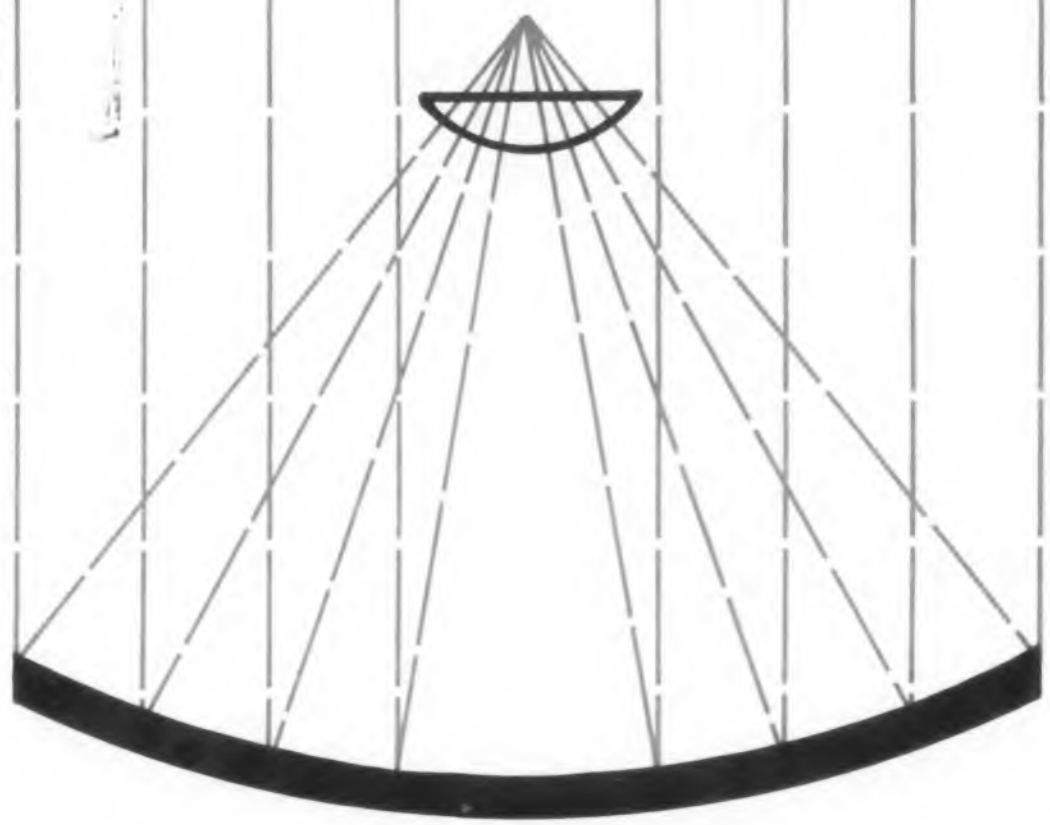
ELECTRONIC DESIGN

MAY 27, 1959



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ELECTRONIC DESIGN NEWS

EDITORIAL

FEATURES

DEPARTMENTS

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Molecular Electronics Stirs Thinking at Two Conferences

MICROMINIATURIZATION continues to generate vast interest in the electronics industry, but the focus is swinging ever sharper to the basic nature of the material rather than packaging. Invitations to pioneer in this new area of molecular electronics were issued at two key parleys this month—the 1959 Electronic Components Conference in Philadelphia and the National Aeronautical Electronics Conference in Dayton, Ohio.

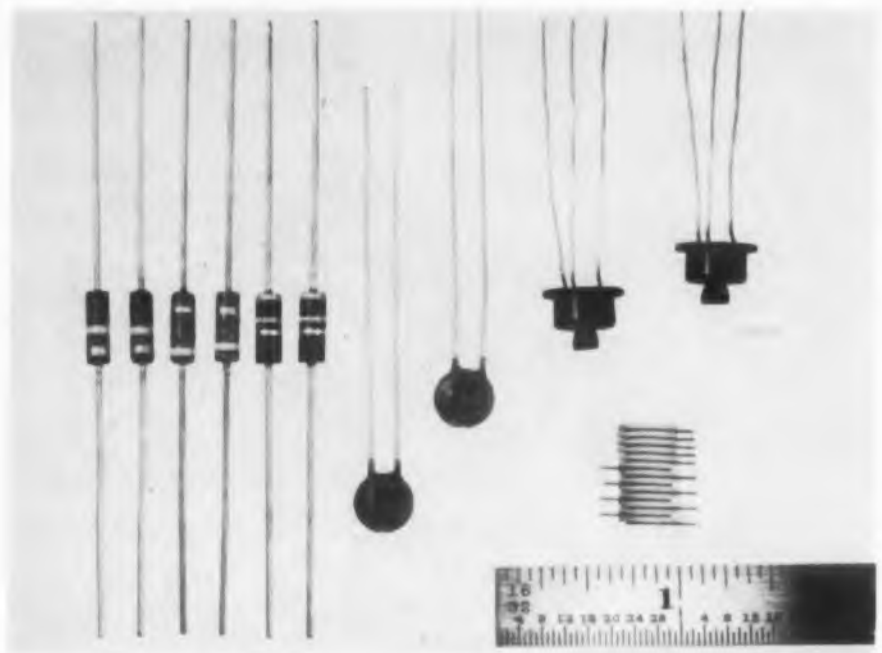
In a keynote address at the three-day Philadelphia gathering, Dr. Jack A. Morton, vice president of Bell Telephone Laboratories, advised system and component designers to "change their basic viewpoints and start asking different questions."

"The system designer must start at a new level of synthesis," he said, "specifying his needs only in terms of basic system functions with properly weighted objectives. This, in turn, will stimulate his imagination and effort to higher levels of sophistication in system organization and logical design."

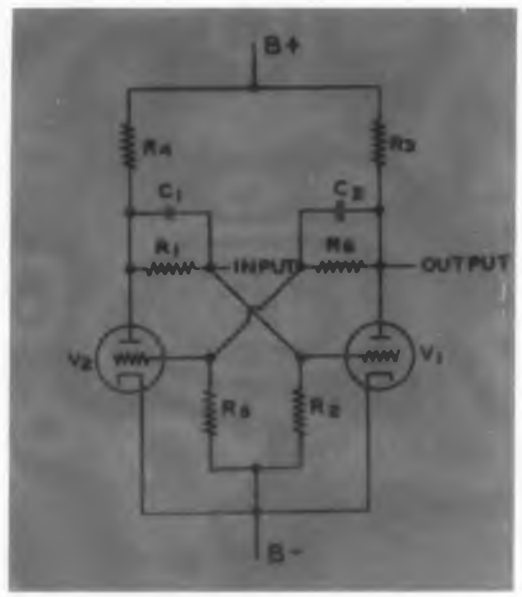
The component designer, Dr. Morton went on, must not be impeded by such circuit-element concepts as resistors, capacitors, inductance, tubes and transistors. "He must go directly to the physics of electrons, atoms, phonons and photons in seeking basic functions," the official said.

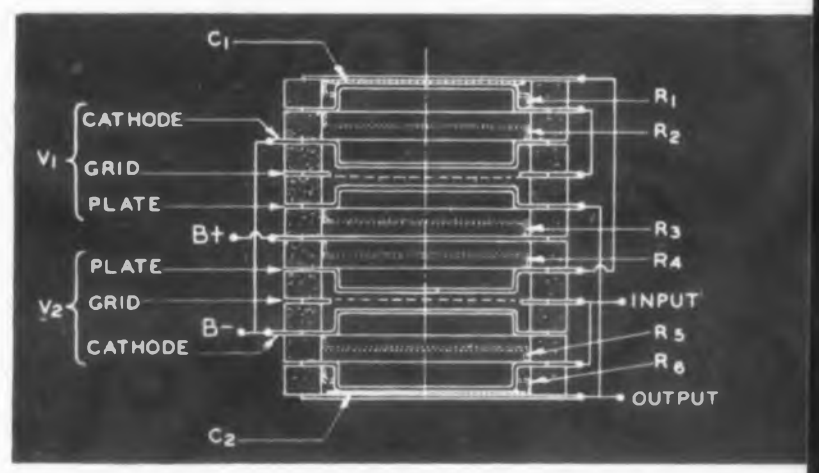
This view was supported by Donald G. Fink, director of research for the Philco Corp. Microminiaturization will be advanced, he asserted, by scientists and engineers working together. He called the engineers the "old timers" in the industry, and the scientists, such as physicists and chemists, the "new timers."

At the same time, Mr. Fink cautioned against the indiscriminate use of micro devices. Putting micromodules in television sets with large picture tubes or in radios with large speakers is not too sensible at present, he pointed out. But putting like units in space vehicles or in more compact



Module at lower right, a "red hot" operating unit, is called a TIMM. Designed by GE for space applications, it comprises the equivalent of conventional transistors, capacitors and resistors, with which it is shown.





Cross-section and schematic diagram of a typical TIMM, unveiled at the 1959 Electronic Components Conference.

NEWS

computers would be of great benefit, he noted.

At the Dayton conference at the Wright Air Development Center (WADC), Lt. Col. George F. Watkins, chief of WADC's Electronic Components Laboratory, said the Air Force hoped to stimulate industrial activity in molecular electronics. When equipment is made small enough, he predicted, men will not have to perform the functions of guidance and control in spaceships.

The molecular approach aims to do as many operations as possible in a single element. It is another step toward putting components into packages on the order of two million per cubic foot. WADC is already embarked on its own program. Roy Sadow, coordinator of the project, told the conferees that the air center planned immediate development of microminiature thermo converters; fixed-tuned, high-gain amplifiers, delay circuits, shift registers and static commutators.

Information-handling functions appear to be the most adaptable to molecular advances, Mr. Sadow said. He noted four facets of the WADC program:

- Applied basic research.
- Techniques.
- Survey and circuit usage of functions.
- Development of subassemblies.

The techniques include work on thin film, pyrolitic deposition, sputtering and the environmental conditions that affect these.

The studies also include a comprehensive cataloguing of the physical phenomena of effects, designed to list every possible application with molecular electronics. Examples include the Hall Effect, electroluminescence, Peletier Effect (electronic refrigerator) and Faraday rotation.

A by-product of the techniques has resulted in a new dielectric film for high-temperature capacitors. Deposited between molybdenum

disks, the film shows excellent dielectric characteristics above 600 C.

Maj. D. B. Netherwood, acting chief of WADC's Advanced Development Branch, is coordinating work on the mathematical phase of the program. Working with Ohio State University and the Burroughs Corp., his group is attempting to determine the logical bases for molecular advances.

Meanwhile microminiaturization continues to move forward with new packaging techniques. General Electric unveiled at the Philadelphia conference its concept of building several radio tubes and their circuits in one tiny ceramic-stacked module for space vehicles. The devices are called TIMMs (Thermionic Integrated Micro Modules). They differ from other packaging concepts in that the aim is to confine heat rather than expel it and to put it to work operating vacuum devices.

A complete circuit, such as a multivibrator or an amplifier, occupies a space no larger than that of a pencil eraser. It operates at nearly red-hot temperatures, taking advantage of high-frequency and reliability features of thermionic electron tubes.

The electron tubes used have no heaters, and auxiliary cooling is reduced or eliminated. The heat losses generated within the equipment increase the over-all efficiency of operation.

Resistors built into the ceramic modules consist of a resistive film on the inside of evacuated and sealed ceramic insulators. Resistors of from one to 500 K have operated stably at 700 C, GE reported.

Built-in micro-miniature capacitors, with synthetic mica as the dielectric, have shown a change of less than 5% in operation over a temperature variation ranging 0 to 700 C.

The heater-less electron tubes built into the stacks have a self-biasing characteristic. No grid current flows until the grid is at least two volts positive with respect to the cathode.

A typical circuit module can contain 10 diodes, 14 triodes, 14 re-

Floyd E. Wenger of the Air Research and Development Command, moderator of meeting in Philadelphia, attaches a microphone to Richard W. Fotland of Horizons, Inc., a speaker at the sessions.

sistors and six capacitors. These 44 components yield an operating circuit density of 250,000 components per cubic foot.

Engineering samples of TIMMs can be developed in a relatively short time, it was said, and production in quantity may be possible after another year.

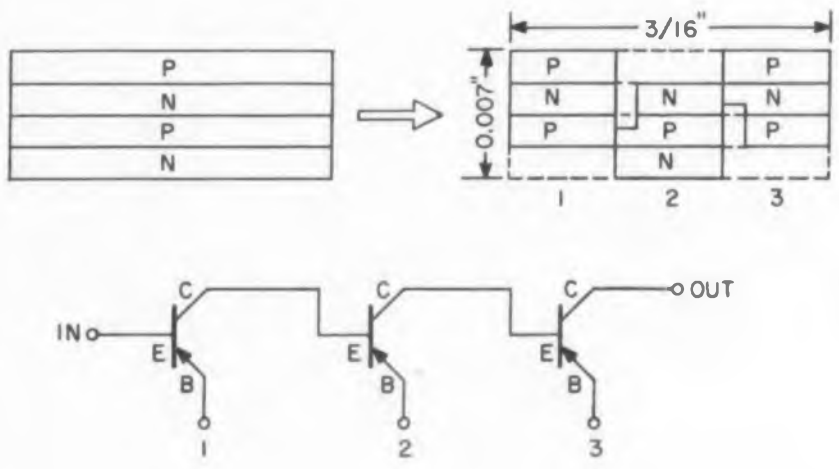
Other developments in microminiaturization were also described at the Philadelphia meeting. Some of these were: component connections for microminiature circuits; RCA's micromodule structural design; a miniaturized ceramic transformer intermediate-frequency amplifier; miniaturized relays, and a microminiature ferroelectric digital storage system.

But despite the advances, A. W. Rogers of the Army Signal R & D Laboratories, explained:

"There will always be a need for conventional components. Microminiaturization will have its biggest applications in low-signal-level circuits. But conventional components will be used for a long time in power applications."

Company representatives at the sessions were inclined to agree.

This conference was sponsored by the Electronic Industries Assoc., the American Institute of Electrical Engineers, the Institute of Radio Engineers and the Western Electronic Manufacturers Assoc. ■ ■



An example of how molecular elecrtonic is made, as shown WADC at Dayton ference. Four layers stacked and eroded form the three-stage rect-coupled amplifier. has a gain of 60 db in volume of 8 x 10 About 37,500 stages of this type could be jammed into a cubic inch.

Five Ton 'Tube' Created

This "radio tube," 80 ft high and weighing nearly five tons, will soon be familiar to Londoners. There is only one switch electronically: it's a dud. The oddity is a modern bronze sculpture inspired by the inside of a radio tube. The work of Geoffrey Clarke, a leading British designer, it will be erected on the tower of a 20-story office building under construction for Thorn Electrical Industries, Ltd., in London's West End.

CIRCLE 7 ON READER-SERVICE CARD ➤

NEWS

Army Gets New Storage Tube

A barrier-grid storage tube capable of resolving 800 to 1200 TV lines at 75 per cent contrast has been developed for the Army.

Said to operate with considerably less signal shading than similar units now available, the tube should find application in radar and infrared moving target indicator work, and binary digital information storage and processing.

The new component utilizes a single electrostatically focused and electrostatically deflected electron beam for both "writing" and "reading" information on a spherically curved target. The target consists of a metal bowl, with a thin dielectric layer fused to its concave side, and a curved, fine mesh screen fused in turn to the dielectric.

The tube was developed by International Telephone and Telegraph Corp. in cooperation with Army Signal Research and Development Laboratories, Fort Monmouth, N.J.

Risky Job? Let Mobot Do It

Arm-like device at right belongs to Mobot, a mobile robot developed by Hughes Aircraft Co. for jobs too dangerous for humans. Mobot, operating a drill here, works with aplomb in such risky spots as radioactive rooms and underwater salvage areas. Its electropneumatic "fingers" can exert a 200-pound squeeze or handle delicate items with tweezer-like care. The operator directs the actions with electronic "reins."

Wrong Name

In the photograph of "The Panel of Experts" which appeared in the meeting report of 1959 Solid State Circuit Conference, (*ED*, April 15, p. 44) the second from the left is Mr. Amos Oka, Manager Circuit Design, Computer Department, GE. For the panel, he championed diode logic circuits.

New Principles Broaden Use, Cut Size of Ultrasonic Flaw Detectors

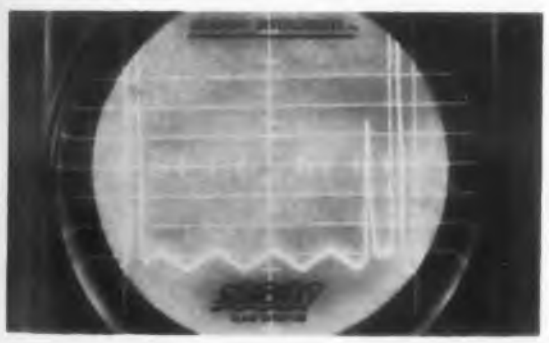
Starting from the pulse-echo detection principle, Bronson Instrument designers, in Stamford, Conn., have developed an ultrasonic detector that operates over a continuous range of frequencies, develops a pyramidal distance marker, and weighs half as much as comparable units.

A novel broadband amplifier, based on a new approach to current broadbanding practice, gives the unit its continuous frequency range. This eliminates changing of transducers, frequencies, and retuning. The Sonoray Model 5 automatically adjusts to any transducer within its range of 0.4 to 0.10 mc. Quick disconnects cut frequency-changeover time to 5 seconds.

New circuits permit for the first time generation of a pyramidal distance marker, which makes weak signals, or those at critical points, easier to detect. The pyramid corresponds to the ultrasonic path and greatly simplifies flaw detection.

A bright trace coupled with circuitry that gives high resolving power permits detection of small flaws only 1/8th of an inch below the surface of a part at very low frequencies.

Redesign of conventional circuits cut down power consumption, making possible the 50% weight saving. Efficient packaging and the greatly reduced power supply needs led to the 65% volume cut.



Unique Pyramid Marker shows on face of new ultrasonic flaw tester.

Coming: Atomic Lighting

Atomic lamps that might eventually be used as warning lights, buoy markers or for signaling on life rafts are under experimentation in Great Britain.

Gaseous radioactive isotopes such as tritium and krypton 85 are particularly suitable for use in light sources. The light is obtained from phosphorus activated by beta particles, which are emitted in the decay process of the radioactive gas.

The A.E.I. Lamp and Lighting Co. of London is seeking to increase by tenfold the present experimental output of .0045 lumens, an efficiency of a little more than 30 lumens per watt.

Meeting Sum-up: We're Closing In On Ideal Power Source From Many Sides

Power sources developed from thermoelectricity, thermionic conversion, fuel cells, galvanic cells, and dynamic heat engines held the spotlight at the Thirteenth Annual Power Sources Conference, Atlantic City, N.J.

Among the highlights:

- Efficiencies up to eight percent have been reached with nuclear sources using water to dissipate thermal radiation.
- A 22-lb, packaged solar unit has been developed to produce five watts.
- Near-future shelf life of three to five years is now anticipated for dry cells.
- Microminiaturization has produced up to 20-fold size and weight reductions in once miniature devices.

Space Applications Already History

Dr. N. W. Snyder of the Advanced Research Projects Agency, Washington, opened the conference by outlining power needs for space vehicles ranging from weather-surveillance equipment to manned satellites to stations in outer space. The possible applications of solar, nuclear, and chemical energy sources were analyzed in terms of relative weight, plant capacity, and service lifetime.

Nuclear and Thermal Sources Still Costly

Nuclear energy, capable of high-energy density independent of temperature, has been hampered by the need for heavy shielding to achieve safety from radiation effects. The use of alpha emitters, devoid of gamma ray radiation, promises freedom from hazards in handling.

Efficiencies of nuclear-heat-to-electrical energy conversion have been pushed up to six per cent. Up to eight per cent efficiency has been gained by using water to dissipate thermal radiation.

Conversion of thermal to electrical energy, by thermoelectric generators and thermionic converters, which have no rotating parts, offers reliability and long life. Dr. A. D. Steele described the 5 w thermoelectric generator, developed by the Minnesota Mining and Mfg. Co. under the A. E. C. Snap III program. The unit, publicly displayed at the White House earlier this year, uses lead-telluride p- and n-elements heated by alpha particles emitted by Polonium 210.

Theoretical and experimental results for close-spaced thermionic vacuum- and gas-filled converters were outlined by Dr. V. C. Wilson of the G. E. Research Lab. Dr. Hatsopoulos of M. I. T., comparing thermoelectric and thermionic converters, concluded that relatively low-temperature

thermoelectric devices could be thermally cascaded with higher-temperature thermionic units to achieve high over-all conversion efficiency of heat to electricity.

Solar Energy Coming Down to Earth

Considerable interest focused on the several solar-energy papers. Mr. G. Hunrath, of the Signal Corps R & D Lab, analyzed design of a double-ring solar-cell grouping for satellites.

RCA's efforts to develop more efficient p-n junction solar cells by using galium arsenide was detailed by Dr. J. J. Loferski. Present silicon cells provide about 11 percent efficiency—galium arsenide only about six percent; future research may move galium arsenide past silicon.

According to Dr. Maria Telkes, Curtiss-Wright, as much as 100 to 125 w/sq ft of solar energy are concentrated on the Earth's surface during a summer day. Solar conversion efficiencies of even 10 per cent can deliver a large amount of useful power when combined with large area collectors. Slides of various spherical and parabolic reflector designs were shown to illustrate the research efforts.

Dry Cells Hold Their Own

Recent developments in sealed nickel-cadmium batteries, silver-oxide cells, and calcium-lead grid alloys were disclosed with test results accumulated from field reports. Advances in dry cell reliability and long life were stressed.

Fuel-cell devices can convert chemical to electrical energy without an intermediate thermal conversion step. Low-temperature fuel cells and Redox-type cells were described; efficiencies up to 70 percent are theoretically possible. Since no moving parts, except for accessories, are required, quiet operation and long life may be expected. Dr. H. F. Hunger, of the Signal Corps' R & D Lab, reviewed basic concepts and surveyed latest developments in each type of fuel cell.

V. J. Kublin, also of the Signal Corps R & D Lab, suggested that to achieve smallest over-all system packaging, power sources must be fully investigated to obtain highest power density and reliability.

Sponsored by the Power Sources Division of the U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N.J., the April 28-30 meeting was attended by over 1000 engineers. Thirty-nine papers were presented by leading experts from military and commercial development laboratories throughout the country.

The full text of all papers is scheduled for publication in September, 1959. Copies can be ordered from the U. S. Army Signal R & D Laboratory, Fort Monmouth, N.J.; price is $10 for the first copy and $5 for each additional copy mailed to the same address.

NBS Semiconductor Study Sparks Design Ideas

A SEVEN-PROJECT research program underway at the National Bureau of Standards is developing new solid-state data that may soon be put to work by electronic design engineers.

The NBS investigation breaks down this way:

- Crystal growth and purification studies—important because solid-state materials are evaluated on the basis of electron and lattice theories. Some results: over 100 crystals of indium antimonide (InSb) have been grown by the Kyropoulos technique; impurities have been reduced to 1 to 10 parts in 10^8.
- Electrical property measurements—conductivity, Hall effect (to distinguish between n- and p-type semiconductors), and thermoelectric-effect measurements are made down to liquid-helium temperatures. Properties vary widely—energy gaps of the important III-V compounds (combinations of elements from the III-B and V-B columns of the periodic table) range from 3.0 to 0.16 ev.
- Optical measurements—mainly in the infrared region because of interest in semiconductors as infrared detectors. Copper-doped indium antimonide gives fairly large photosignals at liquid-helium temperatures in the far infrared range up to 35 C. N-type InSb with a slight copper impurity shows interesting quenching effects.
- Carrier lifetime studies—these lead to critical-value figures.
- Mechanical and electromechanical studies—resistivity tests of InSb under tensile stress have confirmed its energy-band structure.

The temperature or frequency dependence of mechanical damping often reveals relaxation peaks and attenuations which relate to impurities. These internal-friction studies have been made on InSb up to its 523 C melting point.

- Nuclear magnetic resonance—one of the most useful techniques for studying defects and impurities in semiconductors.

Nuclear magnetic resonance investigates the solid state in this rig. Probe holding sample between pole pieces of large magnet, center rear, connects through oscillator circuit in small box, power supply, lock-in detector, and modulator, all in console, to strip-chart recorder. Magnet power supply is at left.

Crystal-growing furnace at the National Bureau of Standards grows crystals by the Kyropoulos technique. Coil surrounds hole in vacuum chamber from which metal-coated seed crystal is withdrawn to cool in large crystal form. Zone melting purifies crystal-forming substance.

ntermetallic compounds under study in- lude oriented crystal of indium-antimonide, ft; cavitron-cut sample of same material repared for elasto-resistance measurements, enter; and specimen of magnesium-tin for ptical investigations, right.

▪ Development of theory—new prin- iples are constantly being sought. From udies thus far, the Bureau notes, have ome a theory for transport phenomena a strong magnetic field, and a better nderstanding of the electronic energy- and scheme of rutile (TiO_2) containing ncancies or impurities.

NBS in Solid-state Research 10 Years

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By 1952 the agency was leading re- earch on a new group of semiconductors the III-V binaries. Many crystals of alu- inum-antimonide, gallium-antimonide, nd indium-antimonide were prepared nd analyzed. Indium-antimonide proved ery promising, and much attention is still eing focused on it.

Other materials studied in the last five ears are magnesium-tin and semicon- ucting gray tin.

What of the future? The Bureau plans o continue concentrating on a few ma- erials. TiO_2 will receive particular em- hasis in the next year.

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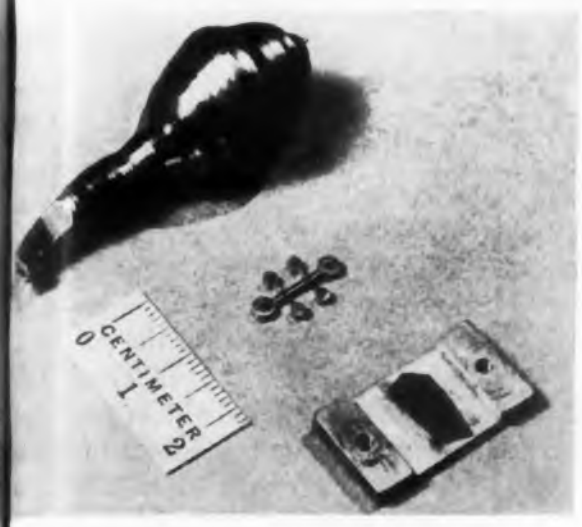

Intermetallic compounds under study include oriented crystal of indium-antimonide, left; cavitron-cut sample of same material prepared for elasto-resistance measurements, center; and specimen of magnesium-tin for optical investigations, right.

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NEWS

Radio Parley Eyes Moon

A radar-equipped satellite may give man his first accurate knowledge of the depth of the moon's surface layer. The technique involving calculation of the power-reflection coefficient at different wave lengths, was among ideas presented at a three-day conference in Washington this month of Union Radio Scientifique Internationale (U.R.S.I.).

W. Fensler, T. Senior and K. Seigel, of the Radiation Laboratory, University of Michigan, proposed the moon-measuring method. They showed that the power-reflection coefficient would be a function of the number and depth of lunar layers and of the electromagnetic constants associated with them. Calculations would be telemetered to earth by the satellite.

In another discussion, V. Eshleman, P. Gallagher and R. Barthle reported that moon echoes could be used to determine cislunar ion densities. Working at Stanford University, the three have been investigating the ionized medium between the earth and the moon, with prime interest in the density beyond the ionosphere.

Predictions of the performance of radio propagation paths through the use of meteorological parameters were described by L. G. Abraham. He analyzed radio and weather data for a year on a propagation link from Bedford, Mass., to General Electric's Research Lab at Schenectady, N.Y. Water-vapor content and stability index were found to be the most significant meteorological variables.

J. Holladay and K. Wright of Collins Radio Co., Cedar Rapids, Iowa, showed the effect of antenna height on transmission over a 172-mile scatter circuit. In their investigation, a 15-foot parabolic antenna was moved from ground level to 200 feet above ground and compared with a second 15-foot antenna on the ground. The results showed no decrease in transmission loss because

of increased antenna height.

A paper presented by Robert Coates described measurements of lunar radiation being conducted by the Naval Research Laboratory with a 10-foot parabolic antenna and a Dicke-type radiometer. Many scans have been made across the moon at different times of the lunar month. These records are asymetric, and the amount of asymetry is a function of the phase of the moon. The sunlit part of the moon surface is considerably lighter at 4.3 mm than the dark part, Mr. Coates noted. The difference between light and dark areas is more pronounced at 4.3 mm than at 8.6 mm wave length.

Looking into the future, Dr. Lloyd V. Berkner told the conference that radio-relay satellites might soon make it possible to telephone any part of the world for 20 cents. The satellite would revolve around the earth at an altitude of 22,700 miles. Two billion phone messages a year could be handled, Dr. Berkner said. He divided the 20-cent charge this way: 10 cents for the ground end of the call and 10 cents for satellite relay.

Hermetic Heat Sealing

Transistors, diodes, relays and crystals can be sealed in five to seven seconds by localized rf heating using new machinery designed to seal glass-to-glass, glass-to-metal, and metal-to-metal.

Developed by Hermetic Seal Corporation, the equipment eliminates soldering or projection welding and completely seals components in one-fifth of normal time.

Correction

Credit for development of the Satellite Tape Recorder, which appeared in the News section (*ED*, Apr. 15, p. 17) was given to Minnesota Mining and Mfg. Co. The corrected credit should be given to John Licht, scientist, U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N.J., for the design and development of the recorders.

WASHINGTON REPORT

Ephraim Kahn

Weapons System Concept under Investigation

The weapons system concept, which is basic to a large proportion of government purchases of electronics, is being given a rough going-over by the Congress. Regardless of its merits as a method of producing military end-items, it has become a political football. Hostility to the weapons system as a way of doing business has long been a staple of the Small Business Committees of the Congress. These groups do not, however, have the power to recommend new laws, though individual members may introduce bills that reflect committee activity.

Dissatisfaction with present military buying practices has also been expressed by the General Accounting Office and a number of members of the Hebert (D., La.) Subcommittee of the House Armed Services Committee, which has made a special investigation of the weapons system concept. Chairman Hebert is "persuaded more and more that the weapons system concept is nothing new," and that it is a "job the government should have been doing in the past but was not doing." Now, he says, "it's being shifted to private industry, while keeping the same number of people at the Pentagon."

Much Congressional criticism is keyed to the notion that procurement under weapons system contracts results in inadequate cost control, particularly in regard to second-tier subcontracts. Congressman Porter Hardy, Jr. (D., Va.) wonders what are the "incentives to keep prices down." As he sees it, there is a "gain" for the prime contractor "when the subcontractor's price goes up."

Sharpest criticism of weapons system procurement was made by the General Accounting Office. Since this agency carries a great deal of weight with Congress, its opinion may well tip the scales against enactment of the bill introduced by Senator Saltonstall (R., Mass.) which is supported by the EIA. The Saltonstall bill, S. 500, is designed to give the military greater flexibility in contracting. Its objective is to cut lead-time in design and development of ad-

vanced and complex weapons. In the interest of speed, it would allow the military to resort more often to procurement through a single commercial manager, erase legal distinctions between purchases by bid and by negotiation, and exempt from renegotiation specified contracts.

GAO sees grave perils in the Saltonstall bill, including "a real danger" that it might aggravate the problems it is intended to cure. If all "operational systems" were placed under weapons-system-type contract, GAO thinks that the entire national defense might become dependent on the "skills, integrity, and business acumen" of a limited number of companies. "Without questioning the integrity of industry," GAO believes "that a contractor without real competition could become complacent and could allow itself to become so concerned primarily with matters of major interest only to its own organization that such matters as delivery time, quality of product, and emergency needs of the government would become of secondary concern."

A number of other serious objections to greater use of weapons system contracting were also raised by GAO. Among them: (1) danger that potential competitors might be denied subcontracts by the prime contractor, which could tend toward monopoly and dominance of the prime contractor in any given area of weaponry. (2) Impairment of the Military Services' ability to perform their missions if the operational system contractor acquired so much delegated authority that the military became excessively dependent. (3) Less ability on the part of the government to exercise control over such items as operational capability and quality, since government engineers and scientists would be inclined to move over to the private firms that would be responsible for actual design, development, and production. (4) Absence of stiff controls over contracting would not provide an incentive for low-cost and efficient production.

Advertised competitive bidding, says the GAO, should be used in government procurement except when it is "impracticable or against the public interest." In fact, GAO believes "that the only way to be certain supplies or service are being offered at truly competive prices is to obtain full and free competition," since "supplies and services which are susceptible of procurement by formal advertising will, overall, be obtained at substantially lower prices on that basis." This phrasing, of course, leaves open the possibility of negotiated contracts.

Design and development of new weapons was found by GAO to justify the use of performance specifications in contracting. The Saltonstall bill would encourage the use of performance specifications.

MEETINGS

Calendar of Events

June

1-3	**IRE-PGMTT National Symposium, Paine Hall, Harvard University, Cambridge, Mass.***
1-3	**National Symposium in Microwave Theory and Techniques (IRE), Cambridge, Mass.**
3-5	**Armed Forces Communications and Electronics Association Annual Meeting, Washington, D.C.**
4-5	**Third National Conference on Production Techniques (IRE), San Mateo, Calif.**
8-11	**Semi-annual Meeting, American Rocket Society, San Diego, Calif.**
10-12	**Second International Symposium on Gas Chromatography (ISA), East Lansing, Mich.**
14-18	**American Society of Mechanical Engineers, Semi-annual Meeting, Chase-Park Plaza Hotel, St. Louis, Mo.**
15-18	**Summer Meeting, Institute of Aeronautical Sciences, Los Angeles, Calif.**
15-20	**First International Conference on Information Processing, Paris, France***
15-20	**Symposium on Electromagnetic Theory, Univ. of Toronto, PGAP, URSI, University of Toronto, Ont., Canada**
16-18	**International Symposium on Circuit and Information Theory (IRE), Los Angeles, Calif.***
17-20	**1959 Engineering Progress Exposition, National Society of Professional Engineers, Hotel Commodore, New York City, N.Y.**
17-27	**International Plastics Exhibition, London, England**
21-26	**Summer and Pacific General Meeting AIEE, Olympia Hotel, Seattle, Wash.**
22-26	**ASEE-ASTM Symposium on Education in Materials, Atlantic City, N.J.**
24-26	**Second Nuclear Instrumentation Symposium, Idaho Falls, Idaho**
24-28	**International Conference on Medical Electronics, UNESCO, Rockefeller Institute, IRE-PGME, Paris, France**
29-1	**National Convention on Military Electronics (IRE), Washington, D.C.***

*** Indicates meetings described herewith.**

1959 IRE National Symposium, June 1-3.

Sponsored by PGMTT, Paine Hall, Harvard University, Cambridge, Mass. Papers to be presented include those on microwave amplifiers, phase shifters, and filters. Another group includes microwave research in Japan, various universities, and industrial laboratories. An evening session involves a visit to the Cambridge Electran Accelerator. Other topics cover masers, analytical technical techniques, ferrites, variable reactance diodes and their use in parametric amplifiers. Arrangements can be made through W. H. from, Ewen Knight Corp., 206 A Street, Needham, Mass. Registration fee is $3.00 for IRE members, $5.00 for non-members, students, free. Ladies program included.

International Symposium on Circuit and Information Theory, June 16-18

University of California, Los Angeles, Calif. The purpose of the Symposium will be to consider recent advances in Information Theory and Circuit Theory, and in particular to explore areas of interest common to two disciplines. For information contact: *Dr. G. L. Turin, Hughes Research Laboratories, Culver City, Calif.*

1st International Conference on Information Processing, June 15-20

UNESCO House, Paris. The conference program has been expanded to six major topics: 1. Method of Digital Computing; 2. Logical Design of Digital Computers; 3. Common Symbolic Language for Digital Computers (includes Automatic Programming); 4. Automatic Translation of Languages; 5. Collection, Storage, and Retrieval of Information; 6. Pattern Recognition and Machine Learning. The formal technical program will be held in plenary sessions. Thus there will be time to visit AUTOMATH 1959, a major technical exhibit, which opens before these sessions and closes afterwards.

Third National Convention on Military Electronics, June 29-July 1.

Sponsored by the IRE Professional Group on Military Electronics, Sheraton-Park Hotel, Washington, D.C. The technical program includes more than 100 papers to be presented at 5 classified and 18 unclassified sessions, covering these topics: missile guidance, radar techniques, operations research and tacts, data transmission and processing, space electronics, instrumentation (two sessions), navigation, surveying and reconnaissance, communications (two sessions), space propulsion, missile electronics, radar systems and equipment, computers, components, space communications, detection and tracking, space guidance and tracking, simulation, navigation and reconnaissance, guidance, reliability. Exhibits of the latest military components and equipment representing the products of more than 100 companies will be held concurrently with the program. Advance registration, including the Proceedings, are $2 for IRE members, $3 for non-members, $1 for students. For more information contact *L. R. Everington, Radiation Inc., Orlando, Fla.*

Paper Deadlines

June 22: Deadline for final manuscripts to be presented at the **4th Annual Magnetic Amplifiers Conference, Sept. 23-25,** in Washington, D. C. Contact *F. G. Timmel, 4601 Forest Park Ave., Baltimore 7, Md.*

EDITORIAL

Technical Seminars on Tour

There are a growing number of electronic component and instrument manufacturers who are conducting technical seminars for customer-engineers.

Many such seminars have been held before in conjunction with national conventions. Companies take a hotel suite and invite engineers to attend lectures put on every hour or so. The latest trend is for a company to put on a one-day course in the vicinity of a customer's plant. Magnetics Inc. of Butler, Pa., has pioneered very successfully in this area. We have attended several of their seminars in New York City and therefore speak with enthusiasm. Edgerton, Germeshausen & Grier, Inc. have recently completed a second annual technical seminar.

Spectrol Electronics Corporation has announced a nationwide tour beginning June 1 to demonstrate the application of electro-mechanical assemblies and solid-state devices to electronic equipment. Spectrol plans to conduct 45-minute technical meetings followed by question and answer periods. Evening programs have been held by William Brand & Co. for engineers in various areas. Mycalex Corporation of America has conducted day-lectures at over a dozen giant electronic companies across the country.

In the face of the ever increasing number of regional and national technical meetings put on by professional groups and of the sectional meetings put on by these groups, one would think engineers would become over-saturated with knowledge.

There is one important distinction. Seminars put on by companies are at a down-to-earth practical level. They are designed to give engineers information that can be put to use immediately. These seminars are not broad surveys or disclosures of recent development work.

If the company's lecturers are at all skilled, the technical seminar should be a very useful and helpful service.

We have long been convinced that equipment design engineers have not taken advantage of knowledge possessed by manufacturers of components and instruments. There is no sure answer as to just how they can get this knowledge efficiently. The technical seminar, however, looks like a good approach.

James C. Kyprios

IR

Evaluating . . .

Infrared Photon Detectors

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Infrared photon detectors are becoming available to systems designers in increasing numbers. But performance data for these detectors is often scanty. This article reviews responsitivity, noise equivalent power, detector noise considerations, and suggests some approaches when data is lacking.

PROPER choice of an infrared detector depends on the application at hand and the conditions of use so that no single "figure of merit" exists. For instance, the systems designer must consider the target's radiant power, the transmission of the atmosphere, typical backgrounds which will be encountered, the scanning method employed. Therefore, the best he can do is to consider each detector independently in view of the systems application. To this end, certain detector parameters are furnished by the detector manufacturer and certain others should be furnished but are not. To make an intelligent detector choice, the system designer must understand these parameters and make extrapolations where the data does not exist.

