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Microminiaturized Designs Heading for Production

SPURRED primarily by the needs of space technology, microelectronics made rapid strides in 1959. Now, for the most part, basic production techniques are well in the advanced development stage. Designers have been concentrating on delivering practical operating units.

Last spring Radio Corp. of America announced the availability of micromodule assemblies for computer applications (*ED*, April 15, p28). Since then, many of the companies working with RCA and the Signal Corps have developed components especially designed for the Army's micromodule program. Other concerns have developed their own microminiature devices.

While most of this work is concerned with miniature assemblies having standard components, interest in solid circuits has grown. Both Texas Instruments and Westinghouse Electric Corp. have active research projects underway in this area.

Tweezers hold a molectronic light telemetry subsystem that is equivalent to the transistorized unit (center) and the conventionally built equivalent (left). Westinghouse used its dendritic crystal-growth process in developing the solid-circuit subsystem.

Standard Parts Made Smaller

Practical and reproducible microminiature devices made with standard components are close to reality. Allen-Bradley has developed a new carbon-composition resistor only 0.155 inches long and 0.025 inches in diameter. These small units have characteristics similar to Allen-Bradley's standard line. Reliability is reported the same as the company's standard units.

In addition to the resistors, Allen-Bradley has developed a line of ceramic capacitors of the same dimensions as the resistors. Capacity values are as high as 1500 microfarads. A ceramic capacitor 0.18 inches square and 0.03 of an inch thick will be available with capacity values as high as 0.33 of a microfarad. These capacitors, as well as the resistors, are still experimental and available only on that basis at this time.

General Instrument Co. has developed a gold-bonded germanium diode under the Signal Corps-RCA micromodule program. The units, now in production, are available in the complete range of the standard silicon and germanium diode type. They are made in the wafer configuration —0.31 of an inch square.

Pacific Semiconductors, Inc., announced a microdiode only 0.08 of an inch long and 0.035 of an inch in diameter (*ED*, Nov. 11, p74). Its ability to withstand extreme shock—20,000 g—and its small size make it suitable for microminiature applications.

Aerovox just announced several new component developments suitable for microminiature circuitry. The company's HP ceramic capacitors are designed specifically for power and transmitting applications. They save up to 70 per cent of the weight of comparable standard units. Space savings may range to 50 per cent.

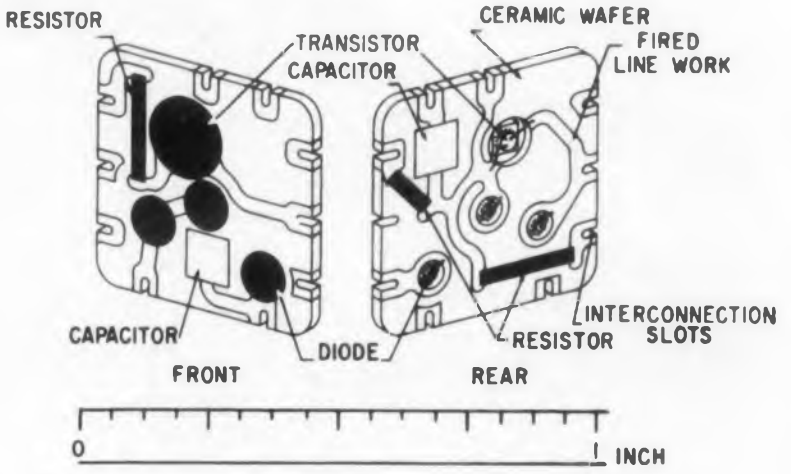
Another development, CEROL, is a new concept in ceramic capacitors. It features extremely high capacities in ranges heretofore unavailable in a ceramic capacitor.

Aerovox has also developed carbon-deposited resistors with an epoxy coating. The coating is applied in the form of 100 per cent solids on automated equipment.

Two Ways to Make Assemblies

Microminiature assemblies take two forms. They can be assembled using standard components, without using deposited film techniques, or they can be made by using all the tricks of the vacuum-deposition and the printed-circuit art.

A binary counter containing 23 standard components, 0.038 of a cubic inch each, was disclosed recently by Walkirt Co. Inside the unit are two Raytheon CK28 transistors, Pacific Semiconductor diodes, Allen-Bradley resistors and Kavamil capacitors. Walkirt says the modules are cheaper than those using deposited-film techniques and more reliable. The company feels that deposited-film techniques are not as reliable as more conventional schemes at present.

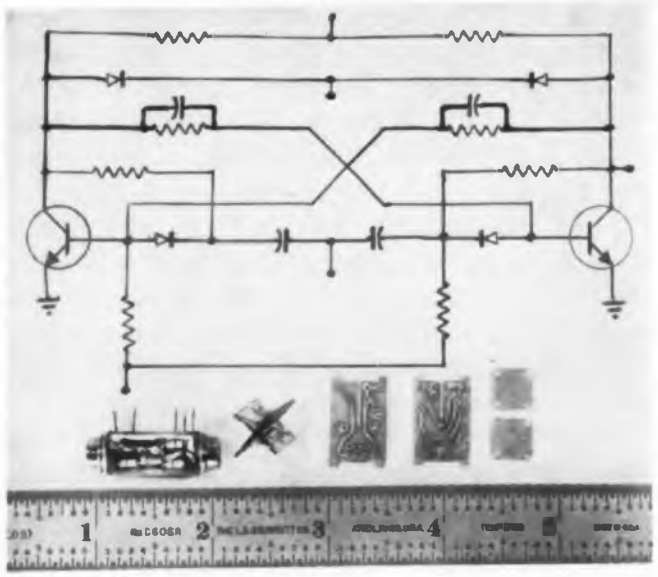


Crossed printed-wiring boards provide the wiring in this subminiature Arthur Ansley Mfg. Co. module. Transistors are mounted on the ends. Sixteen standard components are used in this flip-flop.

Another module in the subminiature class has

NEWS

When completed, these International Resistance Corp. microcircuits will consist of four steps of film deposition on both sides of a glass substrate.



Single flip-flop wafer layout made by Centralab for ARMA's miniature computer.

been disclosed by the Arthur Ansley Mfg. Co. Again, standard components are used in a conventional flip-flop circuit. Two transistors and 16 other components are packaged in a module 0.35 by 0.35 by 1.16 inches. The module occupies 0.14 of a cubic inch. The printed circuits are conventional, with a minimum line width and spacing of 0.02 of an inch.

Extreme compactness is achieved by construction in which two interlocking printed circuits form the diagonals of a square cross-section. Transistors are mounted on end boards that can also be used for circuitry.

Another interesting microminiature device made from standard components is a digital electronic program timer. The entire assembly, being made by Cleveland Metal Specialties Co., is about the size of a cigarette package. It contains 49 transistors and 268 other components. Time can be varied between 0 and 200 seconds.

Many concerns are using their experience in vacuum deposition, thin-film and fine-line etch-

ing techniques in the construction of microminiature circuitry. International Resistance Corp. has announced a microcircuit using deposited thin-film resistors and capacitors. It has made for Arma Corp. some amplifier assemblies in which the wires, resistors and capacitors are evaporated on a glass substrate. Microminiature encapsulated diodes and transistors are integrated into the assembly by dropping them into holes in the wafer and soldering them into place.

International Resistance, experienced in vacuum deposition, has successfully deposited conductors 0.002 of an inch wide. The company can get, with a little difficulty, widths as narrow as 0.001 of an inch. Resistors have been deposited to tolerances of ±5 per cent up to 1000 ohms. Capacitors are manufactured to tolerances of ±10 per cent.

A microminiature amplifier circuit has been supplied to Arma by Centralab. It was made by depositing resistors and integrating capacitors and semiconductors. The circuit is 0.5 of an inch square and 0.03 of an inch thick. Transistors, supplied by Transitron, are inserted into 0.1-of-an-inch-diameter holes. Diodes go into 0.06-of-an-inch-diameter holes.

Using microminiature subassemblies, Arma has designed an airborne computer for space-guidance systems. It is to be intermediate between present computers and an all-solid-state machine. Wafer circuits using Diamond Ordnance Fuze Labs' 2-D concept were adopted for the final design, which used the previously-mentioned Centralab and International Resistance units. The final assembly combined the stacked-wafer assembly method with a welded wiring matrix to provide interconnections. The subassemblies can be easily removed for servicing.

A somewhat related assembly system has been developed by Burroughs Corp. The company's macromodule program involves assembly of a group of two-dimensional circuits of triangular shape. These are stacked and interconnected by back-plane wiring. Thus two-dimensional circuits are stacked to provide a three-dimensional device. Component density is about 290,000 per cubic foot.

Because heat is a problem in an assembly like this, Burroughs engineers inserted a central tube as a heat sink. The flat form of the circuit boards also provides a large surface area for heat removal.

Solid Circuits Moving Ahead

Molecular electronics, the ultimate in microminiaturization, is the complete merger of function and material. Work in this glamorous technology is progressing extremely rapidly. Some experts predict that an all-solid-circuit computer will be in operation in about five years. Present

Molectronic Light Telemetry Subsystem Developed

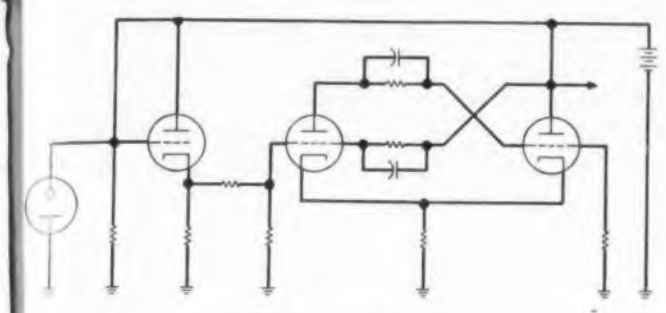
The circuitry shown in the schematic at right was reduced through molectronics to the simplicity shown in the ROOT system drawing. The Westinghouse-developed unit uses incident light to change the oscillation frequency of a multibrator. In the conventional equivalent unit, phototubes and semiconductor photodiodes or phototransistors are used to respond to light with a changing dc level, which is chopped for telemetering. Sixteen components and 18 soldered connections are required to achieve this function. The molecular equivalent, exclusive of power supply and load, consists only of a single semiconductor occupying 0.001 cu in. Only two contacts to the silicon are necessary.

laboratory work indicates that only a small fraction of the phenomena available have been used.

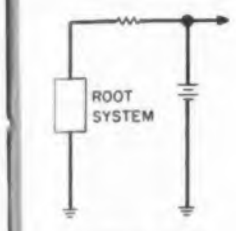
This device, excluding power supply and load, occupies only 0.001 cubic inch and weighs 0.02 gram, compared with 1 cubic inch and 7 grams for its conventional counterpart. Both germanium and silicon have been used as the active element, and other semiconductors can be used. Most of the devices tested to date were constructed of silicon and exhibited a dark frequency of oscillation from about 10 to 100 kc.

Commenting on the molecular light telemetry subsystem, Colonel C. H. Lewis, Director of ARDC's Electronics Directorate, said: "In going to the new concept, the number of component parts in the telemetry subsystem was cut from 14 to 1 and the number of soldered connections was reduced from 15 to 2, thereby offering a tremendous potential to reliability."

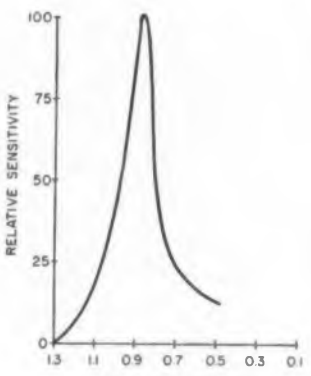
Westinghouse has also examined various representative military electronic systems, including an infrared seeker, a communications subsystem, a ferret reconnaissance receiver, a telemetry encoder and an adaptive flight control system, to evaluate necessary basic functions and determine the functional blocks needed to duplicate these functions. Monolithic blocks corresponding to such conventional circuits as multistage amplifiers, frequency-selective amplifiers, multivibrators and



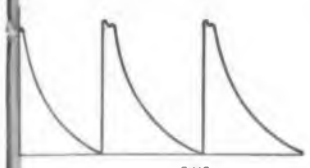
CONVENTIONAL LIGHT TELEMETRY



MOLECULAR LIGHT
TELEMETRY



WAVELENGTH IN MICRONS
SPECTRAL RESPONSE
OF SILICON ROOT SYSTEM
AT CONSTANT VOLTAGE
AND TEMPERATURE



TIME
ROOT SYSTEM WAVEFORM

transducers have been developed. All exhibit the desired inherent reliability, as well as reduced size and weight, reports the company.

Westinghouse is highly optimistic about its dendrite crystal-growth process. "Dendritic germanium has broadened our thinking about the whole technology of solid-state devices of the future," a company spokesman says. "One can envision, for example, the process at work in a machine that continuously, automatically and at high speeds turns out finished transistors directly from an input of raw germanium and the two or three other materials required to put a transistor into final form."

Interconnections Stella Problem

Within the next five years, the main problems will continue to be interconnections; there will be no sudden jump from the use of microelectronic conventional circuitry to solid circuits, some specialists predict. Instead, a gradual increase of solid circuits in conventional equipment will appear, with small, standard solid circuits like flip-flops being included as throwaway parts.

Multifunction solid circuits will have a high rejection rate for the first five years of their manufacture, predicts a representative of Thompson Ramo Wooldridge. The more functions a solid circuit can perform the higher the probability of

rejection in the course of manufacture—and the more expensive it is to reject the circuit because of the failure of any given small section of it. A solution to this problem might be to restrict the total number of functions per solid circuit unit.

But this would defeat one of the purposes of microelectronic solid circuits, because of the now large number of interconnections necessary.

No decrease in interconnections would result from the use of microelectronic unit components instead of solid circuits. This is why the principle problem will be interconnection for a long time to come. With microdiodes (*ED*, Nov. 11, 1959, p74) and microresistors now or shortly available, circuits can be built many times smaller than connectors that put them in the equipment.

One solution to the interconnection problem may be the Planar Method. Here 50 mil holes are etched or punched into a 50 or 100-mil thick printed-circuit board—possibly made of Foto-ceram—and shaped to fit the micropart. At least at first these boards would be hand assembled—the cost of micro components is such that assembly and testing is only about 5% of the total cost; automatic assembly is not a pressing problem.

The microminiature component, having been inserted, would show through both sides of the board. Notches would be cut in the board's edge, and solder made to flow into the notch. A simple sliding pressure contact made of a loop of metal designed to snap into a notch would permit boards to be interconnected in a parallel plane or at right angles.

With the Planar Method, unit assembly of components is preserved, and the components are accessible to repair. Some 100 components per square inch could be put together in this way—1000 per cubic inch if the boards are stacked and plugged into a connection matrix. All connection and components are integral with the board.

Microminiaturization must lead to greater reliability, claims Pacific Semiconductor's manager of R&D Dr. John W. Peterson. "It seems unlikely that microminiaturization will mean much reduction in the total size of equipment," he says, "but more complex circuitry in the same size." This being the case, reliability of each component must be high since with more components the overall reliability of equipment degrades.

Happily, signs point to microminiature components being more reliable than conventional units. PSI's microdiode is claimed to have an-order-of-magnitude-higher reliability than conventional computer diodes, largely due to a new "chemical surface passivation" process, which uses the silicon of the semiconductor itself to build a molecular-

bond film on its surface. No glass bottle is needed and there is little chance of foreign molecule migration to the surface of the silicon, since there is no distinct interface between the semiconductor and the protective film. Other finds of microelectronic components can be processed in this way.

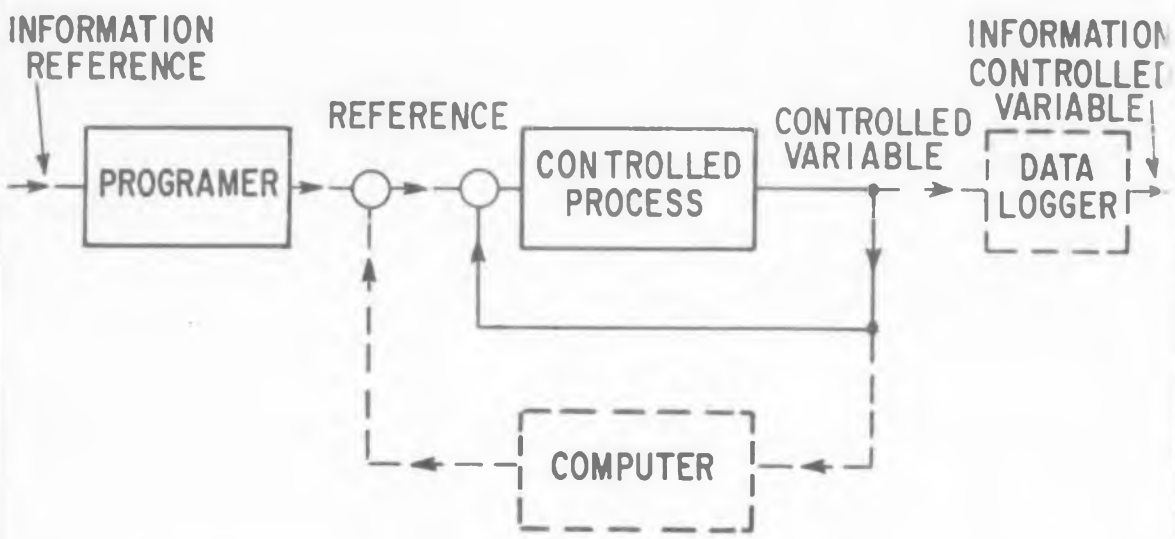
Westinghouse is conducting a heavy molecular electronics research program for the Air Force. To date company engineers have constructed an optical telemetry system and a pulse generator. The telemetry system occupies less than 0.001 of a cubic inch. Basically it is a relaxation oscillator, optically tuned. It can also be used as a free-running multivibrator.

A molecular pulse generator has also been constructed. It is a five-region, semiconductor structure. Applied voltage controls both the repetition rate and the pulse width.

Texas Instruments has used diffusion techniques with a photolithographic process to produce interconnected circuit components. The company has produced circuits of multielectrode transistors to perform complex logical operations. The npnp layer configuration has been used to design a stepping-transistor element. ■ ■

Remote Unit Checks Aircraft

Remote RADFAC system developed by Republic Aviation Corp. speeds checking of electronic gear in the F-105. After a preflight mechanic in the plane's cockpit activates his remote-control unit, the RADFAC locates the aircraft under test, locks onto it and proceeds through a programed series of preflight tests. All aircraft within RADFAC's operational radius can query it and check out their own systems, either one at a time or simultaneously. The system can be adapted to other types of electronic equipment and aircraft, Republic engineers report.



How a conventional control circuit becomes part of a large information conversion system

Information Conversion Now Part of the Control Engineering Art

THE TASK of information conversion has been added to the functions of control engineering. To the control engineer, this means learning much of the language and technique of data processing. These points were made by Harold Chestnut and Walter Mikelson, of General Electric Co., Schenectady, N. Y., in a paper delivered at the National Automatic Control Conference, Dallas, Tex., last month.

"It is possible to divide manufactured products broadly into three primary functional categories that describe the job these products perform," reported Mr. Chestnut. "These categories are energy conversion, information conversion, and materials conversion.

"Information conversion pertains to the generation of signals and information which can be used to control energy conversion or materials processes as well as for the presentation of data or entertainment."

The, authors cite nine basic functions that describe the complete information conversion process. These are sensing, converting, storing, communicating, computing, programing, regulating, actuating and presenting. Definitions of these basic functional tools and examples of their use in control and information handling systems are presented in the Table.

In the adjoining block diagram, the authors show how a conventional feedback control system can become part of a larger automatic system, which may include as supplements, a programer, a computer, and a data logger. Physically, the functions of programing, computing, and data processing may all take place in one or more equipments, the authors report.

As indicated in the figure, the path from information reference to information-controlled variable may form an open-loop automatic control system. Although this outer loop may be closed for some systems, the analysis of such a system is generally much the same.

"It is to comprehensive systems such as these," say the authors, "where product quality, plant efficiency, or maximum yield are the true variables being controlled, that the newer control-system theories and their application may be increasingly

valuable. These new and challenging problems are ones to which control systems engineers can contribute effectively as they have in the past in the simpler feedback control loops."

This National Automatic Control Conference, held in Dallas, Nov. 4-6, was the first PGAC conference held independently of the IRE national conference; 400 attended.

Other papers presented at the meeting described control problems of the space age. A special space session treated the problems of propulsion, attitude and human-environment control. The need for, and results of, using adaptive control systems for automatic flight control was discussed.

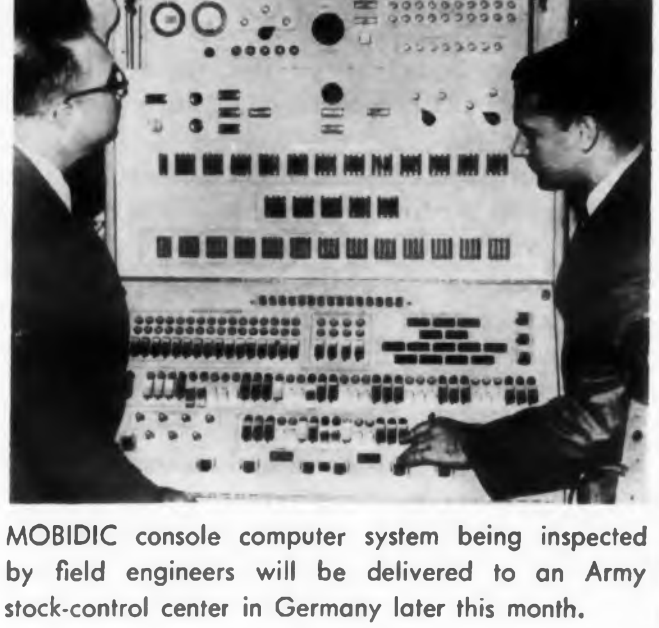
Concurrently with the automatic control conference, five separate sessions were held on control-system components. These sessions reviewed current work in magnetic amplifiers and transformers as well as in hydraulic and electro-mechanical components. Standards for each of these component categories were also considered in panel discussions. ■ ■

Nine Functions that Describe Information Conversion

Function	Definition or Explanation
Sensing	Generates primary data that describes phenomena or things.
Converting	Changes data from one form to another to facilitate its transmission, storage or manipulation.
Storing	Memorizes for short or long periods data, instructions, or programs.
Communicating	Transmits and receives data from one place to another.
Computing	Performs basic and more involved mathematical processes of comparing, adding, subtracting, multiplying, dividing, integrating, etc.
Programing	Schedules and directs an operation in accord with an overall plan.
Regulating	Operates on final control elements of a process to maintain its controlled variable in accord with a reference quantity.
Actuating	Initiates, interrupts, or varies the transmission of power for purposes of controlling "energy conversion" or "materials" conversion processes.
Presenting	Displays data in a form useful for human intelligence.

NEWS

Military Computer Headed for Europe



MOBIDIC console computer system being inspected by field engineers will be delivered to an Army stock-control center in Germany later this month.

Photo-Optical Memory Stores Data In Phone Switching System

An experimental phone switching system that uses a photo-optical memory has been developed by Bell Telephone Laboratories.

The permanent memory of the system stores over 2 million bits of information and can read out a 68-bit word every 2.5 microseconds, reports Bell Labs. Information is stored as clear dots on otherwise opaque photographic areas 2 in. square.

The spots of clear and opaque film are scanned by a crt beam focused by a system of lenses. The beam's movement is controlled by an electronic and optical positioning system, which picks out a particular spot on each area.

Photo-optical switching memory in Bell Labs' "Flying Spot Store," can read out a 68-bit word every 2.5 microseconds.

SIGNIFICANT CONTRACTS . . .

. . . **TO SYLVANIA RESEARCH LABS,** New York, N.Y. $270,000 from Aerojet General Corp., for research and development work on high-temperature materials for solid-fuel rocket engines.

. . . **TO POLARAD ELECTRONICS CORP.,** Long Lsland City, N.Y., $340,000 from Boeing Airplane Co. for a completely automatic signal generator for use in a classified military project.

. . . **TO CORNING ELECTRONIC COMPONENTS,** Bradford, Pa., $61,000 from the Rome Air Development Center and $45,000 from Columbia University for development of ultrasonic delay lines with greater efficiency and versatility.

. . . **TO SIEGLER CORP.,** Anaheim, Calif., $700,000 from Sperry Rand for completely transistorized checkout equipment for the Sergeant missile.

. . . **TO VITRO LABS,** Silver Spring, Md., $140,000 from the Navy for the design and development of a combination mobile deep-water television system and a retrieving device for spent torpedoes. The design calls for an underwater TV camera able to feed images of spent torpedoes to a closed-circuit TV system.

. . . **TO REEVES INSTRUMENT CORP.,** Garden City, L. I., $600,000 from the Diamond Ordnance Fuze Labs for design and development of new-type electronic fuzes for an advanced weapon to be supplied to pentomic troops.

. . . **TO AUTONETICS,** Downey, Calif., $422,000 from the Air Force for design, fabrication and flight testing of the AN/APN-114(XA-1) all-weather, fully automatic landing system to include initial and final approach, touchdown, and runway landing roll. Sinking rates as great as 100 feet per second of airspeeds up to 230 knots will be handled by the system.

. . . **TO CHANCE VOUGHT AIRCRAFT INC.,** Dallas, Texas, from the Air Force, a contract for design and development of a highly-advanced electro-hydraulic actuator system for the Minuteman ICBM.

. . . **TO KEARFOTT CO.,** Little Falls, N.J., from the Army Ballistic Missile Agency, a contract to design, develop and build hydraulic control systems for the Pershing missile. The systems modular construction will consist of three plug-in modules; the motor-pump, the electrohydraulic servo valve-actuator, and the accumulator-reservoir in addition to the positional transducers.

what is the difference between dissipation factor and power factor?

Approximations, to the engineer, are useful and necessary because the solution of an equation can often be made less laborious in its computation by knowing the weight of each factor and its effect in the final answer. Those factors having little weight can be eliminated and the solution is more easily and readily obtainable, although the answer is a "ball-park" figure. Sometimes one forgets the significance of equality and because approximations are made, quantities become equal to each other under *all* conditions with no limits. The set of conditions under which the approximations were made and for which the solution is valid is simply forgotten. Such is the case of Dissipation Factor and Power Factor with respect to capacitors.

By definition, the Power Factor of a capacitor is the ratio of the Equivalent Series Resistance (ESR) to the impedance (Z). In equation form it would be stated as:

$$\text{Power Factor} = \frac{R}{Z} = \frac{R}{\sqrt{X_c^2 + R^2}} \qquad \text{(eq. 1)}$$

Where: R = ESR in ohms

X_c = Capacitive reactance in ohms.

$$[X_c] = \frac{1}{2\pi fC}$$

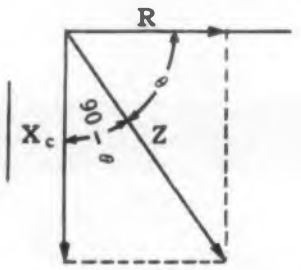
f = frequency in cycles per second

C = capacity in farads

Also, by definition, the Dissipation Factor of a capacitor is the ratio of the ESR to the capactive reactance. In equation form it would be stated as:

$$\text{Dissipation Factor} = \frac{R}{[X_c]} = 2\pi fRC \qquad \text{(eq. 2)}$$

Fig. I



Comparing the two graphically (See Fig. I), several things are apparent.

1. Power Factor $= \frac{R}{Z} =$ Cosine θ; where θ equals the phase angle.
2. Dissipation Factor $= \frac{R}{[X_c]} =$ Tangent $(90 - \theta)$; where $(90 - \theta)$ equals the loss angle.
3. When θ approaches 90° and $90 - \theta$ approaches 0°, Z approaches $[X_c]$, and R approaches 0.

Now after examining the graphic analysis of Dissipation Factor and Power Factor, certain approximations can be made.

1. If when θ becomes very large, approaching 90°, and Z approaches $[X_c]$, then Z can be considered to be equal to $[X_c]$.
2. If this is assumed, then $\frac{R}{Z} \approx \frac{R}{[X_c]}$ and Power Factor $\approx$ Dissipation Factor.

When P. F. and D. F. are almost equal to each other, the cosine of θ and the tangent of $90 - \theta$) are almost equal to each other which can be seen by analyzing Fig. II. You will notice that when θ is large and $(90 - \theta)$ is small, the cosine of θ and the tangent of $(90 - \theta)$ are almost equal, but as θ decreases and the loss angle increases, the values depart from near equality. At this point, large values of dissipation factor differ appreciably from values of power factor — the limit being: tan 90° = ∞ Cos 0° = 1.

Let's consider a practical example of indiscriminate use of Dissipation Factor and Power Factor. Consider a 500 mfd. electrolytic capacitor rated at 25 WVDC that is being used in a filter circuit for 120 cps. The unit was checked for an ESR of 1.325 ohms and its dissipation factor calculated at .5 or 50%. The reactance at 120 cps. is 2.65 ohms. According to equation 2, D. F. $= \frac{1.325}{2.650} = .500 = 50\%$. The phase angle is then approximately 63° and the loss angle is approximately 27°.

If this same ESR were used to calculate Power Factor, equation 1 would yield:

$$\text{P. F.} = \frac{1.325}{\sqrt{(2.65)^2 + (1.325)^2}} = .447 = 44.7\%$$

Also, if ESR were calculated using equation 1 based on a dissipation factor of .5, the ESR would show a value of 1.530, whereas, the actual ESR is 1.325. Not too significant? Perhaps—but there is a difference.

Fig. II

Phase Angle θ	Cosine of Phase Angle θ	Tangent of Loss Angle 90 — θ	Phase Angle θ	Cosine of Phase Angle θ	Tangent of Loss Angle 90 — θ
89.0	.01745	.01745	59.9	.5015	.5797
88.0	.03490	.03492	59.8	.5030	.5820
87.0	.05234	.05241	59.7	.5045	.5844
86.0	.06976	.06993	59.6	.5060	.5867
85.0	.08716	.08749	59.5	.5075	.5890
84.0	.10453	.10510	59.4	.5090	.5914
83.0	.12187	.12278	59.3	.5105	.5938
82.0	.13917	.14054	59.2	.5120	.5961
81.0	.15643	.15838	59.1	.5135	.5985
80.0	.1736	.1763	59.0	.5150	.6009
79.0	.1908	.1944	59.9	.5165	.6032
78.0	.2079	.2126	58.8	.5180	.6056
77.0	.2250	.2309	58.7	.5195	.6080
76.0	.2419	.2493	58.6	.5210	.6104
75.0	.2588	.2679	58.5	.5225	.6128
74.0	.2756	.2867	58.4	.5240	.6152
73.0	.2924	.3057	58.3	.5255	.6176
72.0	.3090	.3249	58.2	.5270	.6200
71.0	.3256	.3443	58.1	.5284	.6224
70.0	.3420	.3640	58.0	5299	.6249
69.0	.3584	.3839	57.9	.5314	.6273
68.0	.3746	.4040	57.8	.5329	.6297
67.0	.3907	.4245	57.7	.5344	.6322
66.0	.4067	.4452	57.6	.5358	.6346
65.0	.4226	.4663	57.5	.5373	.6371
64.0	.4384	.4877	57.4	.5388	.6395
63.0	.4540	.5095	57.3	.5402	.6420
62.0	.4695	.5317	57.2	.5417	.6445
61.0	.4848	.5543	57.1	.5432	.6469
60.0	.5000	.5775	57.4	.5446	.6494

SC—59-9

The unseen enemy

How Summers Gyroscope guards against the invisible anti-missile

Vacuum equipment at each of the 240 individual assembly benches helps insure product reliability.

There is an invisible enemy operating in many plants producing the missile components, flight instruments, gyroscopes and other hyper-sensitive devices on which much of America's power for peace depends. The strength of this unseen foe is potentially as great as that of any anti-missile missile.

Destroyer Of Standards

This reliability destroying, efficiency reducing enemy is dust, lint and other foreign matter. The slightest air borne contaminant coming to rest unseen on sensitive mechanisms during assembly can cause serious, even fatal deviations in performance. Production was often slowed until tests showed the system to be free of dust.

Dust Moved But Not Removed

To combat the dust dilemma at the Summers Gyroscope Co. plant in Santa Monica, California, personnel donned lint free jackets and hats – walked to their work benches in shoe bags. Temperature and humidity were controlled in an attempt to achieve an environment completely free of every possible contaminant ranging from stray hairs to perspiration. However, these precautions proved only partially successful when it was found that a manual dust gathering system in the final assembly "clean room" actually recirculated dust instead of removing it.

Double Duty Production Tool

For a solution to the dust menace, Summers called upon U.S. Hoffman Machinery Corp., pioneers in the use of air as a production tool. Hoffman engineers installed a permanent stationary vacuum cleaning system which provided for necessary cleaning operations at all of the 240 individual work benches in the 12,000 square foot final assembly area. Standard attachments made this same system available for cleaning overhead and under foot, all over the plant.

Before And After

Prior to the installation of the Hoffman stationary system, relative cleanliness tests were conducted. A microscopic analysis of slides revealed lint, dust and other foreign matter in excess of quantities allowable to maintain Summers' high precision standards. A short time after the Hoffman equipment was placed in operation, the same tests showed a truly dust free "clean room".

How It Operates

Heart of the stationary cleaning system at the Summers plant is a 60 hp Hoffman centrifugal exhauster producing the vacuum. A centrally located dust separator outside the assembly rooms collects the material with large filtering area insuring thorough cleaning of the air. Hoses for cleaning are inserted into strategically located inlet valves in the piping system conveniently located throughout the areas to be vacuumed.

Benefits And Advantages

Insuring spotlessly clean work in final assembly and calibration, the Hoffman stationary vacuum system already has paid for itself. It has helped Summers Gyroscope reduce rejects, maintain high reliabilty, increase production and improve employee morale. The Hoffman system enables Summers to meet and exceed specifications in supplying inertial guidance systems, flight instruments and gyroscopes to the U. S. Air Force, U. S. Navy, the Martin Co., McDonnell Aircraft, Douglas Aircraft and the Convair Div. of General Dynamics, among others.

If you have a special cleaning problem in your plant, ask for a free engineering survey to determine the most economical Hoffman system to prevent product contamination, salvage valuable materials, insure better housekeeping and encourage operating efficiency. Write for free booklet – How Stationary Vacuum Cleaning Systems Cut Costs, Increase Plant Efficiency.

U.S. Hoffman Machinery Corp.
Dept. ED1 Air Appliance Division
103 Fourth Ave., New York 3, N. Y.

Note how the Hoffman vacuum system handles both parts cleaning, (rear) and housekeeping chores.

A final assembly area is kept dust-free by the Hoffman vacuum system.

NEWS

Tube Generates Power From Rocket Exhaust

A thermionic generator tube designed to convert the heat of a rocket exhaust directly to electric power has been developed by Radio Corp. of America and the Thiokol Corp.

The device has reportedly produced up to 270 watts of power directly from a high-temperature heat source. Coupled to a solid-fuel rocket motor in a test mount, an experimental tube has generated useful levels of power directly from the exhaust heat. RCA and Thiokol anticipate a power capability of 40 watts per square inch and a conversion efficiency of 35 per cent.

Theoretically the new units reportedly can produce more than 1000 watts of electrical power per square centimeter with an efficiency of 64 per cent and a power-weight ratio of 175 watts per pound.

In the Thiokol test facility the hollow cylindrical tube slips like a sleeve over the rocket-flame tube discharging the burning flue. The inner wall of the thermionic generator tube forms a cathode, the outer wall a second electrode. The narrow space between the two walls is filled with cesium vapor.,

When the cathode wall is heated by the burning rocket fuel, electrons are boiled out of the cathode ma-

Thermionic generator developed by RCA and Thiokol fits over flame tube of solid-propellant rocket engine and converts rocket heat to electric power.

terial into the space between the two walls. The cesium vapor becomes ionized on contact with the hot cathode and encourages the easy flow of electrons to the outer wall. The electrical power generated by this process is fed to the test rocket's steering control mechanism or to electronic test apparatus by cables attached to the cathode and the second electrode.

According to RCA and Thiokol, tests show that it is feasible to use thermionic tubes as lightweight generators in large missiles and satellite vehicles during the critical launching and upward flight stages.

