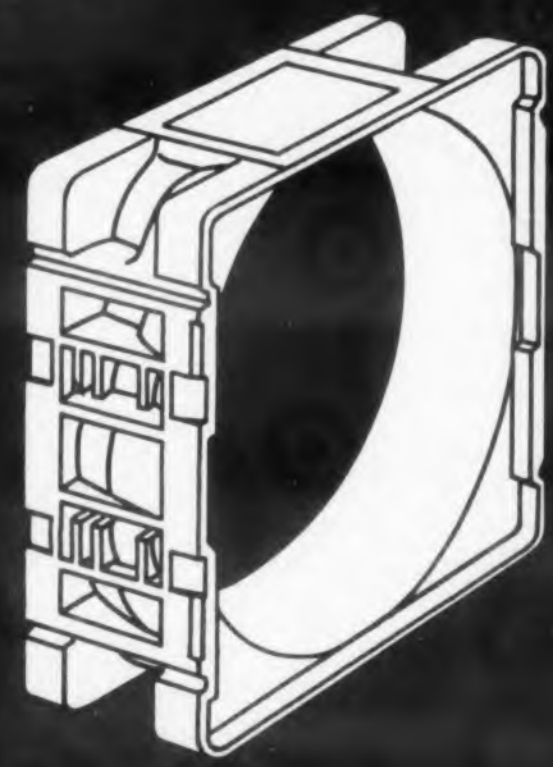
MARCH 18, 1959



Potting....



Casting....



Molding

Potting, Casting, Molding used to produce a low-cost quality fan ..... p. 22

HIGHLIGHTS OF ISSUE

Let's Do Something About Too Many Diodes

Read the Editorial on p. 17 to learn how you can help cut down on the number of types of diodes that are now being produced.

When we question diode manufacturers about the absurdity of producing thousands of different types they say that they are in business to please the customer. If he wants a special type, they'll make it.

There is a prevailing view on how to lick the problem. We all say "Why not make these thirty or forty types? They solve 95 per cent of our problems." But the trouble is one reader's recommended list is as good as another's and they are not alike. George Rostky's editorial suggests a method for getting the consolidated opinion of many readers. With your support, this opinion can be made strong enough to influence manufacturers. Let's work together.

March 18, 1959 Vol. 7

NUMBER 6

SUBSCRIPTION POLICY

ELECTRONIC DESIGN is circulated only to qualified electronic design engineers of U. S. manufacturing companies, industrial consultants, and government agencies. If design for manufacturing is your responsibility, you qualify for subcription without charge provided you send us the following information on your company's letterhead: Your name and engineering title, your company's main products, and description of your design duties. The letter must be signed by you personally.

ANY ADDRESS CHANGES FOR OLD SUBSCRIBERS NECESSITATES A RESTATEMENT OF THESE QUALIFICATIONS.

Subscription rate for non qualified subscribers—$15.00 for 1 year

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

CONTENTS

NBP EPA

ELECTRONIC DESIGN is published bi-weekly by Hayden Publishing Company, Inc., 830 Third Avenue, New York 22, N.Y., T. Richard Gascoigne, President; James S. Mulholland, Jr., Vice-President & Treasurer; and David B. Landis, Secretary. Printed at Hildreth Press, Bristol, Conn. Accepted as controlled circulation publication at Bristol, Conn. Additional entry, New York, N.Y. 32,000 copies this issue.

STAFF

Editor Edward E. Grazda

Managing Editor J. A. Lippke

Associate Editors L. D. Shergalis, G. H. Rostky, H. Bierman

Assistant Editors T. E. Mount, D. S. Viebig, L. N. Tolopko, M. M. Robinson, A. E. Takacs, F. Muehleck

Contributing Editors S. H. Hubelbank, E. Brenner, B. Bernstein, E. Kahn

Editorial Assistants M. S. Buckley, J. R. Feder

Art Director R. A. Schulze

Technical Illustrator B. L. Armstrong

Art Assistant C. Bank

Production Manager T. V. Sedita

Asst. Prod. Manager M. P. Hedrick

Production Assistant M. C. Alexich

Business Manager M. C. Young

Circulation Manager N. M. Elston

Asst. Circ. Manager A. C. Lovett

Reader Service J. Medina

CO-PUBLISHERS

T. Richard Gascoigne

James S. Mulholland, Jr.

ADVERTISING REPRESENTATIVES

Advertising Sales Manager

Bryce Gray, Jr.

New York: 830 Third Avenue, PLaza 1-5530 — Owen A. Kean, Robert W. Gascoigne, Richard Parker, Blair McClenachan, James P. Quinn

Chicago: 664 N. Michigan Ave., SUperior 7-8054 — Thomas P. Kavooras, Berry Conner, Jr., Fred T. Bruce

Los Angeles: 3275 Wilshire Blvd., DUnkirk 2-7337 — Robert E. Ahrensdorf, John V. Quillman, Stanley I. Ehrenclou

Southeastern: 2808 Middle River Dr., Ft. Lauderdale, Fla., LOgan 6-5656 — Lucien Neff

London, W. 1: 24 Baker Street, England — Michael B. Horne

DESIGN

BEHIND THE NEWS

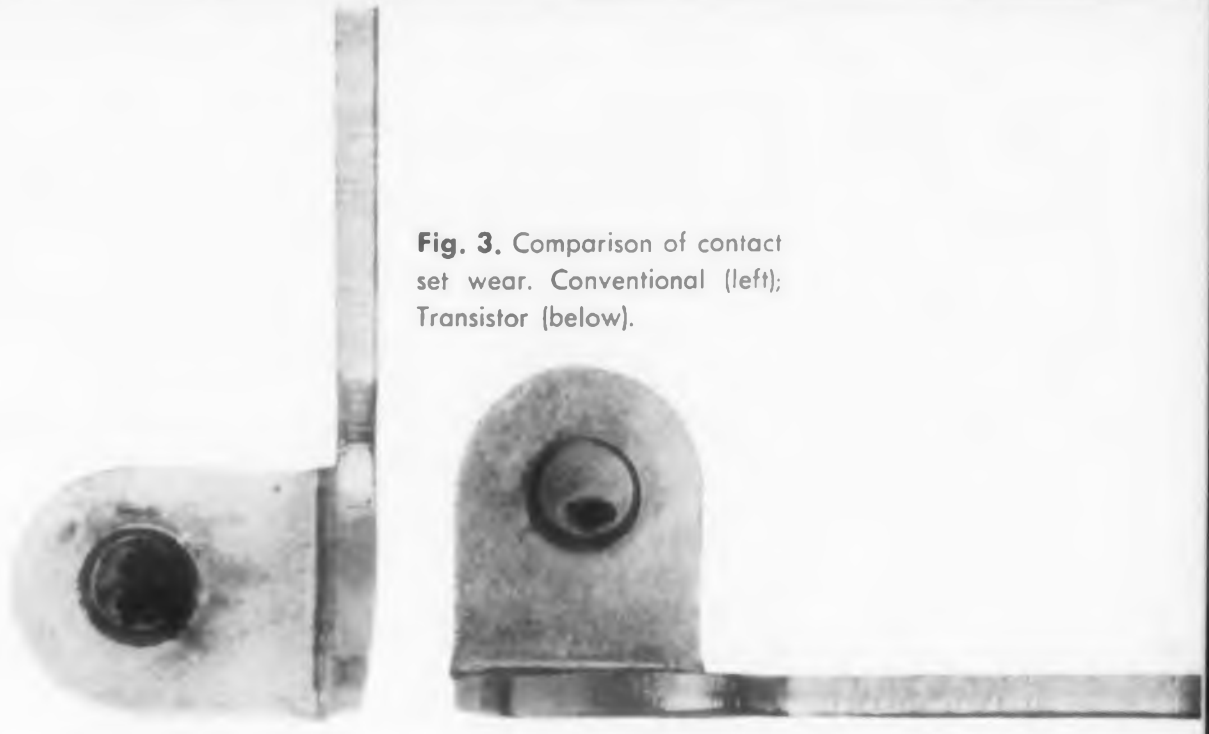


Fig. 3. Comparison of contact set wear. Conventional (left); Transistor (below).

Transistorized Ignition Systems

for . . . Reliability . . . Cold Weather Starting . . . Increased Engine Efficiency

SLIGHTLY LARGER than a conventional ignition coil, a complete, self-contained transistorized ignition system promises lifetime distributor contact service, reliable starting in temperatures as low as —20 F, and constant voltage output for spark plug firing throughout the engine speed range.

Shortcomings in the conventional ignition system are eliminated in the new development announced by The Electric Auto-Lite Co., Toledo, Ohio.

Conventional Ignition System

The conventional ignition system for a simple four-cylinder engine is shown in Fig. 1. Current through the primary of the ignition coil, or transformer, is interrupted by the primary switch. This switch is mechanically operated by a cam, driven by the engine shaft through a gear train. Every time the switch opens, high voltage appears across the secondary of the coil and is applied to the rotating "finger" of the distributor. This finger is driven by the same shaft as the primary switch, and the distributor contains as many equally-spaced fixed contacts as there are cylinders.

No actual contact exists between the rotating finger and the fixed contacts—the spark jumps across the air gap every time the finger comes in front of a fixed contact and, simultaneously, the primary switch opens.

Each fixed contact is connected to a spark plug so that the high-voltage circuit comprises the sec-

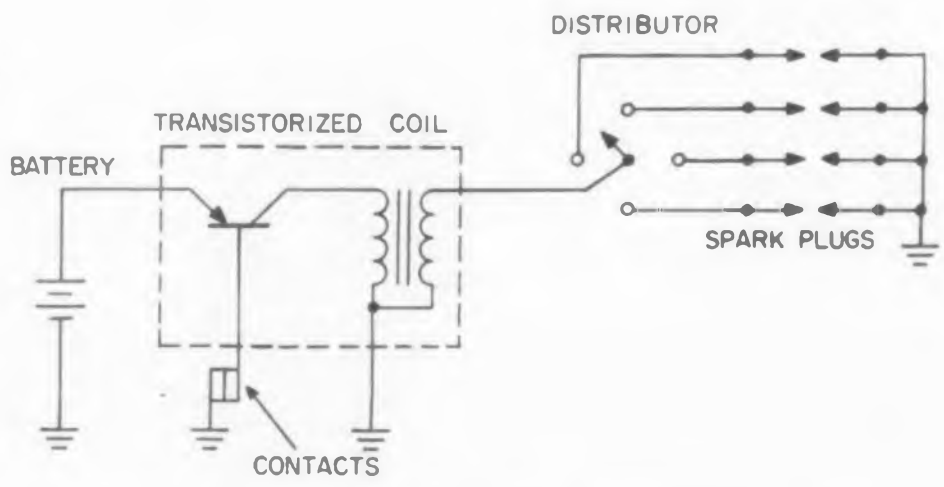


Fig. 1. Conventional ignition system for a 4-cylinder engine.

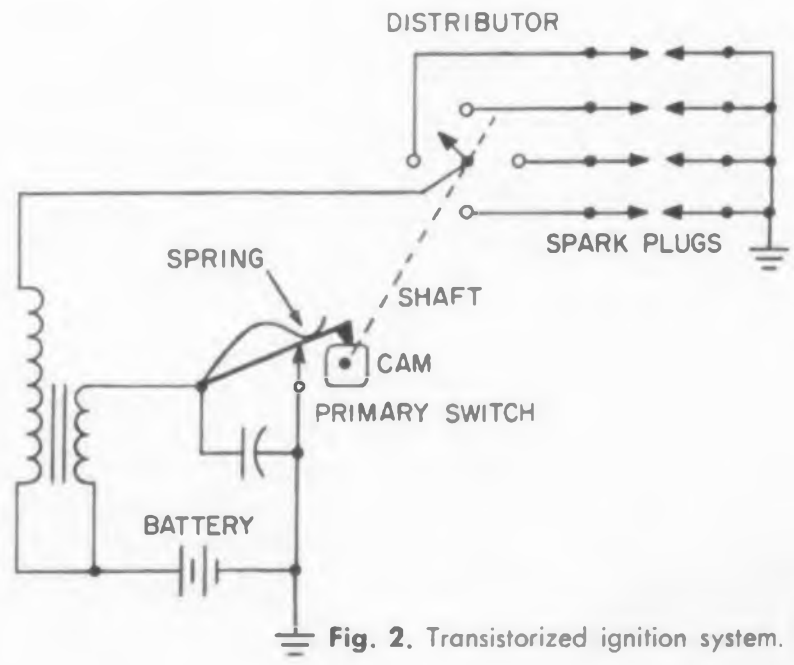


Fig. 2. Transistorized ignition system.

BEHIND THE NEWS

ondary of the coil, the distributor finger, an air gap, fixed contact, spark plug, and return to coil secondary. Most of the troubles due to the ignition system originate in the primary switch or in the coil.

Shortcomings

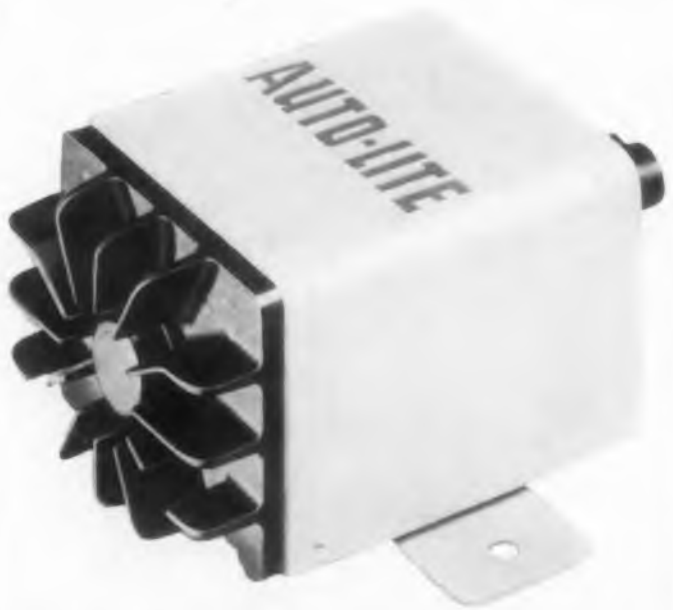
In a mile of average driving, the distributor contacts make and break at rates ranging from 12,000 to 24,000 times a minute, depending on engine speed. With primary currents as high as four amps, current densities exceed 1,000,000 amps/in.^{2} during "break." The resultant heat created erodes the contact surface until ignition failure requires contact replacement.

During average climate conditions, the engine turns over rapidly during starting so that the rate of contact operation does not permit the heat created to raise the contact surfaces to oxidizing temperature. In extremely cold weather, the engine turns over slowly, the contact surfaces remain together longer, and the excessive heat will bring the tungsten surface to red-heat, resulting in build-up of tungsten oxide. This bluish rust-like scale, "blue" points, accounts for poor cold weather starting and is responsible for a large majority of "down" time.

Finally, at high speeds the contacts open and close too rapidly to permit full build-up of input current. This results in reduced output when the engine speed is increased; up to 50 percent drop off in available ignition power may occur, for example, when a driver swings out to pass another car.

Transistor-Switched Transformer System

As shown in Fig. 2, a power transistor is placed



Auto-Lite "Transicoil" package with transistor and heat sink visible.

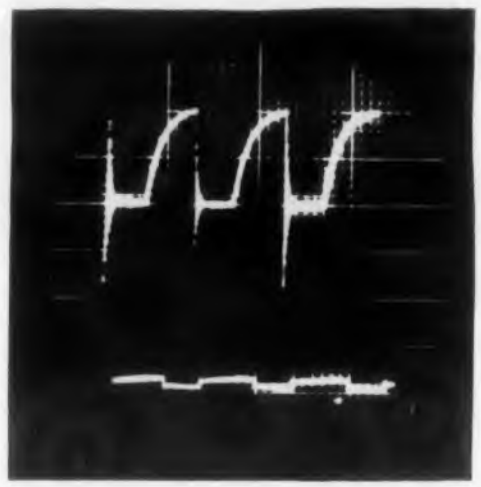


Fig. 4. Conventional system primary current rises relatively slowly (2.5 amps P-P). Transistor base current rises rapidly (250 ma P-P).

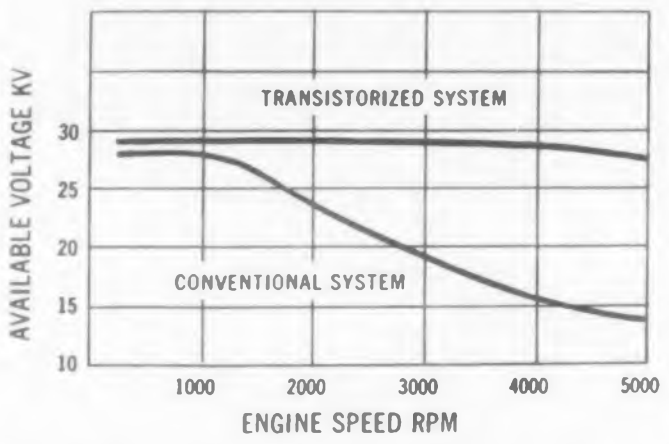


Fig. 5. Transistor system output voltage remains constant despite engine speed changes.

between the battery source and the primary coil; the distributor contacts, triggering the base circuit, handle less than 250 ma while controlling 7.5 amps flow through the primary coil. This results in greatly increased contact life. Prolonged endurance tests of over 3500 hours and 100,000 miles show practically no wear, see Fig. 3. Cold weather starting tests have shown oxidation to be completely eliminated.

The input current of the transistor system rises rapidly to maximum value while the conventional system rises slowly from the time the contacts close, shown in Fig. 4. This rapid rise of current, regardless of engine speed, is responsible for an almost constant output voltage throughout the speed range; comparison between output voltages for both systems is shown in Fig. 5.

A new development in contact set design, called "Power Points," further improve reliability by reducing high speed bounce approximately 15 percent over previous designs.

Applications

The new system can be installed, in a matter of

Don't forget to mail your renewal form to continue receiving *ELECTRONIC DESIGN*.

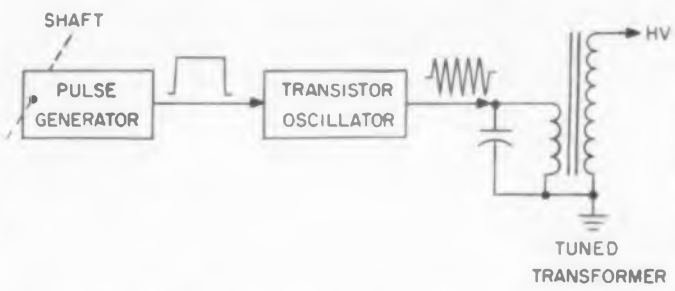


Fig. 6. Block diagram for a typical transistorized ignition system.

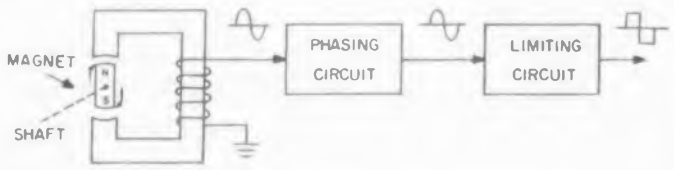


Fig. 7. A typical pulse generator for the new system uses a conventional alternator (driven by the engine), a phasing circuit (to provide spark advance), and a limiter (to clip the sine waves).

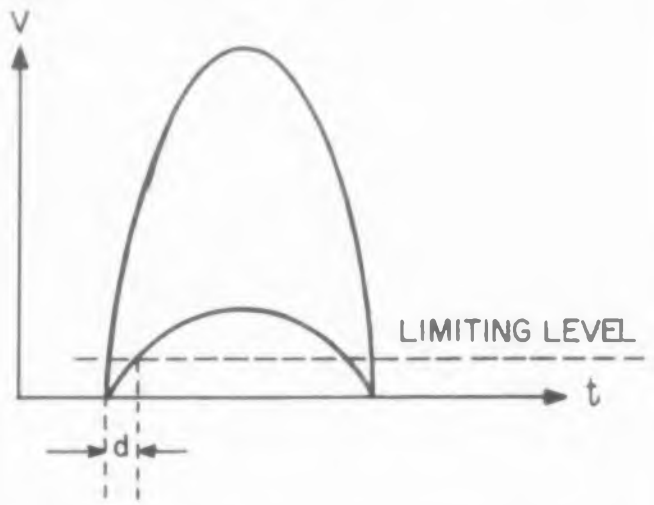


Fig. 8. The time difference *d*, corresponding to the automatic advance, is provided automatically by the difference in the sine wave amplitudes at different engine speeds.

minutes, in any battery ignition system by removing the existing ignition coil and capacitor and mounting the new transistor assembly. Applications include passenger, commercial and military cars, trucks, boats, and tractors.

The complete package, consisting of the transistor, its heat sink, the transformer and associated circuitry, will be available as optional equipment for 1961 passenger cars. The initial cost is estimated to be in the range of power steering.

Foreign Design Approach

A leading French automobile manufacturer, according to A. V. J. Martin of the Carnegie Institute of Technology, is conducting tests on a transistorized oscillator supply for high voltage generation. The primary switch is replaced by an electromechanical pulse generator triggering

Have you sent us your subscription renewal form?

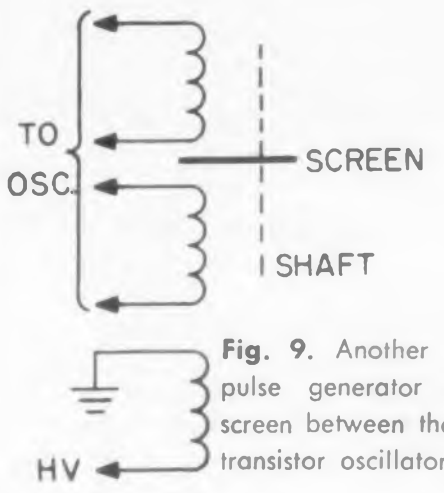


Fig. 9. Another electromechanical pulse generator uses a metallic screen between the two coils of the transistor oscillator.

Fig. 10. This screen, driven by the engine, pulses the oscillator when a slot allows coupling between the two oscillator coils.

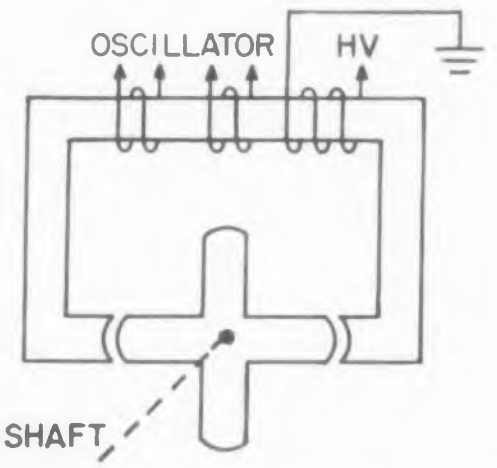
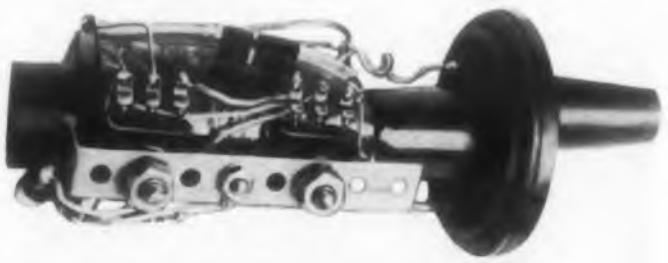


Fig. 11. In the magnetic circuit method, the spokes of magnetic material close the oscillator circuit.



Developmental ignition system built inside the usual high voltage coil can. The two transistors can be clearly seen in the foreground.

the transistor oscillator, as shown in Fig. 6.

The electromechanical pulse generator can take a number of forms. For example, in Fig. 7 a conventional alternator, driven by the engine, provides a sinusoidal voltage whose frequency is equal to a multiple of the rotation speed. A simple limiting circuit will then change the sinusoids into a square

waveform. The phase (and hence the advance) can be adjusted manually or automatically by a phasing circuit connected between the alternator and the limiter.

Moreover, the amplitude of the sinusoidal voltage varies with the speed of rotation. This makes for an automatic increase of the advance, since the same limiting level will cut a large amplitude sinusoid sooner than a small amplitude sinusoid (Fig. 8). The time difference "d" corresponds to the automatic advance. The transistor oscillator, using a ferrite core step-up transformer, operates between 50 to 80 kc.

Direct Pulsing of the Oscillator

The electromechanical pulse generator can be integral with the oscillator, with corresponding simplification and economy. An example is given Fig. 9. A metallic screen is placed between the two coils of the transistor oscillator and prevents oscillation. However, this screen is of the shape indicated in Fig. 10 and rotates with the engine. When the shaft position is such that no metallic part is placed between the coils, the oscillator functions and provides the high voltage. The circular screen has as many slots as there are cylinders.

Another possibility is indicated in Fig. 11. The rotating part is now a star of magnetic material, with as many spokes as there are cylinders. When the shaft position is as indicated on the figure, the magnetic circuit of the oscillator is closed, and the oscillator functions. When the rotation of the star opens the magnetic circuit, the oscillations cease.

In both Figs. 9 and 11, the shaft carrying the rotating screen or star also carries the finger of the distributor.

Practical Advantages

The system indicated in Fig. 11 can be of small dimensions, and has been constructed as a small unit which takes the place of the usual primary switch-distributor combination, and does away with the separate coil, see Fig. 12.

The new ignition system takes less current from the battery for better results at all speeds. It can be parasitic-suppressed to reduce radio interference by virtue of its fixed low frequency and undecaying oscillation during pulses.

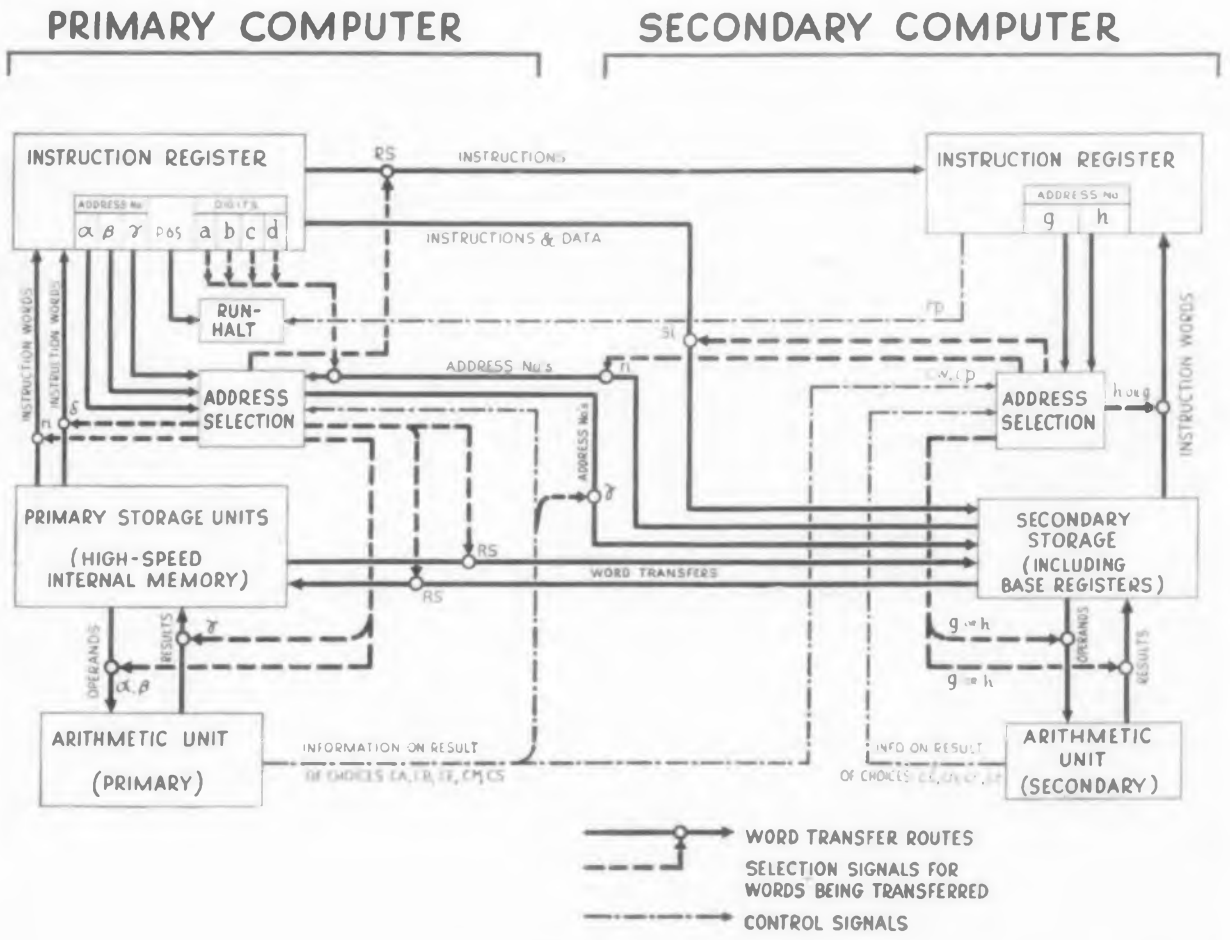
The automobile industry has been concerned with the deficiencies of the classical circuit, and several ideas have been put forward embodying some electronic equipment. Before, however, systems using vacuum or gas tubes suffered from the limitations of the tubes themselves, especially as regards ruggedness, life expectancy, and supply voltages. In aircraft, where safety is at a premium, two complete and entirely distinct ignition circuits of the conventional type are now necessary. The solid state devices seem ideally suited to this kind of problem.

Co-ordinating Computer Networks for Increased Efficiency

ONE APPROACH to developing more useful computing systems is that of connecting together several computers into an integrated network. Techniques have been under study at the National Bureau of Standards for attacking and solving the logical problems encountered in organizing such a network. These problems include devising a scheme for making all the computers collaborate efficiently, and designing an instruction system for carrying out such collaborative operations effectively.

Problems

In organizing such a network, many logical problems are encountered that do not ordinarily occur in the usual single-computer system. One problem is that of devising an efficient scheme for enabling all the computers to share among themselves, automatically, the total workload undertaken by the network. Another problem is that of designing a machine instruction system which can carry out these complex operations effectively and yet is simple enough to code easily. Investigations of the Bureau's data-processing systems laboratory has resulted in the design of the new NBS Pilot Data Processor, a multi-computer network with powerful data-processing capabilities.



Two-computer network

Initial Approach

One mode of approach for increased efficiency is to connect together several computers into an integrated network so that all of the machines in the network could be made to work together on large-scale problems. By dividing up the total task into different pieces, and by having all the different computers in the system work on different pieces of the task simultaneously, an increase in the speed of solution can be achieved.

Under ideal circumstances, the entire job could be split up into pieces that are completely independent, and each computer could carry out its assigned portion of the work without interacting on the other machines in the network. In actual practice, however, this ideal of complete independence cannot be attained because the results of one set of computations will, as a rule, be needed as input data for another set, and the starting of one phase of operations will have to wait for the ending of another phase. When these successive phases are carried out by several different computers, one machine may have to stop and wait idly for data from another if the different steps are not properly coordinated—thereby wasting time.

Multi-Computer System

The new NBS multi-computer system is made up of several independently operating units that run concurrently. From time to time, as the need arises, they can exchange data and instructions.

The primary computer of this system is a full-scale machine that performs a wide variety of arithmetical and other operations. The secondary computer, though an independent internally programmed machine, is more limited in scope and is intended mainly as an adjunct to the first machine. While the primary is performing the major arithmetical processing manipulations, the secondary concurrently carries out specialized procedures that assist the primary's program; these correspond to the "job requests" delegated by the primary.

Associated with the secondary computer is the secondary storage unit containing a certain number of short word-storage locations. Some of these locations are used as "base registers" by the primary computer. These base registers contain numbers used by the primary as automatic address modification constants, or as alternative addresses for its next instruction. Loading of the base registers and manipulation of the numbers stored in them are carried out by the secondary computer.

To make a "job request," the primary instruction program inserts a new instruction in the secondary's computer's instruction register. Alternatively, the primary program can also order data transferred betwen the primary storage unit and

the secondary storage unit.

To synchronize the actions of the two computers properly, the programming system earmarks certain selected instructions in the primary program. Instructions so marked are intended to be performed after certain key instructions have been carried out by the secondary computer. When an earmarked instruction is reached in the primary program, control of the relative time sequencing of primary and secondary operations passes to the secondary program. This program can then regulate the relative priority of execution of subsequent instructions in either program by special sequence-regulating instructions—called an rp (regulate primary program) instruction.

Operation

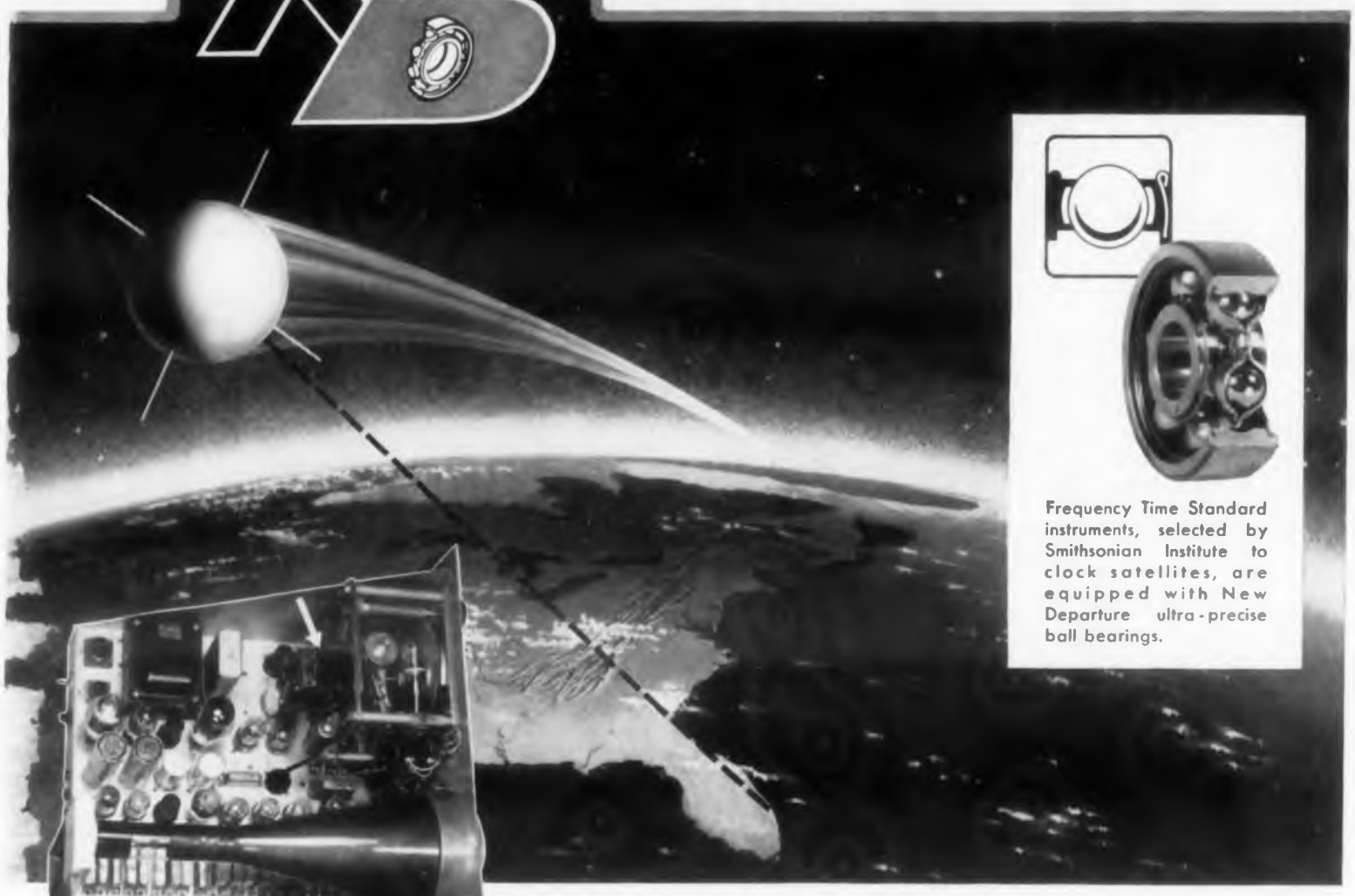
In operation, the primary computer, upon reaching an earmarked instruction, will check, before executing this instruction, to see whether the secondary computer is stopped and waiting with an rp instruction. If this is not the case, the primary waits until the secondary reaches an rp. As soon as both programs have reached a mutual waiting status (that is, with the primary waiting with an unexecuted earmarked instruction and the secondary waiting with an unexecuted rp instruction), the sequencing will take place according to an explicit code written in the secondary (rp) instruction word. Various alternatives are available, under which priority may be accorded to either computer depending on whatever order of sequencing is most appropriate to the logic of interchange. Possible sequencies include repetition or skipping of the primary instructions.

When both computers are in a mutual waiting condition, the secondary computer can also refer to the various base registers and control counters that the primary computer has just referred to or is about to refer to. The secondary computer can make these references either directly, that is, as a result of explicit register numbers written in the secondary instruction or indirectly that is, according to the locations specified in the currently waiting primary instruction. In consequence, the secondary computer can be used to monitor or interpret the program of the primary in a highly flexible fashion.

The new NBS Pilot Data Processor contains not only a primary and secondary computer but also a third independent computer, which specializes in operations that control and interpret the data flowing between the system's internal memory and its external storage and display devices. In the future development of these network systems, it is expected that even larger numbers of independent machines will participate cooperatively in the performance of stringent tasks.

Circle 498 for Ohmite spread ►

CASE HISTORIES



Frequency Time Standard instruments, selected by Smithsonian Institute to clock satellites, are equipped with New Departure ultra-precise ball bearings.

Photos: Courtesy Ernst Norman Laboratories and Bodine Electric Co.

Ultra Precise Ball Bearings Help "Clock" A Satellite!

CUSTOMER PROBLEM:

Require ultra-precise bearing design for Bodine electric motor used in satellite-tracking micro-clock. Bearings must provide uniformly low starting torque, precise location of rotor shaft and minimum maintenance, to help mechanism achieve time determinations to 0.001 second.

SOLUTION:

N/D Sales Engineers studied special bearing requirements, and recommended New Departure ultra-precise ball bearings. These ball bearings measured up to every requirement for micro-clock motors . . . thanks to New Departure's advanced equipment for research, development and production. N/D equipped micro-clocks, selected by the Smithsonian Institute, are operating in a dozen locations around the world right now, keeping track of vital satellite movements . . . to accuracies of one millisecond and better!

If you're manufacturing or designing electric motors for any high precision applications, including instruments, why not call on New Departure? N/D engineering and research facilities are turning out the latest in high precision instrument ball bearings and advanced ball bearing designs. For more information write Department J-3.

NEW DEPARTURE

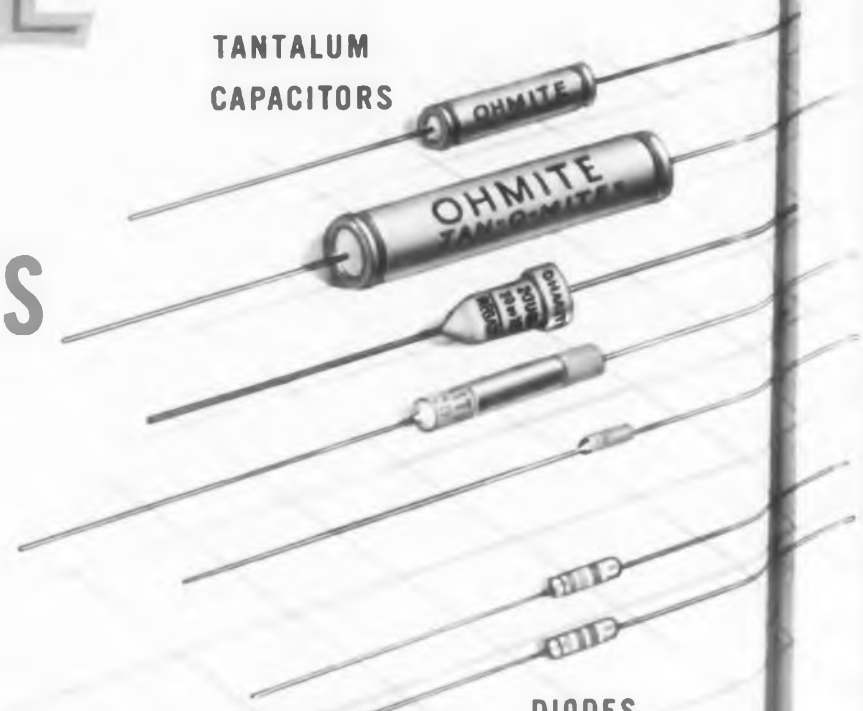
DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

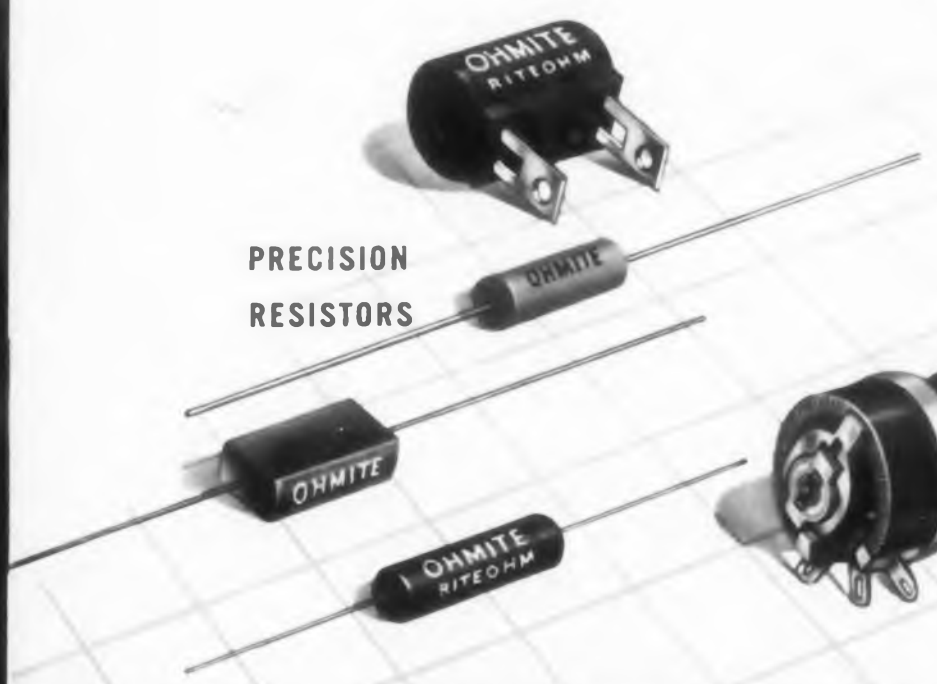
NOTHING ROLLS LIKE A BALL

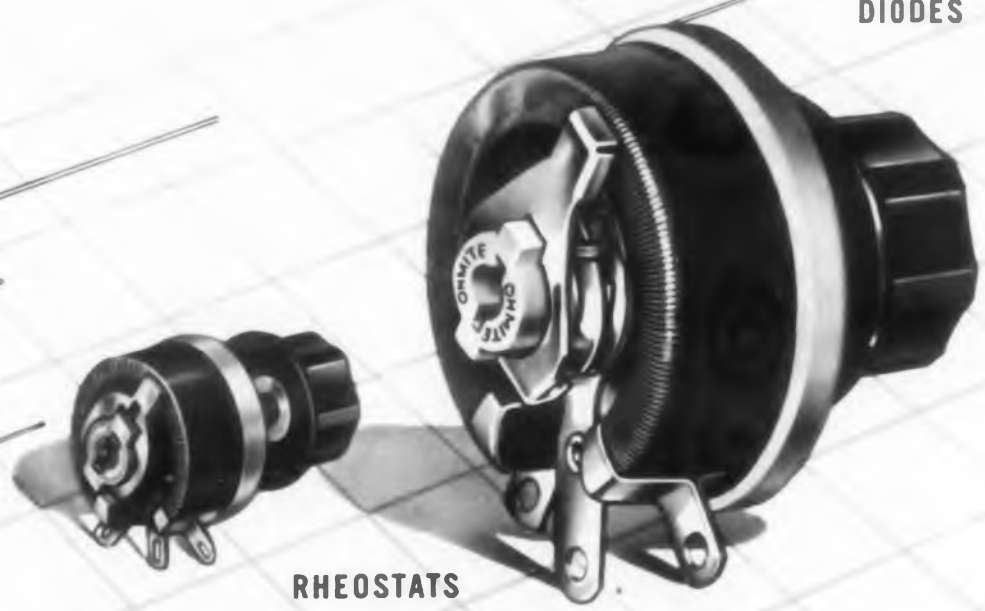
CIRCLE 496 ON READER-SERVICE CARD

OHMITE®

COMPONENTS PACE INDUSTRY'S PROGRESS







High power vibrator and "high shock" test equipment enable Ohmite to develop components for the most severe military applications.

Write on company letterhead for your personalized copy of Ohmite Catalog and Engineering Manual No. 58.

OHMITE
Manufacturing Company
3635 Howard Street
Skokie, Illinois, U.S.A.

RELAYS

VARIABLE
TRANSFORMERS

R. F. CHOKES

TAP SWITCHES

RESISTORS

PRODUCTS SHOWN
ACTUAL SIZE

For forward thinking . . . for new products to meet the needs of tomorrow . . . you can depend on Ohmite. Ohmite maintains a continuous program of research and development to explore new product ideas and to improve present products and processes. Furthermore, Ohmite's superb laboratory facilities permit in-plant testing of its products to meet rigid military specifications.

This unceasing research activity has kept Ohmite components truly "pacing the progress of industry."

Ohmite has complete laboratory facilities where difficult customer application problems are studied.

NEWS BRIEFS . . .

• • • **ELECTRONIC TOPICS**, ranging from computers to communication systems to semiconductor devices, comprised almost 40 per cent of the program offered at the Winter General Meeting of the AIEE, held in New York City during Feb. 1-6. Over 500 papers were presented to an estimated 6500 engineers. Consensus of opinion among members indicates the growing popularity of the informal presentation and panel discussion as contrasted with the stiff, formal reading of prepared papers encountered in the past. Discussions after paper presentations were particularly lively and pointed. In addition, there appeared to be a marked, and healthy, increase in participation by students from various universities throughout the country.

• • • **FOURTEEN NATIONS** are in active competition for positions on the program of the First International Conference on Information Processing to be held in Paris during June 15-20. So far, approximately one-third of the selected papers have been prepared by U. S. engineers and five of the thirteen planned symposia will be coordinated by American computer experts.

In conjunction with the five day technical session, a worldwide exhibition of information processing equipment will be on display from June 13-23. The exhibit, called Auto-Math 1959, will be limited to the latest in equipment and techniques in the field.

• • • **PLEASURE CRAFT**, yachts, and work boats can be outfitted with a new line of marine equipment ranging from low-cost Loran to a portable, transistorized direction finder. Recently introduced by Sperry Piedmont Co., Charlottesville, Va. division of Sperry Rand, the navigational instruments feature a sleek nautical appearance as contrasted with the "black-box" look common to earlier styling. A ten inch radar unit, with range extending to 20 miles, a compact five inch radar with a one- and five-mile range, an automatic pilot, converters, and miniature gyrocompasses round out the full line.

• • • **WRITERS OF GHOST STORIES** and horror movies may soon lose a favorite device for setting an eerie atmosphere . . . the "squeaky hinge" is on its way out. An application for its successor—a silent, non-sticking all-nylon plastic hinge—is now in the U. S. Patent office. The new hinge, developed by American Plastics Corporation, will require no lubrication and is expected to outwear its conventional metal counterpart many times.

This is the time of our annual subscription renewal.

◄ CIRCLE 498 ON READER-SERVICE CARD

WASHINGTON REPORT

Ephraim Kahn

Loose U. S. Patent Policy to be Tightened

Government patent policies, inconsistent and "contradictory", are being examined by the Senate's Subcommittee on Patents, Trademarks and Copyrights. The group's chairman, Senator Joseph C. O'Mahoney (D., Wyo.) points out that the federal government is the "largest single investor in scientific research and development, and both the amount of money it spends and the number of agencies administering its research programs are steadily increasing."

Noting that this activity is presently "producing a large number of discoveries and inventions which may be patentable, and will produce an even greater number in the future," the Senator adds that "the public has a very substantial interest in what the government does with its patent rights."

New Legislation

Legislative action may be suggested "to bring order to this presently chaotic field of important government activity" after the subcommittee completes its study, states Senator O'Mahoney. Though the nature of such recommendations is not yet known, the group has cited, with apparent approval, a report made in 1947 by the Justice Department. This urged that the government take title to all patents produced under research contracts or grants, except in special cases. In the exceptional instances where the government did not take title to the patent, it was to receive an irrevocable, royalty-free non-exclusive license and if the contractor failed to place the invention in adequate commercial use within a designated period, he was to offer non-exclusive licenses at a reasonable royalty to all applicants.

The Government Patents Board, created in 1950, was not given power over the disposition of inventions made by contractors or grantees, according to the subcommittee, and practices with regard to inventions by employees vary. For example, the National Science Foundation (which is considering a change in its rules) has so far taken the view that in no case is it desirable for title to patents produced through government-financed research to rest in the government; it feels that a non-exclu-

sive perpetual license to use an invention is all that it needs. On the other hand, the Tennessee Valley Authority retains all patents produced by government research but grants non-exclusive royalty-free licenses.

NASA Has Long Reach

In the meantime, business and government are trying to unsnarl some of the tangles that result from varying official patent policies. The situation seems particularly acute under contracts let by the National Aeronautics and Space Administration, which is in the business of developing new technology. Under the Space Act, any invention made in the course of work under a NASA contract normally becomes the exclusive property of the government. The NASA Administrator may find, however, that the public interest would be served by having the contractor keep the patent. Furthermore, NASA's reach is long—it covers inventions under subcontracts even though the inventor may be unaware that he is working on a space agency project.

The Space Act's patent provisions require the Commissioner of Patents to notify NASA of any application received—whether stemming from government- or privately-financed activity—which seems to have "significant utility" in the conquest of space. NASA then can take title to the patent for the government within 90 days, or waive this right in the "public interest."

A new federal patent policy seems to be implied in this—that the government has pre-emptive rights to inventions of importance to the national interest regardless of the fact that costs of development may have been borne by industry. It also raises the question of possible retroactive application of the NASA Administrator's ability to buy, condemn, lease, or otherwise obtain title to, or use of, patents that he needs or wants.

ASPR More Lenient

Industry by far prefers the Defense Department's patent rules. The Armed Services Procurement Regulation demands only that the government be given a non-exclusive royalty-free license to all patents on inventions made or reduced to practice in the course of performance of a contract with the military. Several industry associations are trying to have this ASPR rule substituted for the current Space Act provision.

NASA is aware that the law makes it difficult to write patent regulations which will stimulate broad business participation in the space research program. To do so, it will evidently have to take advantage of the latitude given to its Administrator by Congress. NASA is not required to take title to patents; it can settle for a license to use the patent. In addition, provision is being made for special awards to inventors whose patents are

WASHINGTON REPORT

taken over by the agency.

NASA has already gotten ideas both from individuals and companies for projects that may be useful in space exploration. At the end of January, 365 ideas had been received, of which 145 came in during that month alone. The agency stamps each with a time and date, thereby setting priority of submission and authorship. None are to be published without the author's permission. The agency can give awards to authors (individual or corporate) of accepted ideas. They may, of course, also lead to development contracts, though this is by no means certain. In view of the scale of rewards for ideas that is probable, the money aspect is far more likely to be of interest to an individual than to a corporation. But companies might find value in the prestige of having had an idea accepted, particularly for institutional advertising purposes.

Transistor Supply Planning

Possible transistor shortages are being felt out by the Defense Department. Questionnaires are being sent to prime contractors for certain electronic devices because the military want to know which (if any) transistors and related items are likely to be in short supply. Contractors will be asked to state their needs for transistors by category and number. Response to the questionnaire will be mandatory.

New Security Bill

New Industrial Security Bill, endorsed by the Administration, has been introduced by Senator John M. Butler (R., Md.). Purpose of the bill is to protect vital defense facilities, including plants, against sabotage, espionage, and other acts of subversion.

The bill provides that any individual who is barred from access to a defense facility shall be notified in writing of the charges against him and given adequate opportunity to defend himself against such charges. It also provides that any such person summarily barred from access to any defense facility but in whose case the bar is removed as a result of the proceedings shall be compensated by the U. S. Government for his loss of earnings. The measure states, too, that it is not intended to deprive any individual of any right or benefits conferred by the federal labor laws. Penalties imposed for violation would be fines of up to $10,000 or imprisonment up to five years. Chances of passage of the proposed law are considered slim.

Don't forget to mail your renewal form to continue receiving *ELECTRONIC DESIGN*.

EDITORIAL

Let's Standardize Diodes Now!

You can spend many precious hours seeking the diode you need among the 3500 now available. And then, you miss one that does a better job, or an equal job at half the price.

In last year's July 23rd issue, ELECTRONIC DESIGN urged manufacturers to standardize more quickly. Manufacturers have been trying, through committees of IRE, AIEE, EIA, and the military, but progress has been painfully slow, and the number of available diodes grows steadily.

"Why," we asked, "can't manufacturers agree on how to define and measure recovery time, peak inverse voltage, reverse leakage current, and forward conduction? And why can't they get together and eliminate duplicate diode types?"

The reply, though it sounded like passing the buck, made sense: "It's up to the users."

ELECTRONIC DESIGN welcomes the challenge to start the ball rolling. Our readers are all electronic design engineers and, almost to a man, diode users.

Readers, we'd like your help. We'd like to know what are your favorite diodes for each general application (mixer, general purpose, rectifier, computer, photodiode, variable capacitor diode, etc.). Tell us who manufactures your favorite diode types, his price for one unit and for 100. Tell us what you like about the diodes you prefer and what you don't like. You may like the high back resistance and dislike the package or the price, for example.

If you feel as strongly about diode standards as we do, if you spend too much time searching for the diode you need, if you'd like to see a "sensible" diode list, send us your own "Preferred List" right away. We'll publish the results of this "Diode Popularity Poll in ELECTRONIC DESIGN.

If all the letters you send us show a significant trend, our joint efforts may well result in the first major step towards standardizing diodes.

If you prefer to enter your contribution on our prepared form, please pick one up at our IRE Booth No. 1727, or turn to the Reader-Service Card and circle **104**.

George H. Rostky

Impedance Matching

E. W. Schwittek
Electronics Engineer
Stromberg-Carlson, Div. General Dynamics Corp.,
Rochester, N. Y.

Having been intimately involved over the past ten years with the design of communication networks, Elmer W. Schwittek, currently head of the Communication Laboratories at Stromberg-Carlson, shows how to eliminate drudgery from impedance matching problems.

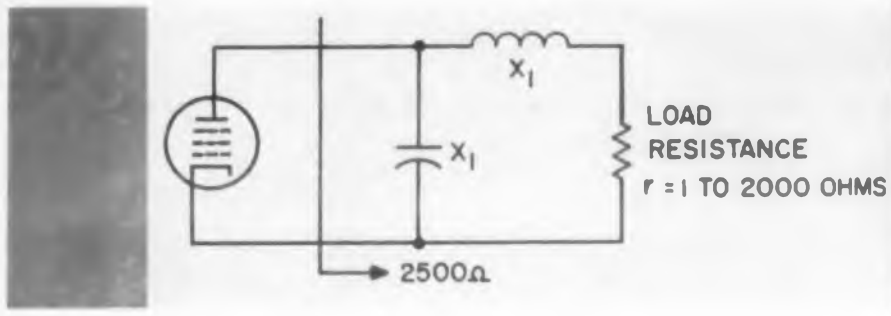


Fig. 1. Simple *L* network.

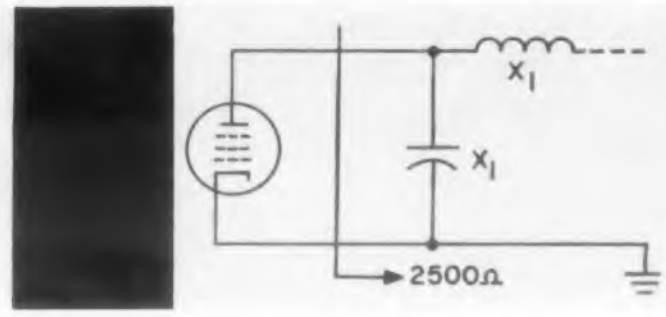


Fig. 2. Pi network.

MATCHING an rf power amplifier to a load can be considerably simplified with just several handy equations and a few design insights. It is not necessary for the engineer to refer to cumbersome reference charts. And, although the case of matching an rf power amplifier to a load is discussed, the procedure is equally adaptable to other impedance matching problems.

Impedance Matching Problem

To illustrate a more simplified approach to impedance matching, an output network will be designed to match a 4X150 class C rf power amplifier to a load which contains a resistance in series with a reactance. The resistance can assume any value between 1 and 2000 ohms and the reactance can assume any value between $+j$ 2000 to $-j$ 2000 ohms. Frequency range is from 2 to 8 mc.

The value of resistance into which the PA (power amplifier) tube delivers maximum power within its ratings has to be calculated. This value, of course, is the required input impedance of the output network. However, this calculation will not be discussed, since Eitel-McCullough (Eimac) has made this graphical procedure available in their tube catalog. The treatment is excellent and yields extremely accurate results. For the sake of this example assume that the proper load for the 4X150 is 2500 ohms.

The design of this network will be considered first on the basis of the load being a pure resistance having a value between 1 and 2000 ohms. This will avoid some confusion throughout the example. After all, the network must at least perform this function and in most cases including a reactance in the load will only effect component magnitude, not this configuration.

If in a PA output network design only the load resistance needs to be transformed to the desired input impedance (2500 ohms), a simple *L* network of the form shown in Fig. 1 would suffice.

However, since the value of r can vary between 1 and 2000 ohms, let us examine the Q of this circuit as determined by the following equation:

$$R = (Q^2 + 1)\, r \qquad (1)$$

If various values of r are substituted in Eq (1), it will be found that $Q < 5$ for all values of r between 96 and 2000 ohms. With a Q less than 5 the harmonic attenuation of this circuit would be low; so low, in fact, that a sizable portion of the tube output would be present in the form of harmonic power in the load and poor tube efficiency would be apparent as far as the fundamental frequency is concerned. A Q of 7 should be considered to be the lower margin of good engineering practice. Higher values of minimum Q may be required if specific harmonic attenuation specifications exist.

Avoiding Low Q Condition

To insure against the above low operating Q condition it is necessary to consider a more complicated network—a pi network, for example. A convenient means of controlling operating Q is to select a fixed value of input capacitance such that Q will never be lower than 7. (See Fig. 2.)

$$Q = \frac{R}{X_1}$$

$$X_1 = \frac{R}{Q} = \frac{2500}{7} = 357$$

If this value of X_1 is what is required to assure a Q of 7 at 2 mc, and the value of input capacitance remains constant, the Q at the upper end of the frequency range (8 mc) will be:

$$Q = \frac{R}{x_1} = \frac{2500}{\frac{357}{4}} = 28$$

The efficiency of an *L* network (assuming lossless capacitors) is related to operating Q and coil Q as follows:

$$Percent\ Eff. = \frac{(Q\ coil - Q)\ 100}{Q\ coil}$$

Assuming a coil Q of 150, the efficiency of the *L* network (which will form the first half of the pi network) at 8 mc will be:

$$Percent\ Eff. = \frac{(150 - 28)\ 100}{150} = 81.3 \text{ per cent}$$

This degree of efficiency is not considered particularly high. For this reason a maximum Q limit of 20 is considered good engineering practice.

To eliminate the high Q condition at 8 mc without, at the same time, reducing the Q below 7 at 2 mc, it is desirable to employ band-switching of the network input capacitor. Two bands covering the range 2-4 mc and 4-8 mc would be

a reasonable choice. Under these new conditions the value of X should be reselected to provide a reasonable compromise between harmonic attenuation and network efficiency. If X were reselected to be 300 ohms at 2 mc (band 1) and 4 mc (band 2), then:

$$Q = \frac{2500}{300} = 8.33 \text{ at 2 mc (band 1) and 4 mc (band 2)}$$

$$Q = \frac{2500}{150} = 16.7 \text{ at 4 mc (band 1) and 8 mc (band 2)}$$

From this point on only the 2-4 band will be examined since the 4-8 mc band calculations would be identical.

The following calculations are only pertinent to the first half of the pi-network shown in Fig. 3.

2 mc (Band 1)

$$R = (Q^2 + 1)r_{f_1}$$

$$r_{f_1} = \frac{R}{1 + Q^2} = \frac{2500}{1 + 8.33^2} = 35.5$$

$$x_1 = Qr_{f_1} = 8.33 \times 35.5 = 296$$

Assuming coil Q of 150

$$Eff = \frac{Q\ coil - Q}{Q\ coil} = \frac{150 - 8.33}{150} = 94.5 \text{ per cent}$$

4 mc (Band 1)

$$R \cong Q^2 r_{f_1} \qquad (Q > 10)$$

$$r_{f_1} = \frac{2500}{16.7^2} = 9$$

$$x_1 = Qr_{f_1} = 16.7 \times 9 = 150$$

Assuming coil Q of 150

$$Eff = \frac{Q\ coil - Q}{Q\ coil} = \frac{150 - 16.7}{150} = 88.7 \text{ per cent}$$

Summarizing:

- To prevent the possibility of a low Q condition a network more complex than a single L network must be used.
- The value of X_1 was selected so that the limits of operating Q of the first L section are firmly established. Regardless of what network follows this L section or regardless of what load is present it is certain that an operating Q of less than 8.33 is not possible when the tube has been loaded to its proper plate current, i.e., presented with a 2500 ohm resistive load.
- The problem remaining is to determine what must follow the first L section in order to transform any of the possible load resistances to r_{f_1} which is 35.5 ohms resistive at 2 mc, 9 ohms resistive at 4 mc, and has resistive values between 35.5 and 9 ohms at frequencies between 2 and 4 mc.

Matching Load Resistance $> r_{f_1}$

To fulfill part of the above requirements another L section following the first will successfully transform all resistive loads greater than r_{f_1} to the value of r_{f_1}. (See Fig. 4.)

The matching capabilities of a pi-network are definitely limited to those load resistances greater than r_{f_1}. The maximum value of x_2 may be found as follows:

$$x_2 = Qr_{f_1}$$

but

$$Q = \frac{R}{x_2}$$

$$x_2 = \sqrt{Rr_{f_1}}$$

The matching capabilities of a pi-network required when R and r_{f_1} are at their largest values, i.e., 2000 ohms and 35.5 ohms, respectively.

$$x_2 \text{ max.} = 267 \text{ ohms}$$

Total value of maximum reactance required in the pi-network coil would be:

$$x_1 + x_2 = 267 = 563 \text{ ; } 44.8\ \mu\text{h at 2 mc.}$$

The value of x_2 will approach zero as the load resistance approaches r_{f_1}.

Minimum value of X_2 will occur when the load resistance is equal to twice the minimum value of r_{f_1}. This fact is obtained as follows:

$$R = (1 + Q^2)\, r_{f_1}, \text{ but } Q = \frac{R}{X_2}$$

$$R = r_{f_1}\left(1 + \frac{R^2}{X_2{}^2}\right), \quad X_2{}^2 = \frac{R^2}{R - r_{f_1}}$$

$$\frac{X_2{}^2}{R} = \frac{(R - r_{f_1})\, 2R - R^2}{(R - r_{f_1})^2}$$

Setting this quantity to zero and solving for R in terms of r_{f_1}:

X_2 is minimum when $R = 2\ r_{f_1}$.

Since minimum r_{f_1} occurs at 4 mc and is equal to 9, X_2 is minimum when $R = 18$ and this minimum value of X_2 is,

$$R = (1 + Q^2)r_{f_1}$$

$$18 = (1 + Q^2)9$$

$$Q = 1 = \frac{R}{X_2}. \text{ Since } R = 18,$$

$$X_2 \text{ min.} = \frac{R}{Q} = \frac{18}{1} = 18 = 2200 \text{ mmfd at 4 mc}$$

To determine if this is actually the largest capacity required, the minimum value of X_2 at 2 mc is determined.

$$R = 2\ r_{f_1} = 2 \times 35.5 = 71.0$$

$$R = (1 + Q^2)\ r_{f_1}$$

$$71.0 = (1 + Q^2)\ 35.5; \quad Q = 1 = \frac{R}{X_2}$$

Since $R = 71.2$, $X_2 = \frac{R}{Q} = 71.2$; i.e., 1100 mmfd at 2 mc.

The maximum required value of X_2 will occur when the load resistance is equal to r_{f_1}. At this condition $X_2 = \infty$. Since X_2 in a practical case cannot equal infinity some additional calculation

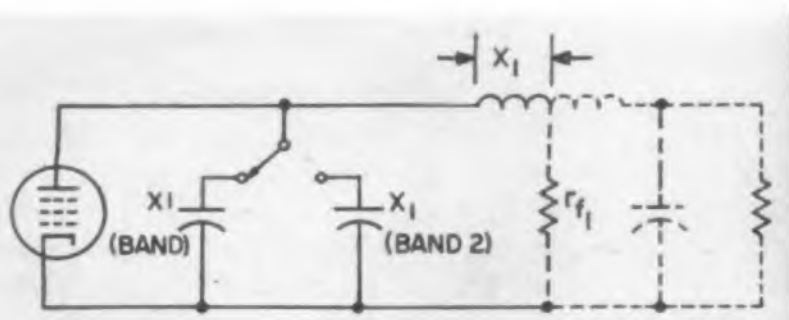


Fig. 3. A more complicated pi network employing bandswitching of the input capacitor.

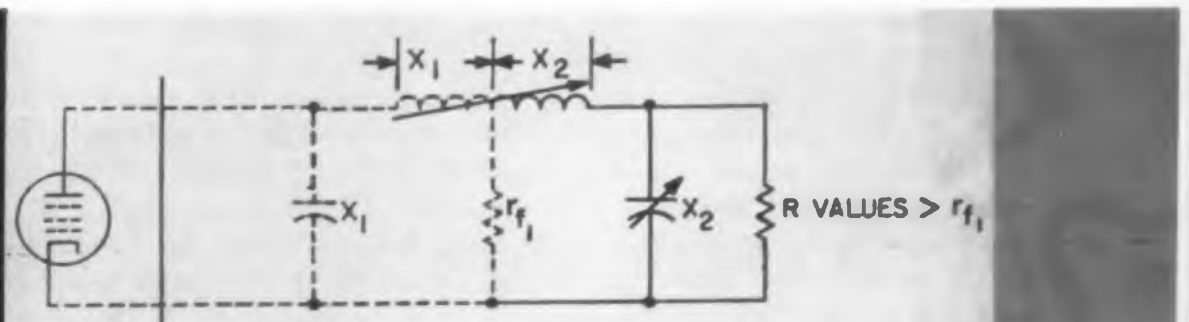


Fig. 4. The addition of another L section transforms all resistive loads greater than r_{f1} to the value of r_{f1}.

is required using the maximum value of X_2 that is possible to determine what the minimum value of resistive load actually can be. This can become important in the 10 to 30 mc frequency range. However, since this example is concerned with frequencies no higher than 8 mc, we will assume that X_2 can go to infinity.

Matching Load Resistances $<r_{f1}$

We have succeeded in determining the circuit required to match load resistances which have a value greater than r_{f1}. The problem remaining is to transform those load resistances below r_{f1} to the required value of 2500 ohms.

The most efficient means of matching to resistive loads less than r_{f1} is merely to use one L section. (See Fig. 5.)

$$R = Q^2 r \qquad (Q > 10)$$

$$Q = 50$$

$$X_1 = 50$$

$$x_1 = 50$$

However, since the value of X_1 has been previously selected so that Q can be controlled when matching higher load values we no longer have the option of employing the above circuit to perform this matching function. Since the load resistance range is so great, since we have already arrived at a practical circuit to match resistive loads greater than r_{f1}, and since it is desirable to keep the number of tuned and switched elements to a minimum, it is advisable to maintain the original circuit configuration to as great a degree as possible and sacrifice some network efficiency.

An approach that is reasonable is to add an additional L section which has the function of stepping up the low load resistance values to values which can be matched by the pi-section. That is, the combination of x_3 and X_3 (the additional L section which has the function of resistance so that the value of r_{f2} is equal to or greater than r_{f1}. (See Fig. 6.)

This immediately means that the demands on the x_3, X_3 section are quite flexible. There is a considerable choice as to just what value of r_{f2} we should demand. Since the pi-section was designed to transform any value of load from r_{f1} to 2000 ohms, obviously r_{f2} could fall anywhere between the value of r_{f1} and 2000 ohms and the x_2, X_2 section could accomplish the matching function. Though any choice will function properly, one approach is to demand that r_{f2} always equals r_{f1}. This means that x_2 can be zero and that X_2 be infinity.

It should be noted, however, that unless the output network tuning procedure is adequately outlined, there is a definite possibility that the transmitter operator will unknowingly choose the value of r_{f2} in spite of what the designer does. It should be the designer's responsibility so to outline tuning procedure and so to limit the value of x_3 and X_3 so that the value of r_{f2} is limited to those values which will yield reasonable efficiences.

To illustrate this flexible matching situation, assume a load resistance of 1 ohm, an r_{f1} of 9 (4 mc, band 1) and an r_{f2} of 9. As previously mentioned if $r_{f2} = r_{f1}$, then $x_2 = 0$ and $X^2 = \infty$.

This would demand an X_3 capacitor of an impractically large value.

By similar calculations, if r_{f2} is chosen to be 2000 ohms, the value of X_3 is quite practical, but then network efficiency is at its least desirable point. A compromise value of r_{f2} is then determined based primarily upon network efficiency and the practicality of the value of capacity corresponding to $X_2 X_3 / X_2 + X_3$.

If a value for r_{f2} equals 50 ohms is chosen it will mean at least a practical value for $X_2 X_3 / X_2 + X_3$. But this choice opens up new possibilities, since it is now possible to match load resistances in the range from 1 to 50 ohms with the pi-L matching circuit. This means that it is no longer essential that the original pi-network be required to match load resistance values down to the value of r_{f1}. This situation can further assist in making the value of output capacity more practical.

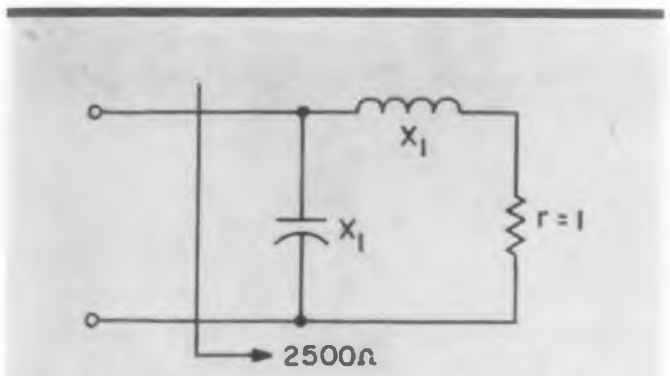


Fig. 5. Matching resistive loads less than r_{f1} with one L section.

From the above example it has been shown that the network shown in Fig. 7 would suffice. Normally X_2 and X_3 will be combined into one capacitor and that x_3 is zero except when the complete pi-L circuit was required for matching. It also has been shown that pi-L network will transform all resistive loads between 1 and 2000 ohms to the desired input impedance of 2500 ohms. The pi-L network was chosen since it performs this function without change in network configuration while at the same time preserving control of minimum network Q.

Reactive Loads

Up to this point reactive loads have been ignored. This has been done primarily to simplify this example. Basically the method of approach for reactive loads is merely to separate the load into its resistive and reactive components, treat the resistive components as the load resistance, and treat the reactive component as a portion of the matching network. This sounds simple enough on the surface, but to illustrate the procedure let us investigate the following example. Assume the load to be $1 + j\,4.9$, a load impedance which is included in the range of those impedances that this output network should be capable of matching. Fig. 8 indicates the series and shunt representation of this load impedance.

Assume that we are operating the pi-L network at 4 mc, band 1, where r_{f1} is 9 ohms. The question arises as to whether we should class the $1 + j\,4.9$ load impedance as being in that category of resistive loads below r_{f1} (since in the series representation the value of resistance is 1 ohm), or above r_{f1} (since in the shunt representation of the value of resistance is 25 ohms) i.e., whether we can match it with the pi-L network only or whether it can be matched with the pi-network ($x_3 = 0$). As a matter of fact the reactive portion of the load allows this load to be matched with either network as shown in Figs. 9a and 9b. Load matched with pi-L network (r_{f2} chosen to be 50 ohms).

It may seem that the required output capacity is less when using the pi-L network to match this load while calculations will show that the efficiency is just slightly greater when the pi-network is used. If r_{f2} were chosen to be 100 ohms rather than 50 the value of required output capacity would be further reduced with a slight additional loss in efficiency.

The point of the above example is to indicate that reactive loads allow the network designer some additional choice in design. Utilizing the load reactance may present an opportunity to provide more practical values of network components. Some reactive loads may require additional range in some of the matching components.