PHOTON DETECTORS *differ from thermal detectors in that their response is proportional to the number of photons incident upon them rather than the total energy. In photon detectors, electrons are optically excited by the absorption of photons, while in thermal detectors, a quantity of heat changes one of its properties, such as its resistance.*

Detector Parameters

In the design of infrared systems, the designer needs a rather complete knowledge of the detector. The following data should be available at the beginning of system synthesis:

- The responsivity of the radiation detector as a function of spectral wavelength and modulating frequency.
- The complete noise energy density spectrum generated by the detector including its dependence on cell parameters such an area, geometry, temperature, impedance, etc.
- Practical consideration such as impedance levels encountered, biasing levels, polarization effects, etc.

Where the above data is available, the performance of the detector in any detector noise limited system can be predicted quite accurately. Even where some data is missing, one can make estimates based on the most likely results to be expected with the data given.

Responsivity

The function of an infrared detector is to convert an infrared radiation signal incident upon it to an electrical signal suitable for electronic processing. For various reasons, the radiation signal is generally chopped or modulated prior to detection so that the electrical signal is time varying. In addition to its time varying properties, the infrared electromagnetic radiation has some spectral distribution associated with it. The response of the detector is a function of the wavelength of this incident radiation as well as its time varying properties. Since both time varying electrical signals and electromagnetic infrared radiation have wavelength and frequency associated with them, it is customary to differentiate between them by speaking of the wavelength of infrared radiation λ and the frequency of electrical signals f.

Under specific test conditions, the transfer function of a given detector may be written:

$$R_o(\lambda f) = \frac{V_s(\lambda, f)}{W_s(\lambda, f)} \frac{\text{Volts}}{\text{Watt}} \qquad (1)$$

where V_s refers to the electrical voltage out of the detector and W_o refers to the incident radiation. R_o (λ,f) is also referred to as responsivity. These relationships are shown schematically in Fig. 1. Most photoconductors may be characterized by a single time constant in the spectral wavelength region of interest, and this time constant is independent of spectral wavelength. If

this be the case, either wavelength or frequency dependence can be integrated out. For example,

$$R_o(f) = \int_0^\infty R_o(\lambda,f)\, d\lambda \qquad (2)$$

and

$$R_o(\lambda) = \sqrt{\int_0^\infty \left|R_o(\lambda,f)\right|^2 df} \qquad (3)$$

The method of integrating differs for the two cases because infrared radiation is usually given in terms of power per unit wavelength (watts/micron), while electrical signals are specified in terms of a Fourier energy density.

The integration in the latter case is then an application of the Fourier integral energy theorem. This integration with respect to frequency does not take place within the detector but rather, in the electronic equipment following it. Consequently, this form is rather artificial. Actually, the detector integrates with respect to λ and with this assumption, the block diagram of the detector can be drawn as in Fig. 2. This block form is more representative of the actual detector. However, it is sometimes convenient to speak of response to monochromatic radiation and therefore the integration represented by Equation 3 is sometimes convenient in analysis.

Since the detector can usually be characterized by a single time constant, the frequency response function $R_o(f)$ can be written:

$$R_o(f) = \frac{R_o(0)}{1 + j2\pi f\tau} \qquad (4)$$

or

$$R_o(f) = \frac{R_o(0)}{[1 + (2\pi f\tau)^2]^{1/2}} \qquad (5)$$

Note that for frequencies small with respect to $1/2\pi\tau$, $R_o(f)$ is approximately equal to $|R_o(0)|$ and above this frequency $|R_o(f)|$ is about equal to $|R_o(0)/2\pi f\tau$. The frequency $1/2\pi\tau$ is often called the crossover frequency.

Signal to Noise Considerations

One of the distinguishing features of military infrared systems is that one must often work close to the detector noise level. The noise generated within a detector is a function of frequency and the bandwidth of measurement. If an ideal filter is used for measurement, the rms noise voltage V_n is given by:

$$V_n = \left[\int_{f_1}^{f_2} \left|V_n(f)\right|^2 df\right]^{1/2} \qquad (6)$$

where $V_n(f)$ is the noise energy spectrum. The rms electrical signal due to monochromatic incident radiation can be calculated:

$$V_s(\lambda) = \left[\int_{f_1}^{f_2} \left|R_o(\lambda,f)\,.\,W_s(\lambda,f)\right|^2 df\right]^{1/2}$$

In specifying detector performance, it is customary to modulate the radiation of a frequency well below the crossover frequency so that

$$V_s(\lambda) = R_o(\lambda,o)\left[\int_{f_1}^{f_2} \left|W_s(\lambda,f)\right|^2 df\right]^{1/2}$$

With this simplification, the rms signal to rms noise ratio at the detector's output terminals may be written

$$\frac{V_s(\lambda)}{V_n} = \frac{R_o(\lambda,0)\left[\int_{f_1}^{f_2} \left|W_s(\lambda,f)\right|^2 df\right]^{1/2}}{\left[\int_{f_1}^{f_2} \left|V_n(f)\right|^2 df\right]^{1/2}}$$

In this equation, it is assumed that the noise is generated within the detector and is not due to fluctuations in incident radiation. In the event that radiation noise is limiting, the noise voltage would be a function of detector responsibility, which in turn is a function of both frequency and spectral wavelength.

Noise Equivalent Power

A most important conception in detector comparison is that of Noise Equivalent Power, or NEP. NEP is defined as the rms radiant energy, measured in watts, which is incident upon the detector and results in an rms signal to rms noise ratio of unity at the detector's output terminals. This quantity is also called minimum detectable power. An analytical expression for NEP can be obtained from equation (9) by setting $V_s(\lambda)/V_n$ equal to unity and solving for the rms radiant power:

$$NEP(\lambda,\Delta f) = \left[\int_{f_1}^{f_2} \left|W_s(\lambda,f)\right|^2 df\right]^{1/2}$$

when $$\frac{V_s}{V_n} = unity$$

$$= \frac{\left[\int_{f_1}^{f_2} \left|V_n(f)\right|^2 df\right]^{1/2}}{R_o(\lambda,0)} \qquad (10)$$

where $\Delta f = f_2 - f_1$. This equation holds only for a particular detector at a given temperature, bias current, detector geometry and for frequencies below crossover. It can be seen that if the complete noise spectrum and responsivity is given, the detector's NEP is determined for the particular detector. For other detectors of the same kind and under similar operating conditions, it is usually found that NEP is a function of detector area. The exact relationship must be known for accurate design, but if it is not given, it is customary to assume the square root of detector area. Thus, one can to a certain extent normalize NEP to unit area as follows

$$NEP'(\lambda, \Delta f) = \frac{NEP(\lambda.\, \Delta f, A)}{A^{1/2}} \; measured \qquad (11)$$

Also, NEP is sometimes normalized to unit bandwidth by assuming that the rms noise depends on the square root of bandwidth, thus

$$NEP'(\lambda) = \frac{NEP(\lambda, \Delta f, A)}{A^{1/2}(\Delta f)^{1/2}} \; measured \qquad (12)$$

Fig. 1. Block diagram representation of an infrared detector.

Fig. 2. Alternate block diagram representation with radiation wavelength dependence integrated.

This bandwidth normalization will be further discussed. As can be noted, the smaller NEP is, the better the detector. Some authors prefer to use the inverse of NEP which is then called Detectivity.[1] This has the advantage that the larger the Detectivity, the better the detector.

Detector Noise

For purposes of infrared detector comparison, it is customary to consider only noise generated within the detector itself. This noise spectrum is usually complex and varied. Some of the common noises encountered are Johnson or "resistor" noise, contact noise, current noise, and generation-recombination noise. For accurate description of detector performance, the complete noise spectrum must be available and usually is not. In these cases, one must make approximations.

(*Continued on page 24*)

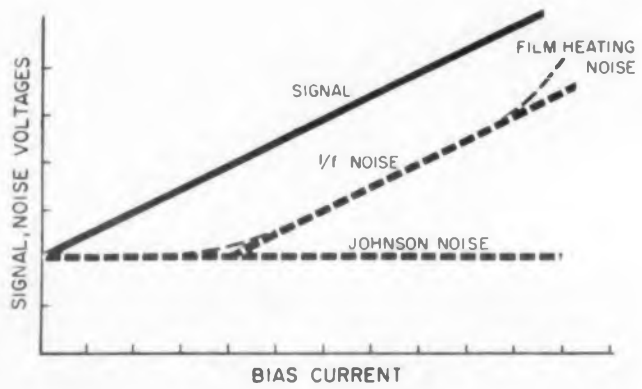


Fig. 3. Effect of increase of bias current on low frequency signals and noise voltages. Detector heating starts after the plateau has been reached for many photoconductors.

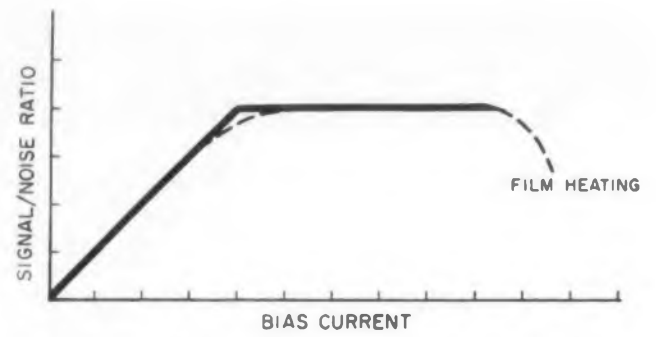


Fig. 4. Effects of increasing bias current on low frequency signal-to-noise ratios for many photoconductors.

Generally, it will be found that two types of noise are dominant, a low frequency noise which decreases with frequency, and a high frequency noise which, for practical purposes, is uniform with frequency. The former noise is usually bias current dependent, the noise power decreasing inversely with frequency. Even where no bias current exists, as in photovoltaic detectors, some such low frequency noise is noted. In these cases, the noise is generated at contacts, across semiconductor junctions, etc. However, in these cases, the $1/f$ noise power generally falls below Johnson noise quickly; at frequencies as low as 1 kc.

If the low frequency noise spectrum is bias current dependent, the bias current is usually increased to as large a value as is possible. The advantage in doing so is that while the noise power increases signal power increases at the same rate. On the other hand, current independent noises do not change and therefore their effective contribution can be reduced. This effect is illustrated in Figs. 3 and 4. Note that as bias current is increased, the signal-to-noise ratio or Detectivity reaches a plateau and remains at this level until photoconductor heating takes place.

With most photoconductors, a current noise decreasing with frequency dominates at frequencies below 5 and 10 kc and is essentially flat thereafter. However, with some of the newer photoconductors, the current noise drops below flat noise at frequencies below 1 kc even when biased. In the case of lead sulfide, the bias current can usually be adjusted that only current noise need be considered to frequencies well beyond the crossover frequency. For some of the newer photoconductors with very short constants, current noise will drop below the white noise spectrum before the crossover frequency is reached. While it is somewhat risky to assume that the high frequency noise spectrum is due to Johnson noise, this is probably the best one can do without more specific information.

The optimum use of a detector hinges on the noise characteristic. With lead sulfide detectors the signal frequency response is approximately uniform to the crossover frequency, and signal power drops at a $1/f^2$ rate thereafter. Noise power drops at a $1/f$ rate to well beyond the crossover frequency. At low frequencies then, signal to noise power ratio improves with frequency at a $1/f$ rate out to the crossover frequency and then drops at a $1/f$ rate.

In contrast, for fast detectors, it is advantageous to increase the chopping rate to the point where $1/f$ noise drops below the white noise spectrum. No further improvement is realized until you reach the crossover frequency when the signal to noise power ratio drops at $1/f^2$. These relationships are illustrated graphically in Figs. 5 and 6.

A complete noise spectrum of the detector is desirable. If this cannot be obtained, the designer should get at least one measurement of NEP at low frequencies and one at high frequencies and some notion of where current noise drops to the high frequency value of noise. In the worst case where only a low frequency NEP is quoted, one should assume that the detector noise drops to Johnson Noise at a fairly low frequency to be conservative. With a liberal adjustment in NEP accounting for the fact that production detectors will seldom meet the performance of laboratory specials, the result should not be greatly in error.

Very often, detectors are specified in terms of Jones "S_J" which is defined as follows:

$$S_J = \frac{NEP\ (\lambda, A, \Delta f)}{A^{1/2}\ ln\ (f_2/f_1)}\ measured$$

Jones "S_J" is derived[2] for, and is particularly appropriate for detectors with a $1/f$ noise power spectrum and whose NEP is square root of area dependent. For $\Delta f = f_2 - f_1$ small, it can be shown that

$$S_J = \frac{NEP\ (\lambda, A, \Delta f)}{A^{1/2}}\ measured \sqrt{\frac{f_c}{\Delta f}}$$

where f_c is the chopping frequency. Most detec-

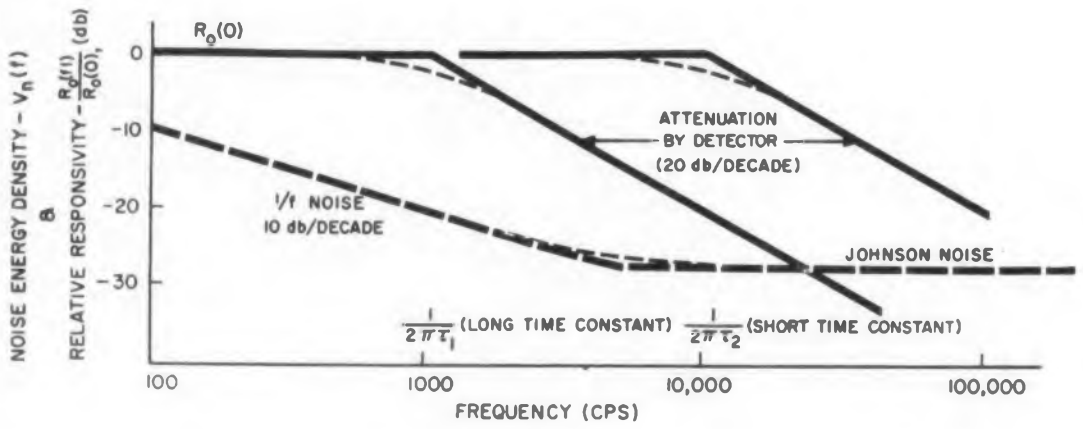


Fig. 5. Responsivity and noise energy density for long & short time constant detectors. Slopes of the curves are shown in db per decade.

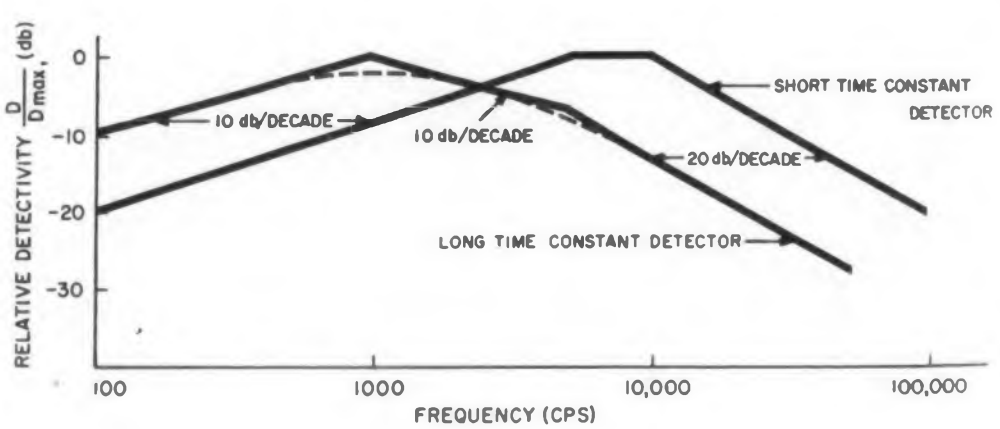


Fig. 6. Detectivity for the two detectors in Fig. 5. Slopes of the curves are shown in db per decade.

tors are evaluated at frequencies low enough that Jones S_f is reasonably accurate. The danger in using this parameter is that for fast detectors, a continual improvement in signal to noise with increased chopping frequency is expected, whereas, such improvement actually ceases where the $1/f$ noise power spectrum drops below other noises has been shown.

Practical Limitations

The impedance level of modern photoconductors usually falls in two categories; those with very high impedances (1-100 megohms), and those with very low impedances (10-1000 ohms). Either is rather difficult to use with vacuum tube inputs. With high impedance detectors, no special difficulties are encountered at low frequencies, where $1/f$ noise is dominant with the exception of vibration effects and stray pickup in the leads. At higher frequencies, these problems are aggravated and in addition, stray capacitance becomes a problem. While the noise level of the detector may drop, at higher frequencies to Johnson noise, this drop is partially offset by the load impedance's noise figure. For example, a matched load impedance at the same temperature as the detector has a noise figure of 2 and even worse when the load impedance is at a higher temperature.

In many instances, the detector's sensitivity may be nonuniform or vary with distance from either electrode. In any event, the primary noise limitation in a practical circuit may be in the electronics rather than the detector, although the detector causes the problem. Such considerations may influence the choice of detector. However, the NEP sensitivity criterion does not factor such problems in.

Most photoconductive detectors sensitive to radiation longer than 3-4 microns must be cooled to liquid nitrogen temperatures or below and are very sensitive to temperature changes about the operating temperature. Also, the cooled detector's sensitivity is a fairly strong function of background radiation to the point where cooling below a certain temperature does not increase sensitivity appreciably. In fact, under certain conditions, one can obtain improved response only by decreasing aperture.[3]

Thus, it can be seen that practical considerations can drastically alter any conclusions reached on the basis of NEP alone. ■ ■

References

1. R. Clark Jones, "Methods of Rating the Performance of Photoconductive Cells," *Proc. of IRIS*, June 1957, Vol. 2, No. 1.
2. R. C. Jones, "Advances in Electronics," Vol. 5, Academic Press, 1953.
3. W. Began, et. al., "Cooled Infrared Detectors," (unclassified) *Proc. of IRIS*, March 1958, Vol. 3, No. 1 (confidential).

How To Select Optimum Values For RF Bypass Capacitors

Dr. Richard E. Lee
Manager, Circuit Development Branch
Texas Instruments, Inc., Dallas, Tex.

Dr. Richard E. Lee is charged with the responsibility of developing new transistor circuits and applications. In this article he shows how to select bypass capacitors, using their series resonance if possible.

THE OPTIMUM value of an rf bypass capacitor should be selected on the basis of its impedance vs frequency characteristic. The series resonant frequency of the optimum capacitor should be approximately in the center of the operating frequency band of the circuit.

This insures that the rf bypass capacitor will have the lowest net impedance. And capacitors of smaller capacitance and possibly smaller physical size can be used to give better performance.

The simple equivalent circuit for a fixed capacitor is a series RLC network, where R is due to dielectric losses and L is usually due to the inductance of the leads. Since lead inductance in a rf capacitor is a significant factor, it is possible to select a value of capacitance that makes a series resonant circuit at the intended operating frequency. For a series resonant circuit, the net impedance includes only the series loss resistance of the capacitor. With the usual mica, or ceramic,

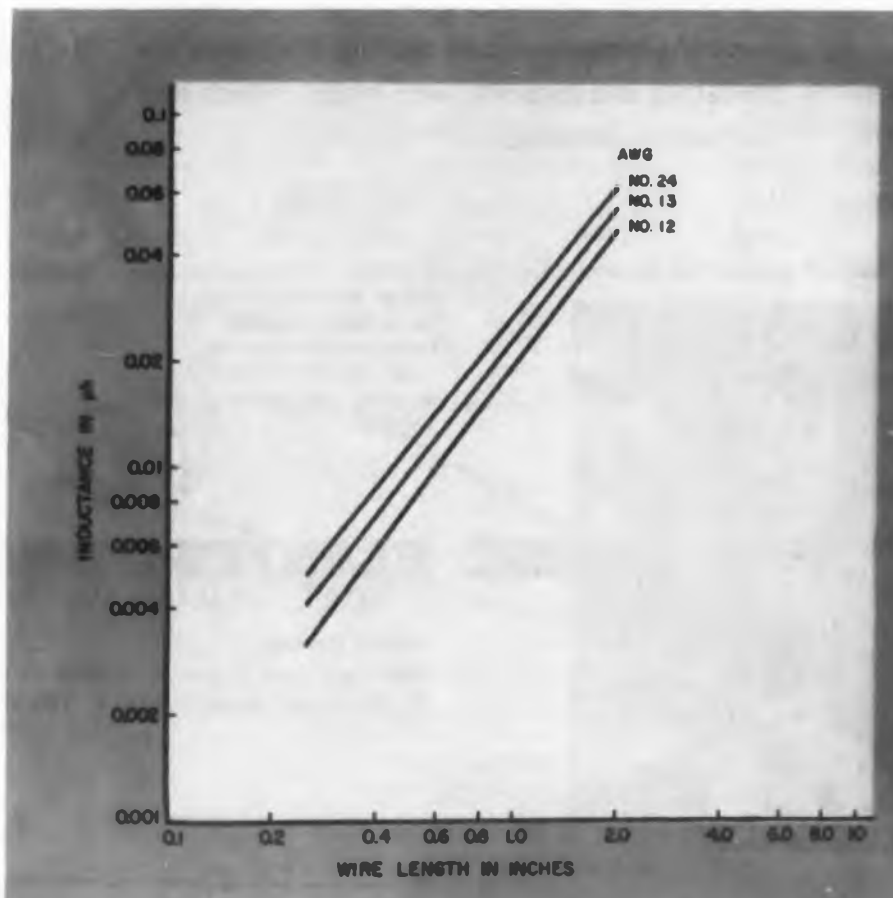
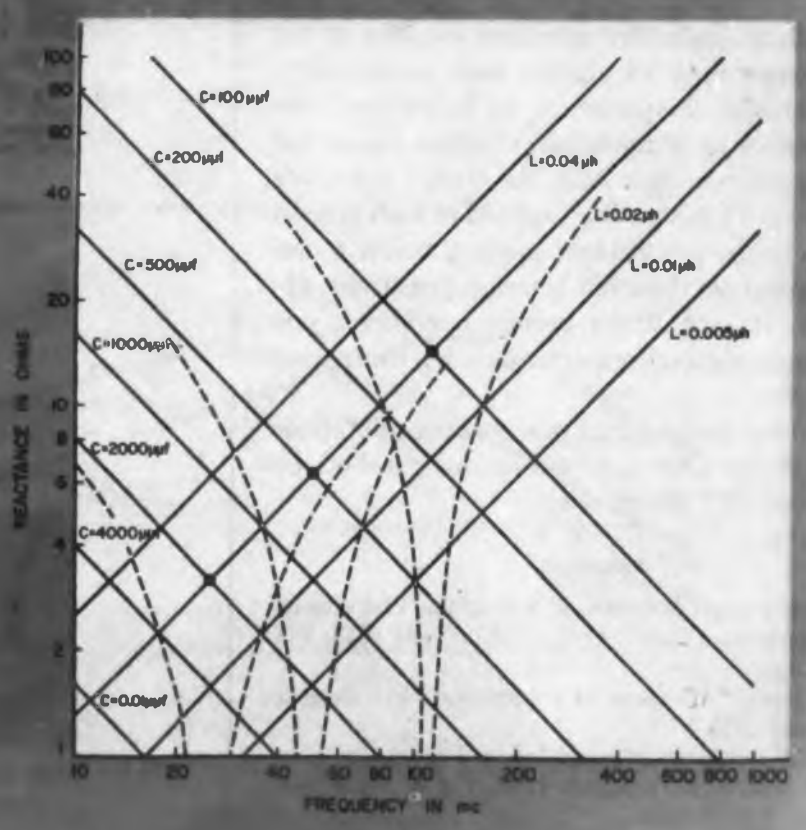


Fig. 1. (left) Inductance vs. length of a straight round wire.

Fig. 2. (right) Reactance vs. frequency for various L and C values.



dielectric rf capacitors, the dissipation factor is very low. Thus, the equivalent series resistance is very small.

Lead Inductance

Consider the lead inductance and its effect upon the choice of capacitor values. The inductance of a straight piece of copper wire may be computed from:

$$L = 0.00508\, l \left[\ln \frac{4l}{d} + \frac{d}{2l} - 0.75 \right] \mu h$$

where l = wire length in inches
d = wire diameter in inches

Using this equation, the inductance of various lengths of AWG No. 12, 18, and 24 wire was calculated and the results plotted in Fig. 1.

The reactance vs frequency data for various values of lossless L and C elements is shown in Fig. 2.

Examples

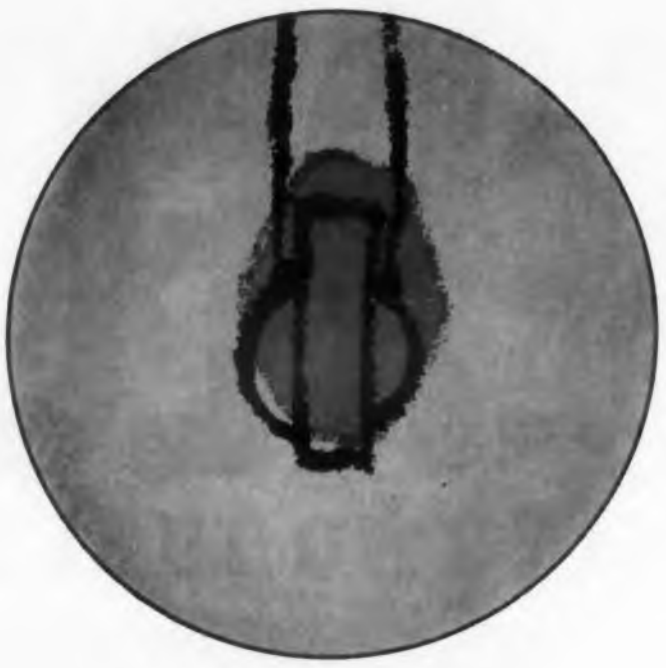
The following examples show the significance of Figs. 1 and 2.

Assume that we must tolerate a 0.44 in. lead length of No. 24 wire on each lead. Since each lead has an inductance of 0.01 μh, the total series L in the equivalent circuit is 0.02 μh. Assume also that we want the optimum bypass capacitors for 55, 49 and 110 mc circuits. For the stated L value, the optimum C values are 2000, 500, and 100 μμf, respectively, as shown in Fig. 2. In each case, the series resonant frequency, f_o, is circled at the point where the capacitive and inductive reactances are equal. Net impedance curves (assuming a zero dissipation factor) for each optimum capacitor were then added to Fig. 2.

Consider the result of using too large a value of C. Assume that 2000 μμf is specified as the value for a bypass capacitor in a 110 mc circuit. For the same total lead inductance, we know from the previous example that a 2000 μμf capacitor had a net inductive reactance of approximately 3.2 ohms at 55 mc. Therefore, although this capacitor had a net inductive reactance of approximately 3.2 ohms at 25 mc, it has a reactance of 14.5 ohms at 110 mc. The optimum value for 110 mc is a 100 μμf capacitor as shown in Fig. 2. This capacitor produces a net impedance of 1 ohm or less at frequencies from 107 to 115 mc, and an impedance of 10 ohms or less from 80 to 155 mc.

Measuring f_o

To measure the approximate value of f_o, connect the capacitor leads together (using the same lead length as required in a circuit) and couple into a one-turn loop into a grid-dip meter. The resultant f_o will not be exactly the series resonant frequency for the same capacitor when soldered in a circuit, because the L of a small one-turn loop is not the same as the L of two small straight lengths of wire. The measured value of f_o is usually within 10 per cent of the true value. ■ ■



Potting with Vinyl Silicone

W. A. Ernst
Supervisory Engineer
and
F. T. Parr
Development Engineer
Air Arm Division
Westinghouse Electric Corp.
Baltimore, Md.

Disadvantages of the common dielectric materials led to the evaluation of vinyl silicone as a potting compound. It has proven to be highly successful as an insulator in airborne power supplies.

PETROLEUM derivative oils, e.g., highly purified mineral oil, provide the most widespread insulation for sealed power supplies due to excellent dielectric properties. But this material has two major drawbacks: limited temperature stability and a relatively low flash point which presents a fire hazard if the sealed container develops a leak.

Silicone fluids such as the methyl siloxanes overcome these problems by virtue of higher thermal stability and flash points but present some unique problems of their own. The coefficient of thermal expansion is greater than mineral oil by a factor of more than two. Low-surface tension allows the fluid to penetrate the most minute flaws in the sealed container. Even though a leak is detected, the silicone oil on the surface makes repair extremely difficult. Lastly, rapid and successive electrical deterioration occurs if any arcing takes place. Thermal expansion can be accommodated by the use of expansion bellows or, in the case of small power supplies, the use of a filling material. This filler must closely match the dielectric constant of the fluid, to displace the oil from the interstices of the assembly. It thereby reduces the volume of oil, hence expansion, which then allows sealing in a container that can adapt to the lesser volumetric changes by "oilcanning."

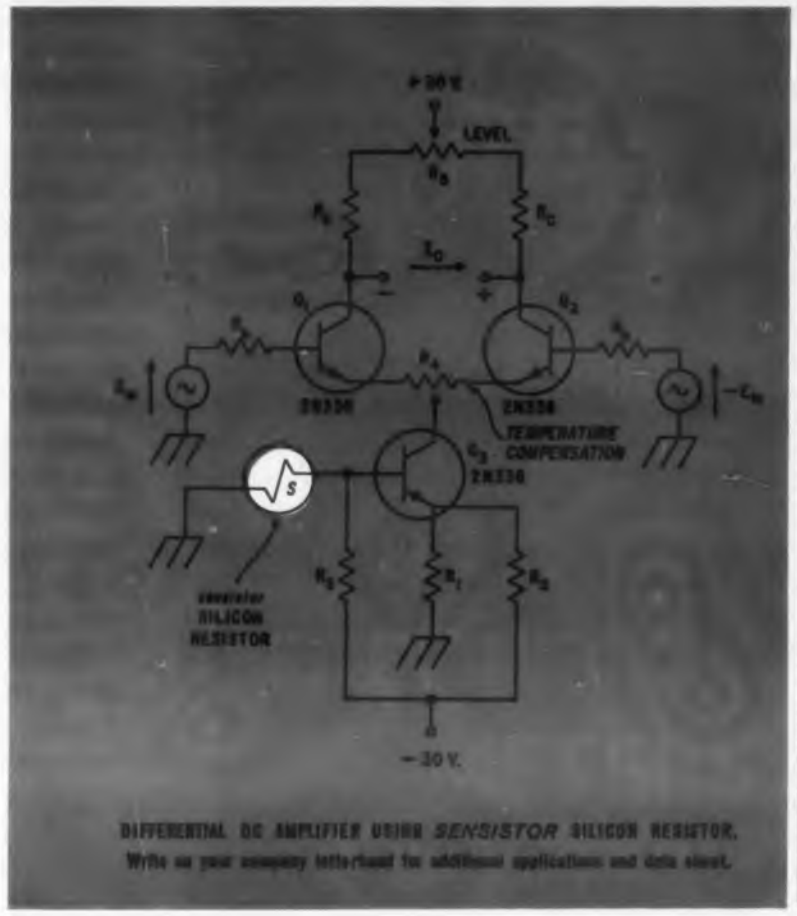
Utilization of a pressurized dielectric gas or a vapor-liquid phase combination overcomes some of these objections but also necessitates heavier container construction and again presents the problem of possible leaking due to fatigue or thermal stresses.

Vinyl Silicone is the Answer

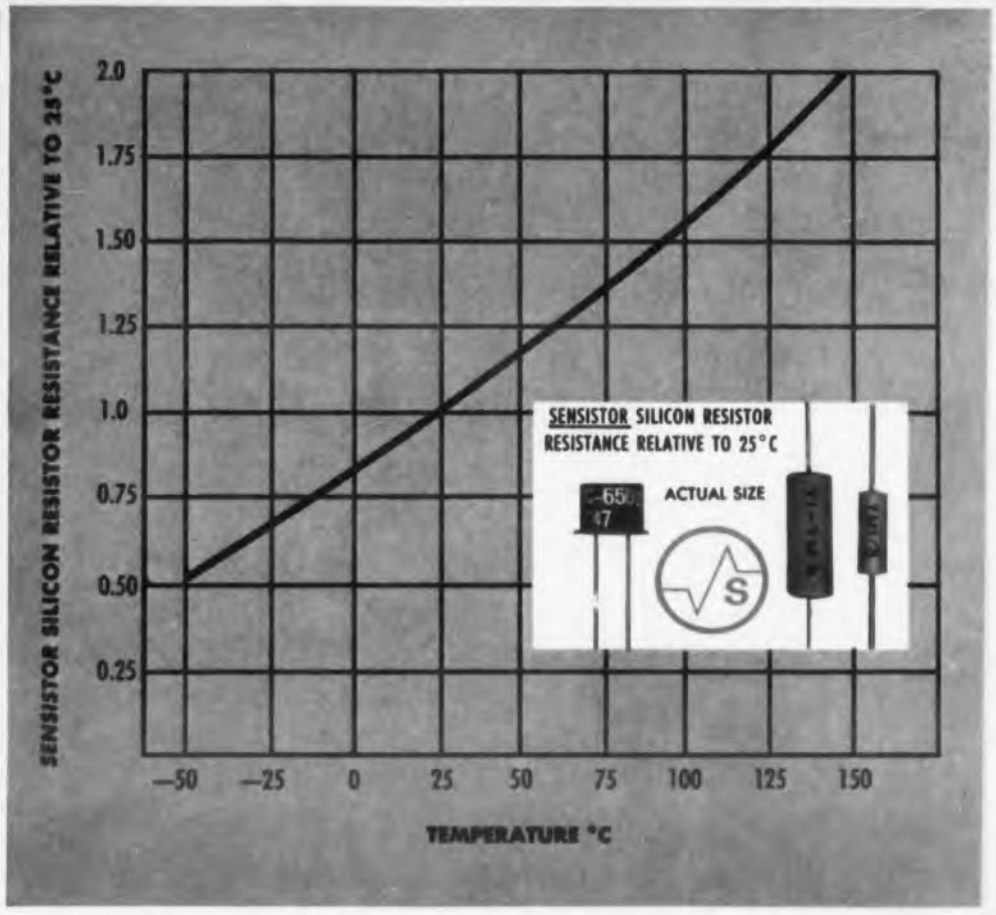
Solventless vinyl silicone potting resins appear to fill all the insulation requirements of small power supplies, and completely resolve the problem of leaks associated with pressurized gas or fluid dielectric power supplies. But vinyl silicone will not in all cases replace an oil-filled power supply, because the rate of heat transfer is lowered to some extent when compared to the oils. However, it can be used as a direct replacement for mineral oil and silicone fluids if the thermal output is moderate or if the design loses the effect of convective heat transfer by the use of filling mate-

Fig. 1. Power supply (left) a block of polymerized vinyl silicone resin (center) and power supply cover can.

TI APPLICATION NOTE



DIFFERENTIAL DC AMPLIFIER USING *SENSISTOR* SILICON RESISTOR.
Write on your company letterhead for additional applications and data sheet.



HOW TO INCREASE DIFFERENTIAL DC AMPLIFIER STABILITY WITH *sensistor** SILICON RESISTORS

Low drift transistor amplifier circuit using *sensistor* silicon resistor gives drift performance superior to vacuum tube amplifiers for low source impedance applications.

The sensistor silicon resistor has a unique positive temperature coefficient of +0.7%/°C plus a constant rate of change as shown in the graph to the right. Over a 15°C temperature range, the *sensistor* silicon resistor's temperature-resistance curve approaches linearity to an extent that allows its use as a compensating component in a differential D-C amplifier.

This low drift amplifier finds a wide range of low source impedance applications in airborne telemetry where the performance of other types of D-C amplifiers is limited by weight requirements, acceleration, shock, and vibration. It is particularly useful with low level transducers such as thermocouples, strain gages and accelerometers.

DESIGN CONSIDERATIONS

TI 2N338 silicon transistor provides excellent performance as a low drift DC amplifier when used in circuits such as the one shown above.

For optimum performance keep $(2R_b + R_t)$ as small as possible, preferably less than 2000Ω, and the collector currents of Q_1 and Q_2 should remain below 100 μA.

Drift cancellation featured in an uncompensated differential configuration provides an amplifier with an equivalent input drift of 400 μV/°C or less with standard production transistors.

Drifts as low as 6μV/°C will result if the compensating circuit composed of Q_3, sensistor resistor S and their biasing resistors is used with a matched pair of transistors.

CIRCUIT OPERATION

Sensistor resistor S and its biasing resistor R_s serve as a voltage source which has an output linearly related to temperature . . . level potentiometer R_5 adjusts output voltage E_o to zero when E_{in} is zero . . . potentiometer R_t adjusts for minimum output drift due to ambient temperature changes.

As temperature increases, the resistance value of S also increases causing the base of Q_3 to go more negative, thereby reducing the collector current of Q_3. This temperature-dependent current is fed into the differential amplifier through R_t.

Depending on the wiper position of R_t, the correcting signal may be positive, negative or zero. When the wiper is centered, zero correction results. As temperature increases, output voltage E_o tends to go more positive if the R_4 wiper is placed nearer the Q_2 emitter and negative if the wiper is placed nearer Q_1. The optimum setting for R_4 can be determined by cycling over the desired temperature range to give a minimum drift for changes in ambient temperature.

*TRADEMARK OF TEXAS INSTRUMENTS

from THE WORLD'S LARGEST SEMICONDUCTOR PLANT

TEXAS INSTRUMENTS
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rials to reduce the volume of the dielectric fluid. Fillers such as silica or sand greatly increase the thermal conductivity, however.

When this factor is considered in the design phase, increased reliability is assured. In addition, since the vinyl silicone is a solid, the resistance to arcing and corona is comparable to the conventional silicone rubbers.

Chemically the vinyl silicone is closely related to the widely used silicone fluids of the dimethyl siloxane type. Electrically, the uncured vinyl silicone also behaves quite similarly to the linear silicone fluids and this feature is used advantageously in the subassembly testing stages.

Catalyzed with benzoyl peroxide the resin cures to a rubber-like solid with very low shrinkage. The curing itself is generally accomplished with 0.5 percent to 1 percent of the peroxide and can be accomplished at between 80 to 150 C. Gellation is generally achieved in one to two hours at 80 C, although the pot life of the catalyzed resin is in excess of six months at room temperature.

Sealing is Easier

This short gel time permits sealing of the container only for a length of time sufficient to allow gellation to occur and therefore greatly simplified seals can be used. The sealing can be accomplished by applying an elastomeric coating to the edge of the base and when the cover is crimped over, sealing is complete.

Briefly the vinyl silicone differs from the well known silicone resins or varnishes, silicone rubbers and silicone fluids but slightly. Silicone resins and varnishes vary between brittle and semiflexible materials. The vinyl potting compound when cured is characteristic of a material between a gelatin and a rubber. Shrinkage during cure can be minimized. The gel structure of the vinyl silicone is not rigid like a casting resin and therefore some external support is required. This can be the actual container used for potting, and the structure itself can be much lighter than that required for oil insulated supplies.

Resilience of the resin serves two very useful functions. It allows crack free operation over a wide range of thermal cycling, by its ability to accommodate large differentials in the thermal expansion of the embedded components. It also provides a vibrational dampening to protect the internal components.

The coarse grade of sand used as a filter also serves two purposes. It increases the coefficient of thermal conductivity and it reinforces the vinyl polymer.