Color Scintillation Counter Would Separate Radiation

A scintillation counter that would use color to distinguish between gamma and beta radiations has been proposed by Dr. Frederick Reines of the Case Institute of Technology.

He would employ the new type of counter in differentiating between the normal gamma radiations present in the earth's environment and the fewer beta radiations present in studies of minute amounts of radioactivity.

Dr. Reines proposes to take advantage of the fact that gamma rays lose energy in collisions over relatively wide spaces, while beta radiations lose energy in a limited area. Thus a small counting volume would be embedded in the larger region. The small volume would detect beta particles, and the larger would spot gamma rays.

To distinguish between the signals from the two regions, Dr. Reines proposes two scintillator liquids. They would produce two different colors when the atomic collisions took place. The resulting light would be passed through appropriate filters, so that the two sources could be distinguished from each other. Equipment is being set up to test the feasibility of such a counter. Theoretical considerations suggest that the device might detect differences on the order of one in a million between the two kinds of radiation.

CIRCLE 15 ON READER-SERVICE CARD ➤

WASHINGTON REPORT

Air Traffic Control Future Unclear But Important to Electronics

Air traffic control, now firmly in the hands of the Federal Aviation Agency, promises to provide much work for the electronics industry over the next few years. Intensive development work is underway to produce equipment to handle fast-growing and fast-moving air traffic until 1980. First installations of this system are planned for 1963, with more to come speedily thereafter. Meantime, interim devices are being used as a first step toward automation.

Electronics firms' contribution to control of airspace and traffic will be widespread. The FAA's authority will require installations overseas as well as in the U.S. Furthermore, it is to be expected that Russia—which has grandiose plans for expansion of Aeroflot as an international carrier—will try to move in with its electronic gear, possibly offering very attractive financial terms to users. U.S. designers may have to hump to provide equipment that is so superior that it will sell itself on performance, even at a higher cost.

Congress has blown both hot and cold on the question of air traffic control. A number of shocking accidents during a single year were doubtless influential in speeding the establishment of a single agency to be responsible for the airways. This no doubt had a role, too, in the appropriation of $175 million for airways equipment in fiscal 1959. In the following year, however, FAA's budget request of $135 million was cut to $118 million. As a result, the agency had to shift $17 million of its funds for new equipment to pay for operating what was already in existence. Whether the

lawmakers will vote money enough to enable FAA to keep pace with traffic growth cannot be foreseen.

The chances are that Congress will be reasonable, or even generous, in appropriating money (1) for experimental purposes and (2) to set up the system that is finally worked out. But electronic engineers will first have to come up with reliable systems to solve some of the problems that now plague air traffic, and someone will have to work out a satisfactory compromise dividing airspace among commercial, general, and military aviation.

The question of division of airspace has politcial, as well as economic and technical aspects. Though it may be argued that, ideally, all airspace should be controlled, this is not now practical. There are far more aircraft in use that are not equipped with the complex electronic gear needed, say, for commercial service, than there are a full complement of black boxes.

FAA says it has "no intention of running minimum-equipped aircraft out of the sky." But it states emphatically that "positive separation of some nature will have to be eventually extended to this group of aircraft and pilots in high-density areas."

Another problem with both technical and political aspects is the future of the Air Force's SAGE system as a useful tool of single-agency air traffic control. So far, FAA has found SAGE radar very useful. But there is more to SAGE than that, and it does not appear to lend itself to integration with FAA's plans.

Shape of the electronics that will dominate the semi-automatic air traffic control envisaged for a few years hence can already be discerned. It will consist of radar, preferably three-dimensional, plus a refined transponder aboard the aircraft. Direct air-ground data links will send aircraft position information to computers, without pilot intervention, for correlation. This material—primarily air-derived—will be presented to ground controllers after computer processing.

CIRCLE 17 ON READER-SERVICE CARD ➤

MEETINGS

Calendar of Events

December

26-30 American Association for the Advancement of Science, Chicago, Ill.

January

13-17 Institute of High Fidelity Manufacturers 1960 High Fidelity Music Show, Pan Pacific Auditorium, Los Angeles, Calif.

11-13 6th National Symposium on Reliability and Quality Control, Statler-Hilton Hotel, Washington, D.C.

*12-15 Society of Plastics Engineers' 16th Annual Technical Conference, Conrad Hilton Hotel, Chicago, Ill.

25-29 Stress Measurement Symposium, Arizona State University, Tempe, Ariz.

February

* 1-4 ISA Winter Instrument-Automation Conference & Exhibit, Rice Hotel and Sam Houston Coliseum, Houston, Tex.

2-4 15th SPI Reinforced Plastics Division Conference, Edgewater Beach Hotel, Chicago, Ill.

* 3-5 1960 Winter Convention on Military Electronics, PGME, Ambassador Hotel, Los Angeles, Calif.

10-12 7th Annual Solid-State Circuits Conference, IRE, AIEE, Philadelphia, Pa.

11-12 7th Annual Cleveland Electronics Conference, IRE, ISA, AIEE, Engineering and Scientific Center, Cleveland, Ohio.

11-13 1st Annual Electronics Representative Association, Drake Hotel, Chicago, Ill.

16-18 1st National Symposium on Nondestructive Testing of Aircraft & Missile Components, SRI, Hilton Hotel, San Antonio, Tex.

*19-23 3rd International Electronic Parts Show, Paris, France.

25-26 Scintillation Counter Symposium, PGNS, AIEE, AEC, NBS, Washington, D.C.

16th Annual Society of Plastic Engineers Technical Conference, January 12-15

The theme of the 16th Annual Society of Plastic Engineers Technical Conference will be the professional achievements and approaching opportunities in the growth of plastic engineering.

Several symposia based on the interests of the Professional Activities Groups of the Society will include plastics in building, injection molding, polymer structure and properties, reinforced plastics, standards for reporting properties, fabricating, finishing, plastics in electrical insulation, casting and plastic tooling, forming, extrusion, thermosetting molding, metals for plastic molds, and vinyl plastics. Conference Chairman is Mr. Charles M. Wasugh of E. I. DuPont de Nemours & Co., Inc., 7250 N. Cicero Ave., Lincolnwood, Ill.

3rd International Electronic Parts Show, February 19-23, Paris, France

The 3rd International Electronic Parts Show, for electronics specialists, will present a full range of elements used in the construction of radio-electrical and electronic appliances. Many new exhibitors from all countries will be taking part alongside the larger international firms. The show is organized by the National Federation of French Electronics Industries, 23 rue de Lubeck, Paris 16, France.

Instrument-Automation Conference and Exhibit ISA, Houston, Texas, February 1-4

The theme of the winter Instrument-Automation Conference and Exhibit will be "Process Control in the Electronic Era."

The Conference Sessions will be held Feb. 1-4 at the Rice Hotel, while the Exhibit will be staged in the San Houston Coliseum, Feb. 2-4. For additional information write to: Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

1960 Winter Convention on Military Electronics, PGME, February 3-5

The convention to be held at the Biltmore Hotel, Los Angeles, Calif., is sponsored by the Institute of Radio Engineers Professional Group of Military Electronics. Chairman: Dr. Lester C. Van Atta, Hughes Aircraft Co., Los Angeles, Calif.

BOURNS

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More engineers specify Trimpot because:

Trimpot line is complete

Bourns offers you the largest selection of leadscrew actuated potentiometers... 20 basic models—4 terminal types—three mounting methods.

Trimpot is small

Space saving size and rectangular shape permit the installation of 12 to 17 units in one square inch of panel area.

Trimpot is accurate

Multi-turn screwdriver adjustment provides 9000° of rotation...you can make and repeat the finest adjustments.

Trimpot is stable

Adjustment shaft is self-locking...settings are virtually immune to severe acceleration, vibration and shock.

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All instruments are 100% inspected before shipment to assure you of reliable performance.

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It is used in more military and commercial equipment than any other leadscrew actuated potentiometer.

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BODY—High-temperature, thermosetting plastic body is sealed, enabling potentiometer to meet Mil-Specs for humidity, sand, dust, fungus, salt spray, etc.

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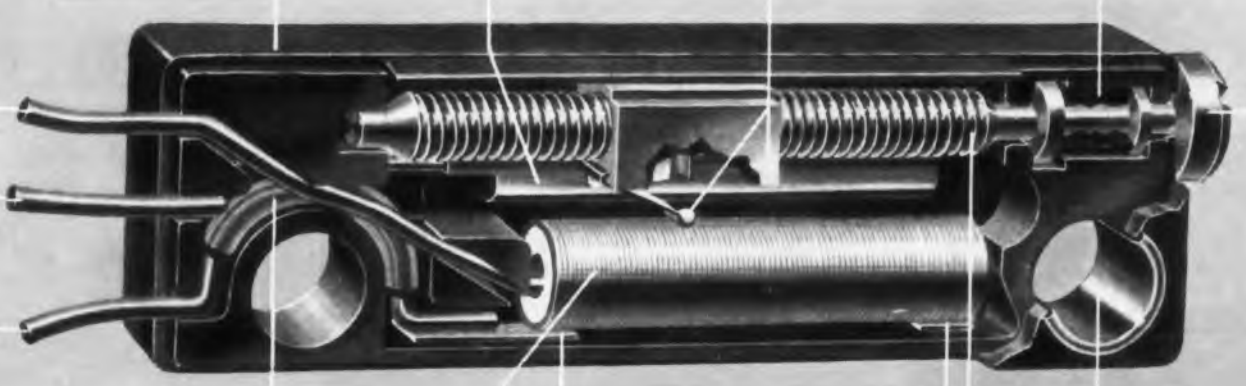
WIPER CARRIAGE—Special high-temperature plastic carriage with precious metal contact spring permits exact settings and stability under severe environmental conditions.

SHAFT HEAD—Stainless steel with machined slot for screwdriver adjustment. Meets military salt spray requirements.

O-RING—Silicon rubber O-ring seals potentiometer against humidity, withstands high temperature.



TUBING INSULATION—Tubing around terminal eliminates possible short or electrical cross-over.

SILVERWELD* TERMINATION—This exclusive Bourns feature is unequalled in ruggedness. There is a metal-to-metal bond from the terminal to the resistance wire.

EYELETS—Stainless steel eyelets are set on ¾" centers and provide easy mounting with 2-56 screws.

TERMINALS—Three terminals are gold-plated copperweld wire or Teflon-insulated leads.

ELEMENT—Special ceramic mandrel is precision wound with low temperature coefficient resistance wire.

LEADSCREW—Stainless steel leadscrew is corrosion resistant, withstands salt spray.

*TRADEMARK

This cutaway of Model 220 is typical of the design of all Bourns Trimpot potentiometers though some features may vary from model to model.

Longest record of reliability

General Purpose Wirewound Trimpot—Model 200. Operates at 105°C / L,S,P terminals / 1/4 watt / 10 ohms to 100K. Available as rheostat, Model 201.

High-Resistance Wirewound Hi-R® Trimpot—Model 207. Operates at 175°C / L terminal / 2 watts / 100 ohms to 100K. Available as rheostat, Model 208 Hi-R Trim R®.

Dual-Element Wirewound Twinpot®—Model 209. Operates at 105°C / L terminal / 1/4 watt / 10 ohms to 20K. Two potentiometer outputs with one adjustment shaft.

General-Purpose Carbon Trimpot—Model 215. Operates at 125°C / L,S,P terminals / 1/4 watt / 20K to 1 Meg. Available as Mil-Spec humidity-proof unit, Model 235 (1K to 10 Meg).

Subminiature Wirewound Trimpot—Model 220. Operates at 175°C / L & W terminals / 1 watt / 100 ohms to 20K. Meets Mil-Specs for humidity.

High-Temperature, Humidity-Proof Wirewound Trimpot—Model 224. Operates at 175°C / L,S,P terminals / 1 watt / 100 ohms to 100K. Meets Mil-Specs for humidity.

Humidity-Proof Wirewound Trimpot—Model 236. Operates at 135°C / L,S,P terminals / 0.8 watt / 10 ohms to 100K. Meets Mil-Specs for humidity.

High-Temperature Wirewound Trimpot—Model 260. Operates at 175°C / L,S,P terminals / 1 watt / 10 ohms to 100K.

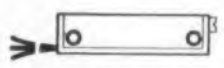
High-Quality Commercial Wirewound Trimit®—Models 271, 273, 275. Operates at 85°C / L,S,P terminals / 1/4 watt / 100 ohms to 10K.

High-Quality Commercial Carbon Trimit—Models 272, 274, 276. Operates at 85°C / L,S,P terminals / 0.2 watt / 20K to 1 Meg.

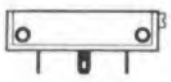
Panel-Mount Trimpot

All models are now available with the added convenience of panel mounting. Unique design permits quick factory attachment of rugged panel-mount assembly to standard "on-the-shelf" Trimpot potentiometers. The Panel Mount Trimpot takes as little as 1/12 sq. inch of panel space, meets Mil-Specs for vibration, shock, salt spray, etc. Recessed head prevents accidental changes of setting. Silicon rubber O-ring and Teflon washer provide moisture barrier.

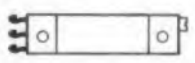
Key to terminals



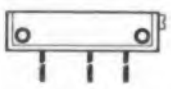
L — insulated stranded Leads



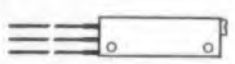
S — Solder lugs



S — Solder lugs (Model 224 only)



P — Printed circuit Pins



W — uninsulated Wires

Standard resistances (ohms)

10	50	200	1K	5K	20K	100K	500K
20	100	500	2K	10K	50K	200K	1Meg

other Resistances Available

Write for detailed specifications and list of stocking distributors.

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Exclusive manufacturers of TRIMPOT®, TRIMIT®. Pioneers in potentiometer transducers for position, pressure and acceleration.

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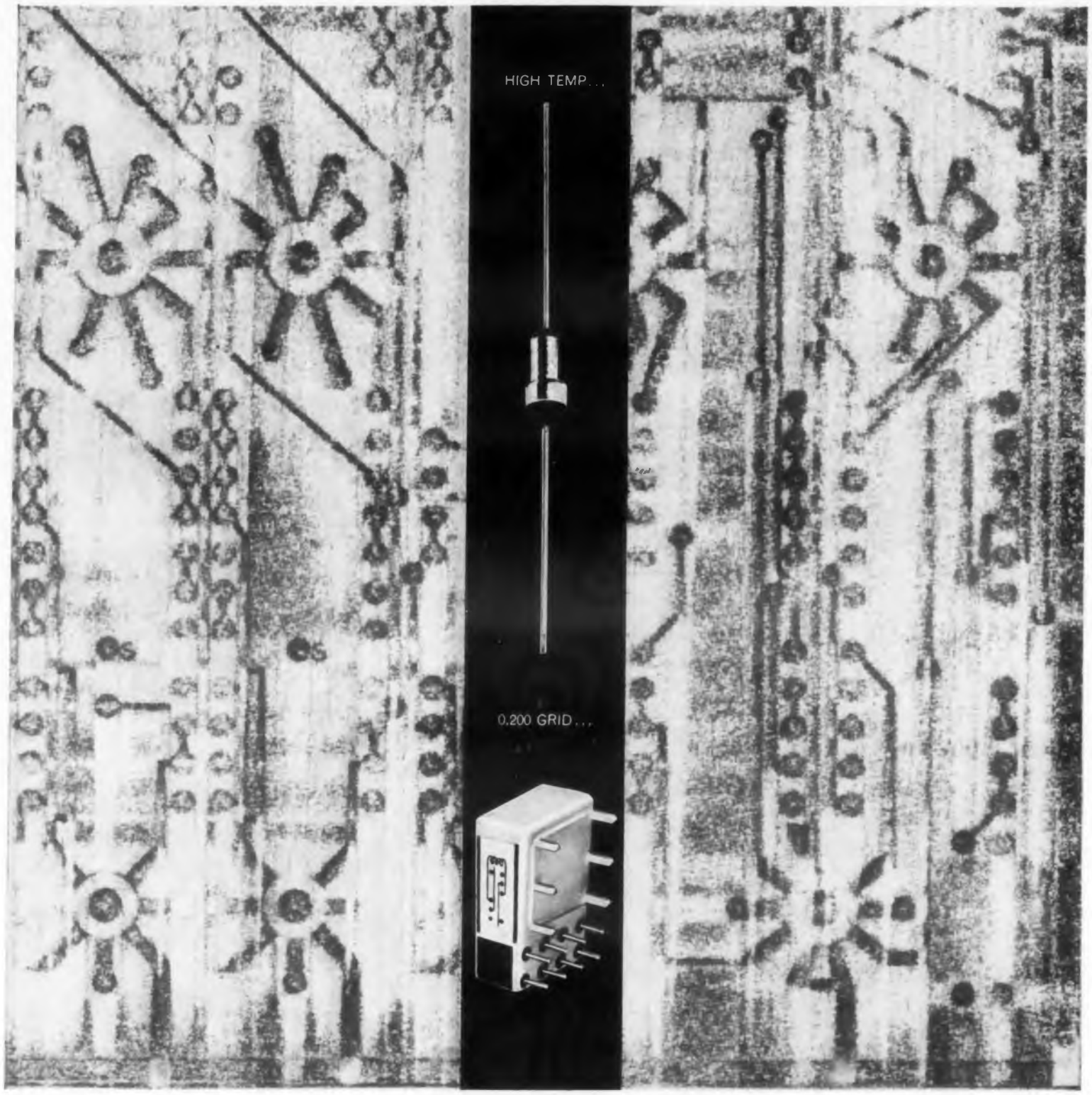
CIRCLE 19 ON READER-SERVICE CARD



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MODULE RELAY 0.200 grid ■ maximum module height, 0.400 inches ■ 25 g vibration to 2000 cycles ■ integral part of printed circuit ■ ideal for dip soldering ■ long life. **FEED-THROUGH CAPACITOR** thermal shockproof ■ up to 2200 uuf ■ temperature range, −55C to 150C ■ 200 WVDC ■ 0.590 inches maximum height ■ 0.155 inches mounting diameter. Write, wire, or phone!

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EDITORIAL

Peace From Space*

Fitting for this time of year when men hope for the fulfillment of the Christmas message of peace and good will to all men, the gentlemen of the American Rocket Society, at their annual meeting, tackled the problem of achieving peace in our time. They look to the space missile as the dove of peace. The very development of giant booster rockets make peace an alternative to war; human effort to establish space law may guarantee world peace.

Faced with the dilemma of preparing for war or preparing for peace, Dr. Franco Fiorio sees space exploration as a substitute for war. It offers promise for economic gain, adventure, and satisfies dreams of conquest. The struggle to conquer space instead of nations has added appeal because it doesn't necessitate killing or destruction. Fiorio sees military budgets being converted to space projects, and, because of the vast cost, cooperation between nations in getting payloads into the universe. This scientific cooperation is also seen by Keith Glennon, Director of NASA, and Eilene Galloway, space consultant to the U. S. Senate. Noted lawyer William A. Hyman, after an exhaustive study of policies of major foreign powers, sees the creation of a world space law as possible and as a necessary step now to " . . . provide the surest means of achieving the goal of all human beings—world peace."

U. S. House of Representatives, Peter W. Rodino, Jr., also addressing the ARS, envisioning the frontier of space in new perspective, believes that although national rivalries may be projected into space it may well be that new doors to international cooperation can be opened. He calls for the U. S. to take the lead in accepting the challenge posed by the U. N. ad hoc committee on Peaceful Uses of Outer Space. He calls for an international conference to promote an international cooperation and the establishment of international law. The new hope for this Christmas time can be Peace From Space.

James C. Koppa

*Title of Dr. Fiorio's paper presented to the American Rocket Society's 14th Annual Meeting.

DESIGN IN THE FIFTIES

Progress has been rapid in all areas of electronics in the last ten years. Every design engineer has been affected in some way by the increasing activity in space exploration and national defense. But because he is usually wrapped up in his own project, he seldom has time to be aware of all other developments.

Here, in one convenient package, is an excellent opportunity for an electronics designer to get a good perspective of the entire industry. He can also see where his own field now stands in the industry. This interesting history, by extrapolation, makes excellent crystal-ball material for future planning.

And for a first-hand report on how the experts predict the future, don't miss "Design in the Sixties" in the Jan. 6 issue of ELECTRONIC DESIGN.

DESIGN IN THE FIFTIES

TRICOLOR KINESCOPE TUBE

1950

PACKAGE 6000 COMPONENTS PER CU FT

PRINTED CIRCUITS

MODULAR PACKAGING

Triple Rise in Sales Rung Up by Industry

SALES IN the electronics industry have more than tripled since 1950. Government and industry figures show that in the last ten years the factory sales of equipment climbed from $2.6 billion to $9.2 billion. If all electronics-generated sales are counted—distribution, service, broadcasting and others—a $15 billion price tag can be put on the electronics industry.

Change as well as growth marked the industry of the Fifties. At the start of the decade, factory sales of consumer electronic goods accounted for three of every five dollars spent on electronic equipment. The volume of these sales leveled in ensuing years, however, once the impetus of the post-war TV-set boom was spent. Each year since 1950 has seen a smaller share of the total equipment market go to consumer electronic goods.

Each of the other hardware segments—replacement, industrial and military—has at least tripled during the Fifties, as measured by factory sales. The replacement equipment business grew in value from roughly $250 million in 1950 to nearly $1 billion this year. Industrial equipment sales in-

(Continued on page 27)

Advances in Communications Design Dictated by Limited Equipment

DURING the last 10 years, necessity has become the mother of invention for electronic communications. A shortage of adequate facilities has forced designers to utilize more efficiently the frequency spectrum; reduce the effects of interference caused by crowding; exploit the use of higher frequencies, and speed calling and switching.

In the early 1950's pulse-code modulation became the subject of renewed interest. Its inherent freedom from interference and its accuracy of transmission appealed to designers of data-transmission systems. Complexity of coding and decoding equipment was then (and still is) one of its major drawbacks. Federal Telecommunications Labs announced in 1952 its system of delta modulation, by which some of this equipment could be simplified.

But progress in digital communications has not been characterized by great spurts of activity. Rather it has been slow and methodical. It was not until 1957 that Bendix Pacific announced Electro-Span, a digital telemetering system for remote process control. Also in 1957, Federal Telecommunications Labs announced a TACAN data link, designed to speed aircraft flight data to Civil Aeronautics Authority controllers. More recently Stromberg-Carlson has developed an automatic binary data link, which operates over existing voice channels.

Voice Links Give Way

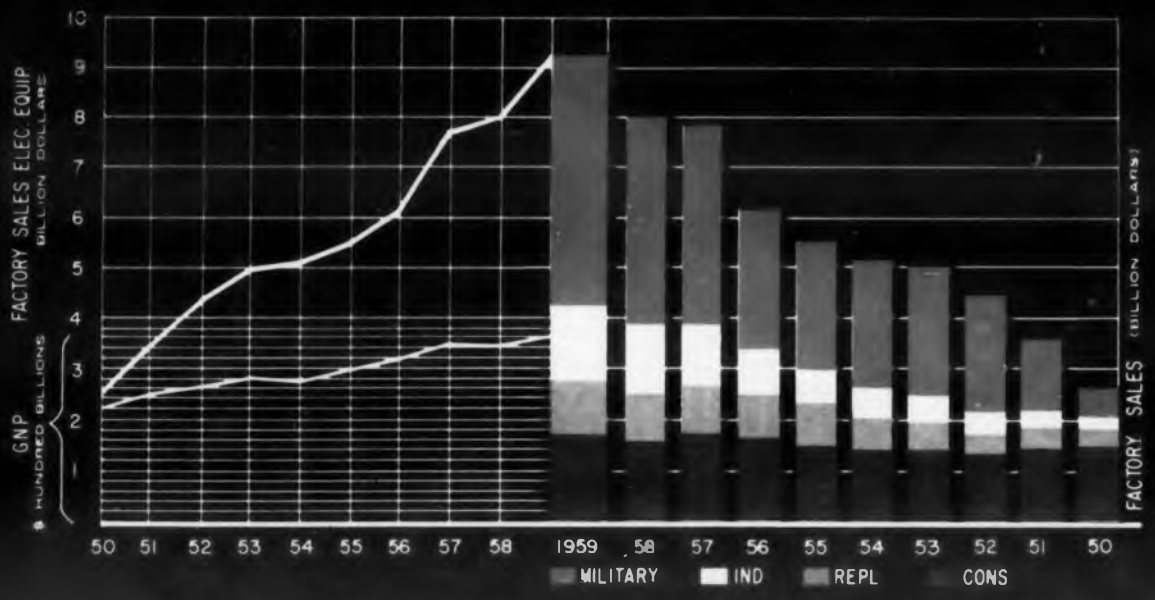
In 1959 it became apparent that voice communications links were gradually giving way to automatic data-transmission links.

In 1952 the phenomenon now known as scatter

(Continued on page 27)

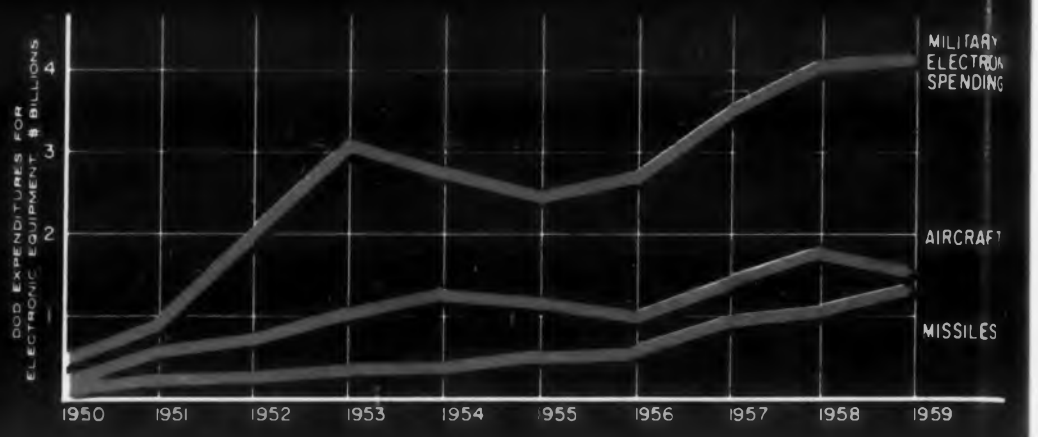
How the Electronics Industry Grew in the Fifties

Factory sales of electronic equipment tripled in 10 years, growing faster than the Gross National Product of the country.

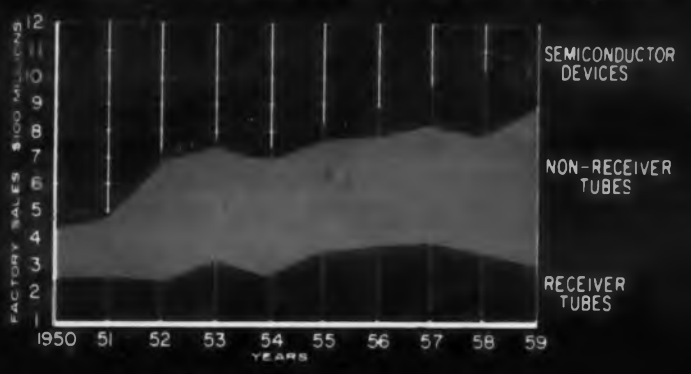


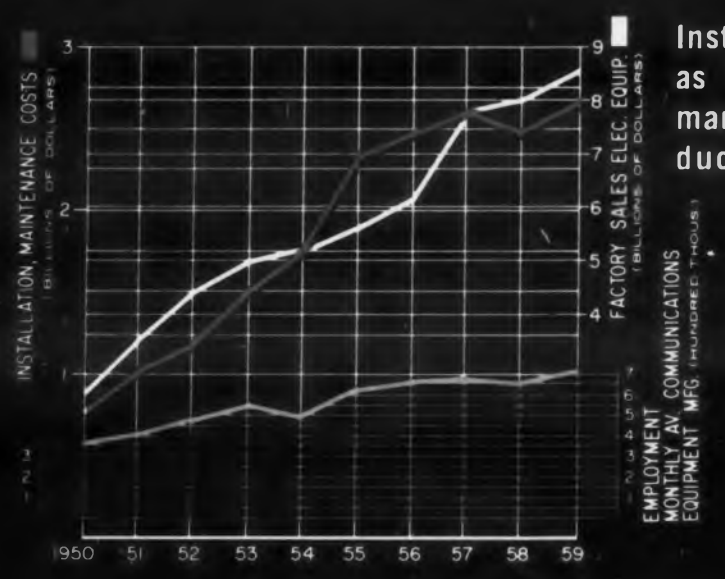
In the Fifties, military electronics passed consumer electronics as the value leader.

The Fifties gave birth to missile electronics, which is about to pass aircraft electronics in value of equipment purchased.



The Fifties have seen the remarkable growth of semiconductor devices and the start of the decline of receiver-tube sales.

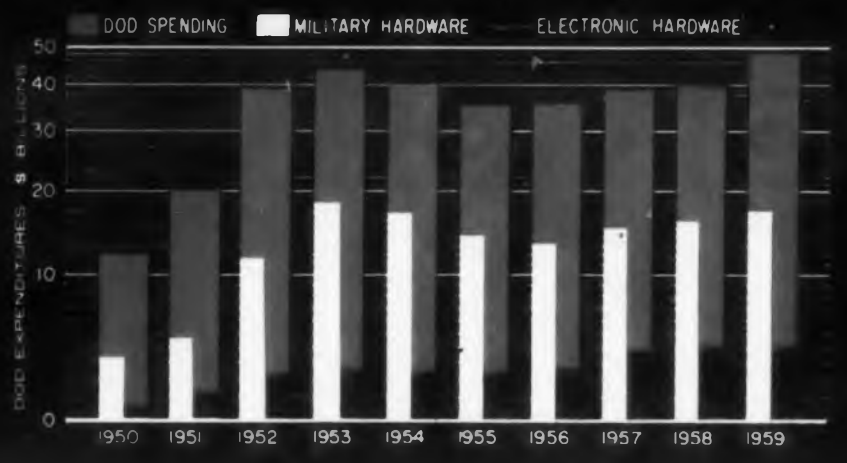




Installations and maintenance costs are rising as fast as equipment sales. Employment in manufacturing is rising, too, but higher productivity is slowing its rate of increase.

How the United States would look if state lines were marked according to the value of electronic products shipped by each state.

Military electronics spending accounts for a growing proportion of total military expenditures.



Business Highlights of the Fifties

1950	TV-set sales triple for second year in row.
1951	Missile electronics becomes a business
1952	Military electronics sales double in one year.
1953	Sales of static components reach a still-untopped high.
1954	First large-scale computer delivered to industry.
1955	Semiconductor sales exceed costs of research and development
1956	One-third of radio-set manufacturers go out of business.
1957	Sales of TV receiving and picture tubes start decline.
1958	Electronics R & D becomes a billion dollar business.
1959	Computer sales to industry double previous year's record level

ELECTRONIC DESIGN

Triple Rise in Sales *(continued)*

creased from $350 million in 1950 to about $1.5 billion this year. The sharpest growth of any of the four major segments of the industry was registered by military electronics. Sales moved from $500 million in 1950 to well over $4 billion in 1959.

Related to this figure are two of the most significant changes in the electronic industry during the Fifties: the growth of missile electronics from an insignificant business to one that sold over half a billion dollars worth of equipment in 1959; and the start of the decline of the military aircraft electronics. Spending by the military for aircraft electronics reached a peak of roughly $1.8 billion in 1958, from which it declined by about $100 million this year. Missile electronics will shortly account for a larger share of the Department of Defense budget than aircraft electronics.

Two developments of even more importance to the industry in general were the rise during the Fifties of semiconductor devices and of data-processing.

The factory value of all types of semiconductor devices shipped in 1959 will exceed that of receiver-tube sales. This is the second successive year in which factory sales of receiver tubes declined. Sales of semiconductor devices are now valued at about $300 million, up approximately one-third from last year.

Sales of data-processing equipment, in the industrial market alone, have already passed $500 million. Shipments to the military and scientific markets will lift the total data-processing sales figure for 1959 to over $1 billion. In 1950 there was no data-processing market. ■ ■

Advances in Communications Design *(continued)*

transmission was being investigated. One objective of the investigation was to determine if there was an orderly way to predict over-the-horizon uhf transmission. In 1955 Bell Labs and the Massachusetts Institute of Technology had succeeded in transmitting microwave signals 200 miles using a 10-kilowatt transmitter.

In 1956 Westinghouse had two experimental uhf scatter systems in operation between Baltimore and Verona, N.Y. They operated at 900 and 2000 mc. The year before, Syracuse University had operated a 250-mile experimental link at 915 mc.

Federal Telecommunication Labs disclosed in 1956 its proposed scatter link between San Juan, P. R., and Cindad Trujillo, Dominican Republic, a distance of 237 miles. Federal placed a commercial scatter system in operation between Florida and Cuba in 1958.

Communication via meteor burst came into being in 1958.

Progress in uhf communications took a step forward in 1954 when Raytheon placed the first rural telephone microwave relay in operation. Frequency of operation was 6000 mc at transmitter powers of 100 mw.

Radio Corporation of America announced in 1956 that engineers had produced a record 4,500,000 watts of rf power in a uhf TV experiment. At a frequency of 537 mc, 100 kilowatts were fed into an antenna with a gain of 50.

General Electric designed a system of bouncing microwaves from "mirrors" instead of repeaters. The first commercial system using the technique was put into operation in Texas in 1957.

Travel Reservations by Electronics

In systems, 1955 began an era in which automatic electronic means were used to speed travel reservations. Several railroads and two airlines put into operation a scheme in which Teleregister equipment was tied into IBM automatic printers.

Two important military communications systems were disclosed in 1956. One was the Missile Master, an automatic remote control firing Nike missiles. Second was the SAGE network, which tied all the air defense radars together and fed their information into a single center. Also in 1956 several radio-controlled auto traffic control systems went into operation. Previously designed experimental systems became practical.

Several military systems consisting of complete communications packages were developed in the late Fifties. Motorola's AN/MRC-66 is a mobile communications control providing single-sideband radio telephone service with selective calling.

Crowding of the frequency spectrum resulted in single-sideband transmission becoming mandatory at frequencies under 25 mc in 1956. Federal Telecommunication Labs announced in 1958 a multichannel SSB transmitter providing 120 telephone channels, each 500 kc wide. The system operates at 900 mc.

Color Television Born

In the broadcast field, 1950 saw the birth of the tricolor kinescope tube. This development set off the famous battle between RCA and the Columbia Broadcasting System over the adoption of a color TV system. RCA won in 1953 when the

DESIGN IN THE FIFTIES

1952

Advances in Communications Design

(continued)

FCC approved the compatible system standards. But color television has progressed very little since. It has been used to advantage in the medical field in closed-circuit systems.

In the search for less expensive and better methods of TV broadcasting, DuMont introduced its Vitascan system in 1955. This method consisted of scanning a scene with light, with photocells picking up the light impulses and translating them into television signals. Cameras were not required. For some reason, the system never got beyond the stage of a technical novelty.

RCA introduced a miniature vidicon tube in 1956 to operate in conjunction with a portable transistorized TV transmitter. The unit consisted of a four-pound camera and a 15-pound transmitter. Power output was 0.5 watt at 2000 mc.

TV Antenna Introduced

GE made available in 1956 a single-bay helical television transmitting antenna. Intended for vhf use, the antenna enables power boosts to 100 kilowatts.

Translator stations for television came into being in 1956. Power output for these "satellite" stations was about 10 w.

Tape recording of TV signals was announced by several companies in 1957. Ampex produced a tape unit capable of recording good quality color signals. RCA demonstrated high-quality taped color broadcasts.

General Electric demonstrated 3-D color television system in 1957.

An attempt to broadcast two television signals simultaneously on one channel was made early in 1958. One successful system was demonstrated by Blonder-Tongue. Bell Telephone Labs disclosed a system of transmitting telephone and

DELTA MODULATION

UNIPOLAR FIELD EFFECT TRANSISTORS

SCATTER TRANSMISSION

television simultaneously.

In other areas of broadcasting, the first fm auto radio appeared in 1954. The same year several experimental transistor radios were shown to the public. In 1955 RCA demonstrated a transistor auto radio. Both GE and Admiral Corp. showed experimental solarpowered radios in 1956. And transistor auto radios became commercially available in quantity in 1956.

