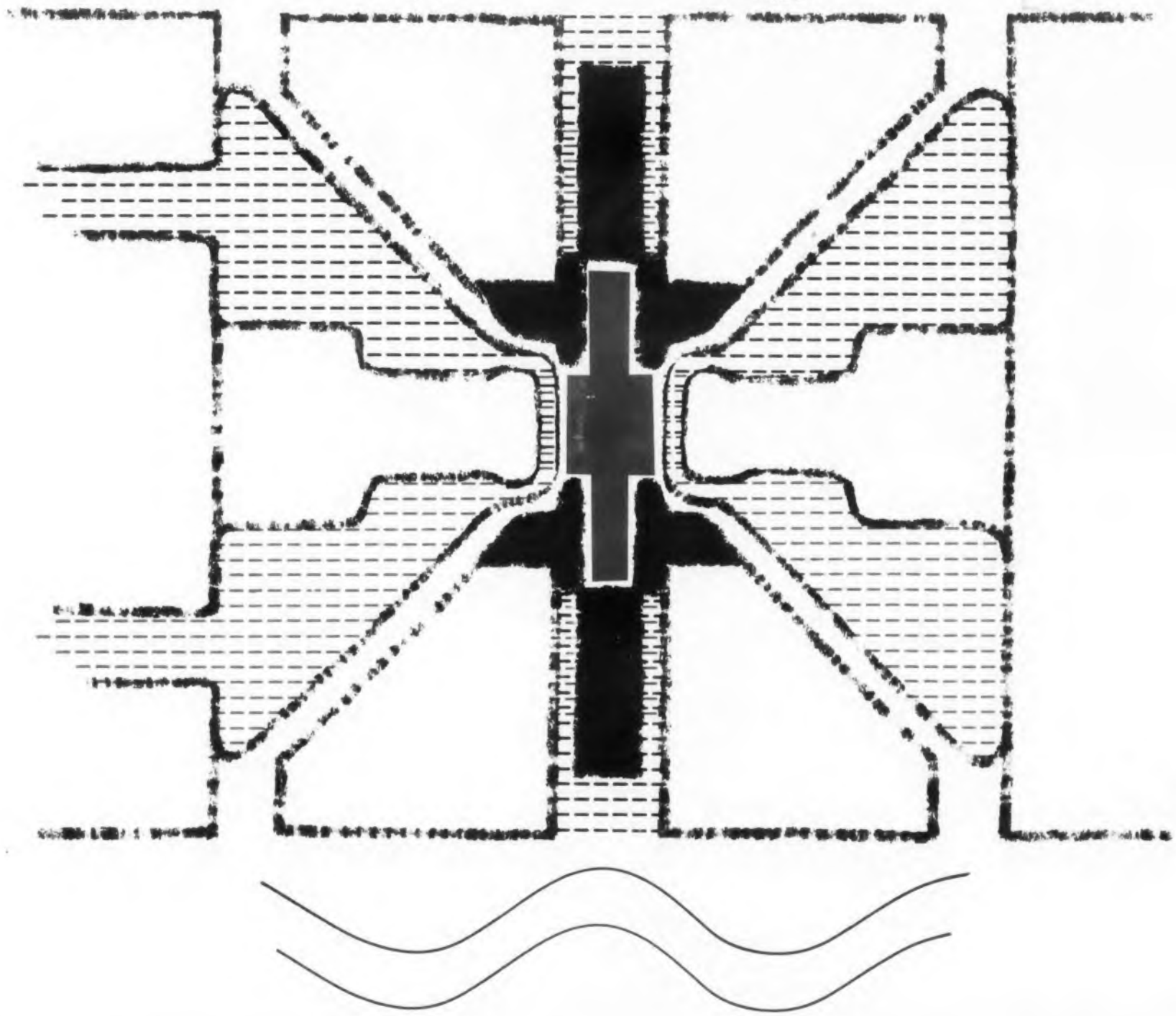
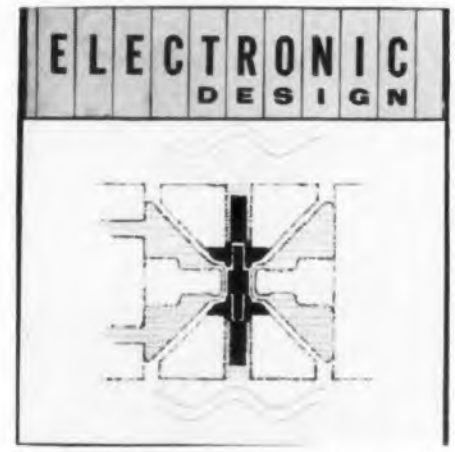
ELECTRONIC DESIGN

DECEMBER 9, 1959

Circulating water through slow-wave structure of X-band Amplitron promises rf super power of 20 kw per square centimeter of anode area ..... page 3



HIGHLIGHTS OF THIS ISSUE



CONTENTS FOR DECEMBER 9, 1959 VOL. 7 NUMBER 25

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

NEWS

EDITORIAL

FEATURES

DEPARTMENTS

HUGHES

G-V Thermal
Time Delay Relays...
used in Hughes
Airborne Armament Control System

The F-102A all weather interceptor and many other planes in the U. S. and Canadian Air Defense Commands are fully equipped with this system developed and manufactured by the Hughes Aircraft Company. G-V thermal time delay relays are relied upon in all of these systems.

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Now in Design:

A 200+ kw Microwave Tube

A MICROWAVE TUBE that will be able to transmit power by focused beam is now being developed. The tube, an S-Band Amplitron, has a predicted output of over 200 kw average power at an operating efficiency approaching 80 per cent. First units are expected to be ready in 12 months.