Passed Mil Specs

Application of the vinyl potting compound to power supplies has so far been limited to fairly small units 3 x 4 x 6 in. (Fig. 1), with design voltages varying from 1-3 kv and test voltages up to 6 kv. The containers are almost identical to those

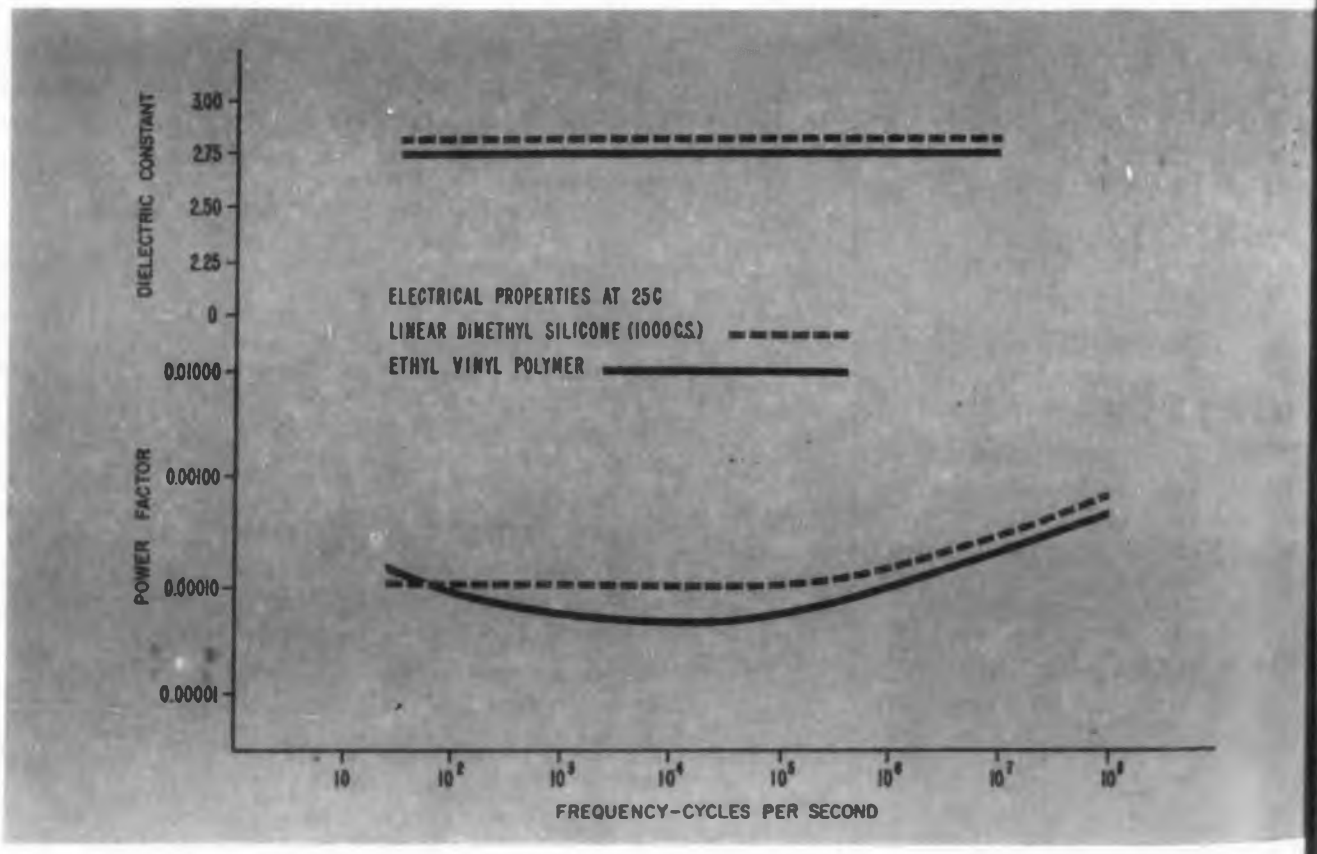


Fig. 2. Comparison of electrical properties of dimethyl silicone fluid and vinyl silicone polymer.

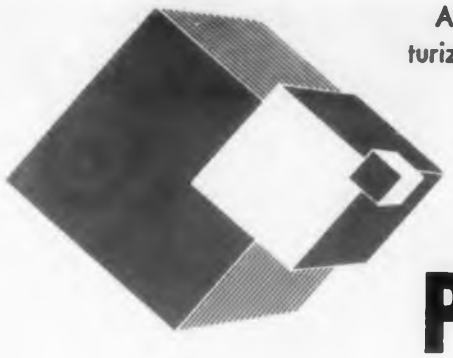
used or oil filled units except that a larger port is used to introduce the filler and resin. The structure itself can be made very much lighter since there is no need to withstand pressures of thermal expansion of oil or gas. Hermetic sealing is unnecessary since the resin itself permits the units to withstand very high humidity. Sample units with holes drilled through the metal casing at critical points have passed the requirements of MIL-E-5272A humidity tests. The possibility of almost direct substitution of polyvinyl siloxane for silicone fluids is apparent from an examination of Fig. 2. Properties are very similar.

Uncured fluid may be used to test the individual components and assembly prior to potting at full voltages. Normally in the manufacture of a power supply the transformer is separately tested in oil and the wired assembly is tested before assembly into the container. Excellent electrical properties (Table I) and long pot life allow the same procedure to be followed, and when the unit is potted there are no rejects because of leaking or residual uncured testing fluids.

The advent of the solventless silicones is not a panacea for all potting or liquid dielectric problems but based on our own and some of our vendor's experiences they should provide one firm step forward in improving reliability. ■ ■

Table I Physical and Electrical Properties of Ethyl Vinyl Silicone Resin

Tests	Values
Viscosity at 25 C	3500-4500 centistokes
Temperature coef. of visc.	0.6
Refractive index	1.4044
Weight loss of polymer 168 hours at 200 C	2.8 percent
Shrinkage on cure	0.4 percent
Thermal shock (MIL-C-16923) (except 200 C to —55 C cycles)	passed
Specific gravity (Cured)	0.976
Dielectric strength (uncured)	300 v/mil
Thermal conductivity (Cured)	
unfilled	5.4 BTU/hr./in./sq.ft./F
sand filled 1:1	16.0 BTU/hr./in./sq.ft./F
Volume Resistivity	
at 25 C	10^{14} ohm/cm
at 125 C	10^{14} ohm/cm
Dielectric Constant	
60 cps	2.80
1 kc	2.80
100 kc	2.80
1.26 mc	2.80
Power Factor	
60 cps	0.01
1 kc	0.01
100 kc	0.01
1.26 mc	0.02
Dielectric Strength	300 v/mil



Another article of the exclusive series on microminiaturization.

Packaging Missile Electronics

Although this article does not disclose radical innovations in the field of miniaturization, an understanding of present applications may enable design engineers to get an added feel for military requirements.

Alvin Steinberg

Reliability Branch, R & D Division
Army Rocket & Guided Missile Agency

GREATER demands in accuracy and reliability of missiles are changing the appearance of the missile electronic package. Our first generation of systems, the Nike Ajax and Corporal, used Jan or commercial parts with conventional World War II wiring in typical block boxes. In the present day systems, Nike Hercules, Hawk, La Crosse, and Dart, a transition is evident by the admixture of some printed wiring boards, encapsulated subassemblies, and a wide use of nonstandard parts. The next generation may use guidance packages of throw-away microminiature assemblies where space restrictions are imposed by waveguides and hydraulic systems, rather than by electronic and electro-mechanical assemblies.

Corporal Missile

To define the problem in packaging electronics, consider the Corporal. A Corporal battalion is authorized some 320 vehicles of equipment. Both operators and maintenance technicians are highly skilled and well trained for their mission. Obviously, the use of microminiature parts, modular packaging amenable to machine assembly, and a revision of operation and maintenance concepts to allow more replacement and less repair would reduce the complexity of present operations.

In Fig. 1, a typical Corporal wiring and layout, note the absence of support ribs in the chassis and the maze of wiring. The Corporal system is not to

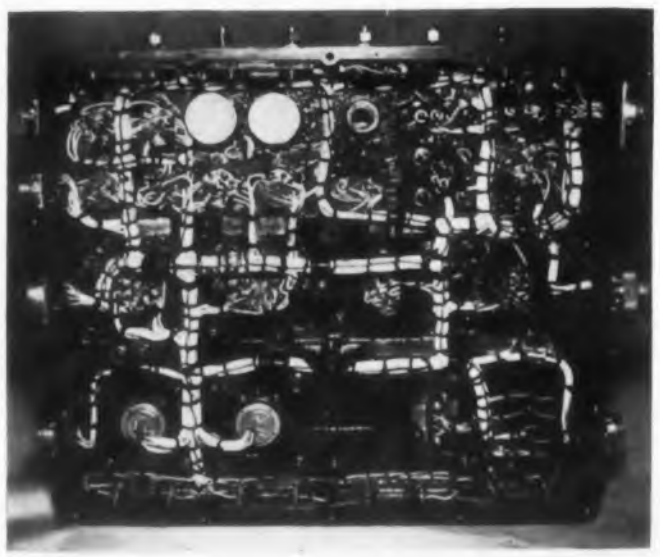


Fig. 1. Original layout of the electronics package in the Corporal.

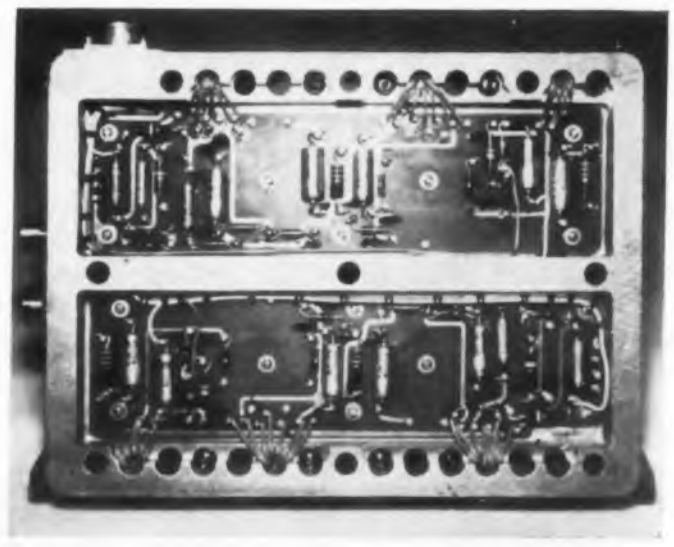


Fig. 2. New configuration of Corporal package is much less complex.

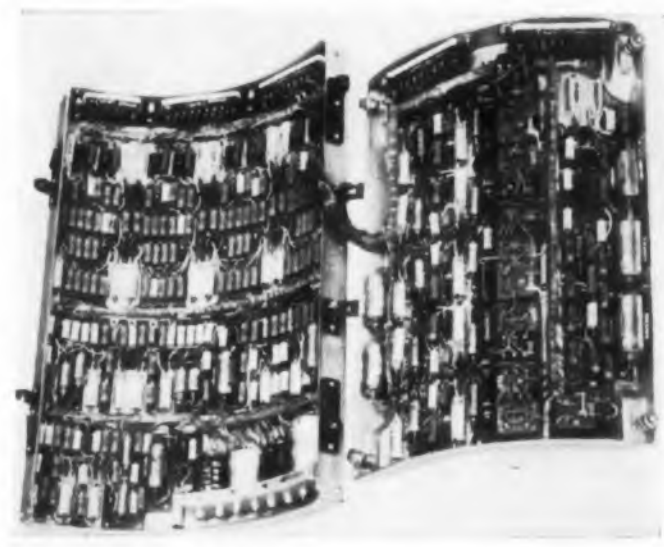


Fig. 3. How the cylindrical platters in the Hawk are assembled.

be written off because of outdated packaging. Readiness dates prevented the designers from incorporating new techniques during research and development.

The Corporal III system has modern ground equipment and would correct these outdated features. Furthermore, in field test firings, the Corporal IIA has demonstrated a higher reliability than any other Army missile system. This reliability has been the result of many factors including a product improvement program whereby over half the missile electronic circuits as noted in Fig. 1 were converted to configuration as shown in Fig. 2.

Hawk Missile

A picture of our progress can be portrayed by a look at our present day developments. The Hawk missile-borne electronics is packaged principally within two units: the seeker and the autopilot. Many parts have been made nonstandard by additional environmental requirements: that is, by further selection processes at the plant. The Hawk missile electronics part count, Table 1, is over 1570 electronic parts exclusive of cables and connectors.

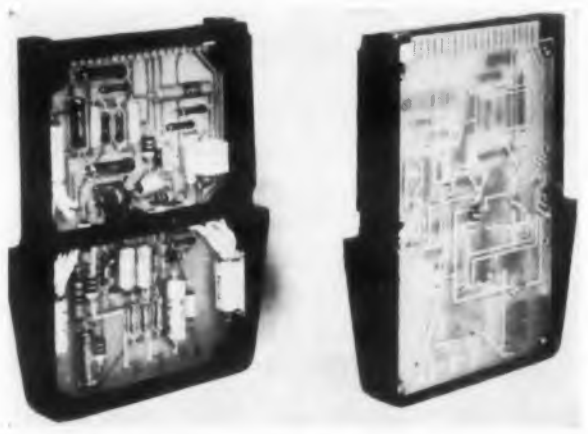


Fig. 4. Module for the Hercules.

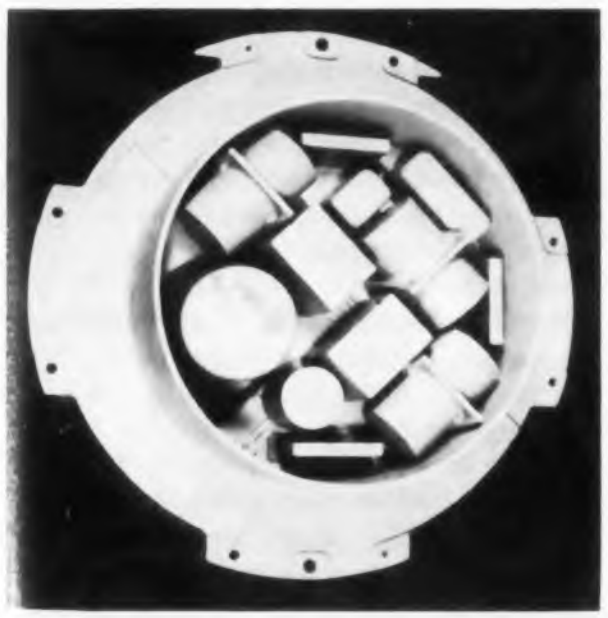


Fig. 5. Makeup of the Hercules "mushroom." This is the instrument side.

Parts are laid out within the cylindrical section of the missile for ready accessibility. Batteries, dynamotors, and large heavy hardware are mounted along the longitudinal axis whereas the circuit parts are neatly mounted on curvilinear laminates in periphery and parallel to the missile skin. Raytheon was directed to provide for repair by part replacement and a more accessible layout for the electronic parts would be hard to visualize. Fig. 3 shows the nature of the assembly of the cylindrical platters. Electronic part density in the Hawk missile is in the vicinity of 2000 per cubic ft. The present day maxima using printed wiring boards is around 50,000.

Hercules Missile

Nike Hercules' guidance package has undergone a recent packaging redesign. Old design is shown in Fig. 4. The new package is a "modular" one with subassemblies more readily accessible and is commonly called the "mushroom guidance" package. The Hercules missile electronic parts count, Table 2, is approximately 724 parts.

Actually, for a tactical operation, the parts count for the Hercules might be considered less than the 700 items assembled. Over half the parts are mounted in printed wiring boards and therefore would not be subject to individual replacement. The Western Electric process for assuring good solder points to printed wiring boards requires a 3 cycle thermal shock after soldering. Field replacement of an item to the board where soldering is involved, is not planned. The high failure items, vacuum tubes, are mounted on the cast frames that house the printed board assembly and are replaceable if need be although even this item is considered better replaced at 5th echelon.

There are 22 printed wiring boards in the Hercules guidance package. Reliability tests showed no general necessity for encapsulation, therefore, only one subassembly is sealed in epoxy resin and a second unit in silastic rubber. The majority of the coils, however, have been encapsulated for better configuration with respect to assembly in the modules and for environmental protection.

The Hercules part density is approximately 2000 per cubic ft. A Hercules module and a mock-up of Hercules "Mushroom" instrument side are shown in Fig. 5.

La Crosse Missile

The La Crosse I missile guidance package in contrast to Hawk, provides all presently available techniques of assembly. The five missile electronic assemblies contain 20 potted subassemblies and use 18 printed wiring laminated boards. The La Crosse electronic parts count for the missile is about 697 as shown in Table 3. La Crosse chassis

Table 1. Hawk Parts Count

Capacitors:	
Ceramic	46
Mica	46
Tantalum	35
Tantalum	156
Glass	73
Electrolytic	3
Titanium Dioxide	8
Total	367
Tubes:	146
Crystals and Crystal Diodes:	81
Transformers:	55
Resistors:	
Composition	484
Wirewound	11
Deposited Carbon	373
Total	868
Inductors:	
AF Reactors	3
AF Toroids	3
RF Coils	46
RF Toroids	3
Others	4
Total	59

Table 2. Hercules Parts Count

Capacitors:	
Mica	29
Paper	97
Tantalum	7
Glass	6
Ceramic	9
Others	13
Total	161
Resistors:	
Composition	77
Wirewound	23
Deposited Carbon	214
Variable	15
Total	329
Vacuum Tubes:	35
Transistors:	28
Crystals and Crystal Diodes:	120
RF Inductors:	18
Audio Coils and Transformers:	19
Other Parts:	14

Table 3. La Crosse Parts Count

Capacitors:	
Mica	102
Glass	32
Paper	40
Tantalum	2
Ceramic	3
Variable	5
Total	184
Resistors:	
Wirewound	23
Composition	207
Deposited Carbon	53
Variable	13
Total	296
Inductors, AF:	15
Inductors, RF:	109
Diodes & Crystals:	30
Tubes:	47
Relays:	10
Miscellaneous:	26

Higher-Temperature Capacitors:

New Dielectric Materials Help Break the Heat Barrier

By Marc F. Warmuth, Staff Engineer, Airborne Accessories Corporation

Special Mylar*, Teflon† and mica constructions permit continuous operation up to 600°F

Three new types of special high-temperature motor-starting capacitors, utilizing Mylar, Teflon and mica dielectric respectively, have been developed recently by Airborne. The Mylar and Teflon types are wound of very thin metallized film for greatest possible miniaturization. The mica type is wound of a sandwich of aluminum foil and thin, pure mica ribbon, metallized mica not being procurable. All are encapsulated with thermoplastic polyamide or thermosetting epoxy resins (depending on temperature range) in sealed, cold-drawn steel cans with fused glass terminals. This construction provides low inductance units of exceptional mechanical sturdiness and environmental resistance.

As an alternate construction for less demanding applications, encapsulation in epoxy sleeves, with leads brought out through potted ends, is also available.

Mica for highest temperatures

The great advantage of mica as a dielectric is its ability to maintain its physical and electrical characteristics at temperatures up to 1000°F. All dielectric materials undergo severe reductions in insulation resistance at high temperatures, but with mica the critical value is reached around 600°F. Full voltage ratings up to this point are thus permitted. And with the right epoxy resin impregnant, mica capacitors are well able to withstand overtemperatures without damage . . . if not simultaneously subjected to full rated voltages.

Mica capacitors are three to four times larger than Mylar or Teflon units of comparable capacitance and voltage rating. This is because a greater thickness of dielectric must be used in addition to a separate layer of aluminum foil.

Mylar and Teflon for intermediate high temperatures and small size

Mylar can be worked continuously up to 300°F and Teflon up to 400°F. For applications below these limits, but above the normal 185°F limit of more conventional insulating materials, metallized Mylar and Teflon offer high dielectric strength. They make possible wound capacitors of very small size with good voltage ratings and excellent capacitance-to-volume ratios.

A further advantage of metallized Mylar and Teflon capacitors is their self-healing characteristic. The short occurring when the dielectric is ruptured instantly burns the thin metallic coating back from the edges of the rupture, making further flashover impossible. Yet the amount of metallic coating burned away is so minute that hundreds of such self-healings have little effect on capacitance. Resistance to overvoltages can thus be considered excellent. Resistance to over*temperatures*, on the other hand, is not an outstanding characteristic of Mylar or Teflon—a design factor to keep in mind.

Summary

MYLAR: For intermediate high temperatures, high voltage and smallest size. Continuous operation at 300°F with ratings up to 1000 WVDC. Capacitance variation with temperature good, but not as good as that of Teflon or mica types.

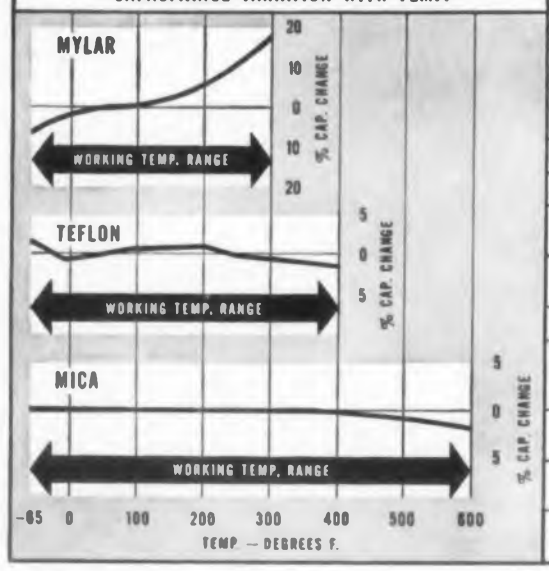
TEFLON: For intermediate high temperatures and small size. 600 WVDC up to 400°F without derating.

MICA: For highest temperatures. Continuous operation, 600 WVDC without derating up to 600°F. Higher temperatures possible with derating. Larger in size than equivalent Mylar or Teflon capacitors.

For proposals on your specific capacitor requirements, write AIRBORNE ACCESSORIES CORPORATION, HILLSIDE 5, N.J.

**DuPont's tm for its polyester film*
†DuPont's tm for its tetrafluoroethylene resin

CAPACITANCE VARIATION WITH TEMP.



TABULATED CHARACTERISTICS—AIRBORNE SPECIAL HIGH-TEMPERATURE CAPACITORS

TYPE	MYLAR Wound, Metallized Mylar Film	TEFLON Wound, Metallized Teflon Film	MICA Wound Alum. Foil with Mica Ribbon
Working temp. range	-65 to + 300°F (-55 to + 150°C)	-65 to + 400°F (-55 to + 205°C)	-65 to + 600°F (-55 to + 315°C)
Voltage ratings	200-1000 WVDC	200-600 WVDC	200-600 WVDC
Capacitance range	.01 mfd up	.01 mfd up	.01 mfd up
Capacitance variation with temp.	Very good to 150°F Good 150-300°F	Excellent to 250°F Very good 250-400°F	Excellent to 350°F Very good 350-600°F
Insulation resistance	50,000 meg x mfd at 78°F 10 meg x mfd at 257°F	500,000 meg x mfd at 78°F 75 meg x mfd at 300°F	10,000 meg x mfd at 78°F 4 meg x mfd at 600°F
Dielectric strength	4000 v/mil	1500 v/mil	1000 v/mil
Size	D L	1.1xD 1.1xL	3to4xD 3to4xL
Capacitance change vs time at max. working temp.	-5% or less after 250 hr	-5% or less after 250 hr	-5% or less after 250 hr
Overvoltage resistance	Excellent (Self-healing)	Excellent (Self-healing)	Non-self-healing
Short-time exposure to overtemperature	Poor	Poor	Very good with derating

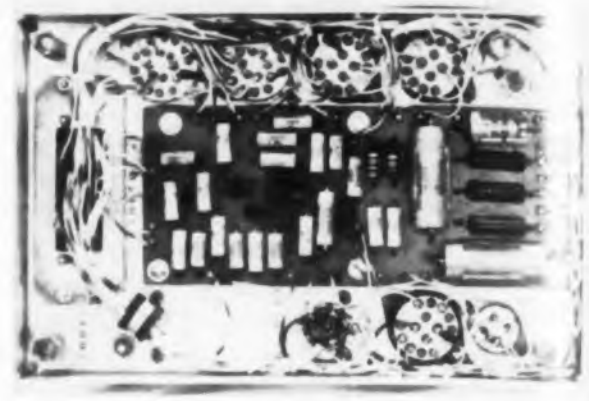


Fig. 6. Lacrosse chassis wiring.

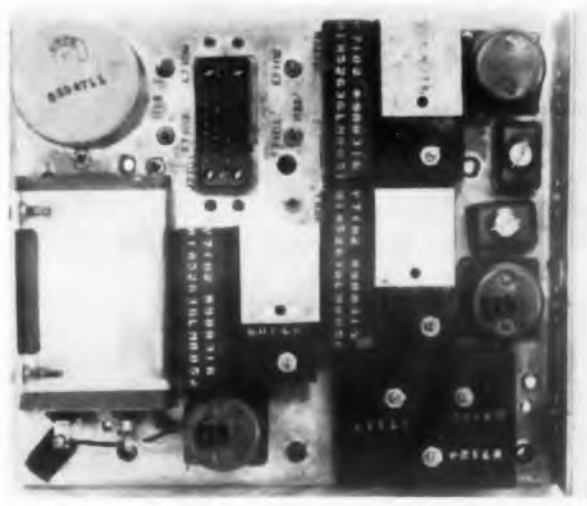


Fig. 7. Top view of the Lacrosse electronics package.

Table 4. Missile Electronic Parts

Total Parts	Hawk	Hercules	La Crosse
Non-Standard	1570	602	697
Type Maintenance—Replacement	90% Part	50% Module	80% Part and Potted Assy

wiring and layout are shown in Fig. 6 and 7.

The La Crosse guidance package is subdivided into five chassis, replaceable by an operator when failure is evident as indicated by an automatic tester. Piece part repair within the five chassis is accomplished by back-up Ordnance Corps maintenance technicians. Parts density in the La Crosse I missile is of the order of 1000 per cubic ft. Many rf cavities contribute to the relative low part density. Hawk, La Crosse and Hercules are compared in Table 4.

Maintenance Problems

Until early this year, the maintenance philosophy promulgated by the Ordnance Corps for missile systems was based on AR 750-5, that is, the traditional five echelons. By interpretation, field repair meant test equipment for fault isolation to

the piece part and repair by part replacement.

This maintenance philosophy has been modified, and repair is now permitted by replacement of modules. Accordingly, the Sergeant, Nike Zeus, and La Crosse Mod I systems will be packaged in modular form and a reduction in field repair and maintenance skills is evident in their Table of Organization and Equipment.

Use of nonstandard parts is of great concern in the industrial phase of a missile program. Each part peculiarly stocked as a replacement part adds an additional burden on the supply system. Furthermore, if the part is a new development which may be inadequately tested, it is also a threat to reliability. Many of the parts in the systems discussed have been made non-standard by the addition of specifications for environmental extremes of temperature and shock not contained in the Mil Spec of the comparable part.

A part selected by environmental testing does not necessarily have a greater resistance to failure than one not so selected. However, complex missiles can hardly be expected to function unless constructed under extreme conditions of quality control and this begins with incoming inspection of electronic parts. Reliability takes precedence over standardization.

By the reliability formula or the product rule, the overwhelming number of missile-borne electronic parts makes the guidance package the most suspect for in-flight failures. There is no evident relationship between reliability and missile electronic part selection and assembly. In field test firings the missile with the greatest part-count has shown the greatest reliability. Factors other than complexity must be more influential in field operations.

Miniaturization of components in servo or hydraulic systems would pay off greater dividends in space savings than in the electronic area. For example, the electronic package in one guided missile is only 2 per cent of the total weight of the missile and 2 per cent of the volume.

Miniaturization efforts on electronic parts and assemblies will be the trend for our future systems. The criteria of reliability and ruggedness point toward miniaturization as a possible solution for better performance. Although the Hawk, Hercules, and La Crosse I may derive no benefit from the miniaturization efforts described at this symposium, our missile designers are anxious to incorporate new features in the next generation of systems now in the planning stage.

More detailed information on the equipment 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.

Measure Fine Wire Fast With

Cross-sections of fine wire. Note typical surface imperfections detected by Sylvania Out-of Roundness Instrument.

IF YOU'VE ever tried to measure fine wire wit a barrel micrometer, and tried to get the sam reading twice in a row, you can imagine wh the electron tube manufacturer is up against. Fo grid laterals, he needs wire diameters that var in diameter from 0.006 to 0.003 inches.

He needs to know if the wire has surface im perfections like flats and ridges. (Such "flashy wire makes inferior grids). He may want to d tect diameter differences in the order of five m lionths of an inch. He wants to know if the wi is out of round. And he'd like to check for these imperfections while the wire is on the f

Sidestepping the usual techniques, D. R. Ke stetter, Section Head of the Materials Enginee ing Group of Sylvania Electric Products Inc. Emporium, Pa., developed an electronic Out-o Roundness Tester.

This instrument, available from Sylvani Equipment Development Plant, uses variatio in reflected light to detect surface imperfectio in wire samples. The wire passes through a d tection head at about five feet per minute. T head has a light source and a sensitive pho tube whose output is amplified by a high ga dc amplifier, then fed to a 500-0-500 μa met The meter needle oscillates back and forth fr the center position depending on the uniform of the wire.

Excellent spools of wire show out-of-roundn in the form of meter deflections of 50 to 100 Very poor wire will deflect the meter some 3 to 500 μa.

If a scope is used as the display device, stead of a relatively slow microammeter, t

Instrument for fine wire measurements detects 0.000005 in. differences in diameters.

wire can be examined at extremely high speeds—limited by the maximum rpm of the take-up spool.

Calibration is Easy

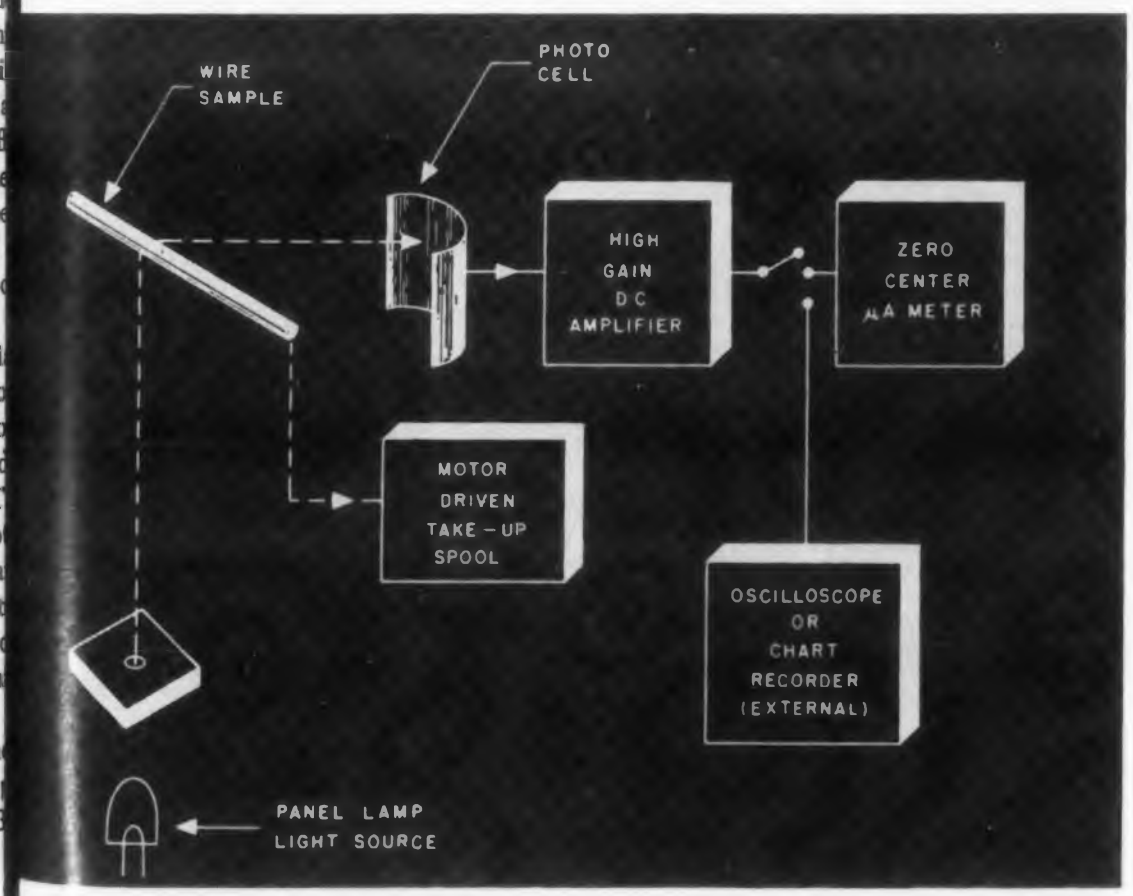
For reproducible results, the instrument must be calibrated for each wire size. This is done by switching resistance (7 ohms) in series with the light source (reducing the light intensity about 10 per cent), and adjusting the sensitivity so a specific change in reflected light from a given piece of wire will produce an equivalent change in meter deflection.

It's a Great Instrument, But . . .

It has its limitations. The instrument doesn't know one imperfection from another. Flats, ridges, and fissures all appear as surface imperfections but the tester doesn't tell which is which. It can't distinguish between true out-of-roundness and nonuniformities caused by oxides, discoloration, or other foreign surface material irregularities.

Fortunately, in the manufacture of grids and other items requiring such fine wire, the wire surface condition is usually quite uniform from the standpoint of oxides and contamination.

The instrument may not be the ultimate, but it certainly represents a distinct step forward in precise measurements of roundness and uniformity in small diameter wire. ■ ■



Variations in light reflected from wire detect surface imperfections.

Designer's Dilemma:

Electronic or Mechanical Multiplexers?

M. M. Kranzler
Applied Science Corp. of Princeton
Princeton, N. J.

RELIABILITY, cost and function—these interrelated factors govern the choice of either electronic or mechanical multiplexer. The first two principal factors are detailed in the text, while all functional parameters are outlined in the adjoining table.

In evaluating the reliability of a multiplexer, the

Functional Parameters of Electronic and Mechanical Multiplexers

Characteristic	Electronic General Range	Mechanical General Range	Preferred
Size (Sealed)	½ cu in. per channel to 1 cu in. per channel	¼ cu in. per channel to ½ cu in. per channel	Mechanical
Cost	$50 to $100 per channel	$5 to $30 per channel	Mechanical
Accuracy	1 to 5%	0.1 to 1%	Mechanical
Contact Res.	—	0.25 to 50 ohms	Mechanical
Open Ckt Impedance	2 K to 1 meg	20 to 1000 meg	Mechanical
Effect on Transducers	Back Currents up to 3 ma	None	Mechanical
Life at 80 C	1000 to 5000 hr	5 to 1000 hr	Electronic
Power Input	2 to 10 w	10 to 20 w	Electronic
Sampling Speed	5 to 20,000 samples per sec	From 0 to 2500 samples per sec	Electronic
Speed Regulation	0.01 to 5%	±2 to ±25%	Electronic
Max. Operating Temperature	to 85 C	to 150 C	Mechanical
Min. Operating Temperature	—55 C	—55 C	—
Vibration	up to 35 g	up to 35 g	Electronic
Duty Cycle	10 to 95%	50 to 95%	Electronic
Rise Time	1 to 10%	5 to 10%	Electronic
Phaseability	±1%	±5%	Electronic
Type of Signal Input	0 to +5 v 0 to —5 v ±2.5 v	0 to 15 mv 0 to 100 v	Mechanical
Max. Source Impedance	25 K	500 K	Mechanical
Min. Load Impedance	1 meg	100 ohms	Mechanical

...esign engineer should consider:

Complexity of Design. The price of specifying a ...multiplexer with a potential life of 10,000 hr, if 500 ...s all that is required, is complexity. Advantage ...f mechanical devices shows up in multipole ap...plications: the addition of 30 more channels calls ...or 60 more stationary contracts and two more ...wipers and springs. Adding a pole to an electronic ...commutator may mean 200 more components.

Ease of Parts Inspection. Mechanical parts are ...easier to inspect than electronic components. This ...s important in quality control work.

Circuit Design and Redundancy. Oscillators are ...more reliable than dc governed motors although ...hey hold a lesser edge over ac devices. Electronic ...devices all have some sort of channel sequencer ...which is also a series element, although some re...dundancy is feasible. Intra-circuit shorts or opens ...re more harmful electronically and can cause ...atastrophic failures, but a mechanical switch ...ives warning before failure.

Basic Component Failures. If the function can ...e chosen to coincide with the speed and pulse ...hape limitations of mechanical devices, for short ...erm reliability, the mechanical device is superior. ...t high commutation speeds, coupled with long ...fe or extremely accurate pulse shapes, the elec...tronic switch assumes prominence.

The price of electronic equipment is between ...wo to five times more expensive than the equiva...ent mechanical device. Costs are proportional to ...he number of channels electronically but the ...echanical switch is priced almost like a step ...unction. The cost of mechanical components is ...igher than for electronic equipment, but fewer ...placement items are required. Instituting a de...sign change in sampling speed is small for elec...tronic equipment and high for mechanical de...vices. Changes in the number of channels or signal ...evel are less expensive mechanically. ■ ■

Acknowledgment: This article is adapted from a paper by the author contained in the Proceedings of the 1958 National Symposium on Telemetering.

Generate Groups of "n" Pulses With Variable Rep Rates

IT IS often necessary to generate groups of constant numbers of pulses with varying pulse repetition rates. Normally, one-shot multivibrators are used for on-off periods, but they require adjustment for different pulse rep rates.

The logic circuitry described here provide the desired results. All the flip flops used are identical, and the device allows variation in on-off periods.

The circuitry has been used to generate repetition rates from 100 to 1000 pps, and seven stages of counters have been used to generate 88 pulses on and 2 pulses off—to simulate a commutator output.

The block diagram of Fig. 1 and the circuit of Fig. 2 show a convenient way to generate groups of pulses with a constant ratio between the number of pulses in a group and the spacing between groups, regardless of the pulse rate.

The waveforms of Fig. 3 are for a device to generate groups of 15 pulses with a space between groups equivalent to that of a pulse. When two pulses have been counted by the first flip flop in the counter chain, a pulse is sent to the gate operator flip flop to open the gate and let the square wave pulses through to the output.

The counter chain continues to operate, and when the fourth flip flop reverts to its original state, thus indicating an accumulated count of 16 pulses, an off signal is sent to the gate operator to close the series gate.

The gate remains closed till two more pulses have been counted, and the action repeats.

Obviously, it is most convenient to have the sum of the pulses in a group and the pulse spacings between groups equal to some power of 2 so that a straight binary counting chain can be used.

However, conventional feedback techniques can be used so any desired preset output can be obtained. Additional flexibility is available by choosing either leading or trailing edges from the flip flops in the counter chain as gate operator triggers.

John H. Porter, President, Portronics, Inc., Tarzana, Calif.