Gains for Mobile Radio

Mobile radio made a great deal of progress in the 1950's. This was mostly due to the advent of transistors and miniature components. In 1955 the Signal Corps showed an experimental voice-powered transistor transceiver with a range of 600 feet. Radio System Lab announced the availability of a five-pound aircraft transceiver. This homing system operated in the 24-52 mc range. In 1957 RCA produced for the New York City Police, a pocket fm receiver that operated at 150 mc. GE announced a 100-watt mobile transistorized transmitter in 1958.

Wire communications were in the limelight in 1956 with the inauguration of a transatlantic telephone cable. The late 1950's saw much progress in solid-state switching devices for telephone systems. These have been slowly replacing the relay.

Stromberg Carlson has developed since 1958 several military wire communications systems using four-wire switching systems. These incorporate the transistorized telephone set, using compound tone signaling with push-buttons.

Bell System started direct long-distance dialing in 1955 in a few selected areas. In 1959 push-button dialing was started experimentally in a few areas. ■ ■

DESIGN IN THE FIFTIES

19
52

AGREE
RELIABILITY
GROUP

IR SEARCH
TRACK SYSTEM

1953

IBM 701

PROJECT
TINKERTOY

Illustrative of the trend toward miniaturization components are these two relays made by the Leach Corp. They are identical in functions: the larger one is the 1950 model and the smaller the 1959.

A dominant trend of the 1950's has been toward compression-installed, solderless connections. The compression method provides a measurable quality control and uniformity of connection assured by a full-cycling tool. The quality of the completed connection is independent of the operator's skill. The units here are made by Burndy Corp.

Progress in fans is apparent here. Each unit moves approximatey 100 cubic feet per minute. The 1950 unit (left) has a blade diameter of 5 3/8 inches and the 1959 unit's comparable dimension is but 3.25 inches. The earlier unit weighs 1.6 pounds and has an efficiency of 46 per cent; the newer unit weighs 0.35 pounds and has an efficiency of 72 per cent. Both fans are made by Rotron Mfg. Co.

Smaller, Tougher, Cheaper Components

—and they perform better, too

SPURRED by vacuum deposition and molecular techniques, electronic components—often called the "backbone" of the industry—have progressed dramatically. They are smaller, tougher, cheaper and improved in performance. In some instances today's components are wholly unlike their predecessors of 10 years ago.

What has motivated this progress? "Military applications in the missile and rocket field," explained a spokesman for Vitramon, Inc. "The military's emphasis on reliability and small-volume, lightweight packages has catalyzed the development of new materials and miniaturized design configurations, especially in the field of solid-state physics."

Examples of why improvements in components were essential in the last ten years were given by a representative of the Leach Corp. "Maximum operating temperatures of components have been generally raised from 71 to 135 C," he said. "And vibration-resistance levels have increased from 1 to 10 *g* at 10 to 55 *cps*, up to 20 and 30 *g* over a frequency range of 10 to 2000 *cps*."

Component Density Raised

One measure of progress is component density. In 1950 it was possible to get from 5000 to 6000 components in a cubic foot. After concerted efforts in miniaturization, it is possible today to get from 50,000 to 60,000 components in a cubic foot —or 10 times as many.

Miniaturization was made possible partly through improvements in tubes and transistors. At the same time passive components were reduced in size—a result of lower power, current and voltage demands of the active components.

Improvements in standard components—resistors, capacitors, inductors, transformers, tubes, and the like—have been essentially small. Many new varieties of moderately improved compopents appeared. Among them were metal film resistors, metallized plastic film capacitors, ferrite core inductors and transformers, ceramic tubes, plastic element potentiometers, precision wirewound resistors through the use of new encapsulating compounds. These units reflect the availability of new materials or new techniques of manufacture. The solid electrolyte tantalum

COMPATIBLE COLOR TV

SURFACE BARRIER TRANSISTOR

capacitor, a Bell Telephone Labs accomplishment, is an example of an advance in the form of a new capacitor structure.

Solid-State Gains Made

The rapid growth in the application of the transistor, silicon rectifier and other related solid-state devices was another component trend of the last 10 years.

There was also progress in connectors and methods of connection. An important trend was the move toward solderless connections. Behind this was the need for higher and higher reliability, lower installation costs and ease of servicing. Crimp-type, snap-locked contacts got an increasingly big play.

"Connectors have become more vital components of electronic devices, because of more and more interconnecting of black boxes and other equipment," a Burndy Corp. representative commented. "In addition the miniaturization of all other components necessitated miniaturization of connectors." Better connectors for both missile and printed-circuit applications were made.

Printed Circuits Are Born

Instrumental in reducing the size of electronic equipment has been the growth of the printed-circuits branch of the industry. It grew from nothing in 1950 to a $50,000,000 trade in "platforms" for components by 1959, an engineer at Photocircuits Corp. explained. The printed-circuit board has developed from a single and double-sided eyelet board to a two-sided, plated-through board. More boards now being made with plated-through holes than eyelet holes, the engineer said. This is the result of progress in controlling the process used in making plated-through holes.

Miniaturization and military requirements made heat a problem in the 1950's, and steps were taken to overcome it. Companies producing fans took up the challenge. The industry came out with better, more compact and easier-to-use devices. ■ ■

DESIGN IN THE FIFTIES

1954

Semiconductor Achievements Mushroom in 10 Short Years

ALTHOUGH major advances have been achieved in the last decade in many phases of electronics, perhaps the most remarkable have been in semiconductor devices.

Since the announcement of the point-contact transistor in 1948, Bell Telephone Labs and transistor manufacturers and research groups have produced outstanding advances in basic knowledge, fabrication, reliability and performance of semiconductor devices.

In 1951 Dr. William Shockley of Bell demonstrated the junction transistor, which he had predicted three years previously. He followed this in 1952 with descriptions of a number of unipolar or "field-effect" transistors offering promise of high-input impedance at high-operating frequency.

Thin-Base Controls Achieved

In 1953 Philco revealed its surface-barrier transistor, followed by a micro-alloy device in 1954. These types demonstrated the technique for accu-

RURAL TELEPHONE MICROWAVE RELAY

SEMICONDUCTOR ZONE REFINING

FIRST RFI CONFERENCE

rate control of thin-base layers using an electrolytic etching process.

During this period research produced the drift transistor, which permitted the control of impurity distribution in the thin-base area to further increase high-frequency possibilities.

Bell's zone-refining technique, reported in 1954, made it possible to produce silicon crystals with electrically active impurities reduced to less than one part in a billion. Raytheon announced experimental silicon transistors tested to 350 C. Sylvania developed devices with mixtures of germanium and silicon for operation up to 350 C.

A major advance in transistor fabrication, the diffusion process, was announced by Bell in 1954. By permitting controlled introduction of impurities into a crystal, extremely thin base layer regions became possible. The diffused transistor family offers the highest frequency capabilities of present types, with the mesa transistor combining high-speed and high-power advantages.

'Intrinsic Barrier' Transistor

The "intrinsic barrier" or p-m-i-p transistor, with a theoretical limit of 3000 mc, was developed by Bell early in 1954.

Dr. R. N. Hall of General Electric announced in 1955 the "meltback" fabrication process, using wire-shaped crystals rather than sliced ingots for small-signal, high-frequency applications. In 1957 GE offered the silicon unijunction transistor, showing highly stable negative resistance characteristics for application in oscillator, timing and bistable circuits.

By combining the features of a surface barrier transistor with a diffused base layer, Philco produced in 1957 MADT (micro-alloy diffused base) units, which could operate above 100 mc. Raytheon introduced the "spacistor" device, using the space charge region in a reverse-bias pn junction,

with injection of carriers into the space charge region by the emitter.

Improved Silicon Rectifiers

Silicon-controlled rectifiers were announced in 1958 by GE. These boast higher efficiency plus faster firing and recovery times than thyratron tubes. In early 1959 Texas Instruments and Fairchild Semiconductors offered mesa transistors as "off the shelf" items.

Now available or in production are the following diffused devices:

- Silicon rectifiers handling up to 100 amperes.
- Reference diodes with accurate breakdown voltages up to several hundred volts.
- Diffused-base silicon transistors with frequency cut-offs approaching 100 mc.
- Diffused base germanium devices with frequency cut-offs to 1000 mc.
- Power transistors which can dissipate 100 w.

Tube Industry Holds Its Own In Transistor-Dazzled Market

DESPITE a tremendous spurt in the development, production and use of transistors, the tube industry has demonstrated advancements in quest of the lion's share of the electronic market.

An extremely rugged "stacked tube" was announced by Sylvania early in 1954. Considerable size reduction with temperature operation ranging from —195 to 540 C were claimed for the device. It used ceramic rather than mica spacers for improved shock and vibration characteristics. The assembly was packaged in a ceramic envelope for further protection against environmental failure.

In 1955 General Electric announced a miniature ceramic tube, only three-eighths of an inch long and five-sixteenths of an inch in diameter. It operates in the uhf region and can

STACKED CERAMIC TUBE
ULTRASONIC MACHINE TOOLS

- Silicon devices useful up to 200 C.

Tunnel Diode Stirs Optimism

The focus of attention in semiconductors today is on the tunnel diode. A result of the research efforts of Dr. Leo Esaki of Sony Corp., the device derives its name from the quantum-mechanical tunneling of majority carriers in highly doped pn junctions.

Major manufacturers are engaged in the development of practical circuits and applications based on the negative-resistance characteristics of the device. Experts predict new types of oscillators, amplifiers, mixers, and computer elements with uses still to be unearthed.

Small, truly portable radios and TV receivers are expected as a direct application of tunnel-diode research. Computer companies have indicated plans to include the devices in units under development. ■ ■

be used at temperatures in excess of 500 C, GE said.

Three developments early this year showed promise of active competition with semiconductors. Tung-Sol's cold-cathode vacuum tube eliminates the need for a heater, the major cause of failure in receiving tubes. Reliability is drastically improved, and other features include ability to withstand nuclear radiation and temperature extremes ranging from liquid air to red heat.

Another step in reliability improvement was Sylvania's "sarong" cathode structure. A skin-tight, wrap-around cathode film replaces the conventional sprayed cathode coating used in receiving tube assembly. With more uniform cathode coating thickness and diameter control, higher and closer-tolerance transconductance can be obtained in tubes, with reductions in noise and cathode-to-grid arcing.

RCA's Nuvistor, smaller than a thimble and particularly suited for mechanized production, represents a radical departure in the electron tube concept. Its electrodes are small, lightweight cylinders supported on a ceramic wafer base. A high degree of freedom from shock and vibration is achieved because of their shape and low mass. Stable performance is offered between 190 to 350 C, and the tube is less susceptible to radiation damage than semiconductors. ■ ■

DESIGN IN THE FIFTIES

1954

INTRINSIC BARRIER TRANSISTOR

Drive for Electronic Reliability Touched Off by War in Korea

THE NEED for greater electronic reliability became clear in the last decade as equipment became more complex, environments more severe, miniaturization imperative, and space exploration a reality.

The Korean War probably started a "chain reaction" in reliability, Kurt Greene, engineer at United States Testing Co., explains. Electronic equipment used in the conflict often malfunctioned and failed. In general it was found unsatisfactory. Investigation led to the realization that too many operational factors had not been studied sufficiently prior to production and delivery. The development and growth of the electronic industry was abruptly threatened.

Both industry and the Government tackled the problem. The Government, in 1952, sponsored the Advisory Group on Reliability of Electronic Equipment, which had nine task groups. Its purpose was to determine procedures for stating reliability requirements in procurement documents and to develop tests for verifying compliance with those requirements. Its report was delivered in June, 1957.

Military Evaluations Urged

Task Group 5 recommended that a permanent group, at Department of Defense level, be established, charged with developing military com-

TAPE-CONTROLLED MACHINE TOOLS

TRANSISTORIZED AUTOPILOT

IR RAILROAD HOTBOX DETECTOR

ponent specifications, testing component parts for design capability, and developing inspection methods. To implement these recommendations, a group called the Ad Hoc Study on Parts Specifications Management for Reliability was formed. It is still evaluating the recommendations and is to issue a report in the near future.

Meanwhile companies, slowly at first, began forming reliability groups and departments. They tested their own components and equipment or sent them to testing laboratories. So much testing was going on that the Government's Task Group 5 concluded:

"Fantastic amounts of engineering manpower and test facilities are being devoted by components and equipment producers and agencies to component reliability studies in complete duplication of work done elsewhere. This must stop."

Two recent examples of industry's concern with reliability are these developments:

Fansteel Metallurgical Corp. announced that it would seal tantalum capacitors with their reliability specified in writing. And General Electric reported that it was spending a million dollars to develop electrolytic capacitors 99.999 per cent reliable.

Professional Symposiums Sponsored

The IRE, EIA, ASQC and AIEE, aware of the problem, jointly sponsored symposia on reliability and quality control. Five have been held so far. A new terminology is heard at these symposia. Phrases such as "product assurance," "confidence level," and "mean time between failures" are now fluently bandied about.

Progress has also been made on the theoretical level. Statistical and mathematical methods for analysis and prediction were explored, proposed and adopted.

One result of all this work is that such phrasing as "best engineering practices shall be used" in military contracts are being replaced with specific reliability numbers. Some of the major

DESIGN IN THE FIFTIES

1955

200 MILE MICROWAVE LINK

weapons systems now have reliability requirements written into them.

Human Error Cited

That there has been progress is undisputed. "But it is difficult to be precise about the degree," explained Sydney D. Scott, an engineering staff assistant at Arinc Research Corp. "This is because equipment improvements are masked by other influences. In brief, the effect of more reliable equipment has been counteracted to a great extent by a corresponding deterioration in the cali-

Modular Packaging Is Born, With Savings in Production

THE 1950's saw the introduction of modular packaging with accompanying production economies.

Project Tinkertoy, Government forerunner of modular construction schemes, came into being about 1953. Its objective was the automatic production of radio sets by a technique of assembling wafers. Each wafer contained a portion of the circuit, and many wafers were interconnected by a series of soldered wires.

In 1955 Malco Tool and Mfg. Co. announced development of an automatic printed circuit machine. Minnesota Engineering Co. also announced

AUTOMATIC AIRLINE AND RAILROAD RESERVATIONS

VITASCAN TV SYSTEM

LONG DISTANCE DIALING

ber of operating and maintenance personnel in the military establishments."

There is some truth in this statement, a Department of Defense official commented. But there are also many career-dedicated and extremely competent men in the armed forces, he added.

Most specialists agree that industry and the Government have come a long way in achieving more reliable electronic equipment—but that both still have much work ahead. ■ ■

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new printed circuit machinery that year, along with an automatic assembly machine.

Westinghouse announced in 1955 the revolutionary Cypak, a tool control without relays. The device was a combination of transistors and magnetic amplifiers.

Tape-controlled machine tools made their debut in the mid-1950's. Several companies announced schemes for automatically controlling machine tools. Some used magnetic tape, others punched tape or cards.

With increasing emphasis on space vehicles, the problem of size and weight spurred the trend toward miniaturization. In 1958 the Signal Corps and Radio Corporation of America began micromodule program. Circuits consisted of an assembly of single-component wafers. This miniature version of Tinkertoy resulted in 1959, with the availability of a few complete computer elements.

Diamond Ordnance Fuze Labs pioneered microminiaturization in another form. Combining etching and vacuum deposition techniques, the concern achieved microminiaturization devices in which a complete circuit was on one wafer.

In 1959 Texas Instruments announced solid circuits or molecular electronics. These experimental devices consist of a complete circuit grown or processed from a block of semiconductor material. Projects toward developing circuits of this type are now under way by other companies and the military. ■ ■

Ultrasonic Applications Spurt in Many Directions

ULTRASONICS is one of the fastest growing industries. With the development of less expensive, more efficient equipment, many new applications have evolved.

One of the most important was the development of Raytheon's ultrasonic machining equipment. Announced in 1954, it made possible precision machining of hard metals and materials, such as quartz.

Another application of ultrasonics was announced by the Veterans' Administration in 1954. Certain types of cancer and some mental disorders responded to ultrasonic treatment.

Sheffield Corp. expanded its Cavitron line of ultrasonic machine tools in 1954. Reed research in the same year perfected a system of nondestructive testing by ultrasonic means.

The year 1955 saw the development of an ultrasonic control for torpedoes by Westinghouse. General Ultrasonics Co. announced a method of descaling metals using an ultrasonic device operating at 19,800 cps. Also in 1955 Mullard, Ltd. introduced a line of ultrasonic soldering irons.

Acoustica introduced a high-efficiency magnetostriction transducer in 1956. These 400-watt units operated at 25 kilocycles. They could be grouped to produce a total power of 150 kilowatts.

Ultrasonic inspection equipment for rotors of jet engines was announced by Electro-Circuits in 1956. About the same time General Electric announced an ultrasonic method for treating paper and cloth for processing as insulating material.

Because of the fast growth of the industry, the Ultrasonic Manufacturers Association was formed in 1956.

In 1957 off-the-shelft ultrasonic cleaning units became available from Narda Ultrasonics Corp. Narda announced in 1959 portable missile cleaning equipment.

Almost every conceivable cleaning job of complex delicate equipment has come within the province of ultrasonics in the last few years. ■

Inner Secrets of Materials Probed for New Techniques

TREMENDOUS effort was put forth in the last decade studying, applying and manufacturing electronic materials.

In the field of microwaves, for instance, the use of ferrite materials in such devices as isolators, circulators and switches, initiated a new art that has matured in 10 years. Underlying these advances have been the development of knowledge in the solid-state sciences and its application to the control of matter. New electronic functions have been achieved thereby. The maser is an example of what resulted when the properties of basic materials were explored.

Thin film techniques, micromodules, integrated functional circuits—these, too, were the products of investigating the nature of material.

Semiconductor Search Pressed

Semiconductor materials were the object of intensive research. Germanium crystals of near-perfect physical and chemical properties were developed. And silicon, after much study, entered the field as an alloy junction diode; later it was used in transistors. Other research in semiconductor materials made the Hall-effect generator feasible.

The properties of ceramics were examined and then used to produce high-temperature components.

Intensive efforts were made to develop new insulation materials, based on new plastic and elastomeric resins, films and impregnants. These materials have contributed greatly to better performance, lower cost and miniaturization of components and equipment. Du Pont, for example, came out with such new materials as Mylar, Teflon and Viton, all synthetic rubbers. And the Rogers Corp. developed a copper-clad reinforced Teflon for high-temperature, low-loss circuitry.

Silicone for Insulation

Silicone was also introduced into the insulation field. Laminates, varnishes, resins, compounds and

IDEAS FOR DESIGN—*ENTRY BLANK*

To the *Ideas-For-Design* Editor of ELECTRONIC DESIGN —
830 3rd Ave., New York 22, N.Y. • PLaza 1-5530

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)

Name_____
Title_____
Company_____
Address_____

(Place illustrations on separate sheet if necessary)

DESIGN IN THE FIFTIES

1956

AVALANCHE DIODE

elastomers made with silicone have given designers more compact units.

Growing interest in environmental protection resulted in increased use of potting, filling and encapsulating techniques. Dow Corning, for example, developed high-temperature silicone materials that cure into hard, rigid structures and

Basic Research in Microwaves Spawns New Families of Devices and Systems

GROWTH in microwaves during the 1950's ha been explosive. New materials and concept came out of basic research and were made avail able to the component design engineer. As a re sult, whole new families of devices came int being.

At the other end of the spectrum, new and cha lenging military and commercial requirement led to development of entirely new system type These system requirements pressed the compo nent designer and researcher for the means t meet the systems' need.

Microwave Sources and Amplifiers

A mechanically tunable magnetron, marketed by Litton recently contributed to ECM protec tion of radar systems and to design flexibility o

ECCA NAVIGATION SYSTEM

4.5 MILLION WATT TV TRANSMITTER

SIDEWINDER MISSILE

others that cure into rubbery materials.

Among the many other areas of investigation was one to find conductive materials with much flatter temperature coefficients. Behind this was the wide range of temperatures in which some military equipment operated. Research in cryogenics holds promise of solving this problem. ■ ■

beacon systems. General Electric announced a voltage tunable magnetron that permits much more rapid tuning. In spite of the efficiency of the magnetron as a microwave source, the inherent limit on the power capacity of M-type tubes led to a reduced interest in them in favor of many O-type tubes developed.

The klystron started and ended the decade as the workhorse of microwave sources. Three developments made practical a power-handling capacity undreamed of before the 1950's.

The first was the convergent electron beam, which allows electrons from a large area cathode to be focused into a small, high-density electron beam. The second was the perfection of precision beam control, which prevents vaporization of the supporting tube structure by the beam itself. The third was the development of practical ceramic windows that permit the high-level energy to be coupled from the vacuum bottle to the pressurized transmission line.

These techniques are incorporated at the beginning of the decade first in Sperry's 40-kilowatt X-band *SAX*-22 and 4-megawatt L-band *SAL*-36. Since then, multi-megawatt sources have become practical and have made possible the enormous AEW radar systems and scatter propagation links.

Development of electrostatically focused klystrons brought the cost, power and heat losses of the klystron into line with many new applications, such as air-traffic control systems. Klystrons are now being developed with higher efficiency (in the order of 50 per cent), higher frequency (millimetric reflex klystrons and sub-

DESIGN IN THE FIFTIES

1956

TRANSATLANTIC TELEPHONE CABLE

MINIATURE VIDICON TUBE

SAGE NETWORK

millimetric dielectric tubes), broader bandwidth (up to 5 per cent) and lower noise figure (as low as 6.7 decibels). New multi-cavity frequency multipliers, rugged klystrons for extreme airborne and missile applications, grid-less construction and parametric operation have been perfected. Developments of this type promise for the klystron a prominent position among microwave sources for some time to come.

The progress of the traveling wave tube from a curiosity to a leading contender among sources and amplifiers is one of the most significant microwave developments of the decade. The long interaction time between wave and electron beam leads to very broad bandwidths, low impedance, low rf voltage, voltage tunability and high gain. Problems with this type of tube are the need for great accuracy in alignment of the long beam, high power consumption of the electromagnets and fragility of the helix at higher frequency.

Many advances in these problem areas have shown great promise recently. Periodic permanent magnet focusing and several forms of electrostatically-focused TWT's were announced.

Several other new sources have been developed. The backward-wave oscillator resulted from an undesirable characteristic noted in TWT's. It has become a useful laboratory source and ECM component because of its broad and rapid voltage tunability. The Carcinotron, developed in France, remains of interest. The amplitron, developed by Raytheon in 1958, has attained remarkable efficiency in the order of 80 per cent. Because it acts as a low-loss waveguide transmission line when not oscillating, it affords simplification of microwave plumbing.

Ferrites Facilitate Designs

Ferrites—ferromagnetics with low conductivity—have had a tremendous impact on microwave plumbing design. This very useful material has led to the development of isolators, circulators, phase modulators and many anisotropic (loaded) waveguide devices. At the close of the decade, new materials, such as yttrium and gadolinium, showed promise to extend the effectiveness of gyromagnetic art built around ferrites.

Parametric Amplifiers and Masers

The concept of parametric amplification brought forward many contenders for the prime component to take advantage of this technique. Ferrites have so far been overshadowed by TWT's because of power and weight. Semiconductor diodes appear to promise longer reaching benefits of cost and size, and are currently receiving consideration for this role.

Masers were of interest early in the decade because of their very low noise level. The development of parametric low-noise devices put masers in disfavor for most applications. However, for such uses as in radio astronomy, where noise is the most important consideration, masers, especially solid state types, are still the ultimate.

Solid-State Art Pressed

Much of the R&D work in microwaves toward the close of the decade has been devoted to solid-state microwave devices. The announcement this year of the tunnel diode has led to even greater interest in solid-state developments.

Among the systems most directly benefited by new component developments are high-power radars. As tactics demanded and tubes permitted, AEW radars increased their range and coverage until both coasts and the polar regions were protected by overlapping antenna patterns. Along with the new high power transmitters, advances were made in huge search antennas, scatter propagation links and a variety of special purpose aircraft, Texas towers and arctic equipment.

But in spite of all these developments, there is still a need for a new type of system to give reasonable warning of enemy ICBM's. A great deal of work is being done in phase-scanning stationary antennas and new detection and ranging philosophies of many types. Much has been learned from minitrack and other satellite-tracking systems developed during the decade. Along with new detection schemes, work is in progress on more efficient data-handling systems that will allow rapid identification and processing of many suspected targets. According to David B. Smith, vice-president for technical planning at Philco, the most significant achievement in microwaves has been the impact of information theory on the handling of information.

Doppler Navigation Radar Utilized

Doppler systems have become of great significance among navigation systems. One of the simplest and most versatile self-contained navigation systems, the Doppler radar has found favor in aircraft ranging from the B-58 Hustler jet to L-19 small observation planes and light helicopters. It is used as an aid to inertial systems and celestial-inertial systems because of its long range stability.

Much interest and work has developed in the last few years in satellite communication links that would allow ocean hopping and economical facsimile air mail. Progress has thus far been limited mostly to simulation work pending availability of satellite vehicles. A recent proposal by Raytheon for a helicopter platform, fed from the ground through a microwave power link, opens new fields for towerless microwave communication links, as well as an entirely new use of microwave equipment.

Among the many other system developments of the 1950's are an array of crossed-baseline tracking systems, such as Convair's Azusa, Cubic's DME and AME, and GE's system. These offer angular accuracies unattained before the start of the decade. Monopulse radar systems have accomplished almost equal advances in more mobile units. Work is in progress on the use of tunnel diodes and other components in microwave computing systems. ■ ■

SOLAR RADIOS

ULTRASONIC MANUFACTURERS ASSOCIATION

Air Navigation, Sorely In Need of Automation, Gets Electronic Assist

FEW FIELDS have required greater electronic progress in the last ten years than air navigation. Whether the progress made was sufficient for the needs is debatable.

In 1950 aircraft movement was controlled almost entirely by voice communications. In 1960 it will still be controlled by voice. But other aids have been developed and placed in operation.

In 1954 the Eclipse-Pioneer Div. of Bendix announced a transistorized autopilot. Its lighter weight and small size were important considerations for smaller aircraft. In the same year Bendix obtained manufacturing rights to the British Decca system of navigation. The Decca plots aircraft position on a map during flight. The system was demonstrated in the U.S. in 1956. A year later Sperry announced a transistorized autopilot for helicopters. It occupied only two cubic feet and weighed 60 pounds. In 1955 TACAN was declassified by the Air Force and made available for civilian use.

Lear and Collins Radio participated in a 1955 demonstration of a computer controlled aircraft flight in which vhf omni-range stations were automatically triangulated to determine positions.

Radio Web, a navigation system designed in France, was being promoted in the U.S. in 1957 by Gavid Engineering. Also in 1957, Laboratory

DESIGN IN THE FIFTIES

1957

for Electronics announced a new Doppler type of navigation system for jets.

Another important step in guidance systems was demonstrated in a B-29 flight from Bedford, Mass., to Los Angeles. An inertial guidance system developed by the aeronautical division of Minneapolis-Honeywell guided the plane across the U.S.

To assist air-traffic control, International Electronics Corp (Intec) disclosed in 1957 a scan converter designed to convert a radar display to a TV signal. It can be piped to a number of locations by using a form of closed-circuit television. The scan converter units were placed in operation in 1959.

In 1958 Intec announced the French development of triple-diversity radar. Its cost and com-

Inertial-Quality Gyro Paces Gains in Guid

IF ONE component development is to be singled out as having the greatest impact on guidance and control in the last decade, it is unquestionably the inertial-quality gyroscope.

Just a design goal at the start of the decade, drift rates of less than 1 per cent of the 15-degree-hour have become rate of the earth reality.

In inertial components the big design problems have been balance and bearing friction. Machining tolerances in small fractions of thousandths were not enough to maintain the ultra-precise gimbal balance under operating conditions. Any change or unbalance in the flow from the heat sources (such as the wheel motors) through the gimbal structure to the heat sink

TACAN

TAPE RECORDED TV

plexity, however, have limited the industry's interest in the equipment.

The Avion Division of ACF announced in 1958 the development of a system that showed the aircraft flight path continuously and automatically. This was a closed-circuit TV system.

Airport surface detection radar was installed at New York International Airport, Idlewild, N.Y., in 1958. Airborne Instruments Lab participated in the development and installation of this equipment.

In 1959 the Federal Aviation Agency formally inaugurated air-traffic control beacons into the New York control center. The beacons permit easier identification of aircraft in a high-density traffic area. ■ ■

yroscope

uidance and Control

would cause creep in the metal, resulting in intolerable shift of the point of balance.

Some superb engineering design, notably at the Instrumentation Lab of the Massachusetts Institute of Technology, has compensated for these effects sufficiently to maintain balance during operation.

Bearing Friction Solved

Overcoming gimbal-bearing friction has taken two distinct approaches. The MIT laboratory has developed the floated gyro design that has formed the basis for many or most of the advanced missiles of the last decade, such as Thor and Titan. It gained notice in 1958 when an air-

DESIGN IN THE FIFTIES

1957

SOLID STATE TELEPHONE SWITCHING

MADT TRANSISTOR

Inertial-Quality Gyroscope Paces Gains in Guidance and Control *(continued)*

plane guided by an MIT-designed Schuler-tuned SPIRE system was flown across the U.S. to within a stone's throw of its destination in California.

Another MIT-inspired inertial system, the SINS (Submarine Inertial Navigation System) gained attention during the first submerged crossing of the North Pole by the Atomic submarine Nautilus. Improved designs of this system will form the basis of navigation for a family of nuclear ballistic-missile submarines.

An air-bearing gyro, designed by ABMA and produced by Ford Instrument Div. of Sperry-Rand, constitutes the second approach to the gimbal-bearing problem. This design guided the Redstone, the nation's first successful inertially guided ballistic missile. It also guided the Jupiter IRBM and the history-making Jupiter C, which put the first U.S. satellite into orbit.

Spin Bearings Improved

With the sizable reduction achieved in gimbal-bearing friction, spin-bearing friction, negligible up to this point, began to be a problem. New methods developed by MIT to select bearings improved the situation temporarily. Basic research in materials helped reduce the "ridge" raised in the metal race in front of each rolling ball, substantially reducing the problem.

Unusual approaches to these problems have been undertaken in the closing few years of the decade. Experimental work is in progress in electromagnetic bearings and electrostatic (Gystat) bearings. In these devices the spinning member is set in motion in a vacuum at the start of a flight by an external power source. It is then allowed to "coast" for the remainder of the trip. It is anticipated that friction levels will be so low that the loss of angular velocity will be insignificant for at least days or weeks.

Another development, underway at Ford Instrument Co. and Chance Vought Electronics, would do away with the gimbal structure entirely. Three orthogonally mounted rate gyros would be rigidly attached to the missile frame at convenient points. The mechanical analog of inertial space, conventionally stored in the gimbal structure, would be replaced by a mathematical analog, stored in a digital computer.

Accelerometer Sensitivity Advanced

Accelerometers are at least as critical in inertial guidance systems as the gyros themselves. In Schuler-tuned systems, they are even more critical, since gravity limits the error buildup caused by gyro drift but not that caused by accelerometer error.

Until recently the most accurate and sensitive accelerometers were nothing more than pendulous rate gyros of the highest quality. Other designs, such as rotating bubbles, were attempted and approached byroscopic accelerometers. Up to now, one serious draw-back of the bubble type, in addition to lower accuracy, has been the inability to buck out gravity. Recent digital accelerometers developed by Arma and Bell Labs employ a vibrating string or a vibrating pendulum and a digitally controlled restoring force.

Base Line Systems Developed

But developments in guidance and control during the decade have not been limited to inertial devices. The principal of interferometry forms the basis of Convair's Azusa system. This crossed-baseline system was developed early in the decade and went into operation as range instrumentation at Cape Canaveral, Fla., in the middle of the decade. Its remarkable accuracy, primarily limited by anomalous propagation through the atmosphere, is supplemented by its ability to predict point of impact almost instantaneously.

A further development of this type of system was undertaken by General Electric in 1958. Simplified instrumentation, employing the same basic principal of operation, has been developed by Cubic Corp. over the last five years in several systems. These systems remain basically launch control and range safety instruments, because of the possibility of jamming and natural interference.

Optical Guidance Reconsidered

Celestial guidance reached a high-degree of precision in the Snark early in the decade and later in the Navaho. Because of the relatively slow cruise type of missiles then employed, errors in inertial guidance systems had time to build up to excessive values. The long-term accuracy of celestial systems led to their use as monitors. When missile speeds increased to the point that 20-minute flight time was near-maximum, celestial monitoring of the improved inertial systems became unnecessary. Now, with the advent of days-long space travel without benefit of Schuler-tuning, optical navigation systems are again receiving a great deal of attention.

The decade has been one of development of a remarkable array of guidance schemes. But more impressive than the variety of approaches has been the degree of success in developing working systems. The sight of a long, basically unstable ballistic missile standing on its fiery tail long enough to lift off the earth into space is still awe-inspiring. ■ ■

SPACISTOR

DOPPLER AIR NAVIGATION

RADIO WEB AIR NAVIGATION SYSTEM

Infrared Manufacturers Improve Detectors, Trackers and Scanners

INFRARED (IR) progress in 10 years has made possible better detectors, tracking systems and scanning devices.

General Electric, from 1952 to 1954, developed an infrared air-to-air, search-track system for night fighter planes. Work along these lines led to an air-to-air IR-guided missile, the Sidewinder. In 1956 the missile became operational. Other companies engaged in the Sidewinder project included Philco, Kodak, ACF and Bulova.

Many new IR detectors were announced in the late 1950's. Greatly improved units were being made in 1957-1958. More efficient and sophisticated detector cooling systems were also developed.

IR applications covered aerial photography. In 1951 Servo Corp. made the first IR aerial photo of New York City. Also in 1951 two Purdue University researchers discovered that germanium and silicon make excellent IR filter materials.

In 1954 GE demonstrated a trackside hot-box detector system for railroads. The following year Servo showed a detector designed to spot overheated journal boxes on moving trains.

Most of the recent advances in infrared are classified. With increased sensitivities of detection equipment, some heretofore unheard of applications have been disclosed. One company showed in 1959 IR photos that were able to detect where objects had been. A recent advance noted that hour-old wakes of submarines could be detected. ■ ■

DESIGN IN THE FIFTIES

RADAR DISPLAY SCAN CONVERTER

1957

3-D COLOR TV

Early Computers Come of Age in a Decade:

From Univac I to IBM and Remington Giants

THE FIFTIES may well be called the decade of the computer. Certainly there were computers before 1950, but they were striplings compared with the full-grown machines of the middle and late fifties.

In the broadest sense, one may regard early desk calculators as computers. Certainly one can consider the punched-card system, designed by Dr. Herman Hollerith for the 1890 Government census, as a true computer. (Hollerith founded the Tabulating Machine Co., which became the International Business Machines Corp. in 1914).

Later machines, like IBM's Harvard computer in 1944 and the University of Pennsylvania's Electronic Numerical Integrator and Computer (Eniac) in 1947 looked more like today's large-scale computers. But they were primitive by comparison.

The Harvard machine was electromechanical, using more than 3300 relays, 225 circuit breakers and 1210 ball bearings. With 1728 electromechanical counter wheels, it presented computations to 23 significant figures. Its program as well as logarithmic and other tables were stored on punched paper tape.

Eniac, with its 18,000 vacuum tubes, was the first large-scale electronic digital computer. It was internally programmed and used vacuum-tube, high-speed storage.

Gains Become Pronounced

The turn of the decade saw real strides in computer development. First came Remington Rand's Univac I, which was installed at the Bureau of Census in 1951. Then, in 1953, the IBM 701 offered 6250 times the capacity of the original Harvard machine.

Univac I used acoustic delay lines to store 12,000 binary digits. In its day it represented a giant step in the computer art. But with its arithmetic time, including access, of 525 μsec for addition, 2150 μsec for multiplying and 3950 μsec for dividing, it was very slow by today's standards.

Its basic pulse rate was 2.25 μsec, and it could read 12,800 characters per second from seven-channel magnetic tape. It used 5200 vacuum tubes of 15 types and 18,000 diodes.

The IBM 701 was the first large machine to use a floating decimal point. It used three types of storage: electrostatic cathode-ray tubes, magnetic drums and magnetic tape.

Its thousands of vacuum tubes and diodes allowed the machine to perform 16,000 additions or subtractions a second and 2000 multiplications or divisions. Its cathode-ray tubes stored the equivalent of 20,000 decimal digits; its drums the equivalent of 80,000 decimal digits, and each reel of magnetic tape 2,000,000 digits.