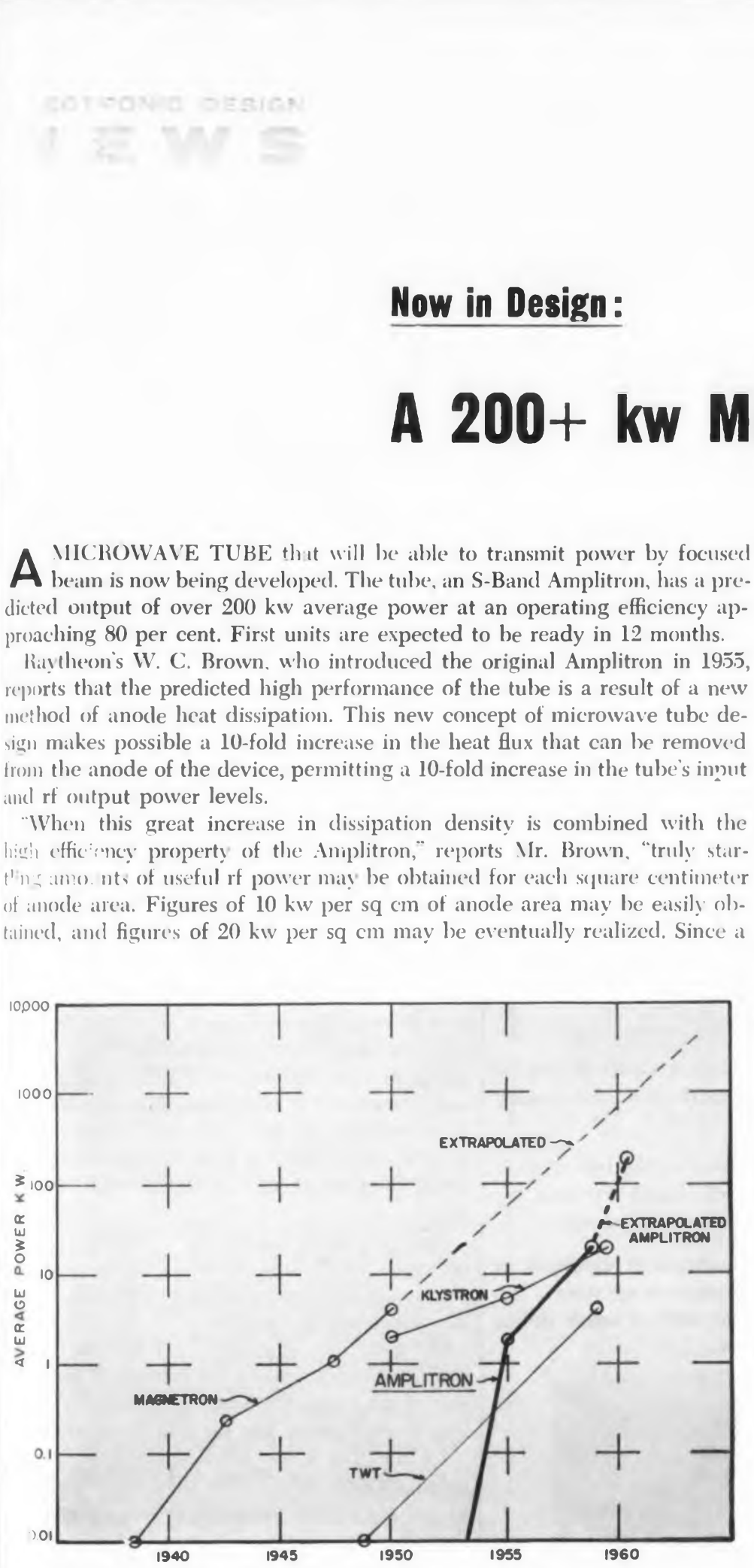
Raytheon's W. C. Brown, who introduced the original Amplitron in 1955, reports that the predicted high performance of the tube is a result of a new method of anode heat dissipation. This new concept of microwave tube design makes possible a 10-fold increase in the heat flux that can be removed from the anode of the device, permitting a 10-fold increase in the tube's input and rf output power levels.

"When this great increase in dissipation density is combined with the high efficiency property of the Amplitron," reports Mr. Brown, "truly startling amounts of useful rf power may be obtained for each square centimeter of anode area. Figures of 10 kw per sq cm of anode area may be easily obtained, and figures of 20 kw per sq cm may be eventually realized. Since a typical S-band pulsed Amplitron may have 20 square centimeters of area, it is immediately evident that we are on the verge of a major breakthrough in power generation in the S-band region."

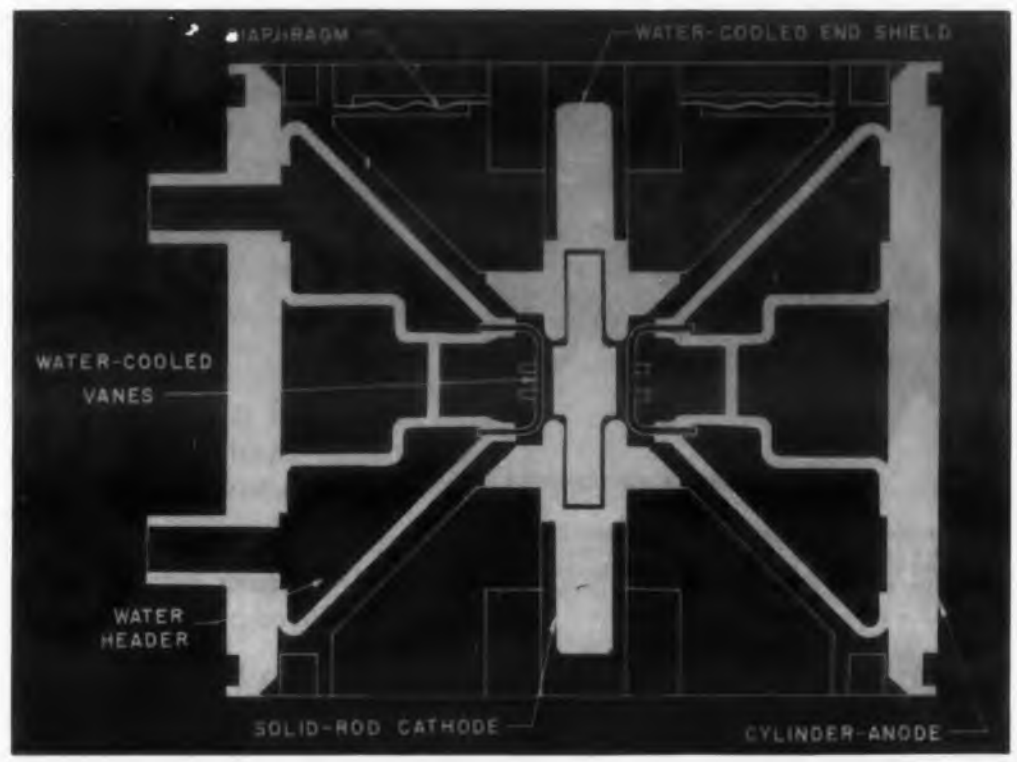
Raytheon has built an experimental X-band Amplitron in which the large anode dissipation densities were confirmed.