Room for Ingenuity

Completely different approaches are possible to provide a solution for the design problem. The solution shown is practical, but there remains considerable room for ingenuity in providing an output network that is simple and easy to tune. Antennas are the usual load for the PA. If antenna impedance characteristics are well established it is quite possible to utilize this information to simplify the network and to further restrict component range. ■ ■

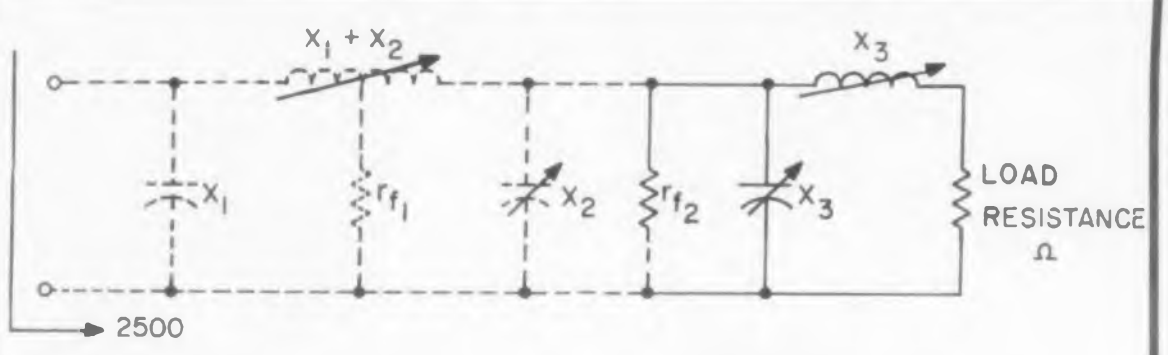


Fig. 6. The addition of an *L* section steps up the low load resistance values to values which can be matched by the pi section.

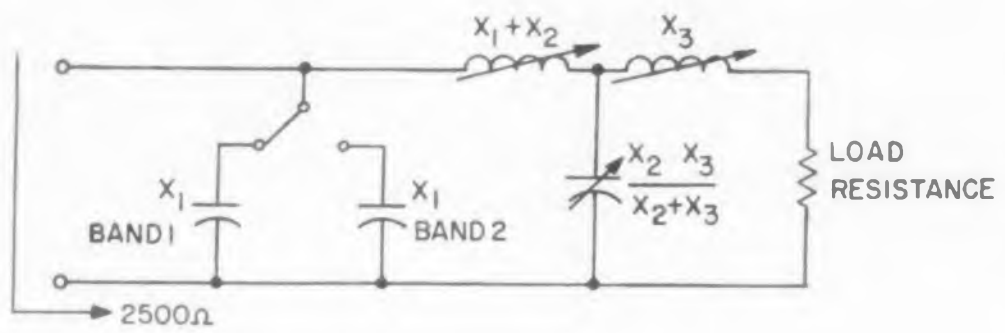


Fig. 7. A more practical pi-*L* matching circuit

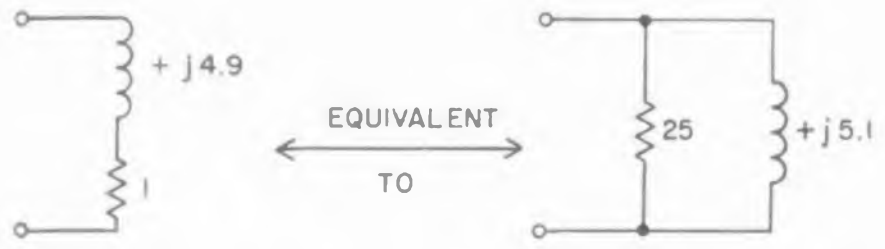


Fig. 8. Series and shunt representation of a load impedance, 1 + *j*4.9.

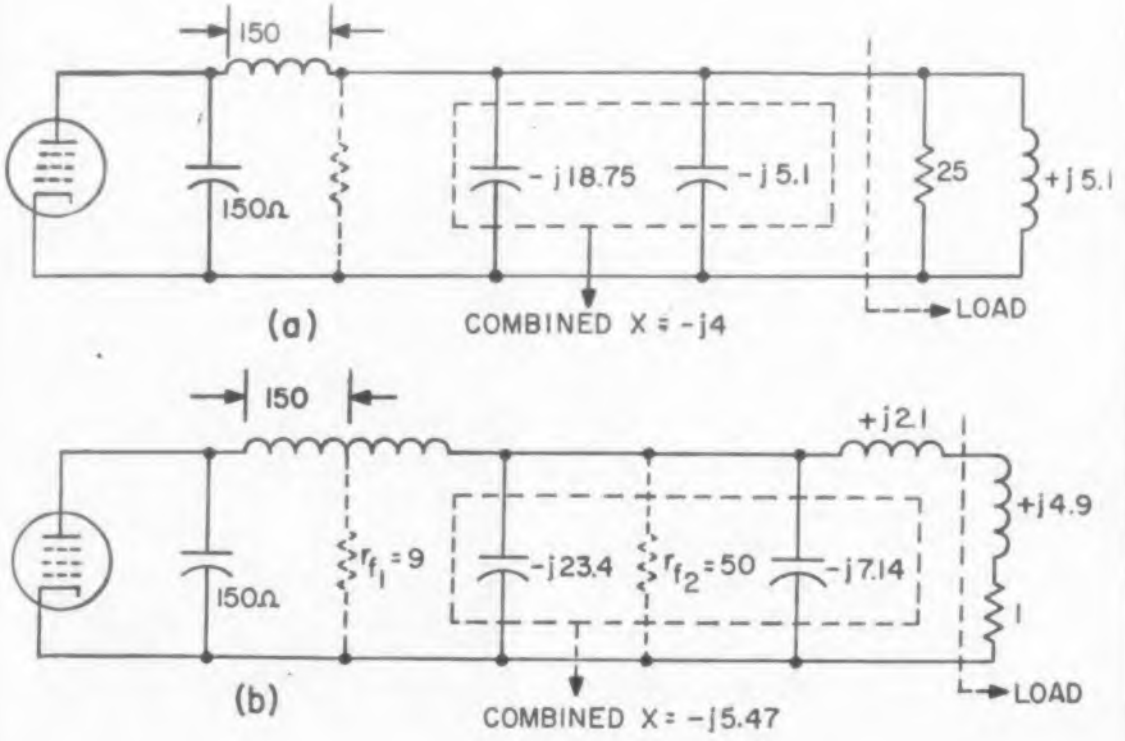


Fig. 9a and 9b. Reactive portion of the load allows the load to be matched with either network, 9a or 9b.

Windings, laminations, bracket held together by epoxy

Potting

Rotor includes stacks, and blades centrifugally cast

Casting

used to produce Low-Cost

THE MAIN portions of this fan—iron laminations, coil windings, bearings, lead wires and holding bracket—are one integral piece, held rigidly together by an encapsulating epoxy resin. Because of this cost saving design approach and others the electronic engineer can buy 100 CFM of cooling air for $6.85°—about one tenth the usual price for quality blowers.

The 60 cycle-powered unit can fit almost anywhere as it is 5 in. sq and 1-1/2 in. deep. Because of a well-engineered propeller design the unit delivers high volume at high pressure at low noise (42 db on the A scale; about 10 db lower than average room air conditioners). Pressure is sufficient to drive air through a dust filter and tightly-packed electronic equipment (see graph).

Called the Muffin Fan by its producer, Rotron Mfg. Co., Inc., Woodstock, N. Y., the motor is the inside-out type with cantilevered bearings. The air-impeller is integral with the rotor. This patented design, which was used successfully to produce miniature military blowers (Aximax, and the Saucer, ELECTRONIC DESIGN, March 5, 1958, p 106), has been further perfected so that it can be made by automatic means. As a result there are only three pieces in the new fan, the molded stator, the centrifugally-cast rotor, and the molded phenolic venturi block. It takes but 15 minutes of labor to inspect

°Quantities of one thousand. Approximately 20 per cent higher for small orders.

Three pieces of fan assemble without screws or bolts. Bezel with grill clamps onto molded venturi block.

Molded venturi block
Molded venturi block needs no machining

Molding

Cooling Fan

and assemble the pieces produced by automatic processes.

Unusual Product Design Cuts Cost

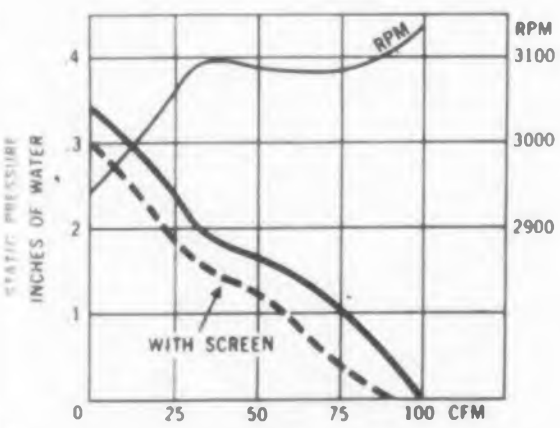
Molded stator. The entire stator assembly comprising motor laminations, stator stack, and wound stator is completely encapsulated. Development of the method to mold this assembly was the biggest tooling problem licked by the manufacturer. The spider arms, or mounting bracket, has embedded in it fiber glass rods for reinforcement. Molds were designed to dispense epoxy on a production schedule. Conveyors, and convection and infrared ovens are used to process the assembly at a fast rate. The epoxy encapsulant is a special mix which maintains its dimensional stability and withstands severe thermal shock.

Rotoprop assembly. This assembly is comprised of rotor laminations, cast propeller and a hardened-and-ground shaft.

The normal manufacturing method to produce this sub-assembly would be to stack the rotor laminations and centrifugally cast the rotor stack and then machine the piece for pressing into the propeller. The propeller would normally be purchased as a die casting and machined carefully to accept the rotor stack and shaft. To save machining cost, the shaft was changed to a hardened and ground part and a method devised to stack the rotor laminations into a mold with the hardened shaft in place for casting. The rotorprop assembly was then centrifugally cast complete in one operation. No additional machining operations were required.

Extreme accuracy as to concentricity between the shaft and the inside diameter of the motor can be maintained.

Venturi block. This part was originally designed to be an aluminum die casting but again to eliminate machining operations the part was changed to a plastic. A dimensionally-stable phenolic that can be molded to blueprint tolerances requiring no machining or finishing operations was used. The multi-cavity mold used to produce the venturi block was no more expensive than the die-casting die would have been.



Performance curves of fan shows high volume and relatively high pressure.

Other Features

The bearings in this fan are unique and came about as the result of a careful re-evaluation of what the industry has been doing in the past ten years. Since only minute quantities of lubricant are actually needed, provided that the lubricant is there when wanted, and that it does not chemically deteriorate, a design using a Teflon seal is used which holds a small quantity of oil and seals air out. Because the quantity of oil is small compared to other motors, the most expensive lubricants can be used—the $20 a gallon variety for example. This approach reverses the trend of other motor designers to produce oversize oil reservoirs.

For more information on this low noise and low cost fan turn to the Reader-Service number and circle **101**.

Microwave Test Instruments

Part 7

The microwave engineer should bear in mind that a number of manufacturers produce test equipment and accessories on a custom basis, fulfilling special needs, and that the companies in the field are not restricted to those mentioned in this series. ■ ■

Miscellaneous

MICROWAVE measurements are made with a wide array of test equipment. Some are of very specialized nature. In this concluding part, echo boxes, standard horns along with a number of other specialized microwave test instruments are covered.

Standard Gain Horns and Echo Boxes

Echo boxes are high-Q resonant cavities which give, in a single reading, an indication of the overall performance of a radar system. Signal generators and power meters are widely used in measurements on radar systems where detailed knowledge is required, but the echo box is convenient for a single overall performance measurement.

The echo box consists of a high-Q resonant cavity which is coupled to the radar by means of either a directional coupler or a pickup antenna. The cavity stores energy during the transmitted pulse, and continues to oscillate after the end of the pulse period, with an exponential rate of decay. This exponentially decaying signal is returned to the radar receiver. It initially saturates the receiver, and eventually decays into the noise level. The total elapsed time between the transmitted pulse and the time the noise level is reached is called the "ring time," and is a measure of overall radar performance. Typical loaded Q's of echo boxes are of the order of 50,000 to 90,000.

Standard horns are used in measurements concerned with antenna design and development. They may be used as standards for calibrating other antennas, as feed horns for reflectors and lenses, as pickup horns for sampling power, and as receiving and transmitting antennas for point-to-point communications. The method by which standard-gain horns are used to calibrate other antennas is essentially one of substitution. The gain standard and the unknown antenna are alternately connected to a well-matched receiver and the difference in level between them is measured—for example, by using a precision attenuator. Horns are available in gains of 10 to 25 db, and the gain at any frequency in a band can readily be computed when it is known at a given frequency. Standard horns along with echo boxes are listed in Table 1 according to manufacturers.

Receivers and Field Intensity Meters

Receivers have many applications in microwave work, including radio noise measurement, field intensity measurements, antenna pattern measurements, and numerous others. General-purpose laboratory receivers feature wide tuning range, accurate frequency and signal level calibration. Receivers intended for antenna pattern measurements are designed for wide frequency range, and maximum sensitivity and linearity.

Field intensity meters are receivers designed for accurate frequency and power calibration and high sensitivity. An internal signal calibrator permits accurate voltage and power measurements. Calibrated antennas are included so that signal level readings can be accurately related to field intensity. Receivers and field intensity meters are listed in Table 2 according to manufacturers.

Miscellaneous Instruments

Microwave test bench is an integrated system for performing laboratory and production tests. It can include such subunits as attenuators, frequency meters, detectors, slotted lines, and directional couplers. Such setups can, also be made by using standard units and assembling them into a complete system by means of mounting stands, supports. Microwave test benches along with a number of other microwave equipment are listed in Table 3.

Traveling-wave tube amplifiers have a number of uses in design and testing of microwave systems. They can be used wherever there is a requirement for broad-band gain, pre-amplification, high-speed pulse generation, or signal amplitude or phase modulation. Microwave amplifiers making use of traveling-wave tubes provide high gain and moderate power outputs, and can modulate the amplitude or shift the phase of the input signal. The units are completely self-contained units incorporating all the power supplies and controls necessary for their operation.

Radar moving target simulator is another type of unit for calibrating radar system performance.

Table 1. Standard Horns and Echo Boxes

Manufacturer	Standard Horns	Echo Boxes
Airtron, Inc.	X, KU, K, V	--
Amerac, Inc.	--	2.7-2.9 KMC
De Mornay-Bonardi	S, C, XN, XB, X, KU, K, V, Q, M, E	--
Diamond Antenna & Microwave Corp.	L, S, C, XN, SB, X, KU, K, V	--
Douglas Microwave Co.	L to Z	--
F-R Machine Works, Inc.	L, S, C, XN, XB, X, KU, K, V, A, M, E	--
Microwave Associates, Inc.	X, KU, K, V, M	34-36 KMC
Narda Microwave Corp.	L, S, C, XN, XB, X, KU, K, V, A, M, E	5.35-5.45 KMC; 9.20-9.45 KMC
Polarad Electronics Corp.	4.19-7.74 KMC; 7.36-10.0 KMC	--
Polytechnic Research and Development Co., Inc.	--	15.8-16.2 KMC
Radar Design Corp.	S, C, XN, XB, X, KU, K	--
Sperry Gyroscope Co.	8.5-9.6 KMC	--
Waveline, Inc.	S, C, XN, XB, X, KU, K, V	

Whereas the echo box may be used for checking transmitter and receiver performance, the moving target simulator tests the radar range tracking circuits. It provides a microwave return signal with the same pulse characteristics as the transmitted radar signal, which may be adjusted so that it has a continuously varying range and then used to check the radar range tracking circuits. It also provides a series of accurate fixed range echo pulses that may be used to calibrate the radar range markers. The simulator may be connected to the radar set directly through a directional coupler, or it may be used with a pickup horn antenna.

Antenna-pattern transmitter is a convenient X band source, particularly designed for antenna measurements. It consists of an antenna assembly, a modulator, and a remote control unit. A motor-tuned magnetron is mounted on the antenna assembly. The unit has variable antenna polarization through 360 deg, two azimuth positions 10 deg apart for dual-range use, and manually adjustable elevation.

Peak power test set provides direct reading of peak power by comparison between the unknown signal and a known reference on a synchroscope. The test set consists of a signal generator and a crystal video receiver, and can also be used as either one. In making power measurements using this unit, the comparison is made by means of an external synchroscope, and the power read-out of the reference source is made by means of an external wattmeter bridge. The signal generator pulses are first matched with the height of the unknown pulse, then the test set is switched to cw operation and the power measured with the power bridge.

Microwave stability tester measures drift and frequency modulation of a microwave signal. It uses a digital type of discriminator, so that very small frequency variations can be quantized and measured as a dc voltage. Any frequency change causes a change in the number of pulses quantized and a change in the voltage level of the integrator, whose amplified output is calibrated in cycles per second on a frequency deviation meter. The amplified output of the quantizer, after filtering and demodulation, also drives a drift meter calibrated in kilocycles per minute.

Microwave Q-meter is useful in measuring the Q of echo boxes and other forms of cavity resonators. Its operation is based on an accurrate comparison of the rate of decay of oscillations in the cavity under test with a rate of discharge of precision capacitors into a highly stable known resistor. It therefore does not require highly stable oscillators, accurate tuning of the cavity, nor precise setting of the ouptput signal to a particular level.

In addition to the measurement of Q, this unit can also be used for a number of other types of measurements, such as measurements of conductivity of metals and dielectric losses of materials at high frequencies.

Precision attenuator calibrator may be regarded as a reference standard for signal levels, and is used for the accurate calibration of signal generators. Signals through the attenuator under test and through a precision reference piston attenuator in the instrument are each modulated by alternate halves of a square wave generator. By adjusting the standard piston, equality of the signals is obtained. The difference is displayed on a cathode ray tube and also operates a phase sensitive rectifier which shows this difference on a meter.

Noise figure indicator, when used with an auxiliary noise generator, continuously and directly indicates the noise figure of a receiver under test. A square wave modulates the noise generator, causing it to go on and off alternately for equal periods. The bursts of noise from the generator are fed into the receiver under test, and the i-f output of the receiver is taken to the noise figure indicator. The signal is detected, and amplified by a video amplifier. From the relative signal levels during the on and off periods of the square wave, the unit computes the noise level of the receiver under test. ■ ■

(Tables continued on following pages.)

Table 2. Receivers and Field Intensity Meters

Type of Instrument	Manufacturer	Model No.	Frequency Range	Sensitivity	Price	Accessory Equipment	General Comments
Receivers	Engineering Associates	AN/APR-4	38-4,000 MC in 5 tuning units	--	Approx. $3000	--	Accuracy of frequency calibration ±1%; I-F bandwidths 0.6 and 4.0 MC; panoramic, video and audio outputs; automatic motor-operated sector sweep tuning at variable speed on all tuning units; originally radar search receiver being sold for use as general purpose laboratory receiver.
	Polarad Electronics Corp.	R	400-46,700 MC using 8 plug-in tuning units	-85 dbm (at 400 MC) to -55 dbm (at 46.7 KMC)	Basic unit and power supply $1500 Tuning units $2500-$4410 each	--	Accuracy of frequency calibration ±1%; I-F bandwidth 3 MC, video bandwidth 2 MC; linear dynamic range 60 db with AGC; receiver AM, FM, CW, MCW, pulsed signals; 60 db image rejection 400-11,260 μ, bandpass and high-pass filter used in higher-frequency tuning units.

Table 2. Receivers and Field Intensity Meters (continued)

Type of Instrument	Manufacturer	Model No.	Frequency Range	Sensitivity	Price	Accessory Equipment	General Comments
	Scientific-Atlanta, Inc.	402	2-75 KMC	-90 dbm (at 30 MC) to -70 dbm (at 65 KMC)	$7500	--	Designed primarily as wide-range receiver for antenna pattern measurements where maximum sensitivity and linearity are required, linear 40 db dynamic range (may be extended by use of R-F attenuator); models 402A and 402C have AGC, others do not; crystal video detector output for oscilloscope, bolometer detector for recorder operation, no direct-reading frequency calibration, tuning chart for approximate settings; no R-F preselection or image rejection.
		402A			$6000		
		402B	30 MC-75 KMC		$8500		
		402C			$9000		
	Empire Devices Products Corp.	NF-112	1.0-10.0 KMC using 4 plug-in tuning units	--	$14,500 complete with all accessories	Standard gain horn antennas, tripods, etc.	Equipped with impulse noise generator for calibrating CW and broadband measurements, includes double tuned cavities preceding the first mixer, maximum peak amplitude 79 db above 1 microvolt per MC.
Field Intensity meters	Polarad Electronics Corp.	FIM	1.0-10.0 KMC using 4 tuning units	--	$20,488.50 complete with all accessories	Calibrated antennas, antenna reflector, tripod	Frequency calibration accuracy ±2%, image rejection 60 db; input R-F voltage range 20 microvolts to 3 volts, 60 db R-F attenuation, 20 db I-F attenuation, includes CW calibration signal 0.2 volts to 5 microvolts RMS.

Table 3. Miscellaneous Instruments

Type of Instrument	Manufacturer	Model No.	Frequency Range	Special Features	Accuracy	Price	General Comments
Microwave Test benches	Ferranti Electric, Inc.	Integrated microwave test bench	9.0-10.0 KMC	Includes: 1. Three klystron input 2. Wavemeter 3. Attenuator 4. Crystal power monitor 5. Slotted line	--	--	Single unit formed from two halves of a light alloy block, attenuator range 30 db, accuracy ±0.1 db, wavemeter in absorption type with micrometer tuning; slotted line has engraved centimeter scale.
	Microwave Associates, Inc.	MA-1019	26.5-40.0 KMC	Includes: 1. Attenuator 2. Wavemeter 3. Standing wave detector 4. MA-1019 has directional coupler	--	$1390	Packed system consisting of standard microwave units manufactured by company; complete specifications for each of these units are available separately.
		MA-1018					
		MA-1018	50.0-75.0 KMC			$1725	
Traveling-wave Tube Amplifiers	Alfred Electronics	505, 501 503, 504	1-2 KMC, 2-4 KMC, 4-8 KMC, 8-12.4 KMC	30 db gain, 10 MW output power, 24 db noise figure	--	$1390 to $1550 each	Consists of general purpose, medium power, high power and low noise groups as indicated; spurious modulation 35 db-40 db below signal; include provision for modulation.
		5-6752, 512; 502; 5-6868; 506, 510, 509, 5-6996	1-2 KMC to 8-12.4 KMC	20 db-30 db gain, 100 MW-10W output power, 25 db-40 db noise figure	--	$1390 to $3390 each	
		5-6826	2-4 KMC	30 db gain, 1 KW peak output power	--	$4850	
		511A, 515A, 523	2-4 KMC to 8-12.4 KMC	25 db gain, 1 MW-5MW output power, 11 db-15 db noise figure	--	$1990 to $3290 each	
	Hewlett-Packard Co.	490B	2-4 KMC	30 db gain, 10 MW output power	--	$1100	Noise figures 25 db to 30 db; modulation provisions on all except 491A; hum and spurious modulation at least 30 db below signal level; prices include traveling-wave tube.
		491A		30 db gain, 1 W output power		$1100	
		492A	4-8 KMC	30 db gain, 10 MW output power		$1500	
		494A	7-12.4 KMC	25 db gain, 5 MW output power		$1500	
	Menlo Park Engineering	TA-1 to TA-44 (26 different units)	L, S, C, X, KU bands	25 db-30 db gain; 1 dbm to 30 dbm output power, 10 db-30 db noise figure	--	$1450 to $3250 each	Complete series of units to cover the frequency and power ranges listed; provision for modulation

Table 3. Miscellaneous Instruments (continued)

Type of Instrument	Manufacturer	Model No.	Frequency Range	Special Features	Accuracy	Price	General Comments
Microwave Leveler	Alfred Electronics	702 to 708 (6 units)	1-2 KMC to 12.4-18 KMC	100 MW max power (mod 708 has 1 W max), RF control range ±2 to -30 db relative to max level	±1 db	$ 750 to $ 950 each	Maintains constant output from microwave signal sources; 0 db indication may be set at 1 MW to 100 MW level; less than 1.5 db insertion less; DC to 100 KC frequency response; CW or square-wave internal modulation.
	Roger White, Inc.	TWA-P1W	0.8-1.2 KMC	1 MW output power	--	--	Noise figures 25 db for W series (1 watt), 20 db for M series (1 MW); minimum gain 25 db (except TWA-S1M has 30 db gain); includes provision for modulating output of the traveling-wave tube
		TWA-L1W	1.0-2.0 KMC	1 W output power			
		TWA-L1M		1 MW output power			
		TWA-S1W	2.0-4.0 KMC	1 W output power			
		TWA-S1M		1 MW output power			
		TWA-C1W	4.0-6.0 KMC	0.8 W output power			
		TWA-C1M		1 MW output power			
Moving Target Simulator	Aircraft Armaments, Inc.	668	X or KU bands (interchangeable R-F heads)	Power output -25 dbm, maintained constant by automatic gain control; manually adjustable over a 70 db range	Variable delay accuracy ±10 ft, range marker accuracy ±5 yards	--	Designed to test radar range tracking circuits and perform other tests on X and KU band radars; provides microwave return signal with the same characteristics as the transmitted signal, provides fixed or varying range echo pulses, AFC maintains output frequency within ±200 KC of input frequency.
Antenna Pattern Transmitter	California Technical Industries	119	8.5-9.6 KMC	Peak power output 20 KW	--	$7950 (excluding antenna), Antenna $4400	Consists of antenna assembly, modulator, and remote control unit; motor-tuned magnetron is located on the antenna assembly; variable antenna polarization; pulse width 1 microsecond, pulse rate 1000 pps.
Peak Power Test Set	Cubic Corp.	100X	As peak power meter and signal generator 8.5-9.6 KMC As crystal video receiver 10 MC-12 KMC	Peak power range 0.01 to 3 MW Power output as signal generator: 0.01 to 3 MW Sensitivity as crystal video receiver 1.6 volts per MW	As peak power meter: ±0.2 db	$1150	Can be used as peak power test set, signal generator, or crystal videoreceiver; generators CW signals having same peak amplitude as the unknown, and comparison is made with an external synchroscope and wattmeter bridge.
Microwave Stability Tester	Laboratory For Electronics, Inc.	5004	1120-3000 MC, 5200-6100 MC, 7000-10,000 MC, 9600-10,500 MC (four R-F heads)	Minimum measurable F-M peak deviation: 2 cps for S band to 10 cps for X band Max measureable FM deviation: 1000 cps (using internal meter); 5000 cps (using external oscilloscope)	2 cps at S band 10 cps at X band	Basic unit $6500 R-F heads $3030 to $3500 each	Indicators peak F-M deviation on one meter, drift on another; also measures at 30 MC, and 30-230 KC; outputs may be viewed on an oscilloscope or spectrum analyzer; K-band head (23.0-25.0 KMC) available on special order.
Microwave Q-Meter	Wayne Kerr Labs.	--	S band, X band	Q range. 10,000-60,000 for S band; 30,000-150,000 for X band	±1%	--	Compares rate of decay of free oscillations in cavity under test with rate of discharge of precision RC circuit; frequency accuracy ±0.05%; maximum range of transmission loss of cavities with which instrument will operate is 26 db.
Precision Attenuator Calibrator	Wayne Kerr Labs.	--	2.7-3.8 KMC	Range of measurement 10^{-4} to 10^{-12} watts	0.015 db to 0.02 db	--	Intended as reference standard for measurement of levels in the power and frequency range indicated; may be used to 10^{-15} watts for leakage measurements, wavemeter accuracy ±0.1%.
Automatic Noise-Figure Indicator	Airborne Instruments Laboratory, Inc.	72	--	Measurable range of noise figure 0 to 20 db	±0.5 db	$1490	Used with type 70 Noise Generator; minimum acceptable noise input (source off) 50 microvolts into 50 ohms; I-F input 30 MC or 60 MC (specify which); I-F amplifier bandwidth 1.0 MC.

Solid State Relay

Operates in the Microsecond

WITH no moving parts, this solid state relay closes in five μsec, drops out in 30. The coil circuit is completely isolated from the switching circuit and can switch several independent circuits within the same unit. Contact bounce, arcing, chatter and contamination are, of course, totally eliminated.

Life expectancy of the relay, if properly applied, is hoped by Pendar, Inc., 14744 Arminta St., Van Nuys, Calif., to be indefinite—meaning millions of cycles and unlimited shelf life. It should find application in sweep tube switching, gating; wherever fast switching and resistance to high vibration is required; and where shelf and operating life are at a premium.

Production units are rated to switch ac or dc from 10 mils to 10 amp in the spst category, and 10 mils to 0.5 amp in the dpst category. Operating on 28 v dc, the coil circuit pulls in at 18 v and drops out at 11 v or less, 14 ma and 6 ma, respectively. Transfer time is better than 50 μsec.

The block diagram of Fig. 1 demonstrates the operation of the new relay. A zener reference element is used to set the pull-in and drop-out

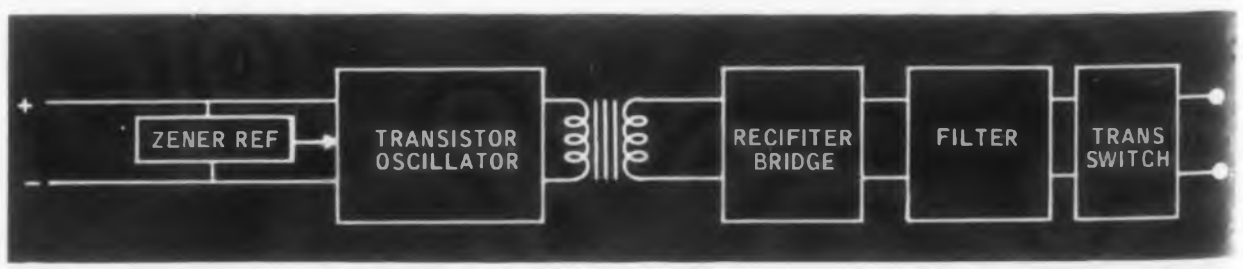


Fig. 1. Block diagram of solid state relay. Rectifier and filter changes ac square waves from the oscillator drive circuit to smooth dc for transistor switch operation. Adjustment of zener diode reference controls pull-in and drop-out voltage.

olid state relay has coil circuit isolated from tran- stor switch, can handle from 10 ma to 10 amperes, pst, 10 ma to 0.5 amperes, dpst. Transfer speed is less han 50 μsec.

nd Range

voltage, while an inductively coupled multivibrator feeds a square wave ac voltage to the isolation transformer. This set-up provides a choice of pick-up and drop-out voltages not easily accomplished by electromechanical relays—the spread can be extended over 7 v by adjusting the driver current to remove the possibility of a transient switching the relay.

A rectifier converts the transformed voltage back to dc and a filter element removes ac components; smooth dc is delivered to the transistor switch. At room temperature noise level on the contacts at 22.5 v, 10 ma, is only 80 mv peak to peak.

The switch consists of one or more transistors or diodes with rating and circuit arrangement compatible with the desired contact voltage, current, switching speed and whether it is to be used ac or dc. Voltage drop at the contacts is 19 mv at 22.5 v, 10 ma.

There is some contact leakage when the "contacts" are open: with 30 v and 10 mils on the contacts there is 11 μa leakage (25 C). For 30 v dc with 1 a on the contacts there is 25 ma leakage.

The relay will handle its rated load at 0.5 v above the drop-out voltage and will continue to carry this rated load up to 30 v. At the 24 v normal level it has an overload factor of four on current and a factor of two on voltage. Entirely potted, temperature range is from —55 C to 125 C.

Six basic units are available: switching 10-100 ma spst NO; 10-11 ma dpst NO; 100 ma-0.5 amp spst NO; 100 ma-0.5 amp dpst NO; 1-5 amp spst NO; 5-10 amp spst NO.

For further information on this solid state relay, turn to the Readers Service Card and circle **102**.

KEEP JUNCTION TEMPERATURES DOWN—

Mount Diodes on Fins

Diodes can be effectively cooled when mounted on fins—if the fins are efficient. Here, Werner Luft outlines steps to be taken to achieve good performance, and provides the design engineer with a graph to enable him to determine the efficiency of a fin. As a result, diode current capacity is increased.

Werner Luft
Product Analyst Engineer
International Rectifier Corp.
El Segundo, Calif.

TO KEEP THE junction temperature of a silicon or germanium diode below its upper limit, the diode often is mounted on fins and cooled by free or forced convection of air or liquid.

Factors influencing the cooling efficiency of a fin are varied. Fin efficiency is defined as the ratio of the heat *actually* dissipated by a fin to that which *would be* dissipated by an identical fin of infinitely conductive material. In practice, it is the ratio of the average fin temperature to the fin temperature at the hottest point.

As the maximum temperature of a fin is generally known, the total heat dissipation from the fin can be calculated if the fin efficiency is obtained.

Temperature Distribution

Heat dissipated from a fin is approximately proportional to the temperature difference between the average fin temperature and the temperature of the environment. Fig. 1 qualitatively illustrates the temperature distribution in a square fin of constant thickness. The temperature is shown along the ordinate and the fin is extended in a plane perpendicular to the ordinate.

In the center of the fin, where the diode is placed, there is a temperature rise above the environment of T_o degrees. At the edges of the fin, the temperature difference above the ambient has dropped to T_L degrees. The average temperature difference will be somewhere between these two points.

Magnitude of the temperature drop from the

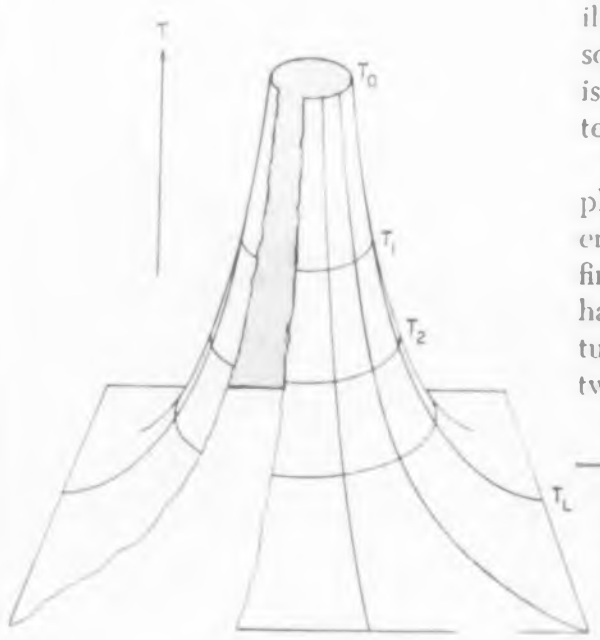


Fig. 1. Three-dimensional surface illustrating temperature distribution in square fin of constant thickness, with highest temperature near center. (Equation of curve is complex—shape shown is qualitative.

enter or base of the fin to the edges, per unit of heat dissipated by the fin, depends on

- the material of the fin, i.e. the thermal conductivity of the fin material—a material of higher thermal conductivity will decrease the temperature difference;
- thickness of the fin—a thicker fin will decrease the temperature drop;
- size of the fin—a larger fin will increase the temperature drop; and
- heat transfer coefficient between the fin and environment—better cooling methods will increase the temperature difference.

Keep Drop Small

Good design requires a fin with high efficiency —a fin where the temperature drop from center to edge is small. To have the same efficiency as a small fin, a large fin either must be thicker, made of a material with higher thermal conductivity, or both.

Two fins of the same size therefore must be of different thicknesses to have the same efficiency, if one has better cooling—a higher heat transfer coefficient—than the other. A fin cooled by forced convection of air, for instance, must be thicker than a fin of the same size and material cooled by free convection, if the same efficiency is expected.

To avoid confusion, it must be remembered that the fin efficiency does not give an actual measurement of the dissipated heat for different sizes of fin or for different cooling methods. A larger fin will dissipate more heat than a smaller

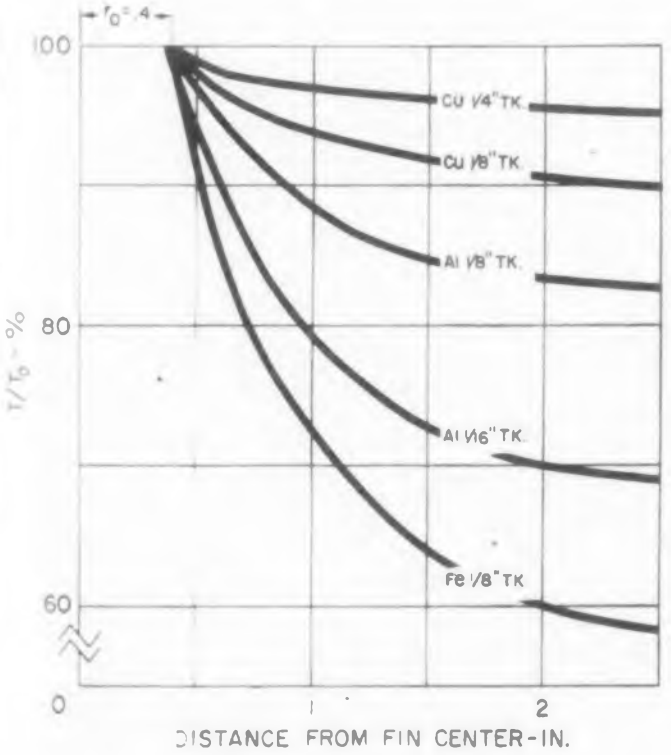


Fig. 2. Temperature distribution in 5 x 5 in. fins of different materials and thicknesses. Heat transfer coefficient: 0.016 w per sq. in. per deg C. Quarter-inch copper is most efficient fin shown here.

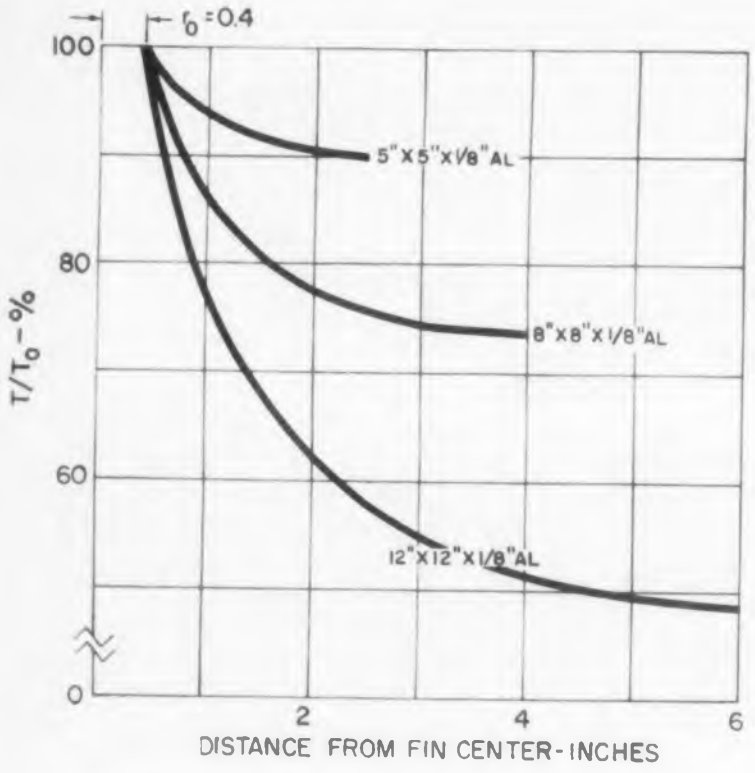


Fig. 3. Temperature distribution in 1/8 in. thick aluminum fins of different areas, cooled by free convection and radiation.

one of the same thickness and material, with the same cooling method. A fin cooled by forced convection will dissipate more heat than the same fin cooled by free convection.

Fin efficiency gives only the ratio of the heat a fin *actually* dissipates to that which the same fin under identical conditions *would* dissipate if there were no temperature drop from the center of the fin—where the heat source is mounted—to the edges of the fin.

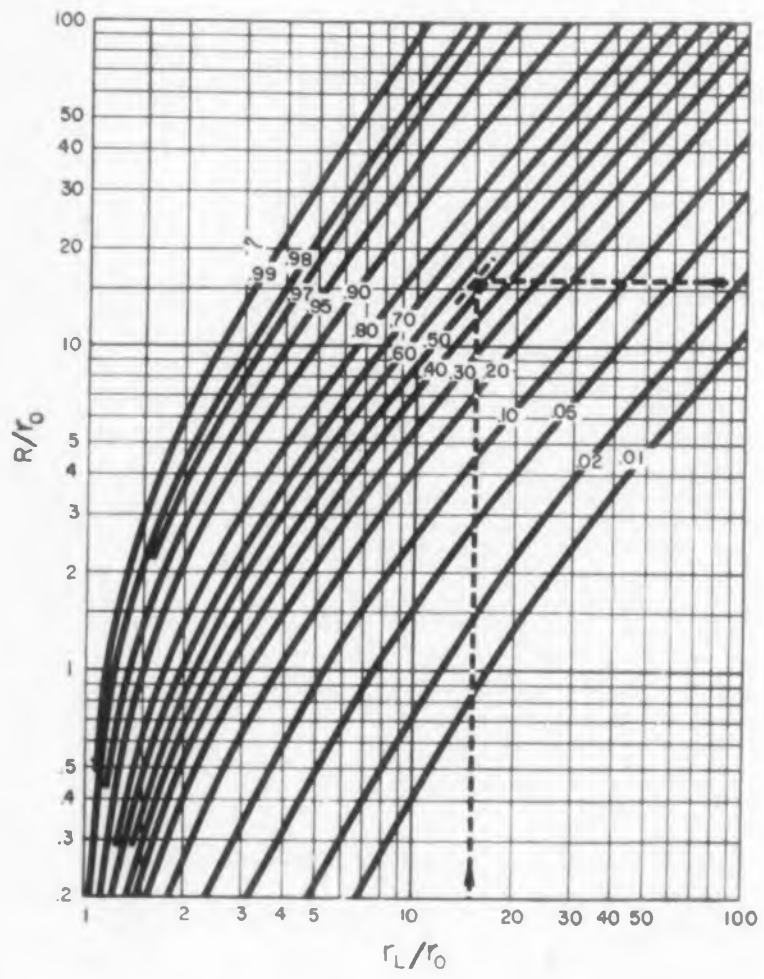


Fig. 4. Efficiency graph for annular fins of constant thickness.

Influence of Material, Dimensions

Influence of fin material and fin thickness on the temperature drop within the fin is shown in Fig. 2. All curves in the figure refer to fins 5 x 5 in., cooled by forced air of such velocity that a heat transfer coefficient of 0.016 w per sq in. per deg C is obtained. The heat comes from a silicon diode International Rectifier type 45L30, mounted in the center of these fins.

On the ordinate is plotted the ratio of the temperature difference above the ambient at each point of the fin to the corresponding temperature difference at the center. The abscissa gives the distance from fin center.

Temperature distribution within the fin from center to edge thus is pictured. The temperature drop from center to edge for the 1/4 in. thick copper fin is only five per cent of the temperature difference between fin center and environment.

Table 1 Approximate Thermal Conductivity for Some Materials in W/in. °C

Material	k
Copper	9.6
Aluminum	5.2
Brass (70% Cu, 30% Zn)	2.6
Steel, sheet carbon	1.1
Steel, stainless	0.4

Table 2 Approximate Heat Transfer Coefficient* on Vertical Fins for Different Cooling Methods in W/sq. in. °C

Cooling Method	h
Free convection of air with impeded radiation	0.004
Free convection of air and radiation	0.008
Forced convection of air 1000 LFM	0.023
Free convection of transformer oil	0.08

***Average values of those encountered for rectifier cooling. The heat transfer coefficient varies greatly with temperature, temperature difference from fin to environment, fin size, altitude, etc. The given values will therefore only indicate the magnitude of expected heat transfer.**

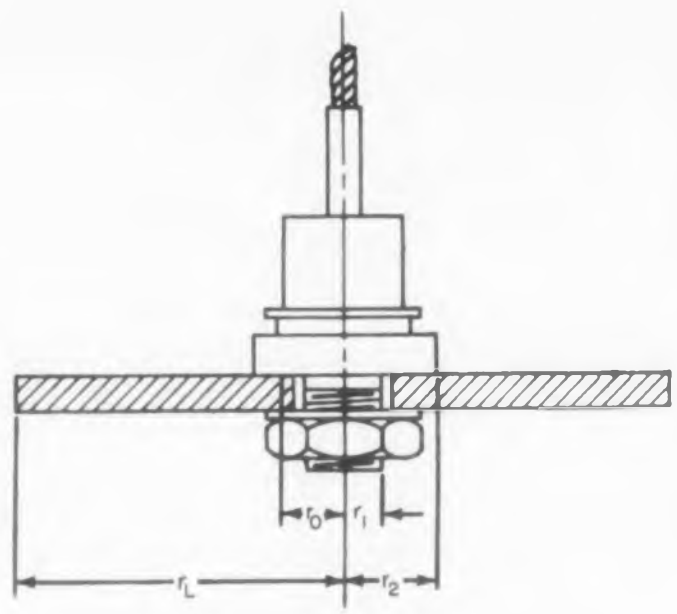


Fig. 5. Cross-section of silicon diode mounted on fin (symbols as used in text).

This, therefore, is a very efficient fin.

The corresponding temperature drop for the 1/8 in. thick aluminum fin is a less efficient 17 per cent; and for the 1/8 in. thick steel fin, an inefficient 42 per cent.

Comparing Three Fins

Influence of fin size is illustrated in Fig. 3. The curves refer to 1/8 in. thick square aluminum fins cooled by free convection of air and radiation, giving an approximate heat transfer coefficient of 0.008 w per sq in. per deg C. Mounted in the centers of the fins are the same silicon diodes shown in Fig. 2.

Inspecting the temperature distribution for the three fin sizes—5 x 5 in., 8 x 8 in., and 12 x 12 in.—we see that the temperature drop from center to edge for the 5 x 5 in. fin is 10 per cent of the temperature difference between center and environment. For the 8 x 8 in. fin, the corresponding drop is 26 per cent, and for the 12 x 12 in. fin, 52 per cent. Thus, while the 1/8 in. fin thickness gives an efficient 5 x 5 in. fin under the stated conditions, this thickness results in a low efficiency for a 12 x 12 in. fin.

Efficiency Graph

The graph (Fig. 4) is calculated for circular fins of uniform thickness with the heat source—the diode—placed at the center of the fin. For practical engineering purposes, it can be used equally well for square fins. For rectangular fins the graph is not especially valid. It will, however, give at least an estimate of the relative fin efficiency of families of rectangular fins having the same dimensional ratio of long side to short side. Rectangular fins with the long side not more than twice the short side can be treated, for practical

urposes, as square fins of equivalent area. But ctual efficiency will be somewhat lower than the graph indicates.

In the graph,

r_L designates distance in inches from the center o the edge for circular fins, and the shortest dis- ance from center to edge for square fins. For ectangular fins, r_L is equal to half the geometric nean of one long and one short side.

r_o designates the distance in inches from the geometric center of the heat source to the point where the heat enters the fin. For diodes with tapered threads, r_o is equal to half the pitch diameter of the thread. For diodes like the one shown in Fig. 5, r_o is $(r_1 + r_2)/2$ (dimensions are designated in the Figure).

$$R = \sqrt{ks/2h},$$

where k is the thermal conductivity of the material in w per in. per deg C; s is fin thickness in inches and h is the heat transfer coefficient between fin and environment in w per sq in. per deg C.

The graph (Fig. 4) is dimensionless. The abscissa of the chart is the ratio r_L/r_o and the ordinate is the ratio R/r_o. The curves represent the efficiency, η.

Example

Assume a 12 x 12 x 1/8 in. aluminum fin, to be cooled by free convection and radiation. The diode to be cooled by the fin is an International Rectifier Corp. silicon diode type 45L30.

- What is the efficiency of the fin?

$r_L = 6$ in.

$r_o = (0.55 + 0.25)/2 = 0.4$ in.

$s = 0.125$ in.

$h = 0.008$ w/sq in. C (cf. Table II)

$R = \sqrt{(5.18 \times 0.125)/2 \times 0.008} = 6.36$ in. (cf. Tables I and II)

$r_L/r_o = 15$, and

$R/r_o = 15.9$.

Entering the graph for these values, we find the point of intersection at $\eta = 54$ per cent.

- How many watts can the fin dissipate if the diode case temperature must not exceed 100 C and the fin is placed in an ambient of 40 C? (The diode is soldered to the fin so the case temperature of the diode will be the same as the temperature of the fin center.)

T_o, the temperature difference–fin center to ambient is 60 deg C and A, the total fin area, is 2.88 sq in.

Total heat dissipated by the fin is

$$Q = \eta T_o h A = 75 \text{ w}.$$

Reference

Thermal Impedance of Cooling Fins, E. J. Diebold and W. Luft, *AIEE Transactions*, Vol. 77, Part 1, November 1958, pp. 739-745.

DESIGN PREVIEW

Automatic Focusing System

This strange looking device is an automatic focusing mechanism. In this design the lens is moved back and forth by a servo-motor. Setup shown is capable of two per cent accuracy in ranging—7 in. at 60 ft. It focuses on any object at which it is aimed.

Sometimes, in our efforts to get news and design information to you *first*, we find ourselves in possession of data about products that are still in the laboratory or design stages —and which you can't buy! When this happens we're frankly baffled. What shall we do with it? Suppress it? Tell you about it? In this case we resolve our dilemma by giving you a *Design Preview*.

You can't buy the OAR . . . yet. It will take numerous forms, we are sure—its applications are limited only by the imagination of the user.

DESIGNED direct from the equations, the Optical Automatic Ranging system will focus a lens on any object it is pointed at, and will tell its range with two per cent accuracy.

Prospective applications include automatic focusing for TV, motion picture or still cameras, microscopes, automatic proximity warning devices, precision inspection for mass-produced items which need to be held to dimensional tolerances of 10^{-5} in., continuous automatic control of color processes, detection, measurement and control of temperature, and many others.

Mell Greene, research director for Comapco, Inc., 17071 Ventura Blvd., Encino, Calif., explains that the laboratory device shown in the photo is a "straightforward mechanical formulation of the equations." He derived the mathematics and turned them directly into a mechanical process without wasting time for frills.

Design

A special case of the OAR system is shown in Fig. 2 to demonstrate the principle. Where R_0 is the radius of the unstopped lens, R the radius of the lens stopped by an aperture, r the radius of the aperture, f the focal distance, a the offset of the focal surface and the centroid of a vibratile aperture, x_0 the excursion of the vibratile aperture along the optical axis and $x_0 \sin\omega t$ is the excursion with respect to time (simple harmonic motion), then

$$E_{sig} = E_{max} f^2 r^2 / R_0^2 \left[a^2 + 2ax_0 \sin\omega t + \frac{x_0^2}{2}(1 - \cos 2\omega t)\right]$$

E_{sig} is the energy on the surface of the photoresponsive element, and E_{max} is the maximum energy through the lens system.

In the pilot model a photocell is oscillated back and forth along the optical axis, instead of vibrating the aperture. It has the same effect and there is less inertia to contend with. When

Fig. 1. Mell Greene, coinventor of the device, claims that the transducer used in the prototype is responsive to broad areas of color.

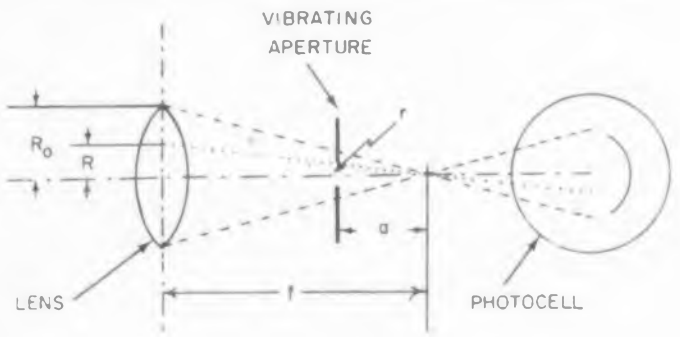


Fig. 2. Principle of automatic focusing. In this derivation, aperture is considered to vibrate; in practice the photocell is oscillated.

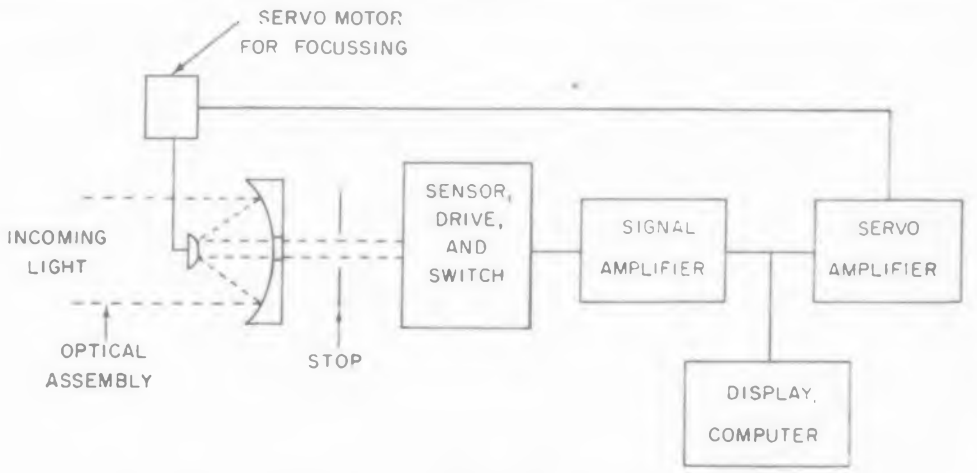


Fig. 3. The OAR system, adapted to ranging devices. Lens assembly shown is the reflecting type. The "stop" is a static aperture, behind which a vibrating photoresponsive element is driven along the optical axis. When the midpoint of the sensor's motion coincides with the image focal surface, the signal emitted has twice the frequency of vibration; shifting of the focal surface decreases the frequency and shows a phase shift indicative of the direction of movement.

the midpoint of the sensor's motion coincides with the image focal plane, the sensor's signal varies at 120 cps—twice the 60 cps vibration. If the focal conditions alter and the plane of image focus moves, the signal frequency diminishes toward 60 cps. This shift of frequency, which is out of phase with respect to the displacement of the centroid of the sensor element, yields an ideal signal for servo command.

A servo motor focuses the lens. Part of the signal can be used to activate a computer or display to give range directly. Setup for ranging and direction finding is blocked out in Fig. 3.

Operation

We went down to see the OAR system in operation. The prototype shown in the photo is bulky and not very beautiful; it's not meant to be. It was built just to demonstrate the automatic focusing principle. Greene says the whole device could be packaged in around 100 cu in.—4 x 5 x 5 in., for example—exclusive of the lens system, with a suitable choice of components.

In operation, the device was aimed at some cars in the parking lot. It gave a preliminary mutter and sat humming quietly to itself. The range indicator showed that it was focused on an automobile a hundred feet away.

A car drove past, the OAR system growled and the lens moved to focus on the new object. Range: 24 ft. When the car had gone by, the OAR unit moved back to focus on the original car. It did this several times, looking very impressive.

The OAR system's accuracy, claim the inventors, is limited only by the focal length and aperture of the lens, the wavelength-shortness of the radiation it is required to detect and the optical quality of the lens system. At 30 miles it should be able to detect and range an object the size of an airliner with two per cent accuracy.

Greene estimates that it should resolve dimensional differences as small as 40 x 10^{-6} cm. This means that precision parts could be monitored during grinding and controlled with a tolerance smaller than anything we know of.

If a PbS detector or other heat-sensitive element is used instead of a photocell and a quartz or sapphire lens instead of glass, the OAR system is suited to detecting, locating and measuring heat sources.

Comapco, Inc., is not a manufacturing concern; it is set up to do research. The applications noted above are not at present in process—they are so far speculation. Comapco plans to license the manufacture of the OAR system for a variety of applications.

For further information on this automatic focusing system turn to the Readers-Service Card and circle 103.

This article presents the key to tube type symbols used by most European tube manufacturers. Using these tables, the filament characteristics, structure and other pertinent data can be quickly determined.

Interpreting European Tube Symbols

Gerardo Gerardi

Boston, Mass.

TABLE 1 Receiving and Amplifier Tube Symbols

First Letter (Filament)	Subsequent Letters (Structure)	Figures (Socket)
A — 4v	A — rf single diode	30-39—Octal
C — 200 ma	B — rf double diode	40-49—Rimlock, special European
D — 1.4 v dc	C — triode, except output and gas filled	
E — 6.3 v	D — triode, output	80-89—9 pin min.
G — 5 v	E — tetrode, except output	90-99—7 pin min.
H — 150 ma	F — pentode, except output	All other numbers indicate special sockets
K — 2 v dc	H — hexode or heptode	
M — 2.5 v	K — octode or heptode	
O — no fil.	L — output tetrode or pentode	
P — 300 ma	M — tuning indicator	
U — 100 ma	P — tube with secondary emission system	
	Q — enneode	
	X — full-wave gas-filled rectifier	
	Y — half-wave vacuum rectifier	
	Z — full-wave vacuum rectifier	

Receiving and amplifier tubes are keyed as shown in Table 1. Special tubes (ruggedized, high reliability, long life) are keyed according to the same table, but the figures are placed between the letters.

For example, an EF 80 is a 6.3 v filament pentode, 9 pin miniature. An E80F would be ruggedized, long life, or other special versian of that type. An ECC-83 is a 6.3 v, dual triode, 9 pin miniature. Equivalent U.S. tube type for an ECC-83 is a 12AX7.

TABLE 2 Cathode Ray Tube Symbols

First Letter (Focusing)	Second Letter (Screen)
D — Electrostatic focussing and deflection in two directions	B — Bluish, short persistence, 1% max brightness after 0.01 sec.
M — Electromagnetic focussing and deflection	F — Orange, long persistence, 0.1% max brightness after 75 sec.
	G — Green, medium persistence, 1% max brightness after 0.05 sec.
	N — Green, long persistence, 0.1% max brightness after 6.4 sec.
	P — Double layer screen, short persistence blue followed by very long persistence green-yellow, 0.1% max brightness after 80 sec.
	R — Green-yellow long persistence, 0.1% max brightness after 20 sec.
	W — White, medium persistence; direct view; 8000 k color temp; projection: 5500 k color temp.

First group of figures—screen diameter in cm
Second group of figures—serial number

Cathode ray tube symbols indicate focussing method, type of screen, screen diameter and serial number (Table 2). A type DG13-2 is an electrostatic type, green, medium persistence, with a screen diameter of 13 cm.

TABLE 3 Transmitting and Rectifier Tube Symbols

First Letter (Classification)	Second Letter (Filament)	Third Letter (Cooling)
D — Rectifier (including grid-controlled)	A — direct, tungsten	G — Mercury filled
M — Triode, amplifier or modulator	B — direct, thoriated tungsten	L — Forced air
P — Pentode	C — direct, oxide coated	W — Water cooled
Q — Tetrode	E — heater-cathode	X — Zenon filled
T — Triode, rf, af or oscillator		

First Group of Figures

Rectifiers — dc output power, watts or kw, for tube in 3-phase half-wave circuit
RF Tubes — Approx. power output, watts or kw, in Class C telegraphy
Modulators — Approx. dissipation, watts or kw.

Added Letters (Socket)

E — Medium 7 pin
ED — Edison
EG — Goliath
G — Medium & pin
GB — Jumbo 4 pin
N — Medium 5 pin
P — P base

Transmitting and rectifier tube types are designated by two or three letters followed by two sets of figures. Tube classification is indicated by the first letter, or first two letters in the case of a dual type. In Table 3, the second letter becomes the third letter in a dual tube designation. Likewise, the third letter (cooling) becomes the fourth letter for dual tubes. Where no third (or fourth) letter is given, the tube is radiation cooled.

Transmitting type QQE 04/20 is a dual tetrode, indirectly heated cathode. Maximum anode voltage is 4 kv; output power is 20 watts. It is important to note that these characteristics must be interpreted in the light of the tube application.

TABLE 4 Phototube Symbols

First Figure (Base)	First Letter (Cathode)	Second Letter (Type)
2 — Loctal, 8 pin	A — Cesium antimony, blue sensitive	G — Gas filled
3 — Octal, 8 pin	C — Cesium on oxidized silver red sensitive	V — Vacuum
5 — Special		
8 — 9 pin miniature		
9 — 7 pin miniature		

Phototube type numbers consist of two figures followed by two letters. Tube base is indicated by the first figure; second figure is the serial number.

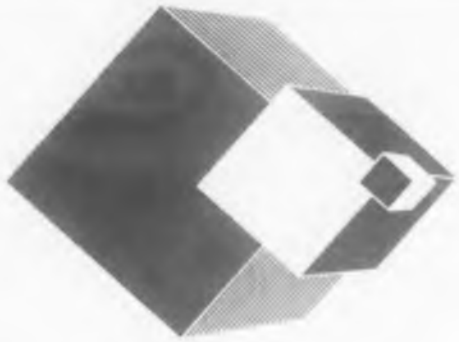
Type of cathode is indicated by the first letter, while the second letter gives the class of tube (Table 4). A 90AV is a miniature 7 pin, blue sensitive, high vacuum type.

TABLE 5 Voltage Regulator Symbols

Number (Voltage)	First Letter (Max current)	Figure	Second Letter (Base)
Average operating voltage	A — 8 ma	Serial number	K — Octal
	B — 20 ma		P — P base
	C — 40 ma		
	D — 100 ma		
	E — 200 ma		

Voltage regulators are coded by a number followed by a capital letter, a second figure, and often by another letter. Operating voltage is given by the first number. Current range is indicated by the first letter. The second figure indicates the serial number, and the last letter, if given, is the base type.

For example, according to Table 5, a type 85A2 operates at 85 v and 8 ma max current. Type 150C1K is a 150 v tube, 40 ma max current, with an octal base.



This is one of a series of papers presented at the Symposium on Microminiaturization of Electronic Assemblies sponsored by Diamond Ordnance Fuze Laboratories late last year. Because symposium attendance was limited to government personnel only, ELECTRONIC DESIGN is publishing these papers as a special service to our readers. In addition, all of the symposium papers will be published in their entirety in bound form available only from ELECTRONIC DESIGN. For further information on these Proceedings, turn to Reader Service Card and circle 100.

Design of a

Two-Transistor Binary Counter

P. Emile, Jr.
Diamond Ordnance Fuze Laboratories
Washington 25, D. C.

Three levels of design are suggested by the author. Each level is aimed for circuit operation under different conditions and the author discusses the various factors important to this operation.

DESIGN of a binary counter of the Eccles-Jordan flip-flop type can be regarded as a three stage problem. First is the design of the basic circuit for laboratory breadboard operation. Second stage involves design of the circuit in field equipment where checking and replacement are possible. The third level of design is that of a circuit to go into a piece of field equipment where unit replacement is not possible due to inaccessibility or microminiaturization.

A typical saturated two-transistor flip-flop equipped with set and reset networks is shown in Fig. 1 (a).

If the "set" and "reset" inputs of the circuit of Fig. 1 (a) are tied together, Fig. 1 (b), the circuit will operate as a binary counter. In this case the positive input pulse goes to both transistor bases, but can only cut "off" the conducting transistor. This circuit is sensitive to the relation of the size of the cross-coupling capacitors, C_c, and the shape and duration of the trigger pulse. Wider variations in this pulse may be tolerated, and cross-coupling capacitors may be omitted, if the input pulse is steered to the proper transistor. The input circuit may be converted to a steering circuit by connecting the diode biasing resistors R_{K1} and R_{K2} to the collectors of T_1 and T_2 respectively. In addition, the resistors R_S may be returned to a positive voltage source, V_{BB}, to insure cut-off of the transistors.

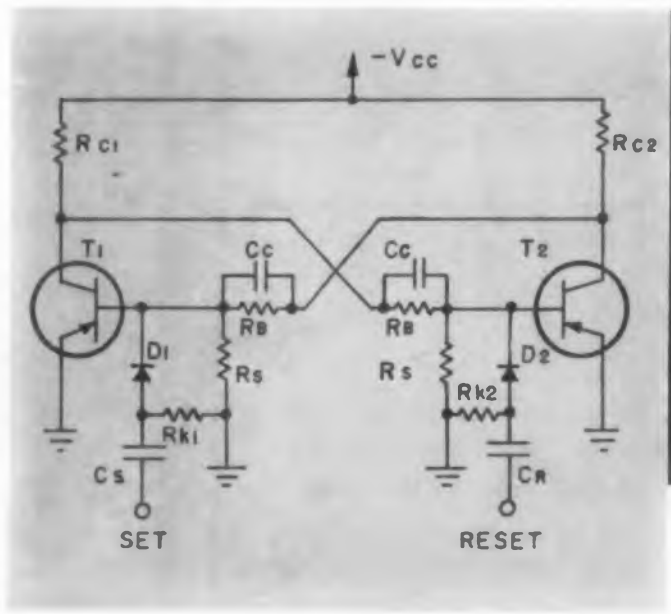
In many applications the input to the binary counter is a square wave from a previous stage as shown in Fig. 1 (b). In this case the time constants $R_T C_S$ and $R_T C_R$ also play a part in determining the recovery time of the counter. Waveforms during operation (Fig. 2) illustrate what happens at various points in the circuit for a square-wave input.

First Level Design

In the first level of design of a binary counter, one needs to consider only:

- Output signal power required
- Input signal power available
- Speed at which the stage must count

The maximum speed at which a binary counter



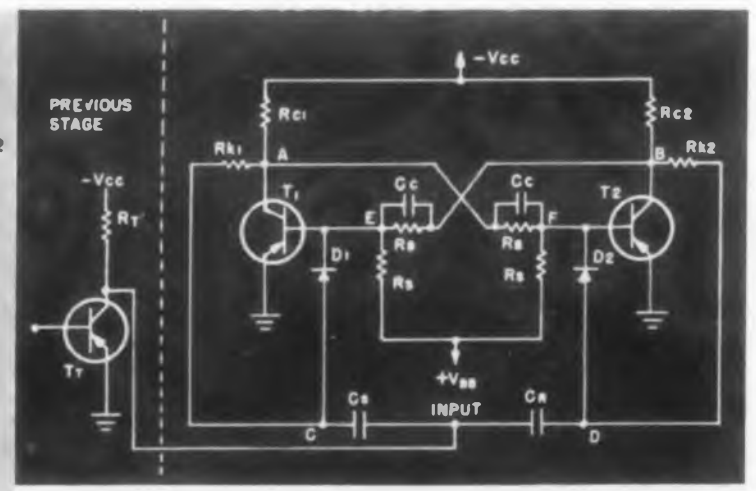


Fig. 1. Two-transistor flip-flop with set and reset networks (a) and reconnected (b) for operation as a binary counter.

will operate depends on the alpha cutoff frequency of the transistors used, in addition to other factors to be discussed. In this type of circuit, a good "rule of thumb" is that the maximum speed at which a counter will run reliably is approximately 1/10 the alpha cutoff frequency of the transistor.

To realize this speed, cross-coupling capacitors must be used. For instance, in the case of the surface barrier transistor, the maximum speed of operation is about 300 kc without capacitors and about 2 mc with cross-coupling capacitors of the proper value.

By employing emitter-follower coupling and faster gating this factor of 1/10 can be increased to about 1/5. If complementary-symmetry circuits and high-speed gates are used, this factor can be increased to about 1/3 or 1/2.5.[1,2] If one chooses the maximum frequency of operation of the binary counter to be 1/10 alpha cutoff, the minimum alpha cutoff of the transistor to be used is specified. To decide exactly what transistor to use one may also wish to consider size, β, and material (germanium or silicon).

Another good "rule of thumb" is that the output voltage obtained from a circuit of this type is from 0.7 V_{CC} to 0.8 V_{CC}, where V_{CC} is the collector supply voltage. Therefore when the desired output voltage is specified the supply voltage can also be immediately specified.

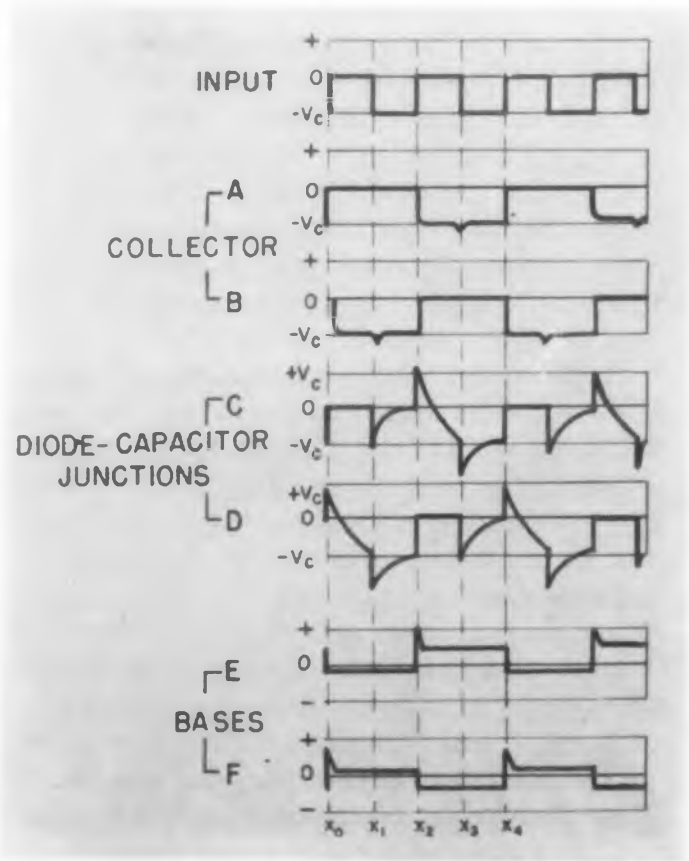


Fig. 2. Waveforms in the two-transistor binary counter shown in Fig. 1(b). Letters refer to points on the circuit of Fig. 1(b).

It may be shown that the relationship

$$R_B \cong \frac{\beta}{4} R_C$$

gives a safety factor ($S = 4$) to allow for decrease in β and still insure saturated operation for a grounded emitter switch as used in the basic flip-flop.[3] In the basic flip-flop the size of the collector resistor, R_C, is limited by several factors. The minimum R_C is limited by the maximum current rating of the transistor and/or the allowable power dissipation by the flip-flop. The maximum R_C is limited by the load R_L which must be driven from the collector.

$$R_L = \frac{R_B R_{EXT}}{R_B + R_{EXT}}$$

where R_B is a base biasing resistor and R_{EXT} is the external load resistance. Assuming that the maximum R_C is desired, one can compute R_C to be:

$$R_C = \frac{\beta - 3S}{3\beta} R_{EXT}$$

The value of R_C is thus specified in terms of the β of the transistor to be used, the safety factor S and the external load to be driven. If the load is capacitive it is well to specify R_C such that

$$R_C C_L \leq \frac{1}{10f}$$

where C_L is the loading capacitance and f is the maximum frequency at which the circuit is to operate. This will insure reasonably square output waveforms.

Results of sample calculations indicate that if all other factors are equal, the use of a transistor with the higher β will result in a larger R_C (and therefore lower power dissipation for the counter). An expression for R_B in terms of the external load, the β of the transistor and the safety factor is:

$$R_B = R_{EXT} (\beta/3S - 1)$$

Resistor R_S is chosen to limit the effect of I_{CBO} in the "off" transistor. It should be five or more times larger than R_B ($R_S \geq R_B$) to prevent loading of the "on" transistor. Often R_S is returned to a positive voltage $+V_{BB}$ rather than to ground.

For shortest recovery time of the binary, R_K should be small. However, a lower limit for R_K of about $5R_C$ ($R_K \geq 5R_C$) is necessary to limit feed-through and loading. A value often used is $R_K = 10\,R_C$.

The cross-coupling capacitors C_C should be large enough to transfer enough charge to switch the transistor from "off" to "on." They should not be so large as to transfer appreciable charge to the collector, of say, T_1, when T_2 is "on" and the reset diode, D_2, is pulsed. Theory predicts that for the highest speed of operation $V_C\,C_C$ should be greater than Q_A, the charge stored in the base region of the "on" transistor, excluding charge due to saturation.

If highest speed of operation is not of importance the cross-coupling capacitors are unnecessary with the type of steering described in this article. In the event that the cross-coupling capacitors are omitted the transition time of the flip-flop is approximately equal to the time for the "off" transistor to turn on with current drive through R_B only. This switching time may be computed from Ebers' and Moll's equations.

It is difficult to calculate the transition time if the cross-coupling capacitors are included. However, experimental results show that the transition time for a circuit with cross-coupling capacitors can be less than 1/3 the transition time for the same circuit without cross coupling capacitors.

The input capacitors C_S and C_R should be as small as possible to allow shortest recovery time of the binary counter. However, for good operation of the binary counter described herein, the input pulse must completely switch the "on" transistor to "off." This requires that

$$V_I\,C_S = V_I\,C_R \geq Q_T$$

where V_I is the minimum input voltage to the binary counter and Q_T is the charge required to turn "off" the "on" transistor. In cases where the turn-off charge and minimum input signal are known the values of C_S and C_R may be computed directly. If Q_T is not known then

$$C_S = C_R \geq \frac{3Q_A}{V_I}$$

will give usable values of C_S and C_R. In circuits which use cross-coupling capacitors it is well to specify $C_S = C_R = 3C_C$. Much larger values of C_S and C_R are sometimes used but one must insure that the time constants $R_{K1}\,C_S$ and $R_{K2}\,C_R$ are small compared to the time between input pulses.

For room temperature operation and at collector current levels high compared to I_{CBO}, e.g. I_C° 1 ma for 2N77 type transistors, practically any diodes will suffice, e.g. 1N99, 1N34, 1N56. For operation at high temperature or at collector current I_C° comparable to $\beta\ I_{CBO}$ the back impedance of the diodes must be high (greater than 10 megohms). Otherwise voltage leakage to the transistor bases from points C and D will offset the effect of the positive bias voltage and cause the circuit to fail. Silicon diodes have performed satisfactorily in some low current circuits.