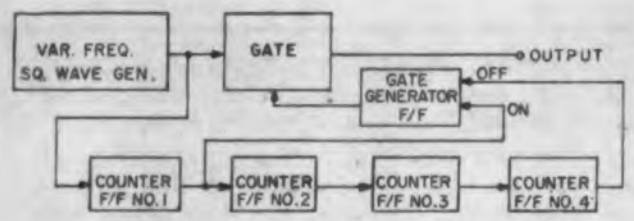
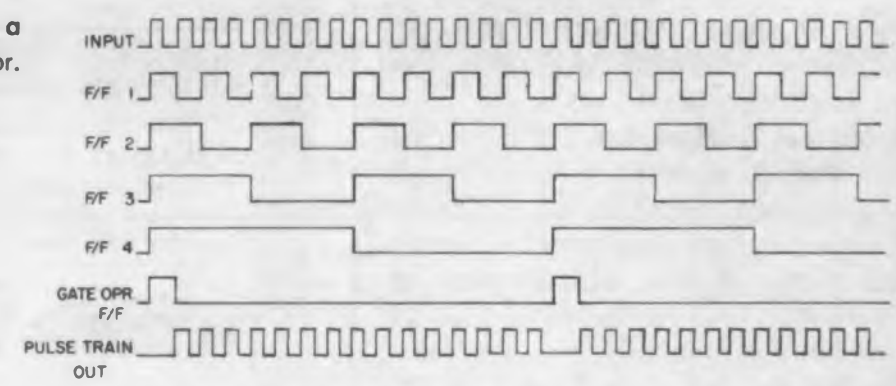
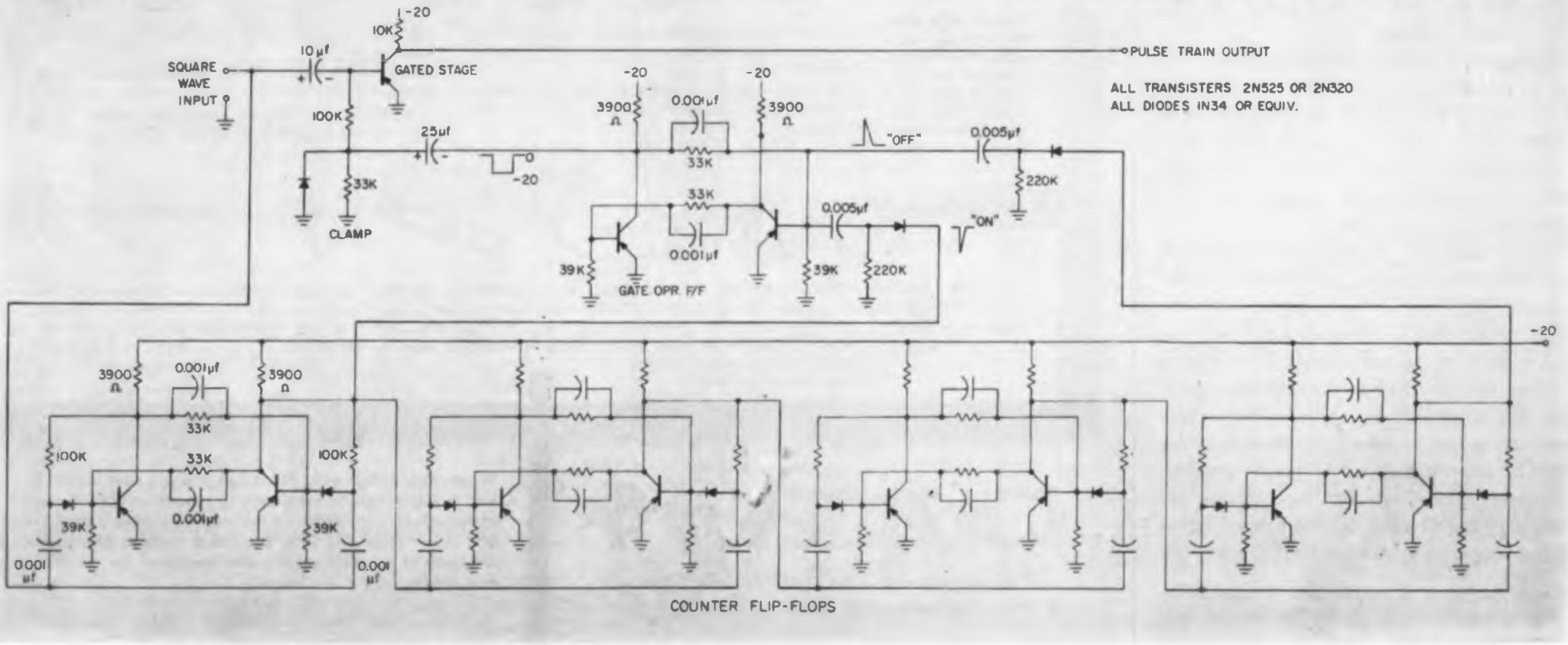


Fig. 1. above Block diagram for a pulse generator with constant ratio between number of pulses in a group and spacing between pulses.

Fig. 2. below The pulse train generator circuit. Each of the four flip-flops are identical.

Fig. 3. right Waveforms for a "15 on, 1 off" pulse generator.



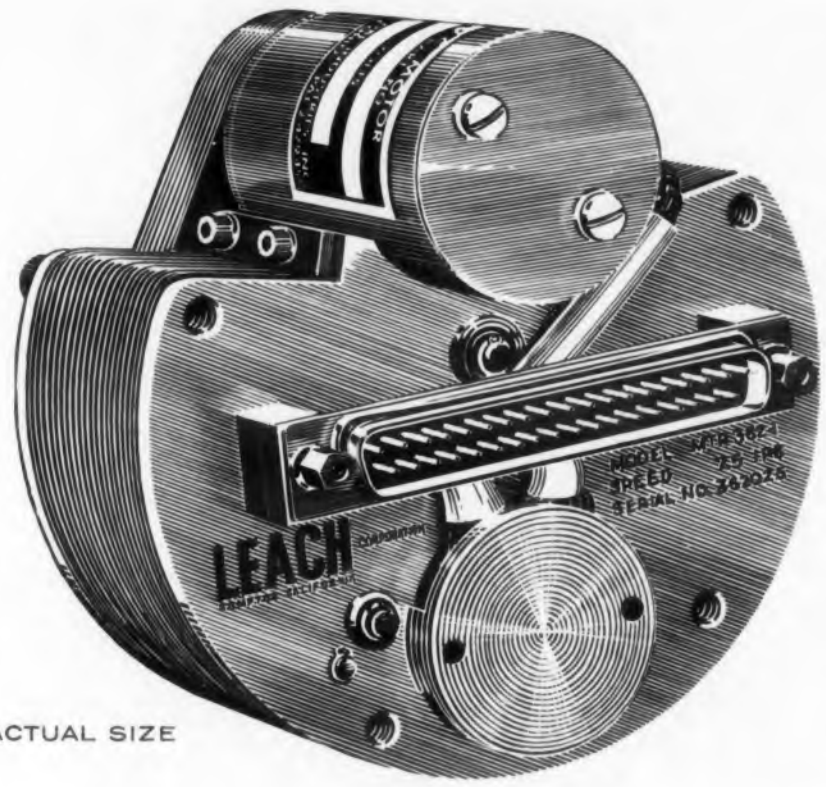


built to take it

...designed to tell

the whole story

with impact!



ACTUAL SIZE

MINIATURE TAPE RECORDER

Testing under severe environments . . . in extremely limited space? Inet's rugged Miniature Magnetic Tape Recorder simultaneously records data on 1 to 14 in-line channels, never loses a record because it's built to survive high impacts.

Weighs just 24 ounces and operates at tape speeds of from ¼ to 15 inches per second in a temperature range of −50°F to +200°F. Among its features: precision in-line recording head; adjustable motor speed and tape tension; and molded rubber pressure roller and drive wheels.

APPLICATIONS: in-flight and static tests; atmospheric, blast, explosion and wind tunnel studies; and acceleration and actuation tests.

Write for complete specifications.

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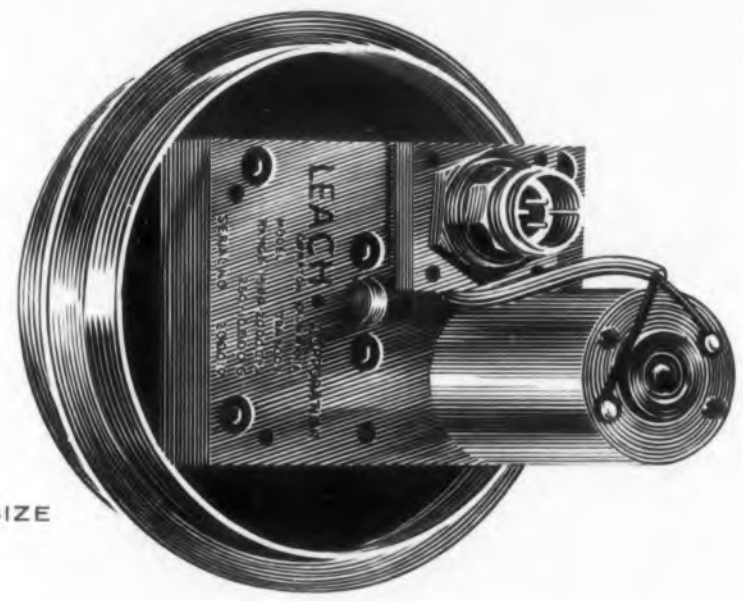


ACTUAL SIZE

TRIAXIAL RECORDING ACCELEROMETER

The compact, self-contained unit shown above is Inet's 6-ounce Triaxial Recording Accelerometer... attached to a 1½-inch-radius missile nose section.

This rugged unit has three sensing elements—reeds—that directly sense and record data on structures and components subjected to high-acceleration loads. It operates on 6 volts in a temperature range of −50°F. to +160°F., requires no connections to external devices except a power source. The unit records data on acceleration-time history along each of three mutually perpendicular axes. Among its applications: water-entry shock studies; ground impact, blast, and explosion studies; and various other tests, including rocket motor, target impact, sled, and switch actuation tests.

Write for complete specifications.

RELIABILITY

LOOK TO LEACH

INET DIVISION . . . LEACH CORPORATION

18435 SUSANA ROAD, COMPTON, CALIFORNIA

DISTRICT OFFICES AND FIELD REPRESENTATIVES IN PRINCIPAL CITIES OF U.S. AND CANADA • EXPORT: LEACH CORP., INTERNATIONAL DIVISION

CIRCLE 32 ON READER-SERVICE CARD

IDEAS FOR DESIGN

The Better Mousetrap Makes Hot Detector

This device is a simple but effective fire alarm for temporary use in unattended areas where flammable articles may be stored or where electrical equipment must operate without supervision.

As illustrated in Fig. 1, a mousetrap is mounted on a ceiling with a nylon thread keeping it cocked. The thread is fastened to a far wall. The business end of the mousetrap keeps it taut a few inches below the ceiling.

Connections from the alarm circuit are made to the mousetrap as shown in Fig. 2. At the first blast of overhead air, the nylon will soften and part, giving an almost instantaneous alarm.

Nylon thread should be used in preference to cotton, as it will not fail and give a false alarm.

Robert M. Slater, Tennessee Valley Authority, Knoxville, Tenn.

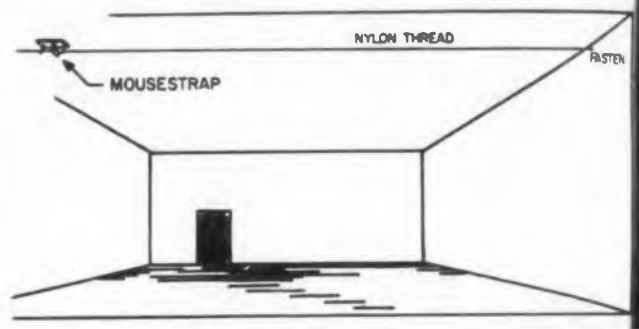


Fig. 1. Nylon thread and a mousetrap can serve as an almost instantaneous fire detector.

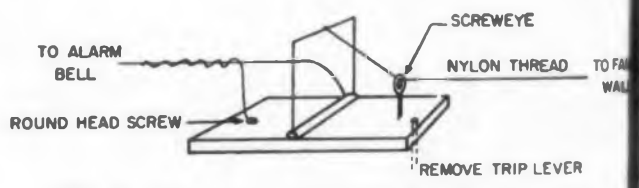


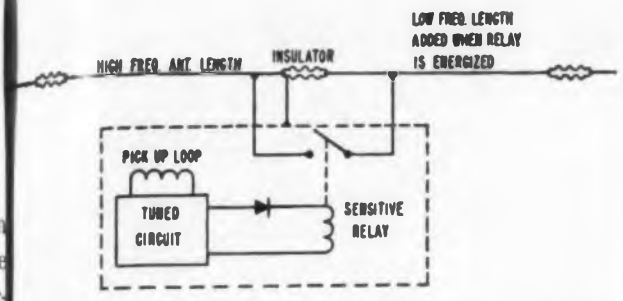
Fig. 2. Mousetrap, prepared for fire detection.

Variable Length Antenna

It is often necessary to transmit on several frequencies using the same antenna. Usually a compromise must be made for the antenna length. It would be very desirable to have an antenna whose length could be varied, depending on the transmitted frequency.

One solution, shown in the figure, uses a tuned circuit, a crystal detector, and a sensitive relay all mounted in a weather-proof housing. The tuned circuit is tuned to the lower of two frequencies which are to be transmitted. The weather-proof housing is suspended at the end of the high frequency antenna wire.

When transmitting at the higher frequency



...e sensitive relay is not energized, so only the ...wer frequency, switches in additional antenna length ...hen the low frequency is transmitted.

...wo-frequency antenna. The relay, powered by the ...ort antenna is in operation.

When the lower frequency is transmittted, it ...nergizes the tuned circuit and operates the ...elay. This switches in enough antenna wire to ...rovide proper loading.

The system requires no batteries. It switches ...ntenna lengths automatically, the relay being ...owered by transmitted rf power.

Robert Marie, Project Engineer, Perfect Circle ...orp., Hagerstown, Ind.

Pulsed Hartley Provides Constant Level Sinusoids

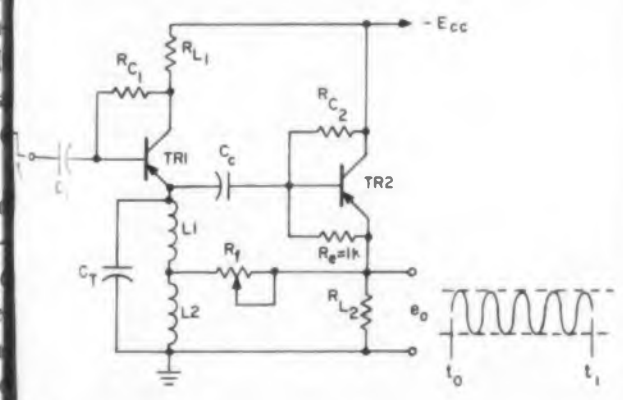
The circuit shown is a transistorized version of ...linear pulsed oscillator, also known as a pulsed ...artley oscillator. This oscillator features an am...litude-stable output.

...n the circuit the component values of R_{C1}, R_{L1}, ...$_{C2}$, R_{L2}, and C_C depend on the transistors used ...nd on the collector supply voltage.

If $L1 = L2$, and $M = K\sqrt{L1\ L2} = K\ L1$, then ...e coupling capacitor $C_C = 2(L1 - M)$. The feed...ck resistor R_f must be greater than $0.46\sqrt{L/C}$, ...here $L = L1 + L2$.

To get the first cycle to start with a negative ...ing, an npn transistor should be used instead of ...pnp, the collector supply should be reversed, and ...e input pulse should be inverted.

...Irving Bayer, Project Engineer, Skiatron Elec...onics and TV Corp., New York, N.Y.



...ulsed Hartley oscillator provides uniform output ...vefor...

IDEAS FOR DESIGN

Zener Diodes Improve Relay Operation

Many relays are characterized by high pull-i to drop-out current ratios. In driving thes relay with vacuum tubes, several problems prese themselves.

Sufficient bias must be applied to keep th tube's quiescent current below the drop-out valu while, on application of a dc signal, sufficient plat current must flow to pull the relay in.

The use of fixed grid bias may be difficult, as requires a negative power supply. Also the inpu signal may exist with respect to ground, so if th input signal is available at a low impedance, may ground out the bias. If, on the other hand the input has a high impedance source, the circu loses sensitivity to the input signal, which is ju what is to be avoided.

The circuit of Fig. 1 does not work because th cathode resistor gives too much degeneration.

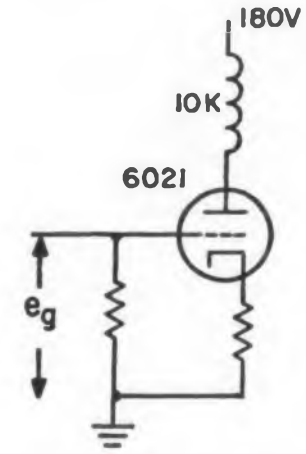


Fig. 1. This relay drive circuit doesn't work because th cathode resistor provides too much degeneration if is to provide adequate bias.

The circuit of Fig. 2 requires a very heavy r sistor and still suffers from degeneration; so larg grid signal voltages are required.

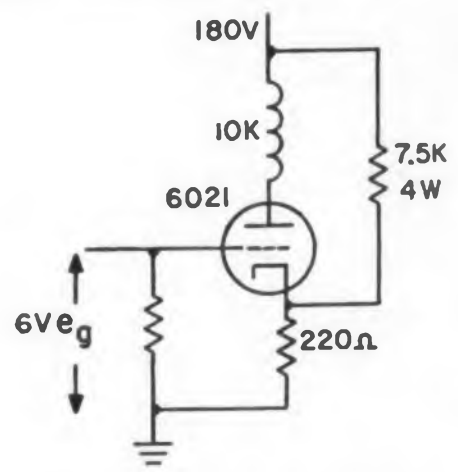


Fig. 2. This circuit doesn't work either because th cathode resistor still causes too much degeneration an a large grid drive is still required.

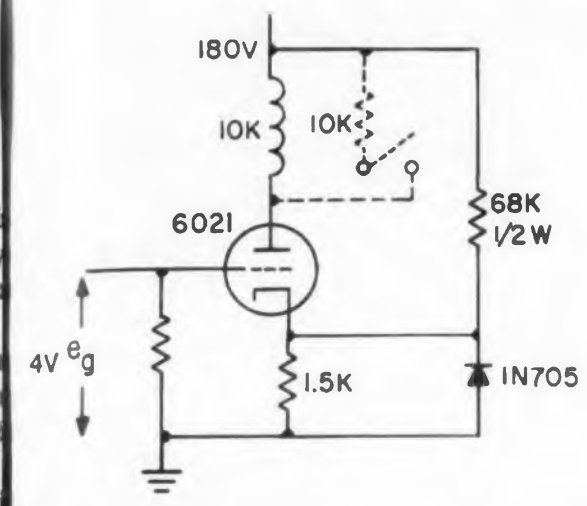


Fig. 3. This circuit works very well, curing the pull-in and drop-out defects.

The circuit of Fig. 1 does not work because the use of a Zener diode; it requires only a low power resistor; and it reduces the required grid voltage.

The circuit of Fig. 3 cures the pull-in defect nicely. By adding a 10 K resistor, and using one of the normally open relay contacts, as shown by the dashed lines in the drawing, the drop-out defect is cured too. The relay drops out at a higher voltage because the resistor shunts some of the current.

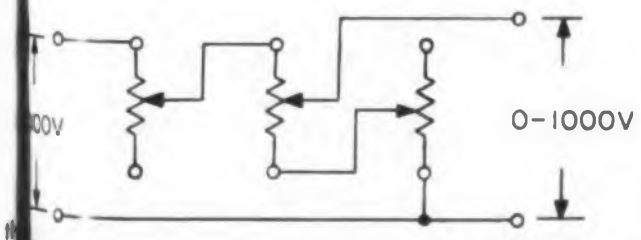
Dr. H. B. Weisbecker, Director of Research, Manson Labs., Stamford, Conn.

Ganged Pots For Higher Voltages

Conventional potentiometers usually have a limiting voltage rating of about 500 v. For many experimental circuits, potentiometers of higher voltage rating can be made by ganging three single units on one shaft. The terminals should be wired as shown in the figure.

Note that the input side sees, effectively, two potentiometers, and the maximum voltage rating of the combination is raised to 1000 v. The output voltage can still be varied from zero to 1000 v. Care should be taken, of course, not to exceed the wattage rating of the pots.

H. Hsu, Senior Physicist, General Electric Co., Syracuse, N.Y.



Three ganged pots take twice the voltage rating of one.

IDEAS FOR DESIGN

Over Voltage Protection For DC Supply Lines

In certain electrical systems overvoltage transients occur on dc supply lines. On 28 v aircraft supply lines these overvoltages sometimes reach 80 v or more and present a serious threat to transistorized equipment on the line.

A device used for "blanking-out" on the transient overvoltage is shown in the schematic. It is basically a transistorized switch in series with the supply and the protected equipment. It automatically opens when the input voltage is greater than a predetermined level and closes again when the line voltage returns to normal. The desired action is accomplished in the following manner:

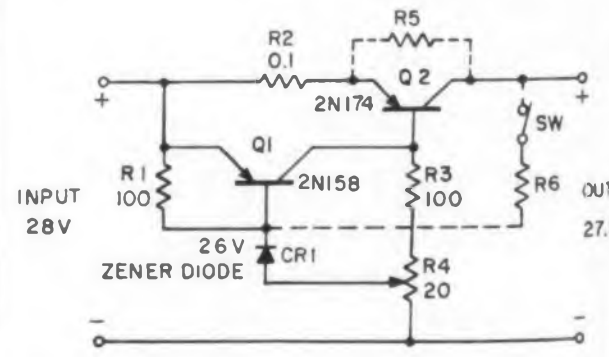
When the input voltage rises to a certain level current flows in the voltage reference diode (*CR1*). Current in this diode acts as base current for *Q1*. When base current is furnished *Q1*, it turns on and provides a better path for current than the *R2*, emitter-base (*Q2*) path.

Thus, current normally supplied to the base of *Q2* via the *R3-R4* path is robbed from *Q2* by *Q1*. This causes *Q2* to open, dropping the output voltage. When the input voltage returns to normal, base current in *Q1* ceases, normal base current is applied to *Q2* and it closes, restoring full voltage to the output circuit.

During the transient it is possible for the full transient voltage to appear across *Q2*. Resistor *R5* acts as a bypass and prevents the output voltage from going to zero, in cases where the full transient is not desired across *Q2*. With the addition of positive feedback (*R6* circuit) the action of the circuit can be made quite sharp and can even be made to latch-off. A push-to-reset switch can be installed as shown by the dashed lines.

Further improvements, making the circuit suitable for use over a wide temperature and load range, can be employed if necessary.

Victor P. Holec, Engineering Department 5-6, Collins Radio Co., Cedar Rapids, Iowa.



This circuit blanks out dc overvoltages. A "push-to-resist" circuit is shown in dashed lines.

Slaved and Programmed Stepping Switches

In th design of scanners and similar type quipment having very large numbers of input hannels it is often necessary to have two or more tra epping switches slaved together to insure syn- ircra ronism. The usual method employs 11 relays reac r 11 position stepping switches) to reverse the tra n-off" sense from the driving switch.

The use of these relays is obviated in the cir- ansie it shown. A bias is developed between *R1* and is b y of the other resistors *(R2-R7)* which turns off ith th e transistors driving the slaved switches. If the toma ved switch is in any position other than that of er th e master switch, the base of the 2N158 is simply en th nnected to ground through a 220 resistor, and actio e switch is allowed to cycle. As many as 7 itches can be slaved together, and since these n leve e available in 8 decks, 7 decks are available on diod ch switch for data inputs. This allows an entry curre 49 x 10 or 490 inputs.

Q1, In the diagram, a "fictional" stepper is shown curre th only 6 positions for clarity. Furthermore, ly the one deck used for positioning is shown. base o external programming is desired, the +24 v by Q e is broken at "*A*," *S1* is replaced with a slaved ut vo e circuit, and a 24 v input signal is applied to norm e desired pin of *J1*.

rrent The tensioning spring on the slaved switches voltag st be reduced from factory settings for proper eration. Speed is not reduced when the tension the fu adjusted properly. Radio interference noise is stor F s than one μv/meter/kc radiated.

voltag *George S. F. Orsten, Senior Engineer, The* ll tra *rtin Co., Denver, Colo.*

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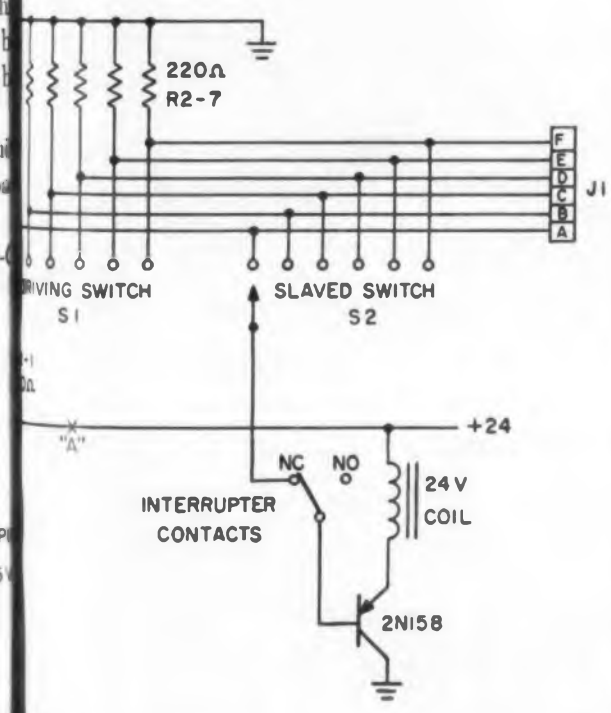


Slaved switches can accept many inputs with- a rela for each input.

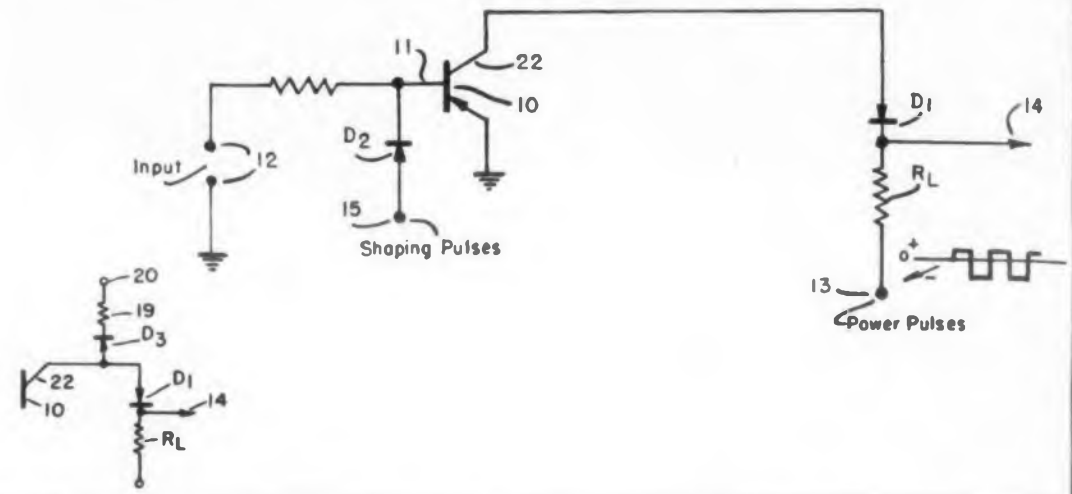
PATENTS

Transistor Logical Device

Patent No. 2,866,105. John Presper Eckert, Jr. Assigned to Sperry Rand Corp.

Semiconductor charge carrier storage is used to improve the gain and frequency characteristics of a transistor amplifier. The enhancement current continues to flow in the output even after the applied input has terminated. Thus power pulses which gate the transistor output are faithfully reproduced and amplified.

In the simple array, the input applied to terminal 12 charges *pnp* transistor by injecting carriers into the lattice structure; load R_L is disconnected from the transistor during the preliminary time by diode D_1. Subsequently, a negative gate power pulse makes diode D_1 conduct. This connects the load resistor to the transistor and load current flows for the duration of the power pulse. A clean pulse may be applied to draw off any residual charge through diode D_2 in order to conveniently terminate the output current.



Coaxic Line Switch

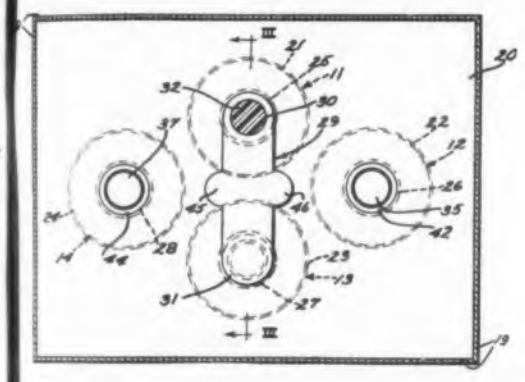
Patent No. 2,876,422. Adolph J. Wozniak. (Assigned to Thompson Products Inc.)

Coaxial lines can be constructed so that they may be positioned close to each other with no overhang of the switch blade beyond the inner conductors. Over a wide range of frequencies, the VSWR is approximately unity.

Fundamentally, a ground-plane type of connecting section exists between the switch blade and the surface of the wall between the outer conductors. The invention lies in shaping the switch blade to make the characteristic impedance of this section substantially less than the characteristic impedance of the coaxial lines.

Switch blade *29*, enclosed in metal housing *19*, engages inner conductor *30* and the blade may be rotated to select inner conductors *26*, *27* and *28*. The intermediate portion of blade *29* is increased by semicircular projecting ears *45* and *46* to produce a smooth discontinuity and the required impedance.

To improve the electrical contact, blade *19* is made of a magnetic material and magnets are mounted at the terminal ends of the inner conductors.

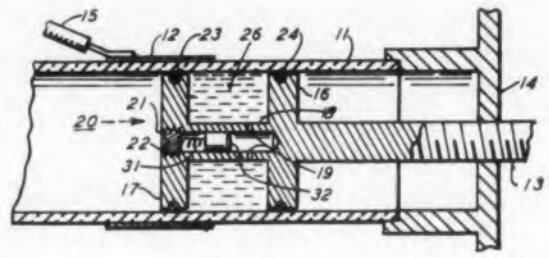


Variable Capacitors

Patent No. 2,855,550. Jack Elliot Bayha. (Assigned to Emerson Radio & Phonograph Corp.)

A miniature plunger-type variable capacitor, of uniform and reproducible characteristics, is particularly useful for mass production. The spacing of the movable element, relative to the stator, is kept constant as the capacitance is varied by making the plunger effectively a cylinder of mercury in pressure contact with the dielectric. For the broadcast range, a tuning capacitor of 350 mmf is 0.25 in. in diameter and 1.5 in. long. Barium titinate, 0.015 in. thick, has a dielectric constant

PATENTS



of 300; this permits the ratio of maximum to minimum capacitance to be several hundred.

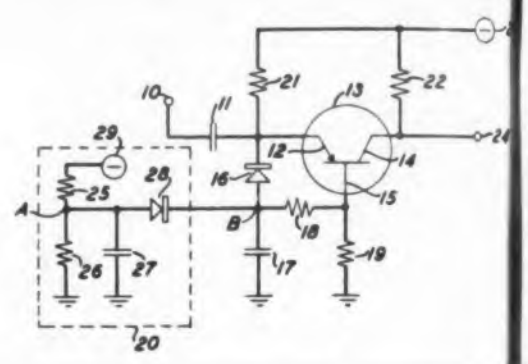
In section, screw *13* drives the plunger which traps mercury *26* between the O-ring sealed outer faces *16* and *17*. Spring-loaded piston *32* forces the mercury into intimate contact with the inner wall of dielectric *11*. The outer plate *12* may be shaped to produce any desired capacitance versus displacement law.

Monostable Transistor Circuit

Patent No. 2,876,367. Eric E. Sumner. (Assigned to Bell Telephone Labs., Inc.)

An extension network may be switched to increase effective capacitance so that a monostable amplifier is kept longer in the triggered state. The trigger [illegible] sensitivity remains unchanged si[illegible] e th[illegible] output voltage is independent of [illegible] e ad[illegible] ditional capacitance.

In the typical circuit, base res[illegible] tor *1*[illegible] in the N-type point contact trans[illegible] tor *1*[illegible] gives the regenerative amplifier it[illegible] nega[illegible]aten[illegible] tive resistance characteristic. Var[illegible] tor *2*[illegible]osep[illegible] isolates capacitor *27* from the [illegible]smalle[illegible]al E[illegible] capacitor *17* in the emitter net[illegible]ork. [illegible] Fla[illegible] positive-going impulse triggers the tra[illegible]ener[illegible] sistor to conduct and capacitor *17* charge[illegible]ischa[illegible] to forward bias varistor *28* and, ther[illegible]idth[illegible] after, both capacitors charge to effective[illegible]t clos[illegible] slow down the decay of the emitter vol[illegible] In[illegible] age. Likewise, when the transistor is c[illegible] off, both capacitors discharge. Howeve[illegible]



apacitor *17* quickly runs down through he smaller resistors *18* and *19* to reverse ias varistor *28* and the network as a result is ready for the next trigger pulse although capacitor *27* is not yet fully discharged.

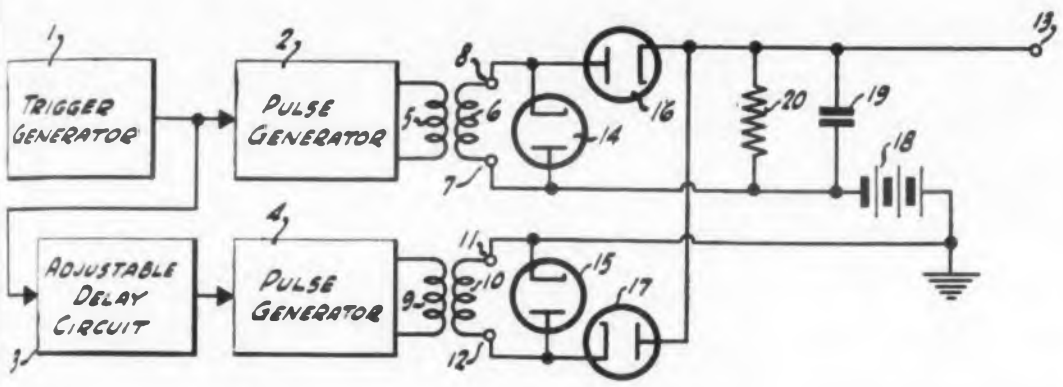
---

igh Voltage Pulse Generator

atent No. 2,871,380. Albert J. Morris and oseph P. Swanson. (Assigned to Levinal Electronic Products, Inc.)

Flat top pulses, 30 kv in amplitude are enerated by alternately charging and ischarging a 5000 mmf capacitor. Pulse idth is variable between 5 and 10 μsec close to 100 per cent duty cycle.

In the figure, generator pulses the transformer to cause capacitor *19* to charge through diode *16*. Subsequently, a delayed trigger fires generator *4* causing the capacitor to discharge through diode *17*. Diodes *14* and *15* clamp the output voltage to that of battery *18* and the time constant of capacitor *19* combined with resistor *20* insures a flat top output pulse and limits the charging current to a safe value.



Harmonic Amplitudes in Class C Operation

E. Brenner

WHEN plate current flow through a triode or a pentode occurs in pulses, the harmonic amplitudes are generally found by graphical approximations. It is possible, however, to find "exact" closed-form expressions for the harmonics if the plate characteristics are approximated through a power law of the form:

$$i_b = (e_g + e_b/\mu)^n \text{ for a triode} \qquad (1)$$

and

$$i_b = P\,(e_g + e_{g2}/\mu_2)^n \text{ for a pentode} \qquad (2)$$

when n is an exact multiple of 1/2.

The grid voltage is given as:

$$e_g = E_c + E_{gm} \cos \omega t$$

while the plate voltage is assumed to be sinusoidal (because of the tank load) and of the form

$$e_b = E_b - E_{bm} \cos \omega t$$

Using these forms, the plate current equations can be written:

$$i_b = P(E_{gm} - E_{bm}/\mu)^n\,(\cos \omega t - \cos \theta) \qquad (3)$$

for a triode, and for a pentode

$$i_b = P\,(E_{gm})^n\,(\cos \omega t - \cos \theta) \qquad (4)$$

where θ is the angle of current flow which gives the ratio of the half of plate current flow to the period of the signal.

The plate current can be written in the form of a Fourier series, for an even function,

$$i_b = I_o + \sum_1^\infty I_k \cos k \omega t \qquad (5)$$

where the amplitude of the kth harmonic has the form

$$I_k = I\, f_{k,n}\,(\theta) \qquad (6)$$

where I is for the triode

$$I = P\,(E_{gm} - E_{bm}/\mu)^n\,(1 - \cos \theta)^n \qquad (7)$$

and for the pentode

$$I = P\,E^n{}_{gm}\,(1 - \cos \theta)^n \qquad (8)$$

The function of $f_{k,n}$ is the current flow function for the kth harmonic and depends also on the exponent n.

In general

$$f_{k,n}\,(\theta) = \frac{\epsilon}{\pi} \int_0^\theta \frac{(\cos x - \cos \theta)^n}{(1 - \cos \theta)^n} \cos kx\, dx \qquad (9)$$

where $\epsilon = 1$ for $k = 0$ and $\epsilon = 2$ for $k > 0$. The result of the integration of Eq. 9 for integral values of n is given in the table. For $n = 1/2$ and $n = 3/2$, f can be evaluated in terms of elliptic integrals. Introducing the parameter

$$\gamma_m = \int_\theta \frac{x^m\, dx}{\sqrt{P\,(x)}}\,; \quad P(x) = (1 - x^2)\,(x - \cos x)$$

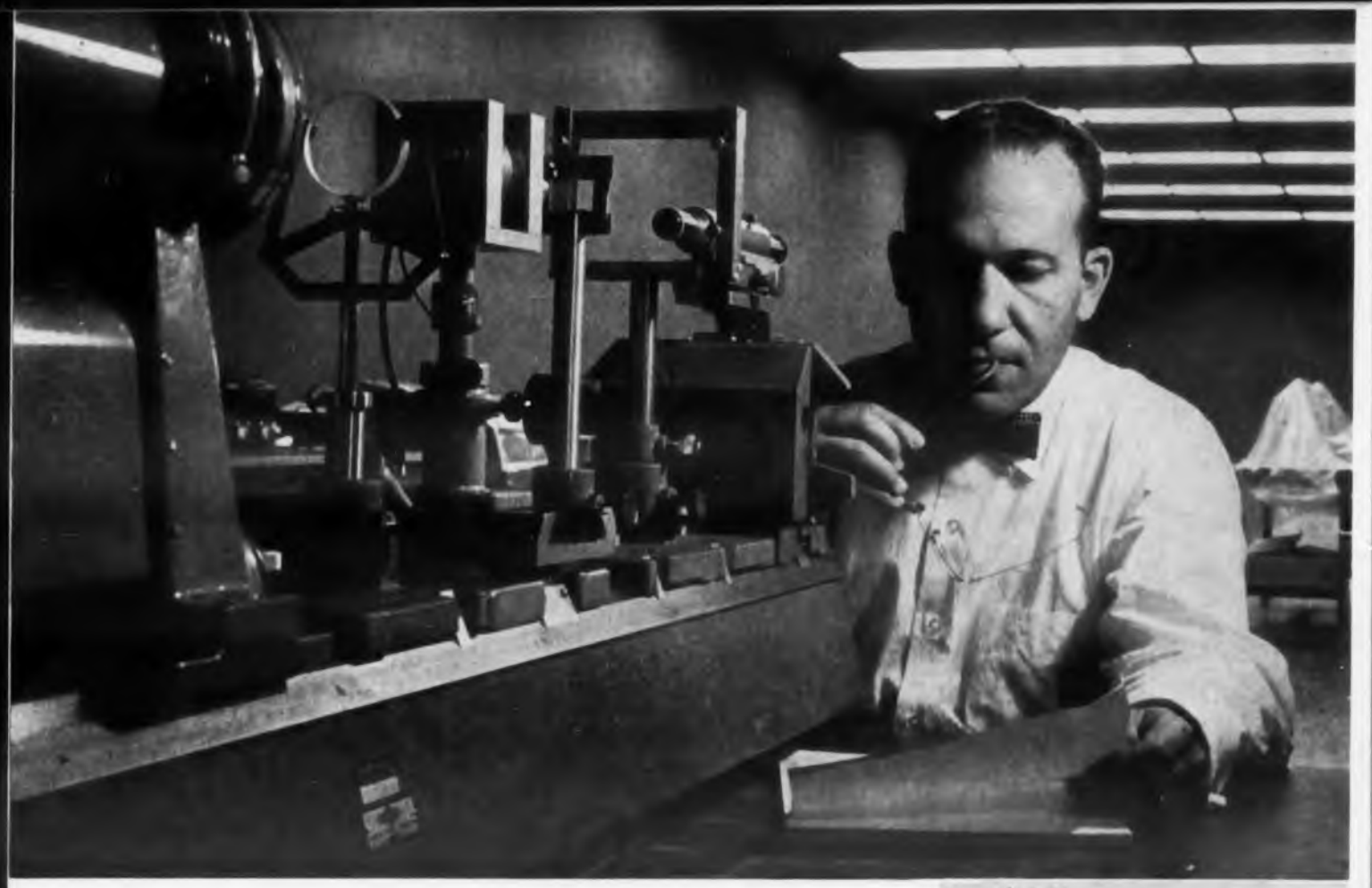
whose dependence on θ is shown in the Figure, the expression for f which corresponds to the values $n = 1/2$ and $n = 3/2$ are as given in the table.