As the decade moved on, many different types of memory units were developed—each with its own advantages and limitations. Some were designed for very rapid access, others for large storage capacity.

Magnetic Tape Used

Punched cards and tape gave way to magnetic tape for speed. Magnetic drums provided much faster access than tapes, but they couldn't store as much data. Large arrays of vacuum tube flip-

Eniac (Electronic Numerical Integrator and Computer) looks pretty crude today. But in 1946 it was a marvel of high-speed data processing.

Installed at the Bureau of Census in 1951, Univac I was one of the first electronic data processors.

FERROMAGNETIC AMPLIFIER

A view of the console of Ramac 305 (Rapid Access Method of Accounting and Control), looking past the disk-storage unit.

flops provided very rapid access, but they were very power-hungry.

In 1956 solid-state techniques began to invade deeply the territory occupied by vacuum tubes. With the advent of faster and better transistors came the growing use of a most powerful memory element—the magnetic core. Core arrays provided extremely rapid access with very large storage capacity.

A novel fast-access, large-capacity memory device was used in IBM's Ramac 305 (Rapid Access Method of Accounting and Control). In Ramac a bank of 50 magnetic metal disks stores data on each side of each disk. The disk banks can be used singly or in pairs to store up to 20,000,000 digits.

(Continued on following page)

DESIGN IN THE FIFTIES

1957

PARAMETRON

PRACTICAL MASER

1958

One of the most obvious changes in computers during the Fifties has been the almost complete disappearance of vacuum tubes in favor of transistors. Today's transistorized computers can process far more information in far less time than could the computers of a decade ago.

Large Units on Market

Among the most modern large-scale computers on the market are Remington Rand's Univac Larc (Livermore Atomic Research Computer) a solid-state device, and the IBM 7090.

For speed alone, one can contrast the Larc's 4 μsec for repetitive additions with Univac I's 525 μsec. Larc's coincident current core memory can store 1,200,000 bits with 4 μsec access, and the capacity is expandable to almost five times that number.

Larc uses 62,000 transistor amplifiers and a fifth of a million diodes in addition to thousands of tiny magnetic amplifiers and a handful of vacuum tubes.

Thousands of ferrite cores in the IBM 7090 can store almost 1,200,000 bits with an access time of 2.4 μsec. The 7090 can multiply two five-digit numbers in less than 21 μsec. That's almost 25 times faster than the multiplication speed in the 701.

The 7090 system uses as many as 80 magnetic tape units, and it can perform eight simultaneous read, write and compute operations.

Engineers at work on one of IBM's proudest achievements, the 7090 Computer.

An artist's view of the Larc (Livermore Atomic Research Computer). This modern machine adds or subtracts a quarter of a million 12-digit decimal numbers per second.

Effects of Computers Cited

Looking back at the decade, one would find it difficult to select the most significant developments. IBM President Thomas J. Watson, Jr. believes that the significance lies in the profound changes that computers have brought about. He says:

"On one thing all are agreed—businessmen, scientists and economists alike—electronic business machines, and especially computers, are already beginning to change profoundly the ways in which we work, the ways in which we search for new knowledge and the ways in which we defend ourselves."

Remington Rand's vice president, Dr. Howard T. Engstrom, looks at another part of the picture—the fact that more people have learned to use computers.

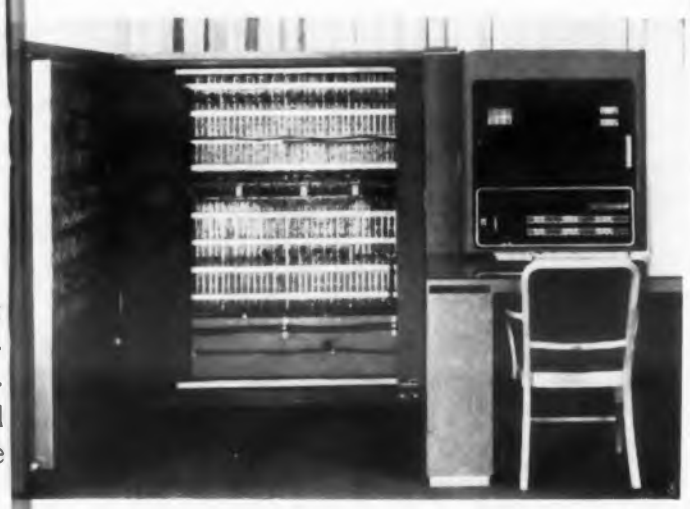
"The uses of these equipments," he says, "are extremely varied. In certain areas, such as the solution of differential equations in hydrodynamics, it is fairly clear that these devices are necessary. In other areas, such as in the guidance of missiles, where real-time operation is required, it seems also clear that this type of equipment is necessary.

"In the commercial areas, such as payroll calculations or insurance premium notices, the need for these high-speed equipments is not as clear intuitively, and I think the last 10 years have demonstrated the value of high-speed equipment in these areas."

Development Called Impressive

Computer development is viewed as impressive by Dr. G. W. Petrie of IBM's advanced systems development division. He says:

METEOR BURST COMMUNICATION



Main frame of the IBM 701.

"Some of the most competent to analyze the situation have estimated that each year during the past decade there has been a factor of improvement of ten in regard to computer speed, memory capacity, reliability and other significant factors."

Others in the industry see the modular principle employed in today's machines as most important. It allows computers to be expanded as the need arises.

Two divergent trends in the industry are apparent: one toward making specialized computers for special jobs, and the other greater versatility.

Dr. Charles R. DeCarlo, assistant general manager of IBM's data systems division, notes the trend toward versatility in pointing out that originally computers were designed only for scientific and engineering work.

"But today," he notes, "there is no area of science or industry that cannot benefit from an electronic system. Recently, for example, a program was devised for translation of English text into Braille on an IBM 704. The same computer is used by industry for design of petroleum processing plants. ■ ■

DESIGN IN THE FIFTIES

1958

Machine Replacing Man as System Engineering Pushes Out on 2 Fronts

SYSTEM engineering has exhibited at least two strong trends in the last decade.

The first is that of moving the dividing line between man-performed and machine-performed functions further in favor of the machine. The second is toward a closer alliance between design and long-distance objectives.

Man has been removed as a system component wherever possible, largely through automation of low-level decisions and through systematic study of his information requirements. This trend became necessary as reaction times shrunk and decision complexity grew beyond the capability of the one-channel, low band-pass characteristics of man.

Where 11 men were required to operate the many sub-systems of the B-52, operational in the mid-1950's, a three-man crew operates the faster and more complex B-58 Hustler weapon system. The weapons system that emerged during the decade was a result of the need for decision simplification, as well as greater control of the weapon design and production program. Greater use of digital computing equipment in airborne applications—such as the Hughes fire control computer—was brought about in the mid-1950's

AMPLITRON

SILICON-CONTROLLED RECTIFIERS

Since then flight-management computers have been developed recently by Litton and Librascope, and the ASN-24 digital navigation computer, by Librascope, promises to extend machine operations to non-decision functions for aircraft crews. Microminiature modules make the increased equipment complexity tolerable.

The contact-analog display concept, developed under the joint Army-Navy Instrumentation Program (ANIP), is an example of removing the human element from the control system. Extensive study determined the minimum of information needed by the pilot of a high-speed aircraft and the type of presentation most readily assimilated. A control system for the aircraft was then designed by Bell Aircraft, Douglas, Kaiser Industries and others in view of these findings.

A similar program, Submarine Integrated Control (SUBIC), is in progress at Electric Boat. It is designed to accomplish a similar dehumanized control system for submarines.

These programs also typify the intensified effort to bring equipment design more completely in line with what it is supposed to accomplish. This is part of the second trend exhibited by systems during the decade—the greater use of operations research (O-R) before system design is undertaken. These techniques, born during World War II, have been employed to reduce design waste and increase ultimate effectiveness of systems.

O-R and feasibility study techniques have been applied to great advantage in designing the super systems that have appeared in the decade. The radar warning net as a system had to take into account the strategic defense objectives to be achieved. The SAGE equipment integrates this and many other sources of input information into a continental defense network. This multi-billion-dollar program is an example of equipment design oriented to a single system objective on the grand scale. Other systems of comparable scale are under consideration for other purposes, both military and civilian. ■ ■

DESIGN IN THE FIFTIES

SIGNAL CORPS MICROMODULE

1958

SELECTIVE CALLING SSB MOBILE RADIO

Instrument Trade Blends Old With New;

Solid States and Etched Circuits Used

IN INSTRUMENTATION one can see some of the decade's evolutionary changes in electronics, as well as some of its most dramatic absence of changes. Many of the instruments in laboratories seems to have been around forever. Yet they continue to provide faithful and reliable service year after year.

An example of an instrument that has remained virtually unchanged for almost a generation is General Radio Company's Type 650 Impedance Bridge. Known by many as the "old, reliable workhorse," it continues in daily use on lab benches throughout the country.

But as the electronics industry moved forward in the last 10 years, so did requirements for wider measurement ranges, greater convenience in handling and measuring, and accuracies even better than what the 650 could provide.

Old and New Combined

The Type 1650-A Impedance Bridge was General Radio's answer. It includes all the desirable features of the 650—and more. With the 1650-A, one can measure dissipation factor and Q with an accuracy of 5 per cent over the entire range of the bridge. That's four times better than the 650 at the lower extreme of its range.

The new instrument includes a patented Orthonull feature, which permits measurement of low-Q inductors and high-D capacitors without a sliding balance. This permits much more rapid readings. The new bridge is housed in a case whose cover can be tilted to hold the instrument at any convenient angle.

Another example of change in instrumentation over the decade is Hewlett-Packard's Harmonic Wave Analyzers. The 1950 Model 300A covered the frequency range of 30 to 15,000 cps. The newer Model 302A covers 20 to 50,000 cps. The 300A weighs twice as much as the transistorized 302A and consumes 35 times as much power.

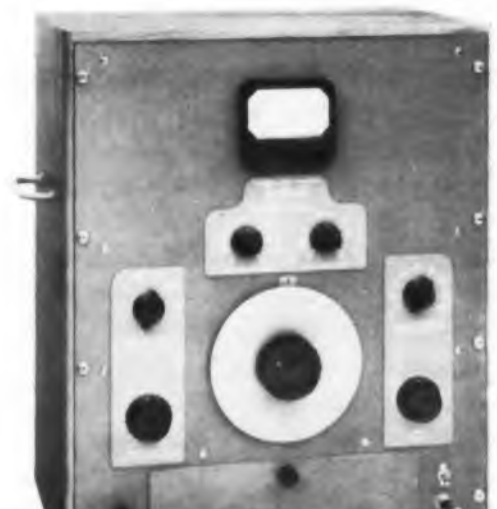
Such improvements symbolize the changes in many instruments by many manufacturers to meet the growing challenges in the industry.

Three Leading Developments

It is difficult to pinpoint the single most significant development. Most authorities would

General Radio's Type 650 Impedance Bridge has remained virtually unchanged for almost three decades.

G-R's Type 1650-A includes all the best features of the 650 and higher accuracy and greater convenience in use.



Hewlett-Packard's Model 300A Harmonic Wave Analyzer of 1950.

AIRPORT SURFACE DETECTION RADAR

H-P's modern, transistorized Model 302A Wave Analyzer surpasses its predecessor with extended range, greater sensitivity and a host of other features.

agree with the comment of General Radio's engineering manager, Ivan G. Easton, who says:

"The most significant developments in the past 10 years are the growing use of transistors and other solid-state devices and the use of etched circuits. In the past five years the single most important development is probably the increasing use of digital techniques in instrumentation."

Hewlett-Packard's director of development, John Cage, points to four developments he considers most significant:

- "The development of photoconductive modulators to measure a microvolt or so of dc voltage by converting it to an ac voltage."
- "The development of the 'clip on' concept, as exemplified in the clip-on dc milliammeter."
- "In the oscilloscope field, the development of the sampling scope for display of extremely fast repetitive pulses."
- "In the microwave field, the development of broadband, accurate attenuators and broadband couplers with improved directivity. Of equal significance is the development of a precision, broadband slotted line for waveguide measurements." ■ ■

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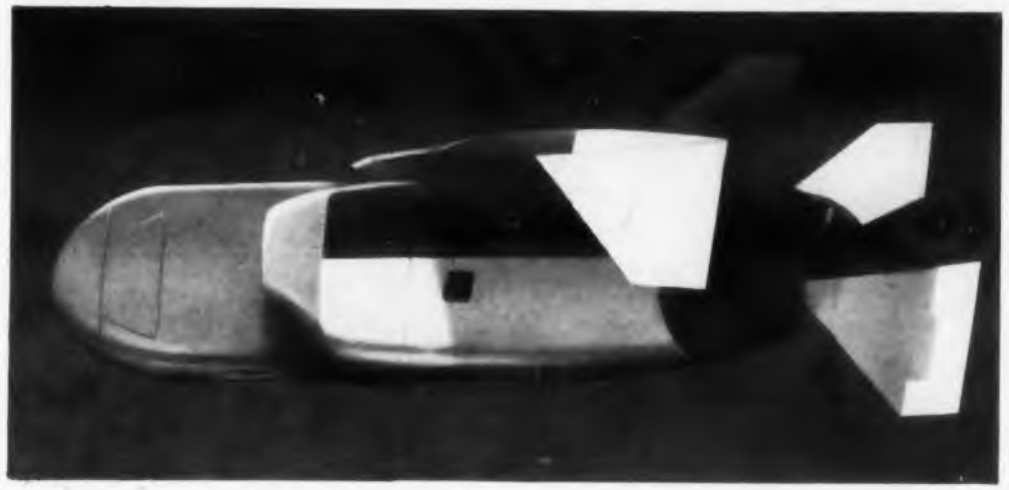

"QUAIL" Contact Arc Suppression Problems
solved with GLOBAR® silicon carbide varistors

Less publicized than its more spectacular cousins, the "Quail" decoy missile, shown above, nevertheless represents an important development of the missile art. It is designed for air launching from bombers such as the B-47 and B-52 and, once in flight, is under continuous radio control. The Quail is powered by a GE J-58 engine and is manufactured for the Air Force by McDonnell Aircraft of St. Louis.

The electronic control circuits involve many relays. Contact arc suppression and suppression of RF interference are achieved with GLOBAR silicon carbide varistors. Choice of these components results from their extreme ruggedness, small size, reliability and excellent performance characteristics — all essential in missile applications.

Catalogs on types, ratings and other characteristics of varistors and other forms of silicon carbide resistors are obtainable by writing to Globar Plant, Refractories Division, Dept. EDS 129, The Carborundum Company, Niagara Falls, N. Y.

Circle 804 on Reader-Service Card

NEW HIGH TEMPERATURE RESISTORS
handle up to 25 watts at 1000F. with no de-rating

Limited quantities of high temperature resistors developed by Carborundum are now available. These answer a definite need in many defense and possible commercial electronic applications. They may be well suited to equipment where nuclear radiation is present, since the materials from which they are made have relatively low sensitivity to induced radio activity.

RESISTANCE RANGE

Watts	Size	Resistance Range
0.5	3/8" x 1/8"	0.2 – 2 K
1.0	11/16" x 1/8"	0.4 – 4 K
2.0	13/16" x 1/8"	0.8 – 8 K
5.0	1 1/4" x 5/16" (i.d. 0.168")	0.1 – 1.8 K
10.0	2" x .4125" (i.d. .288")	0.2 – 2.3 K
25.0	4" x 1/2" (i.d. 3/8")	0.1 – 1.1 K

Terminations are suitable for spot welding or brazing. Fuse clip terminations are also offered in the larger sizes. Write to Globar Plant, Refractories Division, Dept. EDS 129, The Carborundum Company, Niagara Falls, N. Y.

Circle 805 on Reader-Service Card

High Purity MgO Swaging Tubes for Thermocouple Insulation

Insulation of thermocouple wires, used in such equipment as gas turbines and nuclear reactors, involves stringing them through a tube of sintered magnesium oxide, inserting in a stainless steel sheath and then swaging.

For correct packing of the MgO insulation, which is crushed in the swaging operation, close tolerances apply to diameters and location of the holes in the swaging tubes. MgO must be of high purity, particularly for nuclear work.

These tubes are typical of the many examples of magnesia, alumina and zirconia insulating ware made by Carborundum and widely used in electronic components. For information, write Latrobe Plant. Refractories Division, Dept. EDS 129. Carborundum Company, Latrobe, Pa.

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NEW BOOKLET AVAILABLE ON KOVAR® ALLOY

KOVAR is an iron-nickel-cobalt alloy used for making hermetic ceramic- or glass - to - metal seals. It has applications in many types of electronic equipment. This booklet is a complete catalog of specifications and applications. For your copy write Latrobe Plant, Refractories Division, Dept. EDS 129, Carborundum Co., Latrobe, Pa.

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DESIGN IN THE FIFTIES 1958

Power Supplies Meet Challenge Of Military Needs

MILITARY needs and the availability of new and improved components have sparked substantial progress in electronic power supplies in the last 10 years.

The military needed power supplies that could operate in severe environments. And it needed smaller and smaller sizes, so more complex equipment could be installed in high-performance, cramped vehicles or carried by fewer personnel.

Referring to components used in power supplies, a representative of Leach Corp. said:

"In 1950 the large majority of power supplies used vacuum tube rectifiers and regulation systems. During the last nine years a switch has been made to semiconductor elements and magnetic amplifier control and regulation systems."

Controlled Rectifier Advance

The advent of the silicon controlled rectifier last year produced a further improvement in power-supply performance, with minimum size and a minimum of components.

How much improvement was made? In the area of miniaturization, "factors better than an order of magnitude have been the rule rather than the exception," said a spokesman for Microwave Associates, Inc.

Regulation is another criterion. An engineer at Mid-Eastern, Inc., says: "Regulation has about reached the limit of practicability. That is, the regulation of 0.01 per cent achieved in today's models is sufficient for the foreseeable future and is not likely to increase, since there is no need for greater accuracy."

Improvements have also been made in re-

(Continued on page 60)

PARAMETRIC AMPLIFIER

TRANSISTORIZED MOBILE RADIO

Medical Electronics Slashes Death Rate

MAN—whether in a hopsital operating room, a dentist's chair, a physician's examination room or a test chamber for outer space—has been the beneficiary of remarkable advances in medical electronics in the decade.

One example of the progress was the introduction of cardiac monitoring and resuscitation equipment. "It saved at least 60 per cent of the approximate 10,000 deaths that occur each year in the operating rooms due to a condition known as 'cardiac arrest,'" a spokesman for Birtcher Corp. explained.

The decade also saw advances in treating brain tumors with tracers and neutron beam surgery. Measurements in inaccessible body areas were also made possible. A "radio pill" that a person swallows was introduced; it transmits information on the alimentary canal. And miniature microphones were made for use inside a person's heart.

Ultrasonics Aids Medicine

Much research went into the application of ultrasonics to medicine. This work was conducted in bacteriology, dentistry, and medical therapy and diagnosis.

Analysis of tumors for malignancy, particularly brain-tumor detection, is a diagnostic application of ultrasonics. In therapy ultrasonic research was concerned with such areas as tissue diathermy, brain surgery and tumor inhibition. It is estimated by the Birtcher Corp. that over 25,000 therapeutic ultrasonic units were sold in the United States from 1950 to 1959.

Some contend that most of the advances in medical electronics have occurred in the last three

(Continued on page 60)

DESIGN IN THE FIFTIES

1959

PUSHBUTTON TELEPHONE DIALING

COMMERCIAL MICROMODULES

Power Supplies *(Continued)*

sponse, recovery, overshoot and in the elimination of transients. These were prompted by the ever increasing use of transistors.

Ripple has been reduced, too. In most supplies it is around 1 millivolt. This has been the result of reduced noise levels in all types of receiving equipment.

Battery 'Revolution' Reported

Battery power sources have gone through a "revolution" in the last decade, according to a representative of Yardney Electric Corp. He said the major progress consisted of achieving high-energy, lightweight systems. There has also been a growth of battery systems previously known but not sufficiently explored—the silver-zinc, silver-cadium and nickel-cadmium systems.

Development of the transistor prompted great advances in the battery industry. It was "the single most important advance," the Yardney representative said. The transistor reduced the power requirements of electronic equipment and allowed the broadening of battery-power applications to extents never thought possible in 1950. ■ ■

Medical Electronics *(continued)*

years—the period in which the possibility of sending a man into outer space has become more realistic.

Space Medical Equipment

Gulton Industries, Inc., has been particularly active in space medical work. It has developed simple devices for the safety of the space pilot and for finding out the physical effects that space has on man. These instruments include ones for measuring skin temperature; breathing flow, rate and volume; heart rate and sounds; systolic blood pressure; galvanic skin response, and brain waves.

How far medical electronics has come in the last decade was dramatically illustrated in May, 1958. Capt. Norman Lee Barr, chief of space medicine and surgery for the Navy, was in his office in Maryland. About 40,000 feet over Minnesota, 1200 miles away, a Navy balloonist swung in the air. By means of transducers and communication equipment, the captain discovered that the balloonist was developing a dangerous high-altitude reaction called Wolff-Parkinson-White syndrome. The captain ordered the balloonist down immediately—and probably saved him from becoming incapacitated. ■ ■

Beta-gamma meter, an air-ionization chamber type, is typical of styling of commercial nuclear instruments in use at start of decade.

TUNNEL DIODE

MESA TRANSISTORS

Nuclear Instrumentation Shares Only Slightly In Upheaval of 1950's

OF ALL AREAS, nuclear instrumentation probably participated least in the electronic revolution of the Fifties. The character of nuclear electronic design was set in the 1940's and it changed relatively little in the eventful decade now closing.

Though nuclear instruments today are more rugged, reliable, versatile and efficient, they are essentially the same ones developed for research over ten years ago. Only one significant device, the multichannel analyzer, is a development of the Fifties. This instrument, however, illustrates one of the two factors of the last decade that are influencing design of nuclear electronics—the growth of data processing. The other influence is the availability of transistors.

With the rise of data-processing techniques, more and more data collected by instruments in nuclear applications are being handled and analyzed automatically. The multichannel analyzer, particularly the 256-channel unit, is the first instrument designed specifically to take advantage of automatic data processing.

The transistor, with its low power requirements, has changed the design parameters for many instruments. This is true particularly in scalers and ratemeters, where the transistor is being used in switching circuits. But tubes are still good enough and often more reliable for many non-switching applications.

The growing use of plastic and liquid scintillator materials, especially sodium iodide, has

DESIGN IN THE FIFTIES

1959

also affected design parameters. Sodium iodide fluors are giving twice the light output of some organic materials.

Other developments include:

- The growth to maturity of scintillator design.
- The development of versatile gamma-ray spectrometers.

Radio-Frequency Interference, Once a Scorned Imperfection, Looms as Peril to Progress

TEN YEARS ago most design engineers were unmindful of one of the most glaring weaknesses in electronic equipment and systems—radio-frequency interference (RFI). A sizeable percentage of the minority who considered the problem and its disastrous consequences were either too busy to act or reluctant to "clean up" their equipment when other devices would foul them anyway.

A small but devoted group of engineers had enough foresight to envision the chaos that would

SOLID CIRCUITS

PORTABLE ULTRASONIC MISSILE CLEANER

■ The application of linear pulse amplifiers.
■ The use of gas-discharge tubes, such as the Dekatron and trochotron in counting circuits.

A development in reverse was the spread to other areas of electronics of random pulse counting techniques uncovered by nuclear electronic researchers. ■ ■

result from the multifold increase in electronic usage if RFI was not curbed.

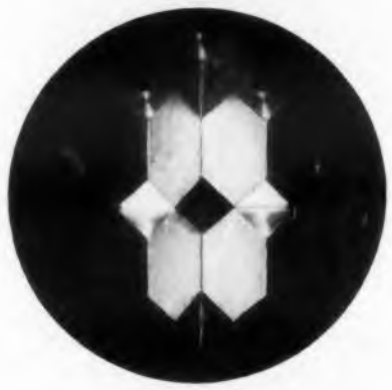
Armour Research held the first conference on interference reduction in 1954. In the next two years other groups tried to form committees on the subject. Then, in 1957, IRE's Professional Group on Radio Frenquency Interference was established.

Spearheaded by engineers in the military and the IRE group, a concentrated program has been hammering home the need to consider RFI during initial design stages of equipment and systems.

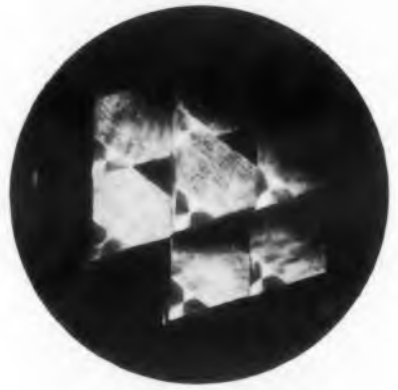
Independent companies have been set up as specialists in RFI control, and most large organizations have RFI groups busily examining new designs for compliance with military specifications. Experts all emphasize that filters, cable routing shielding and other forms of RFI relief can be applied best during equipment design. Tacked on as an afterthought, they increase size and costs substantially.

The rising use of prediction techniques, aided by high-speed computers, has made possible the planning and installation of large-scale military and industrial "electronic cities," with a minimum of interaction between equipment. Similar prediction techniques have been applied in "war games" to evaluate spectrum allocation and priority without loss of communications.

By combining prediction techniques, initial design considerations and proper selection of suppression techniques, RFI control can be successfully achieved, the experts say. ■ ■



How to Choose
The Right Ferrite For the Right Job



Dr. Albers-Schoenberg and Dr. Bachman believe that the field of ferrites has grown so rapidly in the last few years that an up-to-date review of the field would be useful. Hence this article.

Dr. Albers-Schoenberg (seated) is deeply interested in ceramics of all kinds—from Dresden china to chemical stoneware, steatites, alumina, and last, but by no means least, ferrites. He was a member of the commission which decided upon the four-fold classification of ferrites which appears in this article.

One of Dr. Bachman's favorite possessions is an ashtray in which a barium ferrite disk, grooved to hold cigarettes, is suspended above a conventional ashtray by magnetic repulsion. Dr. Bachman likes to spin the disk. Incidentally, he is a non-smoker.

Ernst Albers-Schoenberg George S. Bachman
General Ceramics Corp. Keasbey, N. J.

THE LAST DECADE has seen such a growth in the number of ferrite types available that the design engineer is often hard-pressed to determine which ferrite to use. The wide variety of applications, evident in the *Ferrite Application Chart* in this article, emphasizes the need for an up-to-date roundup.

Ferrites—as the term is used in electronics—may be defined as magnetic compounds containing iron oxide made by a ceramic manufacturing process. Most ferrites are combinations of one or more bivalent oxides with trivalent iron oxide.

They cover a wide range of electrical resistivity. At one end of the scale there are manganese-zinc ferrites with resistivities of only 10 to 100 ohm-cm; while at the other extreme, some manganese-magnesium ferrites have high resistivities, some as high as 10^9 ohm-cm.

All of them are much less conductive than the magnetic metal alloys. This relatively low conductivity suppresses eddy currents and favors the use of ferrites at high frequencies. Ferrites are generally used above 1000 cps, and metals below.

Ferrites became commercially available about 15 years ago. Since that time several groups have been developed for different purposes. A useful system of classification divides them into four main groups:

1. "Soft" magnetic ferrites,
2. Permanent (or "hard" magnetic ferrites),
3. Ferrites for the storage of information, and
4. Ferrites for gyromagnetic effects.

The terms "hard" and "soft" came into use many years ago when permanent magnetism was observed as a property of steel, and easily reversible magnetism a property of soft iron. These two terms are still useful, though they do not apply in a mechanical sense. The hysteresis loop of Fig. 1 illustrates terms describing various magnetic properties of ferrites.

1. Soft Ferrites

A "soft" material has a rounded, S-shaped hysteresis loop. The loop is narrow, indicating a low coercive force (Fig. 2). The two principal sub-groups of soft ferrites are the manganese-zinc ferrites and the nickel-zinc ferrites.

Fly-back transformer cores for television sets are manufactured from a manganese-zinc ferrite. Table 1 gives some typical values for this kind of ferrite.

As for the other sub-group, nickel-zinc ferrites, there are two types: One is dense-fired with a high permeability; the other is porous with a low permeability.

The dense-fired type, most of the members of which contain a small amount of copper oxide, is widely used for recording heads, pulse transformers, and tuning slugs for width control. Important property values for this ferrite are shown

Table 2.

The porous type of nickel-zinc ferrite, with its reduced permeability and lower losses, is well known as an antenna material in broadcast receivers and is also used for cup cores in if transformers for transistor broadcast receivers.

This material is made in several modifications to cover the entire frequency range from 1 to 200 mc. No single material can do this. Typical values appear in Table 3.

2. Hard Ferrites

This group comprises the ferrites used as permanent magnets. Although there are several ferrites that can be used as permanent magnets, only barium ferrite is made commercially.

The hysteresis loop for this material is shown in Fig. 3. The second-quadrant portion of the curve is called the "demagnetization curve," and the product of the coercive force (H) and induction (B) for each point along the curve yields the so-called "energy product" (BH). The maximum energy product is usually taken as a figure of merit characterizing the strength of a permanent magnetic material.

When barium ferrite magnets first appeared on the market they were of the unoriented type—i.e., they consisted of aggregates of hexagonal, plate-shaped particles, randomly directed. In this condition they produce relatively low-energy products of approximately one million gauss-oersteds.

However, if the hexagonal plates are aligned before the final firing, energy products of 2.8 x 10^6 to 3.5 x 10^6 gauss-oersteds can be achieved. The alignment or orientation is carried out in a strong magnetic field.

Oriented barium ferrites are now available commercially. Table 4 compares unoriented and oriented barium ferrites with some magnetic alloys.

3. Square Loop Ferrites

The hysteresis loop for the third group of ferrites, useful for the storage of information, is characterized by a high-remanence point and two very distinct "corners." Such a loop is termed "rectangular" or "square" (Fig. 4). These ferrites are found predominantly in the three-oxide system of magnesium, manganese, and iron; some of these contain small additions of other oxides.

Because of its stability in the state of remanence, a toroidal core of square-hysteresis-loop material is a switching device in which the internal change of domain orientation takes the place of a moving mechanical part. An important use of this material is in the memory systems of electronic computers.

A significant property of ferrite memory cores is the speed with which they can switch. It is in the range of 0.3 to 6 μsec. Table 5 sets forth the

Table 1. Typical Properties of Manganese-Zinc Ferrites

Initial Permeability (at 100 kc)	1500-2000
Maximum Permeability	3600-5000
Saturation Flux Density (gauss) (at 25 oe)	3600-5200
Remanence (gauss)	1000-1600
Coercive Force (oersteds)	0.15-0.20
Curie Point (deg C)	180-250
Power Loss (mw/cc) (at 16 kc, 1600 gauss)	85
Volume Resistivity (ohm-cm)	1000

Table 2. Typical Properties of Dense-Fired Nickel-Zinc Ferrites

Initial Permeability (at 1 mc)	550-850
Maximum Permeability	3800-4300
Saturation Flux Density (gauss)	2800-3400
Remanence (gauss)	1500
Coercive Force (oersteds)	0.18-0.35
Curie Point (deg C)	125-150
Volume Resistivity (ohm-cm)	10^4 to 10^5

Table 3. Typical Properties of Three Porous Zinc Ferrites

Initial Permeability (at 1 mc)	125	40	14
Maximum Permeability	400	115	42
Saturation Flux Density (gauss)	3300	2400	2600
Coercive Force (oersteds)	2.1	4.7	21.0
Curie Point (deg C)	350	450	—
Volume Resistivity (ohm-cm)	$>10^6$	$>10^6$	$>10^6$
Q-Factor	400 (at 1 mc)	250 (at 10 mc)	250 (at 100 mc)
	60 (at 10 mc)	170 (at 50 mc)	70 (at 200 mc)

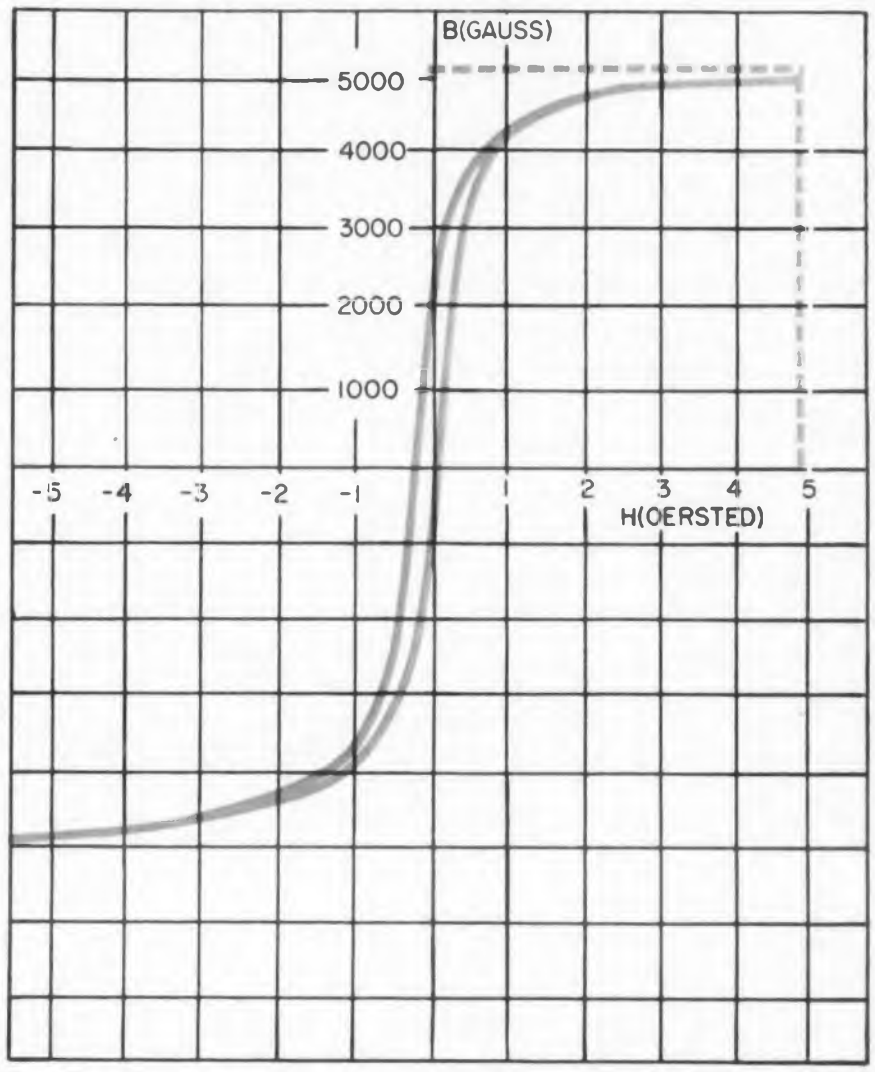


Fig. 2. Narrow hysteresis loop of a soft ferrite (Mn-Zn) shows the low coercive force.

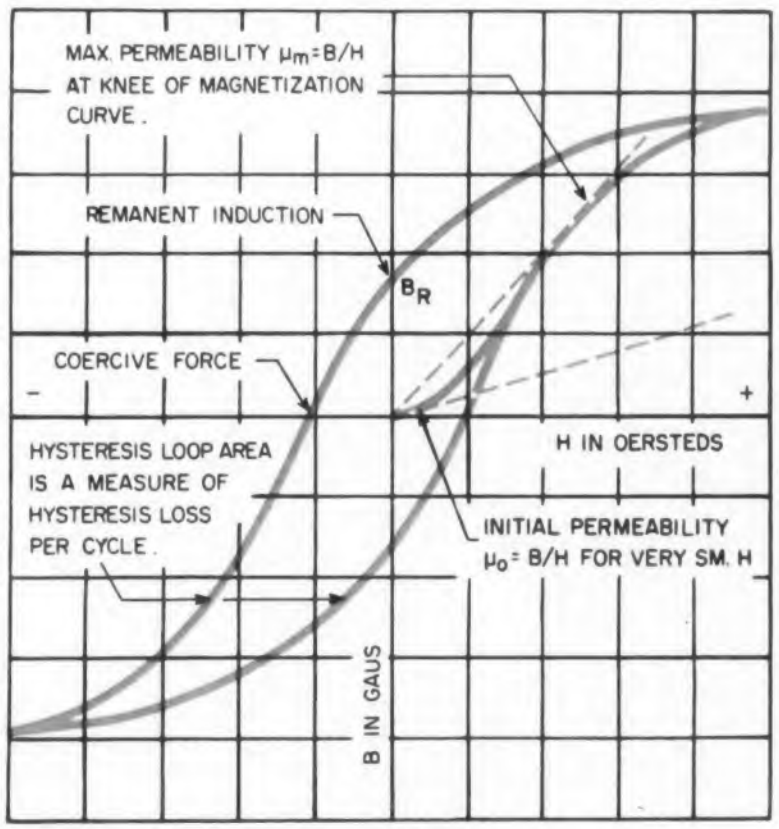


Fig. 1. Hysteresis loop shows magnetic properties of any device at a glance.