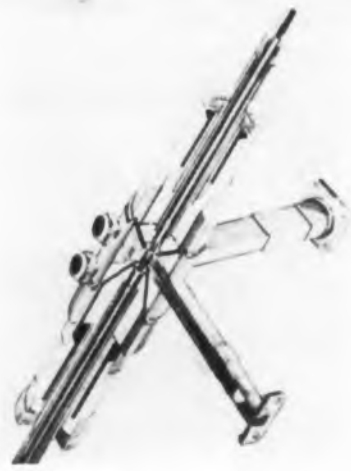
How was the heat dissipated?

Mr. Brown reports that the slow-wave structure of the experimental Ampli-



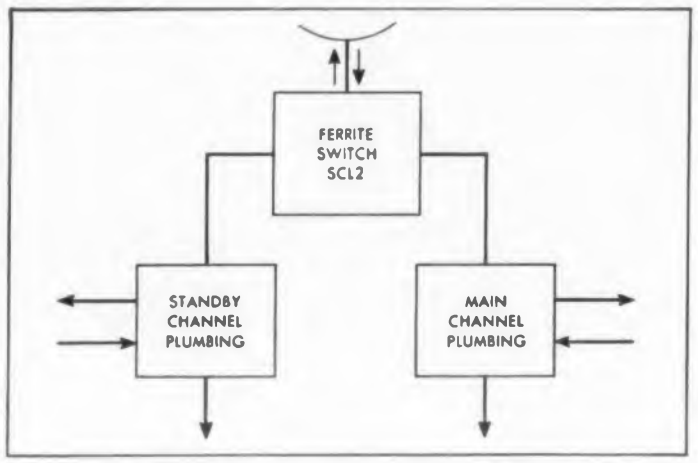
How S-band microwave generating tubes developed since the first magnetron. There might now be magnetrons of over 500 kw average power output had not requirements for sophisticated operation forced development of traveling-wave tubes, klystrons and Amplitrons.



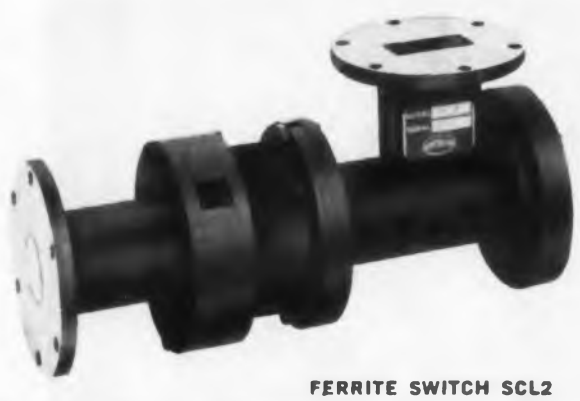


To test performance of the anode cooling method developed for super-power tubes, Raytheon built this experimental cw X-band Amplitron shown in artist's full and cross-sectional view. The tests, according to Raytheon, verified the high dissipation-density capability of the anode and cathode cooling structure. The pure tungsten cathode is cooled by water flowing at high-velocity through thin-wall, small-diameter tubes in the slow-wave structure of the tube.

THREE-POSITION FERRITE SWITCH FOR C-BAND



TYPICAL MICROWAVE CIRCUIT in which Raytheon ferrite switch is now being used. Switch has three positions: antenna to main channel; antenna to standby channel; antenna to both channels simultaneously.



FERRITE SWITCH SCL2

FERRITE SWITCH IS ACTIVATED when fault is detected in sensing unit. Receiver fault causes switch to transfer to intermediate position for comparison of main and standby. Normal baseband receiver noise and pilot tone allow switch to complete switchover.

ADVANCED SWITCHOVER PROTECTION PERMITS MORE RAPID AND FLEXIBLE OPERATION THAN EVER BEFORE

A completely new ferrite switch has just been introduced by Raytheon. The device, which is controlled by a specially designed switchover unit, provides foolproof switchover protection. It has three positions, connecting:

1. antenna to main channel
2. antenna to standby channel
3. antenna to both channels simultaneously

In the third position, the received signal is divided equally between the arms feeding the main and standby receivers.

This allows an actual comparison of the two receiver signals before switching and eliminates the need for complex and unreliable signal injection systems.

To learn more about this significant development or other important Raytheon advances in microwave ferrite devices, please write to the address below stating your particular area of interest.