(continued on following page)

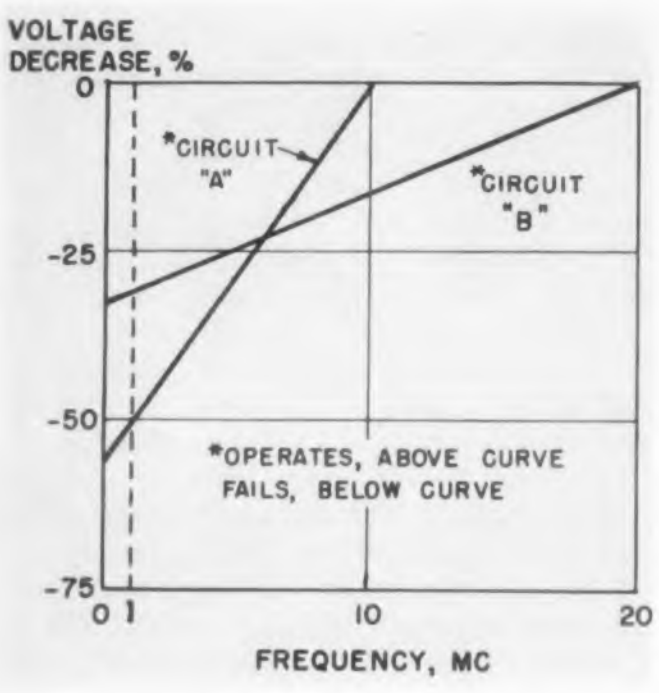


Fig. 3. Lower limit of input voltage before failure versus counting frequency.

Second Level Design

The second level of design is that of a circuit to work in a field system, such as a computer in which marginal checking and unit replacement are allowed. At the second level of design additional factors enter, such as:

- Total power consumption
- Circuit tolerances
- Temperature considerations
- Total number of components
- Cost per unit

Often in large systems, although impedance levels may be fixed, the supply voltages and current levels may be flexible. In such cases a generalized common-emitter NOR circuit may be considered. This circuit may then be designed for minimum power dissipation.[4]

Circuit tolerances of a binary counter must be known if the circuit is to be used in a large system. For example, will the circuit fail to operate (1) if the input voltage decreases 20 per cent, (2) if the supply voltage drops 10 per cent, (3) if the collector resistors are different by 30 per cent?

The curves in Fig. 3 show one concept of margins. The plots are allowed percentage decreases of input voltage before failure occurs vs. counting frequency. The curve labelled "*A*" is for a type of direct-coupled binary counter. The curve labelled "*B*" is for an optimized emitter-follower-coupled binary counter. Either of the circuits will operate if the input voltage is above the lines.

Consider the case of operation at 10 mc. This is practically the upper frequency limit of circuit A. A 1 per cent decrease in the input signal from the nominal 100 per cent input level would cause this circuit to fail. Circuit *B*, on the other hand, will operate if the signal decreases 15 per cent from its nominal input value at 10 mc. However, at 1 mc the situation has changed. At this point the circuit *A* will operate if the input voltage is decreased 50 per cent from the nominal value while circuit *B* must receive a signal within 30 per cent of its nominal value to operate properly. For 10 mc operation it is clear which circuit would be used for reliable operation. For 1 mc operation there is a choice.

In marginal checking, the problem is to find a so-called "handle" to vary which will cause circuits which are near failure, or "marginal," to fail. In the case of the binary counter a good "handle" in many cases proves to be the positive voltage supply, $+V_{BB}$. If a circuit is near failure because of high I_{CBO} due to temperature or age, lowering the positive voltage will cause the circuit to fail. If the circuit is near failure due to a decrease in β, increasing the positive voltage above the design value will cause the circuit to fail. Upper and lower limits before failure may be set in both cases.

The design value of the positive voltage, in particular, must be determined by the highest expected temperature of operation and the expected I_{CBO} at that temperature. However, if low temperature operation is also anticipated the safety factor (*S*) must be chosen high enough that the decrease in β with lower temperature will not cause circuit failure. Silicon transistors must almost certainly be used if high temperature operation is desired, e.g. 150 C.

The number of component parts used in a binary counter circuit is a compromise between a conservative design using 8-10 transistors per stage with each transistor performing a simple separate function (e.g. logical binary counter and a design using only 2 transistors. Reliability may be higher for the more conservative design, but, on the other hand, it may not be because long-term reliability varies inversely with the number of active components. Local experience has shown that the binary counter design (without the cross-coupling capacitors) performs very well for low frequency operation (less than 10 kc) with the 2N207 audio transistor. With cross-coupling capacitors and using surface barrier transistors the circuit performs with greater than 10 per cent margins up to 2 mc.

If emitter-followers are added and higher speed steering gates used, the circuit will operate up to 20 mc. This last is a maximum frequency and 10 mc or 16 mc is thought to be a more practical limit, i.e., 10 per cent or greater margins on input voltage and other design values. The binary counter presented here represents a good compromise among the various factors mentioned. There are circuits which operate faster and there are circuits which theoretically would be more reliable for random counting in that RC time constants would not be used, e.g. the logical binary counter.[5,6]

The average cost of assembly of several breadboard systems at DOFL has been 10 per transistor and associated components. Considering the cost of the transistors, diodes, resistors, and capacitors, the type of binary counter described herein has cost about $30 per stage in a breadboard version. If the cost per transistor remained unchanged the logical binary counter would cost approximately $100 per stage in a breadboard version. Microminiaturized binary counter modules now under investigation may eventually cost in the range of $1 to $3.

Third Level Design

The third level of design is that of a circuit to be used in a system where unit replacement is impossible. This situation occurs in microminiaturization.

The design requirements for a circuit to go in a sealed system are more rigorous than for a circuit which can be replaced if defective. After the circuit has been designed and thoroughly tested in a breadboard model, it is necessary to specify a rigorous acceptance or rejection test for the field models. Analysis of the circuit may be so complete that off-value, weak, or defective components can be identified merely by observing a single-output waveform. This should be possible even if the circuit is not malfunctioning at the time of the observation. The circuit may then be rejected before potting or final sealing, or at least restricted to uses in which its weaknesses will not endanger future operation of the system. For instance, if it were discovered that the I_{CBO} of the transistors was higher than the design value, the circuit might still be used in low temperature applications if all its other characteristics were acceptable.

If the circuit uses standard size components, the waveforms at several points may be monitored. In the case of this binary counter, the waveforms at points *C* and *D*, Figs. 1 (b) and 2, give much information about the circuit. For instance, the decay times of the step waveforms indicate the time constants $R_K C_B$ and $R_K C_R$. These time constants compared to the input frequency show how close the circuit is to its maximum frequency of operation. The voltage levels at points *C* and *D* indicate the collector voltage of the off transistor and thereby indicate the I_{CBO}. The height of the positive spike can be used as a measure of the charge required to turn off the "on" transistor if the input signal and diode characteristics are known. This height indirectly measures the alpha cutoff frequency of

the transistors in the binary counter. The points *C* and *D* in a binary counter would then be good points to monitor for an acceptance test.

In the microminiaturized DOFL-2D binary counter wafers now being studied only one output terminal is available.[7] This point is the output of one collector which would normally drive the following stage. The resistors in this wafer are carbon deposited strips, the capacitors are silver fired areas, the diodes are germanium dots and the transistors are bits of germanium mounted in holes in the 1/2 inch by 1/2 inch by 1/50 inch ceramic plate. Checking the internal connections with a probe and an oscilloscope is difficult unless the probe is very small. If the wafers are potted or stacked, this becomes impossible.

Three different approaches have been made to check the individual circuits through the use of the external connections only.

First, resistance measurements have been made between all terminals taken two at a time. This method can identify some catastrophic failures and is good to detect "leakage paths." However, the test is a dc test and somewhat limited.

Secondly, a series of so-called "standard tests" was set up as follows:

(1) Output voltage was measured; waveshape noted

(2) Positive voltage decreased to zero or until circuit fails to operate correctly. Output voltage at $V_{BB} = 0$ or plus bias voltage when failure occurs was measured.

(3) Upper and lower limits on input voltage before failure was measured.

(4) The collector voltage was lowered until the circuit failed. Operation at −3 volts was also checked.

(5) Maximum resistive load and maximum capacitive load before failure was measured.

(6) Upper frequency limit was determined. Also resistor R_T was varied from 100 to 10 K and the upper frequency limit was noted at each value of R_T.

(7) Circuits were labelled and any anomalies noted.

The expected results of the standard tests can be computed from the circuit design. These results are then compared with the results obtained from a breadboard model. Any differences are corrected by improved theory and redesign. Next, the results from the 2D wafers are compared with the breadboard circuit results. Any differences will be due to off-value, weak or defective components. In some cases the values of the components in the 2D circuit can be determined and if they are too far off, the information can be fed back to the makers of the 2D wafers.

A third method of analysis has also been tried. Resistors, capacitors and diodes in a breadboard model of the binary counter were systematically

bridged, shorted or opened. Also, transistors with very high β and very low β were substituted in the unit. The effect of these mutations was observed on the accessible waveforms, in the case of the 2D binary counter, the output waveform. Knowing these casual relationships a first order analysis of the circuit condition can be made by carefully observing pips, slopes and amplitudes of the output waveform.

More detailed information on the processes described in this article will be found in the complete paper to be published in our Proceedings of the Symposium on Microminiaturization of Electronic Assemblies. For further information on the Proceedings, turn to Reader Service Card and circle **100**.

References

1. Boosting Transistor Switching Speed, R. H. Baker, *Electronics*, 30, No. 3, pp. 190-3, 1 March 1957.
2. High Speed Counter Uses Surface Barrier Transistors, Euyen Gott, *Electronics*, 29, No. 3, pp. 174-8 March 1956.
3. Design Considerations for Two Types of Transistor Multivibrator Circuits, P. Emile, DOFL Report No. TR-487, 1 Nov. 1957.
4. The Design of a Transistor NOR Circuit for Minimum Power Dissipation, E. L. Cox, a paper presented before the Symposium on Microminiaturization of Electronic Assemblies, Diamond Ordnance Fuze Laboratories, 1 Oct., 1958.
5. Higher Speed Computer Circuits, A. K. Rapp, and M. M. Fortini, Digest of Technical Papers, 1958, Transistor and Solid States Conference, pp. 12-14.
6. DCTL Complimenting Flip-Flop Circuits, E. Gray Clark, ELECTRONIC DESIGN, 5, No. 12, pp. 24-27, 15 June 1957. Also, "Part II," 5, No. 15, p. 34, 1 August 1957.
7. Microminiaturization of Internal Electronics 'Microelectronics', T. A. Prugh, Proceedings of the Second National Convention on Military Electronics, sponsored by the PGME, IRE, at Washington, D. C., 17 June 1958.

Acknowledgments

The author wishes to acknowledge the helpful discussions with T. A. Prugh during the preparation of this paper. The author also wishes to thank N. J. Doctor, Amiel I. Goodman and E. L. Cox for help in devising test procedures described in this paper.

Designing a Transistor NOR Circuit for Minimum Power Dissipation

Elbert L. Cox
Diamond Ordnance Fuze Laboratories
Washington, D. C.

Computers make extensive use of NOR circuits because they perform all of the logic functions. In this article, the author describes a method of designing a transistor version of a NOR circuit.

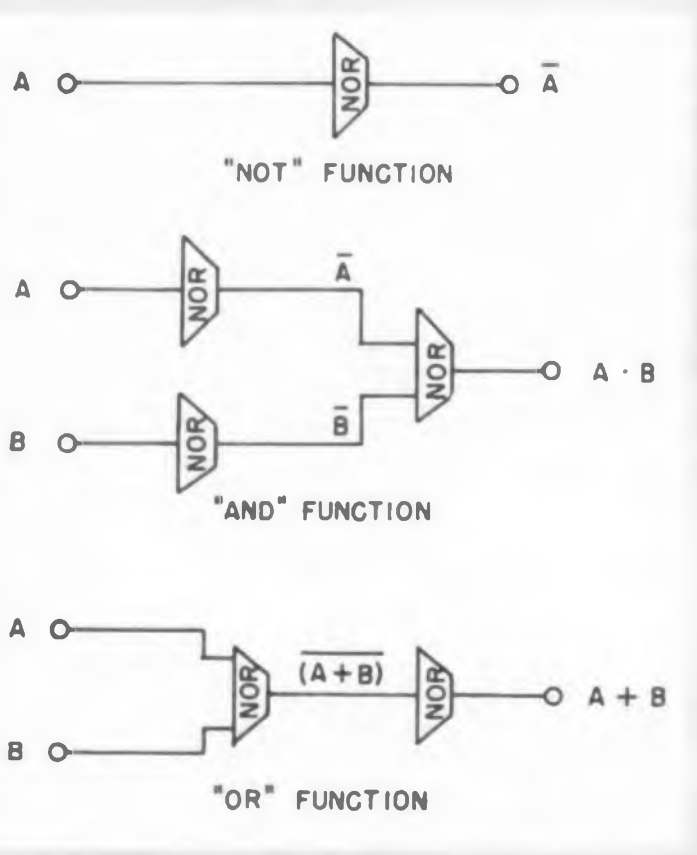


Fig. 1. (left) English logic functions performed by NOR circuits.

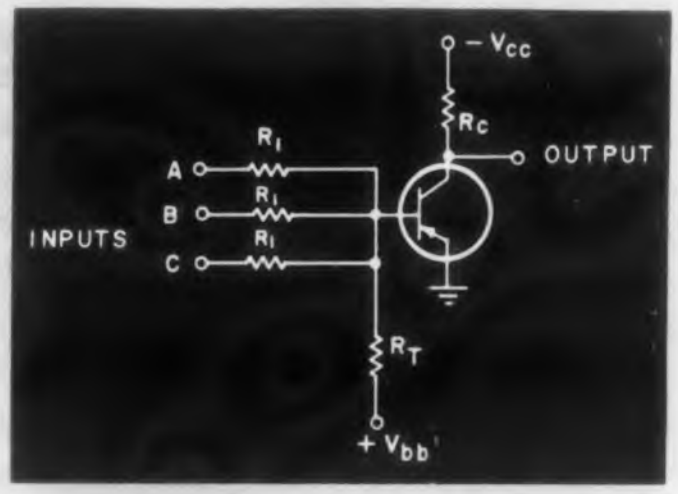


Fig. 2. (above) Basic transistor NOR Circuit.

BECAUSE the transistor NOR circuit is capable of performing all of the English logic functions AND, OR, and NOT, it is extremely useful in computer systems. The NOT function is performed by a NOR with one input. The AND function is performed by three NOR circuits and the OR function is performed by two NOR circuits as shown in Fig. 1.

The basic building block, the transistor NOR circuit as shown in Fig. 2, employs a junction transistor in the common emitter configuration. The transistor is used as a two-position switch rather than as a linear device.

As shown in Fig. 2, the circuit consists of M input lines with input resistors R_1, a base bias resistor R_T, and a collector resistor R_C. The positive bias $V_{bb'}$ supplied through R_T causes the transistor to be turned off if all of the inputs (A, B, and C) are near zero voltage. The transistor is on if one or more of the inputs (A, B, C) are at a negative voltage V_{cc}. V_{cc} must be sufficiently large such that the current I_B through R_1 is equal to or greater than I_C/B, where B is the base to collector short circuited current gain, and I_C is the maximum current in the collector resistor R_C.

When the transistor is cut-off, the output voltage is approximately the same as the supply voltage V_{cc}. When the transistor is in the saturated state most of the collector supply voltage V_{cc} appears across R_C and the output is near ground potential. A voltage signal is present on the output if voltage signals are not present on any of the inputs. Conversely, a voltage signal is not present on the output if voltage signals are present on any or all of the inputs.

A basic question encountered in using the NOR circuit is "will the circuit operate properly when a single collector is required to drive a certain desired number of output circuits?" An expression for this number of outputs, N, in terms of

the circuit components, was derived by W. D. Rowe.[1]

$$N = I_c\left[\frac{1}{SI_c + I_{cmo} + \dfrac{0.25(M-1)}{R_1}} + \frac{R_1}{V_{cc}}\right] \quad (1)$$

Where I_{cmo} is the maximum expected base to collector leakage current with the emitter open circuited. 0.25 is the base to emitter voltage for germanium transistors, and S is the safety factor employed to compensate for a decrease in gain of the transistor and other circuit parameter tolerances.

It was assumed that V_{BE}, the base to emitter voltage when the transistor is in the "on" state, was very much smaller than V_{cc}, the collector supply voltage and that the leakage current I_{cmo} was very much smaller than I_c, the maximum current flowing in the collector resistor. It was also assumed that the transistor acts as a perfect switch when the transistor is in the saturated state. Consequently, under saturated conditions $-V_{cc} = I_cR_c$. All results will be based on these assumptions.

Given a certain number of inputs to a NOR circuit which is to drive a certain number of output circuits, it is desired to minimize the power dissipation $I_c^2R_c$ in the collector resistor R_c, subject to the restriction that eq (1) be satisfied. The objective here is to minimize $I_c^2R_c$ with respect to base resistor, R_1, and collector current I_c.

Input Current Limiting Resistor

From eq (1) the expression for $R_1{}^\circ$ may be derived.

$$R_1{}^\circ = \frac{0.25(M-1)}{I_c\sqrt{\frac{1}{N}\left(\frac{I_{cmo}}{I_c}+\frac{S}{B}\right)} - \left[\frac{I_{cmo}}{I_c}+\frac{S}{B}\right]} \quad (2)$$

This expression gives the value of the input-current limiting resistor for a minimum R_c and also minimum power dissipation $(I_c^2R_c)$, if such a minimum exists. The expression for power dissipation is:

$$I_c^2R_c = \frac{I_c^2R_1}{\dfrac{1}{\dfrac{S}{B}+\dfrac{I_{cmo}}{I_c}+\dfrac{0.25(M-1)}{R_1\,I_c}} - N} \quad (3)$$

Collector Current

Collector current for minimum power dissipation $(I_c{}^\circ)$ is:

$$I_c{}^\circ = \frac{I_{cmo}\left(-1+4N\dfrac{S}{B}+\sqrt{1+8N\dfrac{S}{B}}\right)}{2\left[\dfrac{S}{B}-N\left(\dfrac{S}{B}\right)^2\right]} \quad (4)$$

Minimum power dissipation will be designated as $(I_c^2R_c)^\circ$.

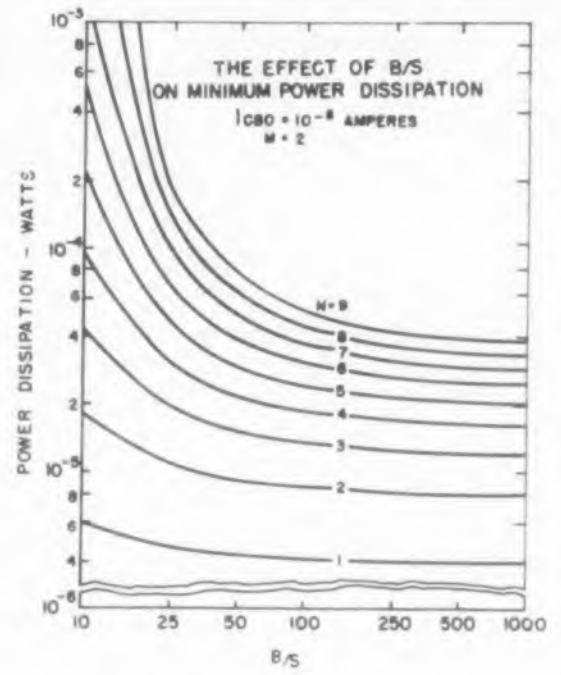


Fig. 3. Effect of B/S on minimum power dissipation.

When (4) is substituted into (2) R_1 reduces to

$$R_1^\circ = \frac{0.25(M-1)}{I_{CBO}} \tag{5}$$

The expressions (4) and (5) for the collector current (I_C°) and the input-current limiting resistor (R_1°) when substituted in eq (3) (power dissipation) give a minimum in power dissipation $(I_C^2 R_C)^\circ$.

Using the expressions for R_1° and I_C° a program of moderate complexity was devised for an IBM 704 Computer to calculate minimum power dissipation as a function of I_{CBO} (base to collector leakage current), B/S (base to collector current gain with safety factor), M (number of input circuits), and N (number of output circuits). The computed values provided sufficient data for the creation of informative graphical results.

Referring to Fig. 3, minimum power dissipation decreases with a decrease in the number of output circuits. The minimum power dissipation decreases with an increase in B/S, and as B/S becomes infinite, this decrease approaches the limit

$$4N(M-1)I_{CBO}$$

It is also interesting to note that as N decreases to 1, B/S becomes decreasingly significant in the determination of minimum power dissipation.

Referring to Fig. 4, I_C° also decreases with a decrease in the number of output circuits. I_C° decreases with an increase in B/S and this decrease approaches a limit as B/S becomes infinite. This limit is $4NI_{CBO}$. Note that as N decreases to 1, B/S becomes decreasingly significant in the determination of the collector current which gives a minimum in power dissipation. It can also be determined that minimum power dissipa-

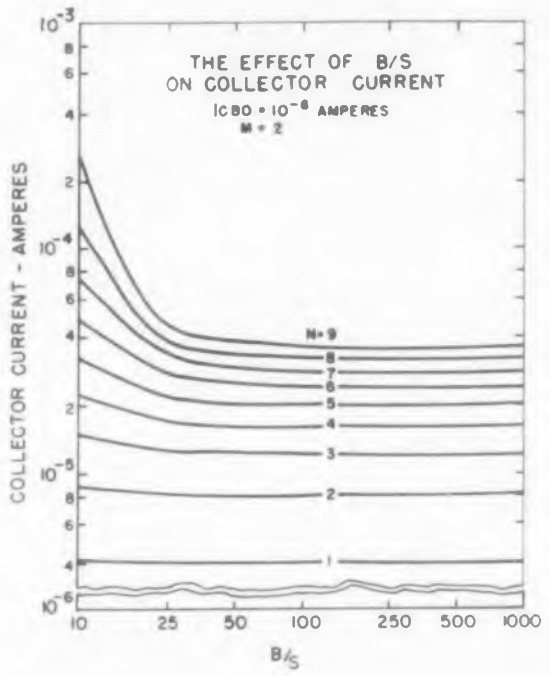


Fig. 4. Effect of B/S on collector current.

tion is linearly related to I_{CBO} and $0.25(M\text{-}1)$:

Specifically if a transistor NOR circuit is to have two inputs ($M = 2$), drive nine circuits ($N = 9$), employ transistors with Betas of 50 ($B = 50$), and I_{CBO}'s of 10^{-6} amperes, correct values of V_{cc}, R_c, I_c and R_1 can be ascertained to effect minimum power dissipation. For this particular design situation a safety factor of 2 is employed. The B/S factor is therefore 25. Values of I_{CBO}, B, and M used in this typical example were chosen because of their practicability to current design situations.

If the above values for I_{CBO}, B/S, M and N are substituted in expressions (4) and (5) the calculations yield

$$R_1^\circ = 250 \text{ K and } I_c^\circ = 47 \text{ μa.}$$

Therefore minimum power dissipation using eq. (3) is 177 μwatts. The collector supply V_{cc} is then calculated to be 3.75 v. Consequently $R_c = 79$ K.

If V_{BE} is not very much less than V_{cc} and I_{CBO} is not very much less than I_c, the NOR circuit may be capable of driving but, say, eight outputs rather than nine. In this case, design for one more output than actually needed.

More detailed information on the processes described in this article will be found in the complete paper to be published in our Proceedings of the Symposium on Microminiaturization of Electronic Assemblies. For further information on the Proceedings; turn to Reader Service Card and circle **100**.

Reference

The Transistor NOR Circuit, W. D. Rowe, ELECTRONIC DESIGN, Feb. 5, '58, p. 26.

Standard Transistor Switching Circuits

Thomas A. Prugh

Diamond Ordnance Fuze Laboratories
Washington 25, D. C.

Circuits described in this article were designed as compatible building blocks to be interconnected to perform complex functions. This is a preliminary effort to solve the standard-circuit problem for circuits to be used at frequencies up to 15 kc and temperatures below 45 C. Future effort will be aimed at adding new and more efficient circuits.

STANDARD circuits and modules are being increasingly considered by the electronics industry because they avoid repetitious design. Also from the standpoint of mass production a few widely applicable standard circuits would permit low unit cost and high reliability. And as the circuits get smaller and are manufactured by printing or vacuum-deposition methods, the system designer will become primarily interested in the functioning of logical blocks rather than the individual component part values. In order to achieve reliable building blocks, the circuit design can and should be considered in detail only during the overall design of the particular wafers or modules. These modules then are stocked as the smallest component to be handled in development and production activities.

Work at the Diamond Ordnance Fuze Laboratories has resulted in circuits useful for rapid assembly of working systems. The circuits are primarily of the low power level, information handling type. Typical applications include digital computing and timing operations. The circuits are restricted to those using the transistor as an off-on or relay-type device.

Specific Circuits

Standard circuits that have been designed are:

- Inverter
- Inverter less load
- NOR
- Flip-flop
- Binary counter
- Monostable multivibrator
- Free-running multivibrator
- Lamp control
- Power switch

These particular circuit types were chosen, in part, because they have been studied extensively. As a result, detailed information is available or calculable on the design, performance, and limitations of the circuits. Specific component part values are shown in the schematics. From the standpoint of presently used techniques of making microminiature assemblies, the resistor elements are the easiest to handle. Accordingly the circuits are designed to use no inductors and as few capacitors as possible.

Inverter (IN). The inverter circuit[1] shown in Fig. 1, as its name implies, inverts the input signal. For —1.5 volts in, the output is 0; for 0 in, —1.5 volts out. One inverter stage can drive several other inverter stages or similar type loads.

Inverter (INLL). A degenerate form of the inverter is shown in Fig. 2. The load resistor of 1 K ohm, normally found in the collector circuit, is omitted. This circuit is used to couple a signal to a common load resistor fed by several circuits.

NOR. The NOR circuit[2, 3] is similar to the inverter except for the number of inputs. The NOR shown in Fig. 3 has two inputs. In principle, any number could be used. In practice, the two-input version is a compromise between versatility and noncriticalness. The two-input version is a compromise between versatility and noncriticalness. The two-input NOR has many similar logical properties to the two-grid pentode gating circuit. The logical function performed by the NOR is shown beside the schematic of Fig. 3. When neither A nor B is present an output exists. The NOR is an elemental building block. With one or more NOR circuits all the logical functions including NOT, AND, OR can be performed.

Flip-Flop (FF). A bistable circuit can be formed by connecting two inverter circuits together to form a toggle or flip-flop.[4] The schematic is shown in Fig. 4. Information can be coupled into the flip-flop by connecting the collector of an INLL circuit to one of the collectors of the FF.

Binary Counters (BC and BCR). The flip-flop can be modified by the addition of input pulse steering circuits to obtain a binary counter[5, 6] as shown in Fig. 5. The added capacitors, diodes and resistors provide alternate feeding of the input pulses to one transistor, then to the other.

When initial conditions need to be set into the binary counter, diodes coupled to the base of each transistor can be added as shown in Fig. 6.

Monostable Multivibrator (MMV). The monostable multivibrator[7] is used to generate a gate or time delay following an initiating trigger pulse. The design shown in Fig. 7 has the delay time adjusted by choice of the coupling capacitor between the two transistors. The start pulse is coupled into the "normally-on" transistor by means of a capacitor, resistor, and diode network.

Free Running Multivibrator (FRMV). The free running multivibrator[8] of Fig. 8 is a source of two

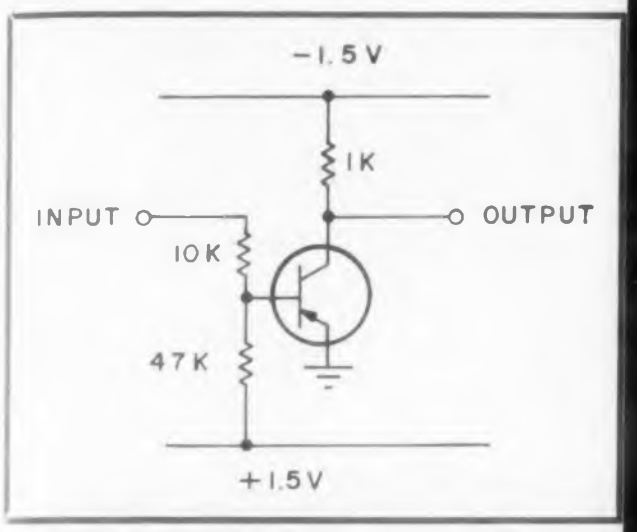
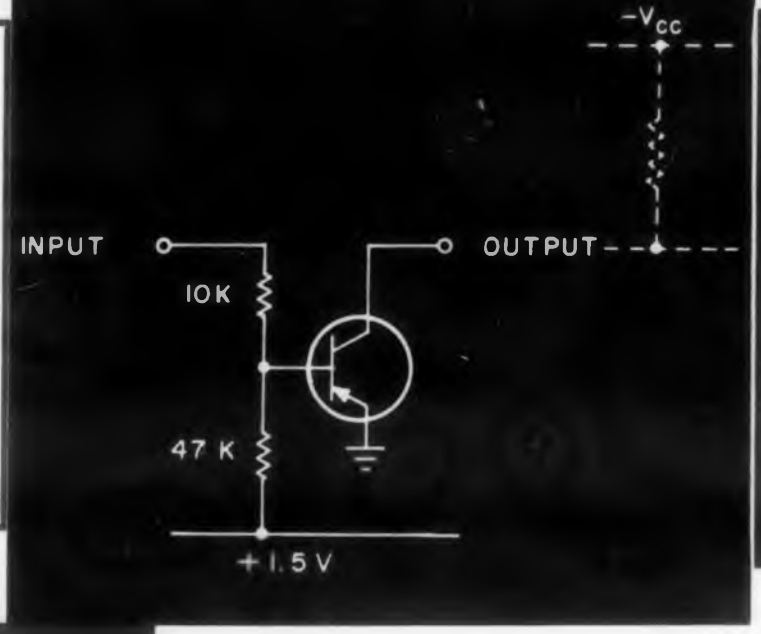


Fig. 1. (above) Inverter (IN)

Fig. 2. (right) Inverter less load (INLL)



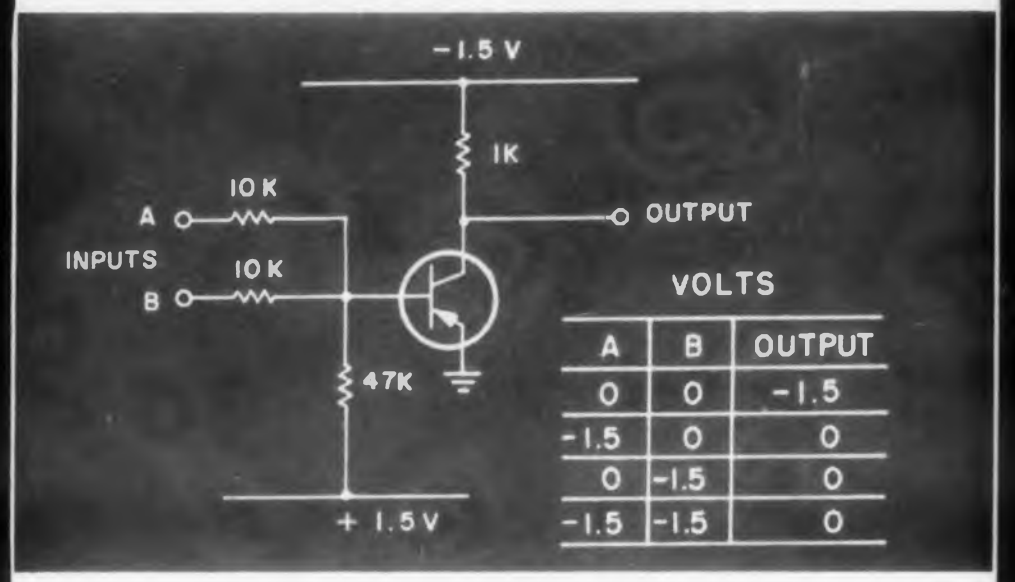


Fig. 3. NOR Circuit

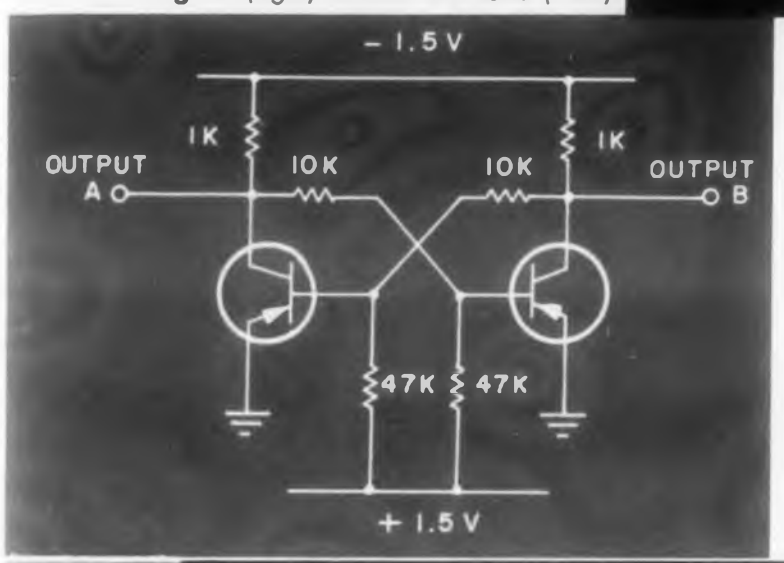


Fig. 4. (left) Flip-flop (FF)

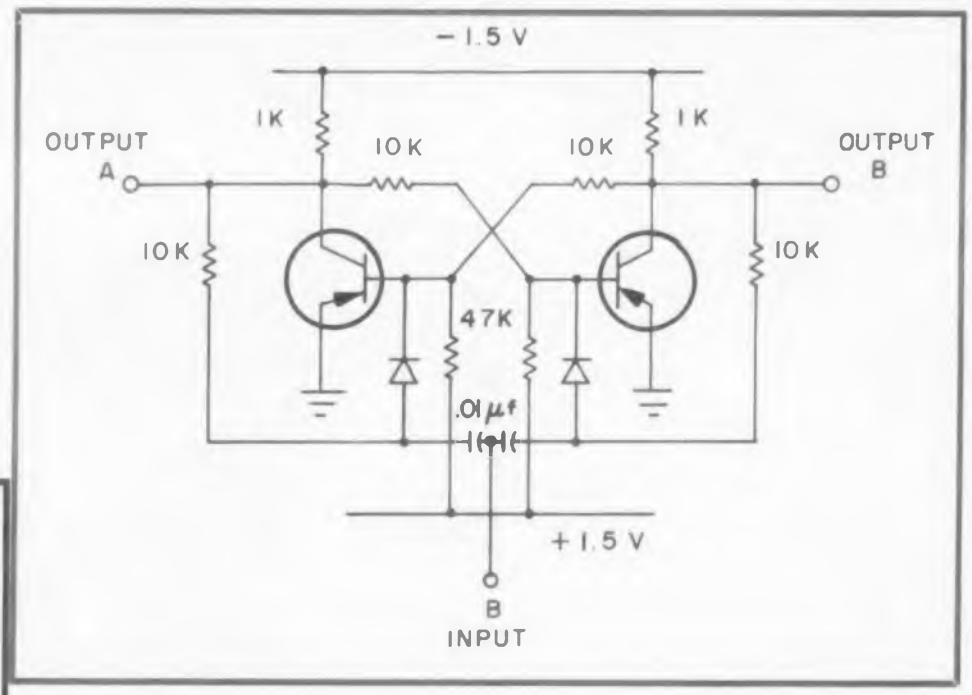


Fig. 5. (right) Binary counter (BC)

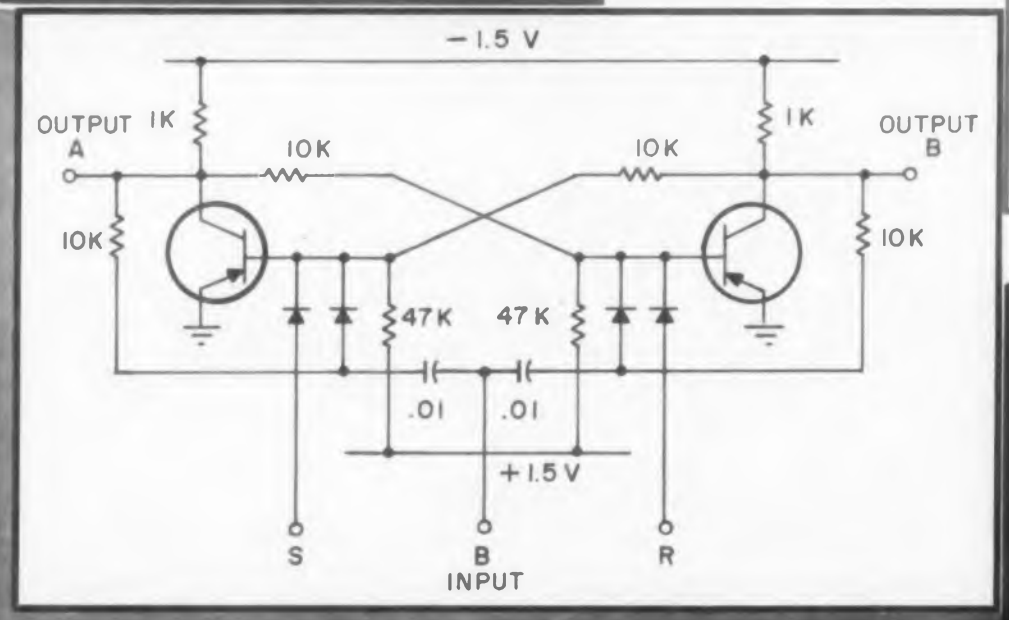


Fig. 6. Binary counter resettable (BCR)

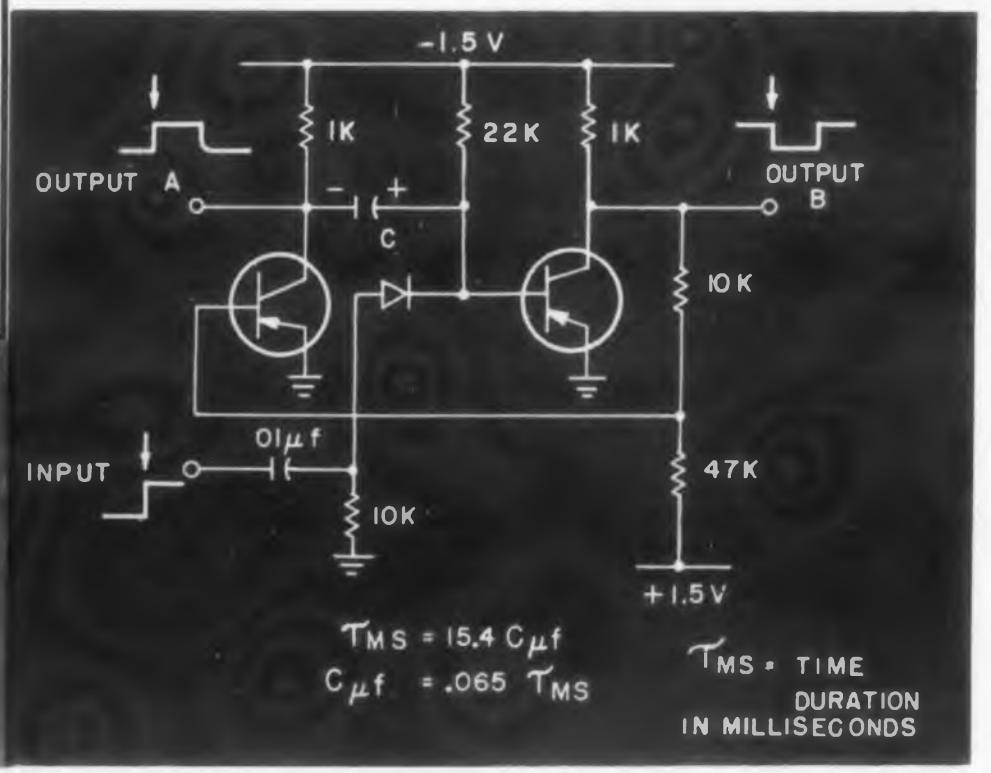
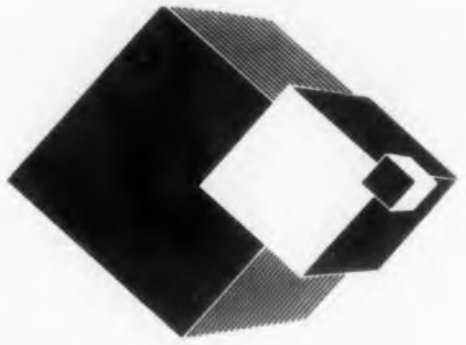


Fig. 7. (right) Monostable multivibrator (MMV)



symmetrical square waves of opposite polarities. The frequency is set by the cross-coupling capacitors.

Lamp Control (LC). The lamp control circuit of Fig. 9 is used when visual indication is required of the binary state of flip-flops or binary counters. A two-stage circuit is used because the lamps have a drain of about 50 ma. A single transistor could not reliably give enough current gain. Both this circuit and the following power switch circuit are designed to be driven by an output signal from one of the previously described circuits.

Power Switch (PS). The power switch circuit of Fig. 10 is similar to the lamp control circuit except for the output load. The power switch circuit will provide a heavy duty positive step in voltage at its output. One use of the circuit is to set or reset a number of binary counter stages simultaneously.

Design and Performance

Choice of Transistor Type. The specific circuits shown are designed for pnp transistors. Simple changes in the polarities of capacitors, diodes, and power supplies would permit the use of npn types. The pnp alloy germanium types are the most common transistors manufactured and are well suited to the circuits. Typical transistors are the 2N77, 2N105, and 2N207. The latter transistor has been used extensively in making small etched board modules. Higher frequency types include the 2N139 and those of the series 2N112-2N114. The microalloy 2N393 is a type of even higher frequency. For high-temperature operation, a silicon alloy type would be necessary.

Transistor Specifications. Two parameters are of major importance to the proper operation of the circuits: common emitter current gain (β) and collector cut-off current (I_{CBO}). The drop in β with decreasing temperature sets the lower temperature limit of circuit operation. The increase in I_{CBO} with increasing temperature sets the upper temperature limit for the circuits. Beta values of 50 or greater are required for all transistors except the output transistor in the lamp control circuit. This latter transistor was chosen to have a β greater than 100.

The β of the 2N207 drops to about 50 per cent

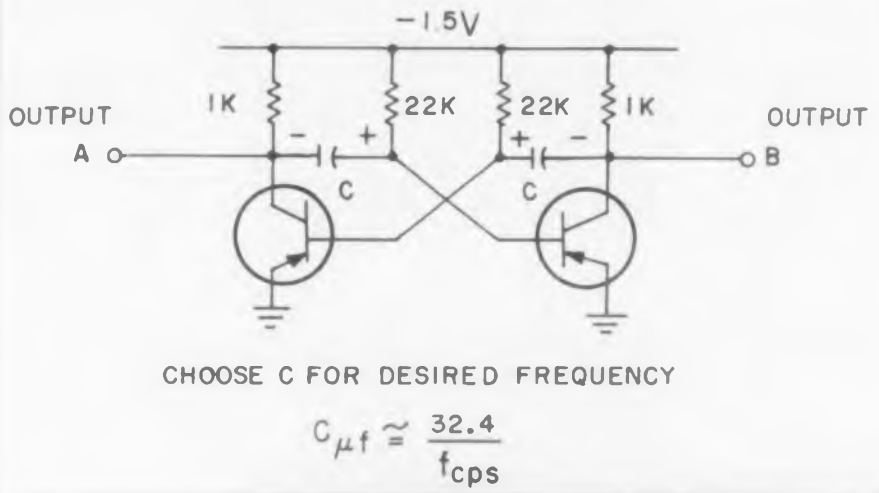


Fig. 8. Free running multivibrator (FRMV)

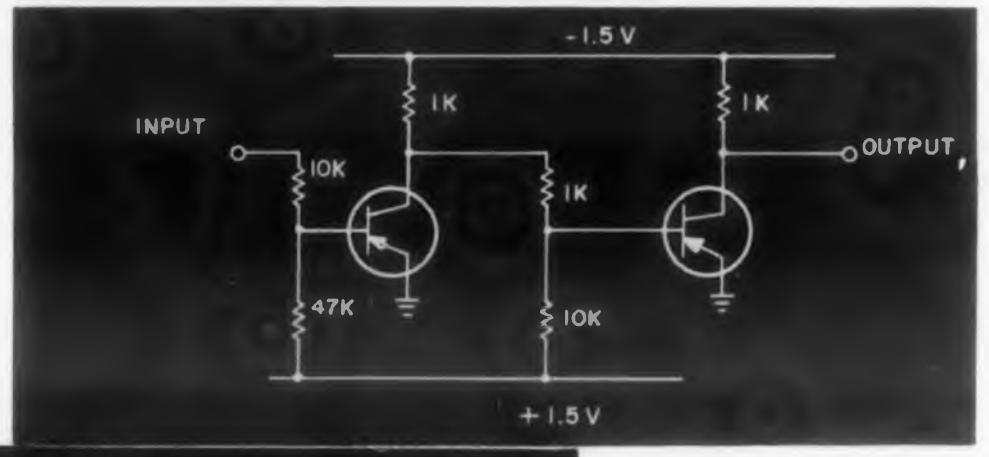


Fig. 9. (right) Lamp control (LC)

Fig. 10. (below) Power switch (PS)

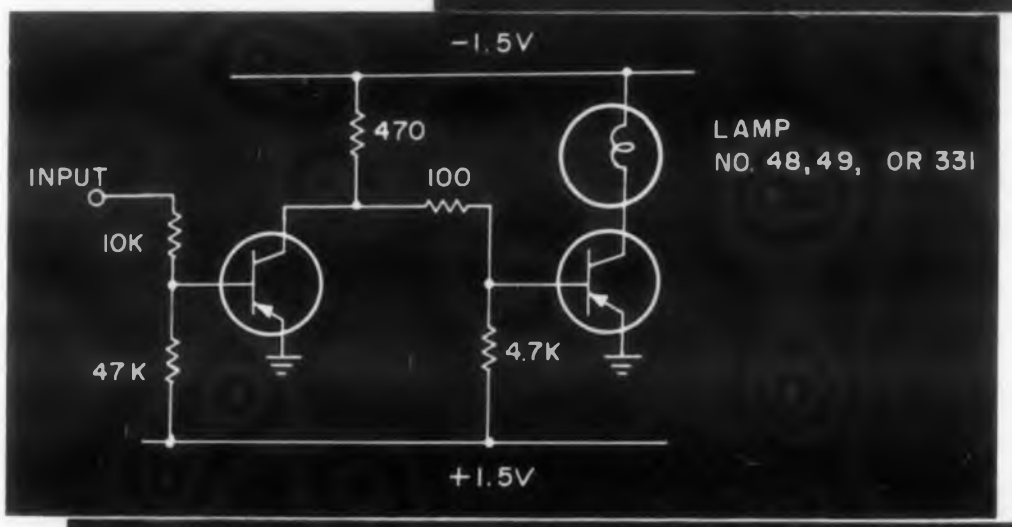
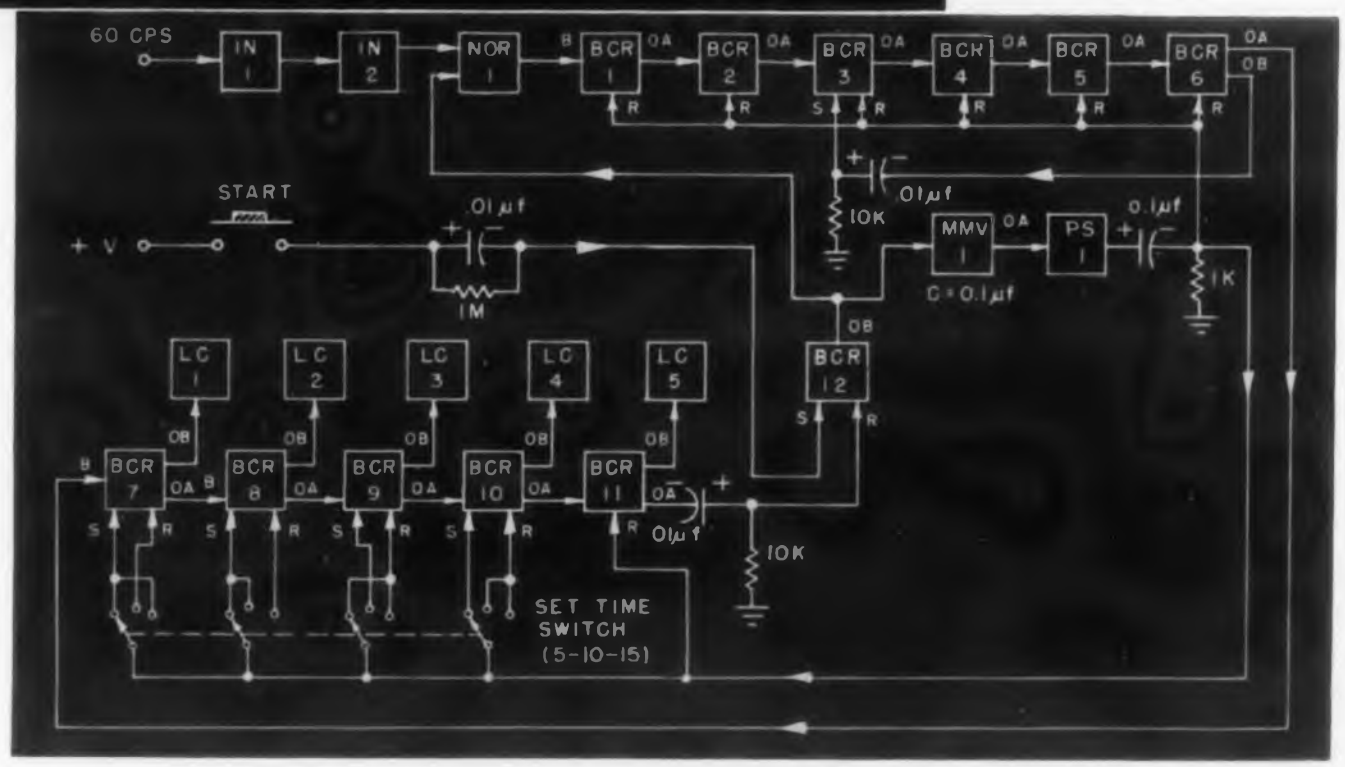


Fig. 11. (below) Block diagram of electronic timer. Code letters refer to the circuits previously described.



of its room-temperature value of —40 C. The circuits should perform properly down to this temperature although this has not been verified experimentally. The circuits are designed to operate with transistors having an I_{CBO} value up to 30μa. For the 2N207 type, this value is reached at approximately 60 C.

Choice of Diodes. The diodes used in the binary counter are noncritical in terms of the characteristics of presently available diodes. Point contact germanium diodes of minimum quality have been used. The 1N90 is typical. It has a minimum forward current of 5 ma at 1 v and a maximum reverse current of 500 μa at 50 v.

Junction diodes of equivalent dc characteristics should operate as well as point contact types in the low-frequency circuits considered so far. If the maximum upper operating temperature is desired for the circuits, the diode should be chosen for minimum reverse current at the upper temperature point.

Choice of Supply Voltages. The circuits are designed to operate from two single cells, one for the negative source and one for the positive source. Either 1.3 v mercury cells or 1.5 v dry cells are satisfactory. Two volt lead-acid cells can be used if the lamp control circuit has a 2-volt lamp (No. 48 or 49).

Upper Frequency Limit. The circuits have not been designed for optimum frequency response. Circuit simplicity and reliable low-frequency operation were stressed in these designs. The Binary Counter, using transistors such as the 2N77 or 2N207, has an upper input counting rate of approximately 15 kc. The input capacitors were chosen for these transistors and would need to be reduced in value to permit higher counting rates with higher frequency transistors. The lamp control circuit is limited in speed by the thermal response-time of the lamp. Observation of several switching cycles per second is possible. The other switching circuits have a transient response-time of about 20 microseconds.

Upper Temperature Limit. If 2N207 transistors and 1N90 diodes are employed in the circuits with other component parts as shown, the upper temperature limit is approximately 45 C. It is stressed that the particular design-values are not chosen to give high-temperature performance.

Techniques For Improving Performance

The circuits presented in the schematics have upper limits in frequency of tens of kilocycles and in temperature of approximately 45 C. The natural question is how to improve these limits, if necessary, for a particular application.

The upper frequency limit can be raised by two approaches. The first is to keep the previously described circuit topology and use higher frequency transistors and correspondingly lower

capacitors[6] in the binary counter stages. Most of the circuit speeds are limited by the transistors and not by wiring capacitances. The upper speed is roughly proportional to the alpha cutoff frequency of the transistors.

The second approach is to use a more complex circuit[7] and more efficiently utilize a particular transistor-type. Speed-up or commutating capacitors can be used to provide better coupling between stages. The transistor can be operated in a non-saturating mode, thus reducing switching time appreciably. Complementary-symmetry operation can be used to obtain positive drive in the rise and fall times of a waveform.

In an analogous manner, the upper temperature limit can be improved. Keeping the same circuits, transistors with lower I_{CBO} currents can be used (if available). The silicon alloy types will prove attractive as they become more readily available at modest prices. The base bias resistors and/or positive supply voltage can be modified for higher temperature operation. More involved circuitry can be used to boost the upper temperature limit.

Application Example

An example of the use of the standard circuits to construct a more involved system is shown in Fig. 11. The system is an electronic timer for generating 5, 10 or 15 second intervals following the activation of a push button.

One-second pulses are generated by dividing down the 60 cps line voltage through a six-stage binary divider (BCR-1 through BCR-6) with feedback to reduce the division ratio from 64 to 60. The input power line voltage is shaped to drive the binary counter by feeding through the two inverter stages (IN-1, IN-2). The NOR block is a gate described later on.

The basic counting register is another set of binary counter stages (BCR-7 through BCR-10). Three time-periods are provided, i.e., 5, 10 and 15 seconds. Using the one-second pulses as an input, the 4-stage binary counter has sufficient capacity (16 counts) to count the maximum time. The four stage counter is preset to the proper count to permit reaching its maximum count at the desired time. The "SET TIME" switch sets up the proper path for preset pulses at the start of the time interval.

The time interval is initiated by pressing the "START" push button. This flips BCR-12, used as a flip-flop, to a position which causes the NOR-1 circuit to pass 60 cps pulses to the 60:1 divider chain. This change in state of BCR-12 also triggers a monostable multivibrator (MM-1) of approximately 1 ms duration. This 1 ms pulse is amplified in the power switch (PS) and used to preset all the BCR stages to their proper positions. The preset pulse is fed through the "SET

TIME" switch to the proper terminals of the BCR stages in the counting register to give the desired time interval. For example, to generate a 10-second interval, BCR-8 and BCR-9 are preset to their non-zero positions. Since BCR-8 has a value of 2 counts, and BCR-9 has a value of 4, a total of 6 counts is subtracted from the total capacity of the 4 stages. Thus, 16 less 6, or 10 one-second pulses are required to cycle the counter to a point where BCR-11 is flipped.

The fifth stage (BCR-11) of the counting register is used as a temporary memory to show that the time interval is over. This stage flips at the end of the time interval and flips back again 16 seconds later. This second change is used to reset BCR-12 and thus stop pulses from passing through the NOR-1 circuit. This completes the cycle of the timer. Pressing the START button initiates a new cycle.

Visual indication of the counter operation is provided by the lamp control circuits (LC-1 through LC-5). One is connected to each of the binary counter stages in the counting register (BCR-7 through BCR-11). The stages LC-1 through LC-4 indicate the instantaneous binary count in the register. LC-5 operated by BCR-11 indicates the end of the time interval.

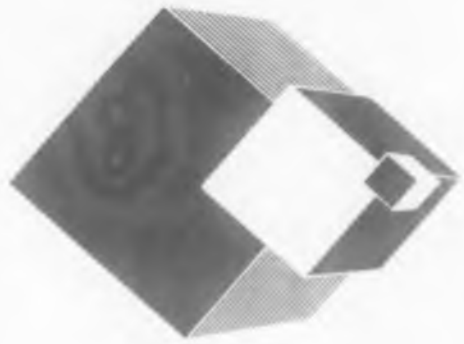
More detailed information on the processes described in this article will be found in the complete paper to be published in our Proceedings of the Symposium on Microminiaturization of Electronic Assemblies. For further information on the Proceedings, turn to Reader Service Card and circle **100**.

Acknowledgments

The circuits described are the result of the contributions of many people. Helpful discussions were held with Philip Emile, Jr. and E. L. Cox. Specific thanks are due Amiel Goodman and Jack Nimitz for conducting temperature studies on the circuits.

References

1. Handbook of Semiconductor Electronics, L. P. Hunter, pp. 15-30, McGraw-Hill Book Co., Inc., New York, N. Y., 1956.
2. The Application of Transistors to Computers, R. A. Henle and J. L. Walsh, *Proc. IRE*, 46, pp. 1240-54, June 1958.
3. The Design of a Transistor NOR Circuit for Minimum Power Dissipation, E. L. Cox, a paper presented before the Symposium on Microminiaturization of Electronic Assemblies, Diamond Ordnance Fuze Laboratories, Oct. 1, 1958.
4. L. P. Hunter, op. cit., P. 15-38.
5. L. P. Hunter, op. cit., p. 15-40.
6. Design of a Two-Transistor Binary Counter, P. Emile, a paper presented before the Symposium on Microminiaturization of Electronic Assemblies, Diamond Ordnance Fuze Laboratories, Oct. 1, 1958.
7. L. P. Hunter, op. cit., p. 15-44.
8. Design Considerations for Two Types of Transistorized Multivibrator Circuits, P. Emile, DOFL Report No. TR-487, Nov. 1, 1957.



Results of a literature survey indicate that it is possible to eliminate large-volume components by employing various circuit techniques. In this article, the authors disclose some of these techniques as related to amplifiers, simulated reactances, and filters and oscillators.

Circuit Techniques to Eliminate Large Volume Components—A Literature Survey

Jerome I. Cooperman and Philip J. Franklin
Diamond Ordnance Fuze Laboratories
Washington 25, D. C.

ENGINEERS have attempted to eliminate large component parts by employing various circuit techniques. While most of these techniques were initially developed for use with vacuum tubes, the extension of these principles to transistor circuits is logical. This paper is a result of a literature survey conducted to uncover and collect in one body some of these techniques; it will disclose their basic operating principles and how they might be applied in the field of microminiaturization. The presentation is given in three main groups: amplifiers, simulated reactances, and filters and oscillators.

Amplifiers

Positive feedback techniques. In designing amplifiers for miniature circuits, it is generally desirable to get maximum amplification per stage, using a minimum number of components, and yet have the system relatively free from instability or oscillation. A controlled amount of positive feedback incorporated in the amplifier design can achieve these ends in vacuum tube circuits, and to some extent in transistor circuits.

In a typical two-stage resistance capacitance coupled amplifier, to establish the proper dc operating conditions for the tubes, cathode bias is generally employed. The cathode by-pass capacitors are the most bulky of the components employed since values of the order of 10 μf and larger are required for audio-frequency applications. If these capacitors are omitted, a great reduction in gain results from negative current feedback in the cathode bias resistor. Sulzer[1] describes a method of applying controlled positive feedback between the stages to offset this reduction in gain, Fig. 1. Positive feedback is applied by a resistor R_f connected between the cathodes. A similar method of applying positive feedback between the screen grids of two pentode stages to eliminate the screen by-pass capacitors is also described.

Anspacher[2] gives an analysis of a two-stage pentode amplifier circuit without by-pass capacitors, the resulting degeneration being nullified by means of positive feedback between the two screen grids.

Unlike vacuum tubes, transistors require a forward bias to establish the proper dc operating conditions. This may be supplied in several different ways. In order to stabilize the transistor against thermal runaway, dc feedback which tends to bias the transistor toward cutoff as the collector current rises, is commonly used. A resistor is connected in the emitter circuit to stabilize emitter current. The emitter resistor is generally by-passed to prevent loss in gain due to degeneration, as in vacuum tube circuits.

Alexander[3] describes a transistor audio amplifier, (Fig. 2), similar to the previous vacuum tube circuits, where positive feedback between the emitters is used to obviate the requirement for large by-pass capacitors across the emitter resistors.

An additional economy involves the elimination of the two-resistor forward biasing network in each base circuit. This function is accomplished by the voltage drop that appears across the base-emitter junction as a result of the leakage current of the transistor. This biasing method is not recommended, since it is sensitive not only to temperature variations, but also to differences between transistors.

Direct-coupled amplifiers. A somewhat different technique for eliminating large-volume components and improving the low-frequency response of an amplifier is to employ direct-coupling. Much of this information is summarized by Landee et al.[4]

"The use of PNP transistors made by fusion techniques and surface-barrier transistors permits a direct connection of the collector of one stage to the base of the following stage without the use of interstage biasing arrangements. This is possible since the collector resistance is high and the current gain is close to its nominal value when the collector-to-base voltage is zero or slightly positive. At low level stages, the use of this technique results in very simple circuitry. However, the collector-voltage swing of any stage directly coupled to the base of a following stage is restricted to a very small voltage (0.2 to 0.6 v). Since the transistors are operated as current amplifiers, the small allowable collector-voltage swing does not adversely affect the operation of low-level stages. In many practical amplifiers this technique may be employed for coupling the first two or three stages of a high-gain amplifier . . ." Hurtig.[5] An amplifier circuit of this type is shown in Fig. 3. It has a power gain of 70 db and incorporates dc feedback for stabilization.[6]

As in the case of the vacuum tube, dc drift cannot be ignored. It is unfortunate that the temperature sensitivity of transistors increases the drift. However, if this circuit is employed as a low-level, high gain pre-amplifier, capacitive coupling at the output will remove the dc component without affecting its properties as an ac amplifier. The economy of component parts and the high gain cannot be overlooked for application in microminiature subassemblies.

Another type of direct-coupling scheme used with transistors is called complementary symmetry, and is discussed by Sziklai.[7] This method is shown in Fig. 4 and can deliver a voltage gain of the order of 25 per stage.

Perhaps the most popular use of the principle of complementary symmetry is in Class B power amplifier applications. The advantage of Class B operation is that the circuit draws negligible current until signal is applied. In the usual configuration, both an input and output transformer are required. Sziklai describes a circuit of a Class B power amplifier with a direct-coupled complimentary-symmetry driver (Fig. 5). This amplifier does not contain any parts other than the transistors themselves and operates from a high impedance signal source directly into a 16-ohm loudspeaker voice coil. The low output impedance and the stable operation are made possible by the over-all feedback which extends down to dc. Incidentally, this is a zero-center dc amplifier. Its economy of component parts recommends it for microminiature power amplifier applications.

Simulated Reactances

With certain circuit configurations, an active element such as a vacuum tube or transistor may behave as a reactance. Some well known applications of this phenomenon are the reactance modulator used in frequency modulation, and the Miller integrator and operational amplifiers used in analog computer work. Very often, however, the reactance effects are not pure, but also introduce resistive effects. For purposes of power supply filtering, the resistive effects are not considered to be as important as the reactive properties of the device. Linvill[8, 9] gives theory on *RC* active filters using transistors.

Inductance. Towner[10] describes a circuit which is composed of resistive and capacitive elements, and three tubes as amplifiers. The device behaves as a true inductance in that it differentiates square waves, integrates triangular waves, and resonates with capacitance across its terminals. Some of the applications described are for a low frequency sine wave oscillator and as a filter circuit for tone control purposes in audio amplifiers.

Tomer[11] describes a circuit wherein a pentode tube may be used in place of a high in-

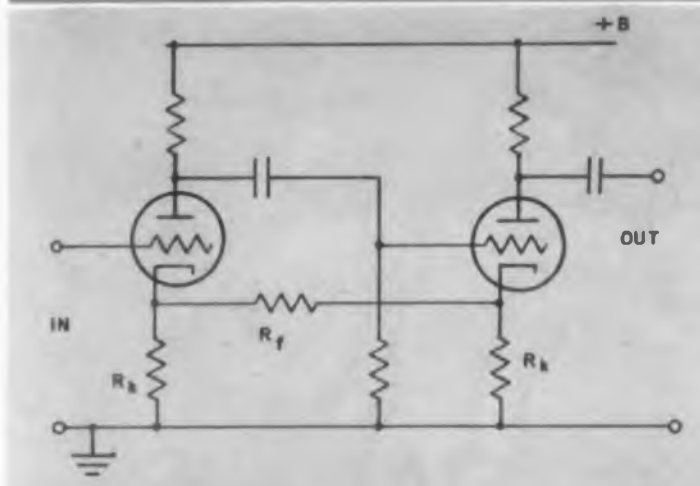


Fig. 1. Two-stage resistance-capacitance coupled amplifier with positive feedback.

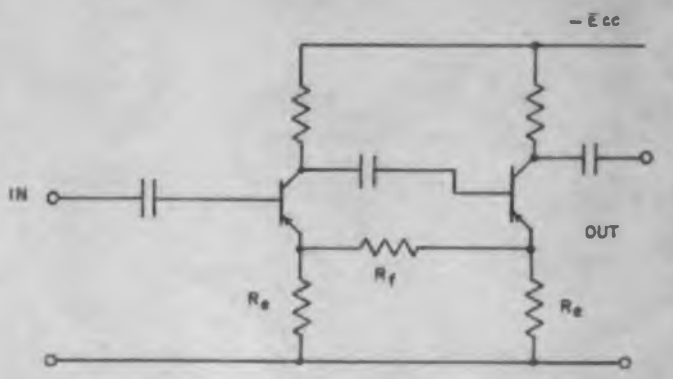


Fig. 2. Two-stage resistance-capacitance coupled transistor amplifier with positive feedback.

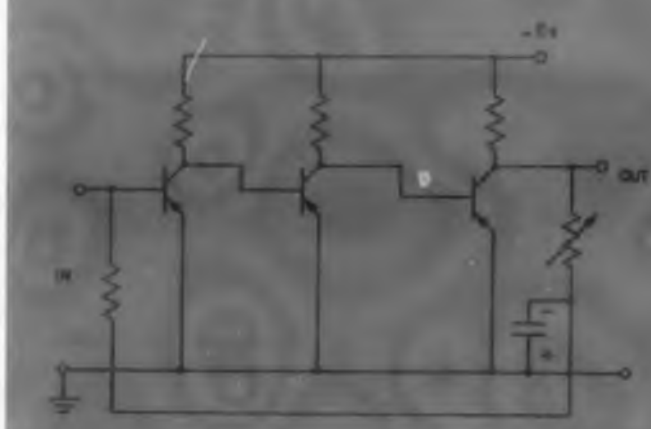


Fig. 3. Direct-coupled transistor amplifier.

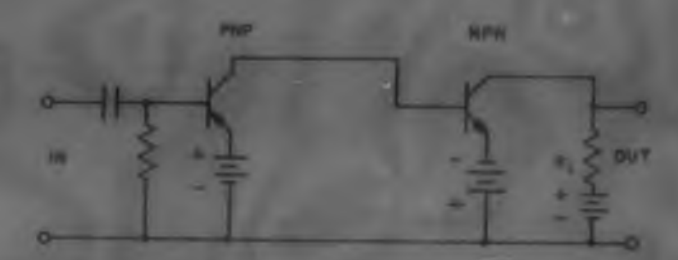


Fig. 4. Complementary symmetry direct-coupled transistor amplifier.

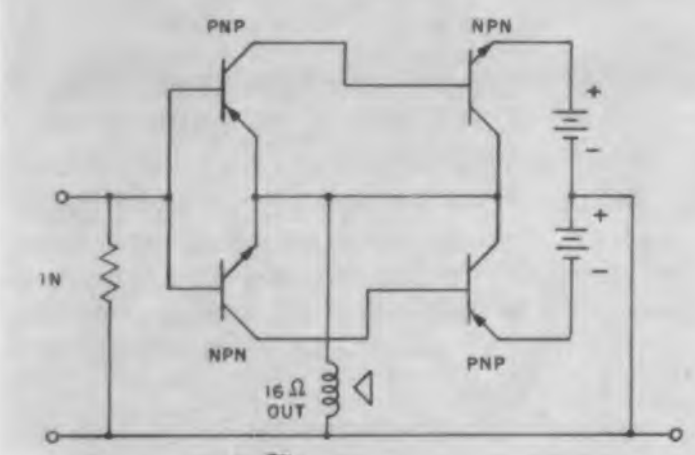


Fig. 5. Complementary symmetry Class B power amplifier with direct-coupled driver.

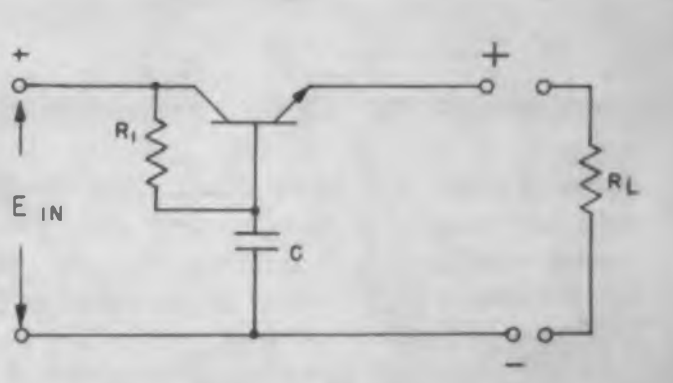


Fig. 6. Transistor-simulated series inductance.

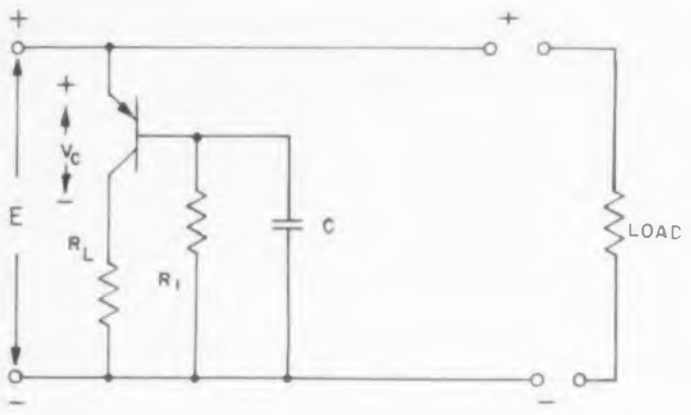
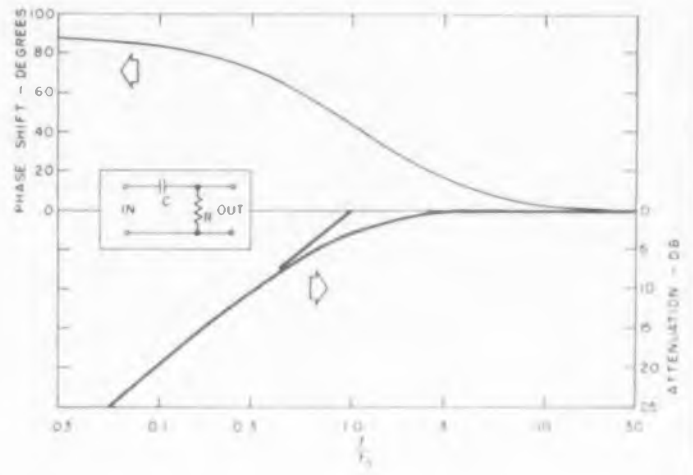


Fig. 7. Transistor-simulated shunt capacitance.



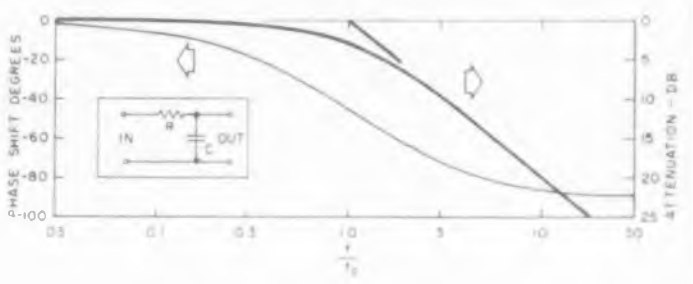


Fig. 8. Single-section high-pass filter with attenuation and phase characteristics (a) and Single-section low-pass filter with attenuation and phase characteristics (b).

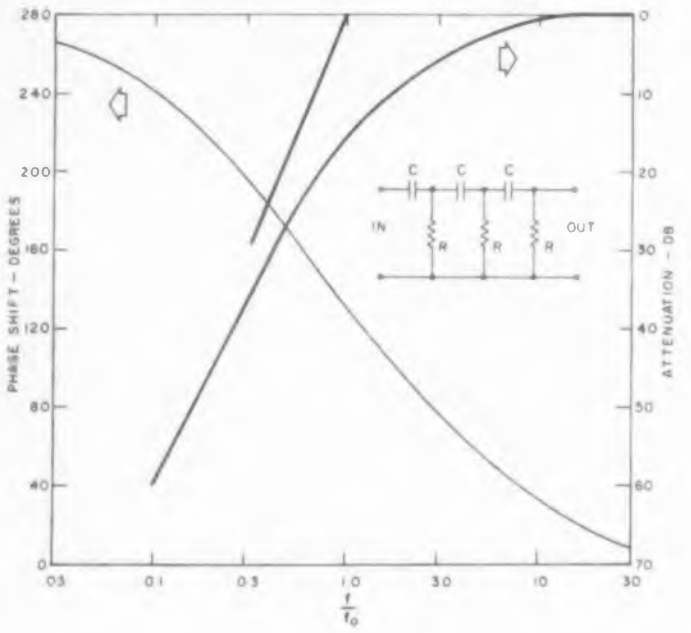


Fig. 9. Three-section high-pass ladder network with attenuation and phase characteristics.