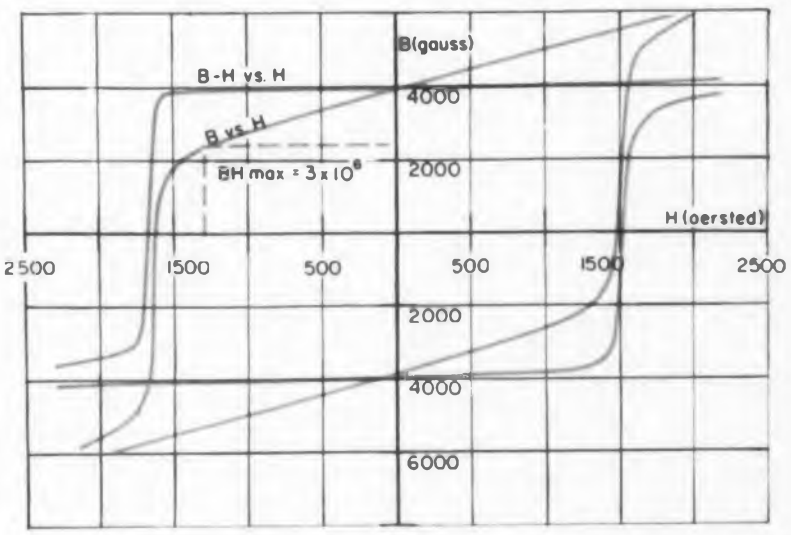


Fig. 3. Hysteresis loop of a barium ferrite permanent magnet. The maximum energy product (BH) serves as a figure of merit for permanent magnets.

magnetic properties of some commercial square-loop materials.

Cores of the first type shown in Table 5 are used in coincident-current memory devices. Those of the other type, which have a much lower coercive force, find application predominantly as switch cores.

4. Ferrites for Gyromagnetic Effects

Some ferrites are useful in the microwave frequency range from 500 to 30,000 mc. The microwave beam interacts with the electrons which carry the magnetic moments in the ferrite, causing a rotation of the plane of polarization of the beam.

This effect is used in the microwave gyrator in which a microwave beam can pass through the device in one direction, but cannot pass through in the reverse direction (Fig. 5).

Other microwave ferrite devices use the absorbing ability of the electrons when they are in resonance with the incoming microwave beam. Table 6 gives the magnetic properties of some microwave ferrites.

The shape and position of the resonance line (Fig. 6) is important, particularly at low microwave frequencies (below 2000 mc) where a narrow line width is usually desired. However, the line width of polycrystalline ferrites, which is about 200 oersteds, is not the only property to be considered.

The absorption loss, which includes dielectric as well as magnetic losses, must also be taken into account. Ferrites with high volume resistivity (10^9 ohm-cm or higher) are required for low dielectric loss.

The saturation magnetization is important since it indicates the amount of interaction that can be expected between the microwave beam and the ferrite.

Outlook for the Future

Ferrites are so new and their development so rapid that the future should see many improvements. For the lower frequency range, ferrites with a higher saturation flux density should be developed. In the medium permeability range, ferrites with less variation of initial permeability

Table 4. Important Properties of Magnetic Metal Alloys and Ferrites

Material	BH_{max} (10^6) (gauss-oersted)	B_r (kilogauss)	H_c (oersted)
Alnico II*	1.6	7.2	560
Alnico V*	5.25	12.5	600
Alnico XII*	1.6	5.5	950
Cunife I*	1.3	5.4	500
Platinum-cobalt	3.8	4.5	2600
Ferramic P1† (unoriented)	1.0	2.2	1825
Ferramic P2† (oriented)	3.5	3.84	2000

*Indiana Steel Products, Inc. †General Ceramic Corp.

Table 5. Typical Properties of Two Square-Loop Ferrites

Initial Permeability (at 1 mc)	40	100
Maximum Permeability (dc)	900	6000
DC Saturation Flux Density (gauss) at H=25 oe)	2000	3500
Coercive Force (oersteds)	1.4	0.20
Switching Time (μsec)	1.0	Varies with driving current
Br/Bm Ratio	0.90	0.95

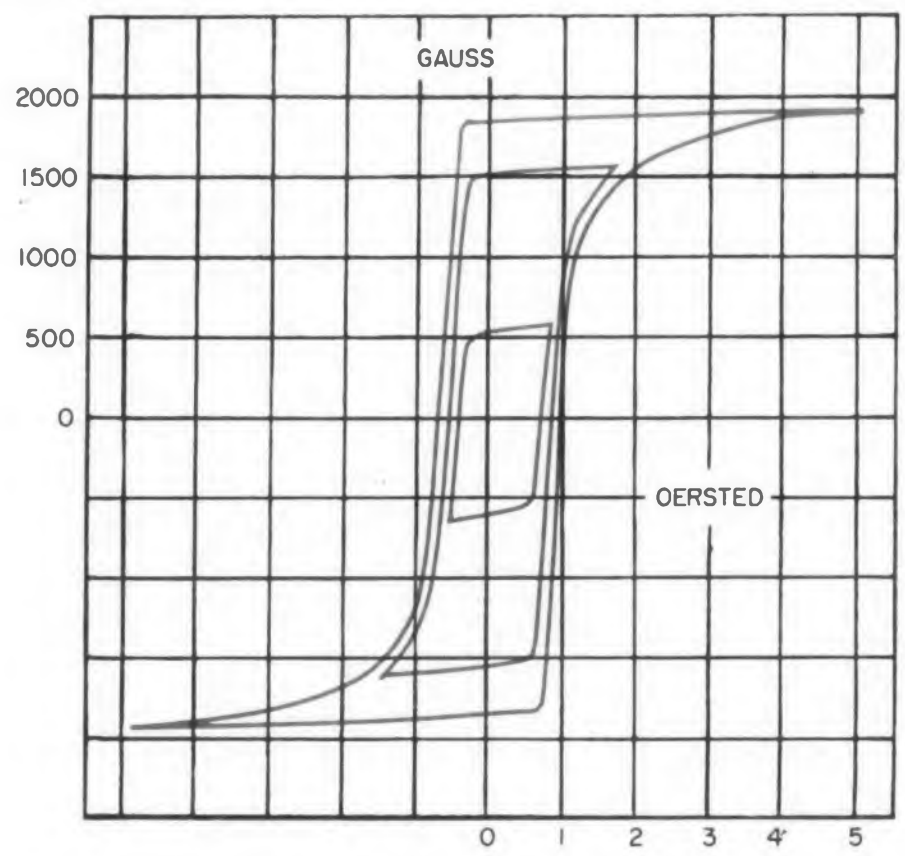


Fig. 4. Hysteresis loop of a "square" ferrite (Mg-Mn). The high, stable remanence makes "square-loop" ferrites ideal for storing information.

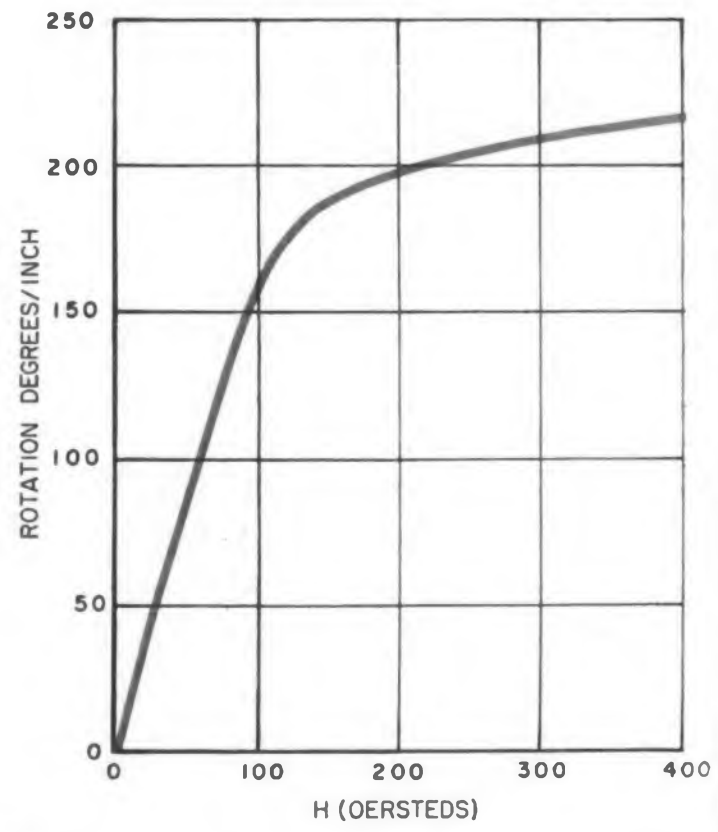


Fig. 5. Faraday rotation for a microwave ferrite (1/4 in. diam, 1 in. long) at X band (5.2-10.9 kmc).

ith changing temperature may be anticipated, nd their use in filters for military and telephone quipment should increase.

In the square-hysteresis-loop category, low-oercivity ferrites should find use with transis-torized circuits. In the microwave field many more specialized materials may be expected. Single crystals may find use in certain cases.

Magnetostrictive materials may be made commercially, thus adding another category of ferrites to the existing four. ■ ■

Reference

E. Albers-Schoenberg, "Ferrites," *Journal of the American Ceramic Society*. Vol. 41, No. 11, Nov. 1958 (Part II), p. 484. For literature references, see this article.

Table 6. Typical Properties of Four Microwave Ferrites

Initial Permeability (at 1 mc)	40	65	70
Maximum Permeability	470	420	480
Flux Density (gauss) (at H=50 oe)	1800	1200	800
Remanence (gauss)	1500	800	500
Coercive Force (oersteds)	1.4	0.8	0.7
Minimum Density (gm/cc)	4.15	3.95	3.90
Curie Temperature (deg C)	320	140	100
Q-Factor (at 1 mc)	15	50	38

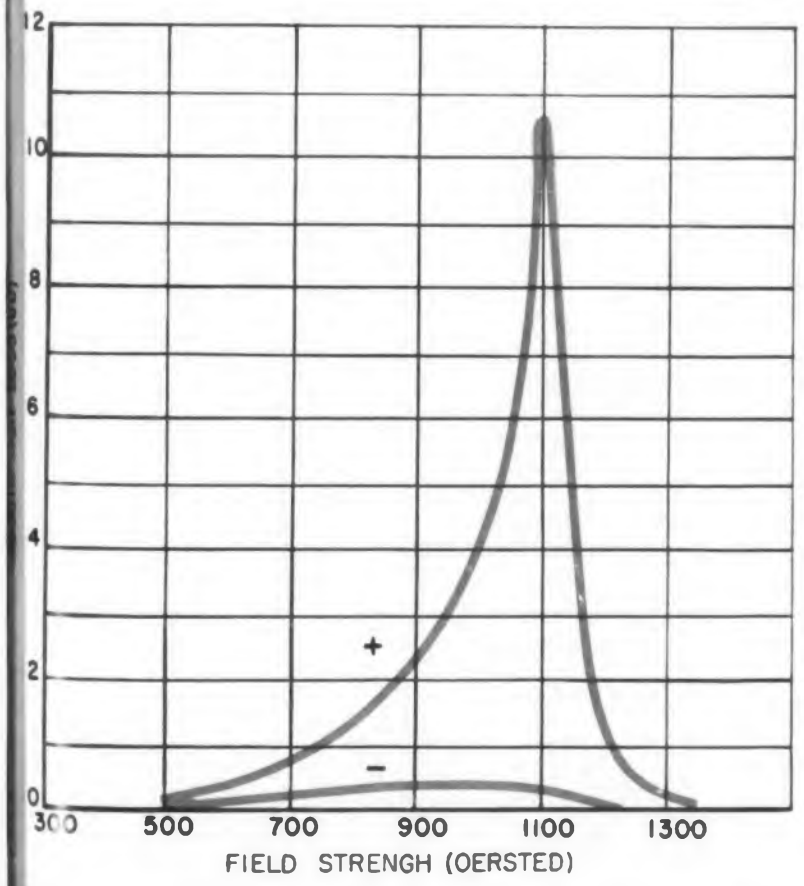


Fig. 6. Absorption loss vs field strength for a microwave ferrite at S band (1.5-5.2 kmc) for two directions of circular polarization.

Ferrite Application Chart

Class	Application	Desirable Ferrite Properties	Frequency Range
Soft	Horizontal output (flyback) transformers	High mu and low losses at high operating flux densities and temperature. High saturation.	Principally 15.75 kc and 60 kc
Soft	Deflection yokes	Moderate mu, low losses.	Principally 60 cps, 15.75 kc and 60 kc
Soft	Antenna materials	High Q, moderate mu, magnetic stability, moderate mechanical strength.	0.5 to 225 mc
Soft	Tuners	Moderate to high Q, high mu, magnetic stability.	To 225 mc
Soft	RF coils	High Q, high mu, temperature stability.	To 225 mc
Soft	I-F transformers	Moderate Q, high mu, magnetic stability.	0.4 to 41.5 mc
Soft	Delay lines	Magnetic stability, high mu-Q product.	To 15 mc
Soft	Recording heads	High mu, low losses high saturation, resistance to wear.	To 15 mc
Soft	Loading coil cores	Magnetic stability, high mu-Q product.	To 600 kc
Soft	Filter inductors	High mu-Q product, magnetic stability.	To 80 mc
Soft	Wide band transformers	High mu, moderately low losses.	To 225 mc
Soft	Adjustable inductors	High mu, moderately low losses.	To 225 mc
Soft	Pulse transformers	High mu, low losses, high saturation, magnetic stability.	To 15 mc
Square Loop	Memory cores	Square hysteresis loop, fast switching times at low drive currents, high value B_R/B_M, uniformity.	Switching time of 0.4 to 5 μsec
Square Loop	Switch cores	Square hysteresis loop, low coercive force, low losses, high ratio of B_R/B_M (greater than 0.95).	Not well defined
Microwave	Microwave components	Low dielectric loss, high Curie temperature; power handling capacity, line width and saturation magnetization compatible with application.	500 to 75,000 mc
Hard	Holding devices (such as door catches)	Large change of total magnetic energy.	
Hard	Loudspeakers	High energy product.	
Hard	DC motors	Large change of total magnetic energy, high air gap flux.	
Hard	Focusing magnets for traveling wave tubes	High air gap flux, magnetic stability with wide temperature change.	
Hard	Biasing magnets for cathode ray tubes	Properties are not critical.	
Hard	Biasing magnets for adjusting permeability of ferrite cores	High electric resistivity, magnetic stability with wide temperature change, high energy product, high coercive force.	

Some Basic Rules

Handling Nodes And Loops

Two-Port Networks, The Topology Equation

Interpretations And Examples

2

Visual Engineering Mathematics

A Self-Contained Course

T. R. Nisbet and W. W. Happ
Lockheed Missile System Div.
Palo Alto, Calif.

This second article on flow graph analysis—a visual form of engineering mathematics—discusses (1) contributive and distributive nodes, and (2) loops. What they are, rules on handling them, and examples are given. Reference is made in the beginning of this article to Equations 1 through 9 and Table 1. They appeared in Part I of this series (ED, p 32, 12/9/59).

THE NUMBERING of flow graphs as though they were equations is no accident; they are equations.

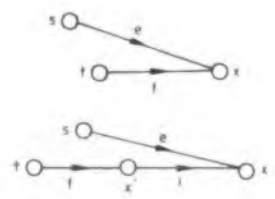
In effect, only addition and multiplication can be expressed in a flow graph. Subtraction becomes the addition of a negative quantity. And division becomes multiplication by a reciprocal. See Table 1.

Another way of expressing the process of dividing is that, if the roles of dependent and independent variables are interchanged, the flow graph path is inverted and the transmittance is then replaced by its reciprocal. The relationships expressed by Eqs. 3 and 4, for example, are identical. But the path of Eq. 3 is inverted in Eq. 4, and the transmittance R is replaced by its reciprocal $1/R$.

Attention must be paid in constructing a flow graph so that every node has transmittances leaving it and entering it. In Eq. 2, for example, it is not permissible to replace the 1 K transmittance with a 10^{-3} mho transmittance joining the 1 v node to the 1 ma node, for these nodes would then appear with transmittances entering but not leaving them, or vice versa. The flow graph is then *illogical.*

Contributive And Distributive Nodes

It is often desirable, especially in the detailed examination of a constructional flow graph maneuver, to introduce a new node, separated from an existing one by a unit transmittance. In many cases, this does *not* mean that the two nodes are equal, for one of them may receive a contribution (transmittance) which the other does not. Consider, for example, the flow graph Eq. 10, and the new node x' which has been introduced into it to form Eq. 11, below:



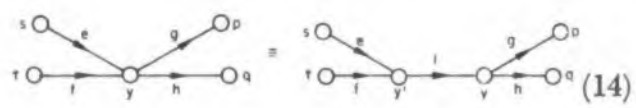
(11)

The value of x is unchanged by the addition of the node x' in Eq. 11. But the transmittance e makes a contribution only to x, and not to x'. This can be seen by writing the equations for x and x', thus:

$$x = x' + es = ft + es \tag{12}$$

$$x' = ft \tag{13}$$

A complicated node can always be split up into a series of simpler ones by the use of unit transmittances. An example, Eq. 14, is given below. The complex node y has been split into two nodes, y and y'.



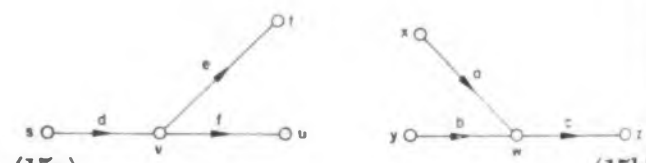
(14)

In this case, the new and old nodes all equal each other. The importance of the operation, however, is that out of the complex node have been created two types of nodes that lend themselves to manipulation by these rules:

Distributive Node. A distributive node is one at which one transmittance terminates and two originate. The flow, as represented by the arrows, diverges as it passes through a distributive node.

Contributive Node. A contributive node is one at which two transmittances terminate and one originates. The flow, as represented by the arrows, converges as it passes through a contributive node.

Tributary Transmittance. The name "tributary transmittance" is given to the one transmittance of the three at a contributive or distributive node which is not considered to form part of the through path. Examples are given in Eqs. 15a and 15b.



(15a) (15b)

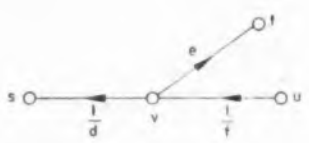
In each case it is optional which of two paths is taken as the through path. For example, if $s \rightarrow u$ is taken as the through path in Eq. 15a, then e is the tributary transmittance.

Any flow graph, however complicated, can always be broken down into a series of interconnected contributive and distributive nodes. In the manipulation of flow graphs, it is necessary to be able to invert paths where required. This is done by rules for path inversion at contributive and distributive nodes.

Path Inversion At A Distributive Node

The rule for path inversion at a distributive node is: Reverse the direction of the arrows in the through path. Replace each transmittance in the through path by its reciprocal. Leave the tributary transmittance unchanged. As an example,

nversion of the through path $s \rightarrow u$ in Eq. 15a ives:

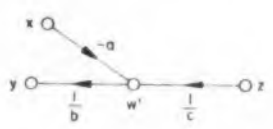


(16)

Note: (1) the node v is unchanged; (2) the node v is still a distributive node; (3) the sign of the tributary transmittance, e, is unchanged.

Path Inversion At A Contributive Node

The rule for path inversion at a contributive node is: Reverse the direction of the arrows in the through path. Replace each transmittance in the through path with its reciprocal. Change the sign of the tributary transmittance. As an example, inversion of the through $y \rightarrow z$ in Eq. 15b gives:



(17)

Note: (1) the node w has changed to a new value, w'; (2) the node w' is still a contributive node; (3) the tributary transmittance has changed from a to $-a$.

Remember: A Contributive node implies a Change of sign.

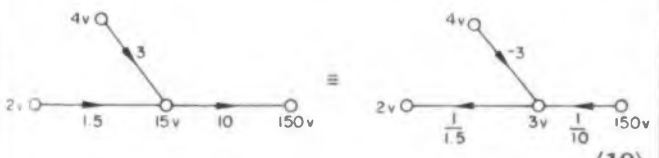
In practice, it is usually found that the change in value of the contributive node is unimportant. This is not because it is small in amplitude, but because we are more often concerned with the overall transmittance along a path than with the value of a particular node.

The effect of path inversion can be studied by these numerical examples:

Reversal of path through a distributive node—

(18)

Reversal of path through a contributive node—



(19)

When manipulating contributive and distributive nodes, it is desirable to think of the three external nodes (e.g., x, y, and z of Eq. 15b) as remaining fixed, while the paths between them are altered. The alteration may consist of inverting one of the two possible through paths, with attention paid to the sign of the tributary transmit-

tance and the value of the central node.

(In constructing a flow graph, remember that no path inversion is valid if it changes a contributive into a distributive node or vice versa.)

Loops

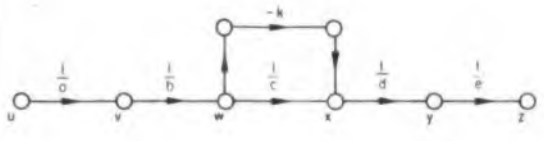
In constructing a flow graph, all the individual equations may first be written in conventional form and then translated into flow graph form one at a time. In this kind of operation, watch for illogicalities—nodes in the final diagram which have transmittances entering but not leaving them, or vice versa. When difficulties like this occur, one of the equations may be rewritten with a different dependent variable. Or the various flow graph rules may be applied to invert one of the offending paths.

The types of system which lend themselves to flow graph representation are often those which are conveniently evaluated by matrix algebra. The flow graph system, however, enables the operator to get answers without constructing and manipulating matrices.

The concept of feedback arises continually in flow graph analysis, sometimes in the most unlikely situations. Feedback, in the mathematical sense, occurs when an independent variable influences a dependent variable, which in turn influences the original variable. In flow graph language, this constitutes a loop.

The number of loops in a given system depends on how the equations are written or the flow graph drawn. Even in a simple system, such as a battery, a T-attenuator, and a load, there can be one, two, or no loops in the flow graph, depending on the selection of variables.

In the central portion of the following flow graph, we can have two alternate paths $w \rightarrow x$,



(20)

and from the definition of a node we can write that:

$$x = \frac{1}{c} \cdot w - k \cdot w$$

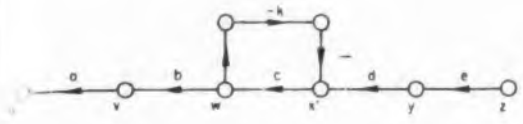
The overall transmittance $u \rightarrow z$, is, therefore:

$$\frac{z}{u} = \frac{1}{a} \cdot \frac{1}{b} \cdot \left(\frac{1}{c} - k\right) \frac{1}{d} \cdot \frac{1}{e}$$

and

$$\frac{u}{z} = a \cdot b \left[\frac{1}{\frac{1}{c} - k}\right] d \cdot e \qquad (21)$$

Inverting the path $u \rightarrow z$, we encounter a contributive node at x and a distributive node at w. We have:



(22)

Note the minus sign and the new node x'.

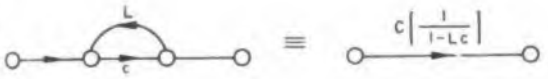
Writing q for the transmittance $y \rightarrow w$, we have:

$$\frac{u}{z} = a \cdot b \cdot q \cdot e \tag{23}$$

And, from a comparison of Eqs. 21 and 23:

$$q = d \cdot \frac{c}{1 - k \cdot c} \tag{24}$$

The transmittance d is part of the original flow graph, Eq. 22, and it has remained intact in spite of the change in the node x of Eq. 20 to x' of Eq. 22. The loop which has been formed in Eq. 22 has a transmittance of $+k \cdot c$, and we can thus formulate a rule for evaluating a loop about a transmittance:



(25)

A loop may also occur about a node, giving:

(26)

Eqs. 25 and 26 say that wherever a loop is formed, either about a transmittance or about a node, the path (defined in the next paragraph) is modified by a factor $1/(1-L)$, where L is the loop transmittance. The loop transmittance includes any part of the path which may be necessary to complete the loop.

A path is substantially what its name implies, a route following a series of similarly directed arrows from one node to another. Note that in the evaluation of a path, no attention is paid to the fact that the various nodes it passes through may receive contributions from other transmittances not included in the path; these contributions are taken care of in the rules governing the use of paths (Table 2). It follows, then, that the value of a path is the product of the transmittances involved. It often happens that the word "path" is used loosely, in a general sense, but in the majority of cases the technical definition and the loose description are interchangeable, or at least do not conflict with each other.

The rules relating to paths and loops are included in Table 2. ■ ■

Parts three and four of the course will follow.

Companies Offer Technica

DURING recent months an impressive assortment of technical information has been received from companies in the servo engineering field. These bulletins and other pieces of information go far beyond mere description of the company's products. It seems to be the aim of these companies to fill in the gap between what is available in textbooks and what is current information in the servo field.

Daystrom Transicoil Div. of Daystrom, Inc., Worcester, Montgomery County, Pa., has prepared a very basic and excellently written handbook entitled "The Servo Engineer's Handbook." Most of the work of preparing this handbook was done by Frank Hagen, who has written several articles for ELECTRONIC DESIGN. The handbook is intended to be a design aid in the day-to-day work of the servo engineer. For this reason, the over-all treatment of the handbook is practical rather than classical, and mathematical derivations have been avoided wherever possible.

The first chapter is an introduction, showing how the different components are related in the servo system. This serves as a foundation for the five succeeding chapters which deal with the theory of operation, system design considerations and other practical consideration of servo motors, rate generators, synchros, gear trains and amplifiers. A separate chapter describes how these are assembled into a coordinated system. The final chapter describes environmental testing conditions, a facet common to all. Other information on this handbook, released September, 1959, is available from Daystrom Transicoil. A price of $3.00 has been placed on the book.

Kearfott Co., Inc. of Little Falls, N.J. offers a booklet entitled "Technical Information for the Engineer." This booklet presents a concise and slightly more detailed description of the theory involved with servo motors, tachometer generators and synchros. After the theory section describing each type of device, specifications for Kearfott components are presented. Information on this booklet can be obtained from Kearfott Co., Inc., 1500 Main Ave., Clifton, N.J.

A booklet prepared by The Helipot Div. of Beckman Instruments Inc. of Fullerton, Calif., entitled "Beckman Rotating Components," gets much deeper into the mathematics of servo motors. The booklet presents a general description of electromagnetic damping of the inertia and the velocity type. After this, the transfer function equations are developed for the servo motor, the servo motor generator, the velocity damped servo motor and the inertia damped servo motor. This treatment is quite mathematical. It is followed by some specifications of Beckman's components.

One of the most ambitious programs of upgrading the knowledge of the servo engineer is undertaken by the Norden Division of United Aircraft Corp. The Ketay Dept. of this company, located at Commack, L.I., presents an excellent five-day course once or twice a year. This course is designed to acquaint the industry, as well as United Aircraft's own personnel, with the latest techniques in the servo art. Ketay engineers act as instructors in this course.

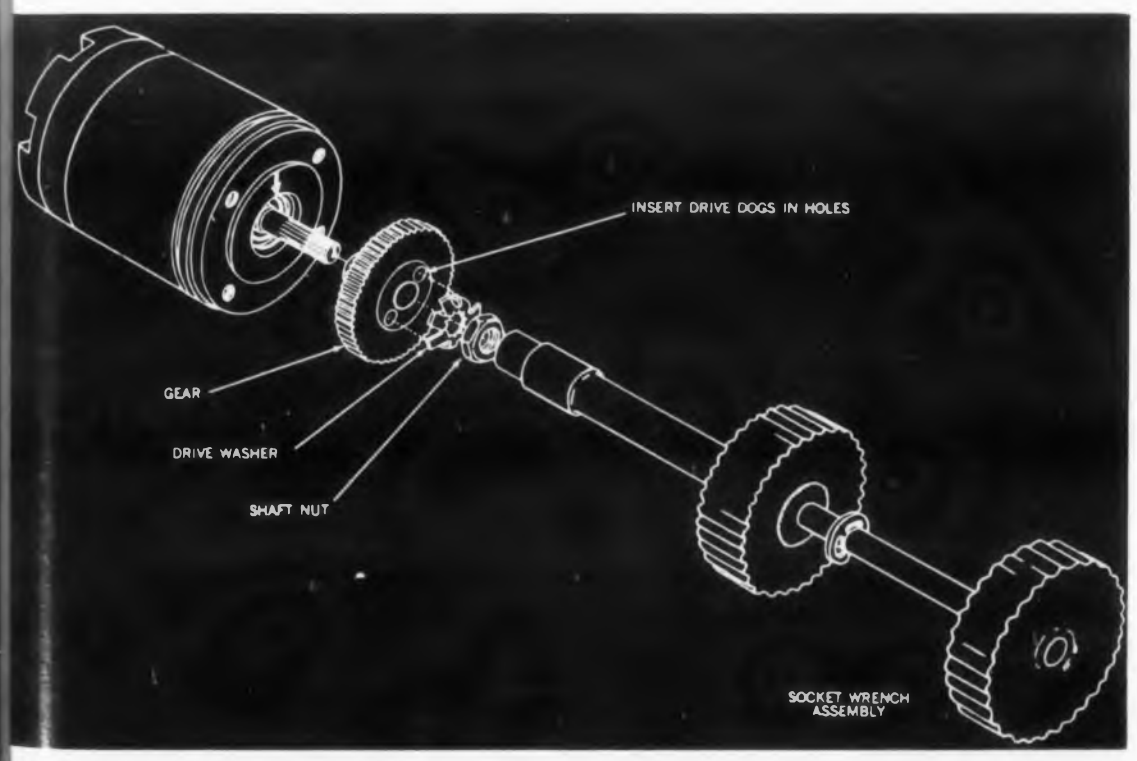
The most recent course, given during the week of October 19th to 23rd, covered theory and application of servo motors and integrating tachometers, materials and environmental testing, quality control and other manufacturing techniques and a description of gyroscopes.

formation For The Servo Engineer

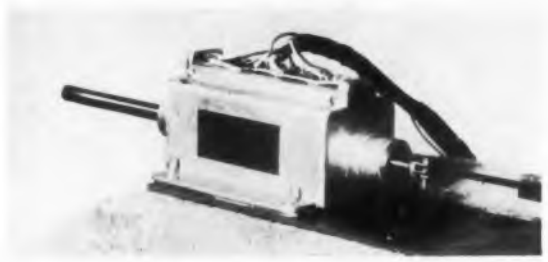
resolver amplifiers, tools and hardware for the servo components. Also covered in the course were the significance of Ketay's metrology laboratory, and test equipment in the production of precision servo components. Present efforts toward standardization of servo components were described and current trends and future possibilities in the servo field are also presented.

Ketay has prepared a booklet entitled "Nomenclature for Rotating Servo Components." This booklet presents explanations of the terms used in connection with synchros, resolvers, servo motors and tachometer generators. The company also has prepared a Gyro Primer. This is an extremely basic and entertaining presentation of the principles that makes a gyro operate the way it does. A price of $1.00 has been put on this booklet by Ketay.

"The United States Navy Synchros, Description and Operation Op 1303," the well-known standard of the servo field, has been revised as of last year. The new revision is an even more useful book than the original version. In addition to including up-to-date information on current synchro types, new material describing the mounting hardware for synchros and other rotating components has been added. The publication may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D.C., at a price of seventy cents. ■ ■



Included in the first revision of OP1303 is detailed mounting information such as fixing a gear to a standard synchro shaft. Drive washer mates with spline shaft and with two holes drilled in gear. Socket wrench assembly is used to hold the shaft and tighten the shaft nut.



The linear positioning motor can be designed to have an unlimited number of positions.

Linear Positioning Motor

Has 0.01 In. Resolution

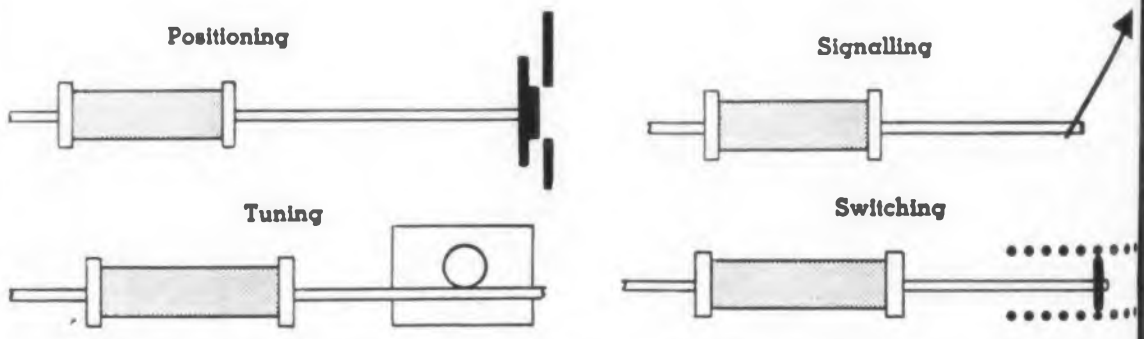
RESPONDING to an input with instantaneous linear movement of its shaft, the model B1002 linear positioning motor can be designed to have an unlimited number of positions with a resolution of 0.01 in. The exact amount of shaft movement is determined and selected by such input devices as switches, relays, pushbuttons, contacts, or by more complex digital inputs.

As the input is selected, the shaft moves to the proper position in a smooth, forceful motion. It is uninterrupted by any intermediate reference points, stops or ratchets. Repeatability within 0.005 in travel times of 100 msec, and thrusts o 100 lb or more—all these are possible.

The only moving part of the moto (which is made by the Tronics Corp. Dept. ED, 3324 Hiawatha Ave., Mi neapolis, Minn.) is the shaft. There ar no gears. The shaft moves in a linea direction only, although it is free to ro tate with the attached load, if necessary

Loads That Can Be Handled

The shaft of the motor can be attache to either a load that requires only simpl



The shaft of the motor can be attached to either a load that requires simple positioning or to a load that requires linear positioning superimposed on an existing rotary motion.

positioning, such as a slide switch. Or it can be attached to a load that requires a linear positioning superimposed on an existing rotary motion, such as the faceplate of a clutch. A variety of couplings and internal bearings can be used for specific applications.

The motor responds to an input by an immediate acceleration of the shaft and load, followed by a deceleration as it approaches the control point (selected position), where it stops. The action of the motor can be compared to that of a piston controlled by an elaborate servo system. The motor, however, does not require external error detection or amplification, since these are inherent. By proper programming and other techniques, overshoot of the shaft can be held to a minimum, or even eliminated, depending on specific requirements.

Both coarse and fine positioning can be had in the motor. The coarse positioning is determined by input taps, and the fine positioning is accomplished by setting a potentiometer or decade resistance box.

Among the applications of the motor are: antenna orientation, computers, communication equipment, data recording, memory storage systems, servo mechanisms, telemetering and tuning.

For more information on this motor, turn to the Reader-Service Card and circle number **100**.

Specifications

Function	Continuous Duty	Intermittent
Operating voltage	115 volts DC max	300 volts DC max
Power consumption	24 watts	162 watts
Stroke	2⅛ inch	same
Number of positions	27	same
Repeatibility	±0.003 inch	same
Spacing between positions	0.085 inch	same
Force Output	2 pounds	6 pounds
Temperature rise (Measured in center tube midway between ends).	70 C	Not to exceed 70 C above ambient of 50 C.