In the original paper tables and charts for the current flow function are given.

Abstracted from an article by D. Thielicke, Nachrichtentechnik, *Vol. 9, No. 2, February 1959, pp 50-55.*

The current flow function $f_{k,n}\,(\theta)$

n \ k	0	1	2
0	θ/π	$\frac{2}{\pi} \sin \theta$	$\frac{1}{\pi} \sin 2\theta$
1	$\frac{1}{\pi} \cdot \frac{\sin \theta - \theta \cos \theta}{1 - \cos \theta}$	$\frac{1}{\pi} \cdot \frac{\theta - \sin \theta \cos \theta}{1 - \cos \theta}$	$\frac{2}{3} \frac{\sin^3 \theta}{1 - \cos \theta}$
2	$\frac{(1 + 2\cos^2\theta)\,\theta - 3 \sin \theta \cos \theta}{2\pi\,(1-\cos \theta)^2}$	$\frac{2}{\pi} \frac{\sin \theta - 1/3 \sin^3\theta - \theta \cos \theta}{1-\cos \theta}$	$\frac{3\,\theta - \sin \theta \cos \theta\,(3 + 2\sin^2\theta)}{6\pi\,(1-\cos \theta)^2}$
1/2	$\frac{\gamma_1 - \gamma_0 \cos \theta}{\pi\,(1-\cos \theta)^{1/2}}$	$\frac{2\,(\gamma_2 - \gamma_1 \cos \theta)}{\pi\,(1-\cos \theta)^{1/2}}$	$\frac{2}{\pi} \cdot \frac{(3-4\cos^2\theta)\,\gamma_1 - \gamma_0}{(1-\cos \theta)^{1/2}}$
3/2	$\frac{\gamma_0\,(3\cos^2\theta_{1-1}) - 4\gamma_1 \cos \theta}{3\pi\,(1-\cos \theta)^{3/2}}$	$\frac{2}{5\pi} \cdot \frac{\gamma_1\,(3 + \cos^2\theta) - 4\gamma_0 \cos \theta}{(1-\cos \theta)^{3/2}}$	$\frac{2}{\pi} \frac{2\gamma_4 - 4\gamma_3 \cos \theta - (1-2\cos^2\theta)\,\gamma_2 + 2\gamma_1 \cos \theta - \gamma_2 \cos^2\theta}{(1-\cos \theta)^{3/2}}$



(above) Setting up a diffraction image for a research study in near-infrared optics

(left) Nation's first successful re-entry tests were conducted with the Lockheed X-17

(bottom right) Research and Development facility in the Stanford Industrial Park at Palo Alto, California, provides the latest in technical equipment

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Nonlinear and Parametric Phenomena in Radio Engineering

Part 19

A. A. Kharkevich
(Translated by J. George Adashko)

Chapter 3

Response of Nonlinear Systems to External Signals

34. Locking

If two oscillations with frequencies ω and exist simultaneously in a linear system, these t oscillations interfere with each other and produ beats. The beat frequency equals the absolute di ference in frequencies, i.e.,

$$\Omega = |\omega - \omega_o|$$

If ω_o is constant, the beat frequency varies wi ω as shown by the two dotted lines in Fig. 121.

In a self-oscillating system under the influen of an external voltage, beats are also observed, b as the frequency varies the phenomenon take different course. When ω increases the beat f quency first diminishes (as ω approaches linearly. Then the beat frequency starts diminis ing more and more rapidly (solid line of Fig. 1

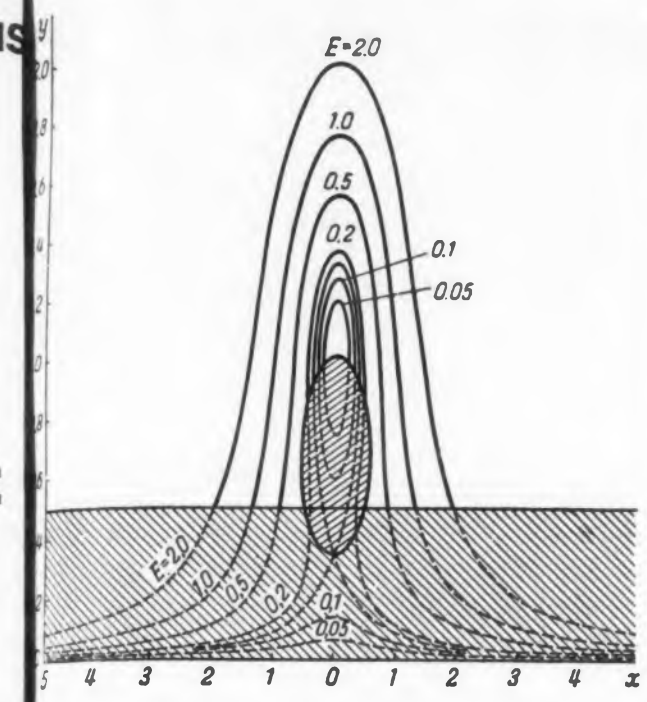


Fig. 119. Resonance curves with shaded areas representing unstable regions.

and at a certain value $\omega = \omega_1$ the beats stop. The frequency of the oscillator becomes ω_1, in spite of the fact that it is tuned to a frequency ω_o. A further increase in frequency to a value $\omega = \omega_2 > \omega_o$ does not change the situation. The generated frequency equals the frequency of the external voltage. There are no beats. Finally, when $\omega > \omega_2$, beats appear again.*

The phenomenon just described, whereby the external voltage forces its frequency on the oscillator, is called locking. The frequency interval $\omega_2 - \omega_1$, within which the oscillator has the same frequency as the applied voltage is called the lock-in band. Our next problem is to determine the width of this band and on what it depends.

Away from the lock-in band, the situation is in fact the same as if there were two components, a "self-oscillation" of frequency ω_o and a "forced oscillation" of frequency ω. However, such a representation is only formal in character, since generally speaking these components are physically inseparable. This is why the terms "beats" and "beat mode," although applicable to these phenomena, have an arbitrary meaning in this case.

To solve this problem let us turn to the phenomena represented graphically by the resonance curves of Fig. 119. The stable mode represented by the solid lines of Fig. 119 is exactly the lock-in mode, when forced oscillations have the frequency of the applied voltage. The transition to the un-

* It is appropriate to remark here that the very term "beats" signifies the presence of two separate oscillations, the addition of which causes the beats. In the case of the nonlinear self-oscillating system we deal with a single nonlinear process, which is characterized by a periodic variation of amplitude outside the lock-in band.

stable region denotes the appearance of b ts.

Thus, the width of the lock-in band (th inte val ω_2-ω_1 in Fig. 121) is none other than th wid of the resonance curve at the boundary of the i stability region. Starting with these conside ation we can now readily determine the width of th lock-in band.

The equation of the resonance curves in Fi 119 is

$$y\,[x^2 + (1-y)^2] - E = 0 \qquad (1$$

At small values of applied voltage, i.e., when is small, the curves terminate on the peak of th ellipse near $y = 1$. Inserting this value into (1) w find

$$x^2 = E$$

or, putting in the full expressions (see Section 33

$$\frac{2\Delta\omega}{\omega_o} = \frac{E_m}{A_o}$$

The quantity to the left is precisely the relati width of the lock-in band. It turns out to be equ to the ratio of the amplitude E_m of the appli voltage to the amplitude A of the self-oscillati voltage in the absence of an external emf. Co

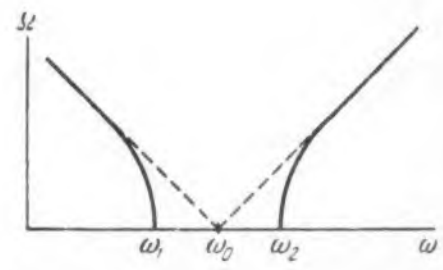


Fig. 121. The beat frequency produced by two osci tions varies with ω as shown by the dotted lines.

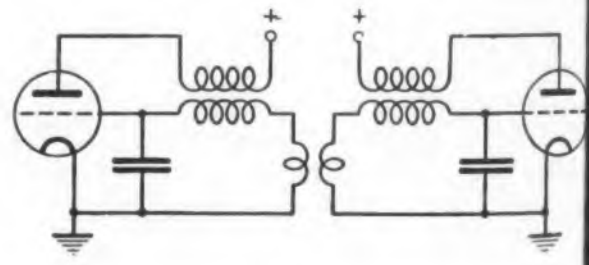


Fig. 122. Two oscillators coupled to each other.

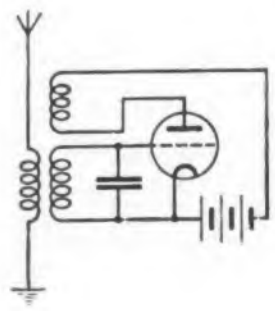


Fig. 123. The simplest type regenerative receiver.

ering the quantity A_o as a constant parameter the system under consideration, we conclude t the width of the lock-in band increases with reasing external signal.

At large values of E_m the resonance curve no ger terminates on the ellipse but on the horital line $y = 1/2$. Inserting this value into (1) get

$$x^2 = 2E - 1/4$$

$$\frac{2\Delta\omega}{\omega_o} = \sqrt{2\frac{E_m^2}{A_o^2} - \frac{\beta_o^2}{\omega_o^2}}$$

the second term under the square root is the are of the initial damping of the system (i.e., h allowance for the feedback). This is in any e a very small quantity, so that we can put

$$\frac{2\Delta\omega}{\omega_o} \cong \sqrt{2}\frac{E_m}{A_o}$$

For intermediate values of E_m, when the resonce curves terminate on the sides of the ellipse, can put

$$\frac{2\Delta\omega}{\omega_o} = k\frac{E_m}{A_o}$$

ere, as we have already established

$$1 < k < \sqrt{2}$$

e exact value of k can be obtained if necessary solving simultaneously equations (9) and (11) he preceding section.

The locking phenomenon is used in radio engiring to synchronize an oscillator by means of external voltage or for mutual synchronization two oscillators. If two oscillators are coupled to h other, as shown in Fig. 122, each oscillator uces in the tank circuit of the other a voltage ch the other oscillator sees as external.

The operation of the circuit is described by a tem consisting of two equations on type (1) ction 33), where the right halves of the equas play the role of the coupling terms. If both illators are identical but tuned to different frencies, they can be mutually synchronized at a ain intermediate frequency, which in general two possible values. But if one oscillator is e powerful it can be considered as an indedent voltage source and consequently imposes own frequency on the weaker oscillator.

35. The Regenerative Receiver

The simplest regenerative receiver, shown in g. 123 reduces to the circuit of Fig. 118. How-er, unlike the preceding case, the feature of the enerative receiver is that it operates under-ex-ed, although near the excitation threshold, for

it is there that the maximum gain is obtained.

The equation of the regenerative receiver is the same as eq (7) of Section 33.

$$\left[(\omega_o^2 - \omega^2)^2 + \omega^2\left(2\beta_o + \frac{1}{4}\gamma A^2\right)^2\right] A^2 = \omega_o^4 E_m^2 \quad (1)$$

Let us first consider the problem of the sensitivity of the receiver when tuned exactly to the received frequency, i.e., when $\omega_o = \omega$. In this case we obtain from (1)

$$\left(2\beta_o + \frac{1}{4}\gamma A^2\right) A = \omega_o E_m$$

By increasing the feedback we can bring the receiver almost to self excitation. In this case the initial damping factor

$$\beta_o = \alpha - \frac{1}{2}\omega_o^2 MS$$

is nearly equal to 0, and we have

$$\frac{1}{4}\gamma A^3 = \omega_o E_m$$

hence

$$A = \left(4\frac{\omega_o}{\gamma} E_m\right)^{\frac{1}{3}} = k E_m^{\frac{1}{3}}$$

Let us find the sensitivity (or, what is the same the gain) of the receiver, defining it as

$$\nu = \frac{dA}{d E_m}$$

Differentiating (3) we get

$$\nu = k E_m^{-\frac{2}{3}}$$

We see that when E_m tends to zero the sensitivity tends to infinity. Thus, a regenerative receiver has a variable sensitivity; the weaker the received signal, the greater the sensitivity. This is naturally a convenient property of this receiver.

In practice the maximum attainable sensitivity is limited by the internal noise of the receiver which becomes very strong near the self-excitation threshold, owing to the large gain.

In its day, the regenerative receiver played

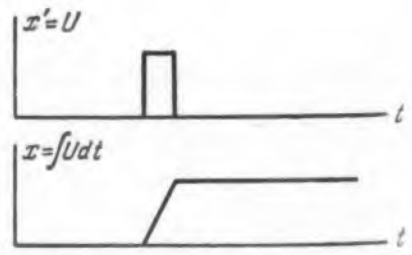


Fig. 124. A voltage pulse and its integral.

y important role because of its exceeding sim-city and high sensitivity. However, the regen-tive receiver has very substantial shortcomings, nely instability and poor selectivity. Further-re, when operating at the very threshold of citation it frequently oscillates, interfering with rby receivers.

This is why the regenerative receiver was sup-nted by more advanced receivers, and the re-nerative circuit is useful only when used as the called regenerative filter.

36. Pulsed Synchronization

In Section 33 we considered synchronization n oscillator by means of a sinusoidal external age. In this section we shall consider synchro-tion by periodic short pulses. This case affords ery clear qualitative explanation of the syn-nization process, and we shall make use of opportunity. We shall not investigate pulsed chronization analytically.

We start out as before with the circuit of Fig. , but assume now that the external voltage is eriodic sequence of short pulses of arbitrary m. To explain the mechanism of synchroniza-we shall represent the phenomenon by dia-ms in the phase plane. We must first represent phically the action of a voltage pulse.

Let the variables be the same quantities as used e example at the end of Section 25, namely

$$x = \int U\,dt,\quad x' = U$$

the pulse be characterized by the fact that the age starts varying from a certain initial value particular, zero) and returns after a short time is initial value. Thus, after termination of the e, the voltage $U = x'$ remains unchanged, e the integral of the voltage acquires an in-ent determined by the area of the pulse. e relations are explained in Fig. 124 for the of a rectangular pulse.

we now plot the same relations in the phase e using x and x' as coordinates, the represen-e point, originally in position *1*, will move r the influence of the pulse to a new posi-2, along the trajectory shown dotted in Fig. The time of the move equals the duration of pulse. We shall assume that the pulse is so t, that the representative point jumps from *1* practically instantaneously.

s to the shape of the trajectory, it depends rally on the shape of the pulse. But we are ally not interested in the shape of the trajec-. All that is important to what follows is that epresentative point move, in the final analysis, stance proportional to the area of the pulse, parallel to the x axis (since the voltage is the

same before and after the pulse). This shift of the representative point is indeed an expression of the action of the pulse. We shall denote it by h.

Let us now turn to the effect of synchronizing pulses on an oscillator in operation. In the absence of pulses, the operation of the oscillator is described by a stable limit cycle. The presence of the pulses, however, should lead to a closed cycle that includes the jump due to the action of the pulse. Such a cycle can be made of only a segment of a spiral as shown in Fig. 125. The scale of the abscissa is $\omega_o x$ instead of x, to equalize the scales of both axes.

With the scales so matched, the limit cycle becomes a circle. We shall assume that the representative point moves along the spiral at a constant

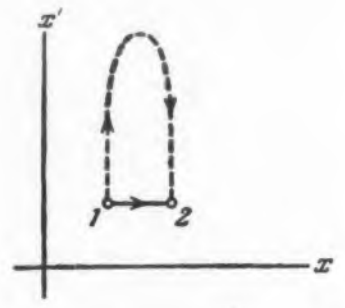


Fig. 125. The voltage pulse of Fig. 124 and its integral, plotted in the phase plane.

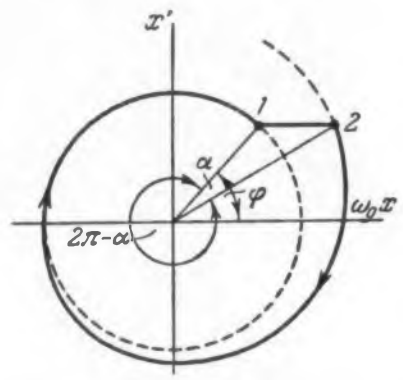


Fig. 126. The oscillator phase diagram for a case when a pulse synchronizes the oscillator to a frequency greater than the tank resonant frequency.

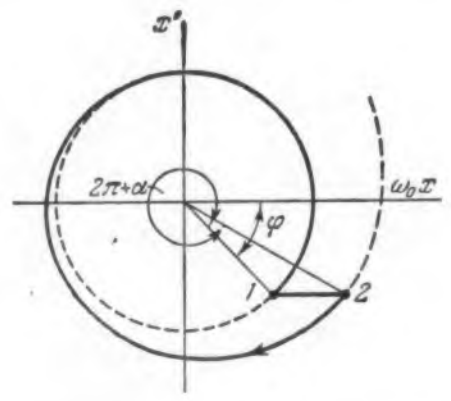


Fig. 127. The phase diagram for $\omega < \omega_o$.

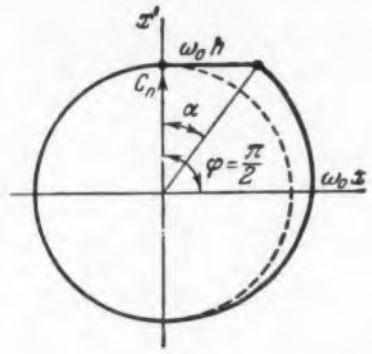


Fig. 128. The oscillator phase diagram for maximum detuning.

angular velocity and that rotation by 2π corresponds to one period of the self oscillation.

$$I_o = 2\pi/\omega_o$$

It is then immediately seen from Fig. 126 that the representative point traverses the closed cycle shown by the solid line in Fig. 126 during the time $T < T_o$. This follows from the fact that the angular displacement equals $2\pi - \alpha < 2\pi$ and consequently, less time is consumed in such a displacement. The jump from *1* to *2* occurs, according to our assumption, instantaneously.

Figure 126 corresponds, so to speak, to the case where the pulse synchronizes the oscillator to a frequency $\omega > \omega_o$. The phase diagram for synchronization to a frequency $\omega < \omega_o$ is shown in Fig. 127.

Here the representative point covers during the cycle, an angular distance $2\pi + \alpha > 2\pi$ for which the time required is $T > T_o$. Diagrams of this type make it possible to determine the width of the lock-in band.

Let us increase the angle ϕ, which determines the phase of the synchronizing pulse relative to the free oscillations of the generator. The maximum value of the angle α, i.e., the maximum detuning

$$\Delta\Omega = |\omega - \omega_o|$$

is obviously obtained when

$$|\phi| = \pi/2$$

The relations obtained in this case are illustrated in Fig. 128. We have

$$\tan\alpha = \frac{\omega_o h}{C_o}$$

where C_o is the self-oscillation amplitude that corresponds to the limit cycle. Actually α is the small angle (in our diagrams the rate at which the spiral unwinds is greatly exaggerated). Therefore $\tan\alpha \cong \alpha$. But α is a measure of the variation of the period (relative to the self-oscillation period which is equal to 2π). Thus

$$\frac{\alpha}{2\pi} = \frac{\Delta\omega}{\omega_o}$$

and consequently,

$$\frac{\Delta\omega}{\omega_o} \cong \frac{\omega_o}{2\pi}\frac{h}{C_o}$$

This is the maximum relative detuning in one direction. The total relative width of the lock-in band is therefore,

$$\frac{2\Delta\omega}{\omega_o} \cong \frac{\omega_o}{\pi}\frac{h}{C_o} \cong \frac{\omega h}{\pi C_o}$$

We can transform this result still further by recognizing that $\omega h/\pi$ is none other than the amplitude of the first harmonic in the Fourier expansion of an aperiodic sequence of short pulses. This component, whose frequency is ω, is the one producing the synchronization.

Denoting

$$\frac{1}{\pi}\omega h = E_1$$

we obtain for the lock-in band

$$\frac{2\Delta\omega}{\omega_o} \cong \frac{E_1}{C_o}$$

i.e., the same result as in Section 34.

Let us note in conclusion that the connection between the detuning and the angle ϕ, which is obvious from Figs. 126 and 126, is the same as given by eq (5) of Section 22.

37. Synchronization of A Relaxation Oscillator

Let us now analyze the very simple mechanism of synchronization of a relaxation oscillator by means of an external sinusoidal voltage. We choose a thyratron circuit (Fig. 129) as the oscillator. This circuit differs from the relaxation oscillator with a gas-filled diode (Fig. 105) in that the firing voltage U_2 depends on the grid voltage of thyratron T, and specifically in that the firing voltage increases with increasing negative grid voltage. The extinction voltage U_1 is practically constant.

Let us note that the circuit contains a current limiter CL so that the charging current is assumed constant and consequently the voltage increases linearly while charging.

In the absence of an external voltage, the oscillator behaves as described in Section 29; the capacitor is charged to the firing voltage U_2. At this value of the voltage the ionic conduction becomes large and the capacitor is discharged rapidly (practically instantaneously) to the extinction volt-

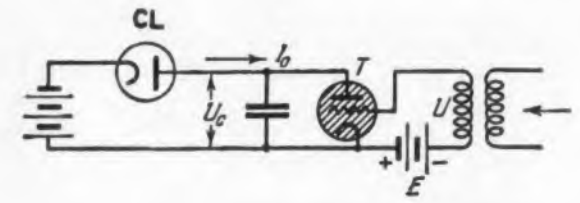


Fig. 129. A simple thyratron oscillator.

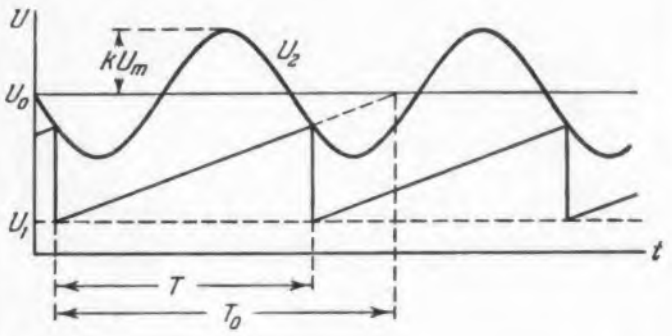


Fig. 130. A plot of the oscillation waveform for the thyratron oscillator of Fig. 129.

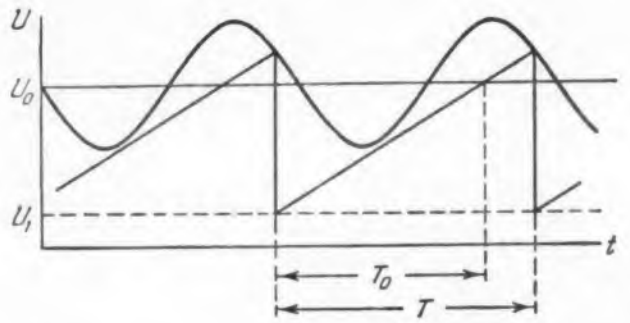


Fig. 131. When the sin of the phase angle φ becomes negative, the oscillation period increases.

age U_1. The charging of the capacitor is then resumed.

Let us now apply to the grid an external synchronizing sinusoidal voltage

$$U = U_m \sin \omega t$$

The firing voltage U_2 will now become a variable quantity. Let us assume that the firing voltage varies in proportion to the grid voltage. We have

$$U_2(t) = k(E + U_m \sin \omega t) = U_o + k U_m \sin \omega t$$

where U_o is the firing voltage in the absence of an alternating external voltage (i.e., at a constant voltage E). Firing takes place when

$$U_C = U_2$$

i.e., the capacitor voltage becomes equal to the firing voltage. At this instant a voltage jump occurs. The capacitor voltage rises during the charging time linearly

$$U_C = U_1 + \frac{I_o}{C} t$$

Figure 130 shows a plot of the oscillation. The figure shows the periodic process and we see that the oscillation period becomes equal to the period T of the external voltage and unequal to the pe-

RUSSIAN TRANSLATIONS

riod T_o of free oscillations of the generator. In other words, the external voltage locks in the oscillator; the oscillator is synchronized by the external voltage.

Let us derive the fundamental equations for steady-state synchronized oscillations. If time is reckoned from the voltage jump, the firing voltage is written

$$U_2 = U_o - k\,U_m \sin(\omega t + \phi)$$

The next jump occurs when

$$U_C = U_o - kU_m \sin(\omega T + \phi) = U_o - kU_m \sin\phi$$

But, on the other hand, during the instant $t = T$ we have

$$U_C = U_1 + \frac{I_o}{C}\,T = U_1 + \alpha\,T$$

Thus,

$$U_1 = \alpha\,T = U_o - k\,U_m \sin\phi$$

Using the relation

$$U_1 = \alpha\,T_o = U_o$$

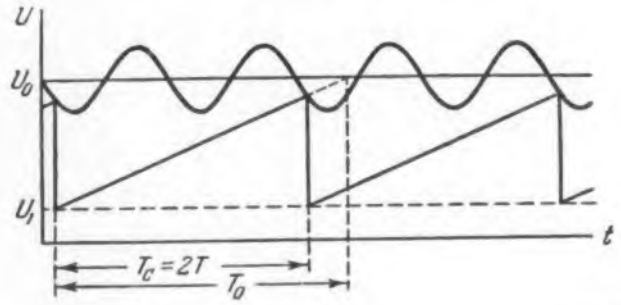


Fig. 132. A plot synchronized oscillation when $k = 2$.

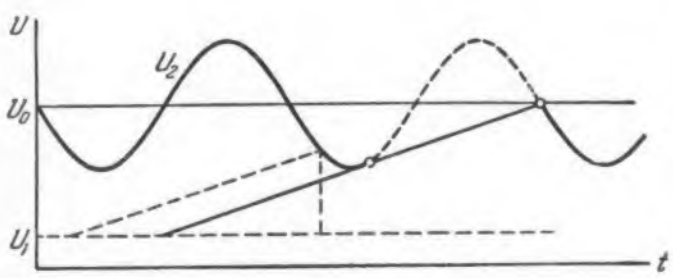


Fig. 133. This plot shows the parts of the sine wave (dotted) where synchronization is not possible.

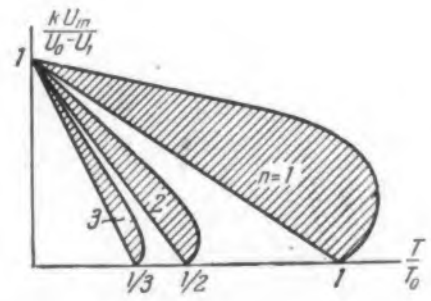


Fig. 134. Regions of possible modes of synchronization for various values of ω.

we get

$$\alpha (T_o - T) = k\, U_m \sin \phi$$

or

$$\frac{T_o - T}{T_o} = \frac{k\, U_m}{U_o - U_1} \sin \phi \qquad (1)$$

or

$$\frac{T}{T_o} = 1 - \frac{k\, U_m}{U_o - U_1} \sin \phi \qquad (2)$$

When $\sin \phi < 0$ the period acquires a positive increment, i.e., it increases. The corresponding graph is shown in Fig. 131. If we consider that the relative change in the period is small, we can equate it to the relative change in the frequency, i.e., we can put (see eq 1)

$$\frac{\omega_o - \omega}{\omega_o} \cong \frac{k\, U_m}{U_o - U_1} \sin \phi$$

The extreme values of $\sin \phi$ are ± 1. We therefore find the total width of the lock-in band to be

$$\frac{2\Delta\omega}{\omega_o} \cong \frac{2\, k\, U_m}{U_o - U_1}$$

An investigation of the stability of the synchronized mode shows that the stability condition is expressed in terms of the phase of synchronization exactly as in Section 33, namely,

$$-\frac{\pi}{2} < \phi < \frac{\pi}{2}$$

The derived relations require some refinement. First it must be noted that the equality

$$U_c = U_o - k\, U_m \sin \phi$$

from which we determine the instant of the voltage jump, can be satisfied not only when $t = T$, but also when $t = nt$, where n is any integer. Thus, we must write in formulaes (1) and (2) in the general case

$$T_s = nT$$

where T_s is the period of the synchronized oscillations. Figure 132 shows the graph of a synchronized oscillation with $k = 2$. This is sometimes called synchronization by means of a subharmonic.

Secondly, certain modes are not realizable for given values for U_o, U_1, α, kU_m, and T, since the line U_o is tangent to the sine curve U_2 and cannot fall on a certain portion of the sine wave. This is shown in Fig. 133, on which the non-realizable portion of the sine wave is shown dotted.

Taking all this into account, we can plot the regions of the possible modes of synchronization at various multiples of n (Fig. 134); these regions are shown shaded on the diagram.

(This concludes Chapter 3. The fourth and final chapter will begin in the next issue of ELECTRONIC DESIGN.)

NEW LITERATURE

Author's Guide 69

"It's Easy to Write for ELECTRONIC DESIGN" answers the most common questions of potential authors by succinctly suggesting areas of editorial interest and technical guidelines for manuscript submission. The guide will simplify writing problems by indicating the most suitable topics for the magazine and the best way to organize information, plus style pointers, length preference, illustrative data, and payment procedures. Here's a self-starter for electronic engineers accustomed to making design decisions and anxious to get them published. Hayden Publishing Co., 830 Third Ave., New York 22, N.Y.

Miniature Rotary Switch 70

In 16 pages this brochure covers most of the basic rotary switch configurations presently available. It provides technical data on construction, quality, operational characteristics, and environmental abilities. Janco Corp., 3111 Winona Ave., Burbank, Calif.

Shielding Magnetic Tape 71

Data Sheet 142 Engineering Report illustrates, gives tabulated summary, and fully describes a proposed technique for comparatively evaluating the effectiveness of shielding magnetic tape in Netic Co-Netic tape preservers versus unshielded tapes. Magnetic Shield Division, Perfection Mica Co., 1322 No. Elston Ave., Chicago 22, Ill.

Closed-Circuit TV Equipment 72

This eight-page illustrated bulletin describes a complete line of closed-circuit television equipment. Catalog 6-103 also illustrates a variety of cameras, camera housings, pan-tilt mechanisms, control panels, monitors, and other components for assembling complete closed-circuit TV systems. Cohu Electronics, Inc., Kin Tel Div., 5725 Kearny Villa Road, San Diego 11, Calif.

Linear Magnetic Amplifiers 73

A new standard line of low level linear magnetic amplifiers is described in Bulletin #S-921. Developed to supply military and civilian needs, the units have applications which include aircraft and missile telemetering instrumentation and industrial measurements. Completely static, the solid state devices are used in connection with such signal sources as strain gage transducers, thermocouples, resistance thermometer bridges, photo cells and meter shunts. The bulletin furnishes complete performance specifications. Also included are detailed data on principles of operation and a characteristics curve chart. Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y.

Electrical Tapes 74

A general guide to the upper temperature limits of electrical tapes is provided in this four-page fold-out brochure. A bar graph indicates the relative life of various tape backings such as vinyl, paper, cotton, acetate, polyester, glass cloth with rubber adhesive and with silicone adhesive, polytetrafluoroethylene and silicone rubber. The graph shows maximum temperatures for: (1) continuous long term operation; (2) functional operation for days to weeks; and (3) functional operation for a short time surge of minutes to hours. Minnesota Mining and Manufacturing Co., 900 Bush Avenue, St. Paul 6, Minn.

Catalog and Calibration Manual 75

This 16-page publication covers the calibration of the newest types of process control systems. Particular emphasis is placed on the testing and calibration of those systems which use proportional currents for signal transmissions and telemetering. The complete electrical and mechanical specifications for three (3) new instruments are given: model MV-I, a combination potentiometer, signal source, and milliammeter; the model AC-I, an automatic cold junction compensator for use with all thermocouples and instruments; the model RU-I, a combination milliampere and millivoltage "run up" source. Technique Associates, Inc., 1413 North Cornell Ave., Indianapolis, Ind.

Motors 76

This 12-page bulletin lists and describes 300 standard stock reducer and nonreducer motors of various types and sizes. Horsepower ratings of nonreducer motors listed range from 1/7 to 1/1500. Reducer motors, with speeds ranging from 833 to 0.7 rpm, have torques of 12.8 in. oz to 219 in. lbs. Bodine Electric Co., 2500 W. Bradley Place, Chicago 18, Ill.

Receiving Tube Manual

A new revised edition of the "RCA Receiving Tube Manual" is available. Highlights include technical data for more than 625 receiving tubes, covering types for black-and-white and color television and series-string applications and more than 75 TV picture tubes including color types; a simplified section on basic tube theory and application; an expanded section on electron tube applications; data on generic tube types, interpretation of tube data, and electron-tube installation. Charts for receiving tube classification and picture-tube characteristics are up-dated to include the latest data. *Manual RC-19 from: Commercial Engineering, RCA Electron Tube Div., Harrison, N.J. Cost* $0.75.

NEW LITERATURE

Cathode Ray Tubes 79

Seventy industrial and government CR tubes are listed in this 2-color, 4-page illustrated folder. Types and technical data is cataloged as radar indicators, oscilloscopes, oscilloscope photography, industrial monitors, receiver check tubes, flying spot scanners, and industrial and government TV applications. Continental Electronics Corp., Industrial & Gov't. Div., 2724 Leonis Blvd., Los Angeles 58, Calif.

Power Packs 80

Two-color catalog sheet, No. 116, covers descriptive data on a line of miniaturized magnetic-transistor regulated power packs. These new power packs combine the characteristics of transistor and magnetic regulators and are intended for all types of electronic powering applications. The data sheet includes descriptive information on specification data, model types, and prices. Electronic Research Associates, Inc., 67 Factory Place, Cedar Grove, N.J.

Terminal Bushings and Seals

This 16-page, illustrated bulletin, [illegible]-40, describes high voltage terminal bushings and ceramic-to-metal seals. It offers specifications on an expanded line of over 100 standard sizes of high voltage terminals, feed-throughs and cable end seals. Each type of terminal is illustrated with a photograph as well as a dimensional drawing and specification chart. Also shown are various types of special hermetic seals and terminals. *Write to: H. Frahme, Alite Div., The U.S. Stoneware Co., P.O. Box 119, Orrville, Ohio.*

Microwave Ferrites 81

Two new microwave ferrites, R-5 and R-6, are described in this brochure entitled "General Ceramics Microwave Ferrites." Data on typical applications, hysteresis loops, magnetic and dielectric properties with relation to frequency, dimensions, and other characteristics of the materials is included. General Ceramics Corp., Keasbey, N.J.

Aluminum Soldering 83

This handy-size brochure includes data on soldering fluxes, irons and flames, and gives complete information on actual soldering methods such as hot plate, dip, furnace, friction, glass fiber brush, and ultrasonic operations. Types and properties of aluminum solders are explained, plus the corrosion of soldered joints and their performance in aluminum. Text includes diagrammatic illustrations. Reynolds Metals Co., Box 2346, Richmond 18, Va.

Electronic Equipment 84

Short form Catalog, No. 8-A, 4 pages, provides information on the operation, construction, and features of sweep generators, plug-in markers, rf filters, detectors, and attenuators. A chart is included, listing all sweep generator models with their major performance specifications. The chart provides the basic information necessary to select the proper sweep generator for specific test or production problems involving measurement of frequency response. Telonic Industries, Inc., Beach Grove, Ind.

RF Measurements 85

Application Notes, #4, describes a dual channel system for measurement of insertion loss up to 20 db with an accuracy of 0.02 db per 10 db at any frequencies for which power sources and bolometers are available. The 8-page, two-color, brochure has been updated to include the latest equipment. Weinschel Engineering, 10503 Metropolitan Ave., Kensington, Md.

Relays

A complete line of basic general purpose relays is featured in this 16-page catalog. Relays shown range from small multi-contact midgets to sensitive, heavy duty, medium power and power types. Each is adaptable to many variations. Each relay is associated with detailed dimensional drawings, available contact arrangements, current and coil operating data, operating speeds, terminals, weights, enclosures, terminal headers and mounting information. *Catalog may be obtained by writing on company letterhead to Guardian Electric Manufacturing Co., 1621 West Walnut St., Chicago 12, Ill., attention D. O. Boucher.*

NEW LITERATURE

Loudspeaker 89

Selection of the proper loudspeaker for a given application is simplified by this foldout brochure. Called form 3R-3509, it permits comparison at a glance of 24 loudspeakers, horns and drivers. Information given for each unit includes response; sensitivity; power-handling capacity; and other characteristics; recommended baffle or horn, and application data. Each unit is illustrated. Radio Corporation of America, Sound Products, Building 15-1, Camden, N.J.

Drafting Equipment 90

This 100-page, 8-1/2 x 11, drafting equipment and supply catalog features: drawing tables, surveying equipment and supplies; slide rules; triangles, T-squares; drawing instruments; lettering devices; graph papers; and tracing papers, mylar and cloth. One of the sections of the catalog illustrates and describes 120 time saving, clear plastic templates. Alfred Mossner Co., 108 W. Lake St., Chicago 1, Ill.

Terminal Tester 91

Specifications and operating characteristics of a terminal pull tester are given in Bulletin 750e. Illustrated with photographs and drawings, the two-page data sheet describes the application, construction and operation of the air-powered tester. Hunter Spring Co., Quality Control Equipment Dept., a Div. of American Machine & Metals, Inc., 1 Spring Ave., Lansdale, Pa.

Potentiometer Catalog

This 28-page technical catalog gives specifications, diagrams and general information on a complete line of single turn precision wirewound potentiometers. Diameters include 1/2" microminiature to 5" high resolution. A series of sine-cosine, and wirewound trimming types are also included. *Write to Electronic Sales Division, DeJur-Amsco Corporation, 45-01 Northern Boulevard, Long Island City 1, N.Y., and indicate company affiliation and title.*

...ultiplier Phototube Catalog

The current line of multiplier phototubes, their specifications and circuit data, in addition to detailed information on a complete line of potted voltage dividers and ultraviolet and "solar blind" response PMT's, are presented in this new catalog. The 90-page catalog, second edition of "Du Mont Multiplier Phototubes," which revises and adds to information listed in the original publication (1956), discusses operational theory, applications, and specifications for standard and special multiplier phototubes. *Write on company letterhead to the Sales Dept., Electronic Tube Div., Allen B. Du Mont Laboratories, Inc., 750 Bloomfield Ave., Clifton, N.J.*

...ttenuators 93

In four pages that have both graphs and pictures, this bulletin covers fixed coaxial-model 50 attenuators. Their frequency range is from dc to 1000 mc, and they are usable to 2000 mc. Electrical specifications are covered in the bulletin. Weinschel Engineering, 10503 Metropolitan Ave., Kensington, Md.

Parabolic Antennas

This catalog contains data sheets on parabolic antennas and accessories. Included is technical data on passive reflectors, commercial communications antennas, unclassified military antennas and waveguide and transmission lines. *Address request on company letterhead to The Gabriel Co., Electronics Div., 135 Crescent Road, Needham Heights, Mass.*

Metal Enclosures 94

Catalogs No. 590 and S-159 cover metal housings and a modular console system, respectively. Pictures, dimensional data and prices are included in the catalogs. Premier Metal Products Co., 337 Manida St., New York 59, N.Y.

Plastics 95

"How to Use Sheets, Rods, Tubes, Tape and Other Shapes of Teflon" is the name of this 8-page brochure. Pictorial material and technical data on Teflon is included. Commercial Plastics & Supply Corp., 630 Broadway, New York, N.Y.