TYPICAL SPECIFICATIONS

	SCL2
Frequency range (mc)	*6,575-6,875*
Isolation, minimum	*20db*
Isolation, maximum	*30db*
Insertion loss, minimum	*0.5db*
Insertion loss, maximum	*0.8db*
Power, average	*10 watts*
Power, peak	*1 kw*
VSWR, minimum	*1.02*
VSWR, maximum	*1.28*
Type of switch	*SPDT reciprocal*
Coil current	*400 ma*
Coil resistance	*60 ohms*
Length	*8 in.*
Waveguide	*RG-50/U**

*Mates with

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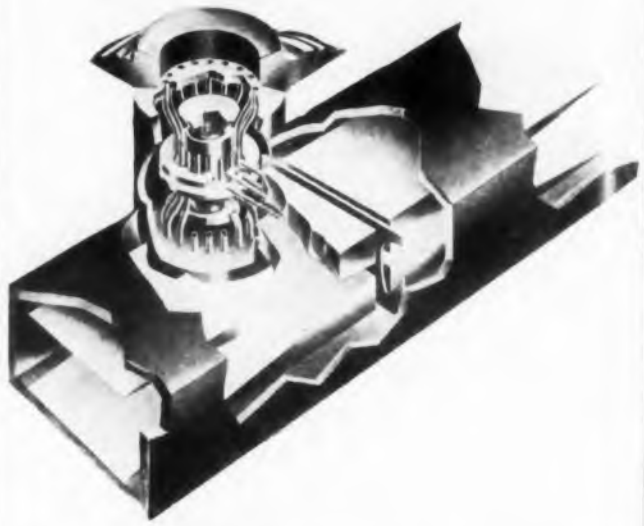
CIRCLE 4 ON READER-SERVICE CARD

NEWS



The heat-dissipation structure in an experimental X-band tube. The high dissipation-density capability of the basic design is expected to make possible Amplitrons of 200 kw average power output.

tron is made of very small tubing having an inside diameter of 0.018 in. through which water is circulated. The wall thickness of the tubing is only 0.006 in., therefore heat generated by electron bombardment of the slow-wave structure is easily conducted to the water coolant.

"The water flow through the tubes composing the slow-wave structure is in parallel flow. Because the tubes are short, a difference of pressure between the input and output water headers of only 100 lb is sufficient to cause the water to flow through the tubes with high velocity. The tube is so small there is no tendency for a layer of steam to form between the tube wall and the water coolant, a condition that would bring about melting of the tube wall." [The assumption is made that the bulk temperature of the water does not exceed its vaporization temperature.]

"In this small Amplitron, which has a total projected anode area of only slightly more than 1 sq cm, it has been possible to dissipate 8 kw in the anode under conditions of close to 50 per cent operating efficiency." (Raytheon defines projected anode area as the product of the diameter of the vanes, the length over which they collect anode current, and the number of vanes.)

"While this figure of dissipation density is a value considerably higher than we would wish to use for design purposes at the present time, there is good reason to believe that higher dissipation densities than those already achieved could result from the use of a larger pressure drop across the vanes with a resultant increase in flow velocity of the coolant," Mr Brown states.

"In view of dissipation-density values that have

been obtained and the prospect of increasing these values, we feel that a value of 3 kw per sq cm is a conservative figure to use for future designs."

In discussing the effect of high efficiency on the power output of a tube with a given anode dissipation, Mr. Brown points out that a tube 50 per cent efficient will turn half of the dc input power into useful rf output and half into anode dissipation.

In a tube 80 per cent efficient, 80 per cent of the dc input is represented by useful rf and only 20 per cent by dissipated power in the anode. "In this case, the ratio of rf output power to dissipated power is four to one. By increasing the efficiency from 50 to 80 percent, the power output has been increased four times, provided, of course, that the anode dissipation is the limiting factor."

What is the combined effect of large dissipation density and high efficiency?

If a dissipation density of 3 kw per sq cm is combined with 80 per cent efficiency, Mr. Brown states, "12 kw of useful rf power may be obtained for each square centimeter of anode area." This table shows the dissipation-density figure of 12 kw per sq cm applied to an existing S-band Amplitron, which has an anode area of slightly over 20 sq cm, and which "might be modified to make use of the improved dissipation techniques."

Experimentally obtained	Experimental X-band tube	S-band QK622
Dissipation density	7 kw/sq cm	
Dissipation density for design purposes	3 kw/sq cm	3 kw/sq cm
Anode area		22 sq cm
Anode dissipation at 3 kw/sq cm		66 kw
Efficiency		80%
Useful rf out, predicted		264 kw

(Dissipation density is the average dissipation divided by the projected area of the anode)

According to Mr. Brown, operation of a tube the physical size of the existing QK622 at the 200-kw average power level will require the cathode to be redesigned to absorb the increased back-bombardment power.

"For cw tubes this can be effectively and simply accomplished, as it has been for the X-band cw Amplitron, by the introduction of a pure tungsten cathode. Such a cathode is directly heated to thermionic emitting temperature by the passage of current through it. After the Amplitron has been started, the heater current is turned off and the back-bombardment power is thermally conducted through the tungsten cathode to water-cooled supports at either end of the cathode."