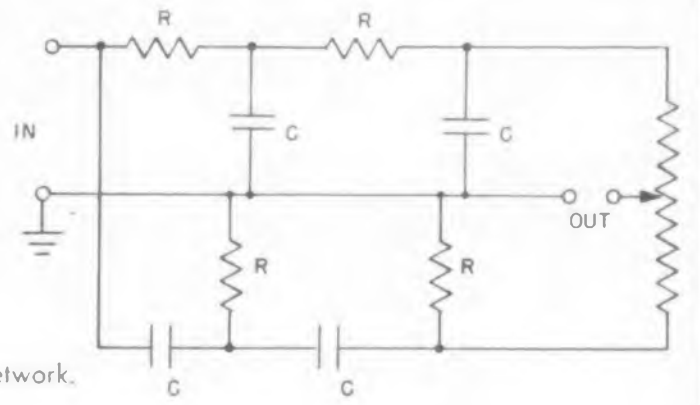


Fig. 10. Hadfield's null network.

ductance choke in a power supply filter. While not a pure inductance element, the high ac plate resistance and low dc drop through the tube permit the circuit to fulfill the requirements ordinarily imposed on a filter choke.

Stern[12] describes a transistor simulated inductance using only capacitance as the reactive parameter. A series simulated inductance is shown in Fig. 6.

Capacitance. The Miller integrator is a particular kind of operational amplifier. It is basically an amplifier stage with a capacitive feedback path from plate to grid. The apparent capacitance between grid and cathode terminals is a function of the size of the feedback capacitor and the gain of the stage. In effect, the plate-to-grid capacitance is amplified by the tube. Thus, it is possible to use a relatively small capacitance with a high gain stage to obtain a large circuit capacitance of low volume.

Stern[12] shows a circuit for a transistor simulated shunt capacitance, Fig. 7. The value of the capacitance used in the base path is multiplied by the transistor gain. As in the simulated inductance case, these circuits are inoperable above the transistor cut-off frequency. Oakes and Lawson[13] use a similar capacitance multiplier circuit in a transistor power supply filter.

Filters and Oscillators

The usual inductance-capacitance filters and oscillators assume very large physical proportions when designed for low frequency operation. In addition, at sub-audio frequencies, the circuit Q of the inductors is so low that inductance-capacitance filters and oscillators are not practical. Both these factors have spurred circuit designers to develop alternative approaches.

When resistance-capacitance networks are used in the feedback loop of an amplifier, it is possible to achieve steeper curves of amplitude vs. frequency (higher Q) than the passive case, or even to invert the transmission characteristics of the network.

Resistance-capacitance oscillators are similar in theory. Sufficient in-phase feedback is employed to overcome the attenuation in the coupling network, and the amplifier then supplies its own input. The frequency stability, of course, is determined by the rate of change of phase with frequency at the resonant frequency of the network.

Ladder networks (*cascaded L sections*). The simplest network to be considered here is the single L section, shown along with its transmission and phase characteristic in Fig. 8.

It has an attenuation asymptotic to 6 db per octave beyond the "corner" frequency of $\omega = 1/RC$, and a maximum phase shift of 90 deg. Depending on the configuration, either low or high frequency attenuation may be obtained.

The attenuation rate of these networks may be made steeper by cascading two or more sections. For each section, an additional 6 db per octave slope, and 90 deg phase shift are obtained. Thus, for example, a three-section ladder has an attenuation of 18 db per octave beyond its corner frequency, and a maximum shift of 270 deg. One such network is shown with its characteristics in Fig. 9.

It can be seen that there is a phase shift of 180 deg at a frequency $f = 1/2\pi RC\sqrt{6}$ for this high pass filter. Although the three-section ladder network has no "resonant" frequency, it has been used in a tuned amplifier circuit by Hansel,[14] and is commonly employed in resistance-capacitance (phase-shift) oscillators as described by Ginzton and Hollingsworth.[15] The network is connected in a negative feedback path between the input and output of an amplifier stage. At some frequency there is an additional 180 phase shift contributed by the network. Thus, positive feedback is obtained, and the amplifier response will show a peak at this frequency.

If the amplifier gain is made sufficiently large

to overcome the attenuation in the network, the circuit will oscillate. For a network composed of equal resistances and equal capacitances, there is an attenuation of 29 at a phase shift of 180 deg, requiring a loop gain of at least this amount for the circuit to oscillate. Sulzer[16] suggests a modification of the ladder network by "tapering" the sections so that the succeeding sections do not load the input sections. The attenuation in this network is only about 8 for a phase shift of 180 deg and so low mu tubes may be used in the oscillator.

Hooper and Jackets[17] have reported on a transistorized *RC* phase shift oscillator.

Epstein[18] describes a variation of this ladder network which has a gain greater than unity with 180 deg phase shift. Thus it is possible to construct an oscillator with only a cathode follower as the active element. Waidelich[19] gives a practical design procedure for oscillators of this type.

Smiley[20] describes another variation of the phase shift oscillator in which the ladder sections separated by active vacuum tube stages. Use is made of the Miller effect to increase the effective value of the capacitances in the network, permitting ultra-low-frequency operation with relatively small components. A further advantage of this oscillator is that three-phase output is available.

Sturm and Cottrell[21] developed a transistorized three-phase, phase shift oscillator in which the ladder sections are separated by active transistor stages.

Hadfield[22] describes a null network composed of two ladder networks connected to a common source (Fig. 10). The null frequency is controlled by means of a very high resistance potentiometer connected across the output terminals of the individual networks. One of these networks is a phase lead network; the other is a phase lag network. The voltages at the respective outputs of these networks are opposite in phase at all frequencies and a zero output or cancellation can be obtained at any frequency by a suitable setting of the potentiometer. A more detailed analysis is presented by Clothier[23] and a variation called the variable-T is discussed by Reid.[24]

Zero phase shift network. A simple selective network, sometimes referred to as a zero phase shift or twin *RC* network, and discussed in detail by Punnett,[25] is shown in Fig. 11 along with its phase and transmission characteristics. Superficially, it appears to be a Wien bridge, and it has been referred to as such many times in the literature. Actually it is not, since the true Wien bridge is a four-terminal network having no common connection between the input and output. The network is a three-terminal network and it has a common connection between the input and output. It has a peak in transmission and

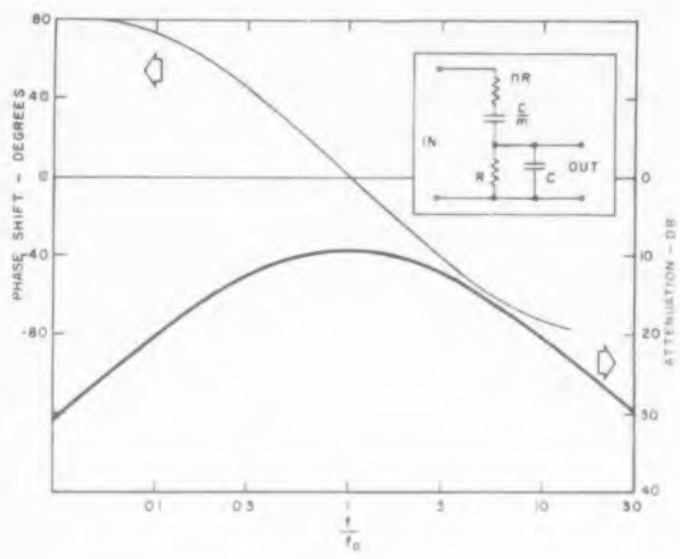


Fig. 11. The zero phase shift network with attenuation and phase characteristics.

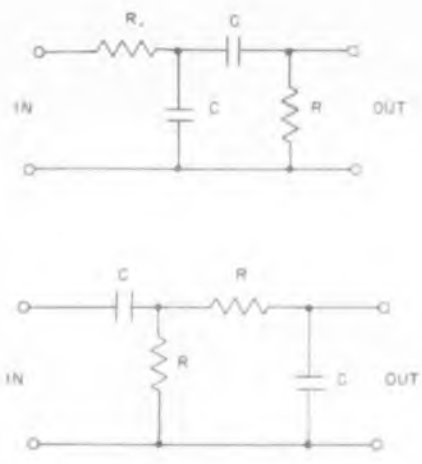


Fig. 12. Two variations of the zero phase shift network.

zero deg phase shift at its "resonant" frequency. Its attenuation is asymptotic to 6 db per octave each side of this frequency. If the general case for this network is considered, it is found that the highest selectivity occurs when $m = n = 2$. The resonant frequency obeys the relation $f = 1/2\pi RC$.

Two other networks composed of the same basic elements in different configurations, but having the same transmission characteristics are shown in Fig. 12.

Whitmer[26] describes a three-stage, broadly tuned bandpass amplifier employing two of these networks for interstage coupling. While not as selective as other circuits, the simplicity of the network and the absence of critical tuning requirements are advantageous.

Beatie and Conn,[27] and Punnett[28] employ this network as the interstage coupling in a two stage amplifier with a positive feedback loop, thereby obtaining a tuned amplifier system with Q's up to 20. Transistorized versions, while feasible, have not yet been described in the literature.

If the loop gain of the amplifier system is made

greater than 3, the circuit will oscillate at a frequency determined by the network and the amplifier phase shifts. Such a vacuum tube oscillator has been described by Terman.[28] Transistor oscillators of this type have been described and analyzed by Achuthan[29] and Hooper and Jackets.[17]

Another variation of this network is also described by Punnett[25] and consists of connecting the network to the ouput of a phase splitter. The operation approaches that of the Wien bridge by being more sharply tuned than the simple selective network and having zero output at its resonant frequency.

Wien bridge. A popular tuned *RC* network, the Wien bridge, is shown in Fig. 13 along with its transmission characteristics. It is more sharply tuned than the previous network, with a theoretical infinite attenuation and a discontinuous phase shift at its resonant frequency. It has been employed in tuned amplifiers by Shaw[30] and in oscillators by Clarke.[31] It has a rather serious disadvantage in that it is a four-terminal network having no common connection between input and output, thus requiring an isolating transformer in many oscillator and amplifier circuits. However, it is possible to employ this network without a transformer. The network may be tuned by varying either the two capacitors or the two resistors in the right-hand branches simultaneously. The resonant frequency obeys the relation $F = 1/2\pi RC$.

Parallel-T network. Probably the most widely used *RC* selective network is the parallel-T or twin-T network. It has a higher Q than the previously discussed simple networks, less than the Wien bridge, and has a theoretical infinite attenuation and a discontinuous phase shift at its resonant frequency. A carefully constructed unit can have an attenuation of 120 db at this frequency. This network, invented by Augustadt,[32]

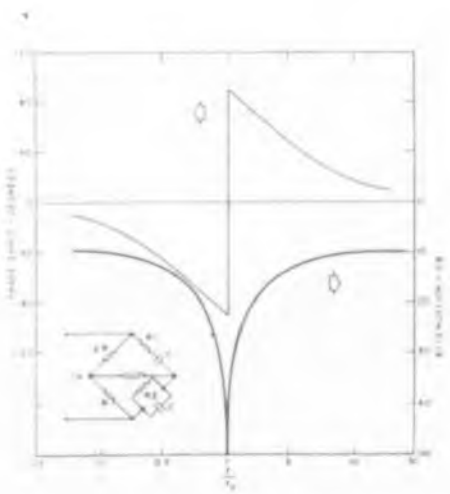


Fig. 13. The Wien bridge network with attenuation and phase characteristics.

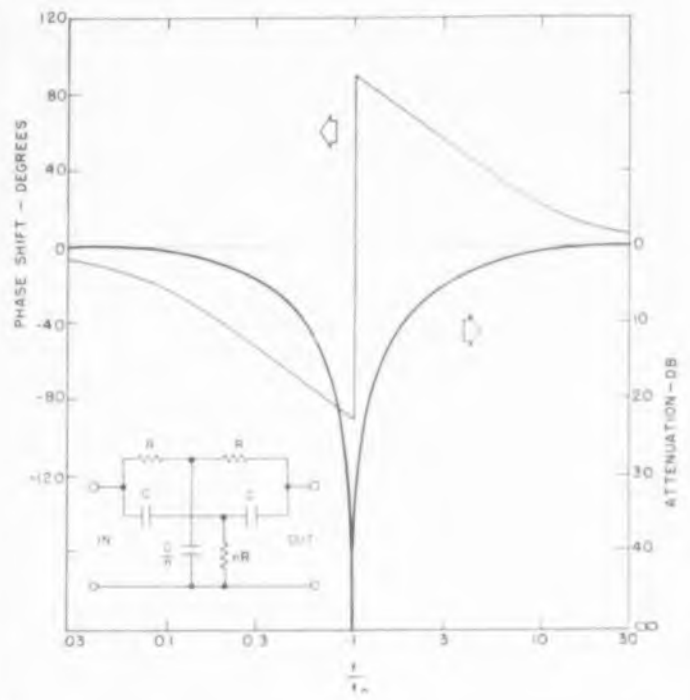


Fig. 14. The parallel-T network with attenuation and phase characteristics.

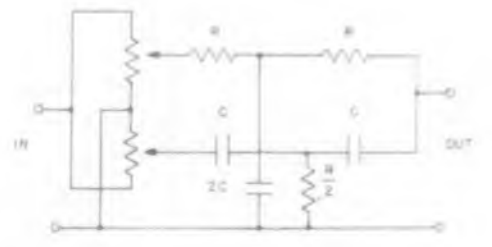


Fig. 15. The dual-input parallel-T network.

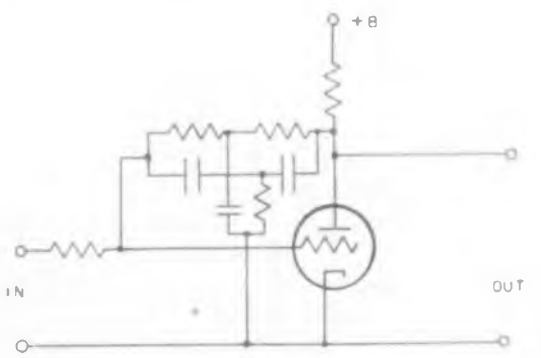


Fig. 16. A simple tuned amplifier employing a parallel-T network in the negative feedback loop.

is shown in Fig. 14 along with its transmission characteristics. The resonant frequency is given by $f = 1/2\pi RC\sqrt{2n}$ where, for the highest Q, $n = 1/2$.

The parallel-T is a three-terminal network; there is a common connection between input and output. This feature makes the applications rather striaghtforward since no isolation transformer or special circuitry is required. Analysis of the parallel-T network and suggested applications have been made by Hastings[35] and Stanton.[34]

One of the sharpest criticisms directed toward the parallel-T network is the fact that in order to vary the tuning frequency, three circuit parame-

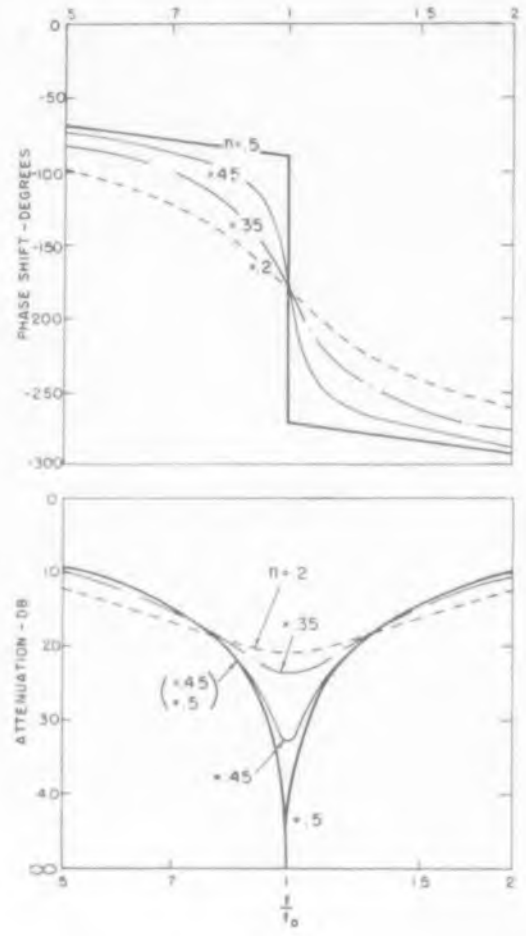


Fig. 17. Attenuation and phase characteristics of a parallel-T network with various values of n.

ters must be adjusted simultaneously and with perfect tracking to maintain the sharpness of rejection. White and Morgan[35] have made an ingenious modification that permits adjustment of the null frequency over a two-decade range without changing any of the circuit parameters. They split the input to the parallel-T, and in the case illustrated in Fig. 15, each T is fed from one section of a dual potentiometer. The null frequency is then only a function of the ratio of the voltages applied to the two T's and the null frequency of the basic network.

The use of the parallel-T network in vacuum tube tuned amplifiers was first described by Scott,[30] but subsequent articles by Fleisher,[37] Punnett,[25] Stanton,[34] and Hyde,[38] are more detailed. The tuned amplifier consists basically of a stage of gain with the parallel-T network in the negative feedback loop and is shown in Fig. 16. There is degeneration at all frequencies except at the resonant frequency of the network which is a transmission null. At this frequency, the amplifier gain is a maximum, resulting in a peak in the amplifier response. Among the articles showing practical circuits of tuned amplifiers employing this network are those by Dixon and Phillips,[39] Gitzendanner,[40] Rayner,[41] and Roualt.[42]

Bowers[43] calls attention to an interesting variation of the parallel-T network. If the multiplying factor, n, of the shunt arms of the network is less than 0.5, there is only a partial null and the network phase shift attains a value of 180 deg at the resonant frequency. The phase vs. frequency characteristic is degraded from the discontinuous function of the infinite attenuation network to a less rapid change, the slope becoming smaller as n is decreased. Attenuation and phase shift for various values of n are shown in Fig. 17. In the previously described amplifier, this phenomenon results in positive feedback or regeneration at the resonant frequency of the filter, thus increasing the amplifier gain at that frequency. Bowers,[43] McGaughan,[44] and Smith[45] have shown practical tuned amplifiers based on these principles. A similar circuit, but using transistors, is described by Sohrabj.[46]

If the loop gain of the amplifier is made large enough to overcome the transmission losses of the network, the system will oscillate at a frequency determined by the network and the phase

shift in the amplifier. The choice of n of the network is dictated by the open loop gain of the oscillator and the frequency stability that is desired. Vacuum tube oscillators of this type have been described by Smith[45] and Tucker.[47] A complete design procedure for parallel-T oscillators is given by Lynch and Robertson.[48] A transistor version is shown by Sohrabji.[46]

Frequency discriminators utilizing parallel-T *RC* networks are advantageous for low frequency applications. There are two basic methods: two networks may be used directly, or in the inverse loops of feedback amplifiers. Tillman[49] and Stine[50] describe practical circuits and design techniques for these discriminators.

Bridged-T network. Still another frequency selective *RC* network is the bridged-T, described by Sulzer[51] and others. The network and its transmission and phase characteristics are shown in Fig. 18. It has a minimum of transmission and zero deg phase shift at its resonant frequency, $f = 1/2\pi RC$. The unsymmetrical networks are characterized by a higher Q than is available from other networks containing only four components. Its relative simplicity and ease of frequency adjustment also make this network attractive for use in a tuned amplifier or oscillator.

Tisdale[52] used the bridged-T network in conjunction with *RC* ladder sections to obtain a continuously adjustable low-pass filter. Sulzer has used this network in a vacuum tube[53] and a transistor[54] audio oscillator which feature low harmonic distortion.

More detailed information on the processes described in this article will be found in the complete paper to be published in our Proceedings of the Symposium on Microminiaturization of Electronic Assemblies. For further information on the Proceedings, turn to Reader Service Card and circle **100**.

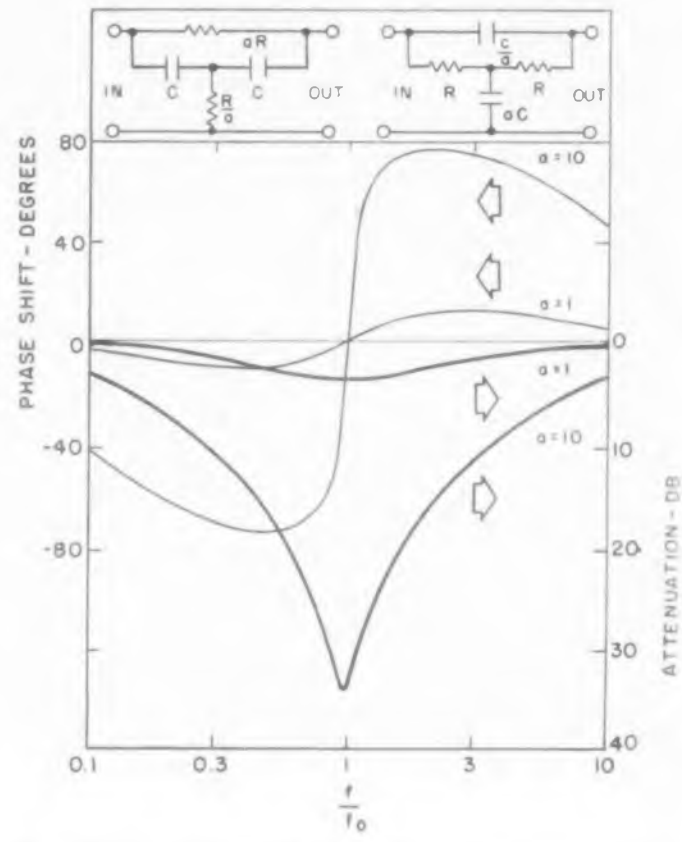


Fig. 18. The bridged-T network with attenuation and phase characteristics.

Acknowledgement

Net work response curves shown in this paper were computed from the network formulas, and with one exception appear on identical scales. The authors wish to thank Louis Nardizzi for his untiring efforts in computing data for the preparation of these curves.

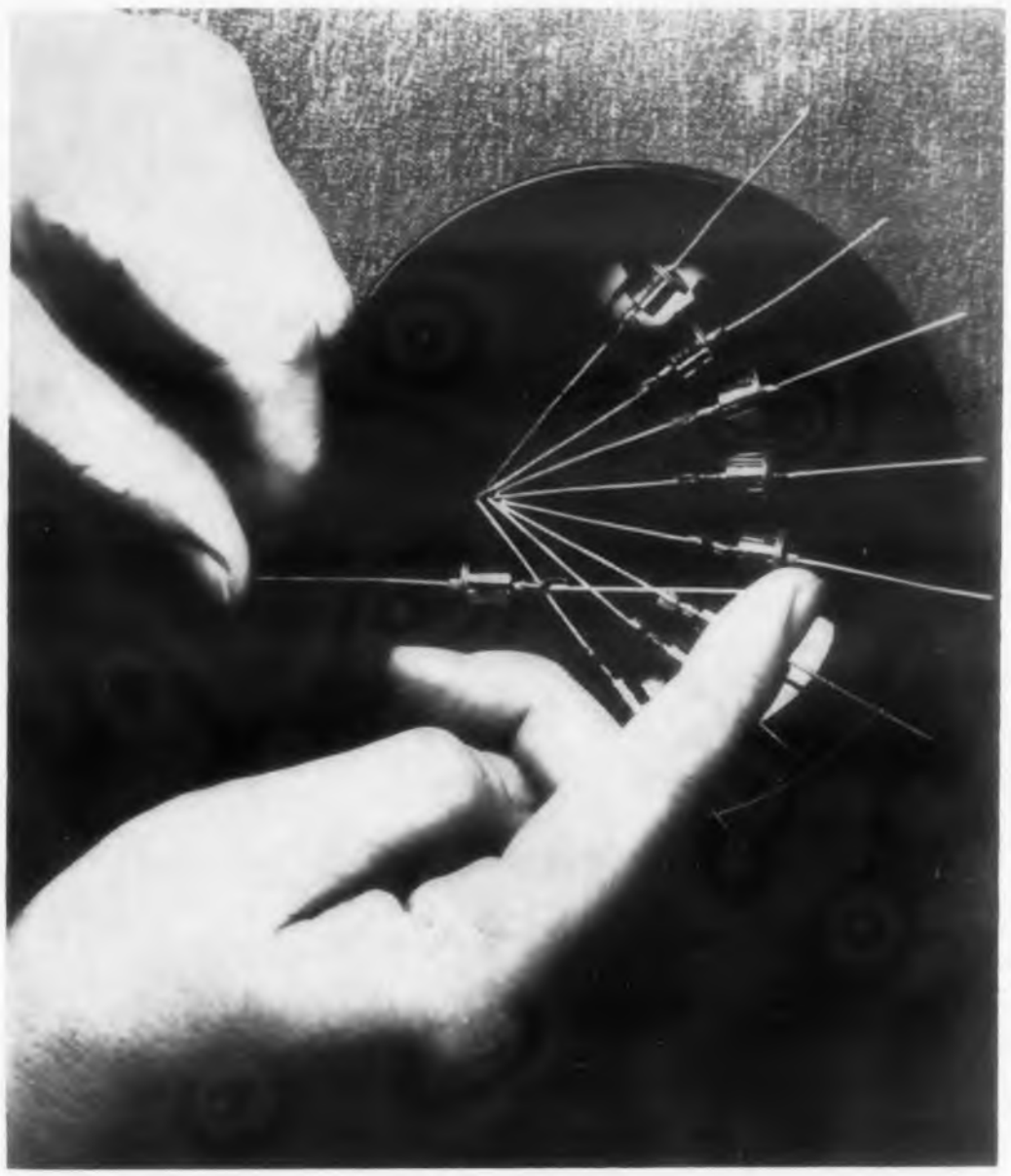
References

1. Circuit Techniques for Miniaturization, P. G. Sulzer, *Electronics*, 22, 98-99 (August 1949).
2. Miniaturizing Pentode Amplifiers by Positive Feedback, W. B. Anspacher, Proc. Nat. Electronics Conf., 6, 103-111 (1950).
3. Transistors Use Emitter-Coupled Feedback, F. C. Alexander, Jr., *Electronics*, 27, 188 (December 1954).
4. Electronic Designers' Handbook, R. W. Landee, D. C. Davis, and A. P. Albrecht, pp. 3-69 to 3-86, McGraw-Hill Book Company, Inc., New York 1957.
5. Handbook of Semiconductor Electronics, L. P. Hunter, editor, 1st ed., pp. 13-12, McGraw-Hill Book Company, Inc., New York, 1956.
6. Philco Semiconductor Data Sheet, type 2N 207 Germanium PNP Transistors (September 1957).
7. Symmetrical Properties of Transistors and Their Applications, G. C. Sziklai, *Proc. IRE*, 41, 717-724 (1953).
8. Transistor Negative-Impedance Converters, J. G. Linvill, *Proc. IRE*, 41, 725-729 (1953).
9. RC Active Filters, J. G. Linvill, *Proc. IRE*, 42, 555-564 (1954).
10. Artificial Inductor, G. H. Towner, U.S. Patent 2,800,568 (July 23, 1957).
11. Electronic Filter Choke, R. B. Tomer, Radio-Electronic Engineering edition of *Radio News*, 19, 11 (December 1952).
12. Transistor-Simulated Reactances, R. H. Stern, Electronic Design, 6, 24-27 (March 5, 1958).
13. Transistor Ripple, F. Oakes and E. W. Lawson, *Electronics*, 31, 95 (April 11, 1958).
14. Dippler-Effect Omnirange, P. G. Hansel, *Proc. IRE*, 41, 1750-1756 (1953).
15. Phase Shift Oscillators, E. L. Ginzton and L. M. Hollingsworth, *Proc. IRE*, 29, 43-49 (1941).
16. The Tapered Phase-Shift Oscillator, P. G. Sulzer, *Proc. IRE*, 37, 1302-1305 (1948).
17. Current Derived R-C Oscillators Using Junction Transistors, D. E. Hooper and A. E. Jackets, *Electronic Engng.*, 28, 333-337 (1956).
18. Synthesis of Passive RC Networks with Gains Greater than Unity, H. Epstein, *Proc. IRE*, 39, 833-835 (1951).
19. Design of Optimum Phase Shift Oscillators, D. L. Waidelich, Proc. Nat. Electronics Conf., 11, 222-22[illegible] (1955).
20. Ultra-Low-Frequency Three-Phase Oscillators, G. Smiley, *Proc. IRE*, 42, 677-680 (1954).
21. Transistors and RC Networks Produce Three-Phase A-C, R. E. Sturm and D. E. Cottrell, *Electrical Design News*, 3, 16 (July 1958).
22. Selective Amplifier or Oscillator, B. M. Hadfield U.S. Patent 2,386,892 (October 16, 1945).
23. RC Filter Networks with Single-Component Frequency Control, W. K. Clothier, *Trans. IRE*, CT-2, 97-10[illegible] (1955).
24. New Null Transmission Networks, E. M. Reid, *Electronic Engng.*, 26, 444-446 (1954).

25. Audio-Frequency Selective Amplifiers, S. W. Punnett, *J. Brit. Instn. Radio Engrs.*, 10, 39-59 (1950).
26. Application of Interstage RC Networks to Provide Selectivity in Low Frequency Amplifiers, W. C. Whitmer, NRL Report No. 3506, (July 13, 1949).
27. A Simple Low Frequency Amplifier, J. R. Beattie and G.K.T. Conn, *Electronic Engng.*, 25, 299-301 (1953).
28. Some Applications of Negative Feedback with Particular Reference to Laboratory Equipment, F. E. Terman, R. R. Buss, W. R. Hewlett, and F. C. Cahill, *Proc. IRS*, 27, 649-655 (1939).
29. Transistor RC Oscillators, M. K. Achuthan, *Electronic Radio Engr.*, 34, 309-310 (1957).
30. A Tunable Audio-Frequency Amplifier of Variable Selectivity, E. A. G. Shaw, *J. Sci. Instrum.*, 27, 295-298 (1950).
31. Wien-Bridge Oscillator Design, K. K. Clarke, *Proc. IRE*, 41, 246-249 (1953).
32. Electric Filter, H. W. Augustadt, U. S. Patent 2, 106, 785 (Feb. 1, 1938).
33. Analysis of A Resistance-Capacitance Parellel-T Network and Applications, A. E. Hastings, *Proc. IRE*, 34, 126P-129P (1946).
34. Theory and Application of Parallel-T Resistance-Capacitance Frequency-Selective Networks, L. Stanton, *Proc. IRE*, 34, 447-456 (1946).
35. The Dual-Input Parallel-T Network, C. F. White and K. A. Morgan, Proc. Nat. Electronics Conf. 8, 588-597 (1952).
36. A New Type Selective Circuit and Some Applications, H. H. Scott, *Proc. IRE*, 26, 226-237 (1938).
37. Vacuum Tube Amplifiers, G. E. Valley and H. Wallman, editors, 1st ed., M.I.T. Radiation Laboratory Series Vol. 18, pp 384-408, McGraw-Hill Book Company, Inc., New York, 1948.
38. Selective Amplification at Sub-Audio Frequencies, F. J. Hyde, *Electronic Engng.*, 29, 260-265 (1957).
39. Some Methods of Improving the Performance of Twin-T Feedback Amplifiers, T. O. Dixon and D. T. Phillips, NRL Report No. 4444, (November 19, 1950).
40. Analysis of Twin-T Filters, L. G. Gitzendanner, Proc. Nat. Electronics Conf., 6, 121-128 (1950).
41. A Selective Detector Amplifier for 10-10,000 cps, G. H. Rayner, *J. Sci. Instrum.*, 30, 17-20 (1953).
42. Voice Frequency Tone Signaling for Mobile Radio Systems, C. L. Ronalt, *Tele-Tech*, 11, 66-68 (November 1952).
43. RC Band Pass Filter Design, J. L. Bowers *Electronics*, 20, 131-133 (April 1947).
44. A Variation of an R-C Parallel-T Network, H. S. McGaughan, *Tele-Tech*, 6, 48 (August 1947).
45. The Characteristics of Parallel-T RC Networks, D. H. Smith, *Electronic Engng.*, 29, 71-77 (1957).
46. RC Filters and Oscillators Using Junction Transistors, N. Schrabji, *Electronic Engng.*, 29, 606-608 (1957).
47. A Twin-T RC Oscillator, M. J. Tucker, *Electronic Engng.*, 27, 346-347 (1955).
48. The Design of Parallel-T Networks for R-C Oscillators, L.E.V. Lynch and S. Robertson, *A.W.A. Tech. Rev.*, 7, 7-25 (1946).
49. Linear Frequency Discriminator, J. R. Tillman, *Wireless Engr.*, 23, 281-286 (1946).
Parallel-T Discriminator Design Techniques, P. T. Stine, Proc. Nat. Electronics Conf., 9, 26-39 (1954).
51. A Note on a Bridged-T Network, P. G. Sulzer, *Proc. IRE*, 39, 819-921 (1951).
52. Continuously Adjustable Electronic Filter Networks, G. E. Tisdale, *Proc. IRE*, 38, 796-798 (1950).
53. Audio Oscillator Has Low Distortion, P. G. Sulzer, *Electronics*, 28, 158-159 (May 1955).
54. Low Distortion Transistor Audio Oscillator, P. G. Sulzer, *Electronics*, 26, 171-173 (September 1953).

NEW PRODUCTS

Covering all new products that might generally be specified by an electronics engineer engaged in the design of original equipment.

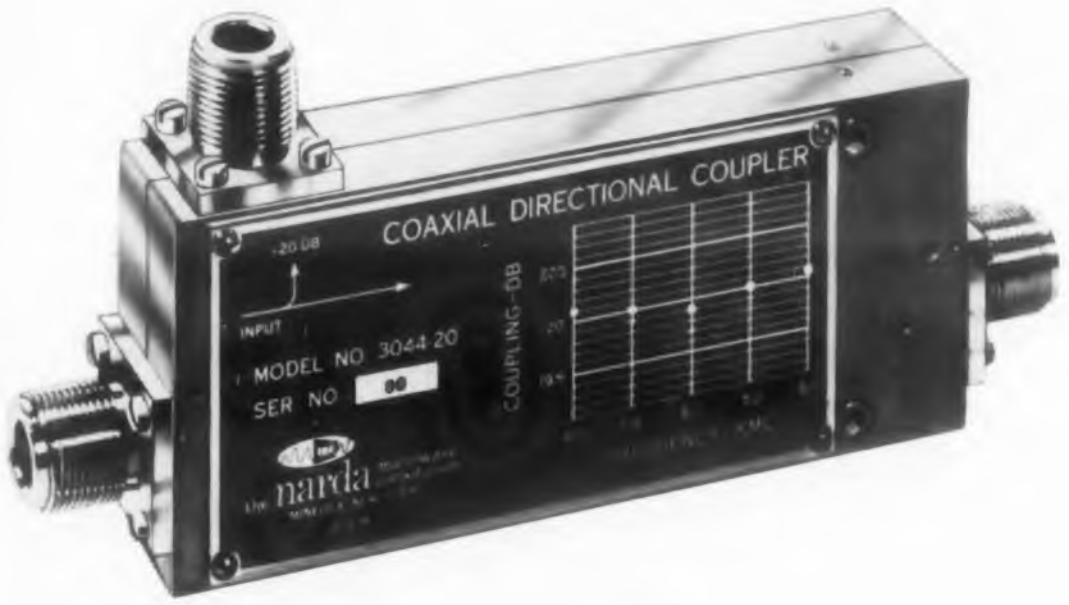


SILICON RECTIFIER

An operating life of 10,000 hr is expected for this silicon rectifier. For general purpose use in power supplies, magnetic amplifiers and variable speed motor controls, the unit's all welded hermetic package can function in temperatures that range from −55 to +150 C. Labeled the S-16, the rectifier provides an output of 500 μamp. In the back direction it can stand 400 v and a maximum reverse current of 100 μamp.

Semicon, Inc., Dept. ED, 258 East St., Lexington 73, Mass.

CIRCLE 44 ON READER-SERVICE CARD



FLAT COAX COUPLER

Limiting frequency response variation to only 0.2 db over a full octave, this series of flat coaxial couplers also present a deviation of mean value from nominal of only ±0.3 db. Six models, designated 3040 through 3045, cover frequency bands from 240 to 11,000 mc with a nominal coupling value of 20 db. Four models are available with 10 db values, covering 500 to 8000 mc. Primary vswr is 1.1 to 1.25, and secondary vswr is 1.2 to 1.3, depending on model.

Narda Microwave Corp., Dept. ED, 118-160 Herricks Road, Mineola, N.Y.

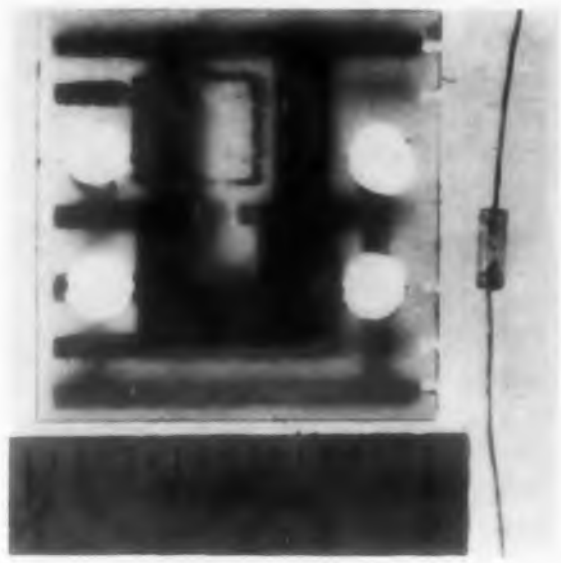
CIRCLE 45 ON READER-SERVICE CARD

SUBMINIATURE TERMINAL BLOCKS

Made with 1 to 21 terminals, these subminiature terminal blocks are only 5/16 in. wide. Called the Series 409, they are molded of high tensile strength bakelite for commercial use. To meet Mil-M-14 they are made from other materials which includes CFG, MFE, MME, MDG and MAI-60, a special reinforced Alkyd for great tensile and impact strength.

Kulka Electric Corp., Dept. ED, 633-643 S. Fulton Ave., Mt. Vernon, N. Y.

CIRCLE 46 ON READER-SERVICE CARD

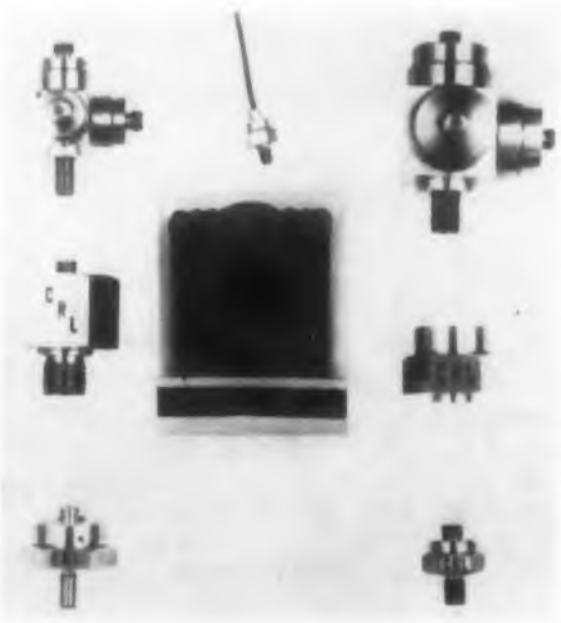


MICROMINIATURE LAMP

This microminiature incandescent indicator lamp operates directly from the output of a transistor. Developed by the Diamond Ordinance Fuze Laboratories (see *ED*, Mar 4 p 78), the lamp operates on less than 1.5 v and has a steady-state current drain of about 30 ma. It measures 0.035 in. in diameter and is 0.1 in. long.

Minitron Components Corp., Dept. ED, 187 Washington Place, Passaic, N. J.

CIRCLE 47 ON READER-SERVICE CARD



HIGH TEMPERATURE ACCELEROMETERS

Without cooling or correction, this line of crystal accelerometers operate in an ambient temperature range of −65 to +540 F. Using a new piezoelectric crystal in a true compression type seismic system, they have an accuracy of ±5% over broad acceleration and frequency range. The line consists of 16 units with sensitivities ranging from 30 mv/g to 1 mv/g.

Columbia Research Laboratories, Dept. ED, McDade Blvd. and Bullens Lane, Woodlyn, Pa.

CIRCLE 48 ON READER-SERVICE CARD

RELIABILITY IN THE PALM OF YOUR HAND...

NEW

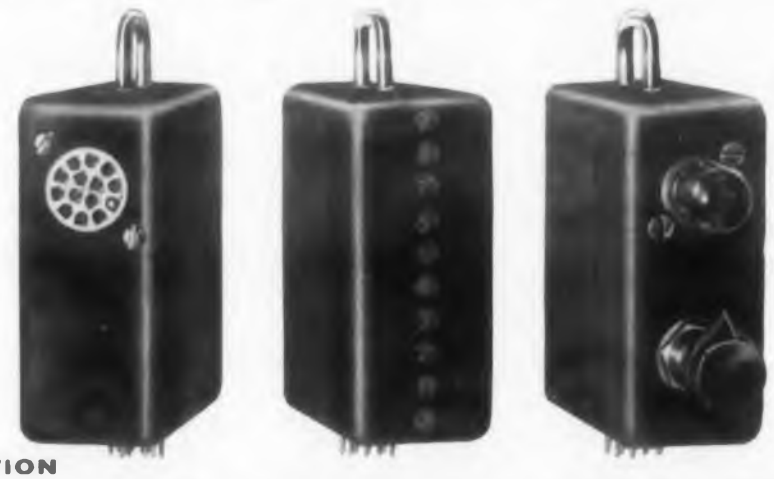
EECO N-Series *Transistorized* DECADES

for extremely reliable pulse-counting and frequency-division applications in the frequency range of 0 to 250,000 pulses per second.

FEATURES

The new EECO N-Series miniaturized and transistorized plug-in decimal counters feature simple power-supply requirements, low power consumption, small size, and extreme reliability. Saturation techniques, along with consistent derating of component tolerances result in a group of Transistorized Decades that will work dependably from 0 - 250 kcs even under adverse conditions of environment and power supply variations. All units are completely compatible with EECO T-Series Germanium plug-in circuits. In addition, an auxiliary 9-step staircase output is available. Most units are designed to plug into a special 13-pin miniature tube socket; other units plug into a standard 29-pin socket (Continental No. MM-29-22S). Mating socket is furnished with each decade.

ONE-HALF ACTUAL SIZE



WIDE SELECTION

EECO N-Series plug-in Transistorized Decades are available in a wide range of models. The counting circuitry is standardized for the various models. Provisions for visual readout and/or preset controls are as follows:

MODEL	DESCRIPTION
N-101	No readout.
N-102	Incandescent readout.
N-104	Incandescent readout (remote). Typically a projection readout module.
N-105	Nixie readout. (Can be cabled to remote Nixie.)
N-106	Nixie readout with preset control switch. (Can be cabled to remote Nixie.)
N-107	Incandescent readout with inputs for external preset control.
N-108	Incandescent readout (remote) with inputs for external preset control.
N-111	No readout, but with 1-2-4-2 code.

TYPICAL SPECIFICATIONS

The N-102 Transistorized Decade (with internal incandescent readout) employs four binary stages operating in a 1-2-4-2 code. Visual readout consists of the numerals 0 through 9 displayed vertically and illuminated by incandescent lamps. Total power consumption is approximately one watt. Outputs include (N/10), (N/10)′, and a 9-step staircase, which may be adapted for a visual display by means of an emitter follower and DC voltmeter.

ELECTRICAL SPECIFICATIONS

INPUT

Minimum Trigger Input: (0-100 kcs): 7 volts positive pulse or step at 0.5 μsec. rise time; (100 kcs to 250 kcs): 7 volts positive pulse or step at 0.2 μsec. rise time.

Maximum Operating Frequency: 250 kcs.

Input Impedance: 470 μμfd. capacitance, max.

DC Reset Input is provided (normally supplied by T-129 DC Reset Generator).

OUTPUT (No Load)

Amplitude: 8 volts, peak to peak.

Output Levels: (N/10) and (N/10)′: −11 volts DC and −3 volts DC, nom. Staircase: −11 volts DC to −3 volts DC in 9 steps.

Rise Time: (N/10): 0.5 μsec.; (N/10)′: 0.5 μsec.

Type: (N/10), (N/10)′, and 9-step staircase.

Load: Typical, two N-Series decades or two T-Series flip-flops. (Load information available on request.)

PHYSICAL SPECIFICATIONS

Dimensions: 1-5/16″ wide x 3″ deep x 3-7/8″ seated height (including handle). Dimensions are exclusive of external addenda found in external preset and Nixie models.

Mounting: Plugs into standard 9-pin miniature socket. (Some other models require a special 13-pin miniature socket, which is furnished with each such unit.)

Pin Connections: Arranged for in-line wiring of power and grounds.

Operating Temperature Range: −54°C to +71°C.

NOTE: 0 to 5 megacycle models available soon.

Additional information on N-Series Transistorized Decades and other EECO products available on request.

ENGINEERED ELECTRONICS Company

ENGINEERED ELECTRONICS COMPANY

(a subsidiary of Electronic Engineering Company of California)

506 East First Street • Santa Ana, California

CIRCLE 49 ON READER-SERVICE CARD

P.S.— See all of our new products, including Relay Drivers, Minisig Indicators, and Transistorized Decades, at the **IRE Show**, New York City, March 23-26, **Booth 3838.**

NEW PRODUCTS

VTVM

Has 6-in. meter

The VT-10 VTVM has an edge-lighted 6-in. meter for accurate reading. Sensitivity of the unit's movement is 400 μa, with 2% accuracy. For measurement stability 1% precision resistors are throughout the range switch. The unit has 7 ac (rms) and dc ranges, 0 to 1500 v. Also 7 ac peak-to-peak ranges, 0 to 2000 v. Other ranges include resistance, 0 to 1000 megohms, and db.

Arkay, Inc., Dept. ED, 88-06 Van Wyck Expressway, Richmond Hill 18, N.Y.

CIRCLE 51 ON READER-SERVICE CARD

Connectors

MS-E type

MS-E pin or socket types, Seal-E electrical connectors are supplied in sizes through O. Constructed with partitive hermetic glass seals they also have interfacial seals for internal moisture-proofing.

Connector Seals Corp., Dept. ED, Rosemead, Calif.

CIRCLE 52 ON READER-SERVICE CARD

◀ CIRCLE 50 ON READER-SERVICE CARD

Gyros

For various uses

Flexible design of the series 1080 gyros allows the unit to be made into a directional gyro or a free gyro as well as a vertical gyro. Weighing a maximum of 4.75 lb, the unit's maximum dimensions are 3-7/8 x 3-7/8 x 6 in. Standard excitation of the gyro motor is 115 v, 400 cps, 3 phase. Optional excitation: 26 v, 400 cps, 3 phase; 115 v or 208 v, 400 cps, 3 phase, 4 wire. Standard pickoff is 115 v, 400 cps, 1 phase, with optional rated at 26 v, 400 cps, 1 phase.

Lear, Inc., Dept. ED, 110 Ionia Ave., N. W., Grand Rapids 2, Mich.

CIRCLE 53 ON READER-SERVICE CARD

Double Plug Accessories

For multiple stacking

These three molded 3/4 in. double plug accessories are built for multiple stacking. Model MDP is designed for cable attachment and features a built-in cable guide to act as a strain relief. Internal set screws provide a rapid means of connection. The plug is rated at 15 amp continuous duty and 5 kv working voltage. Capacity is 0.8 μμf. Model MDPS has an internal shorting bar, and model MDPR has precision 1% resistors molded in. In all models the molded plug body is unbreakable plastic and the banana plug springs are one piece nickel plated beryllium copper.

Pomona Electronics Co., Inc., Dept. ED, 1126 W. Fifth Ave., Pomona, Calif.

CIRCLE 54 ON READER-SERVICE CARD

CIRCLE 55 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Coaxial Termination

Dc to 10 kmc

These terminations are miniaturized low power loads designed to operate from dc to 10 kmc. They are for use with airborne and other applications requiring compact, lightweight components. The units consist of a resistive film center conductor terminated within a matched housing. Their nominal power rating is 2 w, which can be increased by providing an external heat sink or forced air cooling. Known as the TA series, they are provided with either male or female connectors of type N, BNC or TNC. Impedance is 50 ohms and the input vswr over the entire frequency range is 1.1, maximum.

Microlab, Dept. ED, Livingston, N.J.

CIRCLE 56 ON READER-SERVICE CARD

Infrared Detector

Sensitive to six microns

The InSb infrared detector uses the photoconductive effect of indium antimonide. Operating at dry ice temperature, it is sensitive to six microns and has a time constant of less than one μsec. Used with the company's auxiliary low noise transformers and preamplifiers, the noise equivalent power of the detector is 5×10^{-11} w. Low microphonic noise and circuit simplicity make the unit suitable for high speed scanning systems as well as infrared detection devices and remote temperature measurement units.

Radiation Electronics Corp., Dept. ED, 8241 N. Kimball Ave., Skokie, Ill.

CIRCLE 57 ON READER-SERVICE CARD

LCR Comparison Bridge

Direct reading

Parameter deviations of 1 part in 10,000 may be detected between electronic components with the model 544 LCR comparison bridge. The unit compares and measures resistances, capacitances, and inductances at a frequency of 60 cps. Percentage deviation is read directly. Resistance measurment limits are 3 ohms to 5 meg; capacitance, 500 μμf to 1000 μf; and inductance, 3 mh to 10,000 h. The instrument has five meter ranges, indicating full scale differences of 1, 2.5, 5, 10, and 25%. Accuracy on range 1 is ±0.1%. This instrument can serve as an electronic go no-go gage; determine absolute electrical parameter values when used with a decade standard; and indicate or adjust the tracking characteristics of two or more variable resistors or capacitors mechanically coupled by a common shaft. It can also match components that must be duplicated. Either a level or foot operated switch protects the meter circuit from overload while components are being inserted or removed.

Metronix, Inc., Dept. ED, Chesterland, Ohio.

CIRCLE 59 ON READER-SERVICE CARD

Counting Modules

Plug-in

This decimal counting unit has a single-digit display 1-1/4 in. high that is packaged as an integral part of a plug-in counting module. The modules are used in a series of electronic counters, timers, and frequency meters. Digits are formed by illuminating from 5 to 11 character segments, and maximum counting rates of 100 kc and 1 mc are available.

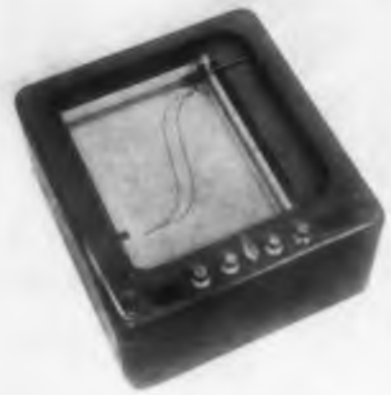
Beckman Instruments, Inc., Berkeley Div., Dept. ED, 2200 Wright Ave., Richmond 3, Calif.

CIRCLE 60 ON READER-SERVICE CARD

NEW PRODUCTS

X-Y Recorder

Accurate to 0.05%



The HR-92 X-Y recorder is used for computer readout and for plotting stress vs strain; magnetic material, tube, and semiconductor characteristics; pressure vs temperature; speed vs torque; or any other two related variables. It is designed for use with standard 8-1/2 x 11 in. graph paper. The unit is ruggedly built and uses self-balancing potentiometer servos to assure 0.05% accuracy and drift-free performance at available sensitivities of up to 1 mv per in. Three turn rebalance slide wires are lubricated to provide years of operation. The pen speed is 1 sec full scale without overshoot.

Houston Instrument Corp., Dept. ED, 1717 Clay Ave., Houston 3, Tex.

CIRCLE 62 ON READER-SERVICE CARD

Miniature Signal Lamp

For production control boards

The Perlite miniature signal lamp is designed for use in production control or power dispatcher boards. It is particularly adapted for metal boards where perforations are made on 1/4 in. centers on a square pattern, or 3/16 in. on a staggered pattern. It operates on 20 v, and a resistor, mounted on the socket, permits the use of a 110 v power supply. At low voltage, maximum lamp life is 2 years to indefinite.

Power Dispatchers Equipment Co., Dept. ED, P. O. Box 1947, Milwaukee 1, Wis.

CIRCLE 63 ON READER-SERVICE CARD

Power Supply

30 kv output

Designated Model PS-30T, this 30 kv, full-wave voltage-doubler power supply operates on 117 v, 60 or 400 cps. The unit delivers 1 ma continuous and 1.75 ma peak current. Ripple is 1.5% at 1 ma and regulation is approximately 7% from no load to full load. It has replaceable 1B3 rectifier tubes and plastic dielectric capacitors. Dimensions of the case are 5-1/4 x 11-3/8 x 9-1/2 in. and the unit has oil-tight solder-seal terminals.

Film Capacitors, Inc., Dept. ED, 3400 Park Ave., New York 56, N. Y.

CIRCLE 64 ON READER-SERVICE CARD

AC VTVM

Covers 0.001 to 300 v in 12 ranges

Model VA-104 ac vacuum tube voltmeter has a 10 cps to 4 mc frequency range and 12 voltage ranges from 0.001 to 300 v. Calibrated to read the rms value of a sine wave, it has an overall accuracy of ±2%. It consumes 70 w and can be used on lines of 115 or 230 v, ±10%, at 50 or 1000 cps. The unit incorporates long life electrolytic capacitors and output jacks which permit its use as a high gain, 4 mc wideband amplifier with a maximum gain of 50 db. A portable instrument, it is 7-3/8 in. wide, 11-3/16 in. high, and 11-5/8 in. deep.

Republic Electronic Industries Corp., Dept. ED, 111 Gazza Blvd., Farmingdale, N.Y.

CIRCLE 65 ON READER-SERVICE CARD

Miniature Crystal Diodes

All glass

These all-glass miniature crystal diodes are designed for radio, television, data processing, and other military and commercial electronic applications. They have a maximum body length of 0.265 in. and a maximum diam of 0.105 in. The line includes: computer types 1N191, 1N192, and 1N198 which offer rapid recovery, good stability, and high conductance; gold bonded types 1N270, 1N276, 1N279, 1N281, and 1N283 which combine high temperature capabilities with high forward conduction; point-contact types 1N126A, 1N127A, and 1N128 which have a wide reverse resistance and voltage range; and silicon junction types 1N251, 1N252, 1N456, 1N464, 1N625, and 1N629 which operate with rapid recovery and high reverse resistance at temperatures up to 150 C.

Sylvania Electric Products Inc., Semiconductor Div., Dept. ED, Woburn, Mass.

CIRCLE 67 ON READER-SERVICE CARD

Portable Calibration Unit

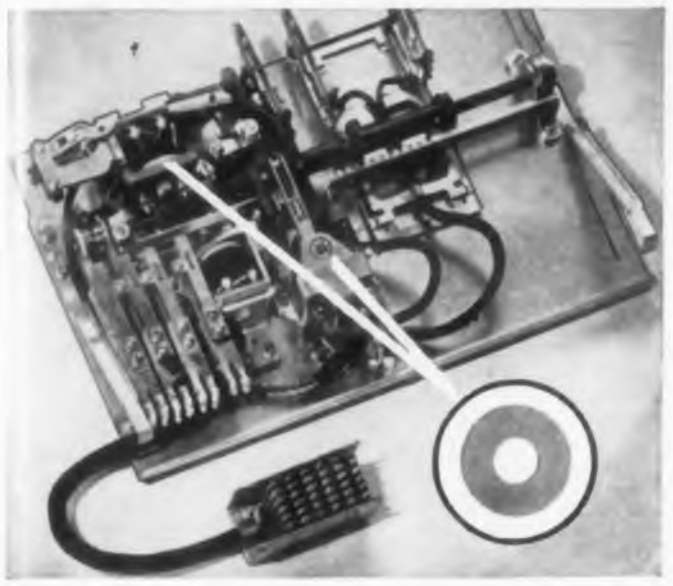
Accurate to 0.01%

A portable, all semiconductor calibrator, model TC-10 is designed for precision alignment and calibration of electronic equipment such as fm record-reproduce systems. With a voltage standard accurate to 0.01%, it provides working calibration voltages in nine steps, each adjustable over a range of 10%. Nine precision oscillators and seven binary dividers provide 63 accurate calibration frequencies ranging from 1012 cps to 151.2 kc. These can be introduced into a system for discriminator alignment or for comparison with the output of a voltage-controlled oscillator. Supplied in a figerglass case, the unit weighs 25 lbs.

Ampex Corp., Instrument Div., Dept. ED, 934 Charter St., Redwood City, Calif.

CIRCLE 68 ON READER-SERVICE CARD

Dow Corning Silicone Dielectrics



Stromberg-Carlson telephone switch insulator

SILICONE-GLASS LAMINATES INCREASE LIFE AND DEPENDABILITY

Laminates made by bonding glass cloth with Dow Corning silicone resins have high arc resistance, low loss factor, low moisture absorption, excellent retention of dielectric properties at high temperatures. Strong, lightweight—produced by leading laminators.

CIRCLE 501 ON READER-SERVICE CARD

SILICONE FLUIDS PROTECT ASSEMBLIES FROM MOISTURE

Southwestern Industrial Electronics seismographs

A protective film of Dow Corning 200 Fluid spray coated on electronic assemblies protects terminals, clips, switches and other exposed connections from the harmful effects of condensation. Glass and ceramic insulators coated with silicone fluid have low current leakage and a high degree of surface resistivity, even under very humid conditions.

CIRCLE 502 ON READER-SERVICE CARD

SILICONE COMPOUND PREVENTS ARCS, GROUNDS, SHORTS

Nonmelting, nongumming Dow Corning 3 Compound stays in place . . . provides an effective, moisture-proof dielectric seal for all types of electronic equipment. As a potting or filling material for electronic components and assemblies, silicone compounds flow into place with gentle pressure . . . have a serviceable temperature range of —40 to 205 C. Free sample available.

CIRCLE 503 ON READER-SERVICE CARD

AN Connector Terminals, Navy Helicopter

For further information on these products write Dept. 1615

Resolver Function Error Bridge

0.01% full scale sensitivity

Resolver function bridge model RF-1 tests computing resolvers for deviation from an ideal sine or cosine function. The result, expressed directly in percentage error, is shown on a 4-1/2 in. zero-center meter. The output voltage from each resolver winding is measured by comparison to a standard voltage. Taps from the standard voltage circuit represent the cosine function at 5 deg intervals. High balance sensitivity is achieved since the carrier phase of the standard is precisely matched to that of the resolver output. The detector blocks all harmonic and quadrature voltages. In a cabinet 19 x 7 x 8 in., the unit accommodates any range of resolver inputs and outputs. Accurate to 0.002%, it has a full scale sensitivity of 0.01%.

Theta Instrument Corp., Dept. ED, 48 Pine St., East Paterson, N.J.

CIRCLE 69 ON READER-SERVICE CARD

Shift Register Package

1-1/4 x 11 x 1-1/8 in.

Model TRA-25-10 register assembly consists of ten core-transistor shift register elements driven by one core-transistor shaper-driver element. Test points are provided for observation of all pertinent waveforms. The unit measures 1-1/4 x 11 x 1-1/8 in. and requires pulse signals from 0 to 25 kc and a 12 v power supply. Custom registers of any size or configuration are also available These are designed around the TRA-25-10 with packaging densities up to 2000 bits per cu ft at 55 C.

DI-AN Controls, Inc., Dept. ED, 40 Leon St., Boston, Mass.

CIRCLE 70 ON READER-SERVICE CARD

NEW PRODUCTS

Amplifier

1/4 million voltage gain

Model 4300 amplifier provides a voltage gain of 1/4 million, a noise level of less than 0.025 μv, and an 8-hr drift of less than 0.1 μv rms referred to input with a 5 cps galvanometer installed. It employs an optical beam-splitter, twin mutual-load photocells, a cathode-follower output and a galvanometer. Galvanometers are available in natural frequency ranges from 2 to 50 cps. Maximum output voltage is 30 v, peak to peak into an open circuit and 16 v peak to peak into 10 K. Dynamic range is 70 db, noise level to clipping level, and linearity is ±2%, noise level to 50% clipping level, based on best straight line.

The Geotechnical Corp., Dept. ED, P. O. Box 28277, Dallas 28, Tex.

CIRCLE 71 ON READER-SERVICE CARD

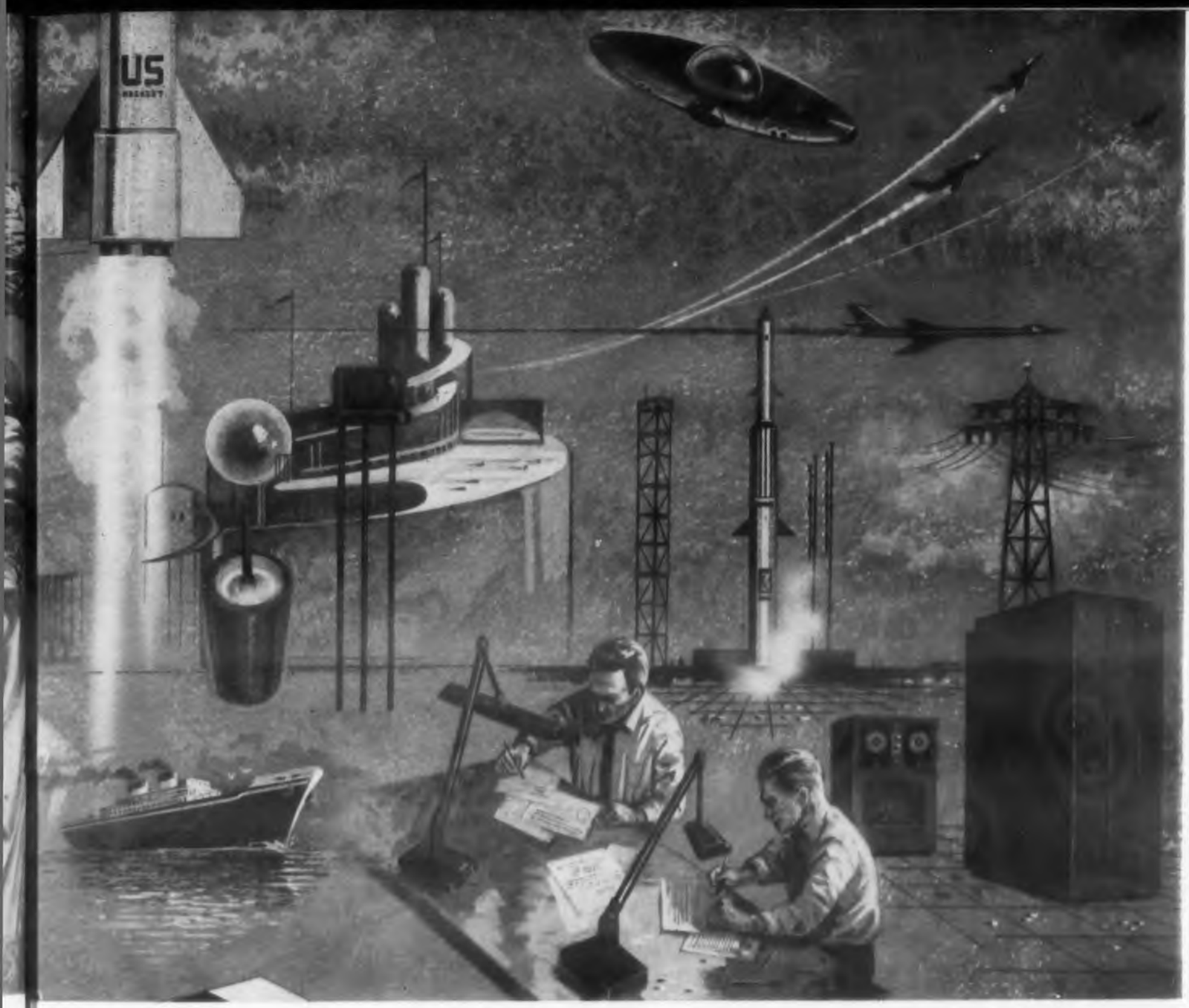
Feed-Through Connector

One-piece

The type 3006 ConheX connector is a grounded-shield, feed-through, one-piece unit which serves as a cable lock. It holds coaxial cable while grounding the braided conductor to the chassis and passing the insulated center conductor through to the other side. This miniature connector is available in 50, 75, and 95 ohm sizes.

Sealectro Corp., Dept. ED, 610 Fayette Ave., Mamaroneck, N.Y.

CIRCLE 72 ON READER-SERVICE CARD



Readout-Recorder

Monitors servo systems

For monitoring any servo system, this two channel readout-recorder provides permanent chart records of servo transmitter angular or displacement data. It can be used for dc to 2 cps recording, servo recording, production testing, inspection, or as a readout for analog computers. Fully automatic, it features zero time flyback. Chart speeds are 5, 10, 20, 40, and 80 in. per hr. Offering infinite scale expansion, the unit has rotating styluses coupled with a four-digit counter which adds and subtracts. It is ruggedly built and meets MIL-E-16400 specifications. Fully transistorized, it weighs 76.5 lb and measures 21.5 x 15.5 x 12.25 in. including shock mounted base.

Brush Instruments, Div. of Clevite Corp., Dept. ED, 37th and Perkins Ave., Cleveland 14, Ohio.

CIRCLE 73 ON READER-SERVICE CARD

Shock Tester

For electronic components

Built to JAN-S-44 and MIL-STD-202A specifications, this tester reproduces the moderate shock that electronic components and instruments receive in mobile and field equipment. The unit has a 0 to 4 lb capacity and handles instruments with diameters to 3.5 in.

Gaynes Engineering Co., Dept. ED, 1642-52 W. Fulton St., Chicago 12, Ill.

CIRCLE 74 ON READER-SERVICE CARD

Shaft Position Encoder

Operates from −65 to +162 F

Shaft position encoder model C-701 provides up to 1024 positions per shaft turn. A sealed unit, it operates at ±8 g to 1000 cps and under a steady 100 g in the longitudinal axis. It may be used from −65 to +162 F.

Datex Corp., Dept. ED, 1307 S. Myrtle Ave., Monrovia, Calif.

CIRCLE 75 ON READER-SERVICE CARD

◀ CIRCLE 76 ON READER-SERVICE CARD

NEW PRODUCTS

Multiplexer

For 7 analog data channels

Model 3515 standard multiplexer will transmit 7 analog data channels, 1 reference frequency channel, and a full-duplex communications channel. Additional channels are possible. System accuracy is ±1%. Output impedance is nominally 600 ohms, and output level is adjustable from 0 to 5 v, peak to peak. From 1 to 8 adjustable and serviceable voltage-controlled fm subcarrier oscillators may be plugged into the unit. Dimensions of the unit are 8-3/4 x 19 x 15 in., it weighs 30 lb.

The Geotechnical Corp., Dept. ED, P. O. Box 28277, Dallas, Tex.

CIRCLE 78 ON READER-SERVICE CARD

Insulated Terminals

For diversified uses

These molded insulated electronic terminals are available in three types. The first is a series of melamine-insulated feed-through terminals with molded outer threadings which mount directly in a tapped hole without additional hardware. The second is a series of diallyl phthalate insulated terminals with tapped inserts and metal flanges. This type is designed for spot welding or soldering onto a metal shell. The third is a series of printed circuit board receptacles designed for plug-in mounting of transformers, relays, switches, and other assemblies. These units are made of half-hard brass and accommodate standard pin sizes up to 0.125 in.

Lerco Electronics, Inc., Dept. ED, 501 Varney St., Burbank, Calif.

CIRCLE 79 ON READER-SERVICE CARD

◀ CIRCLE 77 ON READER-SERVICE CARD

Soldering Iron

Pencil size

This low wattage, miniature pencil soldering iron operates from 110 to 120 v without a transformer and has tips which slide on over the heating element so that all the power converted to heat is radiated through the tip rather than wasted in space. The heating element maintains a constant temperature at around 626 F. With 50 meg of insulation between element and tip and the element grounded through a third terminal, this device is especially suited for use around semiconductors. The whole tool weighs less than 1 oz.

M. M. Newman Corp., Dept. ED, 79 Clifton Ave., Marblehead, Mass.

CIRCLE 80 ON READER-SERVICE CARD

Precision Calibrator

For thermocouples

Precision model TC-2 thermocouple calibrator incorporates a platinum and platinum-rhodium thermocouple calibrated by the Bureau of Standards on 12 points for temperatures to 2200 F. For cold junction compensation it uses a constant-temperature thermocouple reference junction. The unit is 40 x 30 x 70 in., and is equipped with a 24 point rotary switch for error free switching from couple to couple. It also has an F-4 furnace 20 x 20 x 36 in.

Arcweld Mfg. Co., Dept. ED, Grove City, Pa.

CIRCLE 81 ON READER-SERVICE CARD

Nylon Bobbin

Has insulated lead slot

A slot for insulating starting leads is an integral part of this nylon bobbin. This slot eliminates the need for washers or lead taping and makes the bobbin particularly suitable for automatic coil winding.

American Molded Products Co., Dept. ED, 2727 W. Chicago Ave., Chicago 22, Ill.

CIRCLE 82 ON READER-SERVICE CARD

CIRCLE 83 ON READER-SERVICE CARD ➤

NEW PRODUCTS

28 V DC Motor

For aircraft and missile use

Operating at 28 v dc and 69 amp, model D-1000 motor delivers 1.6 hp at 2000 rpm. Output speeds to 25,000 rpm are available in units without a reduction gear box. Of explosion proof construction, the unit incorporates flame quench rings per MIL-E-5272 and a radio noise suppression filter per MIL-E-6181. AND-20000 mounting flanges are standard, but others are available. The motor has a life of over 1500 hr and withstands continuous starting at rated load at 2 sec intervals under severe inrush conditions. Actuator operation is at 260 F ambient at 60,000 ft altitude. Motors for ambient temperatures to 500 F and altitudes of over 200,000 ft are available for missile applications.

Hoover Electric Co., Dept. ED, 2100 S. Stoner Ave., Los Angeles 25, Calif.

CIRCLE 85 ON READER-SERVICE CARD

Polarized Relays

No contact bounce

Bistable type 51A and center stable type 51M polarized relays have 0.7 msec response and no contact bounce. They withstand 4000 shocks at 40 g, and operate from −40 to +70 C. Sensitivity is 1 to 3 amp-turns for the 51M; 2 to 5 amp-turns for the 51A. The units are 2.4 x 1.5 x 0.8 in. and come with 12-pin plug or solder lug bases.

C. P. Clare & Co., Dept. ED, 3101 Pratt Blvd., Chicago 45, Ill.

CIRCLE 86 ON READER-SERVICE CARD

◀ CIRCLE 84 ON READER-SERVICE CARD

Step-Servo Motors

Size 8

Available with impedances of 50 to 150 ohms, these 3/4 in. diameter size 8 step-servo motors contain two center-tapped stator windings and a permanent magnet rotor. They may be operated through voltage ranges of 20 to 40 v dc and have a holding torque range of from 0.5 to 1 oz-in. Stepping rates of up to 120 pulses per sec are achieved through shaft increments of 45 deg. No mechanical detents are used, assuring a long life limited only by the bearings. The units operate over a temperature range of −55 to +125 C and meet the environmental requirements of MIL-E-5272B and MIL-E-5400.

Induction Motors of California, Dept. ED, 6058 Walker Ave., Maywood, Calif.

CIRCLE 87 ON READER-SERVICE CARD

Coaxial Attenuators

For use with Type N connectors

For applications using Type N connectors, type HFA/N-50 fixed pad coaxial attenuators have a nominal impedance of 52.5 ohms and are usable in a frequency range from dc to 2500 mc. Maximum vswr through this range is 1.2. With an average power rating of 1/2 w, the units are available in standard models for attenuation values of 1, 2, 3, 4, 6, 10, 12, 15, and 20 db.

Applied Research Inc., Dept. ED, 76 S. Bayles Ave., Port Washington, N.Y.

CIRCLE 88 ON READER-SERVICE CARD

Silicon Rectifier Test Set

For 1 to 500 amp units

Model 128A silicon rectifier test set is a laboratory and production unit designed specifically to evaluate the dynamic characteristics of silicon rectifiers in accordance with ASESA recommendations. It employs a simulator circuit which permits selection of any forward current or reverse voltage within its range. The set tests rectifiers with forward current ratings between 1 and 500 amp half-wave, and reverse voltage ratings to 2 kv peak. It is equipped with multi-scale instruments to measure all rectifier parameters and includes plug-in provisions for oscilloscope observation of wave shapes.

Wallson Associates, Inc., Dept. ED, 35 E. Runyon St., Newark 8, N.J.

CIRCLE 89 ON READER-SERVICE CARD

Counter Scanner

Transfers multiple data to one recorder

Operating from staircase voltages produced by up to six counters, the DY-2513 counter scanner automatically transfers the information displayed on each counter to one Hewlett-Packard model 560A digital recorder. It also automatically records preset decimal information manually selected by six decimal dials on the front panel. Readings from the scanned counters are recorded sequentially on adding machine tape with an identifying digit for each source. The unit may be used with the company's counters or with Hewlett-Packard models.

Dymec, Inc., Dept. ED, 395 Page Mill Rd., Palo Alto, Calif.

CIRCLE 90 ON READER-SERVICE CARD

Rotary Switch

Has spring locked into switch

A steel alloy spring is built into the index mechanism of the PA-070 switch and it controls the spring return action. Switches with this feature can be supplied as single or double section units, or as single section units with line switch. Up to six positions per section, including the spring return position are available. Spring return can be placed in either the first or last position, and sections are laminated phenolic type PBE per Mil-P-3115, voltage breakdown 1000 v rms.

Centralab, Div. of Globe-Union Inc., Dept. ED, 900 E. Keefe Ave., Milwaukee 1, Wis.