Potentiometer's Life Exceeds 85 Million Cycles

AFTER the wirewound Rotoflex precision potentiometer was tested for more than 85 million cycles, it showed no change in total resistance, no significant change in linearity, and the noise throughout the unit was less than 50 ohms. This high reliability is achieved with a rolling pressure piece—which can be either a microminiature ball bearing or sapphire disc mounted in pivot bearings.

The potentiometer—made by Technology Instrument Corp., Dept. ED, 531 Main St., Acton, Mass.—uses a capsule contact with a wirewound resistance element. The capsule contact consists of a gold foil contact diaphragm with a Teflon-impregnated backing suspended above the resistance element by concentric, insulated stand-off rings. The Teflon-backed foil is depressed to make contact with the resistance element by the dimpling effect of a small-diameter rolling pressure piece.

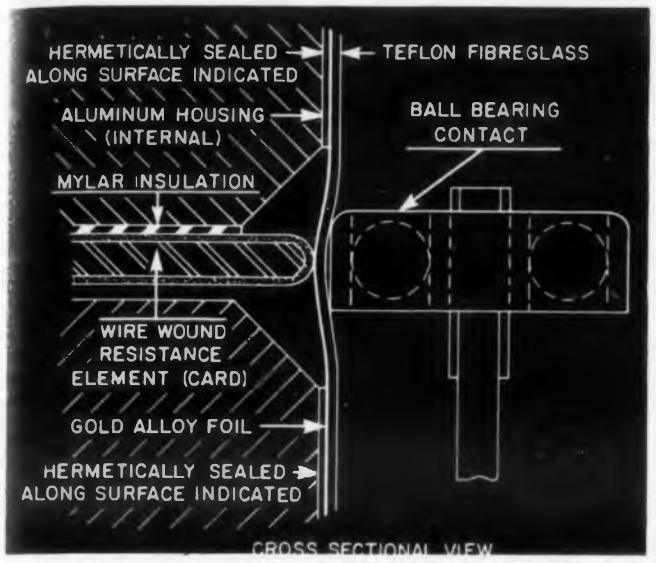
This dimpling action of the foil by the pressure piece eliminates sliding action between the contact and the resistance element. The absence of sliding-contact action eliminates wear of the resistance element, which can cause change in resistance and linearity. Wear particles, dust, and debris are not present, which could cause erratic contact and noise.

The gold foil acts not only as the winding contact—but also eliminates the need of slip ring contacts.

Wear of the diaphragm itself is prevented by use of the rolling pressure piece. The actuation torque of the potentiometer is low due to the low friction offered by the rolling pressure piece to the Teflon diaphragm. Ample pressure of the foil against the winding is thereby maintained, eliminating shock and vibration difficulties.

The capsule contact is normally sealed

A rolling pressure piece increases the reliability of the potentiometer.



Cross-sectional view of the capsule.

A view of the potentiometer with the capsule peeled back.

around the stand-off rings with epoxy potting compounds. Thus, all of the active electrical part of the potentiometer is protected from external dust and moisture. MIL-E-5272 and MIL-STD-202 moisture resistance tests show no significant penetration of moisture to the contact area.

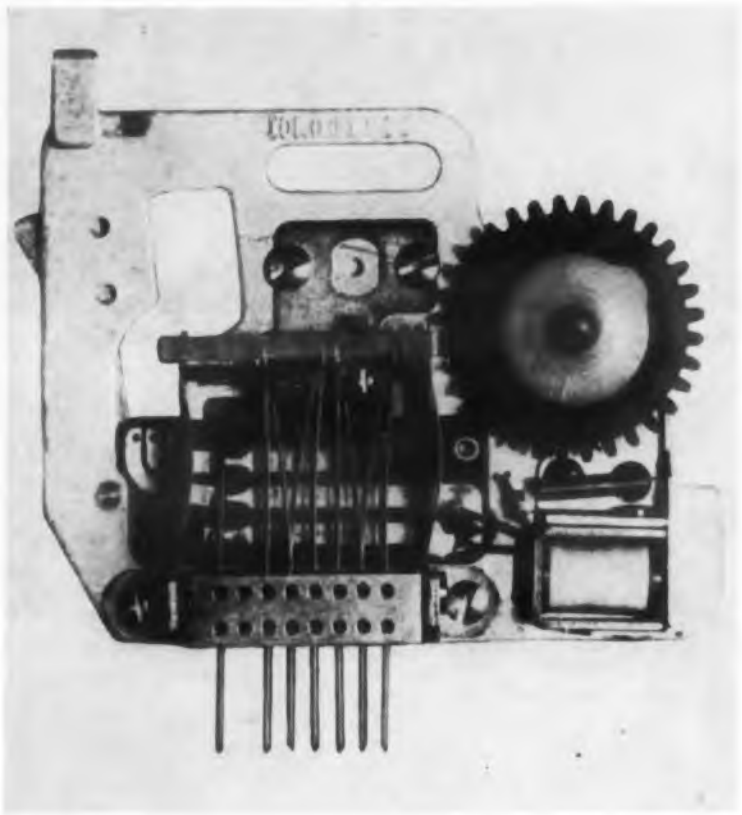
The properties of the epoxy-impregnated fiberglass backing are maintained over a temperature range of −55 to +150 C. The foil-epoxy-fibreglass laminate is carefully selected to provide optimum resilience needed for proper damping action. But it is stiff enough to prevent multiple bridging of foil to resistance element during shock, vibration or acceleration.

Little loss of functional accuracy of the potentiometer in its associated network can be expected over the temperature range of −55 to +150 C due to the inherent low temperature coefficient of the wirewound resistance element which is about 20 ppm per deg C. Nonlinear functions, multiple tapping, and varying resistance values are easily and economically produced. Resistance drift, less than 0.1% due to temperature cycling or heat exposure is low, as is thermal noise. Several watts power dissipation is typical; the substantial area of a card-type winding permits rapid dissipation of heat, so that excessive hot spots are not experienced.

For more information on this high-reliability potentiometer, turn to the Reader-Service Card and circle number **101**.

NEW PRODUCTS

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



Logic Switches Designed For Data Handling Systems 633

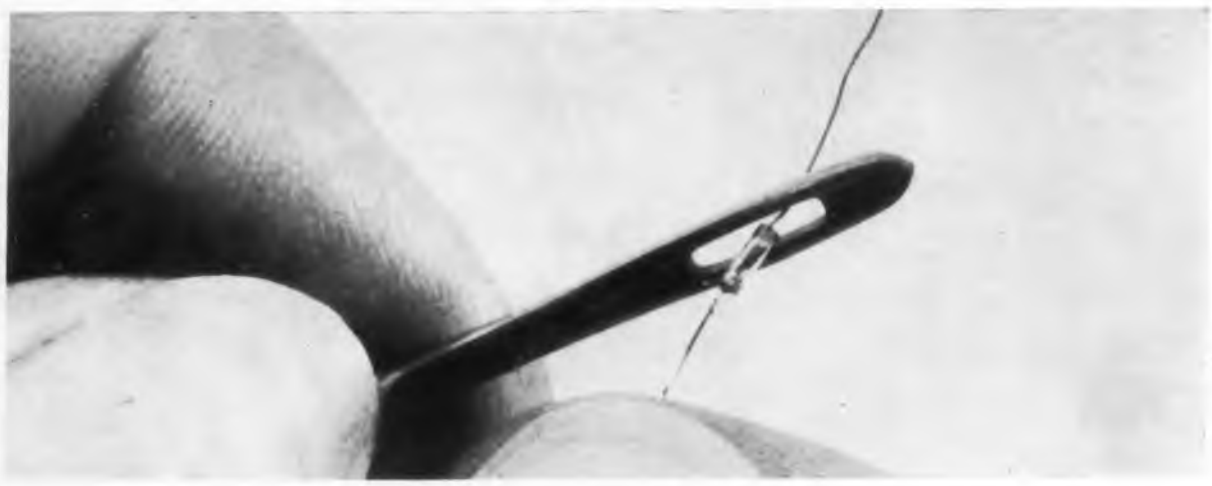
This line of electro-mechanical logic switches and decimal counters is designed for use in large and small data handling systems. They reduce to one-half the pulse times necessary to resolve systems logic. Three basic elements are combined in each switch: a delay element; a bi-stable element; and a number of AND gates associated either with the assert or negative side of the bi-stable element. The switches are suited for communication with high speed transistor counting elements. Some of the specifications are: electrical control requirements, 44 to 55 v pulse of 4.5 ms duration; speed, 0 to 60 pulses per sec; contact rotating, 2 amp dry switching and 5 ma live switching; dimensions, 3-1/2 x 3-1/2 x 5/8 in.; weight, 3 oz.

Tally Register Corp., Dept. ED, 5300-14th Ave., N.W., Seattle 7, Wash.

Infrared Detector Has All Metal Construction 635

The type QK748 infrared detector has all metal construction with hermetically sealed windows. The detector material is a p-type gold doped germanium. Its operating temperature is 78 deg Kelvin and the window material is an antireflection coated silicon or sapphire. Spectral sensitivity range is from 2 to 9 microns. Units with sapphire windows have a 6 micron longwave length cutoff; silicon windows cover the whole 2 to 9 micron range. Impedance range is 50,000 ohms to 1 meg; acceptance angle is about 100 deg. The time constant is less than 1 μsec.

Raytheon Co., Dept. ED, Waltham 54, Mass.



Lamp For Transistorized Circuits Measures 0.125 x 0.045 in. 634

Having applications in transistorized circuits in missiles, computers and electronic systems, the Mite-T-Lite incandescent lamp measures a maximum of 0.125 in. in length, a maximum of 0.045 in. in diameter and has a nominal lead length of 0.375 in. It operates on 1.3 v and passes a current of 35 ma at this voltage. Its resistance when cold is a minimum of 6.5 ohms. When 1.5 v is applied, the resistance is 38 ohms. The light output is 100 millilumens at 1.5 v dc; efficiency is 1.5 lumens per watt.

Sylvania Electric Products Inc., Lighting Products Div., Dept. ED, Salem, Mass.

Inertial Platform System Measures 2.75 x 4.5 in. 636

This non-servoed inertial platform system for short range ballistic missiles measures 2.75 in. in diamter and 4.5 in. in length. System components consist of a free gyro and two subminiature accelerometers that are mounted on the gimbals of the gyro with the sensitive axes orientated perpendicular to the gyro spin axis. The gyro spin axis describes the line space along which the rocket is guided. Within 5 sec after power is applied the system is fully operative. The unit has good threshold sensitivity with no measurable response to cross axis accelerations and vibrations which are present during the initial boost stage of flight.

Giannini Control Corp., Dept. ED, 918 E. Green St., Pasadena, Calif.

Power Resistors Are Rated At 5, 7, 10 and 25 W 637

Wattage ratings of these power, wirewound resistors are 5, 7, 10 and 25 w. The resistors are wound on ceramic cores with special alloy end caps attached. Lead wires and resistance wires are attached by spot-welding. All parts have thermal expansion characteristics matched. The resistance element is imbedded in vitreous enamel and is impervious to moisture. Low resistance units have coreless construction, and the resistance range is 0.05 to 0.09 ohms, ±10%, and 0.1 to 0.5 ohms ±5%. The resistance range of core construction is 5 through 25,000 ohms, ±3%.

Superior Resistor & Electronics Corp., Dept. ED, P.O. Box 274, Frankfort, Ind.

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NEW PRODUCTS

Miniature Nut 427

Stands 160,000 psi

Measuring 0.095 in. in height, 0.172 in. in diam, and having a wrench hex sign of 3/32 in., the Kaylock H14-02 all metal nut withstands 160,000 psi. The weight is 0.02 lb per hundred. They are designed for use in electronic systems of missiles, rockets, and aircraft.

Kaynar Manufacturing Co., Dept. ED, Box 2001, Terminal Annex, Los Angeles 54, Calif.

Beam-Power Pentode 422

Has a low-loss mica-filled base

Type 7581 30-w beam-power pentode, using a low-loss mica filled base, is primarily for audio power output, but also provides good rf performance. A rounded-top envelope reduces the possibility of microphonic action under vibration. A controlled-knee characteristic eliminates signal distortion from this source in properly designed circuits. A bonded metal anode of aluminum, copper, and iron prevents hot spots and permits exceptional heat dissipation. The zero-bias ratings are: plate voltage, 70 v; screen voltage, 300 v; control grid voltage, 0 v; plate current 210 ma; and screen current, 25 ma. The tube is interchangeable with types 5881, 6L6, and KT-66.

General Electric, Receiving Tube Dept., Dept. ED, Owensboro, Ky.

CIRCLE 60 ON READER-SERVICE CARD

ESC DEVELOPS DELAY LINE WITH 170 to 1 DELAY TIME/RISE TIME RATIO

Model 61-34 Perfected For Specialized Communications Application

PALISADES PARK, N. J.—An entirely new Lumped-Constant Delay Line, with a proven 170 to 1 delay time/rise time ratio, has been announced by the ESC Corporation, Palisades Park, N. J. The new delay line, known as Model 61-34, was specifically designed for a specialized communications application calling for the exceptionally high delay time/rise time ratio.

ESC, the world's leading manufacturer of custom built and stock delay lines, is already widely recognized in the electronics industry for its exceptional engineering advances. In October, 1958, ESC broke through an existing design barrier and produced a delay line with a 145 to 1 delay time/rise time ratio. It had been thought, prior to the announcement of the Model 61-34, that ESC had reached the ultimate in this type of delay line.

SPECIFICATIONS OF NEW DELAY LINE MODEL 61-34

Delay time/rise time ratio: 170/1
Delay: 200 usec.
Rise time: 1.16 usec.
Attenuation: less than 2 db
Frequency response: 3 db = 325 KC
50 taps with an accuracy of ±0.2 usec. at each tap.

Complete technical data on the new unit can be obtained by writing to

ESC Corporation, 534 Bergen Boulevard, Palisades Park, New Jersey.

CIRCLE 61 ON READER-SERVICE CARD

NEW PRODUCTS

Photoconductive Cells 419

Measure 0.5 in. long and 0.25 in. in diam

The 600 series of cadmium sulfide and cadmium selenide photoconductive cells are 0.5 in. long and 0.25 in. in diam. These glass-enclosed units are designed to withstand extreme shock and vibration conditions. Like the 400 series, they have a sensitivity 1,000,000 times greater than photomissive tubes. They are hermetically sealed.

Clairex Corp., Dept. ED, 22 E. 17th St., New York 3, N.Y.

Inductor Coils 426

Have range from 0.1 μh to 56,000 μh

Measuring 0.16 in. in diam and 0.375 in. in length and occupying a volume of less than 0.0066 cu in., these coils, called Wee-Ductors, have a range in value from 0.1 μh to 56,000 μh. They are sealed in epoxy resin. Requirements of MIL-C-15305A are met.

Essex Electronics, Div. of Nytronics, Inc., Dept. ED, 550 Springfield Ave., Berkeley Heights, N.J.

Mylar Capacitors 610

For use to 200 C

These uncased Mylar, plastic film capacitors can be used over the temperature range of −65 to +200 C. Both round and flat types are offered, designated UR and UF. Tolerances of 0.5%, 1%, 2%, and 5% are available, capacitances are 1μμf to 10 mf, and working voltages are 50, 100, 150,

250, 300, 400, and 600 v. The units meet RETMA spec 118-A, MIL-C-91A environmental test requirements, and most requirements of MIL-C-25A. The lead sizes are No. 18 and 20 AWG tinned copper wire, 2.25 in. long. Applications include printed circuitry, potted or encapsulated components, guided missiles, computers, and delay lines.

Capcon, Inc., Dept. ED, 61 Stanton St., New York 2, N.Y.

Temperature Control 429

Indicating type

Series 6000 indicating temperature controller features a 12-in. circular readout based on a stable null balance servo system. The instrument is available with either time proportioning or on-off control, with or without an anticipating section. The control stability of the proportional model having an anticipating section is to ±0.1 deg F; for the on-off model with anticipation, control is ±0.5 deg F. Indication accuracy is ±1% of the scale range. Plug-in plastic encapsulated circuitry is used. Operation is ensured under conditions of shock and vibration as well as dust and moisture.

Electronic Process Corp. of Calif., Dept. ED, 436 Bryant St., San Francisco 7, Calif.

Switches 605

Are rated at 2 amp, inductive

Pushbutton switch type WC1506 and Switchlite type WC1501 are both rated at 2 amp, inductive, at 28 v dc. The switch is dpdt and has an over-all length of 1-5/8 in. with a behind-the-panel depth of 7/8 in. It comes with a choice of various adapters, some of which provide for engraving up to 20 characters. The Switchlite has an independent, isolated lamp circuit and comes with a 6, 14, or 28-v lamp. Its over-all length is 2-3/8 in. and it has a depth of 1/32 in. behind the panel. The lens is 5/8 in. in diam and provides space for an engraved legend. Both units are moistureproof.

Hetherington, Inc., Dept. ED, 1420 Delmar Drive, Folcroft, Pa.

NEW PRODUCTS

Plastic Laminate 399

Comes in thicknesses from 1/32 to 5/16 in.

Available in thicknesses ranging from 1/32 to 5/16 in., grade P-63-GS high pressure plastic laminate has a high impact strength and a low power factor. Minimum flatwise flexural strength is 16,000 psi, with a minimum lengthwise tensile strength of 12,400 psi. Insulation resistance is 50,000 meg at 35 C and 90% relative humidity. There is no blistering or delamination on solder floating of etched patterns.

Farley & Loetscher Manufacturing Co., Plastics Div., Dept. ED, Dubuque, Iowa.

Air Conditioner 400

Distributes 2500 cfm of filtered air

This air conditioning unit maintains comfortable conditions at temperatures down to −65 F. It distributes 2500 cfm of filtered air including 100 cfm of outside air through a perforated ceiling. On cooling cycle, the unit will develop a full five tons of capacity when the outside air temperature reaches 120 F. Under these conditions, it will keep the interior at 80 F dry bulb and 50% relative humidity. It is designed for trailer vans housing electronic equipment.

Carrier Corp., Machinery & Systems Div., Dept. ED, Syracuse 1, N.Y.

Instrument Pivots 401

Are 0.05 to 0.75 in. long

These pivots, shafts, and pins are available in a wide range of diameters: 0.16 to 0.125 in. and in lengths from 0.05 to 0.75 in. with radii from 0.0008 to 0.004 in. They are made from high grade carbon steel and are heat-treated for maximum hardness. Conical bearing point angles, from 45 to 70 deg, are turned for perfect centering and smooth operating performance.

John Gillen Co., Dept. ED, 2540 S. 50th Ave., Cicero 50, Ill.

Magnetic Converter 402

Records from 7 or 8-channel paper tape

This paper tape to magnetic tape converter records information on 7 or 8-channel paper tape on 1/2-in. oxide magnetic tape and prepares it for playback on an IBM transport. Eliminating the intermediate conversion of paper tape to cards, this system permits the off-line conversion of paper tape directly to IBM 650 and 704 magnetic tape at the rate of 300 characters per sec. Without special paper tape codes, the converter automatically generates the required magnetic tape format structure: longitudinal parity bits, record and file spaces, and end of file cards.

Gilliland-NRI., Dept. ED, 3124 E. 14th St., Oakland 1, Calif.

Spiraling Lathe 403

For film resistors

Model ABL-6 spiraling lathe is for production and testing of film resistors having the resistance range of 10 ohms to 10 meg. Operation is completely automatic once the parts are fed into the vibratory bowl feeder. Monitoring of the resistors throughout the spiraling cycle is provided by a sensitive automatic bridge. The unit includes a counter for presetting turns per inch and spindle rpm.

Industrial Instruments Automation Corp., Dept. ED, 89 Commerce Road. Cedar Grove, N.J.

Amplifier 408

Measures 1 x 1 x 1-1/8 in.

Measuring 1 x 1 x 1-1/8 in., model 200 transistorized amplifier can drive 2 or 3.5-w servo motors from low level 400 cps signals. The maximum gain, which may be adjusted by an external resistor is 2500. The gain stability is 3 db. Able to operate to 125 C, the unit meets MIL-E-5272 requirements. Internal limiting prevents overdrive or phase shift for high input signals. For computer, servo, and automation applications, the unit operates from an input of 28 v dc.

Control Technology, Dept. ED, 113 Broadway, New York 1, N.Y.

NEW PRODUCTS

RF Signal Generator 608

Operates over the range of 1800 to 4000 mc

Type TS-403/URM-61A rf signal generator is designed to operate over the range of 1800 to 4000 mc. It provides outputs of 1 mv to 0.1 μv. Internal or external pulse or fm modulation is available. The unit meets the requirements of MIL-T-945.

Radio City Products Co., Inc., Dept. ED, Centre and Glendale Sts., Easton, Pa.

Full-Wave Rectifier 425

Delivers 300 v dc

Type 5CU4 full-wave rectifier can be substituted for two rectifiers in TV and hi-fi design. A 425-ma, cathode type tube, it delivers 300 v dc. The tube voltage drop is 24 v. The unit offers improved regulation and replaces the 5U4GB and the 5Y3GT.

Raytheon Co., Receiving Tube Div., Dept. ED, 465 Centre St., Quincy, Mass.

Binary-to-Tape Converter 611

Transistorized

Type ZA-25159 data converter will convert a 27-bit time code, one 20-bit data signal, and two 17-bit data signals into an IBM 704 magnetic tape. The unit will also supply signal outputs to seven central locations also in the IBM 704 coding without gaps between the blocks. The sampling rate of the input may be 10, 20, 40, 80, or 100 pps. Designed for the multiplexing and the recording of range, azimuth, and elevation data from digital radar outputs together with a timing signal, the unit is transistorized.

Electronic Engineering Co. of Calif., Dept. ED, 1601 E. Chestnut Ave., Santa Ana, Calif.

Electrical Tape 609

Has a backing of epoxy resin

No. X-1099 electrical tape has a backing of fully-cured, flexible, 100% solid, epoxy resin reinforced with a 0.002-in. glass cloth. It has a high resistance to cold flow, and is suited for applications requiring the electrical strength of a continuous film epoxy resin plus the physical strength of glass cloth at Class F operating temperatures.

Minnesota Mining and Manufacturing Co., 3M Co., Dept. ED, 900 Bush Ave., St. Paul 6, Minn.

Phasemeter 423

Absolute accuracy is 0.1 deg

Able to measure the phase angle difference between two sinusoidal voltages from 30 to 20,000 cps over a range of 0 to 360 deg, model 901 phasemeter has an absolute accuracy of 0.1 deg and an incremental accuracy of 0.01 deg. A phase detector bridge is used for phase comparison. The phase difference is read directly from a 2-deg step control with a vernier indicator. Capable of self-calibration, the instrument provides sense information to remove 180-deg ambiguity. The input impedance for both channels is 10 meg shunted by 25 μμf. The input signal level varies from 0.5 to 10 v rms. The power requirements are 105 to 125 v at 50 to 60 cps, 200 w.

W. L. Maxson Corp., Dept. ED, 475 Tenth Ave., New York 18, N.Y.

Shielded Containers 606

For recording tapes

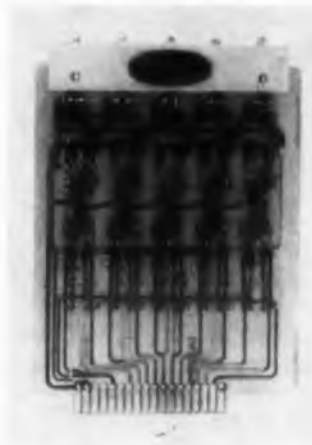
Made to accommodate recording tapes, these Netic Co-Netic magnetically shielded containers come in both round and square designs. They are available in single or multiple reel capacities. The tapes are protected against erasure or distortion caused by extraneous magnetic fields. The alloys used are shock resistant, nonretentive, and do not need periodic annealing.

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

NEW PRODUCTS

Storage Register 428

Contains five transistorized flip-flops



Model 307 flip-flop storage register contains five independent transistorized flip-flops for storage of digital data. Set and reset inputs, and One and Zero outputs are available for each flip-flop. In addition, a common bus is provided for simultaneous resetting of all five flip-flops. The register is a 5 x 6 in. glass-epoxy printed circuit card 1/16 in. thick, and is used with an 18 pin PC receptacle. One voltage, —12 v, is required. Standard levels are —6.8 v for One and —0.2 v for Zero.

Navigation Computer Corp., Dept. ED, 1621 Snyder Ave., Philadelphia 45, Pa.

Furnaces 418

Have temperatures to 2000 F

The Stabel-Glow box type furnaces offer continuous temperatures to 2000 F. When the set temperature is reached, the wattage is automatically reduced to stabilize oven temperature. The units have pushbutton element switch controls. Of heavy-gage steel construction, the furnaces have a front plate measuring 3/4 in. thick. Double break contacts and solenoid type power contactors are used. The applications include annealing, as well as heat-treating of ferrous and nonferrous metals.

Blue M. Electric Co., Dept. ED, 138th and Chatham Sts., Blue Island, Ill.

Torquemeters and Indicators 413

Have ranges to 30,000 lb-in.

This line of torquemeters and indicators, with models designed to meet specific needs, has standard ranges to 30,000 lb-in. full scale. Speeds to 50,000 rpm are provided. The torquemeters, equipped with high speed bearings, have variable inductance transducers to measure the angular twist proportional to torque in the torque shaft. The indicators have a sensitivity range about ten times that needed for standard torque assemblies. They have a calibrating circuit that standardizes over-all electrical gain to within ±1.5% of full scale.

B & F Instruments, Inc., Dept. ED, 3644 N. Lawrence St., Philadelphia 40, Pa.

YIG Spheres and Discs 412

Are highly polished

These highly polished YIG spheres measure 0.02 ±0.002 in. in diam and have a ferrimagnetic resonance linewidth of 0.65 ±0.25 oersteds. They can be used in power limiters, harmonic generators, cavity-tuned filters, and in other microwave devices. Also for microwave applications, YIG discs are available with diameters of 0.05 to 0.15 in. and heights of 0.002 to 0.01 in. The final polishing of the discs and spheres is done with Linde A aluminum oxide.

Microwave Chemicals Lab., Inc., Dept. ED, 282 Seventh Ave., New York 1, N.Y.

Terminals 406

Hermetic-seal type

These hermetic-seal terminals measure 11/64 in. in diam and are 5/64 to 1/4 in. in height. Made with an L-3 steatite, they meet MIL-I-10 specs. They are supplied with a Neoprene or Silicone seal and come in four different head styles: notched lug, turret head, hollow turret, and lug with hole.

The Sphere Co., Inc., Dept. ED, 5 Amity St., Little Falls, N.J.

CIRCLE 68 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Spectrograph 405

Provides analysis to 15 kc

Called the Missilizer, this audi and sub-audio spectrograph pro duces records of complex wave forms of frequencies to 15 kc, an provides three different analyses o their waveforms. The first relate frequency and intensity to time, th second relates intensity over wider dynamic range to frequenc at a particular instant of time, an the third shows the average am plitude vs. time. The unit is ap plicable to data reduction as well as analysis of vibration and noise on aircraft.

Kay Electric Co., Dept. ED Maple Ave., Pine Brook, N.J.

Guidance System 40

For missile control

Type X-887 servo assembly pro gram transmission determine whether the missile is on course and corrects for deviations by trans mitting the proper signals to the guidance system. Able to meet the operational requirements in a tac cal missile, the assembly measure 2-1/2 x 2-1/4 x 3-1/8 in. and weigh about 34 oz. It meets the enviro mental requirements of MIL-E 5272 and operates in ambient tem peratures of −55 to +100 C.

Bowmar Instrument Corp., Dept ED, 8000 Bluffton Road, Fo Wayne, Ind.

Time Delay Relay 41

Range is 0.05 to 90 sec

Providing a range of 0.05 to sec ±5%, this time delay relay made for a life of 50,000 operation The contacts are spdt, 0.25 amp 28 v. It operates over the temper ture range of −55 to +85 C, wi stands vibration of 10 g to 500 c and has a dielectric strength of 3 v rms. Standard units operate fr 24 to 31 v dc; 18 to 50-v dc un can be furnished.

Hydro-Aire Co., Dept. ED, 30 Winona Ave., Burbank, Calif.

Film Resistors 404

Have low noise level

These molded precision metal film resistors have a low noise level and a low controlled temperature coefficient. Five sizes, ranging from 1/5 to 2 w, are available. The units withstand severe humidity conditions.

Electra Manufacturing Co., Dept. ED, 4051 Broadway, Kansas City, Mo.

Time Delay Module 416

Operates solid state or mechanical relays

This time delay module is designed to operate standard solid state or mechanical relays at a range of 0.05 to 180 sec ±5%. The temperature range is −55 to +85 C but can be extended to +150 C. A miniature unit, it is hermetically sealed and has a nickel silver alloy can.

Hydro-Aire, Dept. ED, 3000 Winona Ave., Burbank, Calif.

Slip Ring Assembly 410

Miniature

This slip ring assembly, including 21 rings, 42 brushes, and two bearings, has an over-all maximum length of 0.5 in. and a diameter of 0.25. The temperature range is −65 to +350 F, the noise level is 200:1, and the requirements of MIL-E-5400C are met.

Slip Ring Co. of America, Dept. ED, 3612 W. Jefferson Blvd., Los Angeles 16, Calif.

Mixer Diodes 407

Conversion loss is 5.5 db max

Designed for microwave mixer applications in the L-band frequency spectrum, type D-4097 microwave mixer diodes have a maximum conversion loss of 5.5 db with a maximum output noise ratio of 1.5 times. Applications include radar and missile tracking systems, and similar electronic equipment.

Sylvania Electric Products, Inc., Dept ED, 750 Third Ave., New York 17, N.Y.

CIRCLE 70 ON READER-SERVICE CARD ➤

NEW PRODUCTS

True Airspeed Computers

627

Three models available

These true airspeed computers, called Minitas, consist of a balance transducer, a passive resistance network, and a follow-up servo. Model 620 has an accuracy of ±2.75 knots over the airspeed range of 125 to 450 knots in altitudes of 12,000 to 20,000 ft; model 620-1 has an accuracy of ±0.75 knots over the range of 100 to 200 knots from 0 to 10,000 ft; and model 620-2 has an accuracy of ±12 knots over the range of 300 to 1500 knots from 0 to 80,000 ft. The units meet the requirements for high speed aircraft, patrol planes, helicopters, artillery-directing aircraft, and missiles and conform to MIL-E-5400 and 5272. They weigh 6.5 lb and measure 5 x 8.25 in.

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

Delay Lines

628

Have delays of 0.1, 0.14, 0.2, 0.3, 0.5, and 0.7 μsec

Kit No. 122 provides six lumped constant delay lines with delays of 0.1, 0.14, 0.2, 0.3, 0.5, and 0.7 μsec. Each has a 3:1 delay-to-rise time ratio and is molded in a 0.4 x 1-in. hermetically-sealed brass tube. These phase and frequency compensated delay lines are made for use in transistor and printed circuits. Miniature powdered-iron toroidal inductors and temperature compensating ceramic disc capacitors are used.

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

NEW PRODUCTS

Bandpass Filters 629

Cover 200 to 2400 mc

Type TBP bandpass filters, designed for aircraft and missile applications, cover the frequency range of 200 to 2400 mc. The bandpass may be set from 5% to 25%. The number of sections is 2 to 4; insertion loss is 0.5 ±0.2 db per section. The electrical performance of the filters corresponds to resonant cavities or tank circuits having a quality factor of over 200, unloaded. Made for operation in temperatures higher than 100 C, they withstand shock, vibration, and temperature cycling. A lumped constant filter design is used. The diameter of the units is only slightly larger than that of the BNC connectors at each end.

Telonic Engineering Corp., Dept. ED, Laguna Beach, Calif.

Pulse Modulator 631

Has repetition rates to 4000 pps

Model 12 pulse modulator, with up to 500,000 w peak power, has repetition rates up to 4000 pps. A hydrogen thyratron line type, pulse modulator, it can be furnished with pulse amplifier and generator, or can operate from external power sources. The unit can accommodate pulse-forming networks furnishing 0.5 to 2-μsec pulses. It operates into an output impedance of 50 ohms. Applications are in testing antenna systems or other radar devices.

Electro Powerpacs, Inc., Dept. ED, 5 Hadley St., Cambridge 40, Mass.

Amplifier-Resolver Module 622

Measures 3 in. long

Measuring only 3 in. long, this amplifier-resolver module consists of a size 8 winding compensated resolver and a dual channel buffer amplifier within a size 15 frame. The unit weighs 8 oz. Called the Amplisolver, it offers a transformation ratio of one with no phase shift over the temperature range of −55 to +125 C. It has a minimum input impedance of 1 meg and an output impedance of 270 + j400 ohms. The trim adjustment can be made in the field to ±2% of the unity transformation ratio. Cable connections are eliminated by direct drive from resolver to amplifier. The unit can be adapted to computing chain functions.

American Electronics, Inc., Dept. ED, 9503 W. Jefferson Blvd., Culver City, Calif.

Printed Circuit Boards 626

Use special etching process

These printed circuit boards are made by a special etching process which provides tolerances of ±0.0005. Suitable for military applications, these circuit boards can be gold-plated, flash gold, tin plate, or solder coat plated, with nickel rhodium tips. Completely assembled and packaged boards, including terminal boards are available.

Spec-Tronics, Dept. ED, 13942 Saticoy St., Van Nuys, Calif.

NEW PRODUCTS

Power Supplies 625

Ripple is less than 8 mv

The 880 series and the 870 series of power supplies have less than 2 msec transient response and less than 8 mv ripple. The 880 is offered with a power rating of 0 to 1, 0 to 3, or 0 to 5 amp. Its output voltage range is 3 to 45 v dc, continuously variable. Regulation is 0.1% for combined variations in line and load. It has adjustable load current limiting and remote sensing for maximum regulation at load. The 870 has power ratings of 0 to 0.2, 0 to 0.5, and 0 to 1 amp. It provides an output of 3 to 36 v dc and has a regulation of 0.2% for variations in line and load.

Metrolog, Dept. ED, 169 N. Halstead St., Pasadena, Calif.

Insulation Tester 624

Detects leakages from 20 μa to 3 ma

The Megpot 570RP series of insulation testers provides for continuously variable leakage tests with settings from 20 μa to 3 ma. A relay cuts the current from components being tested in milliseconds. Variable ranges to 10,000 v can be supplied; standard models range from 0 to 3000 v or 0 to 5000 v ac. The voltage is read directly across the output leads. The accuracy is ±5% over the entire voltage range. Full scale output is available with a load capacitance of 0.0025 μf. Designed for modular installations in rack panels, the instrument can be used to test transformers, relays, capacitors, and complete electronic assemblies.

General Hermetic Sealing Corp., Dept. ED, 99 E. Hawthorne Ave., Valley Stream, L.I., N.Y.

SEALED RELAYS—unmatched for reliability

COLD

VIBRATION

SHOCK

HEAT

LIFE

ACCELERATION

To the moon and back without leaving our lab

Rapid acceleration, vibration, violent shock, extreme temperatures—these are the environmental conditions found on a trip to the moon . . . and in General Electric's relay-testing laboratory as well. Here, exhaustive tests—simulating operating and atmospheric conditions—are conducted to continually verify the reliability of G-E sealed relays.

Even in standard production testing, General Electric goes well beyond requirements to assure reliability. Each lot of G-E relays is subjected to 27 tests and measurements before being released for shipment. For example, every relay built is subjected to a 15-cycle dynamic contact-resistance check—the prime indicator of cleanliness.

For one demanding application, General Electric and the customer scheduled 109 tests for each unit. A 5% lot sample was subjected to destructive tests including monitored six-hour vibration and load-life tests. A single relay failure meant rejection of the entire lot. During this contract, 23 consecutive lots (over 4000 relays) were processed without a lot-sample failure!

But testing is only part of G.E.'s reliability story. Design leadership (such as produced the Unimite, the world's smallest 1-amp relay) and advanced manufacturing techniques (including new inert-arc welding to eliminate contact-contaminating solder and flux) consistently produce superior relays.

Obviously, all relays don't require the same testing—but whatever your needs—General Electric has the know-how and facilities to meet them. See your G-E Sales Engineer, or mail the coupon at right. General Electric Co., Specialty Control Dept., Waynesboro, Va.