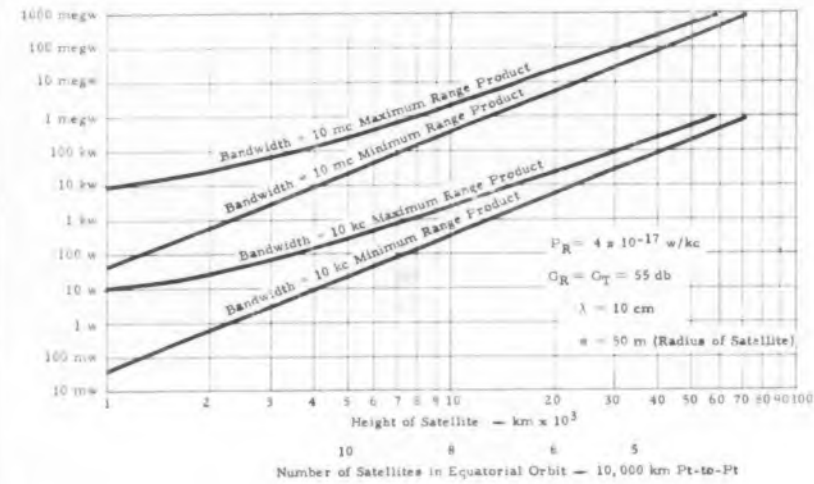
Raytheon expects that the average power-

NEWS

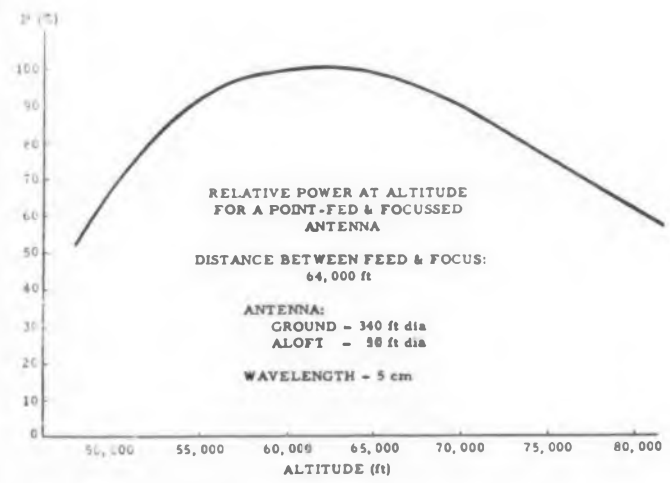
What Beamed Super Power Could Mean

For one-way space communication, an earth installation of 200-kw 10-cm tubes could provide communication at costs shown in this table of trade-off between antenna size and power output. Assumed is a receiver gain of —40 db, a transmitting antenna of 50-m diameter and a 5-m-diameter receiving antenna. Cost figures in left-hand column are for antennas, other figures are power cost and power plus antenna cost.

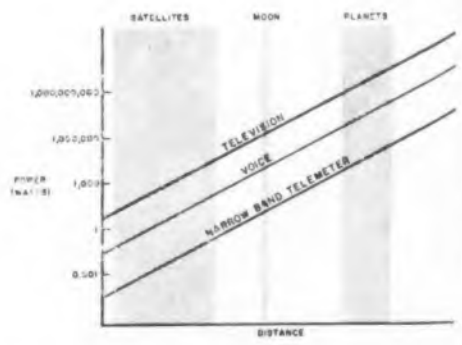
ANTENNA GAIN	BANDWIDTH = 100 kc: MOON	VENUS	MARS	PLUTO	PROXIMA CENTAURI Bandwidth 1 cps
30 db $10 K	$1 K 0.9 w *$11 K*	$400 K 400 kw $410 K	$900 K 900 kw $910 K	$230 M 230 megw $230 M	$1,000,000 M 1,000,000 megw $1,000,000 M
40 db $100 K	$1 K 0.09 w $101 K	$40 K 40 kw *$140 K*	$90 K 90 kw *$190 K*	$23 M 23 mw $23 M	$100,000 M 100,000 megw $100,000 M
50 db $1 M	$1 K 9 mw $1 M	$4 K 4 kw $1 M	$9 K 9 kw $1 M	$2.3 M 2.3 mw *$33 M*	$10,000 M 10,000 megw $10,001 M
60 db $10 M	$1 K .9 mw $10 M	$1 K 400 w $10 M	$1 K 900 w $10 M	$230 K 230 kw $10.2 M	$1,000 M 1,000 megw $1,010 M
70 db $100 M	$1 K 90 uw $100 M	$1 K 40 w $100 M	$1 K 90 w $100 M	$23 K 23 kw $100 M	$100 M 100 megw *$200 M*
80 db $1,000 M	$1 K 9 uw $1,000 M	$1 K 4 w $1,000 M	$1 K 9 w $1,000 M	$2.3 K 2.3 kw $1,000 M	$10 M 10 megw $1,010 M



The power needed for communication with a passive 100-m-diameter reflecting satellite varies with altitude for continuous point-to-point service. Two curves are plotted to show maximum and minimum power because path length from point to satellite to point is not constant.



The proposed Raytheon sky platform can be maintained aloft in still air with super power provided it remains within a 5000-foot segment of altitude, where it will not lose more than 20 per cent of the power beamed to it from the earth.



Power requirements for communications rise steadily with distance and bandwidth. On deep space probes, power for communications rather than power for propulsion, becomes a limiting factor, according to Sundstrand Corp.'s I. J. Adleson.

handling capability of the Amplitron can be increased ten-fold without increasing the physical size or the cost of the tube by a large factor. The company believes there are important economic and technical implications in the construction of such tubes.

In a paper delivered at the Northeast Electronics Research and Engineering Meeting (NEREM) several weeks ago, Mr. Brown noted that the cost of a microwave tube does not go up in proportion to its power output rating.

He said "We may not be in error to think in terms of the availability within a few years of tubes which cost from $10 to $20 per kw output. This reduction in cost will have a profound impact upon the conception of projects using large blocks of microwave power.