NEW LITERATURE

LC Tuners 108

Bulletin No. 216 illustrates and describes the electrical and mechanical characteristics of a new LC tuner series. The 4-page bulletin also includes resonant frequency vs capacitance load charts, and self resonant frequency vs screw-turns graphs for each of the units. JFD Electronics Corp., 6101 Sixteenth Ave., Brooklyn 4, N.Y.

Markers 109

Twenty most common pressure-sensitive materials used for marking, labeling, sealing, holding products and components are described in this 12-page catalog, No. 132-A. It includes serial numbering, logos, trademark reproduction for temporary or permanent identification. Technical and engineering application information on a wide range of tapes is shown in chart form to enable the proper type of self-sticking material to be specified for end product use. W. H. Brady, 727 West Glendale Ave., Milwaukee 9, Wis.

Strip-Chart Recorders 11

In eight pages this brochure describe strip-chart recorders that are light weigh and compact. Full scale balancing time 1 sec. These units are of the null-balanc potentiometer type. A tabulation of p tentiometer versus galvanometer charac teristics is given. A wide range of modula input chassis, accessories and chart-spee options are described. Varian Associate Instrument Div., 611 Hansen Way, Pal Alto, Calif.

Tantalum Capacitors 11

Data on an expanded line of tantalu wire electrolytic capacitors is provided i bulletin 148F. These subminiature capac tors have good shelf and operating stabi ity, high capacitance for small size, an ability to operate efficiently in temper ture extremes. The bulletin provides a lis ing of new values which will now b stocked by distributors for immediate de livery. Ohmite Manufacturing Co., 367 Howard St., Skokie, Ill.

ynchro Data Chart 113

Detailed definitions of the electrical rameters of synchros and resolvers are ven on this chart, suitable for wall-ounting. Also tabulated are the various nnections for Null measurement. This art has been revised in accordance with e latest releases of BuOrd Specification, RP-461. Theta Instrument Corp., 48 ne St., East Paterson, N.J.

echnical Data 114

How companies purchasing test instru-ents can cut instrument costs as much as per cent through use of a centralized urce of organized technical information shown in this 8-page booklet. Described detail is a completely new concept of dustrial procurement which saves ex-nsive engineering man-hours and the me of key company personnel in track-g down the right instrument, in locating alified manufacturers, and in compar-g and evaluating competitive specifica-ns and prices prior to purchase. Tech-cal Information Corp., 41 Union quare, New York 3, N.Y.

Diodes And Transistors 115

In 12 pages this brochure describes the company's silicon diodes and transistors. A description of characteristics, the tests performed on the units and a tabular listing of the units available are included. Sperry Rand Corp., Sperry Semiconductor Div., South Norwalk, Conn.

Chassis Knockouts 116

With pictures and dimensional data, bulletins E-274, E-275 and catalog 35-E provide data on chassis knockouts and a hydraulic knockout punch driver. Greenlee Tool Co., Div. of Greenlee Bros. & Co., Rockford, Ill.

Snap Acting Switches

Information on the application of industrial limit switches has been included in publication IC 3-1959. Part 1 of this publication defines terms used in connection with precision snap-acting switches and remains unchanged. *Send $0.30 to National Electrical Manufacturers Assn., 155 E. 44th St., N.Y. 17, N.Y.*

IMPULSE

A DIGEST OF NEW DEVELOPMENTS IN ELECTRONICS AND AUTOMATION

PUBLISHED BY ROME CABLE CORPORATION, ROME, N. Y.

PIONEERS IN INSTRUMENTATION CABLE ENGINEERING

ELECTRONIC "SEEING EYE." Soon the blind may carry electronic walking sticks to tell them of steps or falls in their path. One such cane is now being produced experimentally by Stromberg-Carlson Division of General Dynamics Corporation. The cane, fitted with two electronic oscillators, senses obstructions ahead of the walker when the tip is held 6 inches or so off the ground, warns him through a vibration in the handle and a whistling sound in a tiny earphone. Operated by batteries, it looks like an ordinary cane except for a thicker handle which houses equipment.

CALL FOR MICROMODULES ANSWERED. Under the heading of "Ideas wanted: $10 million reward," this column mentioned not long ago that the Army was looking for ideas that could lead to the development of micromodules. It wasn't long before the call was answered: a new micromodule concept has been developed that can reduce many military electronic items to at least one-tenth (and up to one-thousandth) of their present size. Micromodules "no bigger than a cough drop" have recently been produced experimentally by one manufacturer—including entire assemblies of transistors, wiring and other elements. The unit can function as an amplifier, oscillator filter and the like to meet specific needs. Any more ideas, anyone?

COLOR-BLIND COLOR CODE. One risk of color coding conductors in multiconductor cable is that of errors due to color blindness. This problem comes up more often than you might suppose and hampers quick, positive circuit identification. So . . . Rome Cable makes instrumentation cable that uses a single-color (neutral) insulation compound and is marked with conductor number and spelled-out color designations. With the color or number printed right on the insulation throughout each length, the cable is error-free—even to color-blind technicians. Of course, you can also get Rome cable that's strictly coded by color and tracer stripes, if you want. There's a complete run-down in Bulletin RCD-400. Write for your copy.

GREATER THAN TRANSISTORS? The field of thermoelectricity (TE) is attracting a large number of firms in anticipation of technological changes which may prove even greater than those brought on by the advent of transistors. One news service agency (name furnished on request) recently has completed a survey of a group of 100 research organizations and manufacturing firms known or reported to be interested in TE. TE should be useful in several areas, including generators for earth satellites and consumer products, possibly even turbine generators. Might be interesting to watch.

CABLEMAN'S CORNER. The subject of cable testing is an important one. This is the phase of production that determines whether or not the cable you are purchasing is in accordance with your standards and requirements. In the field of electronics and automation, cables are required to suit various stringent electrical, mechanical, and/or chemical environments. Many years of study and testing have gone into the design of test equipment to be used for these critical tests. It is not enough to know that a cable has been tested in a manner that is "essentially" the same as the required standard. Slight variations in equipment design or methods of tests can mean the difference between conformance and non-conformance. Make sure the test data you receive gives a true picture of the performance of your cable. When you need cable, call on 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 120 ON READER-SERVICE CARD

NEW LITERATURE

Electrical Insulating Materials 121

GET-2929, 12 pages, describes in text, tables and pictures the characteristics and application range of insulating materials for electrical insulation systems. It includes technical data on available products including mica mat, varnished cloths and papers, insulating varnishes, wire enamels, "Irrathene" irradiated polyethylene, sealing and filling compounds, insulating finishes and adhesives. General Electric Co., Schenectady 5, N.Y.

Crystal Oven 122

A miniature change-of-state crystal oven is described in bulletin RF-594. The bulletin details construction and applications of the model 35c Thermal-Set crystal oven, which is small in size and has precise temperature control, freedom from thermal oscillation or contact noise, low power consumption and long-term cavity temperature stability. Robertshaw-Fulton Controls Co., Aeronautical and Instrument Div., Santa Ana Freeway at Euclid Ave., Anaheim, Calif.

Transistors 123

Entitled "Transistor Characteris[tics] an[d] Interchangeability Guide," this [book]le lists the characteristics and ratin[gs] of wide variety of transistors used in ente[r]tainment, industrial and military [appli]c[a]tions. It contains a substitution ch[a]rt an[d] guide to manufacturers for close to 70 popular types. Including a glossary [o]f transistor parameter symbols and defin[i]tions, the 20-page booklet lists mecha[n]cal specifications and connections for [a] complete line of transistors and socket[s] Sylvania Electric Products Inc., 11[0] Main St., Buffalo, N.Y.

Ultrasonics 124

Ultrasoundings is the name of a ne[w] magazine containing information of ge[n]eral interest in the ultrasonics field as we[ll] as about applications of ultrasonics [in] industry, service organizations, medic[al] establishments and the military. It is pu[b]lished quarterly. Write to: Acoustica A[s]sociates, Inc., 26 Windsor Ave., Mineol[a] L.I., N.Y.

icrowave Equipment 126

The firm's 6 kmc microwave communications system is described in bulletin CM-71, 2 pages. Contained are operating characteristics, channel capacity and details on frequencies in which the equipment may be used. General Electric Co., Communication Products Dept., Lynchburg, Va.

oxy Resins 127

This comparison chart, 2 pages, lists uses and compares the properties of company's epoxy systems. The resins designed for impregnating, potting, ting, sealing, and coating of electrical mponents. Mitchell Rand Mfg. Corp., Murray St., New York 7, N.Y.

ire Table 128

Table ZK-5 permits, from the wire WG number, determination of wire's diameter in inches, area, weight, length, and distance at 68 F. A table of equivalents nates fractions of the inch with decimal millimeter measurements. Alpha Wire rp., 200 Varick St., New York 14, N.Y.

Servo Motors Catalog 129

Twenty-page catalog No. 5000 lists and fully describes all basic models of a complete line of precision made servo motors, sizes 8 to 29, for scientific, military and industrial applications. Included are dimensional drawings, and physical, electrical and mechanical characteristics. John Oster Mfg. Co., Avionic Div., 1 Main, Racine, Wis.

Instruments 130

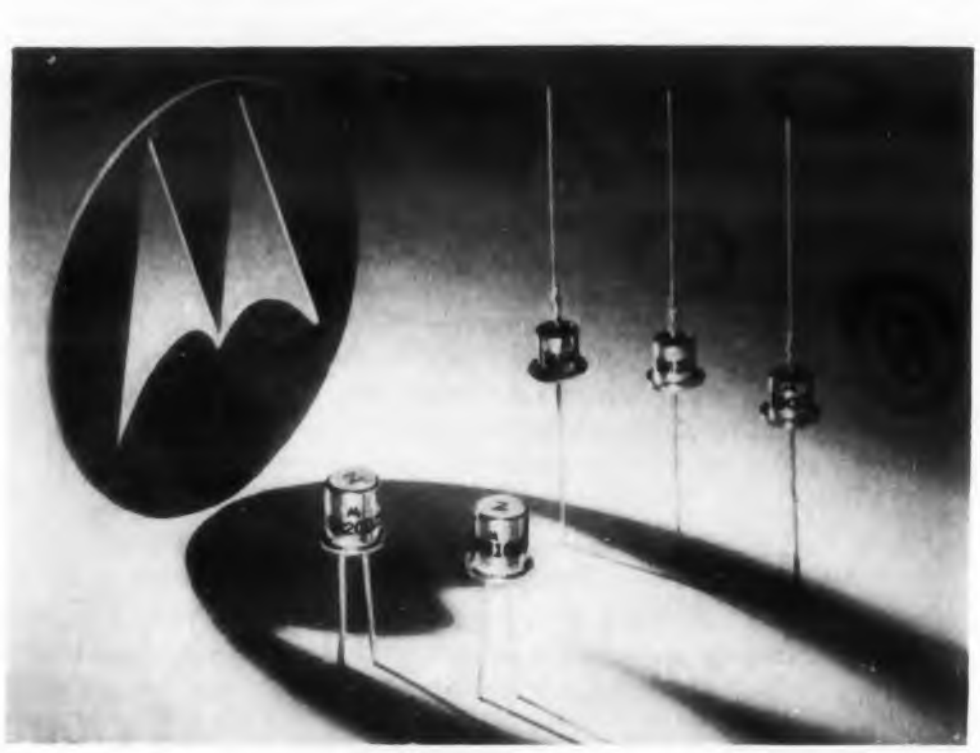
Panel instrument catalog, No. 59-1, 8 pages, provides general information and technical data on such units as: voltmeters, millivoltmeters, microammeters, milliammeters, and portable instrument. Pictures and physical dimensions are also included. The Triplett Electrical Instrument Co., Bluffton, Ohio.

Atmosphere Chart 131

Wallet size, this "ARDC Model Atmosphere Chart" relates altitude to temperature, pressure in millimeters of mercury, pressure in inches of mercury and pressure in pounds per square inch. Conrad, Inc., Conrad Square, Holland, Mich.

NEW PRODUCTS

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



ZENER DIODES

Rated at 1 and 1.5 w, these silicon Zener diodes are rated at from 10 to 200 v. Types 1MZ, 1 w, and 1.5MZ, 1.5 w, are in hermetically sealed packages designed to meet or exceed the mechanical and environmental requirements of MIL-E-1 and MIL-S-19500. The units are tested at both high and low currents to insure a sharp knee on the breakdown curve and to eliminate unstable units.

Motorola Inc., Semiconductor Products Div., Dept. ED, 5005 E. McDowell Rd., Phoenix, Ariz.

CIRCLE 134 ON READER-SERVICE CARD

ACCELEROMETER

Measuring 1.1 x 1.5 x 0.8 in., this potentiometer-type accelerometer has a 2% accuracy over a −10 to +30 range. Designed for telemetering and control purposes, the model 4205 uses silicon fluid for protection against shock and vibration. Temperature range is from −55 to +82 C.

Pacific Scientific Co., Dept. ED, 6280 Chalet Dr., Los Angeles, Calif.

CIRCLE 135 ON READER-SERVICE CARD

TRANSISTORIZED OSCILLATOR

Completely transistorized, this voltage controlled subcarrier oscillator contains a drift free, compensated dc amplifier, a free-running multivibrator, and a low pass filter. The unit has been qualified to operate at up to 140 C and requires less than 1/4 w at 28 or 14 v dc. It is available in all IRIG(RDB) frequencies and special frequencies to 300 kc. Standard units are supplied with frequency deviation limit, sensitivity and output potentiometer, and an output voltage test point.

Vector Manufacturing Co., Inc., Dept. ED, 3040 Overland Ave., Los Angeles 34, Calif.

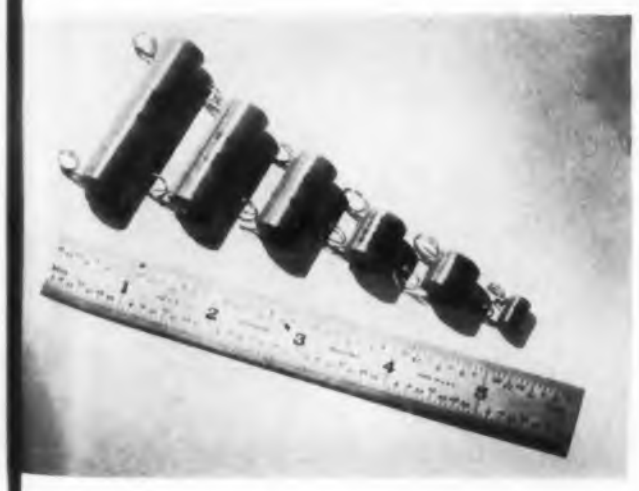
CIRCLE 136 ON READER-SERVICE CARD

TAPE PERFORATOR

This tape perforator has a punching speed of forty columns per second. The unit has a simplified drive mechanism which requires only one eccentric and one cam-generated motion. Standard models will accept any standard tape size up to 1 in. in width and any code column to 8 channels. Safety features include an interlock to prevent the feed from advancing tape until a column has been punched.

Telecomputing Corp., Data Instruments Div., Dept. ED, 12838 Saticoy St.

CIRCLE 137 ON READER-SERVICE CARD



RESISTORS

Resistance tolerance to 0.005% is obtainable in these precision wirewound resistors. Having an operating temperature range from —65 to +135 C, they are available in 40 sizes and wattages. The line surpasses the requirements of MIL-R-93B and MIL-R-9444. Size ranges is from 1/4 x 5/8 in. to 1/2 x 2 in., with wattages from 1 to 5 w.

Leonard Electronics, Dept. ED, 1209 Olympic Blvd., Montebello, Calif.

CIRCLE 138 ON READER-SERVICE CARD

NEW PRODUCTS

Reversible Motor

Has double gear reduction

A reversible fhp motor with built-in double gear reduction, the model CO-843 is available for various inputs ranging from 6 to 48 v dc. Output shaft speeds are 10 to 100 rpm. The unit is designed so that shaft distortion is eliminated and vibration, friction, and wear are kept to a minimum. The motor is 2-7/8 in. long and has 50 in.-oz maximum output torque. The frame and gear case are die cast aluminum.

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

CIRCLE 140 ON READER-SERVICE CARD

Aluminum Spheres

For silicon semiconductor devices

Available in quantity for forming alloy junctions in silicon devices, these aluminum spheres are 99.99+% pure. They can be provided in infinite size increments from 0.004 to 0.125 in. in diameter with sphericity held to ±0.00001 in. They have these advantages in producing alloy junctions: They offer the least amount of oxide per unit volume; they can roll, thus lending themselves to automatic loading into alloying jigs; and they provide reproducible results in a specific semiconductor device.

Accurate Specialties Co., Inc., Dept. ED, 37-11 57th St., Woodside 77, N.Y.

CIRCLE 141 ON READER-SERVICE CARD

Infrared Radiation Source

Has 500 to 1000 C temperature range

The model RS-8A Optitherm infrared radiation reference source is designed to emit black body radiation over the 500 to 1000 C range. It can be used as a standard against which other infrared sources and measuring instruments can be checked and calibrated. The temperature of the source is selected by a single control dial calibrated in deg C, and the area of the black body exit aperture is adjustable with a selector disc containing seven precision apertures. The radiation source temperature is held within $\pm 0.5\%$ despite wide ambient temperature changes, line voltage variations and transients, tube aging, and replacement of most of the individual components.

Barnes Engineering Co., Dept. ED, 30 Commerce Rd., Stamford, Conn.

CIRCLE 143 ON READER-SERVICE CARD

Precision Film Resistor

Glass enclosed

This glass enclosed precision film resistor is impervious to moisture and meets the requirements of MIL-R-10509C, characteristic B. The unit has Dumet leads which are sealed to the thermally compatible glass case, creating a hermetic seal. The leads are welded inside the case to Kovar metal discs, which are fused to the resistance element. The encapsulation does not affect the electrical properties of the unit.

Corning Glass Works, Electronic Components Dept., Dept. ED, Bradford, Pa.

CIRCLE 144 ON READER-SERVICE CARD

NEW PRODUCTS

3/4 Inch Servo Motor

Operates to 200 C

The model 8M100 servo motor is a 3/4 in., size 8 unit that operates at ambients to 200 C and can be certified environmentally under MIL-E-5272A and MIL-T-5422. It produces 1 in.-oz torque at 0 rpm and may be fitted with a variety of output shaft configurations or gear reductions. Input power range is 28 to 115 v ac.

Servo Dynamics Corp., Dept. ED, Somersworth, N.H.

CIRCLE 145 ON READER-SERVICE CARD

Germanium Power Transistors

Provide currents to 25 amp

Germanium pnp alloy power transistors 2N511, -A, and -B through 2N514, -A, and -B have voltage ratings of 40, 60, or 80 v and collector currents of 10, 15, 20, or 25 amp. At maximum rated collector current, R_{cs} is 0.05 ohms maximum. Dissipation is 80 w at 25 C.

Texas Instruments Inc., Semiconductor-Components Div., Dept. ED, Box 312, Dallas, Tex.

CIRCLE 146 ON READER-SERVICE CARD

CIRCLE 147 ON READER-SERVICE CARD

DC Amplifier

Transistorized

Designed for driving galvanometers from a high impedance source, the model AM 103 transistorized amplifier has an input range of ±150 mv, an output range of ±3 v to a 300 ohm lead, and a frequency response of 0 to 10 kc. Input impedance is 10 K; long term drift, 5 mv; and power requirement, +28 v at 32 ma and −28 v at 32 ma. The octal plug-in unit is potted and hermetically sealed in a MIL-27 FA case.

Deeco Instruments, Inc., Dept. D, 14737 Arminta St., Van Nuys, Calif.

CIRCLE 148 ON READER-SERVICE CARD

XXXP Laminate

Self-extinguishing

This XXXP grade laminated plastic is made from cellulose paper impregnated with epoxy resin and comes in both plain and copper-clad sheets. The plain, Dilecto XXXP-31EFR, may be used as insulation for computers, radios, telemetering equipment, and guidance equipment. It is light and humidity resistant and has good cold-punching qualities. Thicknesses are 0.015 through 0.25 in.; sheet sizes are 38 x 38 and 38 x 38 in. The metal-clad material, Di-Clad 31EFR, is the same basic material with 1 or 2 oz copper foil on one or both sides. It can be used for printed circuit boards in the same equipment as the unclad material.

Continental-Diamond Fibre Corp., Dept. E[illegible], Newark, Del.

CIRCLE 149 ON READER-SERVICE CARD

CIRCLE 150 ON READER-SERVICE CARD

NEW PRODUCTS

Spectrum Analyzers

200 cps to 25 mc range

Model SPA-3 and SPA-3/25 spectrum analyze have frequency ranges of 200 cps to 25 and mc, respectively, with 200 cps resolution capabili and up to 20 μv sensitivity for full scale defle tion. The single-package units permit analysis pulse spectra, noise, line spectra, and other co plex ultrasonic and low rf waveforms. They ha a continuously variable scanning width from 3 adjustable down to 0; variable center frequen control; variable resolution from 200 cps to 30 and variable sweep rate from 1 to 60 cps. Th also feature linear, 40 db log and power amplitu scales; a calibrated 100 db attenuator; and bui in, crystal controlled frequency markers.

Panoramic Radio Products, Inc., Dept. ED, 5 S. Fulton Ave., Mt. Vernon, N.Y.

CIRCLE 152 ON READER-SERVICE CARD

Rotor Balancer

For high speed gyros

This rotor balancer is a vibration pickup use with small gyros and servo motors for miss guidance and control systems. It can dynamica balance motor armatures of 7 g and accommod gyros to 32 oz and 2-1/8 in. OD. It has plug- transducer modules that measure rotor displa ments of 0.3 μin. at 1000 to 200,000 rpm. The u mounts in 10 x 15 in. of bench space.

M. Ten Bosch, Inc., Dept. ED, 80 Wheeler A Pleasantville, N.Y.

CIRCLE 153 ON READER-SERVICE CARD

Frequency Recorder

Has 58 to 62 cps range

This frequency recorder was designed for utility and industrial applications. One of the CH line, the instrument features a 58 to 62 cps range and has an accuracy of ±0.05 and completely self-contained construction. Available for compact miflush or surface panel mounting as a portable instrument, the unit features a throw-away inkwell, 150 record roll, multiple chart speeds, chart supply indicator and fluorescent-lighted chart face. The recorder is also available for 50 or cps applications.

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

CIRCLE 154 ON READER-SERVICE CARD

Keyboard Switch

6 pole

Available with either push on-push off or momentary action, this switch has six independent poles that can be supplied in any combination of normally open or closed contacts. It is made with 1 to 2 lb operating pressure, 1/2 in. mounting thread, 3/4 in. case diameter, 1/16 in. travel, and 1/2 amp inductive contacts at 28 v dc. Pushbuttons can be supplied in various colors and shapes engraved to individual requirements.

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

CIRCLE 155 ON READER-SERVICE CARD

Heat Reactive Tubing

Shrinks to fit

Type 3024 heat reactive tubing is a chemical resistant electrical insulating cover for symmetrical or irregularly contoured shapes, bars, tubes and rods. Heated for 4 to 8 min at 275 F, it shrinks to provide a tight

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

CIRCLE 156 ON READER-SERVICE CARD

CIRCLE 157 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Variable Coaxial Attenuator

Has 1 to 6 kmc range

Designed with physically fixed input-output connectors, this variable coaxial attenuator is operated with a smooth sliding motion. It has a frequency range of 1 to 6 kmc, an attenuation range of 18 to 40 db, and a vswr below 1.5.

Radar Design Corp., Dept. ED, Pickard Dr., Syracuse 11, N.Y.

CIRCLE 159 ON READER-SERVICE CARD

Cable Clamps and Ties

Molded plastic

Two molded plastic wiring accessories are offered for electronic and electrical use. One is a reusable cabling tie which looks and works like a beaded key chain. Quickly attached or removed without tools, it is formed of a single piece 4-in. long and withstands a 45 lb pull. The other accessory is a cable clamp that may also be used to hold rods, tubes, capacitors, or pipes. It fastens with a screw or nail and is made of insulating material so that it cannot contribute to ground or short circuits. The clamps are available in extruded cellulose with collar ID's from 1/8 to 1-1/4 in. and in nylon with collar ID's from 1/8 to 5/8 in.

Gries Reproducer Corp., Dept. ED, 400 Bellwood Ave., New Rochelle, N.Y.

CIRCLE 160 ON READER-SERVICE CARD

Adjustable Viscous Damped Motor

Size 11

Designed to replace motor tachometers in feedback damping applications, the size 11 5752-05 adjustable viscous damped motor presents no null or phasing problems in the feedback loop. Damping and gain may be independently adjusted, and no load speed can be quickly adjusted to any speed from 4800 to 7300 rpm. The unit operates from −55 to +125 C and meets MIL-5272A specifications.

John Oster Mfg. Co., Avionic Div., Dept. ED, 1 Main St., Racine, Wis.

CIRCLE 161 ON READER-SERVICE CARD

Line Voltage Regulator

Broadband

The PoweRite model 4K115 line voltage regu-tor is fully transistorized and provides 4 kva gulated to within ±0.5%. It operates equally ell at any frequency from 45 to 400 cps. Response te is 60 v per sec and harmonic distortion is der 0.01%. Output is preset at 115 v ac but can varied between 110 and 120 v ac. Standard its regulate to within 0.5% over a range of 15 v from the set point.

Armour Electronics, Dept. ED, 4201 Redwood ve., Los Angeles 66, Calif.

CIRCLE 162 ON READER-SERVICE CARD

AC Electronic Voltmeter Module

Plug-in

Designed for plug-in use with a remote meter, e model SPD-22 ac electronic voltmeter module ll measure from 10 mv to 300 v rms full scale sitivity, depending on the input voltage deter-ned by the built-in attenuator. Measuring 5 x 1/2 x 4-1/4 in., it contains all vtvm circuitry ex-t the power supply. With this unit, meters be-used for other readings may also be used for voltage measurement. The module imposes al-t no load on the circuit being measured and s an accuracy of ±3% with a meter of 2% accu-y. Frequency range is 20 cps to 50 kc at 2% ac-acy and 50 kc to 100 kc at 3% accuracy.

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

CIRCLE 163 ON READER-SERVICE CARD

Low Noise Preamplifier

Covers 400 to 500mc

Designed to operate with a 50 ohm source and d impedance, model AP-710-1 uhf preamplifier s a noise figure of 4 to 5 db and a gain of 20 db an operating frequency of 400 to 500 mc. The t has a self-contained power supply and fits a 19 x 3-1/2 in. space.

Dixon Electronics, Inc., Dept. ED, 2414 Reedie , Silver Spring, Md.

CIRCLE 164 ON READER-SERVICE CARD

NEW PRODUCTS

Precision Digital Potentiometers

For 7 and 10 digit inputs

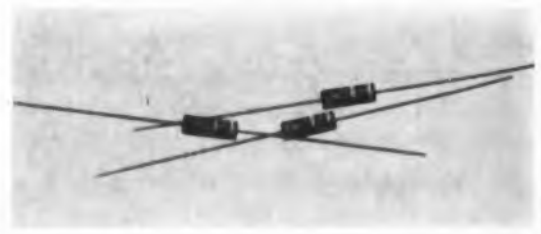
A digital to analog converter, the Digiomet converts a digital number to a precision poten ometer setting. Models are available for 7 and digit inputs, and can also be built to accept bina or binary-coded decimal information. Operati time is 10 msec. The units are shock and vibrati resistant and suitable for missile use.

Systems Laboratories Corp., Dept. ED, 148 Ventura Blvd., Sherman Oaks, Calif.

CIRCLE 167 ON READER-SERVICE CARD

Silicon Diodes

Have working voltages to 300 v



Silicon diodes CD1111 through CD1116 ha working voltages through 300 v and forward c rents of 0.25 amp at 1 v. Reverse currents below 5 mμa at the maximum working voltage.

Continental Device Corp., Dept. ED, 129 Cerise Ave., Hawthorne, Calif.

CIRCLE 168 ON READER-SERVICE CARD

Subminiature Paper Capacitors

For transistorized applications

This hermetically sealed subminiature, t AQF paper capacitor meets MIL-C-25A. Made low voltage transistorized applications, the operates at temperatures from −65 to +12 without derating. It has a capacitance variat of less than ±3 per cent over the entire operat temperature range. The capacitor is available ratings from 0.027 to 2 μf. The smallest size 0.235 in. in diam and 3/4 in. long.

Astron Corp., Dept. ED, 255 Grand Ave., Newark, N. J.

CIRCLE 169 ON READER-SERVICE CARD

Dial Assembly

Servo mounted

Series DA dial assembly permits mounting and dismounting from the front panel of any equipment. The machined groove on its rim is used in the same way as the mounting groove of a synchro. Conventional synchro clamps on the equipment panel firmly hold the dial. The unit has a 360 deg continuous range and 0.1 deg accuracy. It meets MIL-T-945A specifications and has a 5 in. OD

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

CIRCLE 170 ON READER-SERVICE CARD

Transistor Curve Tracer

Displays up to five curves

Model TCT-2 transistor curve tracer can display either one curve or a five curve family. The V_c and I_c axes are directly calibrated. It displays collector voltage-collector current (output) curves for common emitter or common base connection. The unit is designed for use with any standard dc oscilloscope with single presentation possible with any standard ac oscilloscope. Emitter-base voltage for selected input currents may be measured by using an external dc meter to characterize points on the input curve.

Curtiss-Wright Corp., Inter-Mountain Instruments Branch, Electronics Div., Dept. ED, Box 8324, Albuquerque, N. M.

CIRCLE 171 ON READER-SERVICE CARD

Epoxy Molding Materials

Can be molded at pressures down to 75 psi

These epoxy molding materials can be molded in conventional compression and transfer molding equipment at temperatures of about 300 F and pressures down to 75 psi. They can be automatically preformed and molded with cure times approaching those obtained with conventional phenolics. Shelf life is 6 months. Molded parts retain good electrical properties under adverse humidity and high temperature conditions.

The Fiberite Corp., Dept. ED, 512-528 W. Fourth St., Winona, Minn.

CIRCLE 172 ON READER-SERVICE CARD

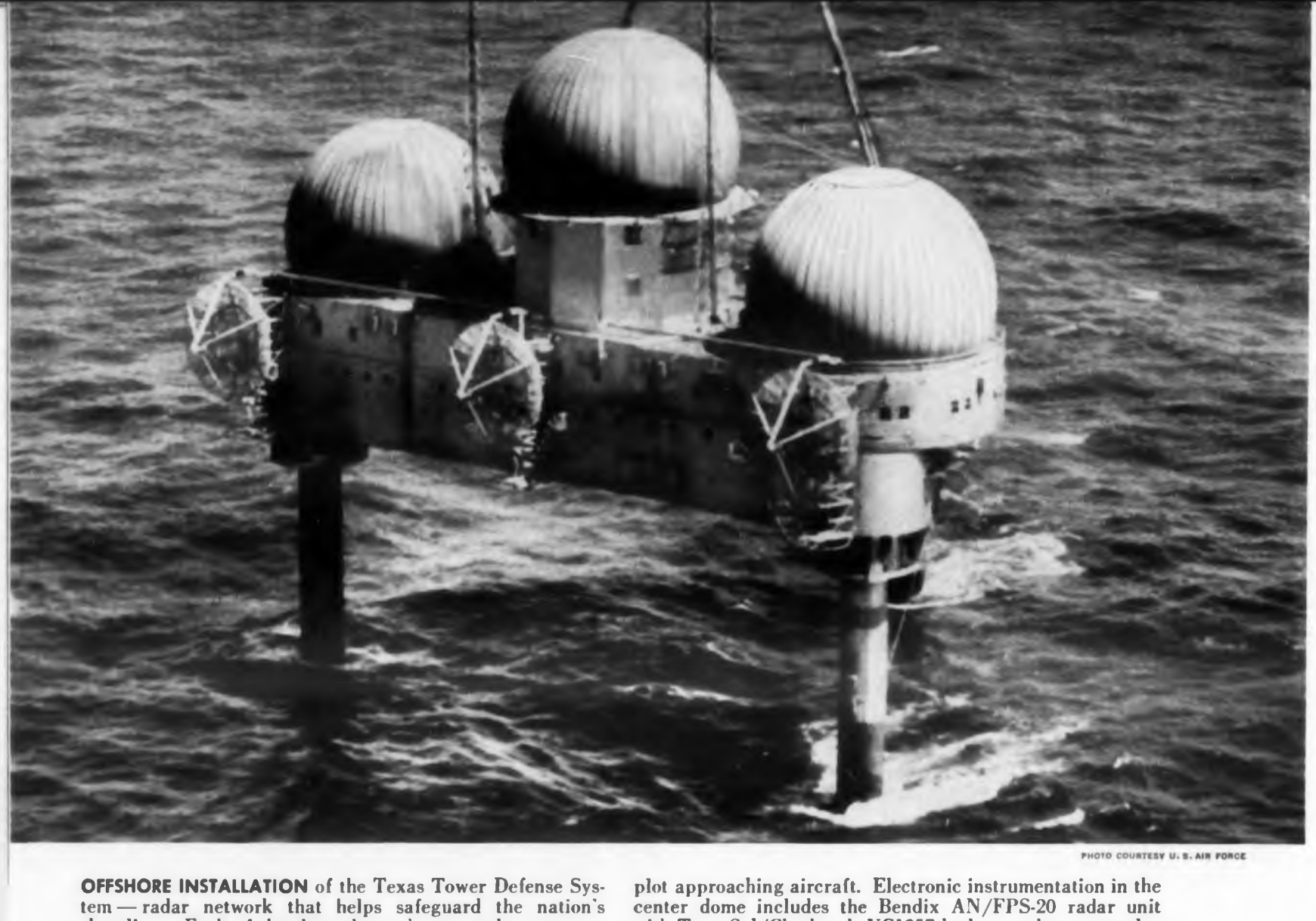


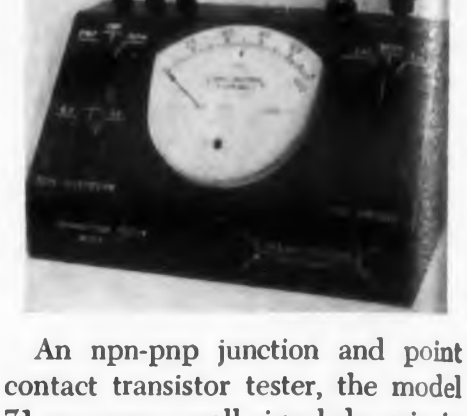
PHOTO COURTESY U. S. AIR FORCE

OFFSHORE INSTALLATION of the Texas Tower Defense System — radar network that helps safeguard the nation's shorelines. Each of the three domes houses radar antennas that constantly sweep the horizon to detect, identify and plot approaching aircraft. Electronic instrumentation in the center dome includes the Bendix AN/FPS-20 radar unit with Tung-Sol/Chatham's VC1257 hydrogen thyratron tube, Tung-Sol/Chatham development.

NEW PRODUCTS

Transistor Tester

Operates on flashlight batteries



An npn-pnp junction and point contact transistor tester, the model 71 measures small signal dc gain in the grounded emitter configuration and collector to base leakage current with an accuracy of 3%. A beta multiplier permits measurements with full scale beta ranges of 0 to 50, 100, and 200. I_{co} is measured with a full scale reading of 100 μa. A short test light with a pushbutton switch identifies shorted transistors immediately. The portable unit operates on standard flashlight batteries.

Trans-Western Electronics, Dept. ED, P.O. Box 1473, Ventura, Calif.

CIRCLE 174 ON READER-SERVICE CARD

Miniature Pushbutton Switch

Has four lamps, four colors

The Quadlite pushbutton switch is a 7/8 in. square unit incorporating four lamps, an spdt switch, and a switch actuator. It features mechanical interlocking for master resetting or mutual cancellation and comes with color filters in combination of any of six standard colors and white. It mounts with or without barriers, or in a matrix on 7/8 in. centers, both directions. All four lamps and the color filter assembly can be easily removed from the front of a panel, and switches and lamps may be interwired or terminated independently.

Electrosnap Corp., Switch Div., Dept. ED, 4218 W. Lake St., Chicago 24, Ill.

CIRCLE 175 ON READER-SERVICE CARD

CIRCLE 176 ON READER-SERVICE CARD

AC Voltage Divider

Has 1 ppm linearity

This laboratory standard measures voltage ratios with a linearity accuracy of better than 0.0001 per cent (1 ppm). Model DT-72 Dekatran has toroidal transformers combined to provide seven decades of accurate voltage division. Accuracy is maintained over a wide range of audio frequencies, input voltages and ambient temperatures. The unit uses an inline dial configuration and can be mounted in a standard relay rack.

Electro Measurements, Inc., Dept. ED, 7524 S. W. Macadam Ave., Portland 1, Ore.

CIRCLE 177 ON READER-SERVICE CARD

Magnetic Shields

For shaded pole motors

These Netic Co-Netic magnetic shields permit lower cost shaded pole motors to be used in servo and other instrumentation applications. With proper grounding, effective electrostatic shielding is also accomplished. The shields reduce the radiated field to under 5 gauss and do not significantly affect motor characteristics. They are nonretentive and structurally rugged.

Perfection Mica Co., Magnetic Shield Div., Dept. ED, 1322 N. Elston Ave., Chicago 22, Ill.

CIRCLE 178 ON READER-SERVICE CARD

Meter Relays

2½ and 3½ in.

Models 195 and 95 are 2-1/2 and 3-1/2 in. round panel meter relays for over and under voltage indication, alarm systems, automatic sorting devices, low level switching, and a variety of other applications. They are available in dc meter relay types, microammeters, milliammeters, and ammeters to 10 amp, self-contained. Higher current ranges have external shunts.

Simpson Electric Co., Dept. ED, 5200 W. Kinzie St., Chicago 44, Ill.

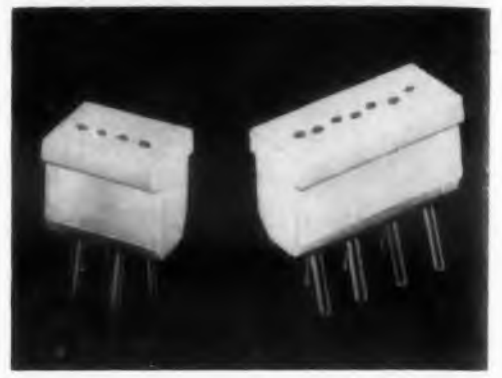
CIRCLE 179 ON READER-SERVICE CARD

CIRCLE 180 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Miniature Sockets

Low loss



Miniature Chemelec SX-423, -424, and -427 sockets are low loss tube and transistor units for wired or printed circuit applications. Three, four, and seven post sockets, respectively, they have Teflon insulator bodies which press fit into mounting receptacles. The countersunk spring tension socket contacts are silver plated, gold flashed brass with flared ends. Other multipost sockets are also available.

Fluorocarbon Products Inc., Dept. ED, Camden 1, N.J.

CIRCLE 182 ON READER-SERVICE CARD

Data Transmission System

High speed

Used with the company's 768G-1 Kinecard converter and an IBM 523 card reader-punch unit, the TE-206 data transmission system reproduces and transmits punch card information at a rate of 100 cards per min. The system can operate in full or half duplex and simplex modes. The TE-206 conveys information at voice frequencies over wire line, cable, carrier, or microwave telephone facilities.

Collins Radio Co., Dept. ED, 2700 W. Olive, Burbank, Calif.

CIRCLE 183 ON READER-SERVICE CARD

Reference Diode

Temperature coefficient of 0.005% per C

Having a temperature coefficient of up to 0.0005 per cent per C from —55 to +185 C, this reference silicone diode is in a case 0.29 in. long and 0.25 in. in diameter. The reference element is rated from 9 to 9.8 v at 10 ma, with Zener impedance of 15 ohms. The internal lead wire and stainless steel diode case have matched coefficients of expansion. Cases are glass-sealed and hermetically welded.