CIRCLE 92 ON READER-SERVICE CARD

Phase Generator

Covers 5 cps to 200 kc

Phase generator model 410 is a combination phase shifter and phase difference generator that covers 5 cps to 200 kc. The addition of an external capacitor extends this range down to 0.1 cps. Accuracy is 0.1 deg over the audio frequency spectrum, decreasing above and below. The unit can be used for the calibration of phase measuring devices, or, with an external phase detector, as a precision phase measuring device.

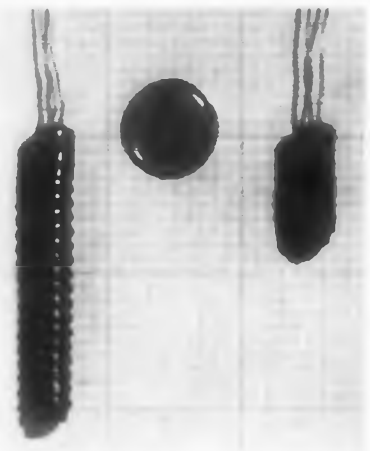
Dytronics Co., Dept. ED, 78 Sunnyside Lane, Columbus 14, Ohio.

CIRCLE 93 ON READER-SERVICE CARD

NEW PRODUCTS

Miniature Bellows Motor

Works around curves



This miniature, squib-actuated bellows motor is designed for missiles, weapons, and weapons systems. Actuated by as little as 100 ergs at 1.5 v, or 0.3 amp, the motor is capable of providing 10 lb of thrust over a 1 in. minimum stroke within an elapsed time of 1 msec. In addition, the bellows can be guided around a 90 deg curve. The 0.32 in. diameter motor is 1 in. long, functions properly from —65 to +165 F, and withstands 20,000 g shock and acceleration. Shelf life is measurable in years.

Atlas Powder Co., Ordnance Materiel Dept., Dept. ED, Wilmington 99, Del.

CIRCLE 95 ON READER-SERVICE CARD

Transformer

Shell type

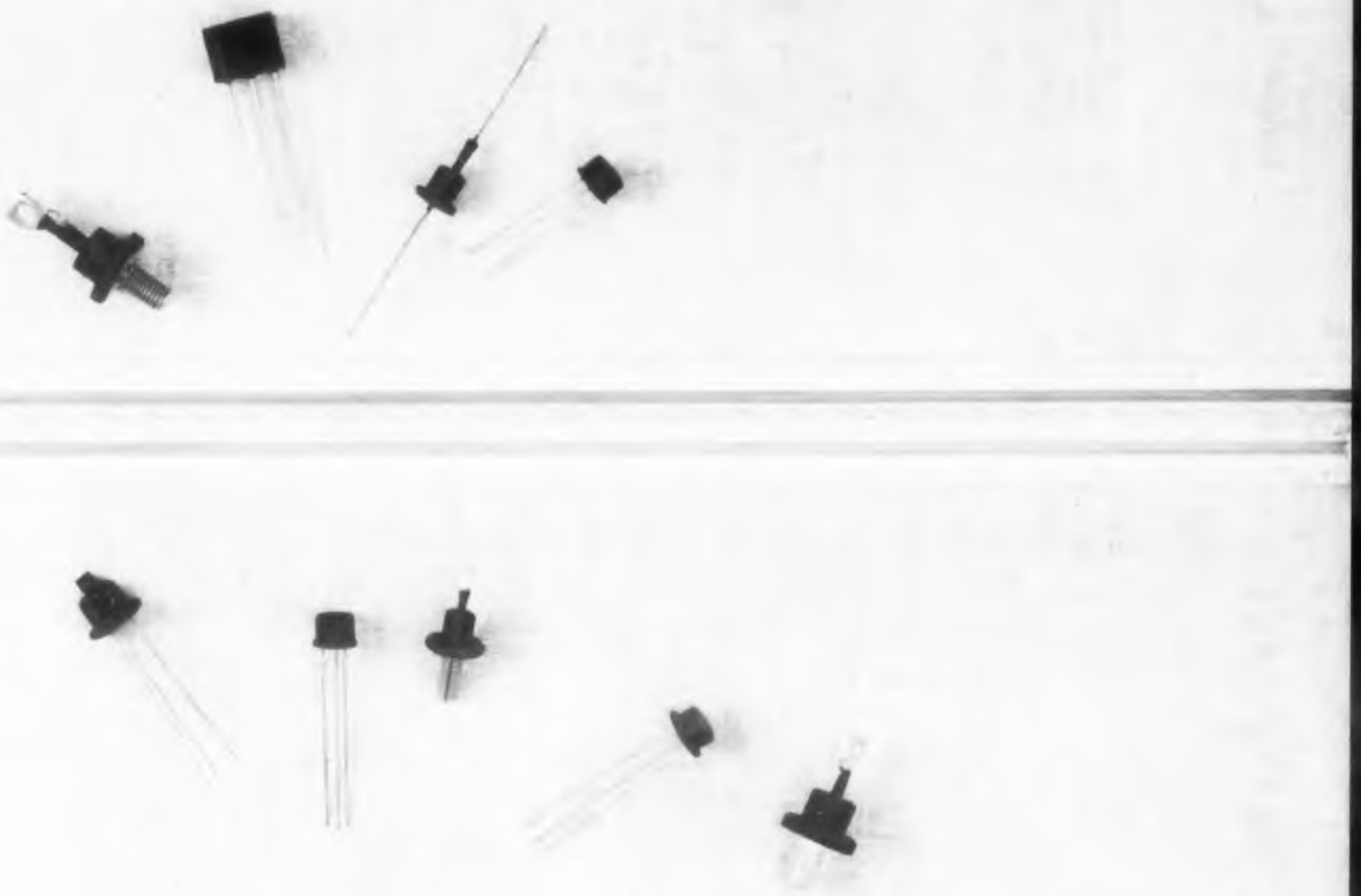
The shell type Donut transformer is used for isolating high voltages on filaments and cascaded high voltage power units. The cost of the unit is reduced by the elimination of ceramic bushings, oil, and tank. In comparison with conventional oil tank units, its size and weight are reduced about 40 per cent.

Nothelfer Winding Labs, Inc., Dept. ED, P.O. Box 455 Trenton, N.J.

CIRCLE 96 ON READER-SERVICE CARD

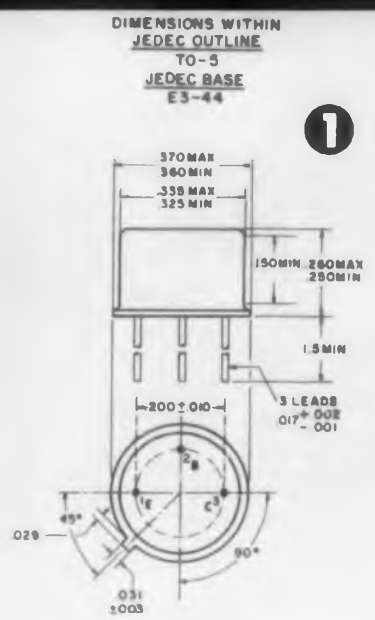
CIRCLE 495 ON READER-SERVICE CARD

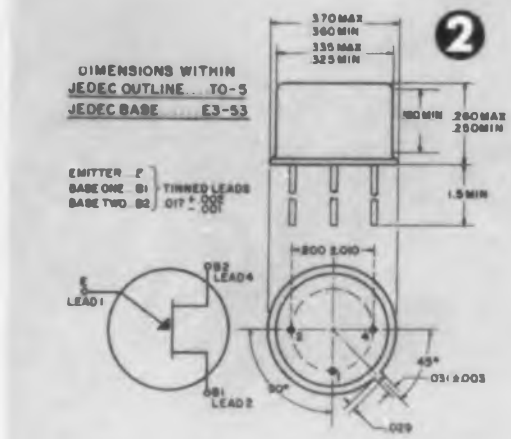
CIRCLE 94 ON READER-SERVICE CARD

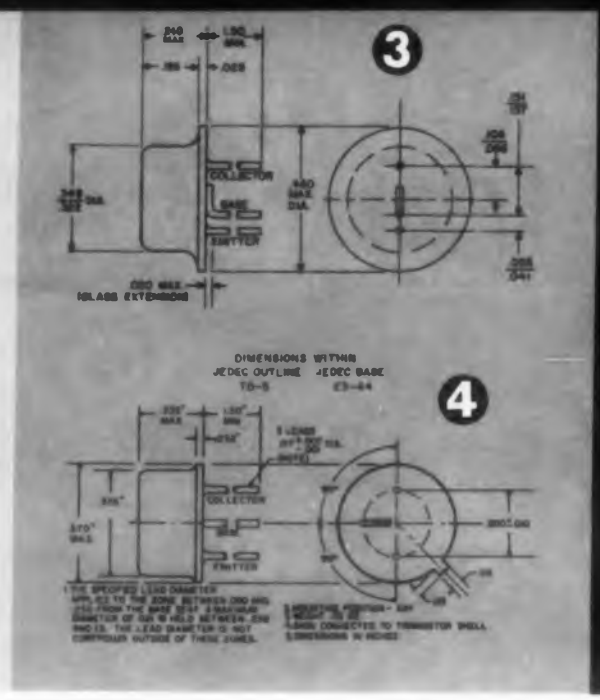


SEMICONDUCTORS

Transistors ● Rectifiers ● Germanium ● Silicon ● Selenium ● Copper Oxide ● Unijunctions ● Controlled Rectifiers ● Fixed-bed Mounting ● USAF ● JAN ● USN ● Low Frequency Audio and Switching ● High Frequency Switching ● Low-Medium-High Current ● High and Low Temperature







TRANSISTORS Germanium • Silicon • Fixed-Bed Mounting • Unijunctions • Tetrodes • High Frequency Switching • Low Frequency Audio and Switching • USAF

NEW TECHNOLOGY

As a result of recent technology advancements in such areas as product engineering, manufacturing-line processing, and quality-control systeming, General Electric Company again offers you the *avant garde* in present-day transistor quality.

EXAMPLES

PNP low-frequency survival records have been shattered by the accomplishment of one-million unit-hours of life survival with the G-E 2N43A transistor.

Higher gain and improved saturation characteristics have been created for high-frequency switching. This was brought about by G.E. through recent improvements in d-c beta at higher collector currents, made with Types 2N123 and 2N450 transistors.

With a collector current of 1½ μa max. at 15 volts, G.E.'s germanium NPN high-frequency 2N167 gives an ultimate in I_{co}. It also has a low collector capacitance of 3 μμf.

The mechanically rugged golf-club/shotgun-tested ceramic fixed-bed transistor mounting has been expanded, product-wise, beyond the Series 2N489-494 unijunction line, and is now also offered in the NPN high-frequency transistor series (2N332-338).

MILITARY TYPES

G-E quality advances are also exhibited by General Electric's over-all success in supplying to an increasing number of military specifications covering semiconductor products. G-E MIL transistors include the USAF-types 2N43A, 2N44A, and 2N167. The G-E Types 2N123A and 2N396A are certified to meet military specs. (See adjacent rating chart.) For G-E military rectifiers, see next two fold-out pages.

ADDITIONAL INFORMATION

For more-detailed information, please contact your nearest G-E Semiconductor Products District Representative. (See back page.)

	USE	OUTLINE DWG. NO.	TYPE NO.	
SILICON	AMPLIFIER AND COMPUTER NPN (Ceramic Fixed-bed Construction)	1	2N332	
		1	2N333	
		1	2N334	
		1	2N335	
		1	2N336	
		1	2N337	
		1	2N338	
	UNIJUNCTION NPN (Ceramic Fixed-bed Construction)	2	2N489*	
		2	2N490*	
		2	2N491*	
		2	2N492*	
		2	2N493*	
		2	2N494*	
			*A PN Device	
GERMANIUM	AUDIO PNP	3	2N43	
		3	(USAF) 2N43A	Per MIL-T-19500/18
		3	2N44	
		3	(USAF) 2N44A	Per MIL-T-19500/6
		4	2N524	
		4	2N525	
		4	2N526*	
		4	2N527	
			*Also supplied as certified to meet MIL-T-19500/60	
	COMPUTER PNP	5	2N123	
		5	2N123A	Certified to meet MIL-T-19500/30
		4	2N395	
		4	2N396	
		4	2N396A	Certified to meet MIL-T-19500/64
		4	2N397	
		4	2N404	
		5	2N450	
		5	2N518	
		3	2N1056	
		3	2N1057	
	HIGH FREQ. AMLIFIER NPN	6	2N78	
		6	2N169A	
	COMPUTER NPN	6	2N167	
		6	(USAF) 2N167	Per MIL-T-19500/11
		4	2N634	
		4	2N635	
		4	2N636	
	TETRODE NPN	7	3N36	
		7	3N37	

RECTIFIERS! Fold out next page

RECTIFIERS Germanium • Silicon • High and Low Temperature • Controlled Rectifiers

Low-Medium-High Current • JAN • USN • USAF

BASIC RATING CHART

Choose the performance range required for your particular needs from one of the most comprehensive line of rectifiers in the industry. Complete specifications are available through your distributor or G-E Semiconductor Products District Sales Office. Order by JEDEC or G-E Type No.

RECTIFIER CELLS

JEDEC or G-E Type No.	PIV	Max. I_{DC} at T°C	Max. 1 Cycle (60 cps) Surge	Max. Oper. Temp. °C	Max. Storage Temp. °C
1N91	100	150ma at 55° amb.	25A	95°	85°
1N92	200	100ma at 55° amb.	25A	95°	85°
1N93	300	75ma at 55° amb.	25A	95°	85°
USN1N93	300	75ma at 55° amb.	25A	55°	85°
1N151	100	500ma at 55° amb.	25A	95°	85°
1N152	200	500ma at 55° amb.	25A	95°	85°
1N153	300	500ma at 55° amb.	25A	95°	85°
1N158	380	500ma at 55° amb.	25A	95°	85°
1N253	95	1000ma at 135° stud	4A	150°	150°
1N254	190	400ma at 135° stud	1.5A	150°	150°
1N255	380	400ma at 135° stud	1.5A	150°	150°
1N256	570	200ma at 135° stud	1.5A	150°	150°
1N315	100	100ma at 85° amb.	5A	85°	95°
USAF1N315	100	100ma at 85° amb.	5A	85°	100°
1N332	400	400ma at 150° stud	15A	170°	170°
1N333	400	200ma at 150° stud	10A	170°	170°
1N334	300	400ma at 150° stud	15A	170°	170°
1N335	300	200ma at 150° stud	10A	170°	170°
1N336	200	400ma at 150° stud	15A	170°	170°
1N337	200	200ma at 150° stud	10A	170°	170°
1N339	100	400ma at 150° stud	15A	170°	170°
1N340	100	200ma at 150° stud	10A	170°	170°
1N341	400	400ma at 150° stud	15A	170°	170°
1N342	400	200ma at 150° stud	10A	170°	170°
1N343	300	400ma at 150° stud	15A	170°	170°
1N344	300	200ma at 150° stud	10A	170°	170°
1N345	200	400ma at 150° stud	15A	170°	170°
1N346	200	200ma at 150° stud	10A	170°	170°
1N348	100	400ma at 150° stud	15A	170°	170°
1N349	100	200ma at 150° stud	10A	170°	170°
1N368	200	100ma at 85° amb.	10A	65°	85°
1N440	100	300ma at 100° amb.	15A	150°	175°
1N440B	100	500ma at 100° amb.	15A	165°	175°
1N441	200	300ma at 100° amb.	15A	150°	175°
1N441B	200	500ma at 100° amb.	15A	165°	175°
1N442	300	300ma at 100° amb.	15A	150°	175°
1N442B	300	500ma at 100° amb.	15A	165°	175°
1N443	400	300ma at 100° amb.	15A	150°	175°
1N443B	400	500ma at 100° amb.	15A	165°	175°
1N444	500	300ma at 100° amb.	15A	150°	175°
1N444B	500	425ma at 100° amb.	15A	150°	175°
1N445	600	300ma at 100° amb.	15A	150°	175°
1N445B	600	350ma at 100° amb.	15A	150°	175°
1N536	50	500ma at 100° amb.	15A	165°	175°
1N537	100	500ma at 100° amb.	15A	165°	175°
1N538	200	500ma at 100° amb.	15A	165°	175°
USAF1N538	200	500ma at 100° amb.	15A	150°	175°
1N539	300	500ma at 100° amb.	15A	165°	175°
1N540	400	500ma at 100° amb.	15A	165°	175°
USAF1N540	400	500ma at 100° amb.	15A	150°	175°
1N547	600	500ma at 100° amb.	15A	165°	175°
1N550	100	800ma at 135° stud	15A	150°	175°
1N551	200	800ma at 135° stud	15A	150°	175°
1N552	300	800ma at 135° stud	15A	150°	175°
1N553	400	800ma at 135° stud	15A	150°	175°
1N554	500	600ma at 135° stud	15A	150°	175°
1N555	600	600ma at 135° stud	15A	150°	175°
1N560	800	250ma at 100° amb.	15A	150°	175°
1N561	1000	250ma at 100° amb.	15A	150°	175°
1N562	800	400ma at 100° stud	15A	150°	175°
1N563	1000	400ma at 100° stud	15A	150°	175°
1N599	50	400ma at 100° amb.	10A	150°	175°
1N599A	50	400ma at 100° amb.	10A	150°	175°
1N600	100	400ma at 100° amb.	10A	150°	175°
1N600A	100	400ma at 100° amb.	10A	150°	175°
1N601	150	400ma at 100° amb.	10A	150°	175°
1N601A	150	400ma at 100° amb.	10A	150°	175°
1N602	200	400ma at 100° amb.	10A	150°	175°
1N602A	200	400ma at 100° amb.	10A	150°	175°
1N603	300	400ma at 100° amb.	10A	150°	175°
1N603A	300	400ma at 100° amb.	10A	150°	175°
1N604	400	400ma at 100° amb.	10A	150°	175°
1N604A	400	400ma at 100° amb.	10A	150°	175°
1N605	500	400ma at 100° amb.	10A	150°	175°
1N605A	500	400ma at 100° amb.	10A	150°	175°
1N606	600	400ma at 100° amb.	10A	150°	175°
1N606A	600	400ma at 100° amb.	10A	150°	175°
1N607	50	800ma at 135° stud	15A	150°	170°
1N607A	50	800ma at 135° stud	15A	150°	170°
1N608	100	800ma at 135° stud	15A	150°	170°
1N608A	100	800ma at 135° stud	15A	150°	170°
1N609	150	800ma at 135° stud	15A	150°	170°
1N609A	150	800ma at 135° stud	15A	150°	170°
1N610	200	800ma at 135° stud	15A	150°	170°
1N610A	200	800ma at 135° stud	15A	150°	170°
1N611	300	800ma at 135° stud	15A	150°	170°
1N611A	300	800ma at 135° stud	15A	150°	170°
1N612	400	800ma at 135° stud	15A	150°	170°
1N612A	400	800ma at 135° stud	15A	150°	170°
1N613	500	600ma at 135° stud	15A	150°	170°
1N613A	500	600ma at 135° stud	15A	150°	170°
1N614	600	600ma at 135° stud	15A	150°	170°
1N614A	600	600ma at 135° stud	15A	150°	170°
1N1095	500	425ma at 100° amb.	15A	150°	175°
1N1096	600	350ma at 100° amb.	15A	150°	175°
1N1100	100	500ma at 100° amb.	15A	165°	175°
1N1101	200	500ma at 100° amb.	15A	165°	175°
1N1102	300	500ma at 100° amb.	15A	165°	175°
1N1103	400	500ma at 100° amb.	15A	165°	175°
1N1115	100	1.5A at 85° stud	15A	170°	175°
1N1116	200	1.5A at 85° stud	15A	170°	175°
1N1117	300	1.5A at 85° stud	15A	170°	175°
1N1118	400	1.5A at 85° stud	15A	170°	175°
1N1119	500	1.5A at 85° stud	15A	170°	175°
1N1120	600	1.5A at 85° stud	15A	170°	175°
1N1487	100	250ma at 125° amb.	15A	140°	175°
1N1488	200	250ma at 125° amb.	15A	140°	175°
1N1489	300	250ma at 125° amb.	15A	140°	175°
1N1490	400	250ma at 125° amb.	15A	140°	175°
1N1491	500	250ma at 110° amb.	15A	125°	175°
1N1492	600	250ma at 95° amb.	15A	120°	175°
1N1692	100	600ma at 100° amb.	20A	115°	125°
1N1693	200	600ma at 100° amb.	20A	115°	125°
1N1694	300	600ma at 100° amb.	20A	115°	125°
1N1695	400	600ma at 100° amb.	20A	115°	125°
1N2154	50	25A at 145° stud	300A	200°	200°
1N2155	100	25A at 145° stud	300A	200°	200°
1N2156	200	25A at 145° stud	300A	200°	200°
1N2157	300	25A at 145° stud	300A	200°	200°
1N2158	400	25A at 145° stud	300A	200°	200°
1N2159	500	25A at 145° stud	300A	200°	200°
1N2160	600	25A at 145° stud	300A	200°	200°
4JA60A*	100	70A at 120° stud	900A	200°	200°
4JA60B*	200	70A at 120° stud	900A	200°	200°
4JA60C*	300	70A at 120° stud	900A	200°	200°
4JA60D*	400	70A at 120° stud	900A	200°	200°
4JA60F*	50	70A at 120° stud	900A	200°	200°
4JA60G*	150	70A at 120° stud	900A	200°	200°
4JA60H*	250	70A at 120° stud	900A	200°	200°
4JA60J*	350	70A at 120° stud	900A	200°	200°
4JA62A*	100	40A at 120° stud	900A	150°	200°
4JA62B*	200	40A at 120° stud	900A	150°	200°
4JA62C*	300	40A at 120° stud	900A	150°	200°
4JA62D*	400	40A at 120° stud	900A	150°	200°
4JA62F*	50	40A at 120° stud	900A	150°	200°
4JA62G*	150	40A at 120° stud	900A	150°	200°
4JA62H*	250	40A at 120° stud	900A	150°	200°
4JA62J*	350	40A at 120° stud	900A	150°	200°

*Also available with reversed polarity.

RECTIFIER STACKS

G-E Type	PIV (up to)	Max. I_{DC} at T°C (up to)
4JA211	630 V	6 amps. at 55° amb.
4JA411	3360 V	18 amps. at 25° amb.
4JA3011	630 V	18 amps. at 55° amb.
4JA3611	1800 V	65 amps. at 55° amb.
4JA6011	840 V	573 amps. at 35° amb.
4JA6211	840 V	430 amps. at 35° amb.

SILICON LOW CURRENT

Series: 1N536-540, 1N547, 1N1095-1096, 1N440 B-445 B, 1N1100-1103, 1N1487-1492, 1N599 A-606 A, 1N1692-1695

Series: 1N536-540, 1N547, 1N1095-96—Provide maximum forward conductance at high operating temperatures (165° C.). **1N440-445, 1N440B-445B**—Similar to 1N536-540 series, but with extremely low reverse current. Ideal for magnetic-amplifier applications. **1N1100-1103**—Similar to 1N440B-445B series. **1N1487-1492**—Essentially the same as 1N536-540 series, except provides lower-cost units for lower-temperature requirements (140° C.). **1N599-606, 1N599A-606A**—Similar to 1N536-540 and 1N440B-445B series, respectively, except for somewhat lower forward-current ratings. **1N1692-1695**—Provides lower current and temperature operation (115° C.) than any of above series—very economical.

Series: 1N1115-1120, 1N253-256, 1N550-555, 1N332-349, 1N607 A-614 A, 1N562-563

Series: 1N1115-1120—Available for stud mounting direct to chassis, or finned. Similar, in characteristics, to 1N536-540 lead-mounted series. Provide maximum forward conductance at high operating temperatures. **1N253-256**—High power-handling ability. Primarily for power supply and magnetic-amplifier applications. Type 1N256 meets JAN spec. **1N550-555**—Similar to 1N440B series, except for stud mounting. Extremely low reverse current, particularly suited for magnetic-amplifier applications. **1N332-349**—Industry-popular series. For applications requiring high reliability at moderate currents operating up to 170° C.. **1N607-614, 1N607A-614A**—Another widely-used industrial line. Ideal for applications requiring high currents at up to 150° C.

4JA411 Series

4JA411 Stacks: Combine high temperature operation (up to 150° C.) with increased ratings (up to 18 amps d-c). Hundreds of stack combinations to meet a variety of circuit conditions. High efficiency plus excellent regulation.

POTTED RECTIFIER CIRCUITS

4JA221 germanium
4JA421 silicon

4JA220-221, 4JA420-421 Series: Mounted in standard eight-pin tube base (4JA220-420 Series) or in rectangular design with solder lug connections (4JA221-421 Series). Available in a large number of circuit configurations. One to 20 cells may be potted in a single circuit. Individual cell specifications determine ratings. 4JA220-221 Series utilize germanium 1N91-93 cells. 4JA420-421 Series utilize silicon 1N536-540, 1N1095-1096 and 1N1487-1492 cells. (See BASIC RECTIFIER-CELL LISTING at left.)

SILICON MEDIUM CURRENT

Series: 1N2154-2160

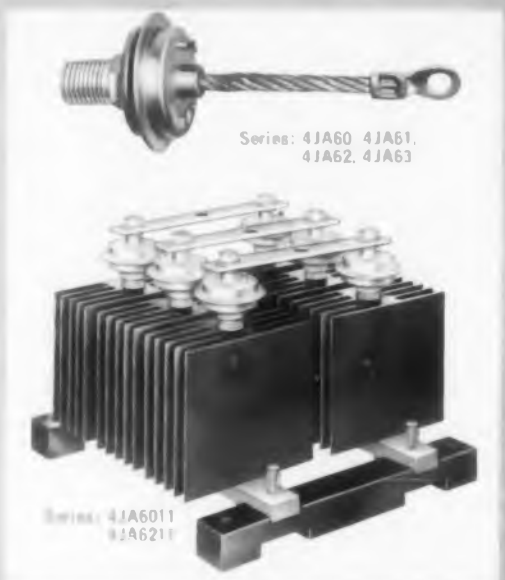
1N2154-2160 Series: First series of silicon medium current rectifiers to be made free from thermal fatigue. Designed for individual cell applications in the 2-to-25 amp range. High junction-temperature ratings. Extremely low forward voltage drop and thermal impedance. May be mounted directly, or electrically insulated from heat sink with mica-washer mounting kit provided with each unit.

4JA3611 Series

4JA3611 Stacks: Provide a wide-range of power applications with d-c outputs up to 65 amps.

Series: C35
ZJ39L

SILICON HIGH CURRENT



Series: 4JA60, 4JA61, 4JA62, 4JA63

Series: 4JA6011
4JA6211

4JA60, 4JA61, 4JA62, 4JA63 Series: Large-area junction stud-mounted rectifiers. Operating temperatures to 200° C. D-c outputs as high as 85 amps per rectifying element. Lower-cost 4JA62, 4JA63 units are for applications which do not require the full-current ratings of 4JA60 line. Reverse polarities provided in 4JA61 and 4JA63 units. **4JA6011, 4JA6211 Stacks:** Hundreds of combinations available in various circuit configurations. D-c outputs up to 573 amps. The 4JA6211 series for lower-current, lower-cost operation.

SILICON CONTROLLED RECTIFIER

CONTROLLED RECTIFIER RATING CHART

G-E Type No.	PIV* and V_{BO}	Max. I_{DC} at Temp. °C.	Max. Temp. °C. Oper.	Max. Temp. °C. Storage	Max. Rec'd Gate Signal
C35U	25	Up to 16A @ 87° C. stud	125	150	3V, 40ma @ 25° C.
C35F	50	Up to 16A @ 87° C. stud	125	150	3V, 40ma @ 25° C.
C35A	100	Up to 16A @ 87° C. stud	125	150	3V, 40ma @ 25° C.
C35G	150	Up to 16A @ 87° C. stud	125	150	3V, 40ma @ 25° C.
C35B	200	Up to 16A @ 87° C. stud	125	150	3V, 40ma @ 25° C.
C35H	250	Up to 16A @ 87° C. stud	125	150	3V, 40ma @ 25° C.
C35C	300	Up to 16A @ 87° C. stud	125	150	3V, 40ma @ 25° C.
C35D	400	Up to 16A @ 87° C. stud	125	150	3V, 40ma @ 25° C.

*Max. PIV and Min. V_{BO}

C35 Series: Revolutionary silicon control device introduced by General Electric. Can do jobs of thyratrons, ignitrons, magnetic amplifiers, power transistors, relays, switches, contactors, circuit breakers, in many power-control and power-switching applications. **Medium-current C35 series** provides blocking voltages to 400V and load currents to 16 amperes. **Low-temperature, lower-cost ZJ39L series** also available. Provides blocking voltages to 400V and load currents to 10 amperes. **High-current, developmental-type ZJ50 series** is now available on a prototype-sample basis.

GERMANIUM LOW CURRENT

Series: 1N91-93, USN, 1N151-153, 1N158, 1N315, USAF, 1N368

Series 1N91-93, USN1N93—Alloyed-junction types combining very low forward resistance with high back resistance to give almost 100% efficiency. 1N93 is commercial version of U.S. Navy MIL-spec. rectifier—the G-E USN1N93. **1N151-153, 1N158**—Single- and two-fin versions of 1N91-93 series cells. **1N315, USAF1N315**—Designed for high operating temp. (to 85° C.) and low reverse current. USAF1N315 meets A.F. spec. MIL-E-1/1088. **1N368**—Features a very low reverse current at a high d-c reverse voltage. For magnetic-amplifier applications.

4JA211 Series

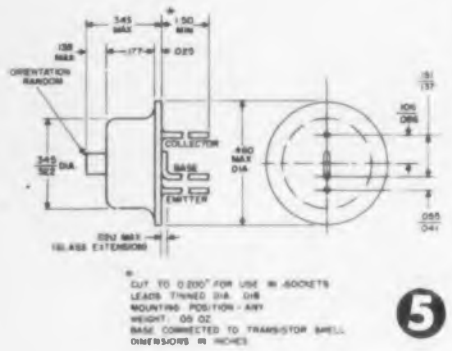
4JA211 Stacks: The industry's most widely-used semiconductor rectifier series. Hundreds of thousands in use. May be arranged in stacks up to 12 fins to produce more than 160 various circuit configurations. Small, lightweight, excellent regulation.

GERMANIUM MEDIUM CURRENT

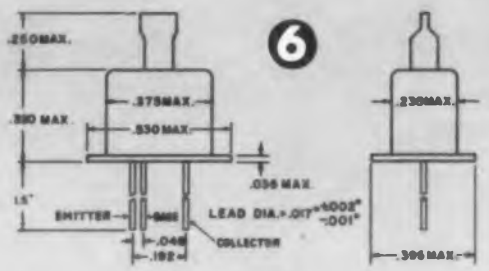
Single-fin Mounting

4JA3011 Series

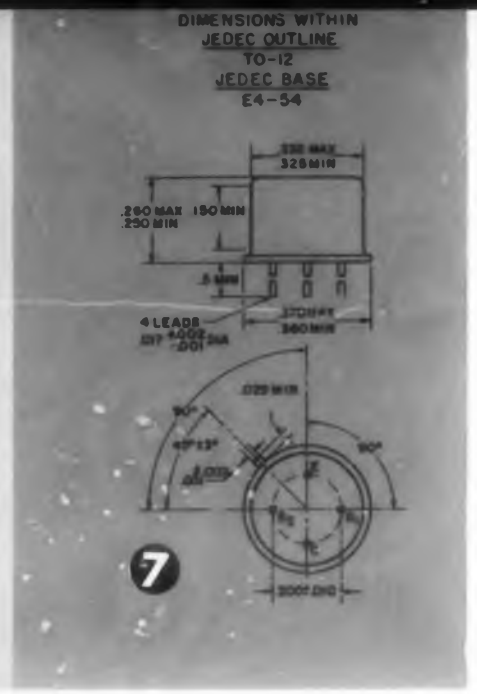
4JA3011 Series: For general-purpose power supplies, control devices, blocking circuits, and many other applications. Extremely low power dissipation and forward voltage drop provide excellent regulation and efficiency. Available in stacks up to 12 fins, providing ratings in thousands of watts, depending upon the circuit design, with operation to 85° C. Also, available in single-fin mounting. Transient PIV's up to 600 volts per cell.



5



6



7

RATINGS

TYPICAL VALUES

	MAXIMUM COLLECTOR DISSIPATION @ 25° C (mw) P_C	MINIMUM BREAKDOWN VOLTAGE (volts) BV_{CBO}	MAXIMUM COLLECTOR CURRENT (ma) I_C	MAXIMUM STORAGE TEMP. (°C) T_{STG}	D-C CURRENT GAIN h_{FE} (A-C h_{fe})*	ALPHA CUTOFF FREQ. (mc) f_{ab}	POWER GAIN (db) G_e (1000 Cyc.)	SATURATION VOLTAGE (volts) V_{CE} (SAT) R_{SE} (ohms)*	COLLECTOR CAPACITY ($\mu\mu f$) C_{ob}	COLLECTOR TO BASE CURRENT (μa) MAX I_{CO}	@ V_{CB}
	150	45	25	200	12*	10	35	90*	7	2	30
	150	45	25	200	18*	12	39	80*	7	2	30
	150	45	25	200	39*	13	40	75*	7	2	30
	150	45	25	200	20*	14	42	70*	7	2	30
	150	45	25	200	120*	15	43	70*	7	2	30
	125	45	20	200	35	30		75*	1.2	1	20
	125	45	20	200	75	45		75*	1.2	1	20
	P_{AV}	V_{RB}(MAX)	I_E		η	f_{MAX}	R_{BBO}	V_E(SAT)	I_{B2}(MOD)	I_{EO}	@ V_{EB}
	450	65	70	175	.56	0.9	5.6	3.1	12	12	60
	450	75	70	175	.56	0.7	7.5	3.3	12	12	60
	450	65	70	175	.62	0.8	5.6	3.4	12	12	60
	450	75	70	175	.62	0.7	7.5	3.6	12	12	60
	450	65	70	175	.68	0.7	5.6	3.8	12	12	60
	450	75	70	175	.68	0.65	7.5	3.9	12	12	60
	P_C	BV_{CE}	I_C		h_{FE}	f_{ab}	G_e	V_{CE}(SAT)	C_{ob}	I_{CO}	@ V_{CB}
	240	−30	−300	100	53	1.3		0.09	40	−16	−45
	240	−30	−300	100	31	1.0		0.09	40	−16	−45
	225	−30	−500	100	35	2.0		0.07	25	−10	−30
	225	−30	−500	100	52	2.5		0.075	25	−10	−30
	225	−30	−500	100	73	3.0		0.08	25	−10	−30
	225	−30	−500	100	91	3.3		0.09	25	−10	−30
	150	−15	−125	85	65	8.0		0.15	15	− 6	−20
	150	−15	−200	100	20 min	4.5		0.1	12	− 6	−15
	150	−20	−200	100	30 min	8.0		0.08	12	− 6	−20
	150	−15	−200	100	40 min	12.0		0.07	12	− 6	−15
	120	−24	−100	85		8.0		0.1	12	− 5	−12
	150	−12	−125	85	30 min	5 min		0.2 max	12	− 6	−12
	150	−12	−125	85	60 min	10 min		0.15 max	12	− 6	−12
	240	−50	−100	100	32	1.0		0.09	40	−18	−75
	240	−30	−300	100	58	1.3		0.08		−16	−45
	65	15	20	85	70	9.0			3	3	15
	65	25	20	85	72	9.0	26		2.4	5	15
	75	30	75	85	30	9.0			2.5	1.5	15
	150	20	300	85	15 min	8.0				5	5
	150	20	300	85	25 min	12.0				5	5
	150	15	300	85	35 min	17.0				5	5
	30	6	20	85	2.2∠− 81°	50 min	11.5		2	10	7
	30	6	20	85	1.1∠−100°	90 min	9		1.5	10	7

RECTIFIERS Selenium

Copper Oxide • Miniature-Intermediate-Large Stacks

Vac-u-Sel* • High Efficiency

Low Voltage

*Registered Trademark of General Electric Co.

TYPICAL MINIATURE Vac-u-Sel RECTIFIERS

General Electric Company's *Vac-u-Sel* rectifiers are produced through the unique *spherical vacuum-evaporation process*—the quality-advancement pioneered in this country by G.E. Briefly, the vacuum-evaporation process makes it possible to closely control the thickness of the selenium layers to satisfy varying requirements, and to obtain a pure, more even deposition of selenium over the entire cell surface.

VOLTAGES AND CELL SIZES

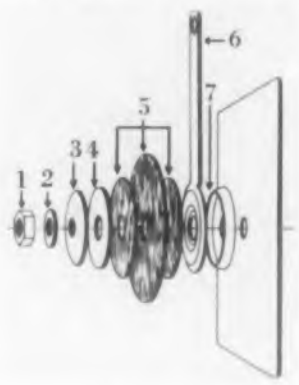
G-E Vac-u-Sel rectifiers are available in cells of 26, 36 and 45 volts (rms), and in cell sizes up to two inches square. Larger sized cells are available in the 26- and 36-volt ranges. Eighteen-volt cells are available as off-standard units in all cell sizes.

FINISHES AND MOUNTINGS

Vac-u-Sel rectifier stacks are supplied with 3 basic finishes: *standard commercial*, *heavy duty*, and *military*. Selected cells are stud mounted, eyelet and tube mounted, oil immersed or embedded.

MINIATURE CELLS

Miniatures (cells up to $^{13}/_{32}$" diameter) have no center mounting hole and are mounted without spacer washers, assuring compact assemblies.



FEWER PARTS—improved G-E Cup-Washer Assembly consists of (1) Nut, (2) Metal Washer, (3) Spring Washer, (4) Pressure Washer, (5) Insulating Washers, (6) Terminal, (7) Cup Washer.

COPPER OXIDE RECTIFIERS

General Electric copper-oxide rectifier stacks operate as efficient, economical devices for converting a-c to d-c. They are particularly ideal for such applications as:

- Blocking
- Magnetizing
- Electrolytic reduction
- Polarizing relays
- Metering
- Circuit breakers
- High-speed relays
- Electroplating
- Telephone and telegraph equipment

Headquarters
General Electric Company
Electronics Park
Syracuse, N.Y.
GRanite 6-4411

For more information, contact your nearest G-E Semiconductor Products District Sales Representative

TRANSISTORS

L. A. BASSETT
General Electric Co.
701 Washington St.
Newtonville 60, Mass.
DEcatur 2-7120

L. A. MOONEY
General Electric Co.
3800 N. Milwaukee Ave.
Chicago, Ill.
SPring 7-1600

A. WOOLAVER
A. B. DALL
General Electric Co.
200 Main Ave.
Clifton, N.J.
GRegory 3-6387

E. E. FARRELL
General Electric Co.
Electronics Park
Syracuse, N.Y.
HArrison 2-2649
GRanite 6-4411 Ext. 2305

RECTIFIERS

D. W. HICKIE
General Electric Co.
200 Main Ave.
Clifton, N.J.
GRegory 3-6387

A. F. LARMANN, JR.
General Electric Co.
Electronics Park
Syracuse, N.Y.
GRanite 6-4411 Ext. 3257

R. C. ROGERS
General Electric Co.
3800 N. Milwaukee Ave.
Chicago, Ill.
SPring 7-1600

TRANSISTORS & RECTIFIERS

J. G. WALTON, JR.
General Electric Co.
777 14th Street, N.W.
Washington 5, D.C.
EXecutive 3-3600

R. E. BERRY
R. R. FAULLIN
G. R. SAHL
General Electric Co.
3800 N. Milwaukee Ave.
Chicago, Ill.
SPring 7-1600

R. W. OLSEN
General Electric Co.
442 Peninsular Ave.
San Mateo, Calif.
DIamond 2-7201

E. W. HOOKWAY, JR.
General Electric Co.
2111 So. Green Road
Cleveland 21, Ohio
EVergreen 2-0680

H. W. GEBHARDT
H. J. HENDERSON
General Electric Co.
11840 W. Olympic Blvd.
Los Angeles, Calif.
GRanite 9-7765

G. R. CURTISS
P. V. HAHN
W. J. HALLEY
General Electric Co.
Electronics Park
Syracuse, N.Y.
GRanite 6-4411
Ext. 2474

GENERAL ELECTRIC

SEMICONDUCTOR PRODUCTS DEPARTMENT

ECG-388 3-59

PRINTED IN U.S.A.

FLIGHT CONTROLS

Expanding the Frontiers of Space Technology

Transistorizing missile flight control systems by Lockheed scientists has meant significant reductions in weight and space requirements.

Flight Controls offers one of the most challenging areas of work at Lockheed's Missiles and Space Division.

From concept to operation, the Division is capable of performing each step in research, development, engineering and manufacture of complex systems. Rapid progress is being made in this field to advance the state of the art in important missile and spacecraft projects under development at Lockheed.

Flight controls programs include: analysis of flight data and sub-systems performance, design and packaging of flight control components, development of transistorized circuits, operation of specialized flight control test equipment, and fabrication of flight control prototypes. Other work deals with the design, development and testing of rate and free gyros; accelerometers; programmers; computer assemblies; guidance control systems; circuitry; and hydraulic systems and components.

In the flight controls simulation laboratory, mathematical representations of elements in a control system are replaced one by one with actual hardware to determine acceptability of specific designs. From these studies, Lockheed obtains information which is used in further refinement and improvement of final control systems designs.

Lockheed Missiles and Space Division is weapons systems manager for such major, long-term projects as the Navy Polaris FBM; Discoverer Satellite; Army Kingfisher; Air Force Q-5 and X-7; and other important research and development programs.

Scientists and engineers desiring rewarding work with a company whose programs reach far into the future are invited to write: Research and Development Staff, Dept. C2-21, 962 W. El Camino Real, Sunnyvale, California, or 7701 Woodley Avenue, Van Nuys, California. For the convenience of those living in East or Midwest, offices are maintained at Suite 745, 405 Lexington Avenue, New York 17, N. Y. and at Suite 300, 840 N. Michigan Avenue, Chicago 11, Ill.

"The organization that contributed most in the past year to the advancement of the art of missiles and astronautics."

NATIONAL MISSILE INDUSTRY CONFERENCE AWARD

Pre-flight check-out on final assembly on X-7 missile. The X-7 holds free-world's speed and altitude records for air breathing missiles.

One of Lockheed's test stands with dynamic thrust mount to simulate flight environment.

Lockheed / **MISSILES AND SPACE DIVISION**

SUNNYVALE, PALO ALTO, VAN NUYS, SANTA CRUZ, SANTA MARIA, CALIFORNIA
CAPE CANAVERAL, FLORIDA · ALAMOGORDO, NEW MEXICO

NEW PRODUCTS

Strain Gage Plotters

High speed

High speed strain gage plotters 220 and 221, designed for plotting structural, engine load, and other tests, can scan and record up to 20 channels per sec and plot up to 96 channels. They automatically plot individual graphs for each channel while a test is in progress. There are three zero positions per channel, separate range selectors, and separate gage factor selectors. Switching is accomplished by heavy duty, large contact, low noise, rotary type multideck switches. Positive gearing to the chart drive insures synchronization between the chart graphs and their particular input channels. The units can be modified for millivolt inputs, such as thermocouples, for use on temperature period tests.

Gilmore Industries, Inc., Dept. ED, 13015 Woodland Ave., Cleveland 20, Ohio.

CIRCLE 97 ON READER-SERVICE CARD

Reversible Motors

1/125 hp

Series M-105 reversible motors are rated at 1/75 hp for intermittent duty or 1/125 hp for continuous duty. The various models have ac or 6 to 48 v dc inputs. They are 1-3/4 in. in diameter and 3 in. long.

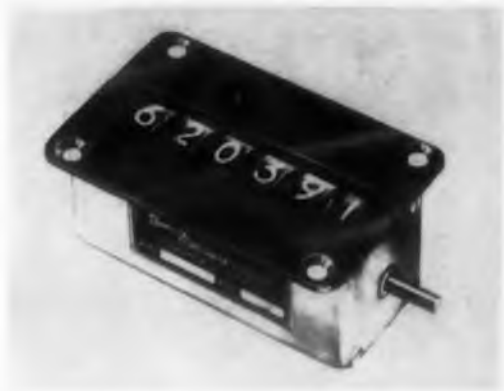
Carter Motor Co., Dept. ED, 2764A W. George St., Chicago 18, Ill.

CIRCLE 98 ON READER-SERVICE CARD

Don't forget to mail your renewal form to continue receiving *ELECTRONIC DESIGN*.

Mechanical Counter

Uses planetary gear



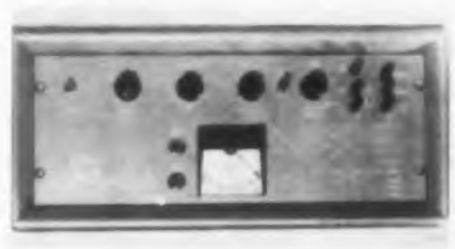
Using a planetary gear drive to rotate the numerals, the PlanetGear mechanical counter can make 10,000 counts per min. The quick transfer of numbers is accomplished by means of a nylon cam and a roller compensating device, which moves the planetary gear. There is no possibility of skips or misses since the gears are always in mesh. The torque required to turn the drums is uniformly low, and any device capable of turning the first numeral drum is capable of driving the entire counter reliably, as there are no peak load points in the counter operation. The planetary gears make it possible to drive the counting wheels at continuous speeds of 1000 rpm, and life tests have been run in excess of 100 million counts. The bearings, gears, cams, and rollers are nylon, and the main shaft is centerless ground, polished stainless steel. The 5/16 in. numbers conform to military specification MIL-S-33558.

Haydon Instrument Co., Dept. ED, 165 W. Liberty St., Waterbury 20, Conn.

CIRCLE 107 ON READER-SERVICE CARD

Magnetic Core Tester

Handles switching time to 35 msec



With model RK-100, an instrument for testing tape wound cores, ferrite cores, and relays, two units may be operated synchronously for core plane and coincident current testing. The unit monitors tolerances on core parameters and determines drive requirements, switching times, and voltage and disturbance output. It provides 0.1 ma to 1 amp current pulses with 0.1 μsec to 1 msec rise time and handles switching times to 35 msec.

Arkay Engineering, Inc., Dept. ED, 225 Santa Monica Blvd., Santa Monica, Calif.

CIRCLE 108 ON READER-SERVICE CARD

NEW PRODUCTS

Panel Switch Light

1-3/8 in. long

This dpdt double break switch-light combination has an independent 28 v lamp circuit for panel mounting. It is supplied in momentary snap action or push-on push-off snap action with contacts rated at 28 v dc, 5 amp, inductive. Operating pressure is approximately 4 lb with 5/32 in. overall travel. The unit has a 5/8 in. mounting thread, a 7/8 in. case diameter, and a 1-3/8 in. length from mounting surface to and including terminals.

Pendar, Inc., Switch Div., Dept. ED, P.O. Box 3355, Van Nuys, Calif.

CIRCLE 110 ON READER-SERVICE CARD

Servo Motors

Size 10 and 11

These size 10 and 11 servo motors are available for 26, 55, or 115 v ac, 400 cps operation. They are 6 pole units with a stall torque of 0.(oz-in. minimum and a no load speed of 6500 rpm. Rotor inertia is 1 g cm², and acceleration at stal is 42,000 radians per sec². The units are 1-11/3 in. long and designed to operate in ambient temperatures from −65 to +125 C. Special voltag requirements are available on order.

Western Gear Corp., Electro Products Div Dept. ED, 132 W. Colorado St., Pasadena, Cali

CIRCLE 111 ON READER-SERVICE CARD

FLIGHT DATA and CONTROL ENGINEERS

Cross new frontiers in system electronics at The Garrett Corporation.

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

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

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

3. FLIGHT INSTRUMENTS AND TRANSDUCERS

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

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

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

Forward resume to:
Mr. G. D. Bradley

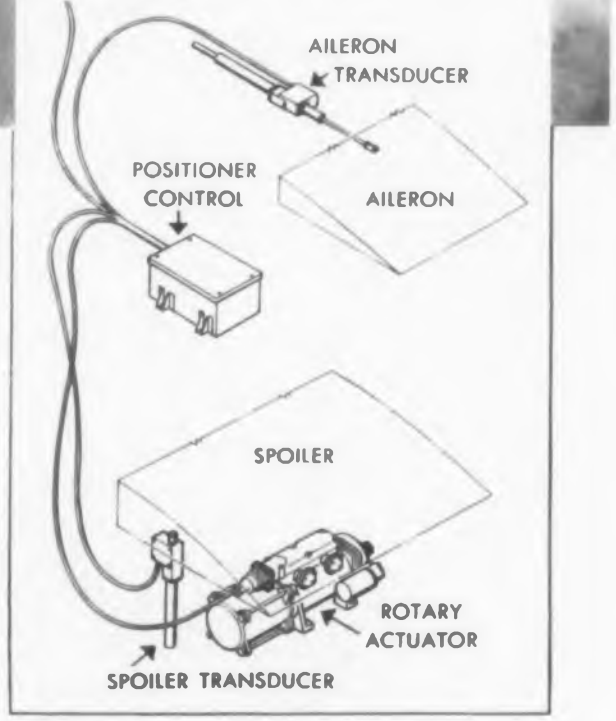
THE GARRETT CORPORATION
9851 S. Sepulveda Blvd.
Los Angeles 45, Calif.

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

CIRCLE 870 ON READER-SERVICE CARD

Advanced electro-mechanical systems

AiResearch Spoiler Servo Control System for Canadair's CL-28 and CL-44



A substantial increase in aileron effectiveness is achieved by the AiResearch Spoiler Servo Control System which augments the function of the aileron by increasing the rate of roll of the aircraft. Full spoiler surface travel is achieved in 0.5 seconds by electromagnetic clutching of the 4 H.P. power servo.

The added control surface of the Spoiler Control Servo System operates on the inboard side of each aileron. This AiResearch electro-mechanical system automatically synchronizes the spoiler control surface to move simultaneously with the aileron by utilizing a magnetic amplifier and position transducers in the closed loop servo system.

This new Spoiler Control System is but one of the many types of electro-mechanical systems developed and manufactured by AiResearch. Other recent examples include radar antenna positioning equipment, magnetron and Klystron tuning devices, and safe-arm mechanisms for missile igniting.

The company's more than 20 years of experience in the development and manufacture of electro-mechanical equipment extends into aircraft, ground handling, ordnance and missile systems of all types. AiResearch capability and system responsibility can meet your specific electro-mechanical requirements. Your inquiries are invited.

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

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

CIRCLE 268 ON READER-SERVICE CARD

NEW PRODUCTS

Altitude Test Chamber

Has low loading level

This self-contained altitude test chamber has a low loading level to simplify the testing of heavy units or components. The bottom of the 64 cu ft test space is less than desk height, or 29 in. from the floor. The low test area also enables the operator to reach the back of the test space more readily. The chamber provides temperatures from —100 to +300 F, simulated altitudes to 150,000 ft, and relative humidity from 20 to 95%. It has all necessary instrumentation for completely automatic operation and recording.

The American Research Corp., Dept. ED, Farmington, Conn.

CIRCLE 113 ON READER-SERVICE CARD

Miniature Lowpass Filters

Have 50 db attenuation

These small filters have 50 db minimum attenuation at the critical frequency. Attenuation of 25 db or more is maintained up to ten times this specified frequency. The pass-band insertion loss falls to 3 db at 0.01 times the maximum attenuation frequency. Encapsulated in epoxy resin for stability in environmental extremes, the units are 13/16 in. in diameter and 1-1/2 in. high. Mounting is accomplished with three no. 18 solid copper tinned leads. Rejection frequencies down to 20 cps may be specified.

T T Electronics, Inc., Dept. ED P.O. Box 180, Culver City, Calif.

CIRCLE 114 ON READER-SERVICE CARD

◀ CIRCLE 112 ON READER-SERVICE CARD

UHF Broadband Amplifier

Provides 100 w output

When driven by a suitable signal, type RA-7 broadband amplifier is capable of providing an output power of 100 w or more in the 470 to 890 mc frequency range. The unit has a variable bandwidth, full metering, and a self-contained power supply and provides a method for adjusting the position of the feed point along the cathode line to insure proper drive impedance and low vswr. Operating as a translator amplifier, the RA-7 makes television services possible for communities shielded from originating TV stations and beyond the range of 10 w translators.

Adler Electronics, Inc., Dept. ED, 1 LeFevre Lane, New Rochelle, N.Y.

CIRCLE 115 ON READER-SERVICE CARD

Underwater TV Camera Cable

Has 0.99 in. diameter

This underwater TV camera cable is composed of two RG-59/U coaxial cables, two insulated and jacketed 7-wire control cable groups, and two 4-wire shielded control cables. A polyvinylchloride belt over the assembly is extruded to fill all voids, and the whole is wrapped in cadmium bronze shielding braid which is in turn covered by a lead cured neoprene sheath. The cable diameter is 0.99 in.

Rome Cable Corp., Dept. ED, Rome, N.Y.

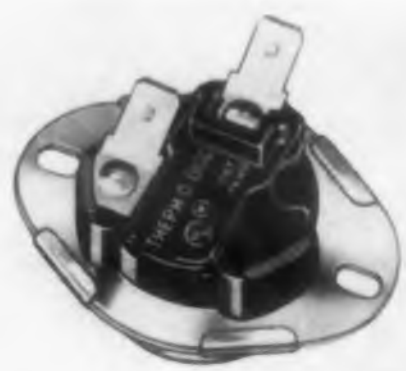
CIRCLE 116 ON READER-SERVICE CARD

CIRCLE 117 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Thermostats

For limit protection



For operating temperatures up to 350 F, series 11-T thermostats have a high electrical rating and occupy a minimum of space. For limit protection, temperature control, or fan control, they can be used in central heating furnaces, air conditioning and ventilating equipment, aircraft equipment, and miscellaneous devices. The snap action units are designed for both spst and spdt operation and are available with normally open or normally closed contacts. They have surface or watertight mountings and enclosed or exposed bimetal discs and come in a choice of terminals that include inclined blades, vertical blades, or screw types. Temperature calibration is factory preset and nonadjustable.

Therm-O-Disc, Inc., Dept. ED, Mansfield, Ohio.

CIRCLE 119 ON READER-SERVICE CARD

Flat Cable

Voltage ratings from 300 to 3000 v rms

Designed to customer specifications, Turbo Ribbon Cable may be assembled from single conductors, twisted and jacketed pairs, triples, coaxial cables, shielded and jacketed wires, or any combination of these. Conductor sizes are 28 to 8 AWG, stranded or solid, and voltage ratings are 300 to 3000 v, rms. Widths up to 2 in. are available.

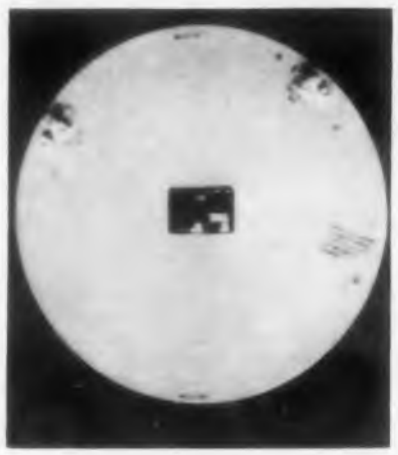
The William Brand & Co., Inc., Dept. ED, Willimantic, Conn.

CIRCLE 120 ON READER-SERVICE CARD

Have you sent us your subscription renewal form?

Ultrasonic Delay Line

Has 10 mc bandwidth



This ultrasonic delay line has: a delay of 900 μsec; an average maximum secondary level of over 70 db below the main delay; triple travel signals of 60 db; and direct feed through over 80 db. It has a 10 mc bandwidth centered at 40 mc. The bandwidth to the 3 db points is 22 mc. Insertion loss into 50 ohms is 55 db with a capacity of 60 μμf at input and output. The unit is designed with a mid-transducer tap for optimizing matching network problems. It weighs under 7 lb and is supplied in a 14-1/2 in. diameter evacuated aluminum case 1 in. deep.

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

CIRCLE 122 ON READER-SERVICE CARD

Phenolic Laminate

Shock-resistant

A glass-reinforced XXXP laminate, NELCO 230-R equals or exceeds the requirements of MIL P-3115-B, Type PBE-P grade. Capable of being cold-punched in thicknesses to 3/32 in., it has low moisture absorption, good electrical characteristics, and an impact strength eight times the standard NEMA requirement. It is furnished plain or copper-clad in thicknesses from 0.032 to 1 in. Standard sheet sizes are from 36 x 42 in. to 36 x 72 in.

New England Laminates Co., Inc., Dept. ED, 481 Canal St., Stamford, Conn.

CIRCLE 123 ON READER-SERVICE CARD

CIRCLE 124 ON READER-SERVICE CARD ➤

NEW PRODUCTS

RF Coaxial Lobing Switch

Has 1.2 to 1 vswr

Type SP2T is a 0.7 lb rf coaxial lobing switch with a range of 100 to 10,000 mc, a maximum vswr of 1.2 to 1, and an isolation rating of 50 db down. Make before break or break before make switching is available. The unit is hermetically sealed, glass to metal, and has a minimum life of 1000 hr. Several models are available with a choice of type N, HN, or SC rf connectors.

Don-Lan Electronics Co., Dept. ED, 1101 Olympic Blvd., Santa Monica, Calif.

CIRCLE 126 ON READER-SERVICE CARD

Precision Dial Comparator

Direct reading in 0.00005 in.

This precision dial comparator is direct reading in 0.00005 in. and has a range of 0.004 in. Fully jeweled and shock resistant, it provides dual gaging contact pressure and fine adjustment on both stand and gage.

Hamilton Watch Company, Industrial Div., Dept. ED, Lancaster, Pa.

CIRCLE 127 ON READER-SERVICE CARD

Catadioptric Light Screen

Sensitive to hypervelocity projectile

Using the catadioptric technique of reflection and refraction this light screen is sensitive to hypervelocity projectiles as smal

◀ CIRCLE 125 ON READER-SERVICE CARD

as 0.22 caliber. Designed for ballistic range instrumentation, the device sets up a screen of light consisting of a collimated light beam which is reflected many times between parallel mirrors before passing into a photoelectric detector. The effective width of the beam interrupted by a projectile is 3/4 in. in any part of a 6 x 6 in. field. This gives a maximum phototube output signal over a wide range of projectile sizes. A current change is caused in the detector when a hypervelocity projectile breaks the light screen at any point. The current change is amplified and is used to trigger a shadowgraph system. These systems can produce photographic records of missile models in flight.

Avco Mfg. Corp., Research and Advanced Development Div., Dept. ED, 201 Lowell St., Wilmington, Mass.

CIRCLE 128 ON READER-SERVICE CARD

RF Choke Coil

Occupies 0.0066 cu in.

Occupying a volume of less than 0.0066 cu in., the Wee-Ductor rf choke coil covers a full range of inductances from 0.1 to 1000 μh and has a high current rating at 125 C. It consists of a high permeability ferrite sleeve and core sealed in epoxy resin for moisture resistance per MIL-C-15305A. The unit is 0.15 in. in diameter and 0.375 in. long.

Essex Electronics, Dept. ED, Berkeley Heights, N.J.

CIRCLE 129 ON READER-SERVICE CARD
CIRCLE 130 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Slip Ring and Brush Assembly

Has 2 mv noise level

With all 40 circuits tied in series and with 50 ma of current flowing through this slip ring and brush assembly, the total combined noise level of the 40 slip rings and 80 brushes is under 2 mv. This noise level can be maintained through 1000 hr of operation at 500 rpm with 10 cps vibration and temperature extremes of −65 to +300 F. The breakaway friction level of the 40 circuit assembly, including ball bearings, is under 75 g cm. Capacitance is less than 20 μμf and insulation resistance is greater than 5000 meg circuit to circuit and circuit to ground. The assembly meets all MIL-5400A requirements.

Slip Ring Company of America, Dept. ED, 5456 W. Washington Blvd., Los Angeles 16, Calif.

CIRCLE 134 ON READER-SERVICE CARD

Solid State Relays

Withstand heavy surges

Included in this line of solid state relays are current, voltage, temperature, time delay, and many other types for both automatic and remote control and for ac and dc operation. These units have no moving parts or magnetic circuits, and do not depreciate with time. Unlike transistors they are uninjured by heavy peaks and surges.

Clark Electronic Labs, Dept. ED, Box 165 Palm Springs, Calif.

CIRCLE 135 ON READER-SERVICE CARD

CIRCLE 136 ON READER-SERVICE CARD

2½-inch size

ACTUAL SIZE

3½-inch size

THE BIG LOOK

IN SMALL PANEL INSTRUMENTS

Truly distinctive appearance, plus excellent readability and reliable operation in a modern new design; BIG numerals, BIG scale, BIG look, yet they will fit into the same usable panel space as ordinary instruments.

Progress Is Our Most Important Product

GENERAL ELECTRIC

THE BIG LOOK

IN GENERAL ELECTRIC'S SMALL PANEL INSTRUMENTS

Now, you can improve the appearance of your finest switchboards and panels with General Electric's dramatic BIG LOOK in small panel instruments. Backed by more than twenty-seven years of leadership and experience in creative panel instrument design, they give you these outstanding advantages:

DISTINCTIVE APPEARANCE

Functional new beauty in a graceful, clean-line design results from a modern blend of round and square elements. Although this attractive design makes the new instruments look much bigger, they will actually fit into the same usable panel space as ordinary instruments. Big border-to-border scale is "framed" in aluminum for better color blending and less reflectance. The color area of the window helps to channel the eye for quick reading. This distinctive color area is available in standard colors or the color of your choice in quantity orders.

EXCELLENT READABILITY

New design makes possible up to 28% increase in scale length over types replaced. Shadows are eliminated by cover design which admits natural light from all sides. Big, clear, upper-case numerals are positioned *above* the scale graduations (except three-digit end points) and cannot be obscured by the tapered pointer. The absence of arc-lines contributes to the pleasing appearance and facilitates quick, accurate readings.

RELIABLE OPERATION

Built-in General Electric quality assures extra long, trouble-free life with these outstanding features:

Shielded Mechanisms—Self-shielding of all d-c movements allows mounting on magnetic or non-magnetic panels without special calibration—cluster mounting bezel-to-bezel without interaction—and the effects of stray magnetic fields are minimized.

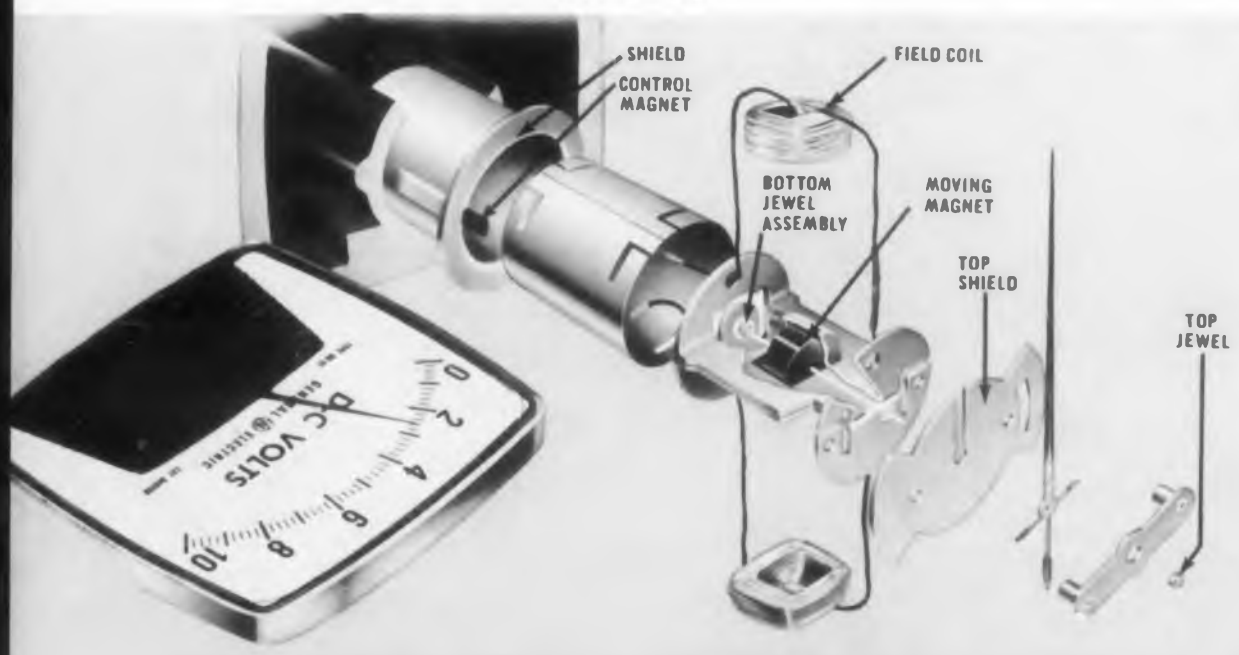
Completely Sealed—Internal parts and movements are protected from dirt, dust and water. Cases are sealed with neoprene gaskets in air-conditioned assembly areas.

Pivots and Jewels—Moving parts are supported on rugged steel pivots which rotate in low-friction, highly-polished glass jewels.

NEW LOW PRICE

Improved manufacturing techniques and facilities enable General Electric to offer you these new instruments at a new low price. See pages 3 and 4 for list prices.

ALL D-C MECHANISMS ARE SELF-SHIELDED



Exclusive moving-magnet mechanism, used in all d-c ratings except ammeters below 5 MA, eliminates need for zero-set because conventional control springs are replaced by a control magnet. When de-energized, moving magnet aligns with control magnet, bringing pointer to zero.

Core-magnet, used in d-c milliameters below 5 MA and all microammeters, has conventional control springs and requires a zero-set.

See General Electric's BIG LOOK in Small Panel Instruments

PRICING INFORMATION — Direct-current Types

Rating	Scale	Approx Terminal Resistance	DW-91, 2½-inch Cat. No.	DW-91, 2½-inch List Price, GO-87A	DO-91, 3½-inch Cat. No.	DO-91, 3½-inch List Price, GO-87A	Rating
D-C VOLTMETERS							
Volts	Volts						Volts
1.5	0-1.5		810X84	$17	640X84	$18	1.5
3	0-3		810X86	17	640X86	18	3
5	0-5		810X87	17	640X87	18	5
10	0-10		810X89	17	640X89	18	10
15	0-15		810X90	17	640X90	18	15
30	0-30	1000 ohms	810X93	17	640X93	18	30
50	0-50	per volt	810X94	17	640X94	18	50
80	0-80		810X95	17	640X95	18	80
100	0-100		810X96	18	640X96	19	100
150	0-150		810X97	18	640X97	19	150
300	0-300		811X1	19	643X1	20	300
500*	0-500		[illegible]	[illegible]	643X2	21	500*
D-C AMMETERS (Self-contained)							
Amperes	Amperes						Amperes
1	0-1	0.0500	810X29	$15	640X70	$16	1
2	0-2	0.0250	810X31	15	640X72	16	2
5	0-5	0.0100	810X33	15	640X74	16	5
10	0-10	0.0050	810X35	15	640X76	16	10
15	0-15	0.0033	810X36	15	640X77	16	15
20	0-20	0.0025	810X37	15	640X78	16	20
30	0-30	0.00167	810X38	15	640X79	16	30
50	0-50	0.00100	[illegible]	15	640X80	16	50
D-C AMMETERS (For use with external shunts—prices do not include shunt or shunt leads.)							
Millivolts	Amperes						Millivolts
50	0-50	2.5	818X34	$15	[illegible]	$16	50
50	0-75	2.5	818X39	15	813X52	16	50
50	0-100	2.5	818X44	15	813X58	16	50
50	0-150	2.5	818X45	15	813X58	16	50
50	0-200	2.5	818X46	15	813X59	16	50
50	0-250	2.5	818X47	15	813X60	16	50
50	0-300	2.5	818X48	15	813X61	16	50
50	0-400	2.5	818X50	15	813X63	16	50
50	0-500	2.5	818X52	15	813X65	16	50
50	0-600	2.5	818X54	15	813X67	16	50
50	0-800	2.5	818X58	15	813X71	16	50
50	0-1 KA	2.5	818X62	15	813X75	16	50
50	0-1.2 KA	2.5	818X96	15	813X77	16	50
50	0-1.5 KA	2.5	818X99	15	814X13	16	50
50	0-2 KA	2.5	819X5	15	814X14	16	50
ϕ100		5.0	ϕ	15	ϕ	16	ϕ100
D-C MICROAMMETERS							
Microamperes							Microamperes
†20	0-20	3400	810X1	$35	698X1	$36	†20
†50	0-50	1600	810X3	27	698X3	28	†50
†100	0-100	1525	810X5	23	698X5	24	†100
†200	0-200	225	810X7	20	698X7	21	†200
†500	0-500	30	810X9	18	698X9	19	†500
D-C MILLIAMMETERS							
Milliamperes							Milliamperes
†1	0-1	7.8	810X11	$17	698X11	$18	†1
†1.5	0-1.5	7.6	810X12	17	698X12	18	†1.5
†3	0-3	2.6	810X14	17	698X14	18	†3
5	0-5	13.6	810X15	15	640X56	16	5
10	0-10	3.0	810X16	15	640X57	16	10
20	0-20	.52	810X17	15	640X58	16	20
30	0-30	1.7	810X19	15	640X60	16	30
50	0-50	1.0	810X20	15	640X61	16	50
80	0-80	.9	810X21	15	64X062	16	80
100	0-100	.5	810X22	15	640X63	16	100
150	0-150	.4	810X23	15	640X64	16	150
200	0-200	.3	810X24	15	640X65	16	200
250	0-250	.25	810X25	15	640X66	16	250
300	0-300	.2	810X26	15	640X67	16	300
500	0-500	.1	810X27	15	640X68	16	500

* *External resistors are used on DW-91 above 300 volts and DO-91 above 600 volts.*

ϕ *When instruments are required for 100 MV external shunt, order 100 MV rating and give scale range desired.*

† *These ratings have core-magnet movements (see Mechanisms).*

NOTE: To establish your quantity discount, contact your nearest G-E Apparatus Sales Office or Distributor.

at Booth 2928, I.R.E. Show, New York Coliseum, March 23—26

PRICING INFORMATION— Alternating-current Types

Rating	Scale	Approx Terminal Resistance Ohms	AW-91, 2½-inch Cat. No.	AW-91, 2½-inch List Price, GO-87A	AO-91, 3½-inch Cat. No.	AO-91, 3½-inch List Price, GO-87A	Rating
A-C VOLTMETERS—Self-contained							
Volts	**Volts**						**Volts**
1.5	0-1.5	3.0	823X54	$17	824X54	$18	1.5
3	0-3	11.1	823X57	17	824X57	18	3
5	0-5	29	823X58	17	824X58	18	5
10	0-10	110	823X61	17	824X61	18	10
15	0-15	251	823X62	17	824X62	18	15
30	0-30	779	823X65	17	824X65	18	30
50	0-50	2500	823X66	18	824X66	19	50
150	0-150	15000	823X70	19	824X70	20	150
300	0-300	54000	823X74	21	824X74	22	300
500	0-500	118000			824X76	29	500
A-C VOLTMETERS—Transformer-rated (Scale marked in terms of transformer ratio)*							
Volts	**Volts**						**Volts**
150	0-300	15000	823X81	$19	824X81	$20	150
150	0-600	15000	823X82	19	824X82	20	150
150	0-750	15000	823X83	19	824X83	20	150
A-C AMMETERS—Self-contained							
Amperes	**Amperes**						**Amperes**
1	0-1	0.16	823X20	$17	824X20	$18	1
3	0-3	0.015	823X24	17	824X24	18	3
5	0-5	0.007	823X25	17	824X25	18	5
8	0-8	0.003	823X28	17	824X28	18	8
10	0-10	0.0024	823X29	17	824X29	18	10
15	0-15	0.0016	823X31	17	824X31	18	15
20	0-20	0.001	823X32	17	824X32	18	20
30	0-30	0.0006	823X34	17	824X34	18	30
50	0-50	0.0004			824X35	20	50
A-C AMMETERS—Transformer-rated (Scale marked in terms of transformer ratio)*							
Amperes	**Amperes**						**Amperes**
5	0-50	0.007	823X39	$17	824X39	$18	5
5	0-75	0.007	823X40	17	824X40	18	5
5	0-100	0.007	823X41	17	824X41	18	5
5	0-150	0.007	823X42	17	824X42	18	5
5	0-200	0.007	823X43	17	824X43	18	5
5	0-300	0.007	823X44	17	824X44	18	5
5	0-400	0.007	823X45	17	824X45	18	5
5	0-500	0.007	823X46	17	824X46	18	5
5	0-600	0.007	823X47	17	824X47	18	5
5	0-800	0.007	823X48	17	824X48	18	5
5	0-1 KA	0.007	823X49	17	824X49	18	5
5	0-1.5 KA	0.007	823X50	17	824X50	18	5
5	0-2 KA	0.007	823X51	17	824X51	18	5
5	0-3 KA	0.007	823X52	17	824X52	18	5
A-C MILLIAMMETERS							
Milliamperes							**Milliamperes**
10	0-10	2158	823X4	$17	824X4	$18	10
25	0-25	341	823X7	17	824X7	18	25
50	0-50	84	823X9	17	824X9	18	50
100	0-100	21	823X12	17	824X12	18	100
200	0-200	4.1	823X14	17	824X14	18	200
500	0-500	0.70	823X17	17	824X17	18	500

* *Cat. No. and prices are only for instruments and do not include external accessories such as potential and current transformers.*
For AW-91 above 30 amperes and AO-91 above 50 amperes order 5-amp transformer-rated instrument for use with external current transformer.