"No longer will the microwave tube represent the limiting cost of the system." This table from Mr. Brown's paper compares costs involved in a large installation of microwave power:

Cost per Kilowatt	
Diesel power	$100
Steam power	$130-$200
Hydroelectric power	$200-$300
Rectifiers and controls	$50-$200
Application	Probably over $500
Tube cost	$10-$20

In powerful microwave installations, the performance characteristic of efficiency becomes of major importance. Mr. Brown pointed out that a saving of $2.1 million in the initial installation and a saving of $12.6 million in operating costs over a twenty-year period would result from the use of an 80 per cent efficient tube instead of a 50 per cent efficient tube in a 10,000-kw installation. (See table on next page)

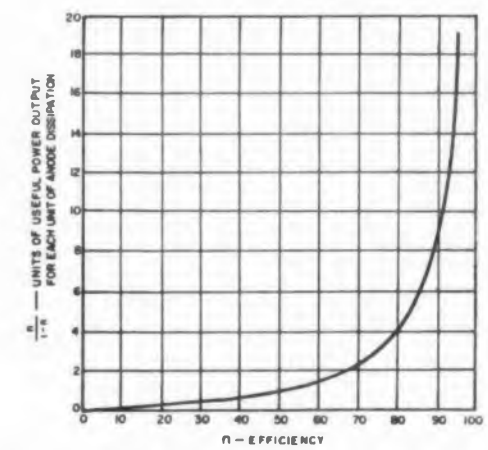
Mr. Brown and Raytheon feel that we are on the verge of a breakthrough in the economic generation of large quantities of microwave power. Because microwave tubes are essentially amplifiers they can be driven in phase from a common source, and the company believes that there is no technical reason

CIRCLE 7 ON READER-SERVICE CARD ➤

How Efficiency Affects Cost In A 10,000-KW Installation

Comparative Costs	50% Efficiency	80% Efficiency
Power Supply	$ 2,000,000	$1,250,000
Primary Power (Supply eff. 80%	2,750,000	1,345,000
Total	4,750,000	2,595,000
Difference	(2,155,000)	2,155,000
Yearly Operating Cost at 0.01/kw Hr.	2,190,000	1,560,000
Cost Difference	(630,000)	630,000
20 Yr. Difference	12,600,000	12,600,000

Assumptions: RF output power: 10,000 kw; Cost of installed primary power: $150/kw; Cost of rectifier power supply: $100/kw; Operating cost (fuel & maintenance): 0.01/kw hr.



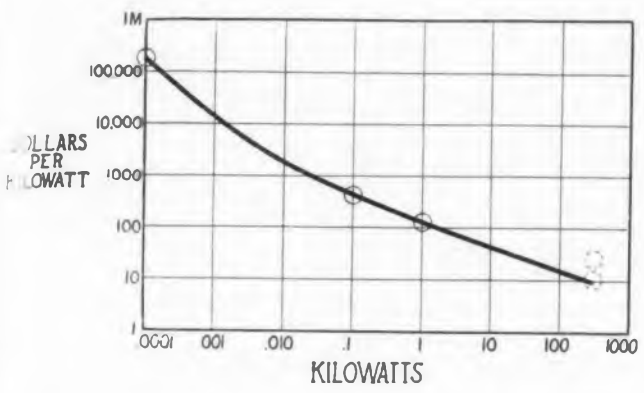
How useful rf power is related to anode efficiency in a device limited by anode dissipation. A boost in efficiency from 50 to 80 per cent increases power output four times.

why powers of almost any magnitude can not be produced. Cost of this power would be only three times that of primary power.

Thinking in terms of horsepower quantities of energy, the company is going forward with its RAMP (Raytheon Airborne Microwave Platform) project (*ED*, June 29, 1959, p3). This is a proposal for a helicopter kept aloft by microwave power beamed from the ground. Raytheon also feels there are important implications for very long-range communications in the generation of microwave super power.

A planning group at the company has developed figures that relate super power to the requirements of very-long-range communications. These are summarized on page 6.

Harold Hart, of Raytheon, reported to a NEREM technical session that 500 super-power tubes, each of about 200 kw, operated in parallel could permit 1 cps-bandwidth communi-



Cost per rf kilowatt goes down with tube rating. The plot points represent two cw magnetrons that have been in sizable production for some time, a very inexpensive klystron in the sub-watt range and projected figures for a 200-kw cw Amplitron after several years' production.

cation to the nearest star, transmitting from a 150-m antenna to a 5-m receiving antenna.

When five production-model super-power tubes are available to produce 900 kw total output, a television link could be established with Mars for about $2 million, Mr. Hart believes.

The sky platform proposed by Raytheon would require 60 tubes producing a total of 12,000 kw. The platform would be kept hovering by the 2000 shaft hp that would survive the system's overall efficiency of 5.9 per cent. Payload would be 2000 lb.

Another application of beamed delivery of power was suggested last month by I. J. Adleson, Sundstrand Corp., at the Washington meeting of the American Rocket Society. Mr. Adleson proposed an orbiting power station for delivery of power to satellites or other space vehicles. He called attention to the possibility of transferring power from the main space generating station to the customer vehicles by focused beam. ■ ■

PRICES AND AVAILABILITY . . .

. . . **TRANSISTORS** in 23 pnp and npn types have been cut in price by 5 to 35 per cent by Raytheon. Four pnp germanium types, 2N658 and 2N660-1-2, received the largest cuts.

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Null Ranges: 10-1-.1-.01v
Imput Impedance: 1 Meg. shunted by approx. 25 mmf
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CIRCLE 10 ON READER-SERVICE CARD

New Directions in Space

Record American Rocket Society Meeting Underlines New Scientific and Sociological Roles of Space Technology.

THE United States may not have a centrally organized, long-range space program powered by the kind of support many Americans would like to see, but we do have a space effort drastically different from, and probably healthier than, that of only a few months ago.

Instead of trying to justify their space programs by finding a link to defense goals, investigators are now directly attacking problems of space conquest. Current programs are aimed at systems to carry men rather than warheads. These programs outreach the needs of the military and establish a new climate for space effort.