U. S. Semiconductor Prod., Inc., Dept. ED, 3536 W. Osborn Road, Phoenix, Ariz.

CIRCLE 184 ON READER-SERVICE CARD

Delay Lines

Variable

These potentiometer type delay lines come in a in. diameter case with 3 to 30 μsec variable de- time and 210 deg shaft rotation. A locking de- ice can be provided for use under high vibra- on. The potentiometer packaging may also be dered for delay lines of greater length, and digi- l shaft knobs can be supplied for accuracy in tting the delay.

Deltime, Inc., Dept. ED, 608 Fayette Ave., Mamaroneck, N.Y.

CIRCLE 185 ON READER-SERVICE CARD

Miniature Free Gyro

Stands up to 2000 cps vibration

Model N4100 gyroscope weighs 3.5 lbs and n stand vibration of 10 to 1000 cps at 10 g and 00 to 2000 cps at 20 g with 2 min sweep cycles ithout the benefit of vibration isolators. It is a geable, 2-axis, free unit designed for missile pplication. Angular displacements are indicated a synchro pick-off on the outer gimbal. Con- uction throughout is of heat treated cast stain- ss steel and a center-of-gravity flange is ovided for mounting.

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

CIRCLE 186 ON READER-SERVICE CARD

Thermal Switch

or activating temperatures from 113 to 1500 F

The Thyrastat is a temperature sensitive, single ot switch available in normally open and nor- lly closed single pole types. Rated at 4, 10, 50, 0, or 300 amp, the unit is preset for activating mperatures ranging from 113 to 1500 F. It has unlimited altitude range and a temperature nge between −100 and +1500 F dependent on e activating temperature. The unit meets MIL- 52721 humidity requirements and withstands 0 g shock for 2 to 4 msec and 2 to 20,000 cps vi- ration at 40 g.

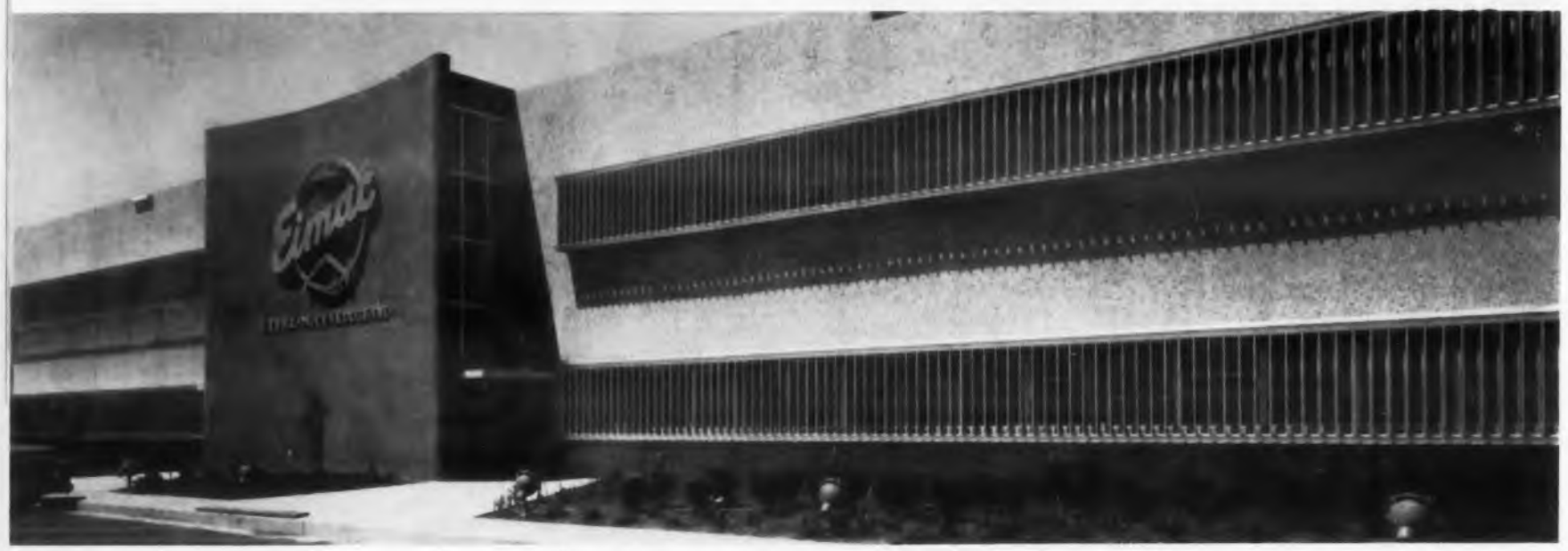
Therm ical, Inc., Dept. ED, 1629 Colorado St., nta Monica, Calif.

CIRCLE 187 ON READER-SERVICE CARD

EIMAC TUBES
NOW IN PRODUCTION
IN AMERICA'S NEWEST,
MOST MODERN TUBE PLANT

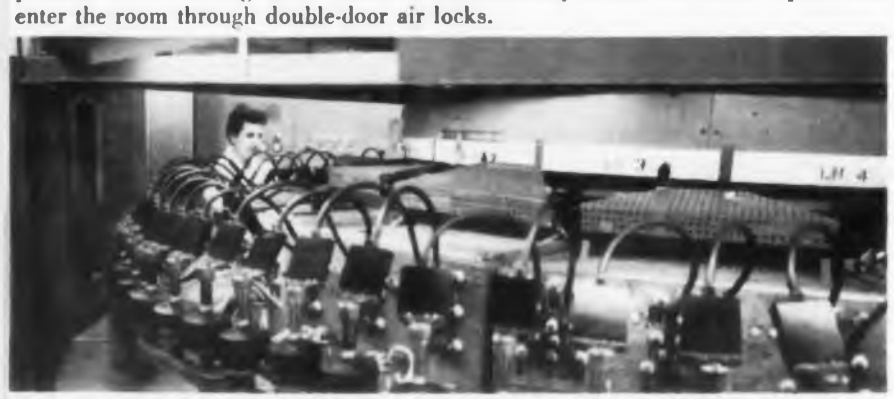
In San Carlos, California, Eimac's third and largest plant is nearing full production to meet the great demand for many popular Eimac electron tube families. Never before have so many advanced techniques and processes been applied to vacuum tube manufacture. Eimac's leadership in new processing methods has brought a new era of quality to electron tubes.

Ready for shipment, these Eimac ceramic tetrodes are just one of more than a hundred different tube types manufactured by Eitel-McCullough. Inc., including negative grid tubes, power amplifier klystrons, reflex klystrons and traveling wave tubes.



Eimac, San Carlos, greatly increasing production capacity, joins San Bruno and Salt Lake City facilities as Eimac's newest plant.

Final tube assembly in near-sterile "clean rooms" assures exceptional tube reliability. These rooms are pressurized with filtered, conditioned air to prevent the tiniest dust particles from entering. Even shoes are automatically vacuum cleaned as personnel enter the room through double-door air locks.



Eimac designed rotary vacuum pumps speed production, achieve hard, clean tube vacuums. Pumping Eimac tubes at high voltages and ambient temperatures assures long life and reliability. These giant rotary pumps are typical of production equipment custom designed by Eimac for transmitting tube manufacture.

Every tube meets rigid Eimac specifications before shipment. On test consoles like this, dozens of electrical characteristics are patiently tested and recorded for each Eimac tube produced. Environmental testing equipment is also available for testing for severe applications.

EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

NEW PRODUCTS

Adjustable Capacitors
Hermetically sealed

Designed for precise circu
where a large capacitance of cl
tolerance is required, these herm
cally sealed polystyrene capacit
may be adjusted over a range
±1% of nominal value. Capacitan
is changed instantaneously a
once set, a unit will maintain
value within 0.1% for almost a ye
The units employ a self-rigid ty
of winding which is completely n
inductive and inherently stable wi
out external pressure.

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

CIRCLE 188 ON READER-SERVICE CAR

Gyro Test Console
Simplifies response testing

Developed to measure the tra
fer function and damping char
teristics of rate gyros, this test c
sole simplifies the procedure
gyro response testing. The equ
ment discriminates in favor of
fundamental frequency to give
curate readings irrespective
harmonics and unmasked by irr
vant oscillations. It consists o
low frequency decade oscilla
low frequency resolved compon
indicator, carrier converter, po
supply, velocity pickup head
plifier, rate vibration table con
unit, and rate vibration table.

Solartron, Inc., Western D
Dept. ED, 10761 Burbank Bl
North Hollywood, Calif.

CIRCLE 189 ON READER-SERVICE CA

CIRCLE 190 ON READER-SERVICE CARD

Miniature Pressure Switch

For missiles

Model 3486 miniature pressure switch, for mis- and similar space applications, is designed for with both hydraulic fluids and gases, and for to 3000 psi systems. It is resistant to accelera-n, shock, and vibration and has a temperature ge of −65 to +275 F. Maximum weight is 3/4 proof pressure is 4500 psi; and burst pressure 500 psi. The snap action unit can be supplied spst, spdt, or dpst arrangements. Solder ter-nals are provided.

Frebank Co., Dept. ED, 711 W. Broadway, ndale 4, Calif.

CIRCLE 191 ON READER-SERVICE CARD

Teflon Insulated Terminals

Feedthrough and test point

Available in feedthrough and test point con-urations, Loc-Fit Teflon insulated terminals are piece devices consisting of a Teflon grommet any of a variety of terminals. They require no cision drill tolerances, deburring, or chamfering chassis preparation and can be installed by hand with automatic production machine facilities. Loc-Fit terminal may be installed in boards thicknesses from 0.04 to 0.062 in.

Litton Industries, Inc., U. S. Engineering Co. v., Dept. ED, P.O. Box 2368, Van Nuys, Calif.

CIRCLE 192 ON READER-SERVICE CARD

Signal Generator Calibrators

500 kc to 100 mc range

Signal generator calibrator types 245-D and 5-C have calibrated output ranges of 0.5, 1, and and 5, 10, and 20 μv, respectively. Both pro-e direct calibrated measurement of per cent am of r voltage at 0.025, 0.05, and 0.1 v. The ts are portable and fully transistorized and re-re no external power source. They have an rf ge of 500 kc to 1000 mc; an am range of 10 to 0%; and an am frequency range of 20 cps to kc. The rf input requirements are 0.05 v.

Boonton Radio Corp., Dept. ED, Boonton, N.J.

CIRCLE 193 ON READER-SERVICE CARD

NEW PRODUCTS

5-Inch Cathode Ray Tube

12 in. long

The type 5BTP flat face, 5-in. cathode ray tub is 12 in. long. It has a sensitivity of 27 v dc per i vertically and 50 v dc per in. horizontally wh operated with 800 v at the second anode and 16 v at the third anode. The tube provides a hig light output and can be operated with voltag up to 2700 and 4400 v at the anodes. It has ele trostatically controlled focus and deflection and available in P1, P2, P7, and P11 phosphors.

Waterman Products Co., Dept. ED, 2445 Eme ald St., Philadelphia 25, Pa.

CIRCLE 198 ON READER-SERVICE CARD

Fixed Coaxial Attenuator

Stainless steel

Fixed coaxial attenuator model 210 has a stai less steel body and stainless steel type N conne tors. Frequency range is 1 to 10 kmc; attenuati range, 1 to 20 db; impedance, 50 ohms.

Weinschel Engineering, Dept. ED, 10503 Me ropolitan Ave., Kensington, Md.

CIRCLE 199 ON READER-SERVICE CARD

Pulse Height Analyzer

Has 20 channel storage

A 100 channel pulse height analyzer with channel storage, model PHA-120 is designed sp cifically for moderate and low counting spe troscopy work. A full 100 channel analysis is ma and read in five steps of 20 channels. The instr ment consists of a preamplifier, amplifier, amp tude digitizer, storage unit, and decade scaler.

The Victoreen Instrument Co., Dept. ED, 58 Hough Ave., Cleveland 3, Ohio.

CIRCLE 200 ON READER-SERVICE CARD

Chopper Reference Kit

Provides 60 and 400 cps driving frequencies

The four precision dpdt instrument choppers in this reference kit have 60 and 400 cps driving frequencies and both mbb and bbm contact closures. They have removable dust covers of Co-Netic magnetic shielding for low noise characteristics and easy contact adjustment.

James Vibrapowr Co., Dept. ED, 4050 N. Rockwell, Chicago 18, Ill.

CIRCLE 201 ON READER-SERVICE CARD

Hysteresis Motors

Size 10 and 11

These size 10 and 11 gearhead hysteresis synchronous motors are 2-17/64 in. long and may be supplied in any gear reduction to 8000 to 1. They operate from —65 to +125 C. Standard units are for 26, 55, or 120 v ac, 400 cps operation.

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

CIRCLE 202 ON READER-SERVICE CARD

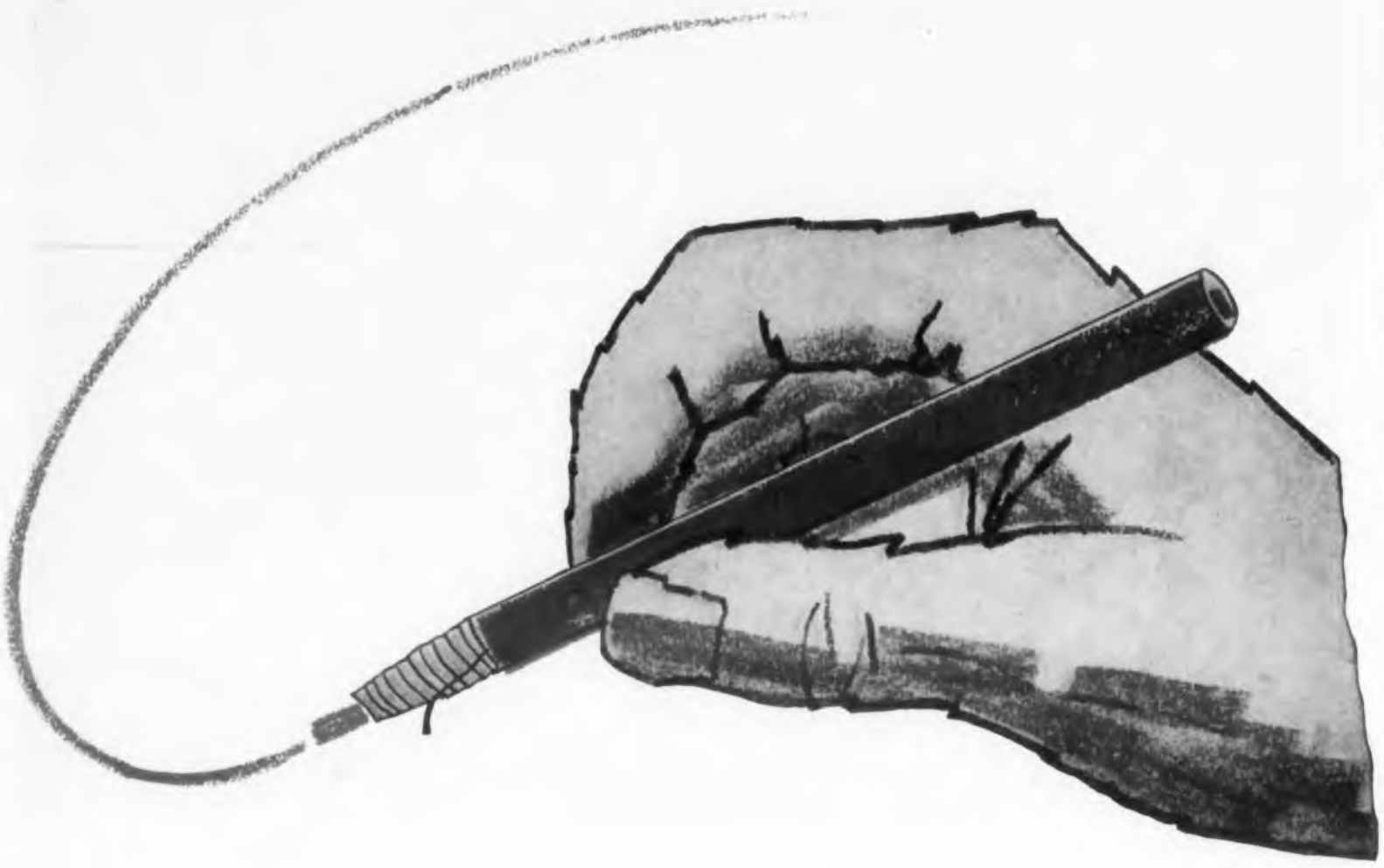
Elapsed Time Indicator

Dimensions less than one in.

Having a nominal diameter and length of less than 1 in. the SM-1 elapsed time indicator weighs 1.25 oz. It has a power consumption of 1.5 w. The unit is designed to operate from a 400 cps source at operating voltages to specification. The unit is designed to meet the general requirements of MIL-I-7793B.

Herita Electronics, Inc., Dept. Ed, 2635 Louisiana Ave., Minneapolis 26, Minn.

CIRCLE 203 ON READER-SERVICE CARD



HANK YOU FOR YOUR COOPERATION

From time to time readers have been asked to help us rate the interest value of our editorial by indicating which articles are read completely, and which are simply noted. We have asked the same question about advertisements.

Because you have taken the time to go through the publication page by page, you have given us an indication of the kinds of articles, design information, and data you need to solve today's design problems. At the same time you have provided us with a concrete measure of *Electronic Design's* readership—highest in the electronic field.

Although we are always anxious to attract new advertisers, our prime concern is to maintain—and improve—the quality of our magazine and its service to the reader.

Reader Recall reports are published in the form shown at left. They help to convey the meaning of *Electronic Design*, and the spirit and interests of our readers to marketing executives in the electronic field.

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Ft. Lauderdale, Fla.: 2808 Middle River Dr. LOgan 6-5656

NEW PRODUCTS

Digital Clocks

Transistorized

Fully transistorized, these digital clocks provide reliable time duration and interval measurements. They have a direct readout, illuminated display and heavy duty output closures for data recorder entry. Time measurement is based on 60 cps line frequency, but provision is made to slave the clock to an external frequency source or time base. Clocks can be provided for operation on any frequency from 25 to 128 cps. Primary measurement of time is achieved by means of transistor flip-flop frequency division.

Electro Instruments, Inc., Dept. ED, 3540 Aero Court, San Diego 11, Calif.

CIRCLE 205 ON READER-SERVICE CARD

DC to Square Wave Power Supply

Has ±1% frequency and voltage regulation

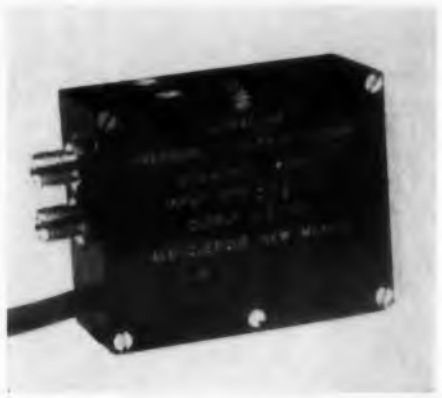
Transistorized power supply model 591AC produces 400 cps single phase, square wave power from a 28 v dc line. It delivers 50 va output with a frequency and voltage regulation of ±1% for input variations of 5 v. An output power of 115 v, 400 cps is standard, but any voltage from 6 to 1200 v rms and any frequency from 400 to 2000 cps can be supplied. The unit is protected against polarity reversal and short circuits and has a ±3% voltage drift from −55 to +71 C. Designed to MIL-E-5272B, it is fully encapsulated and hermetically sealed in a case 3-3/16 in. high with a 3 in. OD.

Arnold Magnetics Corp., Dept. ED, 4613 W. Jefferson Blvd., Los Angeles 16, Calif.

CIRCLE 206 ON READER-SERVICE CARD

Pressure to Voltage System

Provides 0 to 5 or ±2.5 v dc output



Voltage controlled model DCS-4 pressure to voltage system operates from standard unregulated aircraft and missile power supplies and provides a signal output of 0 to 5 or ±2.5 v dc over the rated pressure range. The dc output voltage level is constant within ±1% despite input voltage changes within the 25 to 30 v range.

Ultradyne, Inc., Dept. ED, P.O. Box 3308, Albuquerque, N. Mex.

CIRCLE 207 ON READER-SERVICE CARD

Dual Centrifugal Blowers

Deliver 150 to 500 cfm

Model M2E300A centrifugal blowers deliver 150 to 500 cfm and have panel heights from 3-1/2 to 8-3/4 in. They fit 19 in. racks and have 60 or 400 cps single or three phase motors.

McLean Engineering Labs., Dept. ED, Princeton, N.J.

CIRCLE 208 ON READER-SERVICE CARD

AC-DC Digital Voltmeter

Provides full 4-digit accuracy

With a fifth digit for dc over ranging, the model 502 4-digit ac-dc digital voltmeter provides full 4-digit accuracy across all ranges. Overall range for dc is ±0.0001 to 1000 v with 0.01% ±1 digit accuracy; for ac, 0.001 to 999.9 v, 30 to 10,000 cps with 0.2% ±1 digit, accuracy.

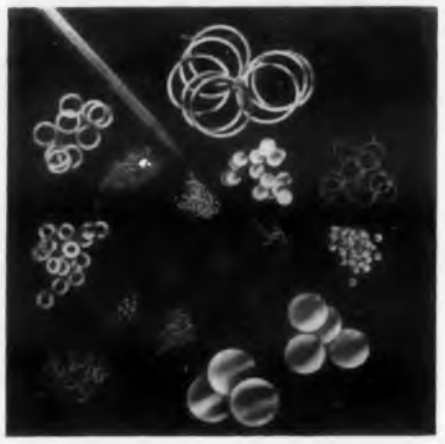
Kin Tel, Div. of Cohu Electronics, Inc., Dept. ED, 5225 Kearny Villa Rd., San Diego 12, Calif.

CIRCLE 209 ON READER-SERVICE CARD

NEW PRODUCTS

Semiconductor Preforms

Variety of shapes and materials



For making alloy junctions in silicon and germanium semiconductor devices, these preformed discs, spheres, washers, and pellets are available in a wide variety of alloys including lead-antimony, indium-lead, gold-gallium, aluminum-gallium, and tin-antimony. Discs have tolerances to ±0.0002 in. on diameters with flatness held within 0.0002 in. T.I.R. Spheres range from 0.001 to 0.125 in. in diameter with tolerances to ±0.0001 in. Washers have OD's from 0.025 to 2 in. with diameters guaranteed to ±0.00025 in. and thicknesses to within ±0.0002 in.

Accurate Specialties Co., Inc., Dept. ED, 37-11 57th St., Woodside 77, N.Y.

CIRCLE 211 ON READER-SERVICE CARD

Panel Indicator Light

Has 1/4 in. diameter

Miniature model T-1 panel indicator light lasts 100,000 hr at 5 v or 60,000 hr at 6.3 v. Both single and two terminal types with either fixed or removable bulbs are available The light is 1/4 in. in diameter, and the light cap, provided in red, white, green, blue, or amber, is 1/8 in. in diameter.

The Sloan Co., Dept. ED, 4029 Burbank Blvd., Burbank, Calif.

CIRCLE 212 ON READER-SERVICE CARD

Expanded Scale Voltmeter

Has 0.1% accuracy

Indicating true rms voltage, this expanded scale voltmeter maintains 0.1% accuracy over a wide temperature range and in the presence of up to 5% harmonic content in the power supply. It has a 250 deg scale on its 115 to 125 v dial and is housed in a single unit that includes a 3-1/2 in. panel meter.

American Machine & Foundry Co., Alexandria Div., Dept. ED, 1025 N. Royal St., Alexandria, Va.

CIRCLE 214 ON READER-SERVICE CARD

Adjustable Fixed Resistors

Rated ¼ w at 70 C

The moving element in type R fixed resistors is self-locking and adjustable through a 25-turn range. The resistors are watertight and dust tight so that they may be potted after adjustment. They are 1-1/4 in. long and rated 1/4 w at an ambient temperature of 70 C and a maximum voltage of 350 v. Total resistance values from 100 ohms to 2 meg ±10 and ±20% are available.

Allen-Bradley Co., Dept. ED, 136 W. Greenfield Ave., Milwaukee 4, Wis.

CIRCLE 215 ON READER-SERVICE CARD

Power Supply

Has three regulated outputs

This power supply, P/N 380-100, was designed to supply three separate, closely regulated output voltages: +150 v, 630 ma; —150 v, 100 ma; and —300 v, 40 ma. For airborne use, the unit will operate at +85 C at full output rating, and is completely transistorized, using no tubes. Housing is black anodized aluminum for better heat dissipation, and the power transistors are mounted directly on the cabinet.

Master Specialties Co., Dept. ED, 956 E. 108th St., Los Angeles 59, Calif.

CIRCLE 216 ON READER-SERVICE CARD

NEW PRODUCTS

Delay Line Kit

Provides delays from 0.1 to 1.6 μsec

With individual or series connected lines in the model 125 delay line kit, any delay from 0.1 to 1.6 μsec may be achieved in 0.1 steps. The kit contains lumped constant delay lines made up of precision toroidal inductors and temperature compensating ceramic disc capacitors. The lines have a characteristic impedance of 500 ohms and a rise time of 0.1 μsec.

Valor Instruments, Inc., Dept. ED, 13214 Crenshaw Blvd., Gardena, Calif.

CIRCLE 217 ON READER-SERVICE CARD

Molded Capacitors

Have dual dielectric

For TV, radio, and general commercial use, these molded capacitors have a dual dielectric of both polyester film and paper. Type 160P has a fully molded case and type 161P a premolded case. Type 162P has a slotted base. The units are suited for printed circuit standup and conventional point-to-point or card mounting applications.

Sprague Electric Co., Dept. ED, 347 Marshall St., North Adams, Mass.

CIRCLE 218 ON READER-SERVICE CARD

Uncompensated Silicon

Semiconductor grade

Available in three semiconductor grades, this uncompensated silicon is free of all impurities except for minute quantities of boron. Type 43 contains less than 2.8 parts per billion boron; type 42, less than 5.6; and type 41, less than 11.2. Another silicon, type 40, is suitable for solar batteries and has a minimum resistivity of 1 ohm cm.

Sylvania Electric Products Inc., Chemical and Metallurgical Div., Dept. ED, Towanda, Pa.

CIRCLE 219 ON READER-SERVICE CARD

CIRCLE 220 ON READER-SERVICE CARD

Low Voltage Capacitors

Operate to 175 C with no derating

LV series capacitors are rated at 15 wvdc and operate continuously from −70 to +175 C without derating. They have a 0.0001 to 0.25 μf capacity range, ±20 to ±1% tolerances, and a 0.1% power factor. Temperature coefficient is 100 ppm per deg C. Hermetically sealed in metal cases with 0.17 to 0.5 in. diameters and 13/16 to 1-5/16 in. lengths, the units exceed MIL-C-25A requirements.

Balco Research Labs, Inc., Capacitor Div., Dept. ED, 49-53 Edison Place, Newark 2, N.J.

CIRCLE 221 ON READER-SERVICE CARD

Fuse Posts

Glows when fuse blows

This series of indicating 3AG fuse posts has a knob design that assures illumination for instant blown fuse indication. Voltage range is from 2-1/2 to 250 v with a maximum current rating of 20 amp. They meet MIL-M-14E type CFG, can be fungus treated on request as per Jan-T-152 and Jan-C-173. Double flat spots on body permits mounting flexibility. Units measure 2-3/8 in. overall length, and 1-9/16 in. back of panel. Mounting hole is 5/8 in. in diameter.

Littelfuse, Inc., Dept. ED, Des Plaines, Ill.

CIRCLE 222 ON READER-SERVICE CARD

Midget Solenoid

For continuous or intermittent duty

This dc midget solenoid, No. 22, is available for continuous and intermittent duty application. Designed for miniaturized assemblies, the unit has a plunger stroke adjustable from 1/32 to 5/16 in. with a maximum lift of 11 oz, continuous duty; 24 oz, intermittent duty. Overall dimensions: 3/4 x 1-1/8 x 3/4 in. wide. Coil values range from 6 to 110 v, dc only.

Guardian Elect. Mfg. Co., Dept. ED, 1621 W. Walnut St., Chicago 12, Ill.

CIRCLE 223 ON READER-SERVICE CARD

CIRCLE 224 ON READER-SERVICE CARD ➤

A technician probes radiated interference from an aircraft hoist in the Los Angeles laboratory of Sprague's Interference Control Field Service Dept.

Improved Service For Radio Interference Control

Fast-growing Department of Sprague Electric Company Greatly Expands its Measurement, Control, and Consulting Engineering Facilities to Provide Fast Service.

Contractors responsible for the design and manufacture of electric/electronic equipment and weapon systems which must conform to military interference requirements will get a major assist from Sprague Electric's expanded industry service in the field of r-f interference and susceptibility.

The service includes: interference and susceptibility measurements up to frequencies of 10,000 mc; complete analysis of all test results; and comprehensive recommendations of appropriate control techniques to bring about a suppression system having the lowest weight, the lowest cost, and the greatest reliability.

Sprague's consulting service applied at the design stage already has proven to be the best approach to interference and susceptibility control. Experienced Sprague engineers invariably save valuable time in the preparation of test plans and their subsequent approval. Sprague engineers prefer to work from the design conception, analyzing original schematics and equipment drawings. This permits them to recommend optimum shielding, isolation, and decoupling techniques before cases and layouts are finalized. Space allowances for suppression components can be made with proper attention to economy of weight and cost.

Once the equipment reaches the prototype stage, Sprague specialists will conduct tests either in the manufacturer's own plant or in one of Sprague's interference laboratories. Sprague will also direct compatibility tests on end equipment or complete weapons systems, and recommend solutions to any integration problems which might develop.

Sprague Interference Control Laboratories are located on the Pacific Coast, in the Mid-West, and on the East Coast. These laboratories are staffed by top interference and susceptibility control specialists, and are equipped with the most advanced instrumentation and model shop facilities.

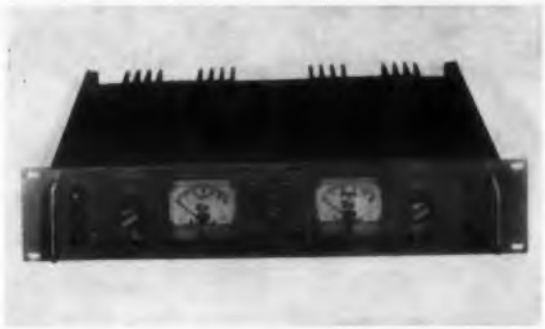
For further information, write to Interference Control Field Service Manager, Sprague Electric Co. at 12870 Panama Street, Los Angeles 66, California; 224 Leo Street, Dayton 4, Ohio; or 347 Marshall Street, North Adams, Massachusetts.

CIRCLE 225 ON READER-SERVICE CARD

NEW PRODUCTS

Power Supply

Permits many biasing arrangements



Power supply model 802A has two identical transistor regulated supplies, each independent and fully adjustable from 0 to 32 v at load currents to 1 amp. The outputs may be isolated from each other and ground to provide a variety of biasing arrangements, or they may be connected in series to provide an output of 64 v at 1 amp. Output variation is not more than 3 mv for 100% load changes and 105 to 125 v ac line changes. The unit has overload protection and occupies 3-1/2 in. of height in a standard 19 in. rack.

Harrison Labs, Inc., Dept. ED, 45 Industrial Rd., Berkeley Heights, N.J.

CIRCLE 226 ON READER-SERVICE CARD

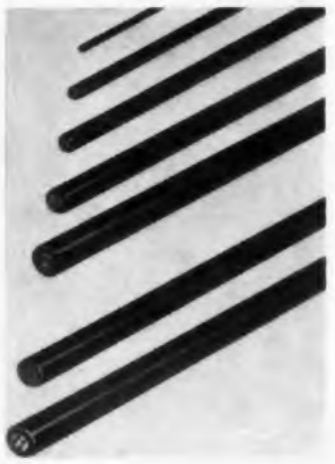
Curve Follower

Traces pencil drawn graph

The Data-Trak curve follower translates a double pencil drawn curve on ordinary graph paper into proportional electrical signals. Any soft or medium graphite pencil may be used, and parts of the curve may be erased and changed. Shown is a three-channel function generator that simultaneously reads three charts mounted on separate revolving drums. Designed for process control and computer programming, the unit is self contained, operates on 60 cps, 115 v current, and mounts in standard relay racks. (More design details on this unit will be covered in a subsequent issue of ED.)

Research, Inc., Dept. ED, 115 N. Buchanan, Hopkins, Minn.

CIRCLE 227 ON READER-SERVICE CARD



NEW PRODUCTS

RF Receptacle

For printed wiring

For connecting coaxial cable to printed wiring, the ConheX type 3007 receptacle has four milled studs, rectangular in cross section, which are dip soldered to the wiring board. The center contact is held rigidly between two insulators allowing no longitudinal or rotational movement. It is soldered to the printed wiring on the face of the board. The 3007 mates with the company's type 3000 straight or type 3005 right-angle plugs or their equivalent.

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

CIRCLE 234 ON READER-SERVICE CARD

Slip Ring and Brush Assembly

Has under 50μv noise level

This assembly has 50 slip rings and 100 ball bearing mounted brushes packaged in a dust sealed housing 1.25 in. long. Noise levels are below 50 μv and breakaway friction level is under 50 g-cm. The brushes are tuned to different resonance frequencies to insure constant electrical continuity in severe vibration conditions. The unit withstands 350 F and meets MIL-5400A.

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

CIRCLE 235 ON READER-SERVICE CARD

Pulse Pattern Generator

Provides 2^{100} possible combinations

Designed to provide simulated time division pulse patterns, test model 110 generates 1 to 100 pulses in any pattern, thus offering 2^{100} possible combinations. It provides a clock pulse every pulse time and a cycle pulse at the beginning of each pulse cycle. Pulse sequence is completely controlled from the front panel. Pulse width bias may be up to ±30%, and pulse rate is continuously variable from 100 to 10,000 pps from an internal oscillator.

La Roe Instruments, Inc., Dept. ED, 1709B E Montgomery Ave., Rockville, Md.

CIRCLE 236 ON READER-SERVICE CARD

RC Comparator Bridge

For in-circuit checking

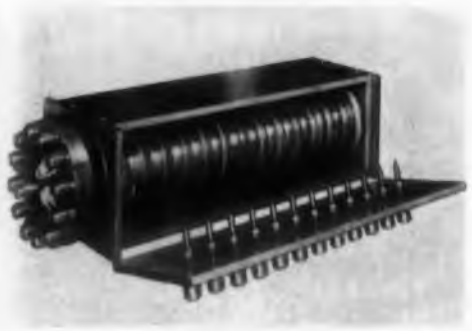
Model 801 RC comparator bridge measures capacitors for actual value, leakage, and power factor and checks them in their original circuit for opens, shorts, or intermittents. It has four capacitance ranges from 10 μμf to 5000 μf and four resistance ranges from 0.5 ohm to 500 meg. The unit checks the ratio between any two capacitors, inductors, resistors, or transformer windings with ratios of 20 to 1 or less. It also checks power factor from 0 to 60% on capacitors of 0.1 to 5000 μf and leakage in all types of capacitors rated between 0 and 500 v dc.

Electronic Measurements Corp., Dept. ED, 625 Broadway, New York 12, N.Y.

CIRCLE 237 ON READER-SERVICE CARD

Slip Ring Assembly

High voltage



This slip ring assembly consists of 12 slip rings and brushes designed to carry 50 ma at 21 kv, ring to ring and ring to ground. The rings and terminals are proportioned to prevent corona, and the terminals serve as controlled air gaps which break down at 28 kv, protecting insulation surfaces from flashover. The unit has rhodium plated rings and chrome plated terminals that accept banana plugs, clip leads, wire ends, wire loops, and spade lugs. Dimensions are 8 x 8 x 10 in.

Genisco, Inc., Dept. ED, 2233 Federal Ave., Los Angeles 64, Calif.

CIRCLE 238 ON READER-SERVICE CARD

Indicator Thyratron

Dual control

Type WC-20 is a miniature, coincidence-control thyratron that provides a bright neon glow which may be viewed from any angle. Two coincident 4.5 v signals and a negligible control current produce the indicating glow. The tube is designed for computers, data processors, signal systems, and keyboard equipment. It has a maximum diameter of 0.31 in. and a maximum length of 1.1 in. without the leads. Filament voltage is 2.5 v ac and filament current 300 ma.

Wiltec Electronics, Inc., Dept. ED, 53 Water St., South Norwalk, Conn.

CIRCLE 239 ON READER-SERVICE CARD

4000 V Power Supply

For microwave tubes

The Microline 62A1 is a 4000 v supply designed to power and modulate any klystron used to test radars and other microwave equipment. It can also operate low power magnetrons and traveling wave tubes. The unit supplies electrode voltages from ±150 to −4000 v and automatically regulates output voltages to less than 1 part in 10,000. Switching of the beam voltmeter is also automatic. The 62A1 supplies square wave, sawtooth, and sine wave voltages for generating pulse, frequency or phase modulation information in the outputs of microwave tubes. It operates on 800 w of 60 cps, 110 v current and contains an amplifier which can boost modulation voltages from external sources.

Sperry Microwave Electronics Co., Div. of Sperry Rand Corp., Dept. ED, Clearwater, Fla.

CIRCLE 240 ON READER-SERVICE CARD

Microwave Diodes

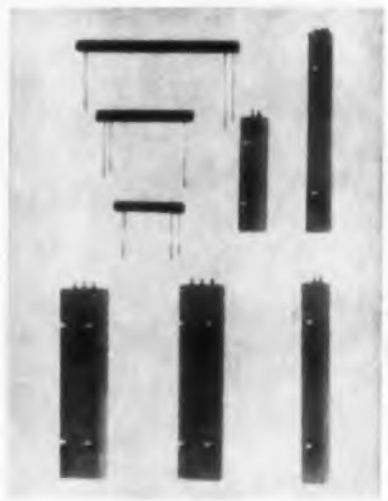
Have 0.3 in. maximum length

For microwave equipment used in radar, communications, missiles, and satellites, Micro-Min diodes are point contact units hermetically sealed in a glass envelope. They have a maximum length of 0.3 in. and a maximum diameter of 0.105 in. Available types include detector diodes in frequencies from 0.1 to 9 kmc and mixer diodes in frequencies from 3 to 9 kmc.

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

CIRCLE 241 ON READER-SERVICE CARD

NEW PRODUCTS



Distributed Constant Delay Lines

Have 0.6 μsec delay per winding inch

Series 25J distributed constant delay lines have a delay period of 0.6 μsec per inch of winding. They are available in various standard cases including hermetically sealed metal cans and epoxy encapsulated sticks for pigtail mounting. Maximum delay per 6 in. of winding stick is 3 μsec. Several windings having the same or different delay time may be cascaded in the standard metal cans. Available impedances include 3900, 5600, or 7500 ohms with respective rise times of 0.33, 0.48, and 0.53 μsec per 3 μsec delay.

Technitrol Engineering Co., Dept. ED, 1952 E. Allegheny Ave., Philadelphia 34, Pa.

CIRCLE 244 ON READER-SERVICE CARD

Multiplier Phototubes

3/4 in. in diameter

Type 6362 and 6935 multiplier phototubes are 3/4 in. in diameter and have ten dynode stages. Suited for aircraft and space vehicles, scintillation probes, and spectroscopes, they feature potted bases for moisture and shock resistance, socket elimination, and noise-free connections. The 6362 has silver magnesium dynodes and provides maximum stability at high voltages, and the 6935 has cesium antimony dynodes and provides high gain at low operating voltages.

Allen B. Du Mont Labs, Inc., Electronic Tube Div., Dept. ED, 750 Bloomfield Ave., Clifton, N.J.

CIRCLE 245 ON READER-SERVICE CARD

POT HEADACHES

One day, we compiled a list of problems which confront the people who buy, use or work with potentiometers. The list included such common headaches as pot "burn-out" in the field... down time on equipment... waits of up to 90 days for replacements... maintenance of a large inventory of spares of which only 8% might be used. We decided then and there to develop a cure for these "pot headaches" and that's how our Modification Kit MLK-1 was born.