For AW-91 above 300 volts and AO-91 above 500 volts order 150-volt transformer-rated instrument for use with external potential transformer.
NOTE: To establish your quantity discount, contact your nearest G-E Apparatus Sales Office or Distributor.

GENERAL SPECIFICATIONS FOR PANEL INSTRUMENTS

Dimensions (in Inches)	DO-91	DW-91	AO-91	AW-91
Flange dimensions	3.5 X 3.5	2.69 X 2.69	3.5 X 3.5	2.69 X 2.69
Barrel diameter	2.80	2.21	2.80	2.21
Barrel depth	1.31	1.30	1.31	1.30
Scale lengths				
Moving magnet	3.0	2.25		
Core magnet	2.9	2.1		
Iron vane			2.9	2.0

Weight	Net	Shipping
All types (maximum)	8 oz.	12 oz.

Accuracy: All instruments are accurate to within ± 2% of full-scale value. (Moving-magnet-types are calibrated for mounting within 45° of vertical and can be calibrated for other positions on request.)

Mounting: Interchangeable with JAN, MIL, and ASA 2½- and 3½-inch round sizes.

Burden: AO-91 and AW-91—5 amp, 60 cycle: 0.5 VA at 0.5 p.f. lag.
AO-91 and AW-91 voltmeters have approximately unity power factor at 60 cycles.

INCLUDING BOTH A-C AND D-C TYPES

An iron-vane repulsion-type mechanism is used for all a-c ratings. Two vanes are employed: one is attached to the moving shaft and the other is fixed to the field-coil frame. As current flows through the coil, both vanes are magnetized in the same polarity and the repelling force causes the moving vane to rotate. The pointer attached to the movable vane indicates deflection on the scale.

A substantially uniform scale distribution is obtained because the repelling force varies both as a square of the current and inversely as the square of the distance between vanes.

MAGNETIC DAMPING

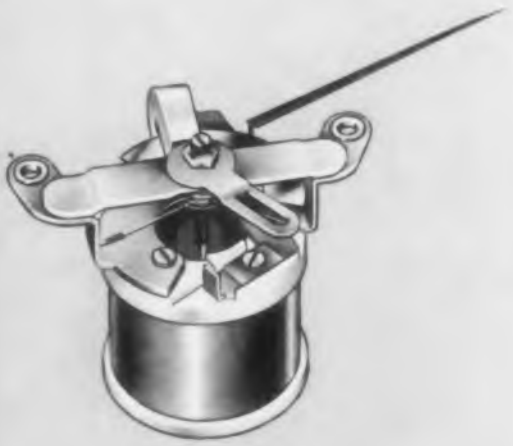
All a-c movements utilize magnetic damping to bring the moving mechanism quickly to rest. Alternating-current instruments are accurate to within 2% of full-scale value.

As with any iron-vane instrument, optimum accuracy is obtained when leads are brought down vertically to terminals.

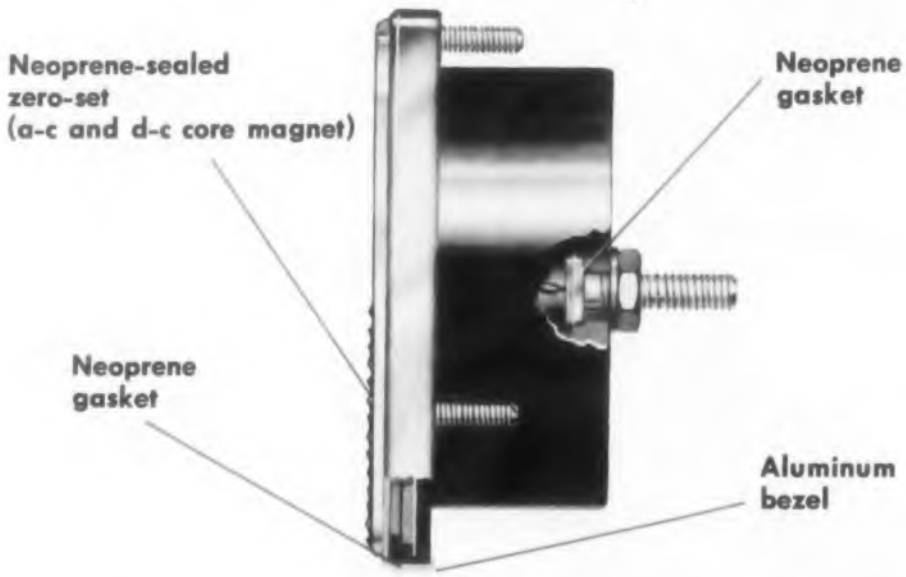
Order General Electric small panel instruments by catalog number from your nearest G-E Apparatus Sales Office or Distributor. For catalog numbers, ratings, and pricing information, see inside fold.

Old round design with 3½-inch diameter has relatively small scale and numbers.

New BIG LOOK design fits into same usable panel space as older style instruments.



Moving-iron mechanism, used in all a-c ratings, consists of field coil, fixed and movable vanes, and control spring.



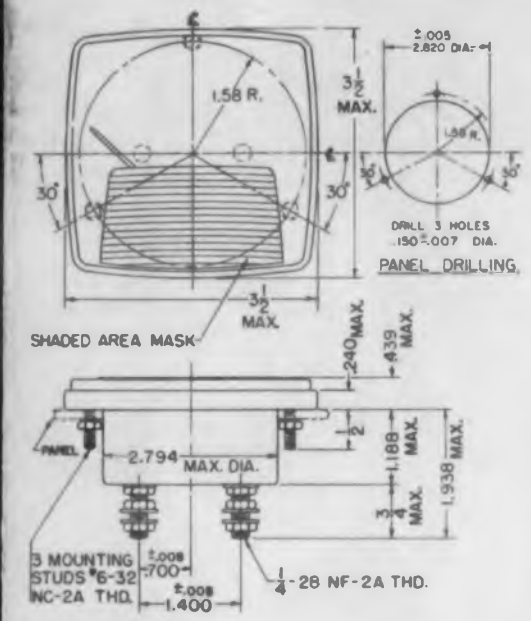
Completely sealed cases protect internal parts of instrument from dirt, dust and water. Even zero-set is sealed with a neoprene O-ring.

at Booth 2928, I.R.E. Show, New York Coliseum, March 23—26

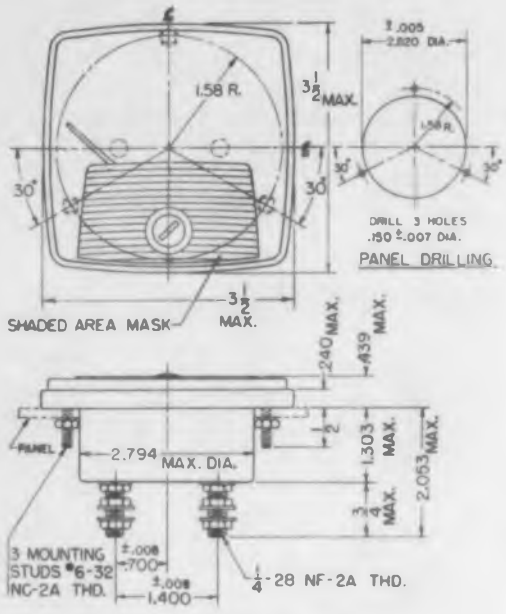
WRITE NOW FOR A QUOTATION

Your nearest G-E Apparatus Sales Office or Distributor can give you all the facts on BIG LOOK small panel instruments, including those with custom-marked scales. Most ratings are available for immediate delivery. Or, write direct to General Electric Co., Section 593-302, Schenectady, New York

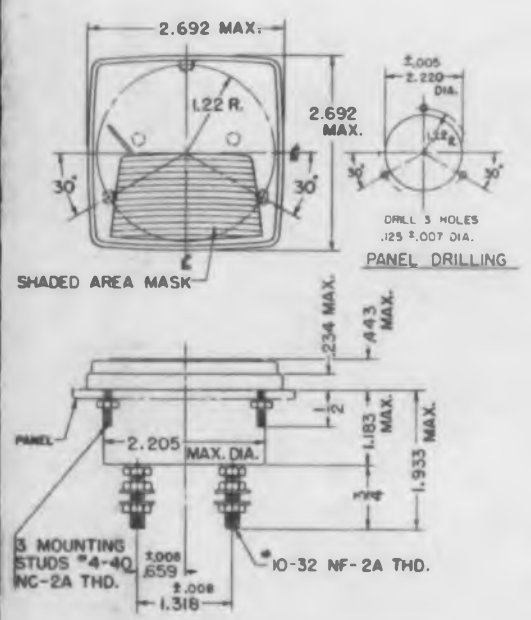
Use these dimensions and panel-drilling specifications to plan your panel instrument needs



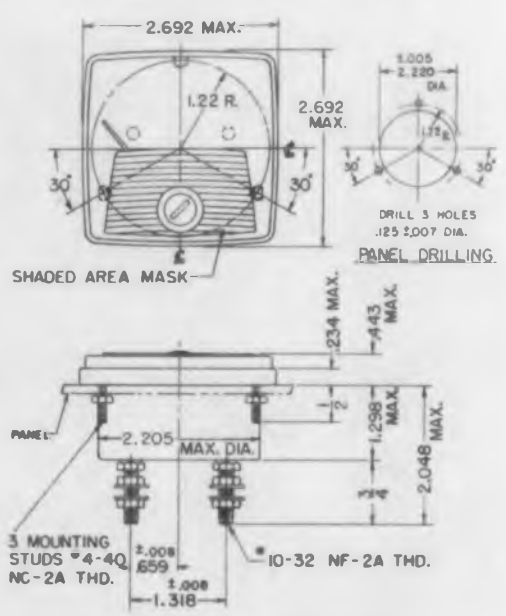
Type DO-91, Moving-magnet



Type DO-91, Core-magnet
Type AO-91, Iron-vane



Type DW-91, Moving-magnet



Type DW-91, Core-magnet
Type AW-91, Iron-vane

to meet all your measurement needs—

General Electric offers this complete line of precision instruments

ELECTRIC-QUANTITY INSTRUMENTS—voltage, current watts, vars, frequency and power factor.

Indicators
- Switchboard and panel-mounted
- Portables
- Hook-ons
  - Switchboard Indicators can be furnished with contacts or "control initiation" to operate alarms or control circuits

Recorders
- Switchboard and panel-mounted
- Portables
- Hook-ons

Auxiliaries
- Current transformers
- Potential transformers
- Shunts
- D-c "current transformer"

LABORATORY INSTRUMENTS
- High-sensitivity recorders
- Gauss meters
- Resistance bridges
- Spectrophotometer and tristimulus integrator
- Instrument standardization console
- Photo cells
- Vacuum gages

PROCESS INSTRUMENTS

Indicators
- Precision, potentiometric type
- Precision, A-c bridge type
- Pyrometer
- Resistance thermometer

Recorders (potentiometer and A-c bridge types)

Strip-chart

Recorder—Controllers
- Strip-chart-recorder, electric control
- Pyrometer, seven control forms
- Resistance-thermometer, seven control forms

Speed measuring systems

DYNAMIC MEASURING EQUIPMENT
- Automatic oscillograph
- Strain gage amplifiers, carrier types

TELEMETERING EQUIPMENT, torque-balance and frequency types

TESTING EQUIPMENT
- Thickness gages
- Viscosimeters
- Paper tensiometer
- Vibration testers
- Surface roughness scales

SUPERVISORY INSTRUMENTS FOR ROTATING MACHINERY
- Vibration detectors and recorders
- Eccentricity recorders
- Speed and camshaft-position recorders
- Shell and differential expansion recorders

REACTOR INSTRUMENTATION

LEAK DETECTORS
- Halogen-types
- Mass-Spectrometer type

TIMING DEVICES

Time Switches
- General-purpose types
- Process types

Time Meters

593-302

GENERAL ELECTRIC

Servo Motor Generator

Size 10

This 2.75 oz motor generator is designed for operation directly from transistor servo amplifiers and will develop a stall torque of 0.3 oz-in. The size 10,400 cps unit has a free speed of 6500 rpm and viscous damping of 31.1 dyne-cm per radian per sec. Generator output is 0.16 v per 1000 rpm at 10 v input, and 0.41 v per 1000 rpm at 26 v input.

Daystrom Transicoil, Dept. ED, Worcester, Montgomery Co., Pa.

CIRCLE 137 ON READER-SERVICE CARD

Light Image Intensifier Tube

Brightens 10^{-7} ft-c 1000 times

Light images at levels of 10^{-7} ft-c can be intensified over 1000 times with the WL-7257 intensifier tube. The unit produces an image of reduced size having a brightness increase of 1000 times minimum for input color temperature of 2870 K, and 2500 times minimum for actinic blue input. The light quantum gain is approximately 50 for input color temperature of 2870 K tungsten and 100 for actinic blue input.

Westinghouse Electric Corp., Electronic Tube Div., Dept. ED, P.O. Box 284, Elmira, N.Y.

CIRCLE 138 ON READER-SERVICE CARD

Rotary Relay

Rated at 5 amp, 30 v dc

Type 4C rotary relay is a hermetically sealed 4pdt dc unit with a contact rating of 5 amp, 30 v dc. It weighs 3.2 oz, operates at 125 C, and withstands 2000 cps vibration at 20 g acceleration.

Couch Ordnance, Inc., Dept. ED, 3 Arlington St., North Quincy, Mass.

CIRCLE 139 ON READER-SERVICE CARD

Don't forget to mail your renewal form to continue receiving *ELECTRONIC DESIGN*.

CIRCLE 136 ON READER-SERVICE CARD

NEW PRODUCTS

Pressure to Voltage System

Provides signal output of 0 to 5 or ±2.5 v dc

The unregulated model DCS-2 pressure to voltage system is a single package that operates from standard unregulated 28 v dc aircraft and missile power supplies. It combines the company's model S-30 variable-reluctance transducer with stable transistorized electronic circuitry and has a signal output of 0 to 5 or ±2.5 v dc over the rated pressure range. Because the stiff metal diaphragm is the only moving part, the instrument is resistant to shock and vibration. With no dc or ac amplifiers in the circuitry, drift problems are eliminated. In operation, a transistorized multivibrator works into a completely passive circuit which includes a temperature-stable, phase-sensitive demodulator with matched silicon diodes. This circuitry confines the necessary ac to within the shielded package, making it unnecessary to run ac lines elsewhere in the system. The resultant dc signal may be used as the input to voltage-controlled oscillators and dc computers as well as to other dc input systems.

Ultradyne, Inc., Dept. ED, P.O. Box 3308, Albuquerque, N. Mex.

CIRCLE 146 ON READER-SERVICE CARD

Rotary Switch

Has 1 in. diameter

Series 1900 Rotary selector switch is totally enclosed and built to exceed MIL-S-6807A requirements. It will carry 10 amp continuously and 5 amp, 115 v ac or 3 amp 28 v dc intermittently. Dielectric strength is 1800 v. The unit is available with a single wafer or up to 16 wafers and with continuous rotation or 2 to 10 positions with stops.

Janco Corp., Dept. ED, 3111 Winona Ave., Burbank, Calif.

CIRCLE 147 ON READER-SERVICE CARD

DC Governor Motor

Holds uniform speed within 1%

Rated at 1/100 hp at 4500 to 9000 rpm, this dc motor is equipped with a governor that controls shaft speed variation within 1%. Rotor torque is rated at 3.5 oz in. for intermittent duty. Overall dimensions are approximately 1-1/2 x 3 in., including the shaft which protrudes about 1/2 in. beyond the frame. Weight of the unit is about 7 oz. Body of the M-120 unit is solid aluminum with anodized finishes available in 6 colors.

Carter Motor Co., Dept. ED, 2761 A W. George St., Chicago 18, Ill.

CIRCLE 148 ON READER-SERVICE CARD

Vernier Variable Resistor

Has 13.5 to 1 reduction

Designed for fine tuning applications, this vernier variable resistor's contact arm rotates 1 deg for each 13.5 deg of shaft rotation. Total contact arm rotation is 300 ±5 deg, and total shaft rotation is approximately 4000 deg. Designated VA-45, it has a 0.25 to 0.5 w dissipation. Resistance range is 250 ohms through 10 megohms, linear taper, with standard tolerance ±30% for 250 ohms through 5 megohms, and ±40% for 5 to 10 megohms. Voltage rating across end terminals is 500 v dc. Available in many tapers and shaft specifications.

Chicago Telephone Supply Corp., Dept. ED, Elkhart, Ind.

CIRCLE 149 ON READER-SERVICE CARD

NEW PRODUCTS

Silicon Transistor

Operates at 200 C

The ARA-46P silicon composite pnp transistor is thermally compensated to operate at temperatures up to 200 C. It has the general characteristics of a small signal transistor at the input and that of a power transistor at the output. Operating specifications are: collector voltage, 40 v; collector current, 3 amp; power dissipation at 25 C, 35 to 50 w; power dissipation at 150 C, 2 to 5 w; current gain, 10,000; input impedance, 2000 ohms; output impedance, 500 ohms.

Advanced Research Associates, Inc., Dept. ED, Semiconductor Div., P. O. Box 68, Kensington, Md.

CIRCLE 164 ON READER-SERVICE CARD

Pegboard Kit

For circuit development

Available on an individual parts basis or in development sets with over 850 components, Erec-Tronic systems consist of precision drilled Duron pegboards, electrical and electronic components mounted on high-impact polystyrene bases with dual plug-in pins, and phosphor bronze Jiffy connectors. They are designed to permit quick check out of circuitry ideas without soldering or wire preparation. The sets can be used to build transistor and tube circuitry for audio, servo, pulse, video, computer, and radio frequency applications up to 20 mc.

Science-Electronics, Inc., Dept. ED, 195 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE 165 ON READER-SERVICE CARD

Voltage Controlled Oscillator

For airborne use

Airborne voltage controlled oscillator model AOV-4S is a rugged, transistorized unit compatible with many existing airborne packages. It incorporates silicon junction diode networks and silicon transistors which permit operation in ambients to 125 C. The unit has ±0.5% linearity, low power drain, and high stability in cases of supply voltage variations. Dimensions are 3 x 1.62 x 1.87 in.

Data-Control Systems, Inc., Dept. ED, 39 Rose St., Danbury, Conn.

CIRCLE 154 ON READER-SERVICE CARD

Thermistors

Interchangeable and matched

This line of interchangeable and close tolerance matched thermistors come in five major groups. More than 30 units are available. Resistance matched units are available such that at 25 C all units are within 1% of the R_0 of the highest resistance unit. Voltage matched units are such that the R_0 of the lower resistance unit is within a specified percentage of the higher unit. Other types of matched units include: series-parallel matched; resistance temperature matched; resistance ratio-temperature matched.

Victory Engineering Corp., Dept. ED, 519 Springfield Road, Union, N. J.

CIRCLE 155 ON READER-SERVICE CARD

This is the time of our annual subscription renewal.

NEW PRODUCTS

Vibrating Reed Electrometer

Measures 10^{-17} amp

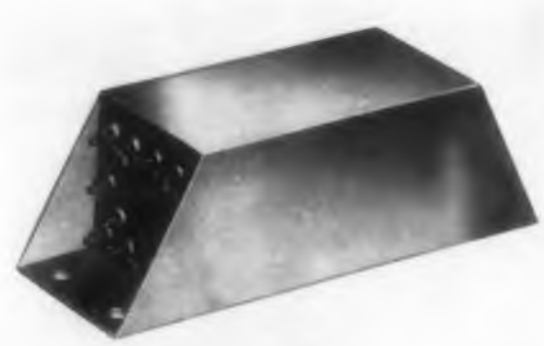
Current as low as 10^{-17} amp, and voltages as low as 0.02 mv can be measured with the Cary Model 32 electrometer. It also measures C^{14} activity to 5×10^{-15} curies per mg $BaCO_3$, and H^3 activity as low as 10^{-10} curies per mg H^3. The unit accommodates ionization chambers from 50 to 1500 ml, as well as solid and liquid sample accessories. Ranges: 10, 100, 1000 mv, 10 v. Accuracy of the unit is $\pm 0.25\%$. It consumes 50 w at 115 v, 60 cps.

Applied Physics Corp., Dept. ED, 2724 South Peck Road, Monrovia, Calif.

CIRCLE 158 ON READER-SERVICE CARD

Servo Amplifier

Weighs 10 oz



This magnetic amplifier, 4.5 in. long and weighing 10 oz, is a wide band pass servo unit designed to drive standard servo valves. It has a low emissivity finish for operation at high radiant energy levels and meets Mil-E-5272A. Input range for the two control inputs (one may be feedback), is -1 to $+1$ v. Maximum output is $+15$ ma and $+15$ v. Gain may be adjusted externally; supply of 115 v, 2400 cps.

Vickers Inc., Electric Products Div., Dept., Dept. ED, 1815 Locust St., St. Louis 3, Mo.

CIRCLE 159 ON READER-SERVICE CARD

Tape Wound Cores

Epoxy encapsulated

Packaged, ready-to-wind, and poxy encapsulated, these aluminum ased tape wound toroidal cores are or use in magnetic amplifiers, satuable reactors, and special transormers. No taping or supplementary insulation of the core case is ecessary, and breakdown rating etween the winding and the case above 1500 v, 60 cps, rms.

G-L Electronics, Inc., Dept. ED. 921 Admiral Wilson Blvd., Camden 5, N.J.

CIRCLE 160 ON READER-SERVICE CARD

Volt-Ammeter

Measures 0.03 μv

Model 150 micro volt-ammeter measures down to 0.03 μv and 2×10^{-12} amp, dc. It may be used as an amplifier, micro-microammeter, and with an external voltage supply as a meg-megohmmeter. As a dc voltmeter it measures from 1 μv to 1 v full scale. As an ammeter it measures from 10^{-3} to 10^{-10} amp full scale. Gains of 10 to 10^{7} are possible when used as an amplifier. The unit has zero stability as a voltmeter within 0.1 μv per day, within 2×10^{-11} amp as an ammeter. The zero center scale indicates polarity and amplitude as well as null point, with 0.5 to 2 sec period.

Keithley Instruments, Inc., Dept. ED, 12415 Euclid Ave., Cleveland 6, Ohio.

Booth 3414

CIRCLE 161 ON READER-SERVICE CARD

NEW PRODUCTS

Trimmer Potentiometer

For high temperature use

Miniature model W-10 trimmer potentiometer has a variable micrometer adjustment which gives a precise selection of resistance from 10 ohms to 150 K. For high temperature use, the unit has an epoxy encapsulated winding and an epoxy sealed case that withstands 500 F.

Atohm Electronics, Dept. ED, 7648 San Fernando Rd., Sun Valley, Calif.

CIRCLE 151 ON READER-SERVICE CARD

Commutator-Gating Units

In standard IRIG sampling rates

Available in all standard IRIG sampling rates and channel configurations, series CAG commutator gating units accommodate high level inputs ranging from 0 to +5 v full scale. Typical signal sources which may be used with the unit are potentiometers, cathode followers, and voltage references. The output may be fed directly to a standard subcarrier oscillator or to an rf transmitter.

General Devices, Inc., Dept. ED, P.O. Box 253, Princeton, N.J.

CIRCLE 152 ON READER-SERVICE CARD

Aluminum Clad Copper Wire

For high temperature use

Composed of an aluminum alloy cladding over a high conductivity copper core, this wire has applications both as magnet wire and as high temperature lead-in wire. Suited for use in aircraft, missiles, and high speed industrial equipment, it has about 70 per cent the conductivity of copper at room temperature.

Sylvania Electric Products Inc., Dept. ED, Warren, Pa.

CIRCLE 153 ON READER-SERVICE CARD

Telemetry Wave Dropout Analyzer

For magnetic tape

Designed primarily for telemetering instrumentation, this instrument measures: the dropout characteristics in a magnetic tape recording over a range of operating frequencies from 7.5 to 80 kc; a dropout amplitude range from 15 to 85%; and a dropout width range from 38 to 360 μsec. For each dropout detected with respect to a predetermined amplitude and width, a 70 v positive going, rectangular pulse is emitted. It measures dropouts in accordance with Mil-T-21029 (Ships).

Acoustronics, Inc., Dept. ED, 156 Olive St., Huntington Station, N. Y.

CIRCLE 167 ON READER-SERVICE CARD

Differential Transformers

Linear stroke

These differential transformers have a linear stroke of 70% of coil length, and high output and low impedance secondary windings. Linear displacement is from ±0.5 to ±8 in. Ratio of output voltage, at range limit, to null voltage is 1000:1. Linearity of ±0.5% over a temperature range of −60 to 250 F is attainable. The units are magnetically shielded, potted and furnished with Teflon insulated leads.

Automatic Timing & Controls, Inc., Dept. ED, Dept. 213, King of Prussia, Pa.

CIRCLE 168 ON READER-SERVICE CARD

Don't forget to mail your renewal form to continue receiving *ELECTRONIC DESIGN*.

NEW PRODUCTS

Scintillation Counter

For X-ray diffraction studies

Model 10-7 is a low noise, high speed counter for X-ray diffration studies. Mounting flanges are available to match the counter to standard commercial X-ray diffraction systems. The unit includes a gain of 10 preamplifier, a selected photomultiplier tube, and a thin *NaI(Tl)* crystal. It measures 1-5/16 x 6 x 4-1/2 in. and weighs 4 lb.

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

CIRCLE 171 ON READER-SERVICE CARD

Wirewound Resistors

Highly stable

Hermetically sealed type RSH-2B precision wirewound resistors have resistances from 1 to 4200 ohms and stability levels of 1, 0.5, 0.25, and 0.1%. Depending on the stability level, power ratings are 0.75 to 1.5 w at 25 C, derating to 0 between 100 and 130 C. Temperature coefficient is 0.00002 per deg C, and tolerances are between ±0.05 and ±3%.

Dale Products, Inc., Dept. ED, Columbus, Nebr.

CIRCLE 172 ON READER-SERVICE CARD

Dual Recorder

Plots two quantities on one chart

The CH-37 Duplex Recorder plots two related electrical quantities side by side on one chart. Its two separate recording mechanisms are housed in a 15 x 16 in. case designed for semiflush panel mounting. The unit is provided with either a single speed synchronous motor giving 11 chart speeds from 1/4 to 30 in. per hr or a double speed motor offering 28 speeds from 1/4 in. per hr to 120 in. per min.

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

CIRCLE 173 ON READER-SERVICE CARD

Skived Teflon Tapes

For high temperature insulation

Made by skiving Teflon billets, these unsupported fused tapes have good electrical properties, resistance to all common chemicals, a low coefficient of friction, and a surface to which nothing will stick. Mainly for high temperature and high frequency wire and cable insulation, they also serve as stock for gaskets, seals, and other small parts. They are available in four grades designated ST-X, ST-C, ST-1, and ST-2; in widths from 1/4 to 12 in.; and in thicknesses from 0.002 to 0.1 in.

Continental-Diamond Fibre Corp., Dept. ED, Newark, Del.

CIRCLE 175 ON READER-SERVICE CARD

Data Processing Equipment

Punched tape

An integrated processing device, the Data Punch consists of a 20 digit per sec tape punch and a full-keyboard adding machine which activates the punch. It produces two records simultaneously: a detailed strip for immediate accounting data; and a punched tape which can be directed to digital computers and processors. Information on the punched tape can be converted to punched cards or magnetic tape for further processing.

Victor Adding Machine Co., Dept. ED, 3900 N. Rockwell St., Chicago 18, Ill.

CIRCLE 176 ON READER-SERVICE CARD

Antenna Pattern Analyzer

Uses rf crystals

Using rf crystals in a video detector system, the IIA-7 antenna pattern analyzer requires a maximum of 1 μw rf power to achieve a maximum measurement range of 45 db in one step. A dc biasing circuit is included to permit the use of conventional barretters, requiring a dc bias between 0 and 10 ma. The unit can be used to measure high power ratios; to determine the rejection coefficients of rf filters; and to calibrate attenuators. It has a wide dynamic linear range, a low noise level, and a wide rf frequency range where video crystal mounts are available.

Weinschel Engineering, Dept. ED, 10503 Metropolitan Ave., Kensington, Md.

CIRCLE 177 ON READER-SERVICE CARD

NEW PRODUCTS

Packaging Material

Low density

A low density, moldable packaging material made from polyurethane, K-Foam is a light weight material which protects all types of light-weight aircraft instruments, missile parts, electronic parts, and tubes. At the same time, it reduces tare and cubage. It can be molded in any density and meets MIL-P-6064A and MIL-C-7769 packaging specifications. Nonabrasive, nonhygroscopic, nontoxic, and flame proof, it has a neutral PH factor.

Henry B. Katz Industries, Inc., Dept. ED, 859-879 Summer Ave., Newark 4, N.J.

CIRCLE 180 ON READER-SERVICE CARD

Miniature Shift Register

One core per bit

Model SR-104 is a one-core-per-binary-bit unit with a 5 kc information rate and a 10 to 1 signal to noise ratio. Its operating temperature range is −55 to +125 C. A 14 μsec, 22 v output pulse is obtained by applying a 10 μsec, 7 ma input pulse and subsequently an 8 μsec, 300 ma shift pulse. Encapsulated in an epoxy compound, the unit occupies a total volume of 0.2 cu in.

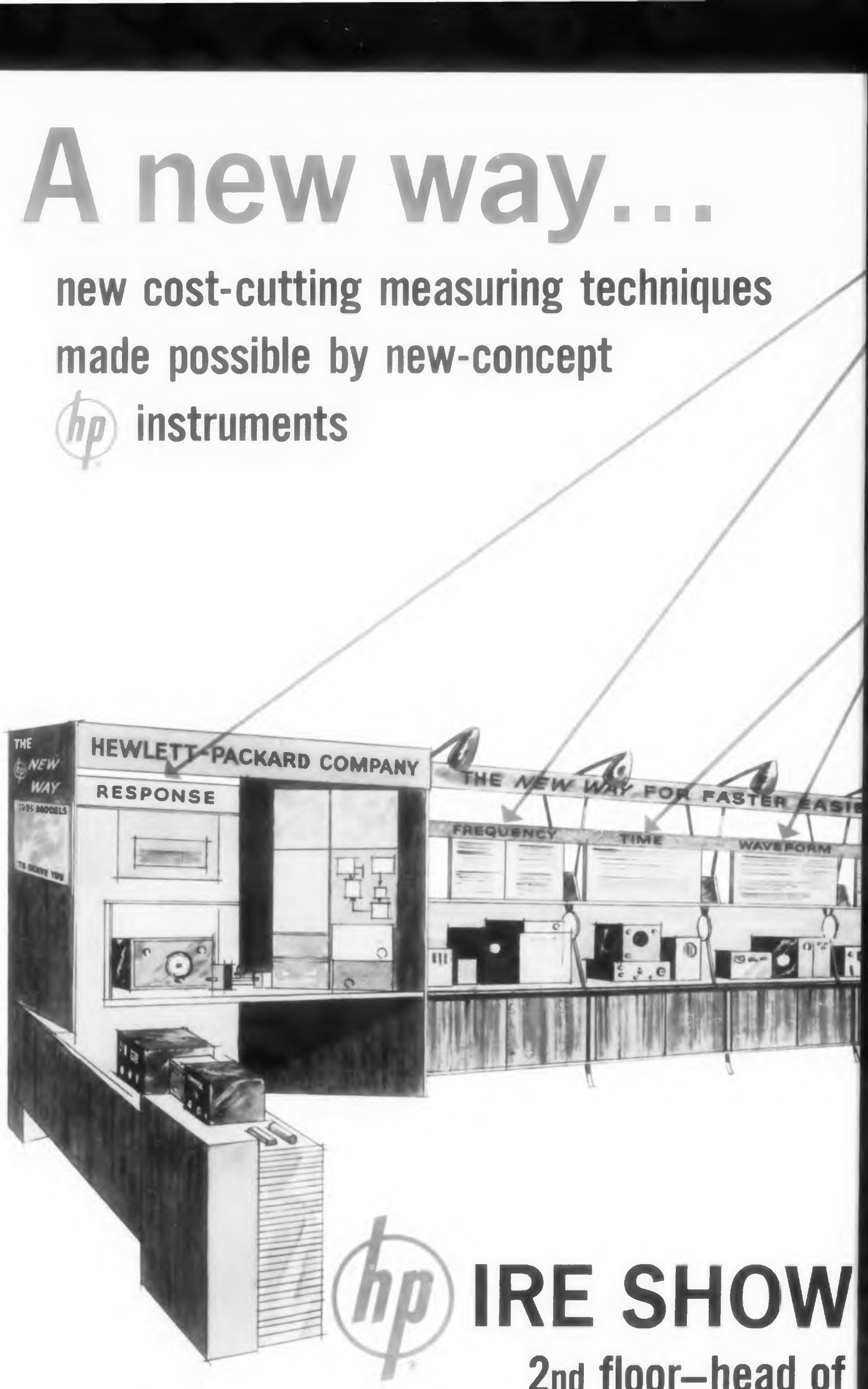
ESC Corp., Dept. ED, 534 Bergen Blvd., Palisades, N.J.

CIRCLE 181 ON READER-SERVICE CARD
CIRCLE 499 ON READER-SERVICE CARD

A new way...

new cost-cutting measuring techniques made possible by new-concept

hp instruments



hp **IRE SHOW**

2nd floor—head of

RESPONSE

New electronic sweep oscillators (left). 5 units cover 2 to 18 KMC. Quick, accurate, convenient response measurements of all types of circuits such as masers, parametric amplifiers, TWT's, couplers, attenuators. Also new microwave wavemeters (right), including K and R bands, provide complete coverage 8.2 to 40.0 KMC.

FREQUENCY

Direct, instant, in-line readings; bright, steady numerals on new counters. New reading ease, wide range, improved sensitivity and accuracy.

TIME

New clock and divider circuit for control of extremely accurate frequency standards and comparison with station WWV within 10 microseconds accuracy ($1/10^{10}$ accuracy).

WAVEFORM

All-new, transistorized wave analyzer—20 cps to 50 KC, compact, versatile, featuring new control simplicity, new tuning ease, automatic features never before in any wave analyzer. Operating at -hp- display with new low cost, dual trace oscilloscope.

VOLTAGE

New, moderately-priced digital voltmeter providing true "touch-and-read" convenience, automatic range and polarity selection; permits readings to be recorded automatically. Also: new, portable transistorized ac voltmeter.

CURRENT

Revolutionary design approach provides new "clip-and-read" dc current measurement ease—no soldering, no circuit loading, no direct connection. Also new plug-in for -hp- 150A series oscilloscopes permits viewing ac current and voltage simultaneously — ideal combination for transistor circuit testing.

escalators

there

IS

a new way!

see it...test it at

hp IRE SHOW

2nd floor—head of escalators

other **NEW WAY** instruments you can see and operate at the hp I.R.E. exhibit

NEW IN-LINE 220 MC COUNTER

New model 524C with plug-ins measures frequency to 220 MC, time interval 1 μsec to 100 days, period dc to 10 KC. New in-line readout, brightly visible under any lighting conditions. Resolution 0.1 μsec, stability $3/10^8$ short term, no calculation or complex setup, highest quality; regarded by many as premium commercial counter offered. $2,300.00.

NEW IN-LINE 1.2 MC COUNTER

Model 523C Electronic Counter provides all-purpose versatility plus the time-saving convenience of bright, steady in-line readout. Measures frequency 10 cps to 1.2 MC, time interval 1 μsec to 27.8 hours, period 0.00001 cps to 10 KC. Stability 2/1,000,000 per week. Results displayed in sec, msec, μsec or KC, automatic decimal. Display time variable, accuracy · 1 count · stability. Price on request.

NEW TRANSFER OSCILLATOR FOR hp COUNTERS

Together with hp 524 series counter, measures frequency to 12 KMC quickly, easily, with counter accuracy. Guesswork, trial and error experimentation, expensive setups are eliminated. Measure on pulsed, AM, FM, CW or noisy circuits. Overall accuracy better than 10 times that of best microwave wavemeters; accuracy on clean CW signals is about 1/1,000,000. Stability better than 0.002%/minute. $750.00.

NEW PRECISION VTVM

Model 412A is a precision vacuum tube voltmeter providing measurements from 1 mv to 1,000 v full scale, with accuracy of 1%. This remarkable new high-accuracy instrument also measures currents from 1 microampere to 1 ampere full scale with 2% accuracy, and measures resistances 0.2 ohms to more than 5,000 megohms. $350.00.

PRECISION FIXED ATTENUATOR

-hp- 372A series provide fixed standards of attenuation for waveguide measurements for all bands and waveguide sizes from 2 to 40 KMC. Their precise accuracy is not affected by temperature, humidity or other external factors. $100.00 to $375.00.

hp at **IRE** · head of escalators · 2nd floor

If you aren't attending this year, please call your -hp- representative or write direct for information on any new -hp- equipment.

HEWLETT-PACKARD COMPANY

5029K Page Mill Road • Palo Alto, California, U.S.A.
Cable "HEWPACK" • DAvenport 5-4451
Field engineers in all principal areas

LOOK FOR THIS CARD IN THE MAIL

YOUR SUBSCRIPTION HAS EXPIRED

Its Time To Renew Your Free Subscription To

ELECTRONIC DESIGN

Regardless of when your subscription started, you must fill out and return a renewal card.

When you receive your I B M renewal card, please fill it out completely . . . and mail it immediately to insure uninterrupted receipt of ELECTRONIC DESIGN.

Our circulation policy requires that all subscribers requalify each year to continue receiving their free subscription to ELECTRONIC DESIGN.

Please help us to serve you better by requalifying as soon as you receive your card.

26 ISSUES IN 59

NEW PRODUCTS

Pancake Synchros and Resolvers

Accuracies to 5 min

Available in size 20 and 27, these pancake synchros and resolvers feature accuracies down to 5 min and are made for instruments such as inertial guidance systems. Their electrical properties are designed to meet specific applications or to match standard components for accuracy, voltage gradient, and impedances. They may be obtained with integral flanges and hubs.

Luther Mfg. Co., Dept. ED, 7312 Varna St., North Hollywood, Calif.

CIRCLE 182 ON READER-SERVICE CARD

AC Voltage Calibrator

Has 0.1% accuracy

Absolute voltages accurate to 0.1% may be obtained by setting the digital controls of this precision ac voltage source. This accuracy is maintained at all frequencies from 35 cps to 10 kc. The unit will provide up to 30 w of power. Output wave form is sinusoidal with less than 0.15% distortion.

Holt Instrument Labs., Dept. ED, Oconto, Wis.

CIRCLE 183 ON READER-SERVICE CARD

This is the time of our annual subscription renewal.

Range and Balance Instrument

For bridge arm resistances

The BR 111 range and balance unit is a full scale, adjustable instrument that balances out small inequalities in bridge arm resistances. It is equipped with gold contact relays that minimize dry circuit problems; a front panel switch for changing to auxiliary power supplies; pushbuttons for controlling both range and balance; and a remote switch for setting all channels into two standardization modes. Built to withstand adverse environments, it contains six independently adjustable, identical channels, constructed on a single chassis for mounting in standard 19 in. racks. It is engineered to permit adjusting bridge current to the proper value by precision calibrating resistors. The unit is designed as a control center for use in coupling strain gages or resistive-bridge-type pickups to direct writing oscillographs, standard meters, chart recorders, and analog-to-digital converters. When coupled with high sensitivity galvanometers in a multichannel photographic recording oscillograph, it permits direct recording without amplifiers.

Computer Engineering Associates, Inc., Dept. ED, 350 N. Halstead, Pasadena, Calif.

CIRCLE 186 ON READER-SERVICE CARD

Alarm System

For industrial processes

Designed with no moving parts, the Fault-Finder alarm system monitors electric sub-stations, industrial plant operations, and unattended microwave repeater stations. The basic system contains a transistorized ring counter scanner that monitors up to 20 separate items at a scanning rate of 10 points per second. Each monitored item is represented by a switch which sounds an alarm for abnormal conditions at the receiving-annunciator unit. The system requires only one communications channel, ranging from a pair of wires to a subcarrier radio or microwave channel. It has plug-in circuit boards and operates from 115 v, 60 cps current or a 125 or 48 v dc source.

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

CIRCLE 187 ON READER-SERVICE CARD

NEW PRODUCTS

Differential Transformer Indicator

Has 1% accuracy

Accurate, large scale indication and recording of linear motion, size, weight, force, pressure, and other quantities measurable by differential transformer transducers is achieved with the model 300A differential transformer indicator. Completely self-contained, the instrument has a 10 in. Weston panel meter, a constant current excitation supply, self-checking features to eliminate drift errors, and five calibrated sensitivity ranges which cover all usual scientific and industrial requirements. Accuracy is 1% with maximum resolution of 0.000005 in. of core displacement. Special dial marking are available as required, and a suitable electrical output is provided for direct operation of standard potentiometer recorders.

Daytronic Corp., Dept. ED, 216 S. Main St., Dayton 2, Ohio.

CIRCLE 190 ON READER-SERVICE CARD

Cable Cutter

Nonshorting

Individual conductors in the cable bundle are not short-circuited when the cutting action of this propellant-actuated guillotine takes place. The unit uses a ceramic cutter blade that is driven through the cable bundle onto a ceramic anvil. Driving power comes from a standard screw-in explosive cell. Designed to eliminate all switches, plugs, relays, contactors, or receptacles, this cutter permits the solidly permanent wiring of all circuit elements to an unactivated battery. Activating the battery energizes the circuit and firing the cutter de-energizes it. Potential applications exist where electrical circuits should be severed with no electrical contact between separate circuits.

Beckman & Whitley, Inc., Dept. ED, 985 E. San Carlos Ave., San Carlos, Calif.

CIRCLE 191 ON READER-SERVICE CARD

Permanent Magnets

Have continuously variable field strengths

With the Variflux magnet, field strengths continuously variable over a 20 to 1 ratio of maximum to minimum are obtained at any chosen gap by means of adjustable magnetic shunt rings. Variability of the gap is 0 to 4-1/2 in. Stock pole faces, readily interchanged, are: 10 cm diameter flat field shimmed pole faces suitable for nuclear magnetic resonance and beta spectrometers; 5 cm diameter high intensity field poles; and 10 cm radius 60 deg sector poles suitable for mass spectrometers. Typical unshunted fields are 3000 gauss at 1 cm separation of the 5 cm diameter pole faces; and 1200 gauss at 2 cm separation of the 10 cm diameter pole faces. The units have negligible hysteresis.

Laboratory for Science, Dept. ED, 5431 College Ave., P. O. Box 2925, Oakland 18, Calif.

CIRCLE 192 ON READER-SERVICE CARD

Precision Multiplier-Divider

Analog computing component

Model K5-M multiplier-divider is a precision analog computing component with long term stability. Based on an all-electronic semiconductor network, it accepts three variable inputs, e_1, e_2, e_3, and provides as output $e_1\,e_2/e_3$. Its accuracy as a multiplier, including drift, is better than 0.1 v in all four quadrants. A three-digit decade provides an adjustable voltage which may be added to numerator, denominator, or output. This voltage also serves as an adjustable scale factor for operations involving only two variables. Dynamic response is determined by an adjustable switch setting. The unit is mounted on a standard 7 in. rack panel. In addition to filament power at 115 v ac, it requires 100 ma at plus and minus 300 v dc. The standard range of inputs and outputs is plus and minus 50 v. Typical applications include analog computation, correlation, precision modulation, and control. No external equipment is necessary to obtain products, ratios, squares, square roots, or absolute values.

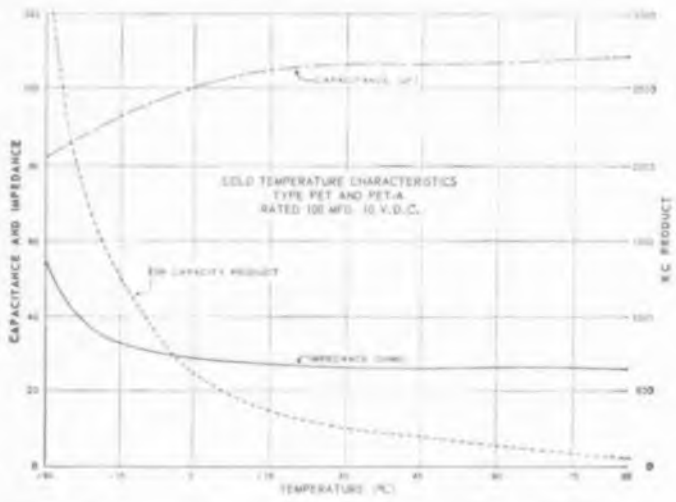
George A. Philbrick Researches, Inc., Dept. ED, 285 Columbus Ave., Boston 16, Mass.

CIRCLE 193 ON READER-SERVICE CARD

New High-Performance Electrolytics

for Printed Circuits and Miniaturized Equipment

A new line of Mallory electrolytic capacitors . . . latest refinement of the industry—standard FP, WP, and TC models . . . now brings extra performance and compactness to designers of printed circuits and miniaturized products. High temperature shelf life, operating life, and capacitance stability have been substantially increased, by the use of new Mallory low-impedance electrolyte.



Typical temperature characteristics of Type PET and PET-A capacitors.

The new design gives more capacity per unit size than previously possible with comparable aluminum electrolytics. Leakage current, power factor and impedance are exceptionally low. Models are rated for temperatures from —30 to +85°C.

Two designs are available. The PET series, specifically for printed circuits, has all leads coming from one end of the case, and is available in single, dual and triple ratings. The PET-A series has axial leads suitable for printed circuit or conventional wiring . . . comes in single and dual ratings.

Excellent performance and protection against humidity are obtained by a plastic case with epoxy end seal.

Case sizes range from $\frac{3}{8}$" x $\frac{5}{8}$" to $\frac{5}{8}$" x 1$\frac{7}{8}$". Maximum capacity is 23 mfd/3 VDC to 3 mfd/50 VDC for the smallest size; 1500 mfd/3 VDC to 238 mfd/50 VDC for the largest size. A complete range of ratings is available. Get full details and a consultation on your circuit applications, by writing to Mallory today.

P. R. MALLORY & CO. Inc.

MALLORY

P. R. MALLORY & CO. Inc., INDIANAPOLIS 6, INDIANA

CIRCLE 195 ON READER-SERVICE CARD

NEW PRODUCTS

Coaxial Terminations

50 to 300 w ratings

These high power coaxial terminations cover the dc to 10 kmc range with a maximum vswr of 1.2. Models RDL-30N and RDL-31N have a dc to 4 kmc range and are rated at 200 and 50 w, respectively, without forced cooling. Model RDL-6N(H) covers 2 to 10 kmc and has a 300 w rating. All units are designed for use with type N connectors.

Radar Design Corp., Dept. ED, P.O. Box 38, Pickard Dr., Syracuse, N.Y.

CIRCLE 196 ON READER-SERVICE CARD

Miniature Indicator

For edge-lighted panels

For all edge-lighting applications, type 855S-E Color-Lite has a 1/2 in. opaque cap, designed for flush mounting, which prevents any light from showing in front of the panel. It uses a standard GE 327 or 328 incandescent bulb, and is available with or without a red filter. The front is removable for easy replacement of bulbs. In both screw body and flange types, the units are 3/8 in. in diameter and have nylon coding collars in standard RETMA colors to simplify wiring behind the panel.

The Sloan Co., Dept. ED, 4029 Burbank Blvd., Burbank, Calif.

CIRCLE 197 ON READER-SERVICE CARD

Automatic Circuit Evaluator

Self-programming

The SPACE Mark Ia. self-programming automatic circuit evaluator is designed for rapid checking of production line electrical equipment. No patchboard arrangement or tape punching is required to place the system in operation

When a verified wiring harness is connected to the instrument, a punched tape program is generated in the analysis mode of operation. This tape is then used to verify harnesses of similar circuit configuration in the verification mode. Errors are printed out as leakage, resistance, open, or short, together with the appropriate coordinates. The primary function of the instrument is testing for leakage and continuity between two test points which are automatically selected from all combinations of 420 inputs by a scanning unit. The system operates at seven tests per sec and is housed in a cabinet 52 x 44 x 22 in.

Brooks Research, Inc., Dept. ED, P.O. Box 67, Rochester 10, N.Y.

CIRCLE 198 ON READER-SERVICE CARD

Stereophonic Cartridges

Have dual tips

Type 8T ceramic stereophonic cartridges have a response that is smooth from 20 to 20,000 cps and flat to 12,000 cps with gradual rolloff beyond. Output voltage is 0.3 v; compliance, 2 x 10^{-6} cm/dyne; recommended load, 1 to 5 meg. Tracking pressure is 5 to 7 g; cartridge weight is 7.5 g; and channel isolation is 20 db. The cartridges have two jewel tips, a 0.7 mil for microgroove and a 3 mil for 78 rpm. They mount on standard 7/16 and 1/2 in. centers.

Sonotone Corp., Dept. ED, Elmsford, N.Y.

CIRCLE 199 ON READER-SERVICE CARD

Deposited Carbon Resistors

Rated at 5 w

In values from 100 ohms to 150 meg, DCH-5 deposited carbon resistors are rated at 5 w to 70 C, and derate to 0 at 160 C. Hermetically sealed, the units have a standard tolerance of ±1% and measure 4-1/4 x 9/16 in.

Dale Products, Inc., Dept. ED, Columbus, Nebr.

CIRCLE 200 ON READER-SERVICE CARD

NEW PRODUCTS

Dummy Load Device

For off-air transmitter tests

The Matchmaster is an instrument which tests transmitters without signals on the air. It consists of a dummy load with a direct reading rf wattmeter and a standing wave ratio bridge. It is useful for measuring the swr in antenna feed lines, the adjustment of radio transmitter power output before going on the air, and many other applications. All components are contained in a cabinet 6 x 8 x 8 in.

Barker & Williamson, Inc., Dept. ED, Bristol, Pa.

CIRCLE 203 ON READER-SERVICE CARD

Slide Rule

For frequency response calculations

Model 1490 control engineering slide rule gives magnitude ratio and phase response angle in one setting. It has scales for direct conversion from decibels to actual magnitude, and from angular frequency to frequency (cps) or period time (time per cycle). Given the various constants, the rule produces the magnitude ratio in db and phase angles in deg for any angular frequency between 0.001 and 1000 radians per unit time.

Frederick Post Co., Dept. ED, 3650 Avondale, Chicago 18, Ill.

CIRCLE 204 ON READER-SERVICE CARD

Miniature Speed Changer

Adjustable over 25 to 1 range

The miniature series 2 speed changer provides ratios continuously variable from 1 to 5 up to 5 to 1 down. It has a maximum horsepower output of 0.025; a maximum speed of 10,000 rpm; and a torque output of 5 to 40 oz-in. depending on the ratio setting. It is encased in a black anodized aluminum housing with a long easy-to-read scale and is supplied with either servo

r foot mounts. The foot mounts may be rotated 0 deg in either direction. The stainless steel input and output shafts are 3/16 in. in diameter and the housing is 2-5/8 in. long.

Metron Instrument Co., Dept. ED, 432 Lincoln St., Denver 3, Colo.

CIRCLE 205 ON READER-SERVICE CARD

Thyratron Tube

Has 6.4 amp anode current rating

Type VTP 7386 thyratron has a peak anode current rating of 100 amp and is adaptable to any circuit employing a C6J, C6JA, 5685, or 5C21 tube. It can control current pulses to the welding transformer in spot and seam welding machines, and convert ac current to dc for running variable speed motors. It can also serve in adjustable dc power supplies and replace lower-rated types in grid controlled rectifier service. The unit triggers when the potential on the control grid falls between −3 and −7.5 v dc, assuming a maximum forward voltage on the plate of 1000 v. It will also pass current with less than +75 v on the plate if the grid carries a positive voltage of at least 3 v. Continuous anode current rating is 6.4 amp. The tube operates over a broad range with a maximum recommended frequency of 440 cps and withstands ambient temperatures from −55 to +75 deg C.

Vacuum Tube Products Co., Inc., Dept. ED, 2020 Short St., Oceanside, Calif.

CIRCLE 206 ON READER-SERVICE CARD

Computer Power Supply

Has multiple outputs

This computer power supply system provides six different dc output voltages that are electrically isolated from one another and two ac outputs, one regulated and one unregulated. It is free from transients and provides a total of 4.75 kw dc from six individual rectifier supplies.

Bogue Electric Mfg. Co., Dept. ED, 52 Iowa Ave., Paterson 3, N.J.

CIRCLE 207 ON READER-SERVICE CARD

Don't forget to mail your renewal form to continue receiving *ELECTRONIC DESIGN.*

NEW PRODUCTS

Preamplifiers

Low noise

Of weatherproof construction, these low noise preamplifiers measure 3-5/8 x 12 x 5 in. Model PRU-L is available for any frequency from 400 to 1000 mc and has a 3 db bandwidth of 10 mc. Noise figure is 6 db ±1 from 400 to 600 mc, 7 db ±1 from 700 to 1000 mc. It provides 10 db gain and has a self-contained power supply rated at 117 v, 50 to 60 cps, 10 w. Model PR is available for use from 50 to 250 mc in 6 mc bandwidths. It has a noise figure of 3 db from 50 to 150 mc and 4 db from 150 to 250 mc.

Community Engineering Corp., Dept. ED, Box 824, State College, Pa.

CIRCLE 210 ON READER-SERVICE CARD

Heat Exchanger

Dissipates up to 7000 w

Model CR-2, CR-5, and CR-7 heat exchangers dissipate 2000, 5000, and 7000 w, respectively, but they can be adapted to any intermediate rating. Designed for airborne, shipboard, and ground support electronic equipment, the largest exchanger measures 10-11/16 x 19-9/16 x 15-1/2 in.

The Hallicrafters Co., Dept. ED, 4401 W. Fifth Ave., Chicago 24, Ill.

CIRCLE 211 ON READER-SERVICE CARD

Plastic Capacitor

Has 0 temperature coefficient from −55 to +55C

Type KYA plastic film dielectric capacitor is a rugged hermetic bathtub enclosure with a temperature coefficient of 0 ±10 ppm per deg C uniform from −55 to +85 C. Capacitance range is 0.01 to 1 μf; voltage, to 1000 wvdc. The unit has a long term stability of ±0.05% and a power factor of under 0.1% at 25 C.

Diamond Electronic Corp., Dept. ED, 6 White St., New York 3, N.Y.

CIRCLE 212 ON READER-SERVICE CARD

Movie Cameras

Incorporate digital recording devices

These cameras incorporate a Magnavox digital recording device which provides a 96-bit matrix image on each frame of film and correlates coded data with pictorial records in real time. The cameras can be operated at any rate up to 80 frames per sec and are useful in engineering tests, missile tracking, reconnaissance, flight tests, and microfilm document recording. They can record time, temperature, pressure, vibration, stress, deflection, shaft position, elevation, azimuth, altitude, range, and similar coded digital data. The Magnavox recorders are offered with the 35mm 75 Fototracker and the Bell & Howell model 71 Eyemo cameras. Cameras of this type now in use can also be provided with the recorders.

Traid Corp., Dept. ED, 17136 Ventura Blvd., Encino, Calif.

CIRCLE 213 ON READER-SERVICE CARD

Right Angle Adapter

Has maximum insertion loss of 0.1 db

Built to USAF specifications, this right angle adapter has a maximum vswr of 1.15 to 1, a maximum insertion loss of 0.1 db, and a power handling capacity of 500 w. Its frequency range is 350 to 5000 mc. The 2000-UG-1264/U adapter features a captivated continuous center conductor covered with a continuous Teflon dielectric. It is qualified according to MIL-E-5272, fits LT male and female connectors, measures 3-3/4 x 3 in.; weighs 7 oz.

Tamar Electronics, Inc., Dept. ED, 2339 Cotner Ave., Los Angeles 64, Calif.

CIRCLE 214 ON READER-SERVICE CARD

Portable Communication Test Set

For audio and carrier frequencies

Model JK audio and carrier frequency test set consists of a transistor oscillator and a meter. The oscillator supplies a stable 1000 cps constant voltage and provides outputs of 0, —13, and —16 db into a 600 ohm line. Output impedance is 600 ohms. The db meter is designed for testing at frequencies from 60 cps to 600 kc and is readable from —20 to +43 dbm. It has a rotary switch for range changing and voltage ranges of 1, 5, 25, and 125. Self-contained loads of 150 and 600 ohms can be selected by switch. Both units fit into one leather case with space for leads.

Stewart Bros., Div. of Instrument Labs, Dept. ED, 315 W. Walton Place, Chicago 10, Ill.

CIRCLE 215 ON READER-SERVICE CARD

NEW PRODUCTS

HIGH TEMPERATURE SURFACE COATING.—Clear epoxide Eccocoat C 26 can be used continuously at 500 F and for short periods up to 600 F. Surface resistivity is above 10^{15} ohms at room temperature and about 10^{14} ohms at 500 F. Moisture and chemical resistant, the material is used for coating printed circuit boards, electronic circuits and components, metals, and ceramics. It can also be used in place of varnish for dipping or impregnation of coils or motor windings. It is applied by dip, brush, or spray and adheres to a wide variety of materials.

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

CIRCLE 218 ON READER-SERVICE CARD

OSCILLOSCOPE TUBE.—For visual or photographic observation, crt type 5WP11 has magnetic deflection and electrostatic focus.

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

CIRCLE 219 ON READER-SERVICE CARD

GALVANIZED STEEL TOWER.—For two-way, broadcast, and microwave use, model 1810 has a triangular cross-section with an 18 in. face. It is produced in standard 10-ft sections for heights up to 290 ft and meets RETMA specifications for a 100 mph wind load.

All Products Co., Dept. ED, Mineral Wells, Tex.

CIRCLE 220 ON READER-SERVICE CARD

MOLDED NYLON HEX NUTS.—In ten sizes from no. 2 through 5/16 in., these nuts have washer faces and are double countersunk. They are made with a single chamfer and, except for the 5/16 in. sizes which are jam nuts, are standard thickness with unified series Class 2B threads.

Gries Reproducer Corp., Dept. ED, 168 Beechwood Ave., New Rochelle, N.Y.

CIRCLE 221 ON READER-SERVICE CARD

COMPONENT HOLDER.—This spring loaded device is used to hold the leads of resistors, condensers, and dials for test purposes. It is gold plated for low contact resistance and maximum corrosion resistance and will handle wires from 0.005 to 0.09 in. in diameter.

General Components Inc., Dept. ED, 225 East 144th St., New York 51, N.Y.

CIRCLE 222 ON READER-SERVICE CARD

FLYING SPOT SCANNER.—Flat face type 5ZP15 has high resolution, electrostatic focus, and magnetic deflection. It uses a P15 phosphor with blue-green fluorescence and short persistence.

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

CIRCLE 223 ON READER-SERVICE CARD

Have you sent us your subscription renewal form?

GAS FLOWMETER.—Accommodating flow rates up to Mach 8, this unit can measure contaminated gases with a low pressure drop. It has an accuracy of ±0.5% of reading and good repeatability over a 10 to 1 linear range. Temperature range extends to —425 F.

Pottermeter Co., Dept. ED, Union, N.J.

CIRCLE 224 ON READER-SERVICE CARD

MEDICAL PREAMPLIFIER.—This EEG preamplifier makes it possible to display electroencephalograph signals on standard medical cardioscopes and electrocardiographs by increasing their sensitivity by a factor of 30. It is designed so that the EEG and ECG signals may be delivered simultaneously to an oscilloscope through a single cable. Noise level is 1 μv peak and 60 cps rejection is 1 million to 1.

Levinthal Electronic Products, Inc., Dept. ED, Stanford Industrial Park, Palo Alto, Calif.

CIRCLE 225 ON READER-SERVICE CARD

ALTERNATE PULSE RELAY.—Designed for easy installation on long production runs, the PA relay mounts with a single bolt in a tapped 8-32 core. It transfers contacts when pulsed for about 30 msec. Contacts are rated at 7.5 amp, 115 v, 60 cps, resistive. Length is 2 in.; height, 1-3/4 in.; weight, 3-1/2 oz.

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

CIRCLE 226 ON READER-SERVICE CARD

THERMAL TIME DELAY.—Series TH fixed time delays have snap action load contacts in many arrangements and switch up to 20 amp. They are easily adjustable and provide automatic ambient temperature compensation. Available either hermetically sealed or in explosion proof housings, they are suited for air conditioning, refrigeration heater controls, computers, and recycling applications.

Industrial Timer Corp., Dept. ED, 1407 McCarter Highway, Newark 4, N.J.

CIRCLE 227 ON READER-SERVICE CARD

TEMPLATES.—Four lettering aids and one electronic drawing aid have been added to the Leroy line: Spartan Medium forms solid or outline capital letters and numbers; Shadow forms shadow type capitals and numerals; Isometric forms caps and numbers sloped for isometric drawings; the Standard Lettering Template forms 0.05 in. capitals in vertical or slanting style; and the Electronic Tube Symbol forms practically all the symbols used for various types of electronic tubes and semiconductor devices.

Keuffel & Esser Co., Dept. ED., Adams and Third Sts., Hoboken, N.J.

CIRCLE 228 ON READER-SERVICE CARD

Electronic Products NEWS

by CARBORUNDUM
Registered Trade Mark

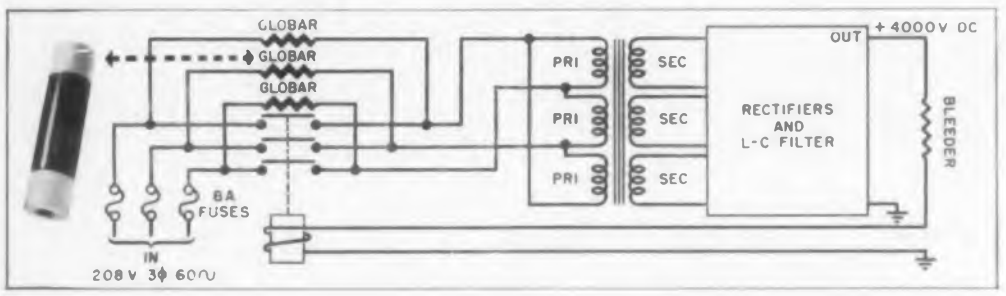
High Energy Resistor Delays Fuse Opening—

Collins Radio uses GLOBAR® resistor to handle short-time overload

A unique application of a GLOBAR high energy resistor is made in a radio power supply unit manufactured by Collins Radio, Cedar Rapids, Iowa. The resistor is used for delaying the opening of a fuse under a short-time overload current condition.

Requirements are rigorous. The resistor has to be capable of handling 21 amps for 3 seconds (140 times rated load) and 10 amps for 5 seconds and must not arc, burn, char or change in resistance by more than ±5 when subjected to 5 seconds of the specified overload currents for 5 cycles on with 5 minutes off. It must operate continuously under 35 watts loading for 1,000 hours in a room temperature ambient, the resistance change being not more than 10%.

A GLOBAR Type SP resistor, 3¼" long, ¾" O.D. and ⅝" I.D. is used. This resistor will operate continuously in ambients up to 1,000° F. It is supplied with metalized ferrule type ends for fuse clip mounting. For information on GLOBAR resistors for similar high temperature, high energy applications, write to Globar Plant, Refractories Division, Dept. EDR 39, The Carborundum Company, Niagara Falls, N. Y.



4000 VOLT SUPPLY FOR AN/FRW-2 SHOWING STEP-START CIRCUITRY

CERAMIC IGNITER for oil and gas burners

A development of high temperature resistors

The versatility of silicon carbide for high temperature resistors is further demonstrated by its application as a ceramic igniter for fuel oil and gas furnaces.

Conventional igniters utilize either a hot wire, which has a relatively short life, or a spark discharge system, necessitating a high potential transformer.

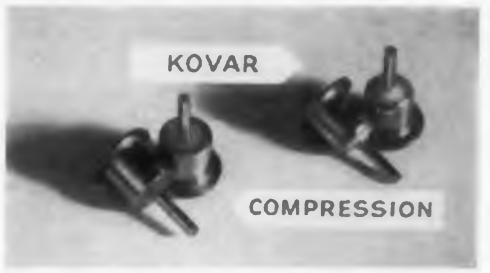
Requirements for the ceramic igniter were that it should operate directly from 12, 24 and 115 volt sources, have high stability, be inexpensive and effective for up to 25,000 cycles of operation. A composition similar to that of the GLOBAR Type SP resistor proved to be the answer. By varying resistivity, operation is possible on any of the desired voltages.

To alert electronics engineers, the success of this application may suggest the many possibilities of utilizing similar resistors in high temperature circuits with ambients up to 1,000° F. Terminals which can be spot-welded or brazed into circuits have been developed. Prototypes of such resistors are now actually being evaluated by several customers as potential components for missiles and other critical applications.

Technical assistance and information can be secured by writing to Globar Plant, Refractories Division, Dept. EDIR 39, The Carborundum Company, Niagara Falls, N. Y.

Matched or Compression Seals?

Which metal-to-glass combination should you choose for packaging rectifiers and other housings?



Two types are available. The first type is represented by KOVAR® matched seals in which the identical thermal expansion characteristics of KOVAR Alloy and borosilicate hard glasses result in a fused hermetic bond. Since KOVAR has about the same expansivity as silicon and germanium, stability in operation is assured. The second type is represented by the compression seal which relies on differences in contraction between glass and metals, like mild steel, to provide a tight joint.

Both types give excellent service depending upon the design and application of the unit. Compression seal applications are often those where the use of heavier metal parts is advantageous.

Among other advantages, KOVAR "top hats" have special value as high voltage seals. The insulating glass does not need to be contained within a compression band and thus can be extended for higher flash-over voltage ratings.

For help in your choice of seals, write Latrobe Plant, Refractories Division, Dept. EDK 39, The Carborundum Company, Latrobe, Pa.

NEW BULLETIN DESCRIBES FIXED NON-INDUCTIVE CERAMIC RESISTORS

Gives data on Types A, B, and CX resistors recommended for general-purpose applications in electronic and electric power circuits. A wide range of sizes, shapes and compositions provide desired resistivities and watt ratings. For a copy, write: Globar Plant, Refractories Division, Dept. ED 39, The Carborundum Company, Niagara Falls, N. Y.

CIRCLE 230 ON READER-SERVICE CARD

NEW PRODUCTS

LIQUID LEVEL GAGE.—Model 0358-1 makes continuous level measurements of a wide range of electrically conductive liquids and granular solids with accuracies of up to 1/10 in. over a 10 ft. range. All electronic, it uses a capacitance circuit which requires no moving mechanism in the material being measured. Readout may be in dial or counter form, or it may be built into a standard 11 in. strip chart recorder.

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

CIRCLE 231 ON READER-SERVICE CARD

ELECTRONIC TEST SET.—The Checkmate automatically tests electronic systems for overall performance. Each test set is designed for a specific system and automatically tests it when the press-to-test button is pushed.

CGS Labs., Dept. ED, Route 7 at 35, Ridgefield, Conn.

CIRCLE 232 ON READER-SERVICE CARD

VINYL INSULATION REPAIR KIT.—Contains Vyna-Kote, a liquid vinyl that repairs all kinds of damage to vinyl insulated wires. Consists of twelve 2 oz bottles, one each of ten colors, one clear, and one thinner.

Spectra-Strip Wire & Cable Corp., Dept. ED, P.O. Box 415, Garden Grove, Calif.

CIRCLE 233 ON READER-SERVICE CARD

MINIATURE TRIODE-PENTODE.—Model 6EA8 combination medium-mu triode and sharp-cutoff pentode is a 9-pin miniature type utilizing a 450 ma heater with controlled warm-up time. Each unit has its own separate cathode with individual base-pin terminal. The tube is intended for use as a combined oscillator and mixer tube in TV receivers with 40 mc i-f circuits.

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

CIRCLE 234 ON READER-SERVICE CARD

COMPRESSOR AND VACUUM PUMP.—A compact, two-stage, motor driven air pump for airborne radar systems, ground support, and electronic test equipment. Operation is entirely oil-free, and requires no lubrication. Operating temperature range is −65 to +200 F; and compressor capacity is 0.025 ppm at 30 psi absolute outlet with 7 in. Hg absolute inlet pressure.

Great Lakes Mfg. Corp., Dept. ED., 4223 Montecello Blvd., Cleveland 21, Ohio.

CIRCLE 235 ON READER-SERVICE CARD

BONDED CONTACTS.—Dense, nonporous, stress-free contacts permanently bonded to rivet or backing. Bonding holds up to the melting temperature of the metal, provides maximum strength and corrosion resistance, and improves electrical and thermal conductivity. Contacts are more economical than brazed contacts of medium to large size silver or silver alloy.

Contacts, Inc., Dept. ED, 1500 Silas Deane Highway, Wethersfield, Conn.

CIRCLE 236 ON READER-SERVICE CARD

REUSABLE SHIPPING CONTAINERS.—Interiors of CDF instrument cases are padded with polyurethane foam 1-1/2 to 2 in. thick. Inside dimensions are 7-3/4 x 2-3/8 x 14-1/8 in.; 7-3/4 x 3-5/8 x 14-1/8 in.; and 7-3/4 x 5 x 24-1/2 in.

Continental-Diamond Fibre Corp., Dept. ED., Newark, Del.

CIRCLE 237 ON READER-SERVICE CARD

ROLLING RULER.—Pocket drafting tool for small drawings. Roller construction carries the rule in a straight line, keeping the edge parallel. Incorporates a protractor, a template for small circles, and inch scales divided into tenths and sixteenths; draws parallel and perpendicular lines, angles, and circles with up to 6 in. radii. Overall size is 6 x 2 x 1/2 in.

Fullerton Engineering Sales Co., Dept. ED., 4623 York Blvd., Los Angeles 41, Calif.

CIRCLE 238 ON READER-SERVICE CARD

POPPET VALVE.—A miniature precision safety pressure relief mechanism designed to protect electronic containers from ambient pressure variations due to altitude and temperature changes. It weighs 7.4 g and is pre-set to customer requirements between 1 and 20 psi.

Glaeser Engineering, Dept. ED., 5642 Bankfield Ave., Culver City, Calif.

CIRCLE 239 ON READER-SERVICE CARD

PRESSURE SCANNING VALVE.—High pressure, high speed 48J Scanivalve is designed for measuring turbo-engine pressures. It makes one 1/2 in. diameter flush diaphragm transducer scan 48 pressures in one second. Various motor speeds are available. Diameter is 2 in.; length, 6.5 in.

General Design, Dept. ED., 631 30th St., San Diego 2, Calif.

CIRCLE 240 ON READER-SERVICE CARD

COLOR FLYING SPOT SCANNER.—Type 5ZP24 has a clear, nonbrowning faceplate, an aluminized screen, and a P24 phosphor of blue-green fluorescence and short persistence.

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

CIRCLE 241 ON READER-SERVICE CARD

NEW PRODUCTS

SSB RADIO TELEPHONE RECEIVER.—High frequency type 52 is compatible with existing transoceanic ssb systems and has two independent sidebands that deliver up to four simultaneous 3 kc telephone and teletype channels. Up to ten crystal-controlled frequencies may be pretuned in the 3.7 to 30 mc range. These can be manually or remotely controlled.

Westrex Corp., Dept. ED, 111 Eighth Ave., New York 11, N.Y.

CIRCLE 244 ON READER-SERVICE CARD

LUBRICANT.—Supplied in a spray can, Paralese mold release and lubricant eliminates sticky and marked molds. Applications result in no build-up.

Foundry Rubber Inc., Para Products Div., Dept. ED., 5200 River Rd., Washington 16, D.C.

CIRCLE 245 ON READER-SERVICE CARD

NUT DRIVERS.—Line of nut drivers with hex shaped heads and color coded handles. Designed to get into tight places inaccessible to standard nut drivers. Available individually or in kits in 3/16 through 1/2 in. sizes.

Hunter Tools, Dept. ED., P. O. Box 564, Whittier, Calif

CIRCLE 246 ON READER-SERVICE CARD

COAXIAL TERMINATION.—For Type N connector application, type HFT/N-50 has an impedence of 52.5 ohms and a maximum vswr of 1.2 from dc to 2500 mc.

Applied Research Inc., Dept. ED, 76 S. Bayles Ave., Port Washington, N.Y.

CIRCLE 247 ON READER-SERVICE CARD

SYNCHRONOUS WELD-TIMER.—Transistorized model T3, called the Tweezer-Weld Trans-Sync Timer, has a 1 kva capacity and is especially suited for precision welding where contact resistance varies widely. A rotary switch adjusts the welding time from 0.5 cps to 10 cps of line frequency. Models T-6 and T-25 are larger versions.

Federal Tool Engineering Co., Dept. ED, Cedar Grove, N.J.

CIRCLE 248 ON READER-SERVICE CARD

AIR-TO-LIQUID HEAT EXCHANGER.—Designed to provide cooling for Klystron anodes, model LC-5 dissipates 2000 w of heat from Monsanto type OS-45 oil at a circulation rate of 3 gal per min. Normally mounted within an electronic rack, it uses room air of up to 125 F at altitudes of up to 10,000 ft as the cooling medium. It is built to MIL-E-4158, MIL-T-4807, and MIL-STD-170 specifications.

Ellis & Watts Products, Inc., Dept. ED, Cincinnati 36, Ohio.

CIRCLE 249 ON READER-SERVICE CARD

NYLON CABLE CLIPS.—These Nylon molded-type clips have a ribbed reinforcing edge that holds indefinitely against the strains of vibration, weather, moisture, and chemical corrosion. They are electrically nonconductive and have no sharp edges to damage insulation or tubing.

Commercial Plastics Co., Dept. ED, 945 George St., Chicago 14, Ill.

CIRCLE 252 ON READER-SERVICE CARD

DUAL HEAT SOLDERING GUN.—Model 8200K has a Triggermatic control which provides 90 and 125 w. A prefocused spotlight illuminates the work while the gun is in use.

Weller Electric Corp., Dept. ED, 601 Stone's Crossing Rd., Easton, Pa.