This new climate for space activities was inescapable at the meeting. Evidence:

- **Large-scale shifts from military missile programs to civilian scientific programs. Of the approximately 130 papers presented, about 70 covered manned and unmanned space flight, 55, technology applicable to either scientific or military projects, and only 4 strictly the military.**
- **International cooperation: several noteworthy papers were contributed by a delegation of Russians and presented a hopeful promise for future cooperation.**
- **World and interplanetary peace as a goal: prestige speakers sounded some hopeful notes in 19 papers for winning humanity's long-cherished hope for peace.**
- **New stature of the space industry: there were 7000 attendees, commercial exhibit booths were sold out a year ago and top government and military leaders were speakers.**

Several of the seven papers on space communication were concerned with loss of telemetry signals during re-entering the atmosphere and also during certain critical periods while missiles were leaving the atmosphere. Both GE and AVCO announced investigation into re-entry communication systems.

Robert White of the Research and Advanced Development Division of Avco Corp. described the finding that the re-entry blackout, that is, the loss of telemetry signals while a space vehicle is re-entering the atmosphere, can be combatted by raising the transmission frequency to the 30 kmc to 50 kmc range. This indicates one of the many new uses for millimetric transmission. Absolute reliability of communication during this critical phase will become very important with a man aboard the space vehicle.

Other papers falling under the category of scientific ranged all the way from frequency standards for use in space clocks for testing the gravitational frequency shift postulated by Einstein, (*ED*, July 22, 1959, p. 6), to several different approaches for providing auxiliary power supply in space vehicles. Also included were several papers on microminiaturization including a discussion of the molectronic program at Westinghouse. Several optical instruments described were an orbiting astronomical telescope, and some optical space navigation devices.

Man into Space

The problems that man brings with him into space travel are the foundation of several new branches of science. One of these is Bio-instrumentation. Several papers described the problems of instrumenting a man aboard a space vehicle.

and several ways of getting around them. One of the most interesting of these papers was delivered by Dr. Leslie Kaeburn, space laboratory consultant and researcher.

The paper, "Space Canaries-Implicit Biological Monitoring," described the technique of connecting sensor devices internally to the vital organs of a dog. These sensors are connected to a transmitter, which is also mounted inside the rib cage of the animal. The measurements made on the dog, by implication, would also describe conditions inside the body of the human astronaut. The object is to free the human astronaut of the encumberances of many wires or other devices.

Other papers of this type describe the problems of maintaining suitable environment for the human astronaut.

Space Cited as Boon to Peace

Among the most interesting series of papers were those describing the sociological and legal problems of man in space. Senators and Representatives of the U.S. delivered papers on space law and the prospects for hope and problems when man meets in space. Andrew G. Haley, general counsel of the American Rocket Society, described the problems of jurisdiction over territories on the planets of the solar system. He pointed out that there are no agreements to cover the situations brought about by manned and unmanned contact with other planets.

Dr. Frank O. Fiorio, editor of *Missili e Razzi* magazine, summarized the implications of space technology's activities:

"With the adoption of new giant booster rockets, the space projects will lose their immediate military usefulness and become mainly a scientific peaceful venture with only secondary military interests . . .

"Space exploration . . . is an excellent substitute for war in the process of blowing off political, and ideological steam . . . The cost of space programs will . . . make impossible the waging of wars in the existence of military organizations except token forces . . .

"Future space programs will be of such magnitude as to require . . . the efforts of all scientists, technicians and industrial capacities existing in such close cooperation as to render absurd any idea of war on earth."

These expressions of hope were, of course, characteristic of the meeting's flavor.

Soviet Delegation Adds to Program

Headed by Professor Leonid Sedov, chairman of the Astronautics Commission of the U.S.S.R. Academy of Sciences, and president of the International Astronautic Federation, five Soviet space

NEWS

flight experts attended and contributed to the meeting.

Professor Sedov delivered a paper describing the orbit of cosmic rockets toward the moon which included a recount of the flight around the unseen side of the moon.

The Soviet delegates showed a movie of experiments with animals in free fall.

One of the highlights of the meeting was Professor Blagonravov's film report of the animal flights. This biological program was begun in 1949. A typical flight lasted 12 minutes. The animals, mice, rats and dogs, underwent accelerations of 6 g's during the power phase, zero gravity for the free-fall phase lasting up to 6 minutes, and 1 g's during the parachute deceleration. Other flights proved that animals could survive flights involving as much as 20 g's of acceleration.

A very spirited question and answer session followed the film. Typical exchanges between the audience and Professor Blagonravov were:

Q. In view of these animal experiments, can you state where Russia stands in the effort to put a man into space?
A. It is possible right now, but it should be carried out only: 1. when absolute safety is achieved; 2. when a safe return is assured; and 3. when there are some tasks to be performed by the man that could not be performed by automatic equipment.

Q. What tasks then, do you predict the astronaut might be required to perform?
A. It's quite difficult to say, because all tasks facing Soviet scientists can be done by automation. When something occurs that can't be done by automation, we'll send a man into space.

Q. Is it true that astronauts have been in training in Russia for two years?
A. I believe that is ungrounded, and comes from the newspapers.

Q. Professor, you and Prof. Sedov were recently quoted in a West German paper as having commented on a forthcoming launch of two men and two women in an orbit around the moon, and that there is very small expectation of a successful return. Is this so?
A. This would not be the first time a newspaper launched a fairy tale.
Q. Is there a man-in-space program underway in Russia similar to our project Mercury?
A. We have no such program, only a program of research on safety in flight.

Q. Since it is obviously desirable to maintain continuous control with the Mercury capsule, would the Professor pass an opinion as to whether we (the U.S. and the Soviet Union) should use each other's voice-communication installations cooperatively and internationally?
A. It would be very desirable that such cooperation took place. It should first be discussed, regarding the type of equipment, frequency and so forth.

Space Industry Achieves New Stature

There seems little doubt that the American Space Industry, represented by the membership of the American Rocket Society, has achieved a new stature. This was evident from the attendance by 7000 obviously interested observers and contributors, and the fact that several of the talks were delivered by Senators, members of the House of Representatives and leading scientists from industry, the military and the Soviet Union.