Progress Is Our Most Important Product

GENERAL ELECTRIC

There's a G-E sealed relay for every circuit need—every reliability requirement

G-E miniature, sub-miniature, micro-miniature and Unimite relays combine small size with unusual reliability under severe temperature, shock, and vibration conditions to make them ideal for electronic jobs, both military and commercial. G.E.'s complete line of sealed relays includes these basic types:

MINIATURE: Long-life type; rated 5 amps at 28 volts d-c; in 2- or 4-pole double throw and 6-pole normally-open forms. Ideal for ground use.

SUB-MINIATURE: 2 amps at 28 volts d-c, 115 volts a-c, double-pole double-throw. Excellent thermal life.

MICRO-MINIATURE: Crystal-can type, double-pole and new welded 4-pole units. Rated 2 amps, 28 v d-c or 115 v a-c. Grid-space terminals available.

UNIMITE: The world's smallest 1-amp sealed relay; single-pole type. Isolated contact chamber, high speed 1.5 millisecond operation.

General Electric Co.
Section C792-11
Schenectady 5, N. Y.

Please send me a free copy of the 1959-60 Sealed Relay Catalog.

Name_____

Address_____

City_____

State_____

GENERAL ELECTRIC

CIRCLE 83 ON READER-SERVICE CARD

NEW PRODUCTS

Indicator Light 587

Legend area is 15/32 x 1-1/4 in.

The Roto-Tellite word indicator light has a visible legend area of 15/32 x 1-1/4 in. It will accommodate up to three rows of 0.125 in. high characters, fourteen per row. It may be used for feedback of information in man-machine systems on control panels at missile launch sites, in computers, and aircraft. Burned out bulbs are replaced from the front, and legends and circuitry are completely replaceable.

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

Plate Transformers 602

Voltage-regulated

These voltage-regulated plate and filament transformers are made for critical electron-tube power supplies. Regulation of dc plate voltage from input to filter is ±3% against line variations of 100 to 130 v ac. The units also provide filament voltages of 5 and 6.3 v ac regulated to ±3%. Model MVRP-40 supplies 275 v dc at 50 ma, 6.3 v ac at 2.5 amp, and 5 v ac at 2 amp. Model MVRP-70 provides 385 v dc at 110 ma, 6.3 v ac at 3 amp, and 5 v ac at 2 amp. Model MVRP-185 provides 380 v dc at 250 ma, 6.3 v ac at 4 amp regulated and 8 amp unregulated, and 5 v ac at 3 amp. All dc voltages are measured at the input to a capacitor-input filter following a type 5Y3GT rectifier for models MVRP-40 and 70 or a type 5U4GA/GB for the MVRP-185.

Sorensen and Co., Dept. ED, Richards Ave., S. Norwalk, Conn.

Insulation Tester 508

Has automatic operation

Model 8515 insulation life tester operates automatically for periods up to 12 hr and makes high voltage breakdown tests on as many as 50 individual components. The leakage current metering circuits have ranges of 0 to 10, 25, 100, and 250 ma. Automatic reject controls are adjustable from 0.5 μa to 250 ma. Testing can be done on transformers, capacitors, and other electronic components. The components or circuits are tested in sequence, at the pre-set potential. When leakage current in excess of the predetermined value develops, the unit sounds an alarm, shuts off completely, or continues checking but allows the test potential on the unit that has failed to drop to zero.

Associated Research, Inc., Dept. ED, 3777 W. Belmont Ave., Chicago, Ill.

Video Sweep Integrators 572

Increase radar range

The 800 Series video sweep integrators increase the radar range by adding up to 1000 sweeps. The units use super-regenerative amplifiers in conjunction with a solid ultrasonic delay line memory. Complete interchangeability of the delay line is possible without amplifier retuning. The integrator provides the high gain needed to compensate for the delay line loss in a single super-regenerative amplifier stage. Suitable for airborne use, the unit has applications such as the integration of hits across the beam in a wide beam search radar and long-time integration in a pencil beam radar which searchlights an active target.

Atronic Products, Inc., Dept. ED, 1 Bala Ave., Bala-Cynwyd, Pa.

NEW PRODUCTS

AC Voltage Regulator 590

Provides ±1% regulation, half load to full load

This miniature, plug-in type ac voltage regulator provides a regulation of ±1%, half load to full load. Completely transistorized, this compact unit can replace heavy, rack-size sources using magnetic amplifiers or frequency sensitive transformers in applications requiring small outputs. Model AR-1 has an output of 115 v ac at 1 amp; model AR-2 has an output of 6.3 v ac at 10 amp; and model AR-3, 12.6 v ac at 5 amp. Dimensions for all units are 4.75 x 5.74 x 5 in. The requirements of MIL-E-5282A are met.

Electronic Assembly Co., Dept. ED, 5 Prescott St., Roxbury, Mass.

Spectrum Analyzer 591

Bandwidth is 70 cps or 1 kc

Type 190 spectrum analyzer measures the power level in a 70-cps or 1-kc bandwidth in the frequency range of 500 cps to 90 kc. Power measurements may be obtained automatically using a swept

oscilloscope or manually. Able to handle signals from 0.1 v to 1 mv, the instrument has a high sensitivity and an accuracy of ±2 db.

Ferranti Electric Inc., Electronics Div., Dept. ED, 95 Madison Ave., Hempstead, L.I., N.Y.

Accelerometers 594

Have 1 in. diam

Series LA34 accelerometers measure 1 in. in diam and 1.5 in. long, and weigh 4 oz. For missile control systems, missile and aircraft tests, and other applications requiring precision measurements, the units have a linearity and an accuracy of 1%. Of steel construction, they are hermetically-sealed and use a glass cylinder-carbon piston damper. Operation under severe environmental conditions is provided for.

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

Reader 586

For oscillograms and strip charts

The Oscar Model K reader is designed for use with oscillograms and strip chart records. The unit has motorized chart drive, channel and time counters patchboard programming, and a serial keyboard for manual data input. The reader can be used to automatically operate a typewriter and card punch.

Benson-Lehner Corp., Dept. ED, 1860 Franklin St., Santa Monica, Calif.

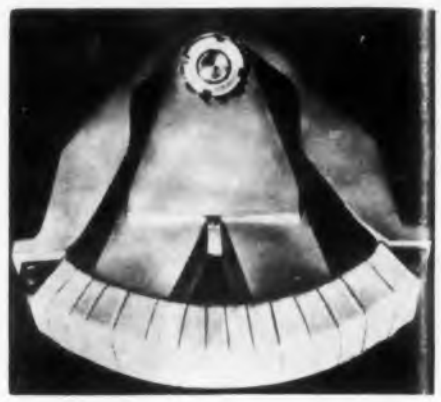
Correction Notice

The 15-mc transistors made by General Electric Co. were reported in the December 9th issue as having a temperature range of 65 to 200 C. Actually, their temperature range is −65 to +200 C.

NEW PRODUCTS

DC Torque Motors 603

Have up to 200 lb-in.



Series ARTQ torque motors come in torque sizes up to 200 lb-in., in various rotational limits up to 60 deg, and have better than 1% linearity of torque vs input current. The slot lock is zero and the resolution is infinite. The units are for use in airborne stable platforms, inertial systems, tracking systems, and other military and commercial applications.

The Aeroflex Corp., Dept. ED, 34-06 Skillman Ave., Long Island City 1, N.Y.

Cable Tester 597

For dielectric testing to 5 kv rms

This automatic cable tester provides for dielectric testing to 5 kv rms and has an adjustable test time of 1 to 120 sec. The maximum short circuit current is limited to 5 ma. The unit has a built-in test cage with a terminal board for components. These characteristics may be ordered to meet individual specifications: test voltages, change in dwell time, variation in number of test positions, and rate of voltage rise control. The uses include the testing of cables, headers, switches.

...ip-ring assemblies, and other mul-...conductor devices.

Peschel Electronics, Inc., Dept. ED, Towners, Patterson, N.Y.

Indicator Light 600

Clip mounted

Series CML clip mounted indicator lights mount in a 0.294-in. hole; the circular clip permits mounting on 0.5-in. centers. Available with a choice of neon or incandescent lamps, with or without hot stamped legends, they are for use in instruments and small equipment as well as on computers and data processors.

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

Insulation Material 582

Stands up to 200 C

FEP Teflon 100 is a melt extrudable jacketing compound that stands temperatures up to 200 C. It can be used as a jacketing material for multiconductor and coaxial cables, and as a primary insulation on hook-up wires. It is a clear material that can be pigmented and striped for identification purposes.

American Super-Temperature Wires, Inc., Dept. ED, W. Canal St., Winooski, Vt.

Right Product, Wrong Company

The type TES tantalum electrolytic capacitors described on page 80 of the November 25, 1959, issue of ELECTRONIC DESIGN are made by Transistor Electronics, Inc., West Road, Bennington, Vt.,—not by Transistor Electronics, Inc.

CIRCLE 88 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Signal Simulator 510

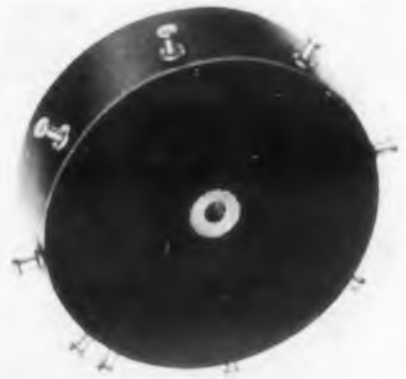
For telemetry and missile check-out uses

Model 52 PDM signal simulator generates pulse trains identical to the video data output of a standard telemetry receiver. Completely electronic and self-contained, the unit provides an accuracy which exceeds the requirements of IRIG No. 103-56. It can be used for conducting check-out before missile firing as well as setting up telemetry stations.

Instrument Corp. of Florida, Dept. ED, P.O. Box 1226, Melbourne, Fla.

Toroidal Transformers 515

Operate from −55 to +130 C



Suitable for transistorized power supplies, these toroidal transformers operate within the temperature range of −55 to +130 C. They have ratings of 25, 60, and 120 w and operate on 12 to 14 v dc. The units are encapsulated.

Barker and Williamson, Inc., Dept. ED, Bristol, Pa.

Count Rate Meter 509

Has ranges to 600,000 cpm

Model 502 count rate meter has eight scale ranges, extending to 600,000 cpm. Time constants of 1, 5, and 10 sec are selected by front panel switching. The input is sensitive to a 250-mv negative pulse. This instrument can drive a

0 to 1-ma or a 0 to 10-mv recorder. Completely transistorized, the unit is built on a standard 3-1/2 x 19-in. relay rack panel and weighs about 10 lb.

Interstate Electronics Corp., Dept. ED, 707 E. Vermont Ave., Anaheim, Calif.

Analog to Digital Converter 484

Readout time is 0.05 sec

Model 3500 analog to digital converter has a readout time of 0.05 sec. Twelve output codes allow application directly. The unit has a plug-in separable connector, bi-directional operation, and provides a high accuracy. Lost motion couplers permit dynamic readout when the input shaft is turning at speeds to 250 rpm. Guaranteed life of the unit is over 20,000,000 operations.

Telechrome Manufacturing Corp., Automation Div., Dept. ED, 26 Edison St., Amityville, N.Y.

DC Power Supplies 512

Operate from −55 to +60 C

Made to operate from −55 to +60 C, these transistorized power supplies have a steady dc output with a ripple of 0.4% max and excellent voltage regulation. Model CA-1263-12 has an output of 300 to 600 v dc at 200 to 400 ma and 120 w. Model CA-12105-10 has an output of 500 to 1000 v dc at 100 to 200 ma and 100 w. Both units operate from an input of 12.6 v dc. Heavy-anodized aluminum chassis and a perforated cover that helps dissipate heat are used. The CA-1263-12 measures 4-1/8 x 3-3/8 x 2-1/2 in. and the CA-12105-10 measures 4-3/8 x 4-1/2 x 2-1/2 in.

Kupfriar Manufacturing Corp., Dept. ED, 167 Prospect Ave., Binghamton, N.Y.

NEW PRODUCTS

Crystal Oven 502

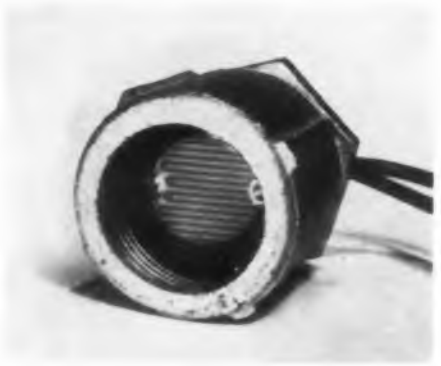
Temperature control is to ±1 deg C

This quartz crystal oven maintains an even temperature to ±1 deg C over a 100 deg C ambient temperature range. It holds either one or two HC-6/U crystals. Contacts are made of platinum iridium.

Federated Electronics, Inc., Dept. ED, 139-14 Jamaica Ave., Jamaica 35, N.Y.

Sensing Element 516

Operates relays or counters



Made to operate relays or counters without amplifications, type P-CE solid state sensing element is a moisture-resistant cadmium sulfide cell. The coil resistance of the solenoid or erlay should be about 2200 to 2800 ohms with a maximum current of 50 ma at 115 v ac. The unit has a threaded mounting hub for a 3/4-in. conduit.

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

AF Filters 479

Insertion loss is less than 2 db

For multichannel band separation use, this

modular line of af filters have input and output impedances of 2 K and an insertion loss of less than 2 db. Center frequencies are 1.05, 3.78, 10.6, 21.6, 36.7, and 52.6 kc. The units measure 2-1/4 x 2-1/8 x 4 in. The unit shown, type BF-118, has a center frequency of 21.6 kc. The 1.5-db bandwidth is 13 kc and the 35-db bandwidth is 34.5 kc. Hermetically sealed, the unit meets applicable Mil specs.

Control Electronics Co., Inc., Dept. ED, Huntington Station, N.Y.

Enclosure Assemblies 571

For control systems

For use in industrial control systems, the Plug-Pak enclosure assemblies are made of No. 16 gage cold rolled steel. Each enclosure consists of a removable cover with chrome handle, mounting plate, and solderless plug. The assembled unit plugs into a standard 10-3/8-in. wide wiring duct. Lengths are from 3 to 12 in. and depth is 11-1/2 in.

Gemco Electric Co., Dept. ED, 25685 W. Eight Mile Rd., Detroit 40, Mich.

Zone Melting Apparatus 504

Speed is 0.1 to 18 in. per hr

Model Z-82 zone melting apparatus can be set for speeds from 0.1 to 18 in. per hr and has a return of 2 in. per sec. Equipped with a vacuum system, including diffusion pump, vacuum valves, and mechanical pump bypass, it can provide a vacuum as high as 10^{-5} mm Hg. The automatic program drive permits zone refining, zone leveling, and crystal pulling without having to use controls.

Materials Research Corp., Dept. ED, 47 Buena Vista Ave., Yonkers, 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

BEHIND THE NEUTRON CURTAIN. It may be that the Russians are planning to create an immense neutron cloud cover by setting off a series of high-altitude (300 miles and up) atom and hydrogen bomb blasts. Such a cloud cover would act as a sort of shield against atomic warheads, heating atomic missiles that travel at speeds of 15,000 mph and causing the uranium 235 or plutonium to melt. The atomic engines of planes would also be destroyed in this way. The destructive clouds would probably move in well-defined paths, the Russians theorize, and could also be used to destroy life aboard manned satellites.

WANTED: *By the Air Force:* a non-radiating range-measuring device capable of ranging 20,000 to 30,000 feet ahead of aircraft flying at 500-1000 feet absolute altitude. *By the Navy:* some sort of electronic device that can detect atomic submarines at long distance. Problems that must be overcome: subs are quiet, don't surface, are fast. Some consider atomic subs to be the greatest menace of World War III. The jackpot could run to billions of dollars for the electronics company that solves the detection problem. *By the Air Force:* a means of identifying overstressed materials before failure occurs, to solve the problem of detecting impending failure in rotor blades and components.

FRIENDLY CHALLENGE. Perhaps the competition between the U. S. and the U. S. S. R. in the field of technology could be diverted to accommodate a new "race" in which the consequences for the loser are less ominous. This thought came to us with the announcement of the recent development in the U. S. of an electronic chess-playing computer, the third and most sophisticated of its kind yet developed, that is capable of giving a "fairly good player" a battle. The Russians, too, have developed a machine of equal merit, so . . . our machine will play your machine, Ivan—just name the date.

CHECK LIST FOR SPECIAL CABLE. As an aid to the engineer who has to design and use special electronic cables, we've printed the following check list which summarizes the desired requirements. Copies of this check list as a Cable Procurement Information Form will be sent at your request if you write to IMPULSE, c/o Rome Cable Corp., Dept. 1112, Rome, N. Y. When writing, ask for Bulletin RCD-400, a summary of special instrumentation cables available from Rome.

Number of conductors . . . conductor's size and stranding . . . desired insulation . . . shielding . . . outer covering . . . desired cable construction . . . maximum and minimum O.D. . . . upper operating-temperature limit . . . lower operating-temperature limit . . . bending radius desired . . . type of duty . . . electrical characteristics . . . special requirements . . . desired shipping lengths . . . specifications.

CABLEMAN'S CORNER. An important phase in multi-conductor cable manufacture is the manner and equipment used to "cable," or "twist," the various components together. The end use of the cable becomes an important factor in the assembly of a cable. Where flexibility is important, the length of lay, direction of lay, and the internal components all play important roles. Where connector fittings are employed, the sequential arrangement of the components may be important. Because of differing machine capabilities, even the selection of the specific piece of equipment for assembling your cable becomes important. To obtain the best results, consult a cable specialist—a man familiar with all the aspects of cable manufacture—your Rome Cable salesman.

These news items represent a digest of information found in many of the publications and periodicals of the electronics 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 96 ON READER-SERVICE CARD

A NEW PERSPECTIVE ON THE NEWS

Look for the *new* news in ELECTRONIC DESIGN—news specially gathered and written, interpreted and edited for one group only, electronic design engineers.

The news section of ELECTRONIC DESIGN has been expanded and fortified to give design engineers news they cannot get elsewhere: first reports on design trends; developments that spell change for designers; news from Washington, from technical meetings, from military sources and from overseas—all written from the design point of view.

To report this ELECTRONIC DESIGN NEWS, two new editors have joined the staff:

Alan Corneretto
***Interest** in electronics started with military radio schools and service as radio technician. After journalism studies at Columbia, began 10 year career in technical writing on business papers, including* Petroleum Processing *and* Product Engineering. *Has traveled widely in industry writing news and feature articles.*

Howard Bierman
B.E.E. from City College of New York. Former electronic design chief engineer in audio and hi fi equipment at Mark Simpson Mfg. Co., senior engineer in TV design at Tech Master Corp., also presently a color TV instructor at RCA Institute. Author of "Handbook of 630-type TV Receivers" and other books.

Watch for, and read, ELECTRONIC DESIGN NEWS . . . in every issue of ELECTRONIC DESIGN.

NEW LITERATURE

Switching Systems 102

Bulletin S-881A, six pages, describes static control through the use of solid state power/logic switching systems. Illustrated with photographs, diagrams and charts, the booklet outlines the structure of a typical system and provides a functional description of its parts. Construction of the device and applications are also covered. Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N.Y.

Static Power Devices 103

This folder contains data sheets on inverters, frequency changers, a multiple output converter, a filter pack, and a regulator pack. Input, output, physical characteristics, and special features are given for each of the 11 models. Also included in this folder is an eight-page bulletin, which describes special features and applications of the firm's static power devices. American Electronics, Inc., 1025 W. 7th St., Los Angeles 17, Calif.

Ferrites 104

"Magnetostrictive Ferrites for Transducer Applications" and "Ferrites for Missile and Advanced Electronics Applications" are the titles of two bulletins, 11 and 19 pages respectively. Illustrated with graphs and schematic diagrams, these bulletins compare the firm's ferrites with the properties of other commercially available ferrites, list characteristics of specific ferrite types, and describe applications of the various types. Kearfott Co., Inc., 1500 Main Ave., Clifton, N.J.

Miniature Electronic Connectors 105

A new catalog insert on Buggie BANTAM Connectors is being released to engineers interested in miniaturization programs. This literature gives complete specifications, and illustrates BT Series insert contact arrangement. H. H. Buggie Div., Burndy Corp., Box 817, Toledo 1, Ohio.

Doppler Shift Calculator

A calculator that provides quick determination of doppler shift for a wide range of velocities and frequencies is available. Simple adjustment of this pocket-size device determines doppler shift in one operation. The calculator scale provides a direct reading converting knots to feet per second. A 12-page instruction booklet accompanies the calculator. *Send 50 cents to Sylvania Electric Products, Inc., 1100 Main St., Buffalo 9, N.Y.*

Silicone Tape 108

Eight different samples of silicone tape are contained in this reference folder. It describes the properties of each tape sample and the outstanding electrical applications. This helps selection of elongation, dielectric strength and other properties for all winding needs. Thermoid Division, H. K. Porter Co., Inc., Tacony and Comly Sts., Philadelphia 24, Pa.

Fail-Safe Annunciator 109

Bulletin 108 illustrates and fully describes a fail-safe annunciator which differentiates immediately between its own component failure and an alarm in the system being protected. The design uses two lamps per annunciator point, one to signal field abnormality and one to signal annunciator component failure. Photographs, and cabinet dimensions are included in the four-page bulletin. Panalarm division of Panellit, Inc., 7401 N. Hamlin Ave., Skokie, Ill.

Signal Generator Specifications

This 28-page book contains complete specifications and prices of 152 signal generators made by 30 American and foreign companies. Specifications are arranged in tabular form using common headings. The instruments are arranged according to upper frequency range and run from 70 kc to 40 kmc. All instruments are indexed by manufacturer and function. *Send $2.00 to Technical Information Corp., Dept ED, 41 Union Square, New York 3, N. Y.*

Pushbutton Switch Assemblies 110

This eight-page data sheet covers three one-shot pushbutton assemblies that have a special circuit to produce one square wave pulse regardless of operating speed. Photographs, graphs, and diagrams are included. Variations are available with pulse widths from 0.1 to 10 μsec. Application information, mounting dimensions, list prices and discounts are given. Micro Switch, a division of Minneapolis-Honeywell Regulator Co., Freeport, Ill.

NEW LITERATURE

Universal Impedance Bridges 113

Catalog sheet C-16, four pages, describes the firm's 250 series of portable universal impedance bridges. The sheet gives complete specifications and operating data on line-operated and battery portable models. In addition to usual component measurements, these bridges can be used for quality control testing, precise component matching and correlation of source and receiving inspection tests. Electro Measurements, Inc., 7524 S. W. Macadam Ave., Portland 19, Ore.

Voltmeter 114

This illustrated bulletin covers features of the firm's model R-2 voltmeter. The two-page bulletin specifies its applications—such as measuring the regulation of power supplies, the resolution of potentiometers, and the linearity of amplifiers. Specifications and a schematic diagram of the unit are given. Southwestern Industrial Electronics Co., a division of Dresser Industries, Inc., 10201 Westheimer, P. O. Box 22187, Houston 27, Tex.

Semiconductor Slicing Machine 115

Literature and an article reprint describe the model MTA-7 machine which can be used to slice semiconductor materials. Photographs, drawings and specifications are included. The DoAll Co., Des Plaines, Ill.

Insulation 116

Bulletin CDS-208 lists the outstanding insulation properties of the firm's Class 900 electrical grade silicone rubber. It also discusses the major application areas in which silicone insulated cable has proved its performance. A comparison of properties vital to cable applications is presented between silicone rubber, butyl, GR-S, and natural rubber. The bulletin has four pages. Silicone Products Dept., General Electric Co., Waterford, N. Y.

Zener Voltage Tester 117

Catalog sheet 115 describes the firm's Zener voltage tester, model DT100. The features and specifications of the unit are given. The tester is a self-contained ac operated instrument designed for direct reading of Zener voltage as well as testing for Zener diode impedance. It is designed for testing all types of semi-conductors including transistors and diodes. Electronic Research Associates, Inc., 67 Factory Place, Cedar Grove, N. J.

Glass-Epoxy Laminates 118

Glass-base, epoxy resin laminated plastic and copper-clad laminates are described in two bulletins, each two pages. Material, characteristics, and typical properties are covered in each bulletin. Thickness tolerances of copper foils and copper clad sheets are given; specifications are listed on each page. Taylor Fibre Co., Norristown, Pa.

Miniature Rotary Switches 119

Bulletin 14A, two pages, describes special assemblies of the firm's model MA-12 miniature rotary switch: the lever-actuated switch and the solenoid-operated switch. Dimensions, mounting data, electrical data, electrical ratings, and a description of the model MA-12 rotary switch also appear. Photos of the three switches are included. Electro Switch Corp., 167 King Ave., Weymouth 88, Mass.

Computer Typewriter 120

This two-page bulletin discusses an alphanumeric typewriter which is used in conjunction with the firm's model G-15 digital computer. Every character on the typewriter has its own code for full and direct input, output, and control of the computer. In addition to a description of the digital computer, there is an illustration of the typewriter in operation. Bendix Aviation Corp., Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif.

Connections 121

This catalog provides data on the firm's Reli-Acon receptacles, plugs, paired receptacles, paired plugs, paired plugs with shell, card receptacles, card plugs, plug with shell, Plyo-Duct cable plug and printed circuit card receptacle locking devices. It contains illustrations, schematics, technical information and other pertinent data. Methode Manufacturing Corp., 7447 W. Wilson Ave., Chicago 31, Ill.

Computer Control Systems 122

Complete details on solid state analog computer control systems are presented in bulletin MSP-163. Illustrated, it describes the entire system, including solid state controllers with operational magnetic amplifiers, interchangeable components, remote control stations and central patchboard networks that interconnect the system. The six-page bulletin has diagrams which show interchangeable circuits possible for various control functions, including addition, subtraction, multiplication, ratioing, differentiating, and integrating. Hagan Chemical & Controls, Inc., Controls Div., Hagan Bldg., Pittsburgh 30, Pa.

INDEX of ARTICLES

July 8 through December 23, 1959

Reference Keys

ABS Abstract
DF Design Forum
ED Engineering Data
GA German Abstract
ID Ideas for Design
PF Product Feature
RT Russian Translation

Bold face type indicates exact title of articles.

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IDEAS FOR DESIGN

Photon Detector Gain-Compensates Itself

IN INFRARED experiments, the effect of atmospheric conditions on transmission must often be determined. Unfortunately, gain variation in the photon detector causes errors in these tests.

A technique was developed to monitor and compensate for variations in detector gain. A conventional system, Fig. 1, used to study atmospheric effects on radiation consists simply of a transmitter and receiver. The main elements of the transmitter are an amplitude modulated source of radiation and an optical radiating system. The receiver consists of an optical system, a detector, and associated electronics. The receiver is tuned by means of filters to the frequency of the amplitude modulated source, D_s. However, the photon detector requires a different approach.

If the size of the detector is large and the distance between the receiver and transmitter appreciable, the receiver's field of view covers an area many times larger than the receiver. The background radiation inherent in the field of view has a biasing effect on the detector which may cause it to operate in a nonlinear region. Secondary effects of age and changes in temperature tend to alter the characteristics of the detector.

Second Radiating Source Added

Variations in the gain of the detector are compensated for with the addition of a second "standard" modulated source. This source is placed behind the receiver's spherical mirror, Fig. 2.

Radiation at a frequency *F1* from the distant source D_s and radiation at a frequency of *F2* from the monitoring source strike the detector. Frequency-selective circuitry direct *F1* in Channel One and *F2* into Channel Two. The gain of Channel One is controlled by the agc voltage developed in Channel Two. Since the agc voltage is now a function of the detector's gain, the overall Channel One gain of the receiver can be held constant. Also, any change in detector gain can be monitored by examining the output of the Channel Two amplifier.

Edward Kleist, Analyst, Ramo-Wooldridge, Los Angeles, Calif.

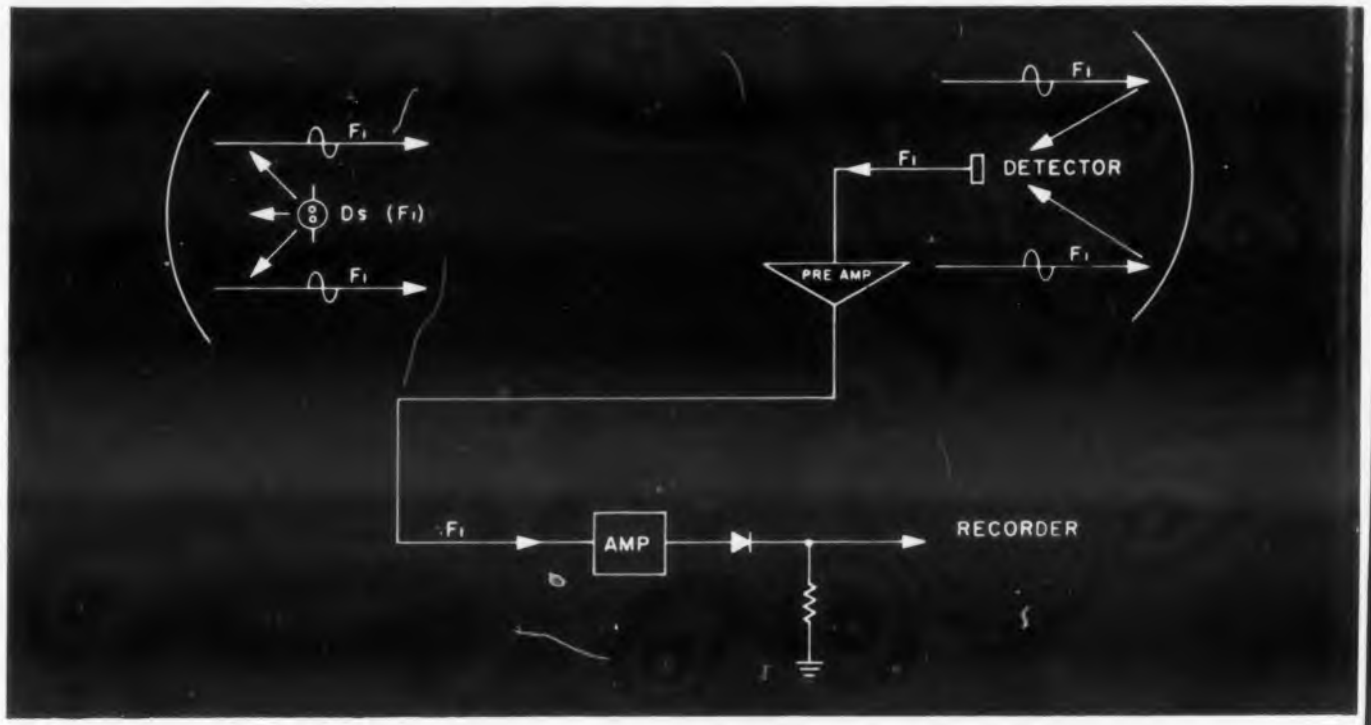


Fig. 1. Measurement of atmospheric effects on IR transmission are subject to detector gain errors.

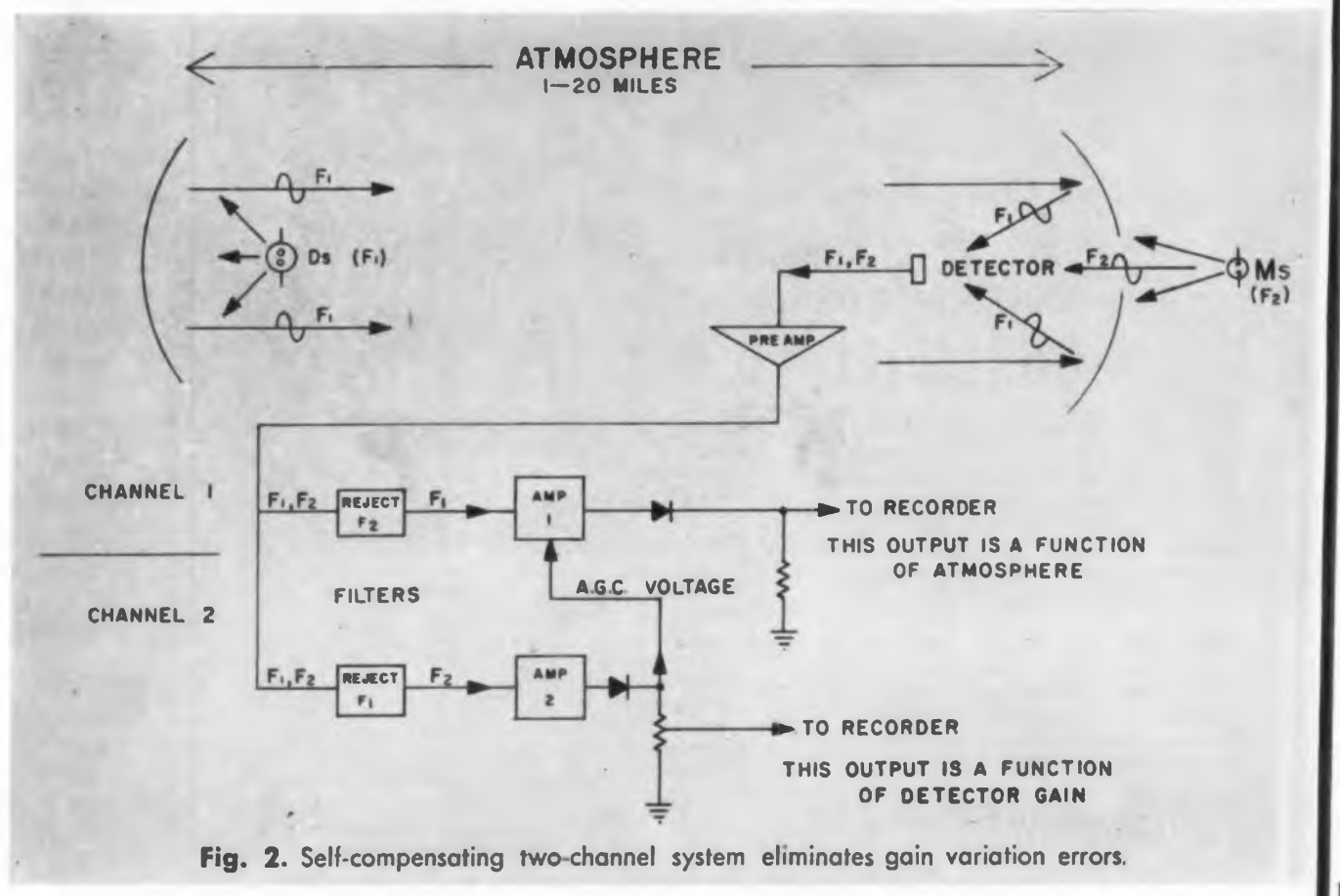


Fig. 2. Self-compensating two-channel system eliminates gain variation errors.

A HERITAGE IN ELECTRONICS

Val Leach, founder of Leach Corporation, wrote the advertisement, left, 27 years ago. In it Mr. Leach laid down a business philosophy that is as valid today as it was in 1933. He knew there would be no room for "yesterday's heroes" among the companies supplying the vital, growing electronics industry. He knew that success would be in direct ratio to uncompromising product reliability. And he also knew that technological progress could only be based on the solving of tomorrow's problems

Today, Leach continues to provide the industry of flight with reliable, high performance relays and contactors in the tradition of the original Leach Relay Company. Over the years, Leach has also pioneered and developed many other advanced technical products and services. Today, their scope greatly enlarged, Leach designs, engineers and manufactures:

ELECTRO-MECHANICAL AND ELECTRONIC COMPONENTS—relays, contactors, solid state devices

INSTRUMENTS—tape recorders, accessory equipment, recording accelerometers

POWER CONVERSION EQUIPMENT—motor generator sets, DC and special purpose power supplies

CONTROL AND DISTRIBUTION EQUIPMENT—control and distribution centers, load banks, bench panels, test benches

..... with the know-how to incorporate them into **ELECTRONIC SUB-SYSTEMS AND SYSTEMS.**

This year Leach Corporation celebrates its 40th anniversary in electronics with a reaffirmation of Val Leach's time honored principles:

Solving problems is the core of the Leach philosophy of doing business. Leach will continue to base its success on anticipating customer needs and meeting them with advancements tailored to specific requirements.

For electronic sub-systems and electro-mechanical components to meet the requirements of the space age . . .