CIRCLE 253 ON READER-SERVICE CARD

PHOTOELECTRIC CONTROLS.—These units provide automatic control of lights regardless of time of day, weather, or season. Lights are automatically switched on at the same darkness value of each night and off again when daylight returns. Model A200 turns on at 35 ft-c, off at 55 ft-c; model B200 turns on at 0.5 ft-c, off at 1 ft-c.

White Engineering Co., Dept. ED, 238 Grand Ave., Rutherford, N.J.

CIRCLE 254 ON READER-SERVICE CARD

PEG BOARDS.—These two additions to the SeeZak electronic component line measure 4 x 7 and 4 x 12 in. They are designed for electronic systems planning and development.

U. M. & F. Mfg. Co., Dept. ED, 10929 Vanowen St., North Hollywood, Calif.

CIRCLE 255 ON READER-SERVICE CARD

POWER SILICON RECTIFIERS.—This unit features diffused silicon junction, a solid copper base, a hot tin dipped terminal, a hermetic seal for the silicon chamber, and tough epoxy protective coating.

Vickers Inc., Electric Products Div., Dept. ED, 1815 Locust St., St. Louis 3, Mo.

CIRCLE 256 ON READER-SERVICE CARD

GLASS PROBE THERMISTOR KIT.—Designed for circuit planning, the KP50 kit contains thermistors in decade steps from 100 ohms to 10 meg. Complete technical characteristics and resistance vs temperature curves are furnished for all six units.

Victory Engineering Corp., Dept. ED, 519 Springfield Rd., Union, N.J.

CIRCLE 257 ON READER-SERVICE CARD

NEW PRODUCTS

SURFACE TEMPERATURE PROBE.—Model 116D measures skin and gas temperatures and is useful for flight testing manned aircraft, rockets, and missiles. The sensor is platinum wire and has 500 ohms resistance at 0 C. The unit's upper limit is 760 C.

Rosemount Engineering Co., Dept. ED, 4900 W. 78th St., Minneapolis 24, Minn.

CIRCLE 261 ON READER-SERVICE CARD

WIRE TIES.—Rubber "Mouse Tails" are available in two forms. One type, in 1 to 4 in. lengths, is tapered at both ends. It is installed by passing one end through a hole in the chassis, looping the shank over the wire bundle, and inserting the other tapered end through an adjacent hole. When clinched up tight, expansion of the rubber holds the "tail" firmly in place. The other type are for intermediate bundle ties between tie down points and are designed to eliminate wax string ties.

Rubber Teck, Inc., Dept. ED, 19115 S. Hamilton Ave., Gardena, Calif.

CIRCLE 262 ON READER-SERVICE CARD

CATHODE RAY TUBES.—Types 5AHP14, 5AHP-14A, 5AHP19, and 5AHP19A are round glass, high resolution tubes with electrostatic focusing and magnetic deflection. They use various screen phosphors.

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

CIRCLE 263 ON READER-SERVICE CARD

LIGHTWEIGHT NUT.—In 1/4 through 1/2 in. sizes, type FN-22 has 220,000 psi tensile strength, good fatigue characteristics, and high reusability. It is cadmium plated either with or without molybdenum disulfide coating.

Standard Pressed Steel Co., Dept. ED, Jenkintown, Pa.

CIRCLE 264 ON READER-SERVICE CARD

FLAT FACE OSCILLOSCOPE TUBE. – Type 3RP1A cathode ray tube has electrostatic focus and deflection, uses a P1 phosphor with green fluorescence and medium persistence.

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

CIRCLE 265 ON READER-SERVICE CARD

RADAR INDICATOR TUBE.—Type 7MP14 is a clear face, round glass, non-ion trap tube with magnetic focus and deflection.

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

CIRCLE 266 ON READER-SERVICE CARD

NEW LITERATURE

Transducers 269

A new four page two color brochure is available on request to furnish useful information for users of strain gages, load cells, resistance thermometers, pressure transducers, or other resistance bridge transducers. This brochure describes in detail how the resistance bridge indicator (RBI) is set up to provide a visual digital display with readout in any desired units such as micro-in. per in. for strain gages, pounds, tons or ounces for load cells, etc. The brochure also contains schematic diagrams and information on typical applications with complete specifications of the RBI. Datran Electronics, 1836 Rosecrans Ave., Manhattan Beach, Calif.

Limit Switches 270

An all new 16-page catalog number 84, covering a complete line of Heavy Duty Limit Switches Catalog 84, a 16-page illustrated booklet covers a complete line of heavy duty limit switches and gives complete details of three types of Micro Switch heavy-duty limit switches for industrial uses—the plug-in "200LS" series, featuring quick replaceability; the compact "LS" series; and the rugged "ML" switches, available in regular or explosion-proof types. Switches with a variety of contact arrangements for either direct or alternating-current applications are listed and several actuator designs in each switch type are shown. The new catalog is published as an aid to the plant engineer and maintenance man, as well as the designer of original equipment. MicroSwitch, Div. of Minneapolis-Honeywell Regulator Corp., Freeport, Ill.

Magnetic Amplifier Design Manual 271

Engineering Bulletin #403-A is a 16-page Magnetic Amplifier Design Manual. The new design manual has 45 schematic diagrams and graphs describing magnetic amplifier design and application techniques. Some of the topics covered in the new manual are: Signal Mixing, Voltage and Current Comparators, Automatic Pilor Systems, Electrohydraulic Valve Drives, Gyro and Position Pickoffs, Insulation & Cable Barriers Checker, Integrators, Limiters, Sweep Generator Potentiometric Amplifier Circuit, Relay Tester, LaPlace Transforms, Transform Generation, Velocity Servos, etc. The new 403-A Design Manual is available without charge to qualified design engineers. *Requests should be made on company letterhead to Aeromag, Inc., 22519 Telegraph Road, Detroit 41, Mich.*

NEW LITERATURE

Miniature Transformers 275

A new short form catalog listing complete specifications on the company's products include miniature, subminiature, transistor, MIL-T-27A and industrial transformers that are available from distributor stock. The short form catalog serves as a ready reference for a quick run-down on the transformers offered by company, showing the wide range of models at a glance. Harold Edelstein, Microtran Co., Inc., 145 E. Mineola Ave., Valley Stream, N.Y.

Precious Metals Plating

The cost of precious metals plating per unit area to specified thicknesses may be seen at a glance with this Metals Data Chart. The slide chart also tells at a glance: cathode efficiency data; milligrams per sq in. and grams per sq ft of particular precious metals for 0.0001 in. deposits; recommended current densities and actual plating time required for nine different precious metals plating formulations; and corresponding thicknesses. *The chart is available for $1.00 (shipped post-paid) from Sel-Rex Corp., 75 River Road, Nutley 10, N. J.*

Plastics Catalog

This 64-page plastics catalog is designed to supply plastics buyers with the best and latest information in a detailed manner. The catalog's 12 sections include: Plexiglas, Vinyls, Acetates, Phenolic Laminates, Nylon, Teflon, Kel-F, Polyethylene, Polystyrene, Rexolite, Fiberglas and "Supplies." The latter section includes all necessary data on coatings and accessories. *Write on company letterhead to Mr. Morton French, General Sales Manager, Commercial Plastics & Supply Corp., New York City, N. Y.*

Germanium Diodes 276

Bulletin 158 describes company's line of gold-bonded germanium diodes. It lists many types for general purpose and computer use, where from one to four operating characteristics are specified. Special computer types with ten specified characteristics are also shown. These incorporate many superlative features for computer applications. The bulletin features a new system devised by company to classify diodes for ease in selection by number and value of characteristics. It should arouse considerable interest among diode users frequently confronted with the complex listings that sometimes make selection, on the basis of operating characteristics, quite a chore. Ohmite Mfg. Co., 3683 Howard St., Skokie, Ill.

Tube Standards

Two international standards recommendations affecting electronic tubes are now available. The third supplement to International Electrochemical Commission (IEC) Publication 67, Dimensions of Electronic Tubes and Valves, provides the basis for the interchangeability of electronic equipment among the 33 participating nations. IEC Publication 100 lists recommended methods for the measurement of direct interelectrode capacitances of electronic tubes. The methods apply to receiving, cathode-ray, gas and photo tubes, photocells and multiplier types, and high-power vacuum tubes. *Copies of IEC Publication 67 (Third supplement) at $2.40 each and of IEC Publication 100 at $4.00 each are available from American Standards Association, Dept. PR 37, 70 East 45th St., New York 17, N. Y.*

Magnetic Amplifier Systems 279

An 8-page color brochure entitled, "Magnetic Amplifier Systems For Nuclear Reactor Installations" describes the rod programmer amplifiers designed for the nuclear electric power plant at Shippingport, Pa. A functional diagram outlines an integrated static control system for a nuclear reactor power installation. Illustrated with photographs and charts, bulletin S-963 gives the details of magnetic amplifier servo drives and applications in nuclear drive systems, covering control rod drives, hydraulic valve control and remote handling control, as well as engineering specifications and transfer characteristics of the units are included. Also described are the manufacturer's STAT-PACK static magnetic switching systems used in reactor control circuits, programming a nd simulators; magnetic amplifier voltage/current regulators and regulated dc power supplies; and low level linear magnetic amplifiers, which have applications in control system instrumentation, console measurements and laboratory experimentation. Magnetic Amplifiers, Inc., 163 Tinton Ave., New York 55, N.Y.

Logic Unit Board 280

An 8-page illustrated booklet describing the versatile new logic unit board discusses many applications, and pointedly illustrates the fact that the logic unit board actually represents an improved technique for development of digital computers and data handling systems. This transistorized digital component is a highly versatile array of basic computer elements which can be connected simply and rapidly to serve whole logic and control functions of complex digital computers. Mechanical Division of General Mills, Inc., 1620 Central Ave., Minneapolis 13, Minn.

NEW LITERATURE

Ceramic Capacitors 284

A new 16-page Ceramic Capacitor Cross-Reference Guide is now being made available to engineers and purchasing agents in the electronics industry. This guide lists all units that are stocked and available for immediate delivery from Company distributors. "Special" or specification capacitors are not covered by the guide. The Guide lists over 600 ceramic capacitors by type and rating. These units are stocked in production quantities at factory prices, by industrial distributors. Equivalent units of other manufacturers, where available, are listed next to the company's capacitors, providing an easy method of determining sources for any given capacitor. The Guide contains separate sections devoted to general purpose discs and tubulars, temperature compensating discs and tubulars, high voltage discs, dual capacitors, buffer capacitors, low voltage capacitors, stand-off and feed-thru, transmitting, high accuracy and trimmer capacitors. Centralab, A Division of Globe-Union Inc., 900 E. Keefe Ave., Milwaukee 1, Wisc.

Vibration Meter 285

A new illustrated technical bulletin, No. WK-B-731A, describes Company's new Type B-731A vibration meter, an instrument with wide electronic, industrial and aircraft application that offers a new method of measuring distance and vibration. The new technical bulletin lists features, brief specifications, and design features, and illustrates the vibration meter. This latest instrument development may be used for vibration tests to meet JAN-MIL specifications in electronic components; to measure vibration in rotating shafts or bearings, on a production line for determining sizes and grades of parts for tolerance; and for testing airframes, either in wind tunnels or on actual airframes. The technical bulletin points out that the new Type B-731A vibration meter avoids hazards and makes remote testing possible. The instrument is particularly suited to the measurement of vibration where direct physical contact is not possible, and for measuring the dilation and eccentricity of rotating parts. Wayne Kerr Corp., P.O. Box 801, Philadelphia 5, Pa.

Cables 286

A six-page folder on plastic insulated and jacketed control cable (rated 600 v) lists the specifications of small diam—station—flexible and supervisory control cables with 2 to 19 conductors. Also IMSA municipal signal cables Specifications 19 and 20—1956 with 3 to 12 conductors. Chester Cable Corp., 159 Oakland Ave., Chester, N. Y.

Thermostat Metals 289

"Graphical Determination of Element Size and Performance" Technical Data Bulletin TRU- saves engineering time in determining the correct thermostat-metal element size and properties for new applications. This 4-page technical data bulletin provides graphical solutions, accurate enough for first sample determinations. A table gives Truflex thermostat metal types, their thermal deflections, mechanical and restrained forces. By using this table, the size and performance of simple beams, cantilever beams, special and helix coils and U-shapes can be determined for any of 40 different Truflex thermostat metals. Metals and Controls Corp., General Plate Division, Attleboro, Mass.

RFI Shielding 290

Comprehensive technical data and product information on RFI gasketing are now available in a handy, new RFI Designers Data File. Prepared to help designers solve specific shielding problems, this fully illustrated reference file offers both technical data and practical information about RFI gasketing materials. Also included are RFI problem outline sheets which may be used by designers to indicate specific problems, and forwarded to the company headquarter's staff of design service engineers for immediate recommendations. Copies from Technical Wire Products, Inc., 48 Brown Ave., Springfield, N. J.

Power Supplies Folder 291

A 4-page folder covers the uses and specifications of Electro Model PS-2 dual purpose filtered dc power supply. The new power supply powers transistor circuits, hybrid sets, 12/6 v auto radios without hum. The illustrated folder features tabulated information on percentage of ripple, continuous maximum current rating, and special features for transistor circuit servicing provided by Model PS-2 as well as other power supplies. According to the manufacturer, the information in this table demonstrates that Model PS-2 outperforms all units in its price class. Two output ranges are provided—0 to 20 v at a rating of 75 ma for operating transistor circuits, and 0 to 16 v with a rating of 5 amps for operating 12/6 v radios and hybrid sets. A special pi-type input filter holds ripple down to 0.15 per cent up to 75 ma (well below the critical requirement for low current loads in servicing transistor radios) and .5 per cent up to 5 amps.

A separate milliameter for each range detects minute variations in transistor current. Each range has its own output terminals. Write R. C. Crossley, Electro Products Lab., 4500 N. Ravenswood Ave., Chicago 40, Ill.

NEW LITERATURE

Ultrasonic Cleaners 294

A new data sheet is now available on the giant size Series 5000 Narda SonBlaster ultrasonic cleaner, which consists of 23 systems for applications to mass-production cleaning or degreasing of mechanical, electronic, optical, horological, aircraft or missile parts or assemblies; to rapid cleaning of radioactive elements, "hot" lab apparatus, medical instruments, ceramic materials, electrical components and technical glassware, and to expediting metal finishing and chemical processing of many kinds. The data sheet describes Model G-5001, a 40-kc, 500-w average output SonBlaster generator designed for energizing a wide range of cleaning tanks, and the G-5002, a 20-kc 500-w average output generator which will operate magnetostrictive transducers for such functions as drilling, dip soldering and other high-intensity or high-temperature applications. Owing to Narda's mass-production techniques this equipment is available at the lowest prices in the history of the ultrasonic industry, starting from $1140. Most items of the series can be shipped from stock. In addition to complete data on the 23 systems of the Series 5000, detailed information is given on applications and processes for which this equipment can be used. Tanks of different sizes, submersible transducer arrangements and metal-working tools are illustrated. Bulletin on Series 5000 Narda SonBlaster ultrasonic cleaner from the Narda Ultrasonics Corp., 625 Main St., Westbury, N.Y.

High Temperature Wire 295

The 1959 Super-Temp catalog on Teflon insulated wires and cables is now available. This elaborate, 64-page publication is completely new and contains 8 sections of the latest engineering information and prices on high-temperature magnet wire, lead wire, cables, tubing, and Teflon tape. Each section is preceded by detailed general information on the products cataloged. This information is consistent from section to section facilitating quick, easy reference on military specifications, temperature ranges, wire and cable constructions, colors, tests, etc. The catalog also contains technical bulletins and other information that provide engineers with design criteria for high temperature wiring. American Super-Temperature Wires, Inc., Winooski, Vt.

Don't forget to mail your renewal form to continue receiving *ELECTRONIC DESIGN*.

ecording and Plotting Systems 296

Two basic systems with time-tested features or recording and processing the multitude of rains required to evaluate complex structural stems in laboratory and industrial applications nd tabulate strains on a typewriter, IBM cards r punched tape are illustrated and described in new two-color, four page folder. The two basic ystems available are: the "B" system, described s printing strain values in sequence together ith channel number while the "C" system, is escribed as plotting strain vs. load for each hannel on an exclusively designed continuous oop of paper reeved over powered sprocketed ollers with flanged floating idlers. The folder describes the many advantages of this new paper loop system and also describes the unique features common to both. Systems can be assembled in multiples of 24 channels utilizing the 24-451 scanning module which is described as the building block of B & F systems. It is designed to balance, calibrate, control and scan the output of 24 strain gage channels containing 1, 2 or 4 active arms and convert these variable resistances to variable voltages. General specifications are described in the folder as well as specifications under the headings: Power Supply, Programmer, Accuracy and Housing. B & F Instruments, Inc., 3644 North Lawrence St., Philadelphia 40, Pa.

Contactors and Relays 482

New line of special purpose contactors and relays, engineered and designed for the computer, power supply and electronic industries, are covered in 16-page booklet. Also, there are designs for the air conditioning and heating and refrigeration fields. Type F, R, B and BR relays are described. This folder contains engineering and cataloging data which will be of interest and help to electrical engineers. The Rowan Controller Co., 2313-2315 Homewood Avenue, Baltimore 18, Md.

Test Equipment 483

New Test Equipment Catalog No. 38-T describes latest electronic, electrical, radio, television and industrial testers. Triplett Electrical Instrument Co., Bluffton, Ohio.

Electronics Catalog 299

Detailed product listings on a wide variety of electronic parts and equipment are included in a 108-page catalog. Items for industrial, service, high fidelity, sound, and amateur radio use are described. Curle Radio Supply Co., 439 Broad Street, Chattanooga, Tenn.

NEW LITERATURE

Relays 302

A unique series of relays designated Model T and TS is described in Bulletin No. 160. These advanced units incorporated "Molded Module" contact springs, that is, spring combinations which are molded into a single compact assembly for permanent alignment and unsurpassed operating stability. Very high sensitivity for their size and high ambient operating capability are other features of these units discussed in the bulletin. For a free copy of Bulletin 160, write to Ohmite Manufacturing Company, 3679 Howard Street, Skokie, Ill.

Right Angle Connectors 303

Illustrated 6-page brochure gives specifications, outline dimensions and general information on right angle pin and socket connectors for printed circuit applications. These miniature right angle connectors are available in various contact sizes and molding compounds. Right angle pins dip solder to printed circuit board. Solder cups on receptacle accept #20 AWG wire. Electronic Sales Div., DeJur-Amsco Corp., 45-01 Northern Boulevard, Long Island City 1, N.Y.

Resistance Thermometer Wire 304

To aid in better resistance thermometer design, a new brochure has been prepared on resistance thermometer wire, showing graphically resistance versus temperature from 0 deg to 500 deg C with various pure metals and alloys used in thermometry. Also included in this brochure are the various types of enamel that can be applied to the wire best suited for your particular wiring requirements, whether it be the standard oleoresinous which is rated for continuous use at 105 deg C, or the Secon Ceramic Insulation which is rated for continuous use at 500 deg C. Secon Metals Corp., 7 Intervale Street, White Plains, N.Y.

Soldering Iron Tips 305

Data sheet catalogs Long-Life Soldering Iron Tips (No. 601, superseding #600), showing 81 new shapes and sizes—a total of 124. Included are plug tips, from 1/16 in. to 1-1/8 in. diameter and screw tips from 7/16 in. to 1-3/4 in. diameter. Various tip shapes are illustrated, complete dimensions given, as well as advice on use and care; includes list prices. Gives detailed specifications on the new Extradur Tips which give up to 20 times longer life than copper tips. Heacon Electric Co., 161 W. Clay Ave., Roselle Park, N.J.

Molded Cable Assemblies 306

A new, twelve-page catalog, covering standard molded-type cable assemblies as well as field, special and coaxial types, illustrates 34 standard types utilizing common connector ends and standard molded terminal ends. Cable assemblies are supplied in lengths as required. There are three pages of tabular reference data giving types, cable numbers, corona levels and special remarks. Corona levels range from 2 kv ac to 15 kv ac and 15 kv dc to 40 kv dc. These cable assemblies are used for missile, aircraft and general applications. H. H. Buggie, Inc., Box 817, Toledo 1, Ohio.

Pressure Transducers 307

Three new instrumentation bulletins technically describe a series of rugged, high performance pressure transducers: Model DP-7 pressure transducer, (Bulletin 58-131), Model GP-15D high range pressure transducer (Bulletin 58-135) and Model DP-15D high range differential pressure transducer (Bulletin 58-140). Each data sheet contains instrument descriptions, application information and performance specifications. BJ Electronics, Borg-Warner Corporation, 3300 Newport Blvd., Santa Ana, Calif.

Rectifier Kits 308

A four-page folder, illustrates and describes a new kit for on-the-spot conversion of Leece-Neville alternator systems with selenium rectifiers to utilize newly developed, more economical silicon rectifiers. According to the literature, the new silicon rectifiers, which consist of six tiny cells in lieu of the previous separate unit, provide greatly improved alternator performance and higher rating; and require only minimum maintenance. The folder pictorially presents the details of the silicon rectifier, what it is, and very importantly, how it is easily installed. Detailed information on its desgn and construction, plus application data is likewise included. Copies may be obtained from the Leece-Neville Co., 1374 East 51st St., Cleveland 3, Ohio.

Digital Systems 309

A new 4-page short-form catalog on the complete digital systems line, as well as a two-page flyer on the digital voltmeter lists product features, brief specifications, and ordering information on the company voltmeter, control unit, pre-amplifier, ac/dc converter, ohmmeter, scanners, printer control units and ratiometer. The dc measurement instrumentation flyer is the beginning of a series of publications on individual units in the Cubic digital line. Cubic Corp., San Diego, Calif.

NEW LITERATURE

Potentiometers 312

A 4-page brochure summarizes key information on Trimpot® and Trimit® lead screw actuated potentiometers. Designed for quick reference, this brochure features a specification table listing available resistances, terminal types, and settings, power ratings, operating temperatures, and dimensions of the more popular models. Cut-away drawing illustrates the internal construction and design features of Trimpot. Bourns Specification Summary #4 from: Bourns Laboratories, Inc., P.O. Box 2112, Riverside, Calif.

Molded Fiber Glass

A 2-color, 32-page brochure illustrates and describes in detail the mechanical, electrical and chemical properties of molded fiber glass. Fabricating and finishing operations which can be performed on this material are also described. *Write directly to: Molded Fiber Glass Companies, Dept. ED, 4826 Benefit Ave., Ashtabula, Ohio.*

Switches 313

Revised 24-page catalog covers the representative line of precision snap-action and mercury switches manufactured by this company. Data on high-temperature, maintained-contact, explosion-proof, high capacity, proximity, oil-tight, invironment-free and multicircuit types are included. Has photos, dimensions, electrical ratings, characteristics and application information. Micro Switch, Freeport, Ill.

Plastics 314

Folder gives information on Kel-F, a fluorocarbon plastic with a combination of interesting physical, chemical, electrical and mechanical properties, which is now processed in all forms by this company. The versatile material has improved performance of electronic, aircraft, missile, chemical handling and processing equipment. Development and properties of Kel-F are covered in this booklet. Fluro-Plastics, Inc., Division of Flexrock Co., Philadelphia 1, Pa.

Data Processing System 316

Illustrated folder U1395 describes the features of the new, large-scale Univac II data-processing system. The computer offers a new, high-speed memory system—the magnetic-core memory, which provides instantaneous access to 24,000 alphabetic or numeric characters. It is the only system to provide direct recording of information on magnetic tape and records information at a pulse density of 250 characters per recording inch. Remington Rand Div. of Sperry Rand Corp., 315 Fourth Ave., New York 10, N.Y.

Bearings and Bushings

Fully illustrated, 70-page catalog covers graphex, coprex and woodex oilless and self-lubricating bearings, bushings and machine parts manufactured by this company. A reference guide for sintered metal parts, this comprehensive catalog details Wakefield alloys and their recommended usage; a complete section is devoted to properties of powered metal compositions determined by test; tables illustrating the standard sizes of bearings available from tools on hand; and plant facilities. Metal structures in various stages of development, which helps buyers compare good and bad sintering, is graphically illustrated with a group of microphotographs. *Copy available by writing on company letterhead to: Wakefield Bearing Corp., Dept. ED, 29 Foundry St., Wakefield, Mass.*

Pulse Control Instruments 317

This 8-page condensed catalog provides capsule technical descriptions of more than 25 pulse control instruments, including pulse generators, flip-flops, coincidence detectors, delays, mixers, counters and power supplies. Burroughs Corp., Electronic Tube Div., P.O. Box 1226, Plainfield, N.J.

DC Measurements 318

This 9-page brochure, "Low Level DC Measurements," details instrumentation and circuit design applications. Low dc potentials in the microvolt ranges can now be read easily by means of a new precision chopper inverter. Microdyne, 300 West Washington, Chicago 6, Ill.

NEW LITERATURE

Glass, Asbestos Woven Tapes 322

"Atlas Asbestos and Glaspun Woven Tapes" describes and contains samples of untreated continuous filament Fiberglas all-purpose electrical insulating tapes. "Atlas Asbestos and Fiber Glass Textiles for Electrical Insulation, Thermal Insulation, Plastic Reinforcement, Pipe Lagging, Filter Fabric and Packing and Gasketing" describes the performance characteristics, uses and sizes of the entire Atlas line of Glaspun and asbestos textiles. Brochures and samples of the products described available from: Atlas Asbestos Co., North Wales, Pa.

Electronic Catalog 323

This comprehensive 1959 catalog contains complete listings on the wide variety of electronic parts and equipment for industrial use carried by Federated Purchaser, Inc., as well as sections devoted to replacement, audio, high fidelity and ham parts and equipment. Federated Purchaser, Inc., 1021 U.S. Hwy. 22, Mountainside, N.J.

Microwave Measurements 324

This 36-page application booklet describes the latest techniques and instrumentation for making various microwave standards measurements. It presents a detailed description of the techniques used in the general areas of standards measurement, including frequency, attenuation, impedance and power. Mr. R. Whitburn, Hewlett-Packard Co., 275 Page Mill Road, Palo Alto, Calif.

Service Offered 325

This is a 20-page, three color, illustrated booklet, which describes the services of the St. Louis Car Company. Resources, capacity, location, diversified facilities, technical staff, and past achievement are factors described and pictured. Company produces transportation equipment, military vehicles, and materiel, and industrial and commercial items ranging from major assemblies to special fabrication. St. Louis Car Co., 8000 North Broadway, St. Louis 15, Mo.

Precision Components 327

A 4-page, 2-color brochure describes and illustrates this firm's standard line of precision components for computers, instruments and control systems. Engineered to high military and commercial standards, these components are available for early delivery. The brochure provides detailed specifications and performance data on cams, synchros, mechanical differentials, oldham couplings and 10-w low-inertia servo motors. Ford Instrument Co., Div. of Sperry Rand Corp., 31-10 Thomson Ave., Long Island City 1, N.Y.

Transformers 328

More than half of this 24-page catalog is devoted to a description of the many types of transformers that can be produced as "custom" units. The catalog also gives a comprehensive idea of the mounting types and electrical ratings possible in custom units. New transistor transformers are described in detail. Harold Edelstein Microtran Co., Inc., 145 E. Mineola Ave., Valley Stream, N.Y.

Winding Machines 329

Six-page Condensed Catalog 58A is a shortened, convenient, quickly-read form of the 16-page Catalog 58. Specifications, features and full descriptions of the company's automatic, semi-automatic and subminature toroidal winders, the tape winding machine, the high speed bobbin winder and the new permeameter are present in this condensed catalog—much of this information in the form of comprehensive, wee-at-a-glance tables. Boesch Mfg. Co. Inc., 45 River St., Danbury, Conn.

Bobbin Cores 330

Bulletin BC-203, illustrated and containing 16 pages, provides preliminary information which designers may use to tentatively complete circuit designs without the need for expensive experimentation. Included are the first published guaranteed maximum-minimum limits for tape wound cores, measured according to industry accepted pulse techniques which are detailed in the test. Magnetics, Inc., Butler, Pa.

NEW LITERATURE

Miniature Plugs 485

MS miniature plugs, Series KM, designed to qualify to Mil-C-25955 (USAF) are described and illustrated in Catalog KM-1. The KM series is used in airborne applications where extremes of humidity and barometric pressure are experienced. The plugs feature crimp-type, snap-in contacts. The 12-page catalog details, among other things, materials and finish, alternate insert arrangements, and end-bell and connector shell variations. Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif.

"Photo-Voltaic" Cells 486

Complete design details, theory of operation and application notes on a newly developed line of silicon "photo-voltaic" readout cells is given in 4-page Bulletin No. 33-58. Illustrated are typical current-voltage curves, variation of available power according to temperature changes and spectral response curves. Hoffman Electronics Corp., Semiconductor Div., 930 Pitner Ave., Evanston, Ill.

Dry-Type Transformers 487

Bulletin GEA-6723, consisting of 24 pages and illustrated, gives original equipment manufacturers a complete reference for selecting small power and control, general-purpose and special-purpose transformers. It contains a complete description of each transformer type including typical ratings, prices and detailed application information. General Electric Co., Schenectady 5, N.Y.

Digital Voltmeter 488

Kin Tel Model 402 ac/dc digital voltmeter is described in this 1 page bulletin. The new digital voltmeter provides 100 μv resolution in dc, 1 mv in ac. A chopper-stabilized control unit drives a projection-type readout which presents 1-1/8 in. digits on a black screen. The readout is connected to the meter by cable and may be rack-mounted at a remote location if desired. Data Sheet No. 19-24 from: Kin Tel, 5725 Kearny Villa Road, San Diego 12, Calif.

Resin Finish 490

Properties of "Poly-Ep," a polyamide-epoxy resin finish, including dielectric strength; resistance to moisture, abrasion, organic and inorganic chemicals; adhesion to synthetic materials and metals and other technical data are included in Bulletin #82. This 4-page bulletin is available from D. J. Peterson Company, Sheboygan, Wis.

RFI Strip Shielding 491

This data folder of 4 pages lists 330 standard RFI strips of different sizes, shapes and materials. It covers over 80 per cent of all RFI shielding requirements. Technical Wire Products, Inc., 48 Brown Ave., Springfield, N.J.

Special Charts 492

Bulletin No. Y1906 describes charts for special requirements (including preprinted photo charts for oscillographic recording). Engineering information and chart samples are included. Manufacturers or users of special instruments may obtain Bulletin Y1906 by writing to The Bristol Co., Waterbury 20, Conn.

Teflon Catalog 493

This 28-page Teflon Stock Catalog and Machining Handbook, prices 1087 sizes of Teflon tubing and rod available for machining into parts, sizes from 3/16 in. to 18 in. diam. All stock prices are on a unit basis, eliminates weight estimating. The manufacturer lists the same sizes as used by them and also details machining methods, speeds, feeds and tool design for machining this unique material. Included are detailed methods for both engine lathe and automatic screw machine work. The catalog also tells how to make envelope gaskets, "0" rings, etc. Write for Catalog C-1, Halogen Insulator and Seal Corp., 9960 Pacific Ave., Franklin Park, Ill.

Ceramic Disc Capacitors 333

This 6-page folder includes complete specification data, charts and graphs on the performance capabilities of the company's ceramic disc capacitors. It covers temperature stable, semistable, general purpose and temperature compensating capacitors. Electro Motive Mfg. Co., Inc., Willimantic, Conn.

NEW LITERATURE

Terminal Boards 337

Complete specifications, outline dimensions and general information on Continental Connector series MT terminal Boards are given in a new, illustrated bulletin. This series is available with four or eight turret terminals molded directly into the body material. Optional mounting holes are available in either size. Molding compounds include mineral filled melamine, glass reinforced plaskon or diallyl phthalate, and mineral filled diallyl phthalate. For a copy of Series MT technical bulletin, write to Electronic Sales Division, DeJur-Amsco Corp., 45-01 Northern Boulevard, Long Island City, N.Y.

Photoelectric Controls 338

New Tubeless Photoelectric Control Catalog describes controls with Cad Cell sensing element; with transistor and with magnetic amplifier, including suitable light sources. This 4-page, 3-color, catalog 58-1 available from: Autotron, Inc., Box 722 HA, Danville, Ill.

Ceramic Design Handbook 339

The technical information in this 16-page handbook is intended to enable designers to determine which Centralab engineered ceramics are best suited for existing applications, or for new devices which require their unique electrical and mechanical properties. It describes the electrical and environmental characteristics of the ceramics and contains information on the advantages and disadvantages of various fabricating techniques. Centralab, 900 East Keefe Ave., Milwaukee 1, Wis.

Thermostats 340

Comprising 4 pages and printed in two colors, Bulletin 8400 pictures all major thermostat types and gives condensed technical information on operating ranges, electrical ratings, optional mountings and terminal arrangements of the company's complete line. Stevens Manufacturing Co., Inc., P.O. Box 1007, Mansfield, Ohio.

Electronics Catalog 342

Catalog No. 101, is a 160-page volume which includes prices and detailed data on a wide variety of electronic parts and equipment for service and sound applications, as well as particularly comprehensive listings of products for industrial use. The Merquip Catalog, c/o Electronic Publishing Co., Inc., 180 N. Wacker Drive, Chicago 6, Ill.

Radiation Meters 343

A new bulletin describing the company's line of portable radiation survey meters, consists of 8 pages, is printed in two colors, and is profusely illustrated with photographs. Equipment covered includes gamma dose rate meter, Cutie pie, Thyac, Scintillac, Victor series of geiger counters and scintillation detectors, and the Vic-Tic. Detailed specifications, performance data, optional accessories, sizes, weights, etc., are given. Copies of "Victoreen Portable Radiation Survey Meters," Form 3044B, are available on request. The Victoreen Instrument Co., Instruments Div., 5806 Hough Ave., Cleveland 3, Ohio.

Control System 344

Bulletin 106 (16 pages, 2-color) illustrates and describes the design approach, materials, construction and modern facilities used in manufacturing a variety of Centralized Control and Data Presentation Systems. Panellit, Inc., 401 N. Hamlin Ave., Skokie, Ill.

Silicones 345

The 1959 Reference Guide to company's silicone products describes what silicones can best meet the needs of an unbelievable variety of problems ranging from adhesives to release agents, resins to rubbers, dielectrics to water repellents. It contains graphic examples showing where many of these silicone products are currently being used, and it gives information on how to get specific data on the silicone material best suited to any application. This 16-page 2-color, up-to-date reference guide is heavily illustrated and features an expanded indexing system to facilitate quick and easy location of the more than 150 silicone products now commercially available. Dow Corning Corp., Midland, Mich.

NEW LITERATURE

Data Loggers 349

A new four-page brochure describes the features, applications, and specifications of company's Data Logger line. These data loggers are used for recording weight, strain, force, flow, pressure, or temperature. Data is automatically recorded and printed out in visual form for "on-the-spot" evaluation or for later calculating and computing. Model 166 supplies a single range typewriter readout and Model 167 includes the necessary additional circuitry for multirange selection. Gilmore Industries, Inc., 13015 Woodland Ave., Cleveland 20, Ohio.

Precision Gears 350

High-performance, precision gears with tooth-to-tooth spacing accuracies of two ten-thousandths of an inch are described in this 24-page Bulletin (GEA-6430). Typical applications of these precision gears include radar power and data gears and guidance controls. General Electric Co., 1 River Road, Schenectady 5, N.Y.

Circular Slide Rule 351

A handy circular Slide Rule for engineers and for other plant and office executives has been introduced. Any executive who must perform simple calculations will find this convenient, pocket-size calculator extremely useful in his work. Operation is simple and the results are accurate. Used to multiply, divide and find proportions, the circular slide rule has complete easy-to-follow instructions printed on the reverse side. For your free Circular Slide Rule, write to General Industrial Co., 5738 Elston Ave., Chicago 30, Ill.

Servo Motors, Amplifiers 352

Bulletin 501 A, 4-pages and illustrated, covers synchro transmitters, transformers, receivers and differential transmitters. With specifications and outline drawings it describes size 8 servo motor and size 8 amplifiers. Merchandising. Ketay Dept., Norden Div., United Aircraft Corp., Commack, L.I., N.Y.

Magnetic Amplifiers 354

Four-page Bulletin EPD 1296-5 gives full specifications on company's new 1290 series super power gapless core magnetic amplifiers. This series consists of 18 standard sizes with power outputs of 500 va to over 32 kva. Bulletin includes tables of electrical characteristics, curves, basic circuit diatrams, and outline and mounting dimensions for both amplifier reactor units and rectifiers. Vickers Inc., Electric Prod. Div., 1815 Locust St., St. Louis, Mo.

Transformer Catalog 355

This 24-page catalog, titled "Pulse Transformers," is designed to assist engineers in the application of transformers to their specific needs. Complete with many tables, charts, and schematics, this manual covers a brief history of low-level pulse transformers, their measurements, specifications, applications, interchangeability, dielectric ratings manufacturing and other data. Included is information on some of PCA's 2000 standard design transformers. PCA Electronics, Inc., 16799 Schoenborn St., Sepulveda, Calif.

Silicon Rectifier Handbook 356

A 2-color, 48-page silicon rectifier handbook contains electrical ratings, performance data and dimensional drawings for every type of silicon rectifier offered by firm. Designated as catalog No. 69, this 1959 handbook also deals with silicon rectifier theory of operation, manufacture and characteristics and offers the design engineer valuable help in silicon rectifier application. Sarkes Tarzian, Inc., Rectifier Div., Bloomington, Ind.

Components, Instruments 357

A new, short-form catalog folder of electronic components and instruments contains condensed descriptive informations and applications data on company's beam switching tubes, Nixie® indicator tubes, decade counters, pulse control instruments, optimeters, beamplexers and visual decoders manufactured by the company. A complete listing of more than twenty items of available literature is included on a convenient literature request card. Burroughs Corp., Electronic Tube Div., P. O. Box 1226, Plainfield, N.J.

PATENTS

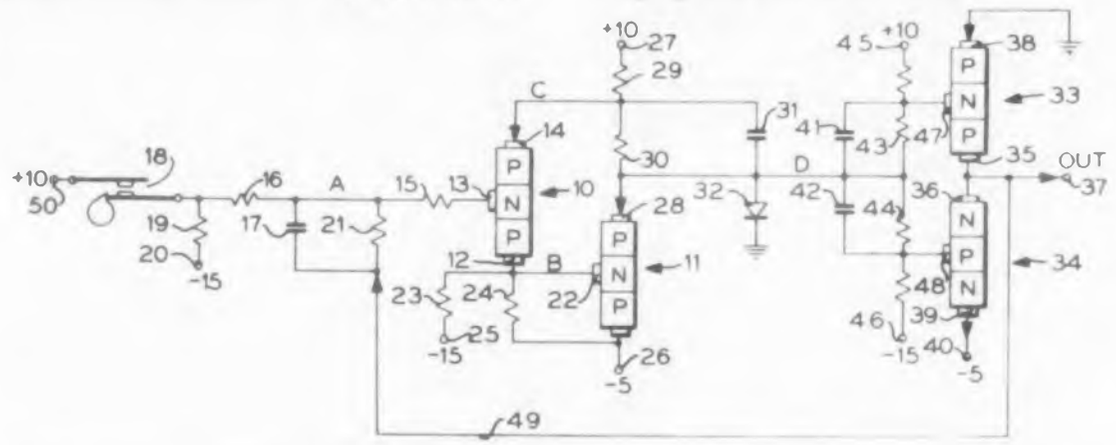
Transistor Trigger Circuit

Patent No. 2,864,007. Genung L. Clapper. (Assigned to IBM.)

Contact bounce is filtered and gated out in a cam-controlled transistor square wave generator.

With switch *18* open, transistor *10* is conducting and transistor *11* is cut off. The impulse at closure of contact *18* causes the transistors to flip such that transistor *10* is cut off and the conduction current through resistor *30* forces transistor *10* beyond cut off. Subsequent contact bounce is filtered by the RC integrator in the input. The reversal of transistor *11* couples a voltage to terminal *D* to cause complementary transistor *33* and *34* to reverse and a positive step appears at output terminal *37*; the positive step is fed back via cable *49* to force transistor *10* further beyond cut off.

The bounce of contact *18*, upon opening, is similarly decoupled from the output. Transistor *10* conducts, causing transistor *11* to cut off and the step voltage in the output falls to zero. The reversal in output voltage coupled by cable *49* forces transistor *10* to conduct harder to insure cut off of transistor *11* so that no ringing appears in the output.

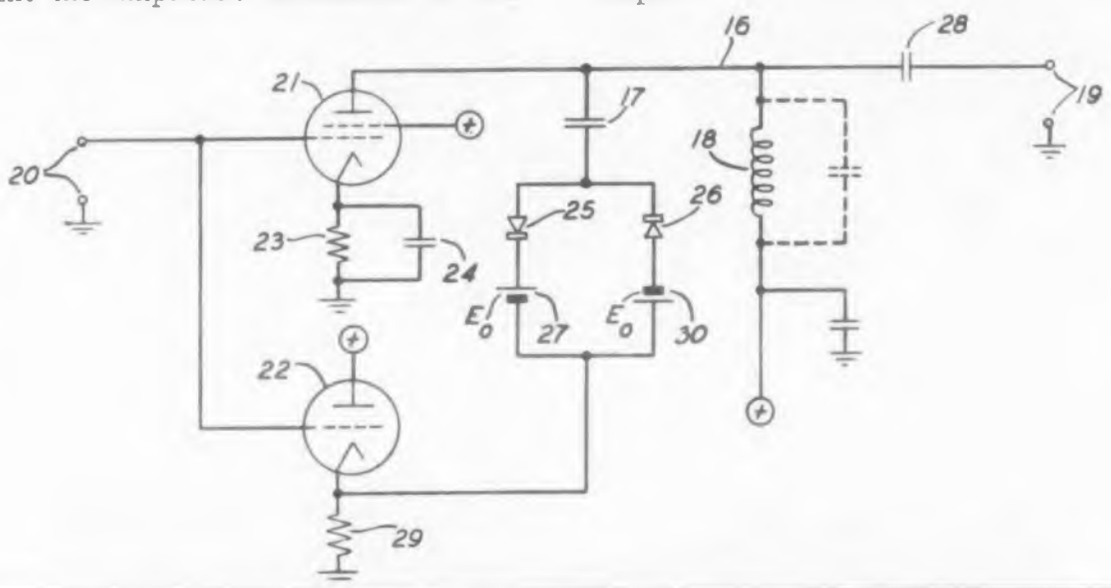


Compensated Plate Type Limiter

Patent No. 2,861,185. Andrew L. Hopper. Assigned to Bell Telephone Laboratories)

Any tendency of an a-m limiter to produce phase modulation is effectively eliminated by circuitry which adjusts the reference level of the clipper stage according to the applied signal.

An improved plate limiter circuit is shown: Diodes 25 and 26, biased by battery supplies 27 and 30, asymmetrically limit the amplitude modulation at the output of amplifier tube 21. However, since diode resistance decreases with increase in drive voltage, the output without compensation will have a nonlinear phase characteristic. The novelty lies in the circuit arrangement wherein the diodes are returned to ground through cathode follower resistor 29. As the signal varies in amplitude, the output signal is compared with an in-phase component of the applied signal and the diode threshold level is automatically adjusted to completely cancel all of the a-m in the output.

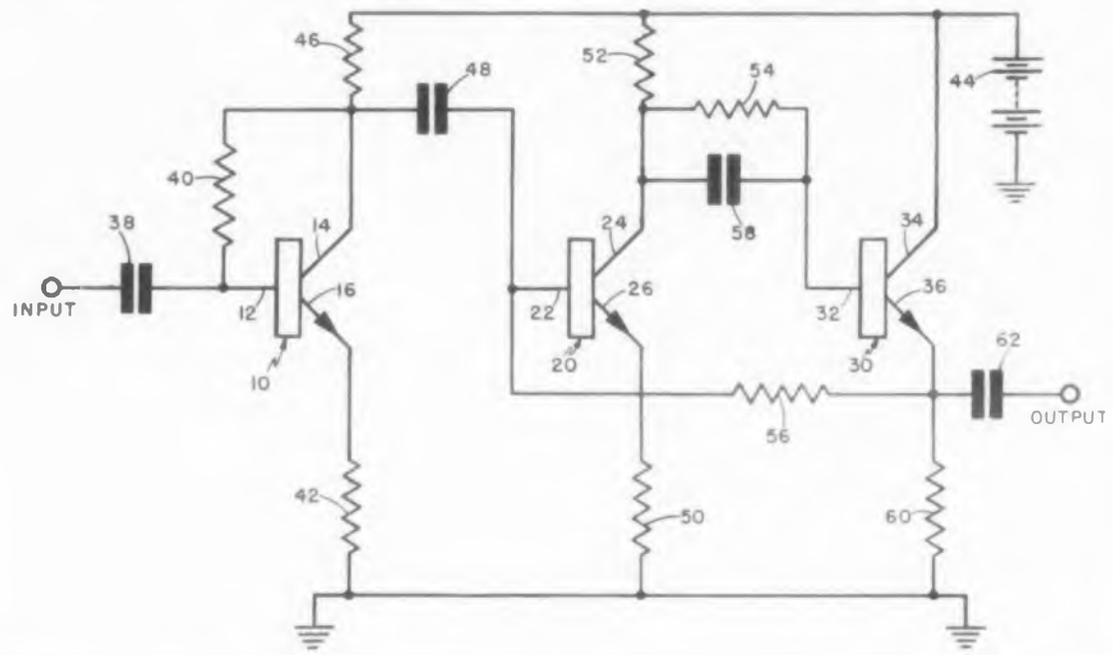


PATENTS

Triad Transistor Amplifier

Patent No. 2,863,957. Robert B. Hamilton. (Assigned to Ryan Aeronautical Co.)

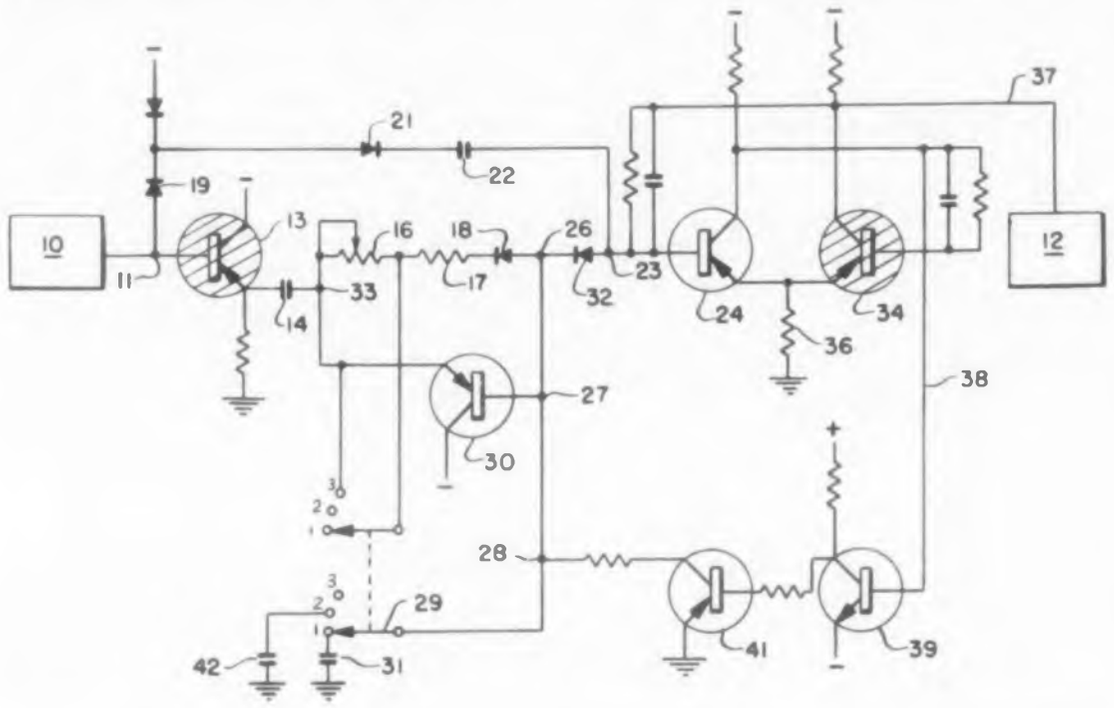
Negative feedback in an ac transistor amplifier minimizes variations in the network parameters. Shunt feedback by resistor *40* between output and input and also series compensation by emitter resistor *42* stabilize transistor *10*. Any drift in transistors *20* and *30* is cancelled in the dc path between collector *24*, base *32*, emitter *36* base *22* and emitter *26*. In addition, temperature compensation is obtained by temperature sensitive resistor *50* which adjusts the input impedance of transistor *20* according to temperature change.



Frequency Divider Circuit

(Patent No. 2,866,104. Frank D. Biggam. Assigned to Teletype Corp.)

By means of a transistor step charging counter, the frequency of a pulse source is divided. Rectangular pulse generator *10* charges capacitor *31* negative through transistor *13*, differentiating capacitor *14* and diode *18*. Transistor *30* feeds back a voltage to linearize the step charging. When the bias on diode *32* is overcome, the succeeding pulse cuts off transistor *24*. Transistors *34* and *39* conduct and transistor *41* discharged capacitor *31*. Thereafter, a positive going pulse through differentiating capacitor *21* flops transistor *24* back to conduction and transistors *34* and *39* cut off to reset the circuit to repeat the count.



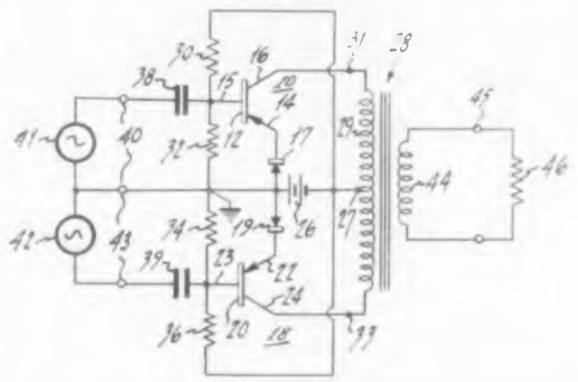
PATENTS

Stabilized Transistor Amplifier

Patent No. 2,860,193. James E. Lindsay (Assigned to Radio Corporation of America.)

Class B transistor amplifiers are stabilized by means of a series combination of diode and resistor in the emitter-base circuit. The diode provides high degenerative resistance to emitter current under static conditions and relatively low resistance for signal currents.

The basic circuit shows complementary transistors *10* and *18* connected in a class B push-pull output stage driven by a balanced source connected to terminals *40* and *43*. A pair of diodes, *17* and *19*, is connected between ground and emitters *14* and *22*, respectively. Forward bias of each transistor is obtained by means of resistors *30* and *36* connecting base electrodes *15* and *23* to the negative terminal of battery *26*. Under quiescent conditions, the diodes impede the emitter currents to stabilize the dc operating point. When signal is applied, however, the increase in emitter current reduces the diode resistance and degeneration of signal current is effectively reduced.

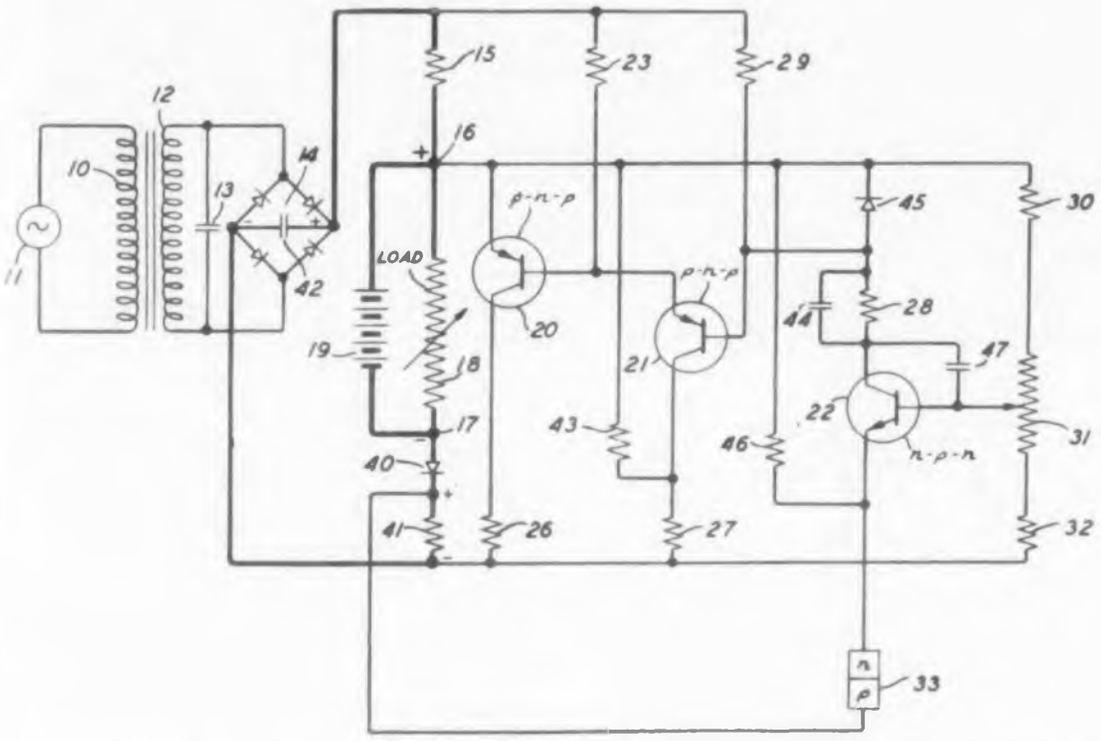


Current Supply Apparatus for Load Voltage Regulation

Patent No. 2,850,695. John D. Bishop. (Assigned to Bell Telephone Laboratories).

Transistor regulator action maintains output voltage at 22 v for a maximum load current of 0.1 amp over the temperature range of −40 F to +140 F.

At room temperature, the network comprises a simple degenerative controller. A reduction in output voltage due to an increase in load current is finally



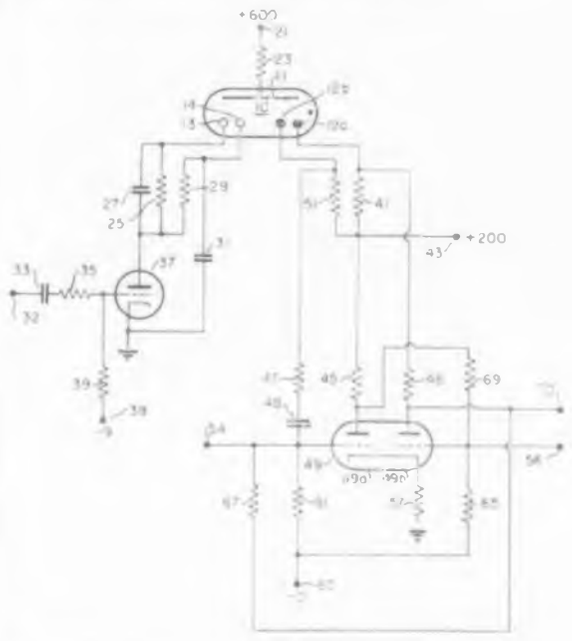
compensated by reducing the emitter current of transistor *20* which is in shunt with the load. When the emitter current of transistor *20* is reduced to zero, the network is controlling the maximum load current. However, at +140 F, the emitter-collector current of transistor *20* is not zero even though the base current is zero. The circuit therefore allows the base current to reverse so as to effectively balance out the emitter-collector current. Diode *45* clamps the operating conditions of the transistors within safe limits to prevent overload and possible damage.

PATENTS

Gate Reset Circuit

Patent No. 2,864,034. John E. Adams. (Assigned to Sylvania Electric Products, Inc.)

Sylvania type 6476 glow discharge transfer counter tube is used in a simple circuit to count only a predetermined quantity and thereafter to reset itself so that the count may be repeated.

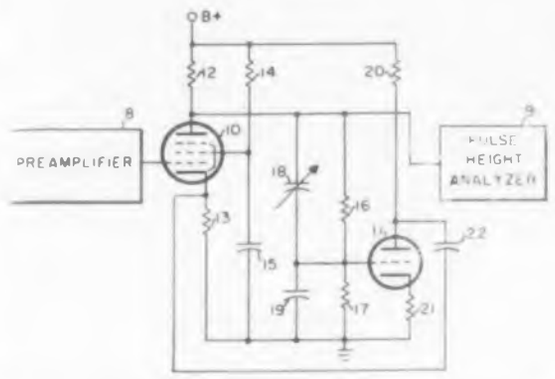


Initially, triode *49b* is conducting and the voltage on cathode *12a* is thereby made sufficiently negative so that the discharge is directed to this cathode. A positive pulse applied to the grid of triode *49a* causes multivibrator tube *49* to switch; triode *49b* cuts off and the voltage on cathode *12a* rises. Now pulses applied to triode *37* will cause the discharge to switch sequentially in the counter tube until the discharge is directed to cathode *12b*. On the next pulse to be counted, the glow leaves cathode *12b* swinging this cathode negative and the negative pulse coupled to the multivibrator cuts off triode *49a*. With triode *49b* again conducting, the glow discharge is toward cathode *12a* and this condition is maintained until the multivibrator is switched to renew the counting.

Linear Amplifier

Patent No. 2,839,287. Garret F. Ziffer. (Assigned to Tracerlab Inc.)

Linear amplification of pulses in the dynamic range of 0.25 v to 200 v is ob-



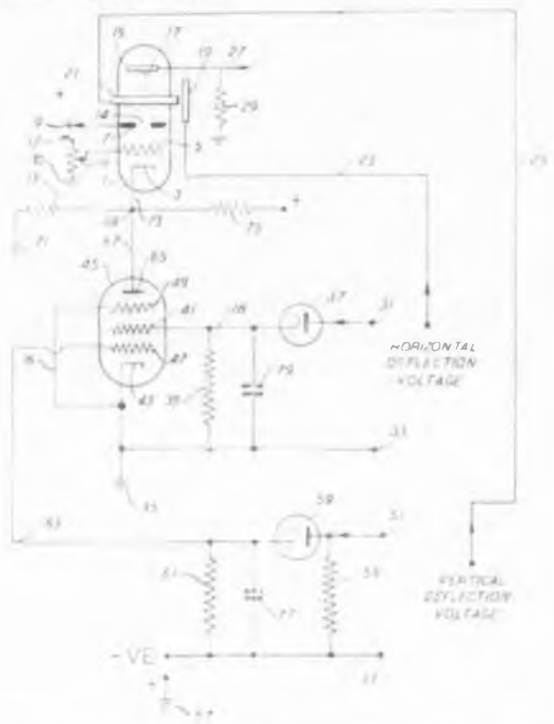
tained by means of a pentode-triode feedback amplifier.

The preamplifier output is amplified by pentode tube *10* and approximately 10 per cent of the amplified signal is coupled back to cathode resistor *13* by means of voltage divider resistors *16*, *17*, and the unity gain inverter tube *11*. For a flat frequency response, series capacitors *18* and *19* are individually in shunt with the indicated resistors. The components of a typical amplifier are given in tabulation.

Electronic Protective System

Patent No. 2,860,283. Irving Horowitz. (*Assigned to Irving Horowitz, Eatontown, N.J.*)

Cathode-ray tube screen burnout is prevented by gating the tube beyond cutoff whenever either sweep signal is absent. Essentially, diodes *37* and *59* rectify the horizontal and vertical sweep voltages such that pentode *47* draws sufficient current through load resistor *75* to maintain cathode ray tube *1* above cutoff. A sweep failure reduces tube *45* current and the cathode ray tube beam is extinguished.



BOOKS

Process Dynamics: Dynamic Behavior of the Production Process

Donald P. Campbell, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 316 pp, $10.50.

Emphasizing a general approach to process dynamics, this book examines the characteristics of processes during unsteady-state conditions or in response to periodic disturbances. The author views process design and control design as an integrated problem in process systems. He also considers the use of linear network theory as a means of predicting the dynamic performance of a plant before it is built. Translating process dynamic performance into mathematical form, the text features applications of feedback control theory to industrial processes, particularly chemical and petroleum operations. It also provides a practical approach to problems in process dynamics such as automatic process control and the damping of pressure and flow pulsation, and suggests methods for controlling process operations involving moving filaments, sheets, and webs. Appendices cover block diagrams and signal-flow diagrams and the use of Fourier and Laplace transformations in treatment-process control problems.

Guide to the Literature of Mathematics and Physics including Related Works on Engineering Science (Second Revised Edition)

Nathan Grier Parke III, Dover Publications, Inc., 920 Broadway, New York 10, N.Y., 436 pp, $2.49.

A handy, comprehensive bibliography, representing every branch of physics, mathematics, and related engineering

science, the Guide is an invaluable aid to the researcher. Part I, an orientation to library techniques, is provided in a 74-page section. An extensive listing of bibliographical aids includes: abstracts, indexes, periodicals, reviews, bibliographies, directories, encyclopedias, documentary reproductions, guides, and library sources. Part II contains the literature to 1956 and lists more than 5500 key works, included under 120 subject headings, which are subdivided into an average of 6 subheads. Discussion of the literature under each heading defines the subject matter and provides numerous cross-references and suggestions for further investigation. A complete author and subject index facilitates immediate location of any book. Features many recently available works in Russian and an up-to-date listing of agencies and individuals engaged in Russian translation programs. Translations of all foreign titles are listed.

Physical Laws and Effects

C. Frank Hix, Jr., Robert P. Alley, John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N.Y., 291 pp, $7.95.

Useful as a quick reference source for the experienced engineer and scientist, this volume provides a convenient centralized source of information on the subject. Compiled so that a search of laws and effects could become a practical part of the engineering approach to problems, an alphabetic listing of subjects is supplemented by three different cross reference systems. The systems include: a description of laws and effects, including an indication of the expected magnitude and references for further investigation; a cross reference index according to fields of science, which lists laws and effects by the discipline to which they are most applicable; and an index by physical quantities, listing not only the law or effect pertaining to the physical quantity under question, but also other quantities covered by the same law.

The reader will find this volume a handy dictionary, a thought stimulator and a problem approach tool. The authors stress, however, that the text is not complete and is not intended to be since a continuing compilation of background information is necessary to produce a guide which can be utilized in problem synthesis.

IDEAS FOR DESIGN

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

Component Holder Speeds Breadboard Circuits

A SIMPLE SPRING clip device promises further time savings in breadboard circuitry.

This device, developed by the Shockley Transistor Corp., Palo Alto, Calif., consists of a phosphor bronze band, shaped like a horseshoe, with a coil spring fastened over the convex top. A rod extends vertically from one leg of the device.

In use, the device, called a component holder, is pushed into a sheet of polystyrene foam. Components, such as resistors, diodes, transistors, or capacitors, are clamped under or within the coils of the spring. The vertical rod is useful for connecting a voltmeter, oscilloscope, or other measuring device to the circuit. Each component holder will hold several component leads, alligator clip leads, or meter leads.

Component holders are readily moved and repeated use does not destroy the polystyrene foam. Furthermore, the coefficient of friction between the legs of the component holder and the polystyrene foam is such that components can be pulled out of the spring without pulling the component holder from the foam.

Many variations of this holder have been fabricated, some of them simpler and less expensive. Some of the simpler devices pull out of the polystyrene foam too easily, don't have enough space for clip leads and are too filmsy.

An engineer working with ten of these component holders and one square foot of two-inch polystyrene foam can assemble a simple low frequency circuit, such as a transistor amplifier, in

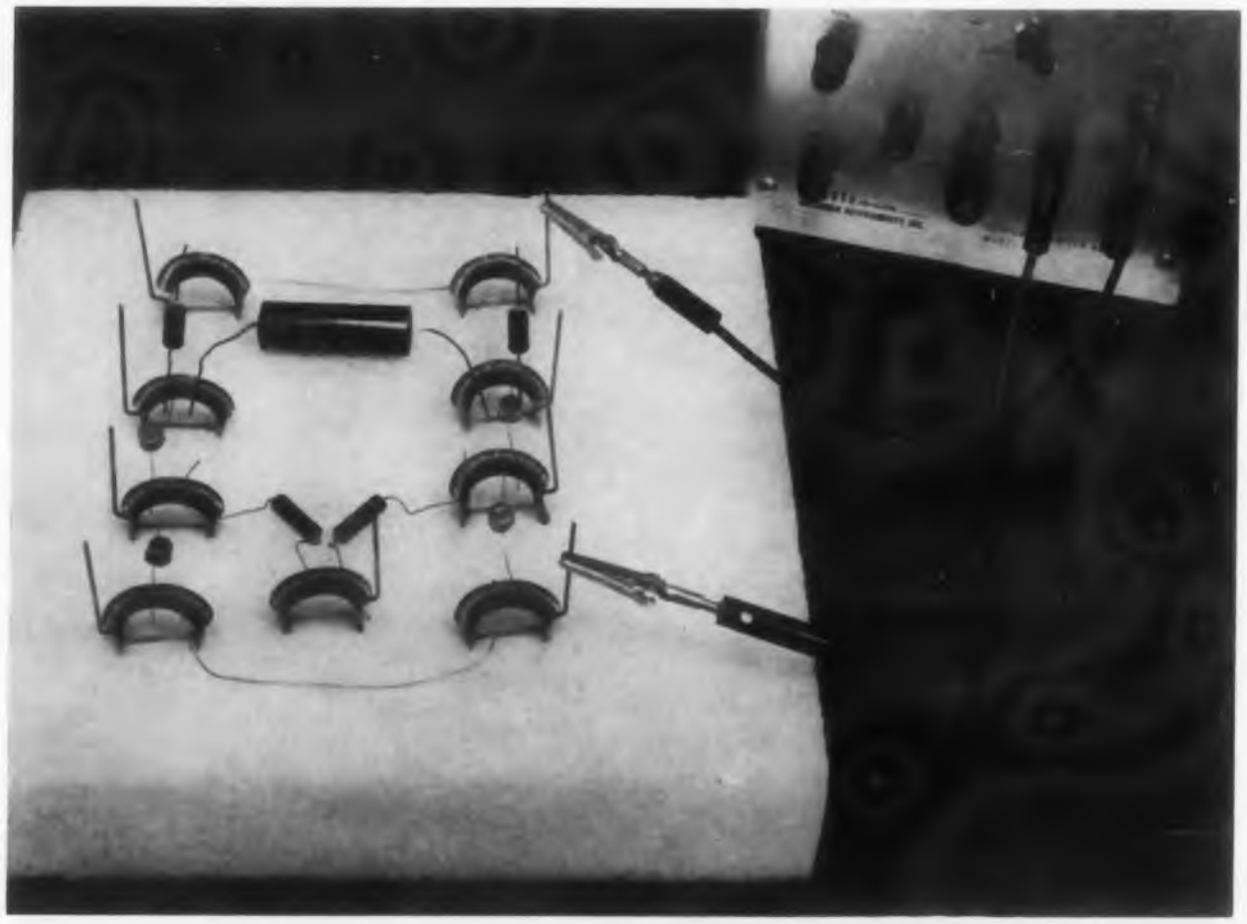


Fig. 2. Components are easily withdrawn from the holder without removing the holder from the polystyrene foam.

Fig. 1. Simple component holder saves breadboarding time.

about five minutes. The circuit can be revised or salvaged in much less time.

With some of the existing methods of making breadboard circuits, a simple circuit may take from thirty minutes to several hours to construct before tests can be started. On one occasion, some one telephoned a laboratory equipped with component holders, and asked if a certain semiconductor device would work in a certain circuit. He was told, "Just a minute—we'll try it." Within five minutes he was told that the application was satisfactory—at least at room temperature.

Oftentimes a designer is reluctant to try a small circuit change that will take a half an hour of reassembly to accomplish. He may spend an hour calculating or thinking out the problem before attacking it with a soldering iron. A breadboarding device that allows fast changes can save time in assembly, soldering, and unsoldering, and can help overcome time-consuming mental inertia.

Walter F. Dimmik, Shockley Transistor Corp., Palo Alto, Calif.

IDEAS FOR DESIGN

Manual Input Circuit For Digital Equipment

The circuit designer must often provide push-button input for digital equipment. He has three basic problems: contact bounce in the switch; noise pickup when the electronic circuit is far from the pushbutton; and the need for a fast signal transition which will be independent of circuit packaging.

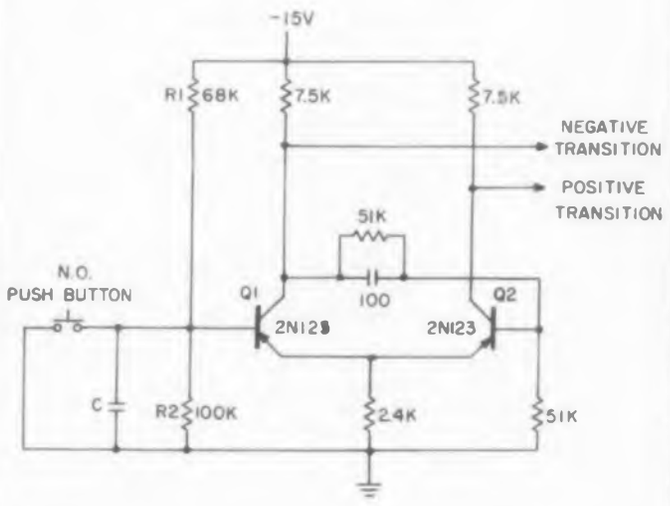
The Schmitt trigger is an ideal solution. In the diagram, *Q1* and *Q2* together with their resistor networks form a normal Schmitt trigger. *R1* and *R2* are chosen so *Q1* conducts, holding *Q2* off when the pushbutton is released. When the button is depressed, the base of *Q1* is grounded, causing the trigger to reverse, turning *Q1* off and *Q2* on.

Capacitor *C* is discharged almost instantly through the low contact resistance of the pushbutton. But it must recharge through *R1* before *Q1* will conduct again when the pushbutton is released. A suitable time constant will eliminate contact bounce from the output.

The capacitor also bypasses the wire connecting the electronic circuit and the pushbutton, thus reducing stray pickup.

Since Schmitt transitions are essentially independent of the rate of rise or fall of the input waveform, the transitions at the collectors of *Q1* and *Q2* provide very reliable triggers.

Norman E. Peterson, Project Engineer, Stelma Inc., Stamford, Conn.



Manual input for digital equipment. These values are typical for C = 0.1 μfd.

Don't forget to mail your renewal form to continue receiving *ELECTRONIC DESIGN*.

Aircraft gyro electrodes use epoxy resins to support and encapsulate a silver ring inside an index ring. Minneapolis-Honeywell Regulator Co. selected Bakelite epoxy for this job for its high strength and for matching the temperature coefficient of expansion of the metals over a range from —65 to 165 F.

Chopper Amplifiers Can Be Used At Higher Frequencies

Many engineers feel that operation of a chopper amplifier at frequencies much higher than 10 per cent of the chopping frequency is not satisfactory. But this is not the case. Mechanical chopper amplifiers are in use which reproduce, for instance, 80 cps from a 100 cycle chopper, and 40 cps from a 60 cycle chopper.

In both cases, the recorders are mechanical direct writers, so paper speed limits good resolution at the higher frequencies. But it is probable that at much over one-third of the chopping frequency, deviations from sinusoidal response will not be important as long as peak amplitude and adequate rise time are reproduced by the pen writer.

At higher frequencies, the response depends mainly on two factors: rapid changeover in the chopper so sampling time or allocation time are as close to 360 deg as possible, and good low frequency response in the carrier amplifier so flat-topped waves (after chopping) are reproduced with minimum slope.

At the higher signal frequencies, a single chopping cycle may involve a considerable part of a sine wave, perhaps both positive and negative parts of it. This does not matter if the rapid changeover and good low frequency response are maintained. Sine waves will be reproduced, after rectification, with useful fidelity.

Dr. E. E. Suckling, State University of New York, Brooklyn, N. Y.

IDEAS FOR DESIGN

Faster, Linear Sweeps On Larger Pedestals

Unless large B supplies are used when designing large pedestals for sweep circuits, sweep linearity and fall time are usually sacrificed. The circuit shown, however, provides a much faster fall time and better linearity with large amplitudes, all with one dual triode.

In this circuit, $P2$ could be the positive pulse output plate of a ppi radar sweep gate generator, and e_i the negative pulse output of the same tube. At time $t1$, the triode $V1_A$ cuts off and $P3$ starts to charge toward E_{bb}. Through resistive addition, parts of the pulse in the ratio

$$\frac{R2}{R1 + R2 + R_L}(E_{bb} - e_b)$$

and the sweep in the ratio

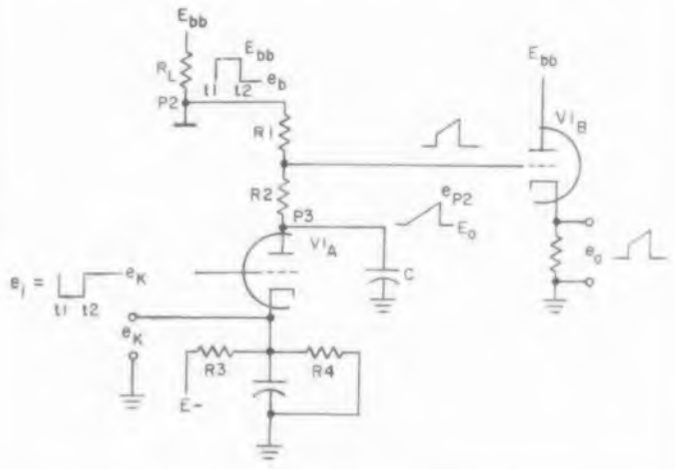
$$\frac{R1 + R2}{R1 + R2 + R_L}(e_{p2} - E_o)$$

are superimposed on each other. Hence,

$$e_o = \frac{R2}{R1 + R2 + R_L}(E_{bb} - e_b) + \frac{R1 + R_L}{R1 + R2 + R_L}\left[E_{bb} + (E_o - E_{bb})\, e^{-(R1+R2+R_L)Ct}\right]$$

The dc level of E_o can be adjusted by varying the ratio $R3/R4$. At $t2$, $V1_A$ conducts fully again and C discharges through the plate resistance of $V1_A$ in series with the parallel combination of $R3$ and $R4$. Therefore $(R3\,R4)/(R3 + R4)$ should be kept as low as possible. The cathode follower $V1_B$ prevents loading of the sweep generator.