The Kit, which consists of 100 tap assemblies, 25 silver buss bar rings and 24 other components, provides a speedy and economical means of modifying or replacing potentiometers in the field. Taps and/or buss bars can be installed, on-the-spot, by field maintenance personnel, with a resultant saving of weeks, or even months of precious time. It's a great money-saver too, for with its taps and tooling, just a minimum stock of basic units (i.e. without taps or buss bars) can be modified to replace any finished pot of like design.

We will be pleased to send you literature and a reprint of a feature story on the MLK-1 Kit, which appeared in ELECTRONICS MAGAZINE.

MICRO-LECTRIC DIVISION OF MICRO MACHINE WORKS

19 DEBEVOISE AVENUE
ROOSEVELT, L. I., N.Y.
FReeport 8-3222

CIRCLE 47 ON READER-SERVICE CARD

Control Transformer

Size 8

Control transformer model CTC-8-A-6 is a size 8, 400 cps synchro with the following impedances: $Z_{ro} = 2625$, 72.2 deg; $Z_{so} = 465$, 75 deg; $Z_{rs} = 970$, 17 deg. Maximum error is 7 min of arc, voltage input is 11.8 v, and power input may be 0.058 w.

Clifton Precision Products Co., Inc., Dept. ED, 9014 W. Chester Pike, Upper Darby, Pa.

CIRCLE 248 ON READER-SERVICE CARD

Subminiature Switch

Has roller-plunger actuator

Type ISR-I subminiature, snap-acting switch is designed for cam operation. The plunger mechanism is integral with the mounting bracket, in which a USM5 subminiature switch is secured. The unit is rated at 2.5 amp, 30 v dc, inductive; 5 amp, 30 v dc resistive; 5 amp, 125/250 v ac and has a spdt action.

The W. L. Maxson Corp., Unimax Switch Div., Dept. ED, Ives Road, Wallingford, Conn.

CIRCLE 249 ON READER-SERVICE CARD

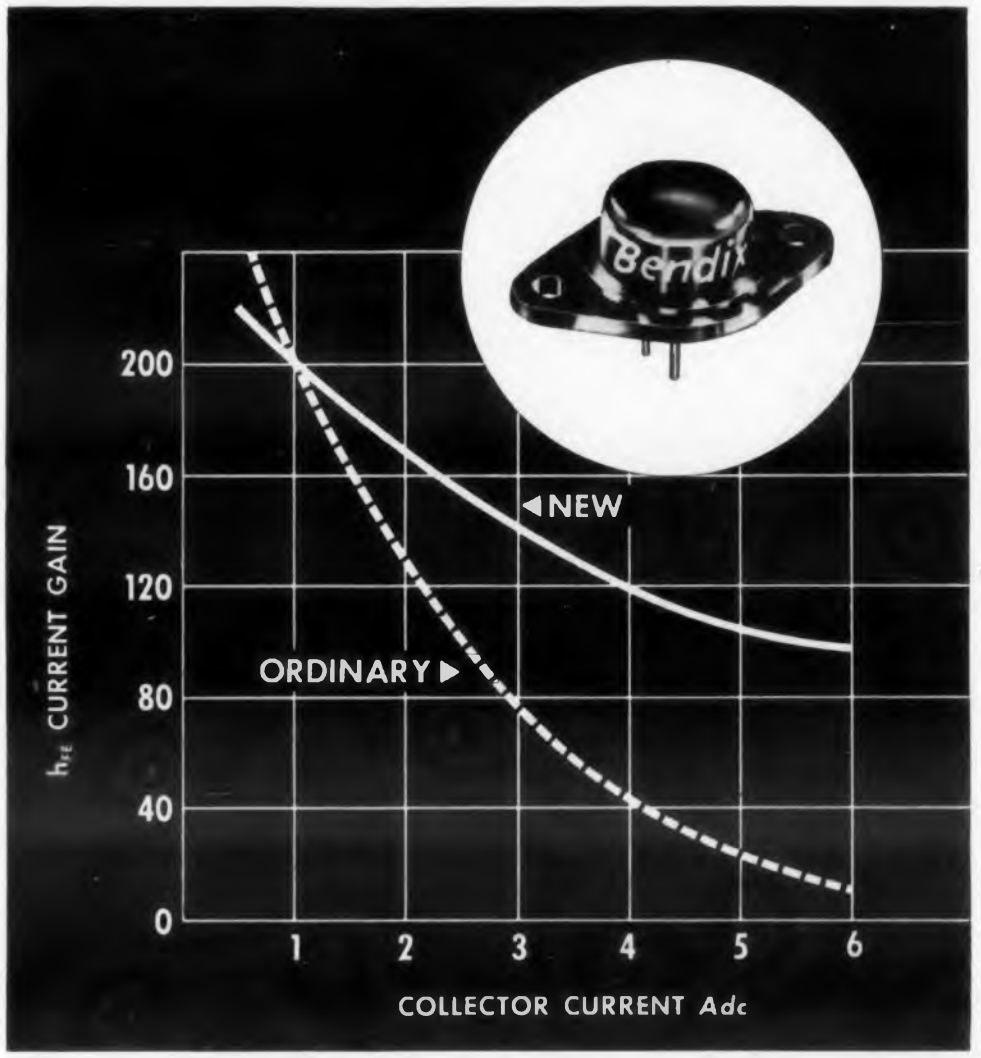
FHP Motor

Highly efficient

Designed for use in ventilators, recorders, business machines, and many other types of equipment, the Unitized motor is presently available in 4-pole, KSM 59-frame, shaded pole and permanent split capacitor ratings through 1/15 hp. The unit is up to 40% more efficient than conventional motors of the same type. A resin developed for strong holding power unitizes its parts and maintains critical dimensions. The unit can be mounted in any position and accommodates a variety of mounting arrangements.

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

CIRCLE 252 ON READER-SERVICE CARD



Solid line indicates the low beta fall-off of one of the new Bendix transistors as compared to that of an ordinary transistor.

NEW BENDIX HIGH GAIN INDUSTRIAL POWER TRANSISTORS OFFER FLATTEST BETA CURVE

Now available—a new series of power transistors with the flattest beta curve in the industry, made possible by an exclusive Bendix process. This new series has very high current gains—up to 200 at 3 Adc—and a 10 ampere peak current rating.

Featuring ten-amp performance at a five-amp price, the 2N1136,A,B; 2N1137,A,B; and 2N1138,A,B series provide:

LOW BETA FALL-OFF ——→ LESS DRIVE AND LESS DISTORTION
LOW SATURATION RESISTANCE ——→ GREATER CIRCUIT EFFICIENCY
VOLTAGE BREAKDOWN RATINGS ——→ ELIMINATION OF BURN-OUT
CURRENT GAIN MATCHING ——→ OPTIMUM CIRCUIT PERFORMANCE

Ideally suited for use in static convertors and regulators, these powerful transistors also have numerous applications in relay replacements and drivers for relays, magnetic clutches, solenoids and other loads requiring high current. In addition, their extremely high current gain and excellent hFE linearity make them the most practical and efficient television vertical output amplifiers.

For complete information, contact SEMICONDUCTOR PRODUCTS, BENDIX AVIATION CORPORATION, LONG BRANCH, NEW JERSEY.

West Coast Sales Office: 117 E. Providencia Avenue, Burbank, California
Midwest Sales Office: 4104 N. Harlem Avenue, Chicago 34, Illinois
New England Sales Office: 4 Lloyd Road, Tewksbury, Massachusetts
Export Sales Office: Bendix International Division, 205 E. 42nd Street, New York 17, New York
Canadian Affiliate: Computing Devices of Canada, Ltd., P. O. Box 508, Ottawa 4, Ontario, Canada.

Red Bank Division — Bendix AVIATION CORPORATION

CIRCLE 253 ON READER-SERVICE CARD

NEW PRODUCTS

Temperature Test Chamber

—100 to +500 F range

Temperature test chamber model 6545R has a —100 to +500 F range and a 10 x 7 x 7 in. test volume. It is 10-1/2 in. high and fits a standard 19 in. rack. A direct reading thermostat automatically controls temperature within ±2 F, and a solenoid operated valve injects liquid CO_2 for rapid attainment of low temperatures. The unit incorporates a heating element and a centrifugal blower and operates on 117 v ac.

Delta Design Engineers, Inc., Dept. ED, 7460 Girard Ave., La Jolla, Calif.

CIRCLE 255 ON READER-SERVICE CARD

Stationary Coil Clutches

Miniature

Miniature model SAC-100 and SAC-130 stationary coil clutches have minimum static torques of 15 and 55 in.-oz and consume 2 and 3-1/2 w, respectively. The electromagnetic units are completely self-contained without slip rings or brushes and can be supplied for various types of mountings. They feature zero backlash when energized and zero residual drag. Voltage ratings are from 6 to 100 v dc; current ratings, 28 to 500 ma; and resistances, 12 to 3500 ohms.

Dial Products Co., Dept. Ed, P.O. Box 456, Bayonne, N.J.

CIRCLE 256 ON READER-SERVICE CARD

Cable Retracting Device

Prevents chassis entanglements

The CR-100 cable retractor eliminates cable entanglement with tubes and components in a lower chassis when an upper one is withdrawn for service and returned to position. It maintains a constant tension and oorrect suspension of cable at all times, permitting adequate cable length for full extension and tilting of chassis without the hazard of snagging.

Western Devices, Inc., Dept. ED, 600 W. Florence Ave., Inglewood 1, Calif.

CIRCLE 257 ON READER-SERVICE CARD

Servo Amplifier

1 cu in.

Transistorized servo amplifier model 412 will drive 3.5 w, 40 v, center-tapped size 10 and 11 servomotors from low-level ac signals. Gain is 2500 ±5% with 10 v output. The 1 cu in. unit is completely self-contained and requires 28 v dc excitation. Its ambient range is —55 to +100 C.

ACF Industries, Inc., Avion Div., Dept. ED, 11 Park Place, Paramus, N.J.

CIRCLE 260 ON READER-SERVICE CARD

Portable Meter

Measures E.I.R.

This battery powered portable meter, model 110A, with transistorized circuitry, is designed to measure dc voltages, current, and resistance. It measures voltages of 1 mv to 1000 v full scale in 13 ranges; input resistance is 101 meg. 18 current ranges provide measurement of full scale values from 1 mμa to 300 ma; voltage drop for all ranges is 100 mv. Direct-reading resistance scales show resistances, from 10 ohms to 100 meg, center scale. Accuracy of indication is ±2% of full scale for voltage and current measurements, and ±4% mid-scale for resistance. Design features include a transistorized meter circuit, high overload capability, 1000 hour battery life, and the use of printed circuit techniques.

Belleville-Hexem Corp. Dept. ED, 638 University Ave., Los Gatos, Calif.

CIRCLE 261 ON READER-SERVICE CARD

Power Transistors

Germanium

Audio power transistors 2N350A, 2N351A, and 2N376A are germanium, pnp, alloy junction types for general industrial use. They are controlled for high power gain and low distortion at output levels to 4 w Class A and 15 w Class B. Power switching characteristics are controlled up to 3, 4, and 5 amp, respectively.

Motorola, Inc., Semiconductor Products Div., Dept. ED, 5005 E. McDowell Rd., Phoenix, Ariz.

CIRCLE 262 ON READER-SERVICE CARD

NEW PRODUCTS

Static Switch

Handles up to 16 amp

Measuring 2 x 1.25 x 1 in., this silicon semiconductor switch will close 400 v circuits with steady currents to 16 amp and surge currents as high as 150 amp. Weighing 3.5 oz, the unit will stand high shock and vibration and has a 3 μsec switching time. The unit has an isolated signal and load circuit and operates in temperatures up to 125 C.

Jordan Electronics, Dept. ED, 3025 West Mission Rd., Alhambra, Calif.

CIRCLE 265 ON READER-SERVICE CARD

Vacuum Tube Electrometers

Measure low currents

Suitable for rack, panel, or console mounting, these vacuum tube electrometers are designed for measuring low currents. Models VTE-0 and VTE-1 cover a current range from 10^{-3} to 10^{-11} amp, while model VTE-2 covers 10^{-3} through 2×10^{-13} amp. The latter two instruments include a bucking current supply for observing minute fluctuations in the current source.

The Victoreen Instrument Co., Dept. ED, 5806 Hough Ave., Cleveland 3, Ohio.

CIRCLE 266 ON READER-SERVICE CARD

Coaxial Variable Attenuator

Wideband

Coaxial variable attenuator model AU 10 is designed to operate from 300 to 5000 mc with less than 0.5 db insertion loss at zero setting. Maximum attenuation values are above 40 db over most of this band, and vswr is less than 1.35. The unit is designed to permit calibration and is resettable to 0.1 db. It will dissipate up to 10 w of rf power.

Merrimac Research and Development, Inc., Dept. ED, 137-28 Northern Blvd., Flushing 54, N.Y.

CIRCLE 267 ON READER-SERVICE CARD

Silicon Solar Cell Battery Modules

Provide 1.5 v dc at 65 C

Designed to power transistorized equipment, type SM5-1020B silicon solar cell battery modules provide an output of 1.75 v dc at 30 C cell temperature and 1.5 v dc at 65 C. Each module directly replaces a 1.5 dry cell battery and will supply a load current of about 35 ma in direct sunlight. In applications requiring continuous day and night operation, the solar units can be combined with storage cells to provide continuous power without the need for replacement. The modules contain five series-connected 1 x 2 cm cells embedded in an epoxy mold. They may be assembled in series or in parallel.

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

CIRCLE 270 ON READER-SERVICE CARD

Log Count Rate Meter

Has 1% linearity

For use with scintillation dectors, G.M. counters, BF_3 counters, and reactor instrumentation, the rack mounted model N-701C log count rate meter counts pulses resulting from nuclear disintegrations. It has a limit switch that can activate an alarm system. Ranges are 1 cps to 1 kc, 10 cps to 10 kc, 100 cps to 100 kc, and 1 cps to 100 kc; and optional input sensitivities are —50 to +100 v, —0.25 v to +1 mv, or —5 v to +1 mv. The unit has a 0 to 10 mv output for recorder, 1% linearity, and 1% per day stability.

Hamner Electronics Co., Inc., Dept. ED, Princeton, N.J.

CIRCLE 271 ON READER-SERVICE CARD

NEW PRODUCTS

Photorelay

Weatherproof and shock resistant

Mounted in a Crouse-Hinds FD-1 Condulet box with a 1/2 in. threaded fitting, the model R-CH photorelay withstands the effects of dust, moisture, shock, vibration, and other adverse conditions. Using a solid state photocell it automatically triggers on-off and go no-go circuits at predetermined light levels. It is sensitive to 10 ft-c and operates on 60 cps, 115 v ac. Power consumption is 2.5 w, and the spst contacts are rated at 5 amp, 115 v ac. The unit measures 3 x 3-1/2 x 4-1/2 in. and weighs 4 lb.

Berkeley/Dynamics, Dept. ED, 2831 Seventh St., Berkeley, Calif.

CIRCLE 274 ON READER-SERVICE CARD

Portable EIR Meter

Has 39 ranges

Model MV-77A portable multimeter has 13 voltage ranges from 0 to 1 mv to 0 to 1 kv; 13 current ranges from 0 to 1 μa to 0 to 1 amp; and 13 resistance ranges from 0 to 1 ohm to 0 to 1 meg. Accuracy is 3% on the current ranges, 1% on the others. The unit is 12 x 8 x 9 in.

Millivac Instruments, Div. of Cohu Electronics, Inc., Dept. ED, P.O. Box 997, Schenectady, N.Y.

CIRCLE 275 ON READER-SERVICE CARD

Low Capacitance Standard

Accurate to 0.01%

Constructed to value of 10μμf, this capacitance bridge provides an absolute standard which eliminates substitution methods of measurement. It is accurate to 0.01%. Ratio transformers can provide multiplying factors without loss of accuracy so that a standard impedance of any value can be effectively produced from the single standard.

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

CIRCLE 276 ON READER-SERVICE CARD

Epoxy Glass Laminates

For printed circuit use

Available both copper clad and nonclad, Insurok T-525 and T-525N epoxy glass laminates meet MIL-P-18177B and NEMA G10 specifications. Type T-525 copper clad is for normal printed circuit applications, while T-525N copper clad will withstand cyanide solutions for gold plating. Standard sheet size is 36 x 42 in. and standard thicknesses are 1/32 to 1 in. for unclad, and 1/32 to 1/4 in. for copper clad sheets.

The Richardson Co., Dept. ED, 2700 Lake St., Melrose Park, Ill.

CIRCLE 278 ON READER-SERVICE CARD

Subcarrier Oscillators

For all standard IRIG bands

Series FO 4 solid state subcarrier oscillators are available for operation on all standard IRIG radio telemetry bands from 1 through 18 and may be obtained in various packaged system forms with silicon power supplies, signal calibration and conditioning equipment, and other telemetry apparatus. They may be used for the measurement of positive and negative dc and ac voltages. Dimensions are 2-1/16 x 2-5/16 x 9/32 or 2-1/16 x 1-3/4 x 9/32 in.

General Devices, Inc., Dept. ED, P.O. Box 253, Princeton, N.J.

CIRCLE 279 ON READER-SERVICE CARD

Silicon Rectifiers

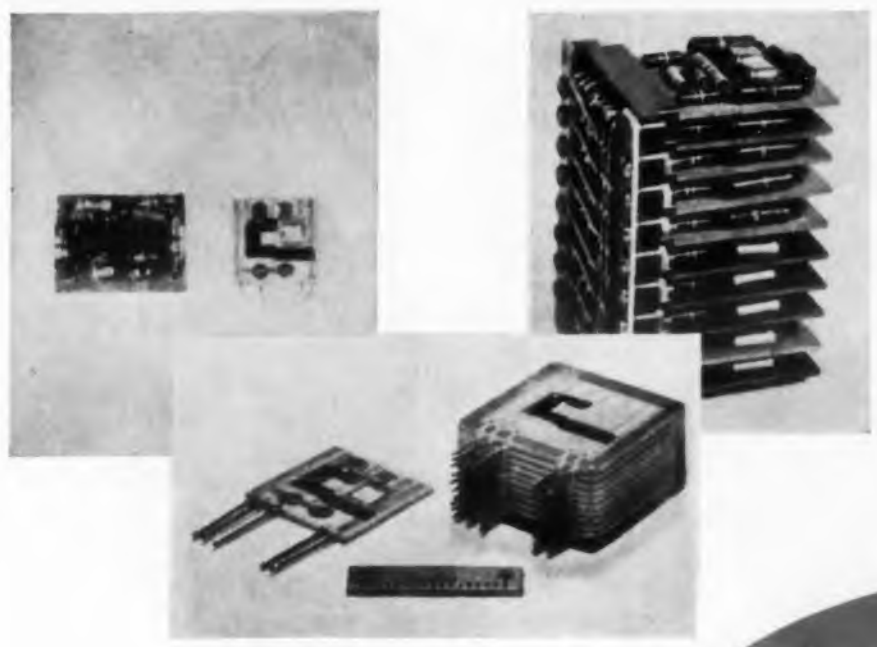
Magnetic amplifier and high voltage types

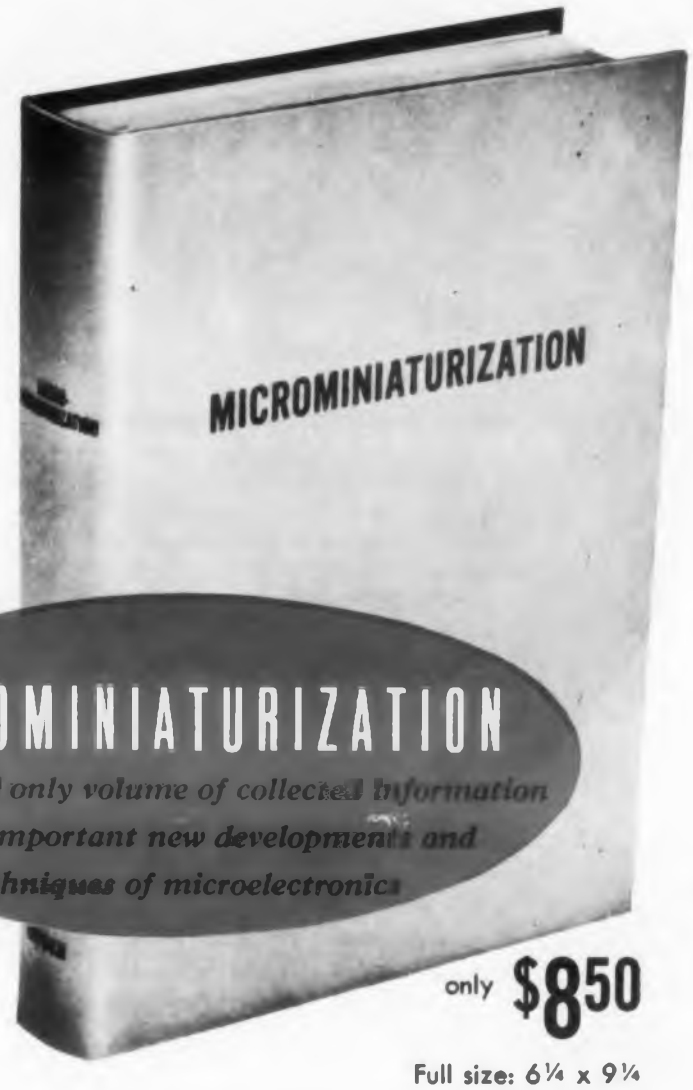
These top hat silicon rectifiers are hermetically sealed with axial leads. JEDEC series 1N440B through 1N444B and 1N599A through 1N606A are magnetic amplifier types with low leakage and low forward drop. JEDEC 1N223 through 1N226 and 1N1095, 1N547, 1N1096, and 1N561 are high voltage types for power supplies, blocking applications, and clipping circuits.

Columbus Electronics Corp., Dept ED, 1010 Saw Mill River Rd., Yonkers, N.Y.

CIRCLE 280 ON READER-SERVICE CARD

Special Pre-Publication Offer





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HAYDEN BOOK COMPANY, INC. 830 Third Avenue, New York 22, N.Y. PLaza 1-5530

NEW PRODUCTS

I-F Amplifier Stages

Provide gains to 20 db

Model IF-1 through IF-5 miniature Amplitran i-f amplifier stages are packaged in metal cases 1-1/2 in. high and 13/16 in. in diameter and provide gains from 10 to 20 db. Center frequencies range from 455 kc to 30 mc, and bandwidths are 10 to 500 kc. The transistorized units plug into 7-pin tube sockets and may be cascaded to obtain a desired gain. They have a negative feedback circuitry that permits them to be encased without danger of oscillation or instability.

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

CIRCLE 283 ON READER-SERVICE CARD

Strain Gages

For use with magnesium

For use on magnesium parts series C15-101 and C15-100 strain gages provide a low coefficient of resistance, or apparent strain, when mounted on material with a thermal expansion coefficient of 15 ppm per deg F. The first are epoxy-black types for temperatures from subzero to +200 F; the second are strippable types for use to +500 F.

Tatnall Measuring Systems Co., Dept. ED, Box 245, Phoenixville, Pa.

CIRCLE 284 ON READER-SERVICE CARD

Glass Cloth

Teflon impregnated

For corrosive applications and for use as flexible electrical insulation in radar windows, printed circuits, and tape cable, Dilecto GB-108TED is a laminated plastic made from glass cloth impregnated with Teflon resin. It can be used continuously at 500 F.

Continental-Diamond Fibre Corp., Dept. ED, Newark, Del.

CIRCLE 285 ON READER-SERVICE CARD

Analog Computer

Has 120 amplifiers

The model 120 analog computer has 120 amplifiers, 48 of which are interchangeably summers or integrators. It also has 16 servomultipliers, each with five 10-turn potentiometers and a slip clutch which disengages the motor from the potentiometers when the input reaches ±100 v. The 240 linear scale-factor potentiometers on sliding racks facilitate storage of problems for multishift operation. Amplifier drift is 25 μv, grid current is less than 30 μμa, and noise is 0.25 mv. The unit has an automatic time-scale change.

Dian Labs, Inc., Dept. ED, 611 Broadway, New York 12, N.Y.

CIRCLE 287 ON READER-SERVICE CARD

Sine Wave Oscillator

Holds voltage amplitude from —55 to +105 C

This transistorized sine wave oscillator has a high voltage stability from —55 to +105 C. Its voltage output is 3 v, its power output is 30 mw, its power input is 2.5 w, and its output impedance is less than 30 ohms at an output level of 3 v rms. Frequencies can be set from 20 cps to 50 kc. Harmonic distortion is under 1%; frequency stability, ±0.25%; and variation in output voltage amplitude, under 0.2% for ±10% variation in input voltage. The unit is potted in a MIL-T-27 size FA can and weighs 12 oz.

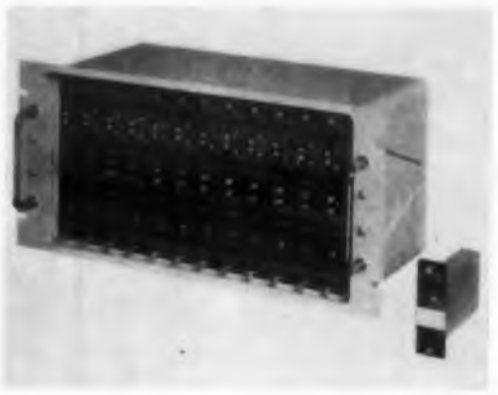
General Controls Co., Dept. ED, 801 Allen Ave., Glendale 1, Calif.

CIRCLE 288 ON READER-SERVICE CARD

NEW PRODUCTS

Modular Normalizing Network System

Accepts variety of transducer signals



This modular normalizing network system accepts a wide variety of transducer signals. Each of the eight different types of plug-in networks contains circuitry applicable to a particular transducer type and provides means for a normalized output acceptable by a wide variety of multiplexing and encoding systems. Each plug-in contains means for setting transducer excitation; balancing or completion of a bridge; attenuation of transducer output; automatic calibration; and a low pass filter. The system enclosure holds up to 24 modules and can be supplied for airborne or rack and panel mounting.

Kauke and Co., Dept. ED, 1632 Euclid St., Santa Monica, Calif.

CIRCLE 290 ON READER-SERVICE CARD

Tantalum Wire Capacitors

0.01 to 8 μf

In case size H, these capacitors have dimensions of .075 in. in diameter by .255 in. in length. Their capacitance range is 0.01 to 8 μf. All units are insulated with Mylar plastic, have axial leads, and are a part of the TW series. Polar type units, they have an effective operation at temperature extremes of −55 to +85 C.

Ohmite Mfg. Co., Dept. ED, 3672 Howard St., Skokie, Ill.

CIRCLE 291 ON READER-SERVICE CARD

Sweep Generator

Wide band

Model 900-A sweep generator supplies a sweep signal in vhf and uhf ranges with center at any frequency from 500 kc to 1000 mc and sweep widths from 100 kc to 400 mc. The rf output is flat within ±0.5 db up to 800 mc.

Jerrold Electronics Corp., Dept. ED, 15th and Lehigh Ave., Philadelphia 32, Pa.

CIRCLE 292 ON READER-SERVICE CARD

NEW PRODUCTS

Crystal Filters

37 mc range

Series 354 crystal filters are designed to be directly paralleled with no isolation padding networks. System selectivity is achieved at the rf frequency, eliminating false triggering due to undesired adjacent signals. The units have center frequencies of 38.864, 36.9, and 37.04 mc, ±500 cps. Attenuation is 6 kc minimum at 6 db and 20 kc maximum at 60 db. Passband response variation is ±0.5 db; input and output impedance, both 50 ohms; midband insertion loss, 3 db maximum. Center frequency variations are ±2 kc and temperature range is —40 to +85 C. The units measure 3-9/16 x 3/4 x 1-1/2 in.

Hycon Eastern, Inc., Dept. ED, 75 Cambridge Parkway, Cambridge 42, Mass.

CIRCLE 300 ON READER-SERVICE CARD

Miniature Rotary Switch

Has 1 in. diameter

This miniature concentric shaft rotary tap switch, fully enclosed, is only 1 in. in diameter. Each shaft controls from one to three decks, with two to 10 shorting or non-shorting positions per deck. It is available as standard in over 6500 various combinations of decks and positions. Contacts are rated to break 1 amp 115 v ac, or to carry 5 amp.

Grayhill, Inc., Dept. ED, 561 Hillgrove Ave., La Grange, Ill.

CIRCLE 301 ON READER-SERVICE CARD

Synthetic Felt

Withstands 400 F

For use as sound insulating material, as a lifetime seal for delicate instruments, or as a packing material, Troyfelt is a strong, nonwoven synthetic felt that can withstand 400 F continuously. It is resistant to abrasion, moisture, and most acid and alkalis.

Troy Blanket Mills, Dept. ED, 200 Madison Ave., New York, N.Y.

CIRCLE 302 ON READER-SERVICE CARD

AC Voltmeter

Accurate to 1%

The model SZV-125 suppressed zero ac voltmeter provides expanded scale reading accuracy without sacrificing scale space for compression at the low end. Full scale deflection is accomplished for the 100 to 125 v range, thus providing adequate coverage for the normal range of 115 v ±10%. Reading accuracies of ±0.2 v and meter accuracies of better than 1% are obtainable. The unit has a time constant of less than 0.5 sec and may be used on frequencies from 50 to 450 cps. It measures 2-1/4 x 5-1/4 x 6-3/4 in.

ERA Pacific, Inc., Dept. ED, 1760 Stanford St., Santa Monica, Calif.

CIRCLE 306 ON READER-SERVICE CARD

Tape Reader

For any speed to 1000 characters per sec

Photoelectric tape reader type TR7 is a self-contained, free standing unit suitable for reading 5, 7, or 8 level tape at any speed up to 1000 characters per sec. It rewinds 1200 ft of tape in under 30 sec. The unit operates under computer or manual control and will read character by character at high speed. By means of a double row reading head, each character on the tape is read twice and the readings are compared by a built-in comparator circuit which serves as a checking facility. Dimensions are 27-3/4 x 20 x 52 in.

Ferranti Electric Inc., Electronics Div., Dept. ED, 95 Madison Ave., Hempstead, N.Y.

CIRCLE 307 ON READER-SERVICE CARD

IDEAS FOR DESIGN—*ENTRY BLANK*

To the *Ideas-For-Design* Editor of ELECTRONIC DESIGN —
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Here is my design idea for possible publications in your *Ideas For Design* department. I can expect $10 for this idea if accepted for publication.

(Ideas suitable include: *1.* new circuits or circuit modifications, *2.* new design techniques, *3.* designs for new production methods, *4.* clever use of new materials or new components in design, *5.* design or drafting aids, *6.* new methods of packaging, *7.* design short cuts, or *8.* cost saving tips)

STATEMENT OF THE PROBLEM—

MY SOLUTION. AND WHY— **(Please be explicit. Include sketches or photos that will help the idea across)**

Signed _____
Title _____
Company _____
Address _____

(Place illustrations on separate sheet if necessary)

Fast Character 'Painter' Conventional

BY USING a "painting" technique, the Alphadyne Character Generator can provide readout on any oscilloscope or crt device with *X*-*Y*-*Z* input. Letters, numerals, or symbols can be painted on the face of the crt at any rate from 60 to 5000 per second.

Clear, crisp characters are painted in one continuous motion. A conventional gain control varies the character size.

Manufactured by Skiatron Electronics and

Typical readout on a conventional rectangular cathode ray tube.

This character generator paints characters on most scopes in one continuous motion.

Reads Out on Scopes

Television Corp., 180 Varick St., New York, N. Y., the Alphadyne "writes" characters on an oscilloscope as easily as one might "write" a sine wave

Thus, to display the "7" in the accompanying photograph, the *X* input would receive a sawtooth voltage to paint the horizontal part of the "7." Then both *X* and *Y* inputs would receive signals to complete the slanted part of the character.

An auxiliary stepping generator would be used at the *X* input to display several characters side-by-side. To display characters on separate lines, as well as side-by-side, one could use a stepping generator at both *X* and *Y* scope inputs.

Operation is Simple

The Alphadyne is certainly simple to operate. It requires only a switch closure for each symbol to be displayed. The switch can be a mechanical type, a relay, or a diode gate. One input line to the instrument is energized, either manually or automatically, for each character to be displayed.

Image retention is easy too. A cathode ray tube with even a very short persistence phosphor can "retain" a display indefinitely when the Alphadyne's fast writing rate is used repetitively. Of course, tubes with long persistence phosphors, or memory types tubes can be used also.

The Alphadyne's three output signals, (*X* deflection, *Y* deflection, and beam intensity) can be used to transmit characters to remote display units as far as 150 feet away.

Models of the instrument are available to generate as few as 20 characters or as many as 50. The 50-character model, for example, can generate the complete alphabet, numbers from zero to nine, and fourteen symbols.

For more information on this unusual character generator turn to the Reader-Service Card and circle 103.

Full Wattage From Transistors With New Heat Exchanger

THE FIRST of a new line of heat exchangers has been built in which full wattage can be obtained from power transistors. Designed to operate in the one-to-ten cfm range, the exchanger will permit a 50 w transistor to be run at 50 w's instead of the 15 to 20 w maximum common today. The efficient use of rationed coolant air makes the device effective in airborne applications, where high pressures and small quantities of air are available.

The exchanger, a laminar-flow type called the LF-101, has been built by the Gasket Manufacturing Co. of 319 W. 17th St., Los Angeles. It is intended for use with a large family of transistors produced by Delco.

The LF-102, not yet in production, will be specifically adapted to the oblong transistor configuration commonly used by many manufacturers. All models in the LF-100 series will mate with one another, permitting the mechanical interchange of different transistor types.

Construction, as shown in Fig. 1, is of copper, styrofoam and aluminum. Cooling air passes over 15 copper fins with gentle turbulent mixing. Styrofoam filler guides air over the fin surfaces only.

When installed, the duct is sealed; maintenance and replacement of the transistor are possible without having to go into the duct. Sponge rubber gasketing takes up any mechanical mismatch. Electrical insulation is achieved by deep anodizing of the copper and aluminum. No mica washers need be installed to insulate the transistor from the mounting plate.

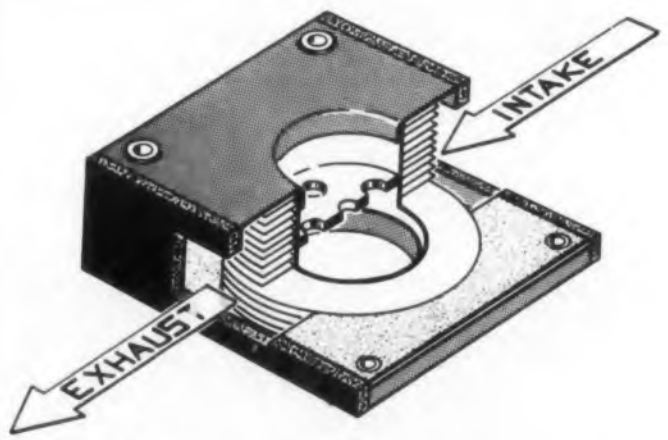

Fig. 1. Cutaway of heat exchanger. Cooling air is ducted by styrofoam filler so it passes over 30 copper surfaces. Flow has gentle turbulence.

Thermal impedance as a function of cfm and pressure drop at one atmosphere pressure is shown in Fig. 2. Not much is gained by using more than 10 cfm of cooling air because the thermal impedance approaches a limiting value.

How It Works

Prototype tests show that with any Delco transistor similar to the 2N277 (95 C junction temperature recommended), the following results are obtained:

- At 30 w (stud temperature of 70 C max. recommended)—Collector-to-emitter voltage is 25 v, 1.2 amp collector current. Input air is 25 C, cfm 3.5, pressure about 0.1 in. H_2O. Exhaust air is 40 C and the stud temperature is 56 C.
- At 40 w (stud temperature of 60 C max. recommended)—Using 25 v at 1.6 a, input air of 25 C, 13.6 cfm (comparable to a gentle breath against the hand) and a pressure of 0.75 in. H_2O, the exhaust air is 30 C, stud temperature 52 C.

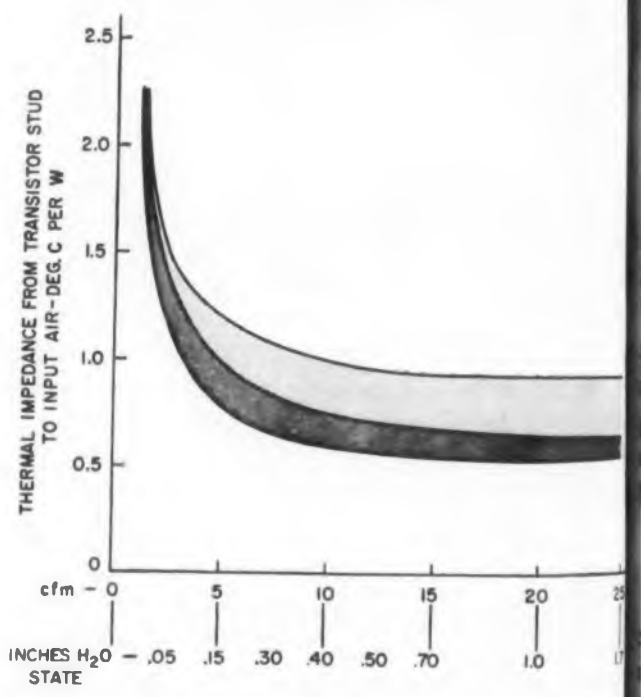

Fig. 2. Thermal impedance characteristics of LF-101 heat exchanger. Top edge of darkly shaded area represents the worst condition —50 w. Curves included in area were plotted for 10 w, 15 w, 20 w, 25 w, 30 w, 40 w and 50 w. Measurements were made at one atmospheric ambient pressure. This spread was made by testing prototype exchangers. To allow for variations in transistors, the lightly shaded area is more representative of average performance.

Fig. 3. Series (top) and parallel (bottom) mounting of exchangers. Calculation of air flow is the same as for current through resistors.

▪ At 20 w (stud temperature of 80 C max. recommended)—This is an easy one, says the designer. With 25 v and 0.8 a, input air 25 C, 1.05 cfm, 0.01 in. H_2O, the exhaust air is 59 C and stud temperature is 69 C.

For a given temperature control problem, it is necessary to know the dissipation rate, desired stud temperature, coolant air temperature and maximum air-pressure drop that can be provided across the heat exchanger. The difference between the desired stud temperature and the coolant temperature, divided by the transistor dissipation rate, gives the maximum allowable thermal impedance. The intersection of this thermal impedance and the available air pressure on Fig. 2 will reveal the existence of excessive or insufficient cooling.

Still-Air Use Explained

If the heat exchanger is used in still air, the thermal impedance in degrees per watt can be computed by using $Z_t = 6.7 - 1.3$ (*Watts*). While the LF-101 will handle 10 w safely in still air, the designer notes, it would be like hitching a race horse to a pushcart. The unit's design emphasizes the forced-air characteristic over still-air performance. The manufacturer could make a less expensive unit for still-air work.

Series and Parallel Mounting

Series mounting of two or more LF-101 exchangers as in Fig. 3 means that the total pressure drop is divided equally between them. The exhaust air from one becomes the coolant air to the next. Although expansion with heat takes place, volume flow rate can be considered identical; only the input temperature differs. Units should be positioned so the transistor having the highest dissipation rate is upstream from the rest. For further information on this full-watts transistor heat exchanger, turn to the Readers Service Card and circle **104**.

ADVERTISERS' INDEX

May 27, 1959

◀ CIRCLE 598 ON READER-SERVICE CARD

CIRCLE 599 ON READER-SERVICE CARD ➤

May 27, 1959

ELECTRONIC DESIGN

HAYDEN PUBLISHING COMPANY, INC.
830 Third Avenue, New York 22, N.Y.