LOOK TO LEACH

LEACH CORPORATION, 18435 SUSANA ROAD, COMPTON, CALIFORNIA • DISTRICT OFFICES AND FIELD REPRESENTATIVES IN PRINCIPAL CITIES OF U. S. AND CANADA • EXPORT: LEACH CORPORATION, INTERNATIONAL DIVISION

CIRCLE 141 ON READER-SERVICE CARD

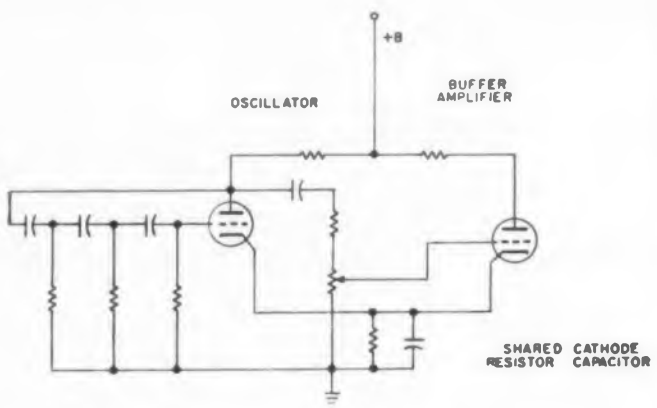
IDEAS FOR DESIGN

Save Amplifier Components

Vacuum tube amplifiers usually require separate cathode resistors and capacitors in each stage because low frequency oscillations may occur unless the cathode capacitor is very large.

In constructing a phase shift oscillator and buffer amplifier it was found that the amplifier could share the cathode resistor and capacitor of the oscillator section because a fixed attenuator had to be used to prevent overdriving the amplifier. This suggests that very often a cathode resistor and capacitor can be shared whenever the loss in the interstage network is high at frequencies for which the bypass is necessary. This is often the case as in pulse, equalizing, and differentiating amplifiers.

Lawrence E. Cowles, Electronic Design Engineer, The Superior Oil Company, P. O. Box 63, Bellaire, Tex.



Cathode resistor and capacitor can be shared.

Small Inductance for Faster Switching

Diode clamping is frequently used in transistor switching circuits to preserve voltage levels and decrease switching speeds. A typical application is shown in Fig. 1.

During the upward excursion of the input, the transistor cuts off and the output voltage heads toward −15 volts, but is clamped when it reaches −3 volts.

When the input returns to its negative level, the transistor begins to conduct, but the output will

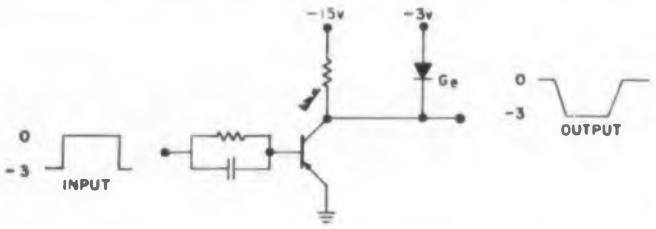


Fig. 1. RCTL inverter with clamped output.

FC-43 IS PRESSURE TRANSFER MEDIUM IN STATHAM TRANSDUCER Statham Instruments, Inc., Los Angeles, California, uses 3M Brand Fluorochemical Inert Liquid FC-43 in a transducer which measures differential line pressures of corrosive media. The stainless steel transducer contains FC-43 enclosed between two diaphragms against which a flowing medium is forced. FC-43's high bulk modulus (weight per unit volume) helps in accurate measurement of bi-directional pressure of this medium in the presence of high line pressure. FC-43's thermal stability allows transducer to be used in a temperature range of —40°F. to +200°F. And, it does not affect metals used in the construction of the transducer.

Fig. 2. "Notching" effect caused by large clamp current.

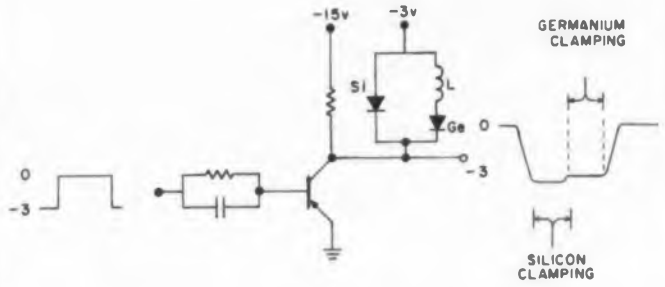


Fig. 3. Inverter with improved clamp eliminates notch, increases rise time.

not increase positively until the clamp diode cuts off. Eventually, the transistor saturates and holds the output at approximately ground potential.

To maintain fast switching speeds, it is often necessary to keep the collector load resistor as small as the dc current rating of the transistor permits. This results in a large clamping current which prevents the diode from turning off rapidly, and causes the "notching" effect shown in Fig. 2.

The "notch" can be removed and the output rise time substantially reduced if the clamp circuit shown in Fig. 3 is used.

As the input goes positive, the transistor cuts off; initially, the germanium diode will not conduct since the current through the inductance does not build up immediately. During this part of the transient, the output is clamped by the silicon diode and is more negative than —3 volts by the drop across the silicon diode.

Eventually, current builds up through the inductance and the germanium diode takes over the clamping action. The silicon diode then cuts off, since its conducting voltage drop is higher than that for the germanium.

When the input goes negative again, the transistor begins to conduct. Part of the inductor current then flows into the collector of the transistor and allows it to saturate rapidly. While the transistor remains saturated, the inductor current decays and the germanium diode cuts off.

Using this technique, improvements of 20 millimicroseconds on the rise time of the output have been observed.

The value of L used depends on the clamp current and the maximum pulse repetition rate. A value of 20 μh has been found satisfactory for most applications.

Two germanium diodes in series may be used in place of the silicon diode if desired.

Joseph L. Kozikowski, Associate Development Engineer, Burroughs Research Center, Paoli, Pa.

BOOKS

Principles of Analog Computation

George W. Smith, Roger C. Wood, McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 36, N. Y., 234 pp, $7.50.

Designed for the user of analog computers, this book presents those methods of analog computation which form the fundamental tools for the analyst working in the field. This has been done by emphasizing analog-computer techniques, rather than discussing the detailed design of analog-computer components.

In general, the plan has been to present only enough discussion of component principles to afford an understanding of their operation. In doing this, the component devices are introduced, and the mathematical operation performed by a particular device is stressed. Then the book goes on to present detailed information on circuitry and considers the types of problems which can be solved using the computer techniques. Several new techniques are introduced involving diodes, and a discussion of smoothing methods for diode function generators is also included.

Nuclear Electronics

Distributed by National Agency for International Publications, Inc., 801 Third Avenue, New York 22, N. Y., 452 pp, $4.00

This volume is a collection of scientific papers on nuclear electronics given at the 1958 International Symposium on Nuclear Electronics, France. The Symposium was divided into five sessions, the topics of

which were: Scintillation Radiation Detectors, Radiation Detectors using Ionizing Methods, and Gamma-Ray Spectrometers, Pulse Technique: Fast Electronics, Pulse Technique: Classical Electronics and Reactor Control: Measurements. It is to be noted that about half of the papers presented are printed in French.

Nondestructive Testing Handbook

Edited by Robert C. McMaster, The Ronald Press Co., 15 E. 26th St., New York 10, N. Y., Vol. I, Vol. II, $24.00.

This handbook has been prepared under the auspices of the Society for Nondestructive Testing and tries to bring together all vital testing information in a single reference work. It is designed for all those who have an interest in the management, engineering, or research of testing in the production, processing, or maintenance phases of any industry. It presents treatments of all major methods of nondestructive testing, enabling the measurement of significant properties, the detection of discontinuities, and the prediction of performance capabilities without impairing serviceability.

Discussed also are the fundamental principles and policies of nondestructive testing, the evaluation of tests for specific applications, the detailed analysis of all basic methods and equipment, and the interpretation of test indications. Test selection charts furnish guidance on the best testing methods for given types of materials and defects. It is organized in 54 sections, is illustrated with charts, drawings, forms, and photographs, and supplies considerable standard data in tables and graphs.

Bodine Fractional-Horsepower Motor Handbook

Bodine Electric Co., 2500 W. Bradley Place, Chicago 18, Ill., 66 pp, $1.00.

This is a new technical information handbook on fractional horsepower motors. It contains the following information: definitions of classes of motors and of types of enclosures, general motor terms, application fundamentals such as selection considerations, performance characteristics, speed control, reversing, etc.; care and servicing of small motors, and formulas, charts and tables useful in motor application work.

RUSSIAN TRANSLATIONS

J. George Adashko

Driving a Pair of Pulses Through a Chain and Ring of Triggered Multivibrators

A. F. Ivanov and V. R. Telesnin
Moscow State University
U. S. S. R.

A MULTIVIBRATOR with a positive grid,[1] such as the one shown in Fig. 1, produces a nearly rectangular output pulse when a short starting pulse is applied to its input. The duration of this pulse τ_u is determined by the equation[2]

$$\tau_u = R_C\, C \ln \frac{U_0 - I_{02}R_k + I_{01}\, R_{a1}}{U_0 + U_{C2} - I_{01}\, R_k}$$

In this equation, U_0 is the supply voltage, I_{01} and I_{02} are the quiescent currents of tubes *1* and *2*, U_{C2} is the cutoff voltage of tube *2*, and the significance of R_k, R_{a1}, and R_C is clear from Fig. 1.

The operating threshold of the multivibrator,

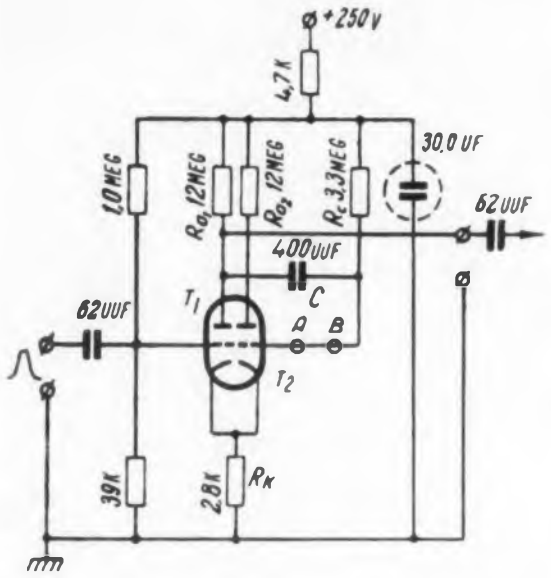


Fig. 1. A basic multivibrator with a trigger pulse applied to one grid.

i.e., the minimum amplitude required of trigger pulses, depends, in general, on their duration. This threshold is quite high after the termination of the multivibrator pulse. It then decreases and asymptotically approaches the limiting value.

The process can be assumed to be exponential. Its time constant is determined by the quantity

$$C\,[R_{a1} + R_{ak} + (1 + SR_k)R_{gk}]$$

where R_{gk} is the grid-cathode resistance of the second tube, and S is its transconductance. The capacitor-charging time constant can be increased by adding resistance to the grid circuit of tube 2.

An experimental investigation showed the dependence of the operating threshold on the time elapsing after the termination of the multivibrator's preceding pulse. A double-pulse generator was used to apply a pair of short-duration pulses to the input of the multi.

The time interval τ_{12} between the pulses, as well as the amplitude U of the second pulse could be varied over the range $100 < \tau_{12} < 1000$ microseconds and $0 < U < 20$ volts. The repetition period T of the pair of pulses was much greater than τ_{12}.

Voltage from one of the plates of the multi was applied to a driven-sweep oscilloscope, with the sweep chosen to display several pulses.

The amplitude of the first pulse was chosen to be high enough to operate the multi. At a fixed value of τ_{12} between the pulses of the pair, the second pulse operates the multi if the pulse amplitude exceeds the threshold value of U.

(Continued on p 130)

RUSSIAN TRANSLATIONS

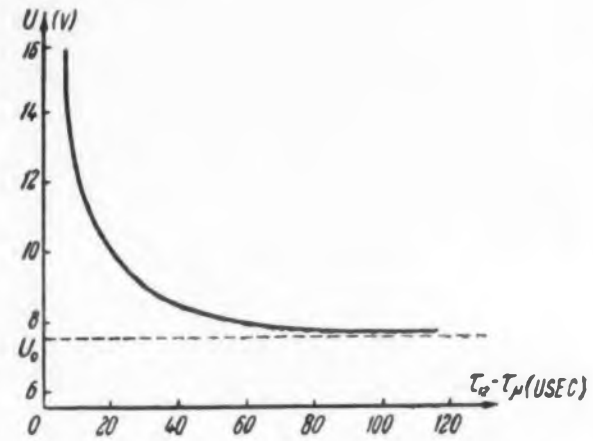


Fig. 2. Output voltage of the multivibrator varies as a function of the time interval between the applied pulses. The horizontal dashed line represents the limiting value of the operating threshold.

The value of U was determined at different time intervals between pulses, making it possible to determine the relationship

$$U = F(\tau_{12} - \tau_u)$$

One of the experimental curves for this relationship is shown in Fig. 2.

Processes in a Chain

Let us consider a chain of triggered multivibrators with approximately equal parameters. Each multivibrator is triggered by a pulse formed by differentiating the trailing edge of the negative pulse of the preceding multi.

The triggering pulses thus obtained have a leading front of finite length. Consequently the triggering of the multivibrator occurs with a delay τ relative to the rear front of the pulse from the preceding multi. This delay depends on the magnitude of the operating threshold.

Let us consider the case where two pulses are applied to the input of the triggered multivibrator, and the interval between them is greater than the duration of the multivibrator pulse, Fig. 3a. We assume that the operating threshold of the multivibrator has a limiting value U_0 at the instant of arrival of the first pulse.

In this case the multivibrator will be triggered by the first of the pulses of the pair at a certain instant t'. After a delay τ_u, the pulse of the multivibrator terminates and the threshold of its operation starts varying along a curve $U(t)$, shown in Fig. 3a.* By the instant that the second pulse is

*The voltages are relative to the dc voltage on the grid of T_1.

applied $U(t)$ will be greater than U_c, which causes an additional delay of the instant t'' of operation of the multivibrator.

The latter leads to an increase in the distance between the pulses of the multivibrator by an amount Δt_0. The passage of the pulses to the second multivibrator leads to a further increase in the distance between them. This distance can be determined graphically using the construction of Fig. 3a and selecting on it an initial distance between pulses $\tau'_{12} = \tau_{12} + t_0$. (See Fig. 3b.)

However, it is possible to avoid replotting the curve $U(t)$, and to follow the change in the distance between the pulses in the manner shown in Fig. 3c.

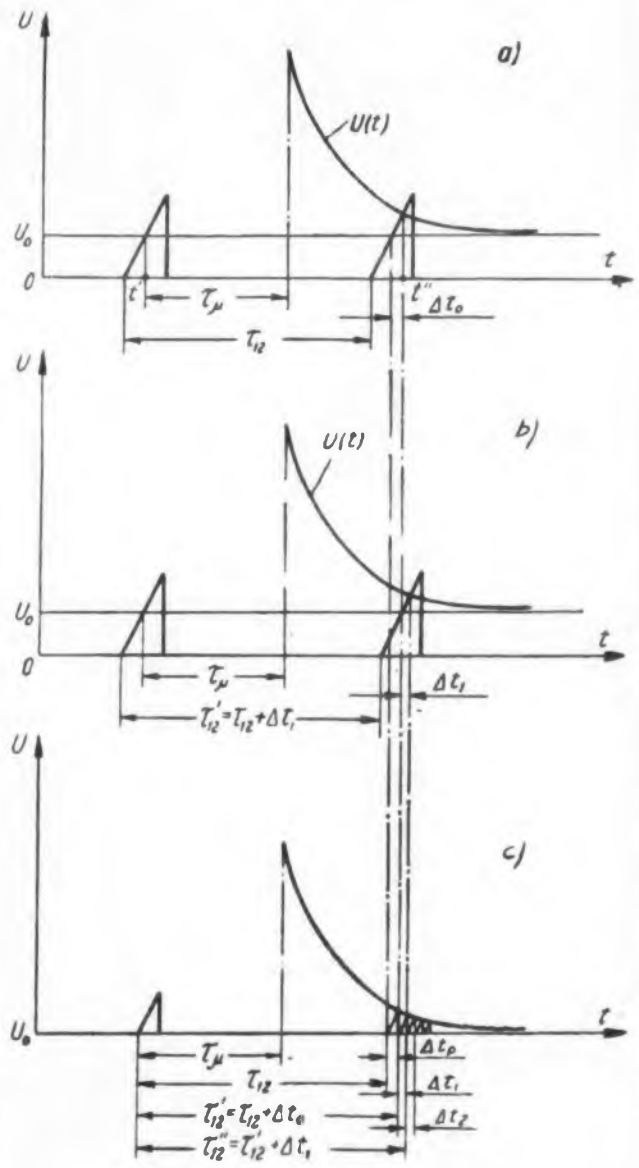


Fig. 3. Three situations in which two pulses arrive at a multivibrator's input. In each case U_0 is the operating threshold.

In Fig. 3c the voltage is reckoned from the value U_0. Here the quantity Δt_1 characterizes the increase in the interval between pulses after pas-

RUSSIAN TRANSLATIONS

sage through the second multivibrator. For the third multivibrator, the interval between the pulses is

$$\tau''_{12} = \tau_{12} + \Delta t_0 + \Delta t_1$$

and the corresponding delay is Δt_2. Continuing this construction, we obtain a sequence Δt_0, Δt_1, Δt_2, . . ., Δt_n, . . ., which characterizes the increase in the interval between pulses.

Processes in a Ring

Let us consider first a triggered multivibrator, the input of which is connected to its output by a delay line with a fixed delay time T. Let the multivibrator be triggered by the first pulse at the instant $t = 0$, and let the multivibrator operate at the instant $t = t_0 + \Delta t_0$ under the influence of the second pulse. Here Δt_0 is the delay in the operation as shown in Fig. 4a.

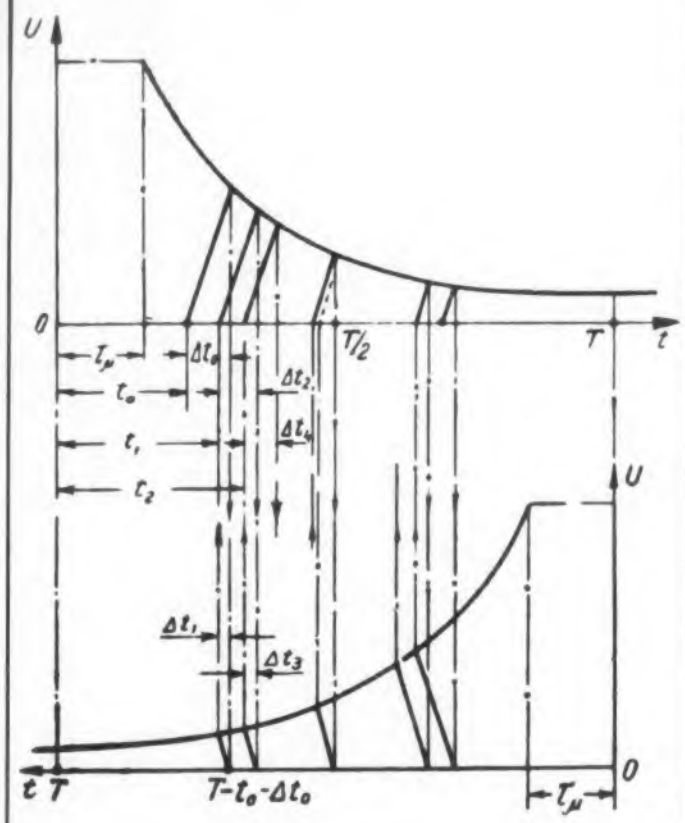


Fig. 4. Pulses arriving at a ring of triggered multivibrators.

At the instant T the first pulse will again reach the multivibrator, and will cause operation at the instant $T + \Delta t_1$. The interval between the second and third instants of operation of the multivibrator is

$$t_1 = T + \Delta t_1 - t_0 - \Delta t_0$$

Continuing this process, it is easy to verify that, depending on the ratio of τ_{12} and $T/2$, the delays

Δt_0, Δt_2, Δt_4, . . ., will cause an increase (or reductions) while the delays Δt_1, Δt_3, Δt_5, . . ., will cause a decrease (or increase) in the time interval between pulses.

The process can be investigated as shown in Fig. 4.

The graphic construction proceeds in the following manner. The value of Δt_0 is found by the method indicated in Fig. 3a. Since the first pulse returns to the multivibrator at the instant T, the interval between the second operation of the multivibrator and the return of the first pulse is $T - t_0 - \Delta t_0$.

This interval can be plotted (Fig. 4), after which the value of Δt_1 is found in the usual manner. Here, subtracting Δt_1 from Δt_0, it is possible to find a point on the curve $U(t)$ corresponding to the second pulse.

Continuing this construction, we obtain the sequence t_0, t_1, . . ., t_i, . . . of the intervals between pulses. From the graph it is easy to see that this sequence tends to $T/2$ regardless of the magnitude of the initial distance between the pulses.

The foregoing arguments apply also to a ring of triggered multivibrators. In fact, the passage of a pair of pulses through the second multivibrator of the ring differs little from the second passage of the pair of pulses through the multivibrator of the equivalent circuit shown in Fig. 4.

Therefore, in the first approximation, we can assume that the ring of trigger multivibrators can be replaced by this circuit, considering the delay time to be $T = m\tau_u$ (m is the number of multivibrators in the ring). We notice that the process of establishing the stationary state in the ring is faster than in the circuit consisting of a trigger multivibrator and a delay line.†

The ring of multivibrators can be used for "normalization" of the time intervals between pulses, and may prove useful in certain applications. The "normalization" can be speeded, also, by tightening up the trailing front of the multivibrator pulse, or by increasing the time constant in establishing the operating threshold.

References

1. L. A. Meerovich and L. G. Zelichenko, Impul'snaya tekhnika, (Pulse Techniques), Soviet Radio Press, Moscow 1954.

2. B. Kh. Krivitskii, Impul'snyye skhemy i ustroystva (Pulse Circuits and Devices) Soviet Radio Press, Moscow 1955.

(*Translated from* Izvestiya Vysshykh Uchebnyhk Zavedeniy (News of the Higher Institutions of Learning), *Radiophysics Sections, Vol. II, No. 1, 1959.*)

†A more detailed examination, which permits a more accurate determination of the time required to establish a steady state, can be made by using the construction of Figs. 3c and 4.

REPORT BRIEFS

Search and Detection

This report is a study of how a detection system should operate to maximize detection in the absence of information regarding the signal to be detected. The results of this study indicate that the best methods of search can be developed for any transmitter without time cycle, or one whose time cycle is known. *Philosophy of The General Problem Of Search And Detection, Patricia M. Langendorf, Rome Air Development Center, Griffiss AFB, N. Y., May 1959, 10 pp, Microfilm $1.80, Photocopy $1.80. Order PB 142183 from Library of Congress, Washington 25, D. C.*

HF Ground-To-Air Voice Communications

This report describes an extensive series of tests which were conducted to obtain a practical comparison between (1) single sideband suppressed carrier (SSBSC); (2) double sideband amplitude modulated (DSB-AM); (3) double sideband suppressed carrier (DSBSC); and (4) pilot carrier or synchronous single sideband (SSSB). These tests were conducted by RADC, USAF, over a period of one year. Data were gathered by means of sequentially transmitting phonetically-balanced (PB) word lists via the various modes, and analyzing the recorded results for intelligibility. *Comparison Testing Of Modulation Modes For High-Frequency Ground-To-Air Voice Communications, Donald E. LeBrun and Adolph J. Uryniak, Rome Air Development Center, Griffiss AFB, N. Y., May 1959, 19 pp, Microfilm $2.40, Photocopy $3.30. Order PB 142184 from Library of Congress, Washington 25, D. C.*

Designing Video Interstages

This study presents a method of designing interstages for transistor video amplifiers. The transistors are represented by the hybrid-pi equivalent circuit. The problem of designing interstages is shown equivalent to the problem of synthesizing a transfer impedance function proportional to the stage gain where the resulting interstage network must have certain specified terminating impedances. These terminating impedances represent the effects of the transistors. The interstage synthesis technique developed emphasizes the importance of the interstage using a limited number of elements and providing a satisfactory gain-bandwidth product. *Interstages For Transistor Video Amplifiers, J. J. Spilker, Stanford Electronics Laboratories, Stanford University, Calif., April 21, 1958, 139 pp, Microfilm $6.90, Photocopy $21.30. Order PB 139459 from Library of Congress, Washington 25, D. C.*

CW Solid State Masers

This report is concerned with several aspects of the theory of cw solid-state masers which use crystals containing paramagnetic ions as the active material. The density matrix describing a particular ion is calculated in the presence of the pump and signal fields. It is used to determine the engineering characteristics of various maser amplifiers. *Theory Of CW Solid State Masers, P. N. Butcher, Stanford Electronics Laboratories, Stanford University, Calif., Dec. 16, 1957, 143 pp, Microfilm $7.20, Photocopy $22.80. Order PB 137391 from Library of Congress, Washington 25, D. C.*

Traveling-Wave Amplifiers

The work presented in this report is concerned with the study of external-circuit traveling-wave amplifiers. It directly follows a series of earlier studies conducted in these laboratories on the theory of such tubes and their operation as backward-wave oscillators. The distinguishing feature of external-circuit traveling-wave tubes is that they consist of a combination of two separate parts: a vacuum interaction structure containing an array of equally spaced drift tubes through which the electron beam is sent, and a removable external slow-rate structure which is connected onto the interaction structure and which can be modified at will. Such an arrangement provides great flexibility in both experimentation and practical applications. The vacuum interaction structure utilized throughout this investigation is the one previously used by A. R. Matthews and it is not described here in detail. *External-Circuit Traveling-Wave Amplifiers, G. A. Loew, Stanford Electronics Laboratories, Stanford University, Calif., Apr. 21, 1958, 172 pp, Microfilm $8.10, Photocopy $27.30. Order PB 139460 from Library of Congress, Washington 25, D. C.*

Pulse-Type Magnetic Modulators

A summary is given of previous investigations of the all-magnetic, ac, resonant-type magnetic modulator. These investigations include (1) the measurement of core loss and saturated permeability of thin magnetic tapes under pulse excitation, (2) the development of a design procedure for magnetic modulators with either a pulse forming network or pulse clipper and a linear resistive or biased-diode load, (3) the design and construction of a 2-megawatt modulator, and (4) the paper design of an 8-megawatt modulator. *Studies of Pulse-Type Magnetic Modulators, A Summary, E. J. Smith, Microwave Research Institute, Polytechnic Institute of Brooklyn, N. Y., July 9, 1957, 34 pp., Microfilm $3.00, Photocopy $6.30. Order PB 137378 from Library of Congress, Washington 25, D. C.*

REPORT BRIEFS

Ceramic Capacitors

Techniques have been developed to measure temperature coefficients of capacitors to an increased degree of accuracy. Capacitance increments due to temperature variations can be measured to 0.0001 mmf or one per cent, whichever is greater, with the exception of a very small range of capacitors. A test-panel sample holder was developed with a maximum contributing error of 0.00001 mmf per degree C change over a 225 degree C total temperature variation. A switching mechanism to allow measurement of one hundred samples in a day was devised, utilizing statistical techniques to reduce resettability errors as small as desired. A capacitance sensitive device in the form of a variable oscillator and standard increment capacitors were designed and developed for detecting and recording 0.0001 mmf capacitance changes. A discussion of the specifications of temperature coefficients of capacitors and recommendations for their amendment are included. Details concerning the construction of a temperature coefficient test set and measurement techniques are also given. *Design Study Toward Development Of A Test Set To Measure Temperature Characteristics Of Ceramic Capacitors, Joseph Seton Smith, New York University College of Engineering, N. Y., Aug. 15, 1950, Oct. 14, 1951, 87 pp, Microfilm $4.80, Photocopy $13.80. Order PB 142176 from Library of Congress, Washington 25, D. C.*

High-Power Traveling-Wave and Hybrid Tubes

The work under this contract has resulted in a considerable advance in the high-power traveling-wave tube art. The last of the cloverleaf tubes built displayed quite satisfactory characteristics in gain, power output, and bandwidth; and it was quite free from the rather severe oscillation problems which had interfered with satisfactory operation of previous tubes which used the same general circuit. The performance characteristics of this satisfactory tube were reported in Scientific Report No. 7. Some of these are repeated in the present report for summary purposes. Preliminary results with the first hot-test tube built using the centipede circuit have also been encouraging. *These are covered in the present report. (See also PB 136050) Development of High-Power, Traveling-Wave and Hybrid Tubes, M. Chodorow, Microwave Laboratory, Stanford University, California, Aug. 1958, 41 pp. Microfilm $3.30, Photocopy $7.80. Order PB 139396 from Library of Congress, Washington 25, D. C.*

Corona Type Loudspeaker

This report describes the development of a high frequency (1-50 kc), high power (1.3 kw) speaker needed in a biological research. It includes a theoretical discussion of corona sound generation (thermal) and the reasons for upper (corona size) and lower (corona cooling rate) frequency limitations. Eleven speaker designs were tested. A 60 watt and a 1.3 kilowatt speaker system are described. *Corona Type Loudspeaker, Fujio Oda, Pennsylvania State University, University Park, July 1958, 74 pp, Microfilm $4.50, Photocopy $12.30. Order PB 142024 from Library of Congress, Washington 25, D. C.*

Periodic Structures In Trough Waveguide

A center fin in trough waveguide can be modified in a periodic fashion to alter the propagation characteristics of the guide. Two such periodic modifications, one an array of circular holes and the second a periodic array of teeth, have been measured fairly extensively and analyzed theoretically. These configurations are useful in connection with antenna scanning or waveguide filter applications. The array of holes produces only a mild slowing of the propagating wave, but the toothed structure, which may alternatively be described as a series of flat strips extending beyond the edge of the fin, can cause the propagating wave to vary from a very slow to a very fast wave. The periodic structures are theoretically treated by two methods, a transverse resonance procedure and a periodic cell approach. These theoretical results agree very well with each other and with the measured data. *Periodic Structures In Trough Waveguide, A. A. Oliner and W. Rotman, Microwave Research Institute, Polytechnic Institute of Brooklyn, N. Y., July 9, 1958, 46 pp., Microfilm $3.30, Photocopy $7.80. Order PB 137482 from Library of Congress, Washington 25, D. C.*

Radar Reception Problems

The problem of radar reception in the presence of jamming is treated by an application of the theory of games. The game formulated is as follows: assume the radar receiver employs a matched filter, matched to the radar echo signal, and let the choice of band-limited power spectral distributions for both the radar signal and the jamming noise constitute the respective strategy decisions for the radar designer and the jammer. Games with strategies of this type are known as function-space games. *Application Of The Theory Of Games To Radar Reception Problems, Nils J. Nilsson, Rome Air Development Center, Griffiss AFB, N. Y., May 1959, 22 pp, Microfilm $2.70, Photocopy $4.80. Order PB 142182 from Library of Congress, Washington 25, D. C.*

Blocks to Creativity

A. L. Simberg, Supervisor
Personnel Research & Development
AC Spark Plug Div.
General Motors Corp.
Flint, Mich.

Part IV
Advice to Frustrated Creators

This is the last of a series of articles discussing blocks to creativity.

THERE is no magic in removing the shackles that bind creative thinking. Essential at all times is a positive attitude, rooted in self-analysis and a desire to improve. The person who has been foiled in a creative problem must begin his new attempt by questioning: What caused the block? How can I remedy it?

Bearing in mind that there are three major blocks to creativity—perceptual, cultural and emotional—the frustrated innovator can assure himself that no matter what their cause, these blocks lie within his own mind.

What caused the block?

Sit down and analyze yourself

The perceptual blocks obscure the problem as it really is. They frustrate recognition of the "need area." The cultural blocks, instilled by traditional upbringing in the home, teaching in the school and the pressures of society, restrain imagination, inquisitiveness, boldness. The emotional blocks are irrational fears and anxieties that make us reluctant to take appropriate action on our ideas and beliefs.

Recognize the Blocks

The first step toward a remedy therefore is to recognize these blocks. Certainly little can be done about personal shortcomings that you do not recognize and that others cannot or will not point out to you.

Sit down and analyze yourself. Think about the blocks to creativity. To which of these do you feel you are prone? If you are honest with yourself, you can isolate the ones that have been hindering your idea output. If you are having genuine difficulty in recognizing them, ask someone close to you who you respect—but do not ask unless you are willing to be open-minded.

Now that the blocks are out in the open, have been recognized for what they are and their effect upon you, take the next step—admit them. Go back to specific problem situations that were not solved because of blocks like these. Review them and decide how you might have acted had it not been for these blocks. Look for problems that were subsequently solved by someone else. What was it they saw that you missed? Question them about it. Try to see how you might have reoriented your thinking or synthesized the facts to yield a different, unblocked view. Next look for new situations or problems where you can attempt solutions with your new "frame of mind."

Try a Check List

Many engineers have developed for themselves a little check list that they keep in front

of them when they are working on problems. Anyone can devise such a check list. Refer to it regularly when you are stumped on a problem. Do not, however, make the mistake of using it as a crutch. First let yourself go. Use your imagination. Use all of your creative faculties.

When you run into a roadblock—when you can go no further—then refer to your check list. Remember, its only function is to help ensure that you are not failing to solve the problem because of blocks within yourself, which are making you either:

(1) Unable to see the problem.
(2) Not able to take a different approach.
(3) Afraid to come to grips with the situation.

Awareness is the key to overcoming creative obstacles. You must be constantly aware of all the different ways in which your thinking and idea output may be blocked.

Supervisors, Take Note

A word to those who supervise the activities of technical people is not amiss either. Give the innovators a chance! When making an assignment, do not be so overly specific in what you want done that no room is left for imagination on the part of individuals. State the problem in a general manner, ask them how they would go about solving it or what ideas they have about it.

Above all, have confidence. Everyone has within him not only these blocks but also the capacity to rid himself of them. If you think about it this way—that you are not going to become more creative but are going to try to use more of the ability you already have—the task confronting you may not seem so insurmountable after all.

Good luck! ■ ■

Above all, have confidence

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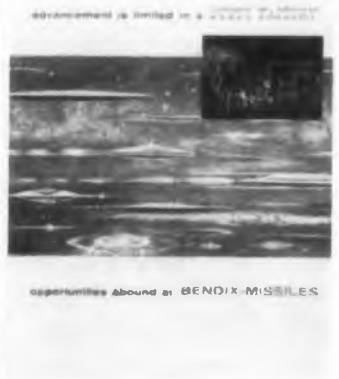

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Opportunities at Bendix Missiles Division for both recent technical graduates and experienced engineers are presented in this 30-page brochure. A chart serves as an introduction to the company's organization, and the pages that follow describe the various functions briefly. The areas covered are systems engineering, design engineering, production, field engineering, specialized engineering, services and supporting services. Educational opportunities, cultural and living facilities and employe benefits are listed.

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"A lot of people have been debating why Johnny can't read today, but a lot more should be concerned with why Dr. Johnson can't write."

With this as a text, an editor delivered a sermon recently on scientific writing before a national technical group. He put the problem this way, according to the Publications Institute Newsletter:

"The inability of the Dr. Johnsons to report their scientific findings clearly in writing is posing an increasingly urgent problem to innumerable administrators, documentalists, editors and the general public."

How does one write clearly when the subject —be it science or engineering—is often so complex? The newsletter furnishes some clues. A few decades ago Edwin E. Slossom, the first director of Science Service, publishers, drew up a list of "don'ts" for science writers. Still valid, they include:

- Don't overestimate the reader's knowledge and don't underestimate the reader's intelligence.
- Don't leave out the human interest. Your reader is a human being, even if you are only a scientist.
- Don't forget that your reader is interrupting every 10 lines to ask "Why?" "What for?" or "Well, what of it?" and if you don't answer his tacit questions, he will soon stop reading.
- Don't say "this discovery is interesting" unless you can prove it is; and if you can prove it, you don't have to say it.
- Don't fail to put your best foot forward; otherwise you may not have a chance to use the other foot. Note the construction of the news story in any first-class paper. The opening paragraph gives succinctly the main point of interest—the gist of the story—just as the first movement of a musical composition expresses the theme or motif. But:
- Don't imagine that you must add a pretty but superfluous paragraph at the end, like the coda of a sonata. The most effective close is to quit when you get through.