Irving Bayer, Project Engineer, Skiatron Electronics and TV Corp., New York City.



Without very large B supplies, this circuit provides good sweep linearity and fast fall time on a large pedestal.

Fuse Wound Peaking Coils For Faster Breadboarding

The usual process for adjusting peaking coils to the correct value in a circuit involves unsoldering one lead, peeling off a number of turns of the coil wire, skinning the insulation, then resoldering to a terminal. This process is tedious and often damages the coil.

A more convenient method involves winding a number of test coils on burned out fuses, preferably of the glass AG type. The wire is wound to the proper inductance and the ends soldered to the metal caps of the glass fuse. Each coil can be color coded. Instead of normal terminals, the breadboard can be equipped with a plug-in type fuse holder (except in very high frequency circuits, where the added capacitance may affect circuit performance).

The coil fuse forms can then be changed as easily as ordinary fuses.

Sol Abrams, Design Engineer, Polarad Electronics Corp., Long Island City, N. Y.

Missile telemetry package, designed for Boeing's IM-99 Bomarc by Texas Instruments, Inc., must operate to beyond 145 deg. F. Since the transistors in the package will not work well beyond 145 F, and since the missile's surface temperature, at Cape Canaveral, may reach 160 F, cooling was required.

Engineers at the Boeing Airplane Co. solved the problem by designing an auxiliary cooling system for ground use only. It blows a jet of cool air through the interior of the wing where the equipment is housed.

In flight, a small methyl alcohol evaporator keeps the equipment cool for the relatively brief period necessary.

Don't miss an issue of *ELECTRONIC DESIGN;* return your renewal card today.

IDEAS FOR DESIGN

Standard horizontal deflection coils and toroidal vertical deflection coils are wound on a ferrite wedge-shaped ring in this TV yoke made by the Videon Company in France.

Two small Ferroxdur permanent magnets are supported by the yoke, along the horizontal axis. By bending or twisting the long lugs to which they are attached, any pincushion or barrel distortion on the sides of the raster can be corrected to within five per cent.

Dr. A. V. J. Martin, Carnegie Institute of Technology, Pittsburgh 13, Pa.

Battery Savers Be Careful

On page 69 of the Dec. 24 '58 issue of ELECTRONIC DESIGN, Mr. Robert W. Blanchard suggests a warning light in series with a diode between the automobile ignition switch and the main light switch in such a manner that the warning light will be illuminated if the lights are on and the key off, thus acting as a battery saver to hurried drivers.

There is a note of caution to be recalled, however. Although many modern automobiles ground the lead to the ignition coil when the key is off, still others let the lead float. Even with a small panel lamp in series from the battery supply to the otherwise floating ignition lead, sufficient current may flow to keep the spark plugs firing under the condition of key off, lights on, with Mr. Blanchard's circuit.

One solution is to connect the lamp not to the ignition coil wire but to the accessory terminal of the switch. Then a 15 ohm or so resistor from the accessory terminal to ground will complete the circuit even with no accessories (heater fan, radio, etc.) turned on. This is convenient for

those cars that have separate terminals on the ignition switch, as is the case usually when the ignition key is used also to actuate the starter.

If, however, the car doesn't ground the ignition coil lead with the key off and doesn't have a separate accessory terminal on the switch, some method of more elaborate safety feature must be installed. On my car I found it convenient to interconnect the light and ignition circuits so that, under normal operation, turning off the lights completely will drop out a holding relay to the ignition circuit, thus turning off all lights, radio, etc., with one switch. Either circuit can be operated independently, however.

There is no end to the gadgetry one can profitably add to the electrical circuit of a vehicle. At any rate, letting even a small amount of current (such as from a warning light) leak into the ignition circuit may be hazardous and should be avoided.

Roger L. Boyell, Hempstead, New York.

Another Battery Saver

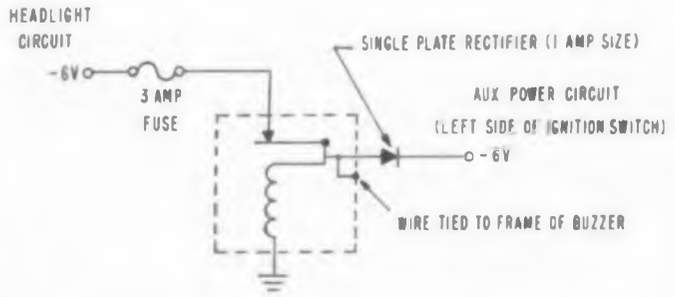
The operation of the "battery saver" circuit given in the December 24th issue depends on the ignition circuit having a ground when it is shut off. This is true only in three cases:

1. When there are other loads connected to the ignition circuit.
2. When the ignition switch intentionally grounds the circuit.
3. When the engine happens to stop with the breaker points closed.

Possibly you will receive sad letters from readers who install this circuit and discover that it does not always work.

The circuit shown here has its own ground. The buzzer works as a logic device, not merely as an indicator. Blocking voltage for the buzzer is taken from the auxiliary power circuit instead of the ignition circuit, so that the headlights may be left on quietly, if desired, by leaving the auxiliary power on. There is nothing in the circuit to impair the reliability of the headlights.

Marriott Dickey, Richmond, California.



The buzzer in this automobile "battery saver" serves as a logic device as well as a warning device. (The buzzer is an Edwards Model O. Its frame is insulated from the car.)

REPORT BRIEFS

Transistor Magnetic Amplifier Circuits

Advantages and disadvantages of transistor and magnetic amplifiers. A combination of the two is discussed and schematic diagrams are given for various example circuits and applications which utilize the better points of each. *Transistor Magnetic Amplifier Circuits, Niels Jasper, James C. Taylor, and William T. White. U. S. Army Ballistic Missile Agency, Development Operations Division, Guidance and Control Laboratory, Huntsville, Ala. Mar. 1957, 21p, microfilm $2.70, photocopy $4.80. Order from Library of Congress, PB 132806, Washington 25, D. C.*

Dielectric-Filled Waveguides

Dielectric-filled waveguides were developed in an effort to eliminate the decrease in power handling capacity of waveguides in airborne equipment at high altitudes and temperatures. Although they exhibited temperature limitations, the new waveguides proved suitable for high-altitude operation. The temperature limit of 71C could be raised to 150C at the expense of slightly increased attenuation. The report also discusses the problem of maintenance of sea-level power handling capacity of the waveguide at high altitudes and wide temperature ranges. *A Dielectric-Filled Waveguide Development, J. I. Meulemans, Wright Air Development Center for the U.S. Air Force, April 1958, 19p, $0.75. Order PB 151213 from OTS, U.S. Department of Commerce, Washington 25, D.C.*

Airborne Data Recorder Development

An improved airborne data recorder was developed for recording aircraft environmental conditions and physiological measurements of flight personnel. The device, developed during a study of cockpit air conditioning, is described as being reliable and accurate in extreme environmental changes. The NS-2 is a small, direct-writing, 20-channel recorder which employs special transducers to measure relative humidity within the aircraft and physiological temperature of the flight personnel. Operating, calibration, and maintenance instructions are included in the illustrated report. *Development of Type NS-2 Airborne Data Recorder, W. B. M. Clark, Douglas Aircraft Company, Inc., for Wright-Air Development Center, U. S. Air Force, Feb. 1958, 30 pp, $1.00. Order PB 131806 from OTS, U. S. Department of Commerce, Washington 25, D. C.*

This is the time of our annual subscription renewal.

Vanguard Sequence Diagram

Featured in this report is a description of the Vanguard sequence diagram, a system which shows at a glance the state of every component in a complex device as well as all events occurring and the components involved in each event. According to the report, the sequence diagram fills a need for a means of graphically presenting the operation of a complex device in which a predetermined sequence of events occurs. The diagram represents system components and their changing states as they interact sequentially. Utility and applications of the sequence diagram are discussed and method of interpreting the diagram is illustrated. A complete application of the diagram to the complete nominal flight operation of the first Project Vanguard rocket test vehicle is also presented. *Project Vanguard Report No. 31: The Vanguard Sequence Diagram, a Graphical Method of Presenting Complex System Operation, W. J. D. Escher and R. W. Foster, U.S. Naval Research Laboratory, Aug. 1958, 15 p, $1.75. PB 131922 from: OTS, U.S. Dept. of Commerce, Washington 25, D.C.*

Cooling Design of Airborne Electronic Equipment

Design data, methods, and principles for cooling of airborne electronic equipment with both gaseous and liquid coolants are presented including application to the redesign of four typical equipments for which design procedures and thermal evaluation of the constructed equipment are shown. The first five sections contain general thermal design principles and thermal classification of electronic equipment. *Cooling Design of Airborne Electronic Equipment, Charles D. Jones, Ohio State University Research Foundation, Columbus, Ohio. Dec. 1957, 458pp, photocopy $69.60, microfilm $11.10. Order PB 135164 from Library of Congress, Washington 25, D.C.*

Ferrite Loop Antenna Theory

Simplified theory for electrically small ferrite-loaded loop antennas is presented. The theory is based on the principle of reciprocity and known solutions for fields in and about an ellipsoidal core. Approximate methods are given which extend the theory to cores of almost arbitrary cross section. Example calculations for antenna Q and efficiency show good correlation with experiment. *Research in Magnetic Antennas. Final report under Contract No. DA 36-039-sc-73189, J. L. Stewart, California Institute of Technology, Pasadena, Calif. Sep. 1957, 70p, microfilm $3.90, photocopy $10.80. Order from Library of Congress, PB 132459, Washington 25, D. C.*

IMPULSE

A DIGEST OF NEW DEVELOPMENTS IN ELECTRONICS AND AUTOMATION

PUBLISHED BY ROME CABLE CORPORATION, ROME, N. Y.
PIONEERS IN INSTRUMENTATION CABLE ENGINEERING

FLAME-RETARDANT POLYETHYLENE. Just published, and now available to IMPULSE readers, is an interesting 12-page bulletin entitled "Flame-retardant Polyethylene for Wire and Cable." Co-authored by R. C. Graham of Rome Cable and C. A. Neros of Diamond Alkali Company, this paper was presented at the 7th Annual Wire and Cable Symposium, held under the auspices of the U. S. Army Signal Corps. Contact your nearest Rome Cable salesman for a copy of this paper.

FREE INFO. You can get this *free* 9-page illustrated bulletin that discusses cable insulation and jacketing material and lists typical multi-conductor cable constructions available for use with telemetering equipment, data recording equipment, circuit control testing and electronic computers. Every design engineer working with electrical cable should have a copy! To obtain yours, get in touch with the Rome Cable salesman near you.

"BLUE SKY" DEPT. The National Inventors Council, speaking for the military services, let it be known recently that the Military needs inventions to answer some of its more baffling "blue sky" problems. One of the most unusual inventions requested was a man-made "electric eel" generator to power repeater amplifiers in undersea cables. The point is to emulate the generation process used by the electric eel. That start you thinking? If so, the NIC might like to hear about it. They also would like to hear about a whole list of items they have recently released . . . you can probably get a copy by writing them at the Department of Commerce, Washington, D. C.

CABLEMAN'S CORNER. The subject of circuit identification in cables is somewhat complex. Its purpose is obvious—to identify a particular circuit, phase, polarity or other end use, thus bringing about easier installation and maintenance. The means of circuit identification range all the way from the most conservative, in which all the conductors are alike, to the most liberal, in which each conductor has its own distinctive color combination.

Industry standards for a particular type of circuit identity have been established by many groups such as IPCEA, NEMA, NEC, ASA, IMSA and Underwriters' Laboratories. Military specifications written to cover specific cable constructions indicate the required color coding. Military specifications written to cover a general class of cable constructions many times list a coding table and a recommended method of conductor identification. Caution should be exercised in referring to these particular specifications to make sure that the coding combinations will do the job you are after. For instance, Table V of MIL-C-3432A makes provision for 21 color combinations. For cables containing more than 21 conductors, these color combinations are repeated. Therefore, in a 45-conductor cable you will find 3 colors repeated 3 times and 18 color combinations repeated 2 times.

Under today's rather hectic conditions, delivery schedules are always of prime importance. When circuit identification requires a variety of solid base colors, delivery schedules have to be adjusted accordingly to compensate for machine setups and change-overs, etc. Careful consideration should be given to the use of a solid neutral base color and colored identifying stripes. A very satisfactory combination has been the use of solid white as the base color. With the employment of one or two colored stripes, a total of 73 color combinations can be achieved.

The ways and means of circuit identification are numerous. The methods employed to gain the desired objectives must result in quick and clear intelligible information, conveyed in a method which is reasonably permanent and economical to achieve. Circuit identification is important in your work. Make sure you have competent cable identification. Call in a cable specialist. Our number is Rome 3000.

These news items represent a digest of information found in many of the publications and periodicals of the electronic industry or related industries. They appear in brief here for easy and concentrated reading. Further information on each can be found in the original source material. Sources will be forwarded on request.

CIRCLE 400 ON READER-SERVICE CARD

REPORT BRIEFS

Training Devices to Motivate Trainee

Training devices designed to furnish varied training may provide greater transfer to operational equipment, and may also help to maintain interest and motivation of the trainee, according to the results of this study. Transfer among perceptual-motor paired-associates tasks was studied as a function of the two variables: the degree of variation in training, and the amount of training. It was found that transfer increased as a direct function of the number of sets of training stimuli. The transfer superiority of varied-over-constant training was not significantly affected by variations in the amount of training. Another conclusion was that training with different sets of stimuli leads to the development of general skill which facilitates dealing with new stimuli. It is suggested that this skill is an observational or perceptual nature. *The Effect on Transfer of Varying Stimulation During Training, C. P. Duncan and B. J. Underwood, Northwestern University for Wright Air Development Center, U. S. Air Force, Dec. 1957, 38 pp, $1.25. Order PB 131-653 from OTS, U. S. Department of Commerce, Washington 25, D. C.*

Synthesis of Voltage Transfer Functions

The synthesis of voltage transfer functions in the form of linear, lumped, finite, passive, bilateral networks containing no ideal transformers or mutual coupling, is considered. The basic realizability conditions are derived and realization procedures are developed based on these conditions, showing them to be both necessary and sufficient. *Synthesis of Voltage Transfer Functions, Philip M. Lewis, II, Massachusetts Institute of Technology, Research Laboratory of Electronics, Cambridge, Mass. Jun. 1956, 107p, microfilm $5.70, photocopy $16.80. Order from Library of Congress PB 133460, Washington 25, D. C.*

Frequency Swept Oscillator

Principal advantage of slot antenna-oscillators are their simplicity of circuit and mechanical construction. They also present possibilities as wide-range tuning systems. Their principal disadvantage, as compared to "lumped-circuit" units, lies in the presence of dragloops which generally make it impossible for a specific unit to generate certain frequencies. *Frequency Swept Oscillator, Ellis L. Roney, Sylvania Electric Products, Inc., Mountain View, Calif. Mar. 1956, 56 pp, microfilm $3.60, photocopy $9.30. Order PB 134884 from Library of Congress, Washington 25, D.C.*

Semiconductor Devices Research Program

Silicon power transistors can be fabricated by diffusing impurities in from the surface to form the base and emitter regions. Transistor structures can be formed using a number of impurities, but gallium and phosphorus were most thoroughly studied. Suitable emitter, base, and collector contacts can be made using titanium or tungsten support plates and the transistors mounted in a hermetically sealed, welded package of low thermal resistance. The fabrication process, consisting of diffusion, lead attachment, etching, and packaging is described. The performance of the units in typical circuits is shown. *Semiconductor Devices Research Program, James E. Keister, General Electric Co., Syracuse, N.Y. July 1958, 157pp, OTS U.S. Dept. of Commerce, Washington 25, D.C., $3.00 PB 151201.*

Transistor Blocking Oscillators With Variable Pulse Lengths

The length of the output pulse of a given transistor blocking oscillator can be electrically varied by as much as 50:1. For low power alloy junction transistors and ferrite cup transformers, variations in pulse length from 2 to 100 μsec have been obtained with a variation of the bias voltage. This variation is studied for a blocking oscillator having collector-to-base feedback. *Transistor Blocking Oscillators with Variable Pulse Lengths, S. H. Dinsmore and D. O. Pederson, California University, Berkeley, Calif. July 1957, 22pp, microfilm $2.70, photocopy $4.80. Order PB 134745 from Library of Congress, Washington 25, D.C.*

Realization of Broadband Matching Networks For Arbitrary Impedances

The general problem of the realization of optimum lossless matching networks for an arbitrary load impedance is investigated. The starting point for this investigation is Fano's work on the theoretical limitations on the tolerance and the bandwidth of match. It is shown how any arbitrary impedance can be matched to a resistive generator by considering examples of several important types of loads. *Realization of Broadband Matching Networks for Arbitrary Impedances, Bharat K. Kinariwala, California University, Electronics Research Laboratory, Berkeley, Calif. Feb. 1957, 103pp, microfilm $5.70, photocopy $16.80. Order PB 133536 fom Library of Congress, Washington 25, D.C.*

Don't forget to mail your renewal form to continue receiving *ELECTRONIC DESIGN.*

RUSSIAN TRANSLATIONS

Nonlinear and Parametric Phenomena

Part 14

A. A. Kharkevich

(Translated by J. George Adashko)

Chapter 2

Generation of Oscillations

21. Excitation of Oscillations in a Generator

After considering the steady-state mode of the generator, we examine how the steady-state is excited. We shall trace the development of the oscillations from the instant the circuit is turned on until the instant when the amplitude and the frequency are practically constant, i.e., when the oscillations can be considered steady.

The problem reduces to tracing the time variation of the quantities that characterize the oscillation, i.e., of the amplitude and frequency. The waveform of the oscillations will be assumed to be close to sinusoidal.

The problem will be solved by a method known as the method of slowly varying amplitudes. This is essentially a quasi-linear method; the possibility of applying it to this problem is based on the fact that the amplitude, although not as constant as in the steady state case, is

s

d

c

a

in Radio Engineering

assumed to vary slowly. A criterion for "slowness" will be given below.

Let us write the oscillator equation in the form

$$L\frac{dI}{dt} + RI + \frac{1}{C}\int Idt = M\frac{dI_a}{dt} \qquad (1)$$

We have already employed this equation in Sections 17 and 20. But in Section 17 we assumed $I_a = S_a U$ and thus reduced eq (1) to a linear one since our purpose was to find the self-excitation condition. In Section 20 we wrote the equation for the first harmonic in complex form, introducing the average transconductance into the equation. Our problem then was that of investigating the steady-state mode. Now, however, we shall write eq (1) in a general nonlinear form.

The dependence of the plate current on the grid voltage is represented by the nonlinear function

$$I_a = f(U)$$

Let us write the right half of eq (1) in the form

$$M\frac{dI_a}{dt} = M\frac{dI_a}{dU}\frac{dU}{dt}$$

But

$$\frac{dI_a}{dU} = \frac{df(U)}{dU} = S(U)$$

is the differential transconductance, expressed

RUSSIAN TRANSLATIONS

graphically by the slope of the characteristic of the triode at a given point i.e., (at a point with abscissa U). Introducing, as before

$$U = \frac{1}{C}\int I\,dt$$

we obtain instead of eq (1), the initial oscillator equation in the form

$$\frac{d^2U}{dt^2} + \frac{1}{L}\left[R - \frac{M}{C}S(U)\right]\frac{dU}{dt} + \omega_0^2\,U = 0 \quad (2)$$

Assume that the system considered is soft. In this case the nonlinear characteristic can be approximated by a third-degree polynomial:

$$I_a = a_0 + a_1\,U + a_3\,U^3$$

Differentiating, we obtain an expression for the transconductance

$$S = \frac{dI_a}{dU} = a_1 + 3a_3\,U^2$$

Inserting this in eq (1) we obtain a nonlinear equation

$$\frac{d^2U}{dt^2} + (2\,\beta_0 + \gamma U^2)\frac{d^2U}{dt^2} + \omega_0^2\,U = 0 \quad (3)$$

Here

$$\beta_0 = \alpha - \frac{1}{2}\,\omega_0^2\,MS_0$$

is the initial damping factor (taking the feedback into account), and γ is shorthand for

$$\gamma = 3\,\omega_0^2\,Ma_3$$

The method of solving eq (3) consists of assuming a solution in the form

$$U = A(t)\sin\omega t$$

The quantity A is the variable "amplitude" of the oscillation; the function $A(t)$ represents what is called in electronics the envelope. As to the still unknown frequency ω, we shall assume it constant.*

Differentiating the assumed solution in eq (3) twice

$$U' = A'\sin\omega t + A\,\omega\cos\omega t$$

$$U'' = A''\sin\omega t + 2A'\,\omega\cos\omega t - A\,\omega^2\sin\omega t$$

and inserting the values of U and its derivatives into eq (2) we get

*This is only a first approximation. Actually both the amplitude and the frequency of the oscillations vary during the transient. But the change in the frequency is usually small. Allowance for this change would yield in second approximation only a slight correction to the amplitude variation.

$$A'' \sin \omega t + 2A' \omega \cos \omega t - A \omega^2 \sin \omega t + (2\beta_0 + \gamma A^2 \sin^2 \omega t)(A' \sin \omega t + A \omega \cos \omega t) + \omega_0^2 A \sin \omega t = 0$$

After trigonometric transformations and equating to zero the coefficients of sin ωt and cos ωt separately, we obtain the two equations

$$\left.\begin{aligned} A'' + \left(2\beta_0 + \frac{3}{4}\gamma A^2\right) A' + (\omega_0^2 - \omega^2) A &= 0 \\ 2A' + \left(2\beta_0 + \frac{1}{4}\gamma A^2\right) A &= 0 \end{aligned}\right\} \quad (5)$$

Here the terms containing the triple argument $(3\omega t)$ are discarded by virtue of the initial assumption that the oscillation is sinusoidal [see eq (4)].

Equation (5) can be simplified further. The point is that the various terms of these equations have different orders of smallness. We assume that the function $A(t)$, which represents the variation of the amplitude, is a slowly-varying function.

This means that the changes in the amplitude are much slower than the voltage oscillations themselves. The function $f_1(t)$ is assumed to be slowly-varying compared with any other function $f_2(t)$, if its derivative $f'_1(t)$ is much less than the derivative $f'_2(t)$. For comparison it is first necessary to normalize the derivatives, for example, by dividing by the rms values of the functions themselves.

The absolute value of the derivative of the function that represents the oscillation, i.e., of $U = A \sin \omega t$, does not exceed ωA. Denoting the derivative of the envelope $A(t)$, by A', we can write the condition for the slowness of $A(t)$ in the form

$$|A'| \ll \omega A$$

In other words, the quantity A' is of first-order of smallness compared with ωA. But if this is so, then the second derivative of the function $A(t)$ will now become a second-order quantity compared with the second derivative of U, which is of the order $\omega^2 A$.

On the basis of these considerations, it is possible to eliminate from the first equation (5) the term A'', which is of second order compared with the last term.

As a result we obtain instead of (5)

$$\left.\begin{aligned} \left(2\beta_0 + \frac{3}{4}\gamma A^2\right) A' + (\omega_0^2 - \omega^2) A &= 0 \\ 2A' + \left(2\beta_0 + \frac{1}{4}\gamma A^2\right) A &= 0 \end{aligned}\right\} \quad (6)$$

The equations obtained by crossing out the higher-order terms are called simplified equations. The simplification of equations is a general procedure in the method of slowly-varying amplitudes. It makes it possible to reduce the order of

RUSSIAN TRANSLATIONS

the equation and simplify the structure. Incidentally, in our case these advantages will remain unused, since we shall employ only the second of the two equations in (6). This has not been simplified.

Eqs. (6) are nonlinear, since the coefficients depend on the amplitude. Let us first find the steady-state amplitude and frequency from these equations.

In the steady-state mode $A' = 0$ and $A = A_0$. The first equation gibes immediately

$$\omega = \omega_0$$

and from the second equation

$$A_0 = \sqrt{-\frac{8\beta_0}{\gamma}} \qquad (7)$$

or expressing β_0 and γ in terms of the initial parameters

$$A_0 = \frac{2}{\sqrt{3}}\sqrt{\frac{a_1}{a_3} - \frac{2\alpha}{\omega_0^2 M a_3}} = \frac{2}{\sqrt{3a_3}}\sqrt{S_0 - \frac{R'}{M}} \qquad (8)$$

This is the same value we would have obtained from eq (7) of Section 20 by putting $a_5 = 0$. We see that the oscillation amplitude is determined by the nonlinearity, which is expressed in our case by the coefficient a_3; the amplitude depends also on the attenuation of the tank circuit proper, on the initial transconductance, and on the extent of the feedback.

If we examine eq (8), we see that the amplitude diminishes with increasing nonlinearity (i.e., with increasing a_3); the greater the margin with which the self-excitation condition, i.e., condition

$$S_0 > \frac{R'}{M}$$

is satisfied, the greater the amplitude.

Let us now find the law by which the ampli-

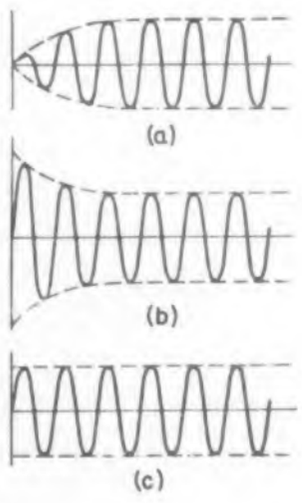


Fig. 73. Steady state oscillations may be established after various initial conditions.

tude assumes it steady state, i.e., the function $A(t)$, using the second equation of (6). To solve this equation we multiply each term by A, so that we can write

$$\frac{dA^2}{dt} + \left(2\beta_0 + \frac{1}{4}\gamma A^2\right)A^2 = 0$$

Separating the variables

$$\frac{dA^2}{\left(2\beta_0 + \frac{1}{4}\gamma A^2\right)A^2} = -dt$$

We expand the left hand side of this equation into partial fractions

$$\frac{dA^2}{A^2} - \frac{d\left(2\beta_0 + \frac{1}{4}\gamma A^2\right)}{2\beta_0 + \frac{1}{4}\gamma A^2} = -2\beta_0\, dt$$

Integrating, we get

$$\ln A^2 - \ln\left(2\beta_0 + \frac{1}{4}\gamma A^2\right) = -2\beta_0 t + C$$

or

$$\ln\left(\frac{1}{4}\gamma + 2\beta_0\frac{1}{A^2}\right) = 2\beta_0 t - C$$

hence

$$\frac{\gamma}{8\beta_0} + \frac{1}{A^2} = \frac{1}{2\beta_0}e^{-C}e^{2\beta_0 t} = Be^{2\beta_0 t}$$

and finally [see (7)]

$$A(t) = \frac{A_0}{\sqrt{1 + De^{2\beta_0 t}}}$$

In this expression $D = BA_0^2$ is a constant of integration, determined by the initial conditions. Depending on the value of D, the amplitude at the first instant can have values of A_0 which are either less or greater than the steady-state ones, or may be exactly equal to the steady-state values when $D = 0$). The quantity β_0 is the resultant initial attenuation factor. This quantity is always negative—this is inherent in self-excitation. Taking this into account, we see that the exponential term under the radical will diminish with time, and we will obtain in the limit (when t approaches infinity) the steady-state value of the amplitude, as given by eq (7).

Fig. 73 shows the establishment of the steady-state oscillations for various initial conditions. The physical meaning of the various initial conditions is best determined by using a graphic representation of the settling process, as will be done in Section 23.

(To be continued.)

Open Hearing

Dear Sir:

I fear that the audio portion of your Design '59 (Jan. 7 *ED*) is not beyond challenge.

When you say "sound reproduction has been developed to the point where further improvement probably could not be heard," you are being far too optimistic. As applied to present day commercial loudspeakers, pickups, and tape equipment, this simply isn't so.

Talking about turntable speed control, you say "frequency at any one time may be as much as five per cent off." As applied to most of the users of phonographs, this is rather pessimistic. Most power users today are served from network sources; these have sensitive frequency recorders on the line at all times. A brief checkup seems to indicate an absolute peak deviation of 0.05 per cent as much more realistic. Granted that you can point to a summer hotel with its own waterwheel generator, or a little gasoline driven control station in Northern Minnesota. In such cases the frequency is so unsteady, and perhaps cyclically modulated, that a mere speed adjustment would mean little. These examples are not of any statistical or practical significance.

You complain about lack of measurement standards and refer especially to turntable noise. There has been an NARTB standard in this field since 1953, and if truly "no one" is able to compare, it is not for lack of a standard.

C. J. LeBel
Audio Instrument Company, Inc.
135 West 14th Street
New York 11, New York

▶ There are several methods used to relieve overload on a power system including: (1) voltage reduction; and (2) reduction of frequency. When equipment becomes overloaded, frequency on the system may be dropped slightly. While few power systems suffer equipment shortages that would force them to resort to this scheme, it is always a possibility to consider. The 60 cps supply was not intended as a frequency standard.

There is no argument that the standards for

LETTERS

measurement exist. But the problem is having manufacturers interpret them properly.

Lack of Communication

Dear Sir:

While perusing the article concerning communication in the January 7, 1959 issue of ELECTRONIC DESIGN, it was rather disconcerting to read in the section on meteor communication the statement that "design engineers will have to come up with something to detect a useable trail, start a transmitter, etc . . . ". This in view of the fact that meteor-burst communication links for both teletype and voice have been developed and operated successfully by the Canadian Defense Research Board, National Bureau of Standards, Naval Electronics Laboratory, Stanford Research Institute (for AFCRC), and others; in the case of the Canadian group, as long ago as 1955.

This work has been described in many of the leading electronic and scientific periodicals notably the IRE Proceedings for December 1957. Ferranti Electric Ltd. of Canada even markets a package meteor-burst teletype system. This does not mean to imply that the meteor-trail propagation mode is understood sufficiently to make possible optimum system design. On the contrary, a tremendous amount of theoretical study and experimentation will be required to achieve this end. But the contributions already made have been most encouraging and to say the least, spectacular.

Russell Wolfram, Research Engineer
Stanford Research Institute
Menlo Park, Calif.

► True, meteor-burst systems have been in limited use for some time. But the real problem is to determine when to turn them on. That is, detecting a useable meteor trail, then sending as much information as possible over the link while the trail is still in existence. All this involves, for example, ways to store the necessary information and have it available for instant transmission. There is still a great deal of work to be done to make the method practical.

STANDARDS AND SPECS

Sherman H. Hubelbank

FM Receiver Measurements

IEC No. 91, Recommended Methods of Measurement on Receivers for Frequency-Modulation Broadcast Transmissions

Use of this publication enables comparison of the performance of radio receivers for fm sound broadcasting in the range of 87.5 to 108 mc, as determined by different observers. A catalog of selected measurements recommended for assessing the essential properties of these receivers is neither mandatory nor limiting. A choice of measurements and additional measurements can be made in each case. Methods proposed in this standard assess the performance of the particular receiver without going into the details of the apparatus or its components. Sensitivity, interference, frequency response, distortion, stability, and other aspects are covered. Copies of this publication may be purchased from ASA.

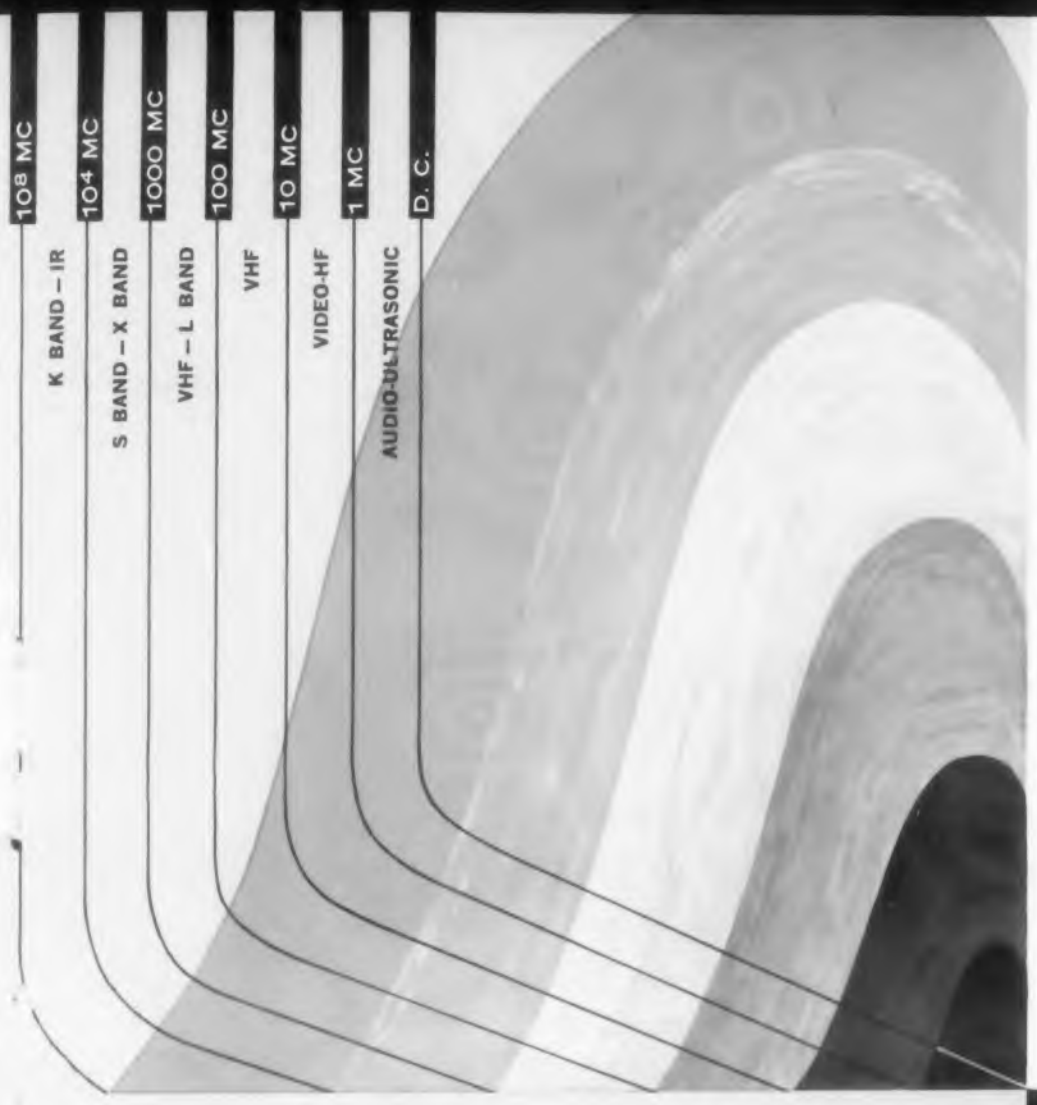
Measurements

ASME PTC 19.14, Linear Measurements, 1958

Contains descriptions and illustrations of the following types of instruments which are used to obtain the linear dimensions of objects: tapes, rules and scales, calipers, dividers, slide calipers, depth gages, vernier calipers, vernier depth gates, micrometer calipers, thickness gages, gage blocks, etc. Copies of this publication are available from the American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N.Y., for $1.50 per copy.

ASME PTC 19.12, Measurement of Time, 1958

Describes the following types of time keepers: general purpose clocks, chronometers, clocks or regulators for indicating time to the nearest second, astronomical clocks, watches, stop watches, timers, chronographs, and oscillographs. Methods that are available for measuring time and time intervals are also included. Copies of this publication are available from the American Society of Mechanical Engineers, 29 West 39th Street, New York 18, N.Y., for $1.50 per copy.



Engineering Challenge Across the Spectrum–

FROM DC TO IR

Light Military demonstrates a breadth of professional opportunity unique in the industry—opportunity created by a range of products which span the entire electromagnetic spectrum.

Equally important however, to engineers seeking long term futures, is the fact that this diversity contributes to a high order of growth in staff, contracts and facilities.

These two factors—diversification and growth—provide the engineer joining LMED with a firm career foundation, whether he seeks professional advancement in managerial or scientific consulting positions.

AUDIO-ULTRASONIC
JET ENGINE CONTROLS
MISSILE GUIDANCE
NUCLEAR DETECTORS
LOGIC CIRCUITRY
SONAR

VIDEO-HF
DATA PROCESSING
DIGITAL SUB-SYSTEMS
DISPLAY DEVICES

VHF
SPACE COMMUNICATIONS
SONAR RECEIVERS

VHF – L BAND
SEARCH RADAR
DATA LINK

S BAND – X BAND
FIRE CONTROL RADAR
SURVEILLANCE RADAR
ELECTRONIC FUZES
BOMB/NAV RADAR

K BAND – IR
NAVIGATION-DOPPLER RADAR
IR DETECTION & SURVEILLANCE

MULTI-BAND ACTIVITIES
MISSILE GUIDANCE &
IR TERMINAL GUIDANCE
ELECTRONIC COUNTERMEASURES
AUTOMATIC TEST EQUIPMENT

LMED
LIGHT MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

FRENCH ROAD, UTICA, NEW YORK

First Class
Permit No. 579
Utica, N.Y.

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

POSTAGE WILL BE PAID BY

Mr. William Gilmore
General Electric Company
Light Military Electronics Department
French Road, Utica, New York

For details of the specific engineering challenge...and the advanced programs offered, turn to the reverse side of this page ▶

ENGINEERS — EE, ME, PHYSICISTS

LET'S GET SPECIFIC ABOUT DIVERSITY

A few examples of projects now in progress at Light Military are described below. Each of them provides opportunities for — and often demands — contributions advancing the state of the art ▼

A SOUND BASIS FOR CAREER GROWTH

Because of Light Military's wide-ranging diversification, our future — and yours too, when you join LMED — is *not* dependent on the success or continuation of any single program. This is well documented by Light Military's 600% growth in Engineering Staff since the Department's inception, 6 years ago.

— a few more advantages at LMED to consider:

Graduate Study Plan that covers the cost of tuition and textbooks at a local graduate school.

An Opportunity to Consult with top scientists in G.E. laboratories and gain access to the newest technical concepts.

In-Plant Courses provide broad coverage in technical and managerial subjects — are open to all professional personnel.

Comprehensive Orientation Program assists new professional personnel in feeling "at home" immediately.

Top Salaries that range to $16,000 for current professional openings.

G.E.'s Famous Benefit Program that includes comprehensive insurance and the valuable savings and security plan.

For your family Utica is a modern, growing city located in New York State's famous Mohawk Valley. Close at hand are skiing, hunting, hockey, fishing, swimming, boating, golf, tennis. City and suburban housing of all types, well-staffed schools and excellent stores round out a picture of full family living in an invigorating 4 seasons climate. Relocation assistance is furnished to help you find a home (house or apartment) and offer counsel on all aspects of your relocation. In addition, we pay moving and transportation costs for you and your family.

MAJOR PRODUCT GROUPINGS AT LIGHT MILITARY INCLUDE:

Airborne Early Warning and Control Systems / Airborne Electronic Warfare Systems / Airborne Fire Control and Bombing Equipment / Airborne Navigation Systems and Equipments / Automatic Test Equipment / Aircraft and Space Communications Systems / Digital and Analog Computers / Missile Guidance and Control Equipment / Undersea Warfare Systems

Investigate the career opportunities that exist for you at Light Military right now. To make your initial contact most convenient, use the postcard at right. Simply fill it out, and mail today. ▶

"CLAIRVOYANT" COUNTERMEASURES

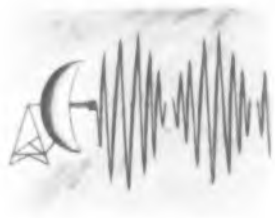
Light Military's "intelligent" airborne ECM Intercept System will have the capability of detecting **and defeating** enemy radar devices **automatically.** The system will appear clairvoyant by instantly analyzing radiations from enemy systems, making decisions and immediately responding with counter-radiations to provide continuous protection for our aircraft.

MASTERING THE VARIABLES FOR POLARIS TRAJECTORIES

As one of its functions, the fire control computer now under development at LMED keeps the submarine-borne Polaris in constant readiness to fire, with a freshly calculated trajectory towards its pre-programmed target. The system will operate **continuously,** calculating new trajectories as a function of the submarine's location and attitude, and inserting them into the memory circuits of the missile's guidance system.

AEW WITH THE AUTOMATED VOICE OF COMMAND

This new concept in Airborne Early Warning and Control will provide protection for a mobile unit by detecting enemy aircraft at unprecedented ranges, tracking, adapting itself to changing combat situations, and transmitting tactical data automatically to combat information centers. The system will match a 3-Dimensional radar with novel correlation techniques and an automated data handling system which — for the first time — will practically eliminate Man from the control loop.



PROGRAMS WE'RE PROUD OF BUT CAN'T REVEAL

There are a number of highly classified programs under way at Light Military that embody some of the most advanced electronics concepts. Among them are Bomb/Nav, Surveillance, and Fire Control Radars that utilize such techniques as frequency diversity, signal correlation and signal analysis methods of obtaining high order resolution.

LMED

LIGHT MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

FRENCH ROAD UTICA, NEW YORK

29-MK

Mr. William Gilmore:

I am interested in professional career opportunities at Light Military.

Name_____

Home Address_____

City_____ Zone____ State_____

Phone_____

Degree (s)_____

Year (s) Received_____

I am particularly interested in the following technical areas:_____

(U.S. citizenship or Secret clearance required.)

Airborne Radio

Revisions to the following were issued by the Radio Technical Commission for Aeronautics, dated 13 November 1958:

14-53/DO-48, Minimum Performance Standards Airborne Radio Communication Transmitting Equipment, Operating Within the R-F Range of 1.5-30mc

15-53 DO-49, Minimum Performance Standards Airborne Radio Communication Receiving Equipment, Operating Within the Range of 1.5-30mc

87-54 DO-57, Minimum Performance Standards Airborne Radio Marker Receiving Equipment Operating on 75mc

87-55 DO-64, Minimum Performance Standards Airborne Radio Communication Receiving Equipment Operating Within the R-F Range of 118-132mc

88-55 DO-65, Minimum Performance Standards Airborne Radio Communication Transmitting Equipment Operating Within the R-F Range of 118-132mc

89-54 DO-59, Minimum Performance Standards Airborne ILS Localizer Receiving Equipment

225-55 DO-69, Minimum Performance Standards Airborne VOR Receiving Equipment Operating Within the R-F Range of 108-118mc

45-57/DO-78, Minimum Performance Standards Aircraft Audio and Interphone Amplifiers

83-56/DO-70, Minimum Performance Standards Airborne Radio Receiving and Direction Finding Equipment Operating Within the Range of 200-415kc

100-54/DO-60, Environmental Test Procedures, Airborne Radio Equipment

Copies of these revisions may be obtained from the Radio Technical Commission for Aeronautics, Room 1072, Building T-5, 16th & Constitution Ave., N.W., Washington 25, D.C.

Don't forget to mail your renewal form to continue receiving *ELECTRONIC DESIGN.*

◀ CIRCLE 881 ON READER-SERVICE CARD

COMPUTER ENGINEERS

HERE ARE THE TYPES OF ENGINEERS WE NEED:

- ***SENIOR SYSTEMS ENGINEERS***
- ***SENIOR CIRCUIT DESIGNERS***
- ***SENIOR LOGICAL DESIGNERS***
- ***SENIOR ELECTRONIC DESIGN ENGINEERS***

COMPUTER ENGINEERS:

Senior Systems Engineers—Strong Theoretical and Design Knowledge in Electronic Engineering, including familiarity with electromechanical digital machines. Prefer experience with commercial application of digital-processing equipment, will consider scientific or defense application. Operational experience a distinct asset. Advance degree desired.

Your Work at NCR—analyze and direct product improvement of digital computers.

Senior Circuit Designers—experienced in the design, development and analysis of transistorized computer circuits, including application of magnetic cores to high-speed memories.

Your Work at NCR—opportunities involving decision making concerning reliability, cost and component selection are offered.

Senior Circuit and Logical Designers—similar experience and duties as noted for Senior Circuit Designers plus evaluation and debugging arithmetic and control areas of computer systems.

DATA-PROCESSING ENGINEERS:

Senior Electronic Design Engineers—experienced in the development of logical design using standard computer elements.

Your Work at NCR—to evaluate and design transistorized circuits including voltage regulated power supplies and circuitry related to decimal to binary coding.

WHERE YOU WILL WORK . . .

at NCR's NEW Engineering Research Center, Dayton, Ohio.

You'll be working under the most stimulating and advanced R and D facilities with broad creative freedom in the engineering field which is *yours*.

HOW DO I APPLY?

Simply send your résumé to: Mr. K. C. Ross, Professional Personnel Section C, The National Cash Register Company, Dayton 9, **Ohio.**

* TRADEMARK REG. U.S. PAT. OFF.

*National**

VERSATILE DATA PROCESSING
ADDING MACHINES • CASH REGISTERS
ACCOUNTING MACHINES • NCR PAPER

THE NATIONAL CASH REGISTER COMPANY, DAYTON 9, OHIO

ONE OF THE WORLD'S MOST SUCCESSFUL CORPORATIONS

75 YEARS OF HELPING BUSINESS SAVE MONEY

CIRCLE 871 ON READER-SERVICE CARD

ENGINEERS

A FINER CLIMATE

TO WORK IN...

...TO LIVE IN

At Sylvania's Mountain View Operations in California
(SAN FRANCISCO BAY AREA)
you'll discover more than just one kind of climate.

PROFESSIONAL CLIMATE—Advanced programs will challenge your technical creativity. You'll make major contributions in the fields of electronic defense, radar, communications and data processing systems. Because Sylvania is one of the nation's fastest growing electronics organizations, there are an unusual number of growth opportunities.

LIVING CLIMATE—You and your family will enjoy the healthful atmosphere and sunny climate of the San Francisco Peninsula. You'll find plentiful housing, excellent shops, fine schools and year round recreation.

Openings in:

System Studies / Circuit Design / Computers & Data Handling / Electronic Packaging / Development Engineering / Concept & Planning / Advanced ECM Circuitry / Equipment Development / Product Engineering / Tube Engineering / Tube Application Engineering / Mechanical Engineering / Tube Production Engineering / Theoretical Physics / Experimental Physics / Mathematics / Microwave Engineering.

You may communicate in confidence to Wayne L. Pearson
MOUNTAIN VIEW OPERATIONS

SYLVANIA
SYLVANIA ELECTRIC PRODUCTS INC.

P.O. Box 188
Mountain View, California

Tektronix, Inc.

Portland, Oregon

A manufacturer of universal recognition in cathode ray oscilloscopes and allied instrumentation, Tektronix is continually seeking to advance the oscilloscope art. To this end we rely on internal design of fundamental components as well as complete instruments.

Creative physicists and engineers with experience in vacuum and cathode-ray tube design, semi-conductor research, and circuit design will be interested in a program of major expansion in our Engineering Division.

For further information please contact Mr. Robert Mitchell, Barbizon-Plaza Hotel, New York City, March 20, 21 and 23 through 27.

CIRCLE 872 ON READER-SERVICE CARD

name your sport

Whatever your sport, you'll find it in abundance in Florida and you can enjoy an interesting career to boot with fast-growing Radiation, Inc. The climate here is ideal for outdoor sports the year around.

We have many openings for challenging and rewarding work in electronic design and development. Radiation is well known in DATA PROCESSING, TELEMETRY, ANTENNAS, INSTRUMENTATION, and other areas of MISSILE ELECTRONICS. Our stable growth indicates a secure future with professional advancement for qualified electronic engineers with ideas and energy.

Write today for complete details on opportunities available.

Technical Personnel Dept. 37

RADIATION, Inc.

MELBOURNE, FLORIDA

CIRCLE 883 ON READER-SERVICE CARD

FROM CONCEPT TO HARDWARE

ENGINEERS

See your personal efforts integrated into the total flight system with a prime contractor...

REPUBLIC AVIATION

It's an unnerving experience, in this era of systems engineering, for a man to work long and hard on a subsystem or component project and then see the product of his labor leave the plant in a packing case on its way to a prime contractor for systems installation. How different is the picture at Republic Aviation! Working for this prime systems contractor you will have the opportunity to see the total flight system take shape and the satisfaction of seeing your personal efforts become an important part of it. You'll broaden your experience and professional interests by working with capable men from varied disciplines on advanced electronics for every type of flight vehicle-from guided missiles to helicopters.

Decide NOW to join this Prime Contractor

Gain accelerated advancement by becoming a ground floor participant in Republic's $35 million R&D program aimed at bringing about substantial breakthroughs in aeronautics and space technology. A new order of career progress is waiting for engineers and scientists at Republic Aviation.

Investigate these electronic opportunities with Republic

Inertial Guidance & Navigation / Digital Computer Development / Systems Engineering / Information Theory Telemetry-SSB Technique / Doppler Radar / Countermeasures Radome & Antenna Design / Microwave Circuitry & Components Receiver & Transmitter Design / Airborne Navigational Systems Jamming & Anti-Jamming / Miniaturization-Transistorization Ranging Systems / Propagation Studies Ground Support Equipment

NEW YORK INTERVIEWS DURING IRE NATIONAL CONVENTION

Plan now to visit Republic representatives at the Convention Hotel (March 23-26)

Please send resume in complete confidence to:

MR. GEORGE R. HICKMAN
Engineering Employment Manager, Dept. 12C-3

REPUBLIC AVIATION

Farmingdale, Long Island, New York

ADVERTISERS' INDEX

March 18, 1959

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE • DALLAS 9, TEXAS

Advanced facilities permit work of highest caliber.

company*

from over 800 to almost 8,000 and Sales have increased from under $5,000,000 to over $91,000,000.

Six major resorts and fishing lakes are within one hour of Dallas. Dallasites own 38,700 outboards; are served by a dozen boat manufacturers and 40 boat retailers. Houston, of course, is "next door" to Galveston, nationally known seaside resort.

Expand your professional potential where you and your work are recognized as vital. Enjoy a favorable engineering climate, major factor in the swift, steady growth of this dynamic company now in its 29th year *and still expanding!*

If you have a high order of ingenuity, technical skill and engineering ability, you can hit your stride at Texas Instruments — now one of the 500 largest industrial companies in the country. In association with outstanding colleagues, you can explore new horizons in any of a wide choice of fields:

apparatus division **Design, development and manufacture of systems —reconnaissance, airways control, antisubmarine warfare, missile and anti-missile, countermeasures, airborne early warning, navigation, attack control, and engine control. Equipments, including: radar, infrared, sonar, magnetics, digital circuits, timers, telemetering, intercom, microwave, optics, detector cells, engine instruments, transformers, time standards, and other precision devices.**

Please write **J. R. Pinkston, Dept. 1101** CIRCLE 877

semiconductor-components division **Design, development and manufacture of semiconductors — transistors, diodes, rectifiers — and other electronic components including capacitors and resistors. Special studies in materials purification and analysis, surface treatment, circuit design, and circuit applications. Design of mechanized production and test equipment. Supervisory positions in manufacturing engineering and production management.**

Please write **H. C. Laur, Dept. 1101** CIRCLE 878

central research laboratory **Basic and applied research in solid state physics, materials, devices, data systems, and earth sciences with particular emphasis on semiconductors, electroluminescence, ferromagnetics, resonance, low temperature phenomena, dielectrics, infrared, geophysics, digital techniques, masers, memories, and transistors; physico-chemical studies of diffusion, alloying, crystal growth, and crystalline structure.**

Please write **A. E. Prescott, Dept. 1101** CIRCLE 879

industrial instrumentation division **Design, development and manufacture of commercial electronic and geophysical instrumentation including data gathering, recording and processing; circuit and instrument packaging; meter movements and transducer elements; remote measurement and control systems. *(NOTE: This division is located in Houston.)***

Please write **D. G. Turner, Dept. 1101** CIRCLE 880

Come grow with us in the pleasant climate of highly sophisticated Southwestern cities, Dallas or Houston — each large enough to be urbane, small enough to be neighborly. Modern plants are within the city but away from downtown traffic . . . near fine residential areas. You will live within minutes of year-around recreational, amusement and cultural activities.

Sailing on White Rock Lake; within Dallas.

(Continued on Cover III)

Regulated Transistor Power Supplies

E. Brenner

CONSTANT supply voltages, required in transistorized equipment, demand regulated power supplies which can be well attained with transistor circuits. A comparison of three regulator methods shows that circuits in which transistors are used as switches have certain advantages over those circuits in which a control transistor is continuously in the circuit.

A typical regulator, in which a transistor is continuously in series with the load ("series compounding") is shown in Fig. 1. A reference voltage is derived from a zener diode and compared to a fraction of the output voltage. The difference is amplified and used to control the series transistor so as to minimize the error. The circuit is characterized by comparatively large power dissipation in the control transistor (see Table) but has low hum content in the output.

The losses in the control transistor can be reduced materially by use of a switched transistor as in the "two-point" circuit, Fig. 2. The error voltage in this circuit activates a Schmitt trigger which gates the control transistor as the tolerated error is exceeded. At full load and overvoltage, power loss occurs in the series resistor R_s. The efficiency is the same as in Fig. 1 but the transistor loss is reduced. The maximum current is limited by the peak collector current of the series transistor. A continuously varying output

Comparison of the Properties of Three 12v 100 ma regulated transistor power supplies.

	Continuous Regulator Fig. 1	Two-point Regulator Fig. 2	Controlled Rectifier Fig. 3
Output Impedance ohms	0.3	0.3	0.5
Voltage variation for 10% input variations (%)	0.2	0.2	0.2
Overall Efficiency at full load and 10% overvoltage (%)	45	45	60
Loss in control transistors at full load and 10% overvoltage (mw)	600	50	100
Control speed	high	high	low
Output noise voltage at full load (mv eff.)	1	20	60

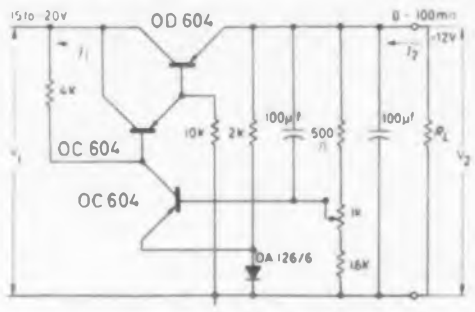


Fig. 1. Regulated power supply using a continuously active transistor.

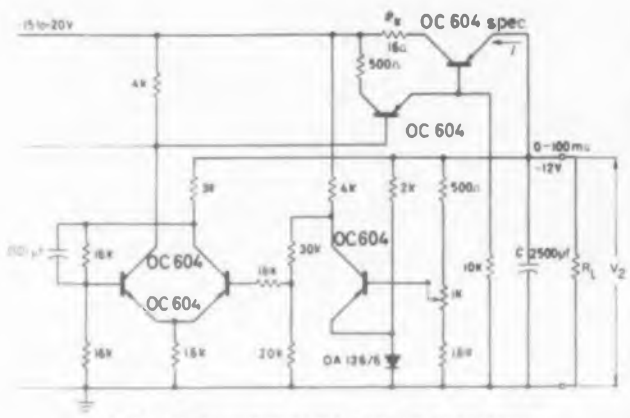


Bild 6. Stabilisierschaltung mit Transistor-Zweipunktregler

Fig. 2. Regulated power supply using transistor two-point control.

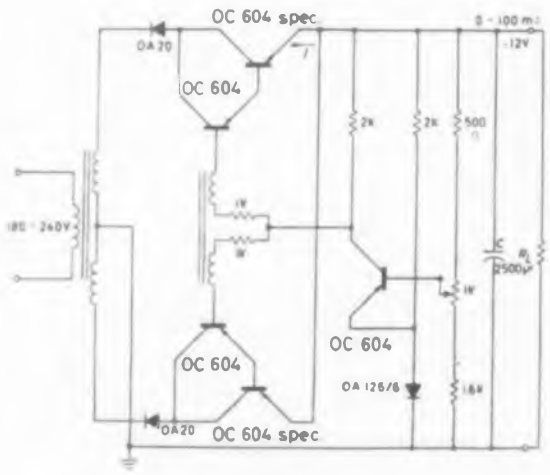


Fig. 3. Transistor controlled rectifier.

voltage is necessary for operation (see output noise voltage in Table).

In the controlled rectifier (Fig. 3), the conduction angle is controlled in the same manner as in power Thyratron circuits. Hum voltages are therefore not reduced by the regulator action: only the filter counteracts this component of the noise. Except for this error, it is possible in practice to obtain perfect regulation with this circuit.

Comparison between the three circuits is made in the Table. The efficiency values include a 66 per cent transformer efficiency figure.

Abstracted from an article by G. Meyer Broetz, Elektronische Rundschau, *Vol. 12, No. 10, October 1958, pp 342-344.*

GERMAN ABSTRACTS

E. Brenner

Noise In Silicon Diodes And Transistors

ON THE BASIS of the Shockley diffusion equation, it can be shown that, for a p-n junction, noise current through noise resistance R_n is given by

$$\overline{i_n^2} = 4KT\,\Delta f/R_n \qquad (1)$$

where

$$2R_n = R\,[1 + exp\,(-eV/kT)] \qquad (2)$$

and

$$R = \frac{kT}{e\,(I_D + I_o)}$$

I_o = saturation current

I_E = diffusion current

While this formula is adequate for alloyed germanium diodes, significant deviations occur for silicon junctions. One of the reasons for these deviations is the recombination and generation of carriers in the depletion layer. On the basis of this theory, the equivalent noise resistance can be shown to be half of the total (differential) resistance in the forward direction.

The mean squared noise current is calculated (using certain simplifying assumptions which are eventually justified by experimental confirmation) by adding the contributions due to recombination and diffusion. The result is the formula

$$\overline{i_n^2} = 4kT\,(Re\,Y)\,\Delta f - 2eI\,\Delta f/m \qquad (3)$$

where Y is the total junction admittance, I is the total current through the junction and m is an empirical parameter which is determined by fitting the dc volt-ampere curve of the diode to the form $I = I_o' \exp(eV/kTm)$. Usual values of m are between one and two. At low frequencies, for $I \gg I_o$, an adequate approximation for Y is

$$Re\,Y + eI/mkT$$

and then

$$\overline{i_n^2} = 2eI\,\Delta f/m \qquad (4)$$

so that using an equivalent noise resistance R_n,

$$2\,R_n = 1/ReY \qquad (5)$$

To take the recombination effect into account for transistor noise calculations, two separate diodes are calculated. Eq. (3) applies to the emitter noise if Y is replaced by Y_{11}, the short circuit input admittance of the intrinsic transistor and I and m are replaced correspondingly by I_e, m_e. The collector noise can be approximated by

$$\overline{i_n^2}C = 2eI_c\,\Delta f \qquad (6)$$

The noise factor is approximated by

$$F = \frac{2eI_e[(1/Y_{11} + R_e + R_b)/\alpha_{fb}]^2 - 2eI_e(R_b + R_e)^2/m_e}{4kT\,R_n} \qquad (7)$$

where

R_b = base resistance

R_e = source resistance

α_{fb} = ac current amplification factor in the common base configuration.

The original paper includes experimental results as well as other analytical work and proofs.

Abstracted from an article by B. Schneider and M. J. O. Strutt, Archiv der Elektrischen Uebertragung, *Vol. 12, October 1958, pp 429-440.*

Polynomial Approximation for Complex Transfer Functions

IN THE synthesis of two-ports, it is often the practice to approximate the desired amplitude response and subsequently to correct the phase response with cascaded all-pass two-ports. It is, however, possible to form polynomials so that in a given band of frequencies, both amplitude and phase response can be approximated with any desired degree of accuracy.

The frequency band over which the approximation is to hold is normalized to be the band $0 \leqslant \omega \leqslant 1$. The problem can then be formulated as follows:

A given complex function $F(j\omega)$ is to be ap-

proximated in the stated band by an *n*th order *Hurwitz* polynomial. Since the roots of this polynomial $F^{(n)}(p)$, where p is the complex frequency variable, must have negative real parts, the angle of $F(j\omega)$ must increase monotonically with increasing frequency and the locus of $F(j\omega)$ must encircle the origin $n/4$ times where n is the order of the approximating polynomial. If ϕ_o is the angle of $F(j)$, n is chosen by the rule

$$\phi_o \gtrsim n\ \pi/4$$

where the inequality is used for $n > 6$.

According to the scheme mentioned below, m points on the complex locus $F(j\omega)$ are chosen and it is desired that the approximating polynomial exhibit least squared error property. Using the substitution

$$\omega = \cos\theta$$

the approximating polynomial can be written as

$$F^{(n)} = a_o + a_1\cos\theta + a_2\cos\theta + \ldots + a_n\cos n\theta \quad (2)$$

where the coefficients a_k are real for even values of k and imaginary when K is odd. While these coefficients can be evaluated analytically by expanding the real and imaginary parts of $F(j\omega)$ in Fourier series when F is known analytically, the schedule type method of Fourier analysis is well suited to this problem. The scheme for choosing the m points mentioned above consists then of calculating $F(j\omega)$ at the radian frequencies

$$k = \cos(k\ \pi/2m) \quad (3)$$

and the equation

$$F(\omega=1) = \sum_{k=0}^{m} a_{2k} + j\sum_{k=1}^{m} a_{2k-1} \quad (4)$$

serves as a check of the numerical work.

Once the coefficients a_k are known, the polynomial is obtained by the use of the *n*th order Tschebyscheff polynomial, $T_n(\omega)$, i. e.

$$T_n(\omega) = \cos(n\cos^{-1}\omega)$$

in Eq. 2 so that

$$F^{(n)}(\omega) = \sum_{k=0}^{n} a_k T_k(\omega) = \sum_{k=0}^{n} b_k \omega^k$$

Then, $F(p)$ is obtained by setting $\omega = -jp$ and the result is checked using the Routh criterion.

In the original paper, the procedure is illustrated in detail. The function

$$F = exp\ (\omega^2 + j\ 5\ \omega\ \pi/4)$$

is approximated by

$$F^{(5)} = 1.032 + 4.012p + 7.302p^2 + 6.824p^3 + 4.317p^4 + 0.877p^5$$

Abstracted from an article by E. Schuon, Frequenz, *Vol. 12, No. 10, October 1958, pp 318-323.*

MEETINGS

1959 IRE National Convention
Technical Program

All A. M. sessions begin at 10:00;
P. M. sessions at 2:30; Eve. sessions at 8:00

Abbreviation Key: Waldorf—Astor Gallery (A), Empire Room (E), Grand Ballroom (G), Jade Room (J), Sert Room (Se), Starlight Roof (St). Coliseum—Morse Hall (Mo), Marconi Hall (Ma), Faraday Hall (F).

Session and Number	Time and Location
Audio	
Contributions to Stereo Sound Reproduction (12)	Tues am-Se
Speech and Circuits (20)	Tues pm-Se
Automation and Control System	
Adaptive Control Processes and Allied Systems (1)	Mon pm-St
Theory and Practice in Russian Technology (40)	Thur am-St
Frontiers of Industrial Electronics (44)	Thur am-E
Broadcasting	
Broadcasting—I (11)	Tues am-J
Broadcasting—II (19)	Tues pm-J
Communication Engineering in Broadcasting (52)	Thur pm-Mo
Circuit Theory	
New Techniques for Analysis (9)	Tues am-St
The Statistical Theory of Signals and Circuits (25)	Wed am-St
Symposium on Sequential Circuit Theory (34)	Wed pm-A
Circuit Theory II—Analysis and Synthesis (41)	Thur am-A
Circuit Theory III—Applications (49)	Thur pm-A
Communications	
Vehicular Communications (2)	Mon pm-A
Communication by HF Radio and by Wire Line (37)	Wed am-Mo
Communication Engineering in Broadcasting (52)	Thur pm-Mo
Components	
Component Parts—I	Wed am-J
Component Parts—II	Wed pm-J
Concepts	
Concepts and Programs (51)	Thur pm-Se
Education	
Symposium: Psychology and and Electronics in the Teaching-Learning System (29)	Wed am-G

Session and Number	Time and Location
Computers and Data Systems	
Digital Telemetering (28)	Wed am-Se
Electronic Computers: Systems and Applications (33)	Wed pm-St
Symposium on Sequential Circuit Theory (34)	Wed pm-A
Theory and Practice in Russian Technology (40)	Thur am-St
Electronic Computers: Components and Circuits (48)	Thur pm-St
Instrumentation for High Speed Data Acquisition (54)	Thur pm-F
Electron Devices	
Electronic Devices (8)	Mon pm-F
Panel: Widening Horizons in Solid State Electronics (16)	Tues am-F
Human Engineering	
Man-Machine System Design (45)	Thur am-Mo
Information Theory	
Information Theory (17)	Tues pm-St
The Statistical Theory of Signals and Circuits (25)	Wed am-St
Theory and Practice in Russian Technology (40)	Thur am-St
Instrumentation	
Nuclear Instrumentation Techniques—I (10)	Tues am-A
Nuclear Instrumentation Techniques—II (18)	Tues pm-A
Instrumentation: Devices and Circuits (47)	Thurs am-F
Instrumentation for High Speed Data Acquisition (54)	Thur pm-F
Interference	
Radio Frequency Interference (4)	Mon pm-Se
Land and Space	
Navigation and Traffic Control (7)	Mon pm-F
Land and Space Electronics (15)	Tues am-Ma
Panel: Future Developments in Space (24)	Tues eve-St
Space Electronics (36)	Wed pm-Se
Military Electronics—Looks Forward (43)	Thur am-Se
Communication by HF Radio and by Wire Line (37)	Wed pm-Mo
Management	
Engineering Management Techniques (5)	Mon pm-E
Engineering Management—II (13)	Tues am-G

(Continued on page 184)

MEETINGS

Session and Number	Time and Location
Medical Electronics	
Medical Electronics—I (14)	Tues am-Mo
Medical Electronics—II (21)	Tues pm-Mo
Panel: Future Developments in Space (24)	Tues eve-St
Microwaves	
Microwave Tubes (23)	Tues pm-F
Microwave Devices (32)	Wed am-F
Microwave Theory and Techniques (39)	Wed pm-F
Military Electronics	
Panel: Future Developments in Space (24)	Tues eve-St
Military Electronics Looks Forward (43)	Thur am-Se
Navigation and Traffic Control	
Navigation and Traffic Control (7)	Mon pm-Ma
Panel: Future Developments in Space (24)	Tues eve-St
Production	
Production Techniques (6)	Mon pm-Mo
Propagation	
Communication by Scatter System (30)	Wed am-Mo
Propagation and Antennas—I (38)	Wed pm-Ma
Antennas—II (46)	Thur am-Ma
Communication Engineering in Broadcasting (52)	Thur pm-Mo
Antennas—III	Thur pm-Ma
Radio and TV Receivers	
Speech and Circuits (20)	Tues pm-Se
Radio and Television Receivers (26)	Wed am-A
Reliability	
Reliability Techniques (22)	Tues pm-Ma
Mathematical Approaches for Reliability (31)	Wed am-Ma
Russian Technology	
Theory and Practice in Russian Technology (40)	Thur am-St
Telemetry	
Digital Telemetering (28)	Wed am-Se
Ultrasonics	
Ultrasonic Engineering—I (42)	Thur am-J
Ultrasonic Engineering—II (50)	Thur pm-J
Writing and Speech	
Engineering Writing and Speech (3)	Mon pm-J

Figure Instruments

TWO NOISE FIGURE METERS

- MULTI-FREQUENCY; UP TO 5 SEPARATE INTERMEDIATE FREQUENCIES
- SPECIFY I-F'S YOUR SYSTEMS REQUIRE
- DIRECT READINGS, "NON-TECHNICAL" SIMPLICITY

THREE NOISE SOURCES

- I-F, VHF AND WAVEGUIDE NOISE SOURCES

340B Noise Figure Meter. Automatically measures and continuously displays rf or IF noise figure. Supplied with 30 and 60 MC standard intermediate frequencies, *or any two intermediate frequencies between 10 and 60 MC.** Independent adjustments on gas tube and diode current controls (diode control has vernier) insure highest accuracy settings. Meter offset provision permits use of high sensitivity external meter for expanding noise figure readings.

342A Noise Figure Meter. Multi-frequency model normally supplied to accept 60, 70, 105 and 200 MC intermediate frequencies plus 30 MC. *Also available with standard IF of 30 MC plus any 4 additional frequencies from 38 to 200 MC.** Like 340B, has front panel intermediate frequency selection, extreme operating simplicity, direct readings.

343A vhf Noise Source. 10 to 600 MC, a broad-band temperature limited diode noise source providing 5.2 db excess noise into 50 ohms. Specifically designed for use with 340B and 342A Noise Figure Meters. $75.00.

345B IF Noise Source. 30 and 60 MC, *or any two frequencies 10 to 60 MC.** Similar to 343A; front panel control selects frequencies; a second switch selects source impedances of 50, 100, 200 and 400 ohm impedances. 5.2 db excess noise. $75.00.

347A Waveguide Noise Sources. 2.6 to 18.0 KMC, six models covering S, G, J, H, X and P bands. Provide uniform excess noise of approximately 15.2 db over the full waveguide range. SWR is 1.2 or less, even when source is cold. Noise sources are Argon gas discharge tubes mounted in waveguide sections. $190.00 to $180.00.

Brief specifications of Models 340B and 342A are given here; for complete data on these instruments and new Noise Sources please call your Representative or write direct.

**On special order at slight extra cost.*

SPECIFICATIONS

Model 340B Noise Figure Meter

Frequency Range:	Depends on noise source used.
Noise Figure Range:	3 to 30 db, indication to infinity with Waveguide Noise Source. 0 to 15 db indication to infinity, with vhf and IF Noise Sources.
Zero Offset:	Permits low values to be read on sensitive external meter.
Accuracy:	Noise Diode Scale, ±0.5 db, 0 to 15 db. Gas Tube Scale, ±0.5 db, 10 to 25 db; ±1 db, 3 to 10 db and 25 to 30 db.
Input:	−60 to −10 dbm (noise source on). Corresponds to gain between noise source and 342A of:
	vhf or IF Noise Source, Approx. 50 to 100 db. Waveguide Noise Source, Approx. 40 to 90 db.
Input Frequency:	30 and 60 MC. Any two frequencies between 10 and 60 MC on special order.
Bandwidth:	1 MC minimum.
Input Impedance:	50 ohms.
Price:	$700.00 (rack mount). $715.00 (cabinet).

(Note: This instrument is available in the U.S.A. and Canada only.)

Model 342A Noise Figure Meter
(same as 340B except)

Input Frequency:	30, 60, 70, 105 and 200 MC. 30 MC and any four other frequencies between 38 and 200 MC are available on special order.
Price:	$800.00 (rack mount). $815.00 (cabinet mount).

(Note: This instrument is available in the U.S.A. and Canada only.)

Data subject to change without notice. Prices f.o.b. factory.

HEWLETT-PACKARD COMPANY

5189K PAGE MILL ROAD • PALO ALTO, CALIFORNIA, U.S.A.
CABLE "HEWPACK" • DAVENPORT 5-4451
FIELD REPRESENTATIVES IN ALL PRINCIPAL AREAS

major new instruments from hp

CIRCLE 479 ON READER-SERVICE CARD

TWO NEW RCA "FIRSTS"

0.6-watt heater-power Vidicons

...for transistorized TV cameras

RCA-7263 for Severe Environmental Conditions

RCA-7262 for Moderate Environmental Conditions

Lowest heater-power Vidicons in television today, these new short-length types are opening a new era in compact transistorized TV camera designs. Only $5\frac{1}{8}$ inches long, these remarkable camera tubes operate with only 0.6 watt of heater power—actually one-third less than any other commercial type Vidicon. Both types feature fast cathode warm-up time. And, thanks to a closely controlled photoconductive layer, both types *provide pictures with uniform background—and consistent performance from tube to tube.*

RCA-7263 is for use especially in new TV cameras designed for operation under severe environmental conditions involving shock, vibration, humidity, and altitude. This Vidicon type is tested in combination with associated components under environmental conditions according to the techniques of military specifications MIL-E-5272B and MIL-E-5400.

RCA-7262 is for use in new, compact camera designs for industrial and broadcast applications—where environmental requirements are moderate.

Want more details on these remarkable low-heater-power Vidicons? Just call your RCA Field Representative. Or, for comprehensive technical data on either or both types, write to RCA Commercial Engineering, Sec. C-18-R2, Harrison, N. J.

RADIO CORPORATION OF AMERICA

Electron Tube Division — *Harrison, N. J.*

Also Available at Authorized RCA Industrial Tube Distributors.

Visit the RCA exhibition at the N.Y. I.R.E. Show, Booths 1602-4-6, 1701-3-5-7

RCA Field Representatives are *here* to help you

INDUSTRIAL TUBE PRODUCTS SALES

- Newark 2, N. J., 744 Broad Street, HUmboldt 5-3900
- Chicago 54, Ill., Suite 1154, Merchandise Mart Plaza WHitehall 4-2900
- Los Angeles 22, Calif., 6355 E. Washington Blvd., RAymond 3-8361
- Detroit 2, Mich., 714 New Center Bldg., TRinity 5-5600

GOVERNMENT SALES

- Newark 2, N. J., 744 Broad St., HUmboldt 5-3900
- Dayton 2, Ohio, 224 N. Wilkinson St., BAldwin 6-2366
- Washington 6, D.C., 1625 "K" St., N.W., District 7-1260

March 18, 1959

ELECTRONIC DESIGN

HAYDEN PUBLISHING COMPANY, INC.
830 Third Avenue, New York 22, N.Y.