The seventy booths available for commercial exhibits were sold out a year ago. This, plus the fact that a convention on the scale of the IRE national is planned for October, 1961, is already well on its way to filling the Coliseum with exhibits is another indication.

Do we Have a Space Program?

The question of whether or not we have a realistic space program was posed by Dr. William H. Pickering, director of California Institute of Technology's Jet Propulsion Lab.

Dr. Pickering pointed out the reaction of the audience watching our efforts in space. At stake, as he put it, is the answer to the question, "Is it Russia, or is it the U.S. which is the technological leader."

At another point in his speech, Dr. Pickering stated, "As far as the rest of the world is concerned, it is perfectly clear that we are in a space race with Russia; we have clearly stated that we have undertaken space developments and space explorations." During an interview before his talk, Dr. Pickering also stated that he would like very much to see the president of the U. S. make the statement that we actually are in a space race.

Brig. General H. A. Boushey, director, Advanced Technology HQ USAF, made the point that, "There is no conflict between peaceful purposes for the benefit of all mankind, for which space is to be exploited under the National Aeronautics and Space Act, and the use of space vehicles for military purposes." This point was our military establishment devoted to maintenance of peace. Three uses of space important to the military were mentioned: 1. a communication satellite; 2. the early warning satellite; and 3. The reconnaissance satellite.

(continued on p. 14)

NEWS

(continued from p. 13)

A full scale Titan ICBM, set up in front of the Sheraton Park hotel where the meeting was held, along with a launcher-full of Hawk missiles, were among the few military notes presented at the meeting. Others were among the commercial exhibits.

The contrast between the existing hardware and the projects in the planning stage lent emphasis to the new direction taken by space activity. Hardware-in-being is primarily for the military; projects in planning are primarily scientific and concerned with manned travel to other planets. It may be, that this meeting of the American Rocket Society is also indicative of a turning point in history. ■ ■

NEREM Now Third Largest Electronic Meeting in U.S.

With the lively support of a rapidly growing local electronic industry and a nearby complex of research institutions, the Northeast Electronics Research and Engineering Meeting (NEREM) passed the National Electronics Convention last month as the nation's third largest electronics show. Only the National IRE show and WESCON scored higher totals this year than NEREM's 12,000 registrants, more than 300 booths and more than 75 technical papers.

Here are some of the highlights of the meeting:

■ General Radio's vice-president and chief engineer D. B. Sinclair reported on the Hungarian Colloquium on Microwave Communications, which he attended as the only guest invited from the U.S. Dr. Sinclair reported that Hungary is trying hard to establish an electronics industry and is finding it necessary to be self-sufficient. Although some equipment and parts are imported from Communist-bloc countries, many equipment plants in Hungary make their own parts. In one plant visited by Dr. Sinclair, some 70 of about 1000 workers were engaged in tooling. Another plant made its own cooling fans and ferrites. Hungarian products, said Dr. Sinclair, are designed to be rugged and to work well, but look old-fashioned and heavy. A Hungarian, Tibor

Over 300 NEREM booths filled three halls of Boston's Commonwealth Armory to make the show one of the most successful ever held in the area.

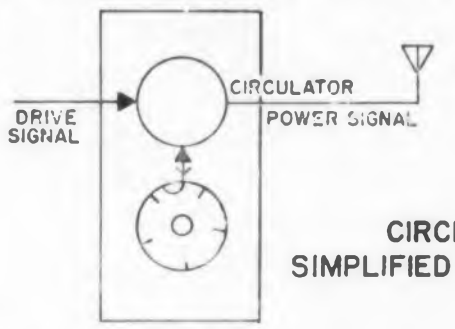
Hoffmann, delivered what was said to be one of the best papers at the colloquium. The paper described an atomic-hydrogen maser with a noise figure of 4 to 10 K at room temperature. A 6000-mc microwave communication system was described in a Soviet paper.

■ The theory of a traveling-wave transformer was reported on at NEREM by Transitron's H. G. Rudenberg. In this device, now coming into use, the transmission line and transformer properties of helical windings are combined in distributed-capacitance circuits to provide wide bandwidth and reasonable transformation ratios. Frequency-bandwidth ratios of 10^3 to 10^5 may be achieved, Dr. Rudenberg reported. He added that traveling-wave transformers may remove the high-frequency barrier to use of transformers in computers. With such devices, trade-off can be made between delay and rise time to give rise times of one tenth of a millimicrosecond.

■ An experimental pentode with a gain-bandwidth figure of merit of 350 mc was described by G. R. Henderson, of CBS Electronics, who said the CBS 7548 is a secondary-emission tube designed for fast rise time and a life longer than comparable tubes. Mr. Henderson attributed the tube's reported long life to its thick magnesium-ovide dynode, which he said is not destroyed by normal tube temperatures, and which stands up under short overloads.

■ N. E. Beverly, of IBM, described the circuit packaging being designed into the Stretch scientific computer now in construction for the AEC. Double-sided etched wiring, plated-through holes and double layers of components are used in a basic 4.5 x 6.5 x 0.5-in. package to achieve a reported 5-to-15-per-cent better performance than previous IBM packaging techniques.

■ The Circlotron amplifier was described by John Kline, of Sanders Associates, Nashua, N.H.;



CIRCLOTRON
SIMPLIFIED SCHEMATIC

it is a cross-field microwave amplifier designed to retain the efficiency and simplicity of the magnetron. The still-in development device is a one-port nonlinear, high-power amplifier that uses a magnetron as a negative resistance element much as a maser uses an active material, reported Mr. Kline. He said experimental models have given gains greater than 10 db over a 10-per-cent bandwidth in the X-band at efficiencies between 30 and 60 per cent. Peak power output was 7.

NEWS

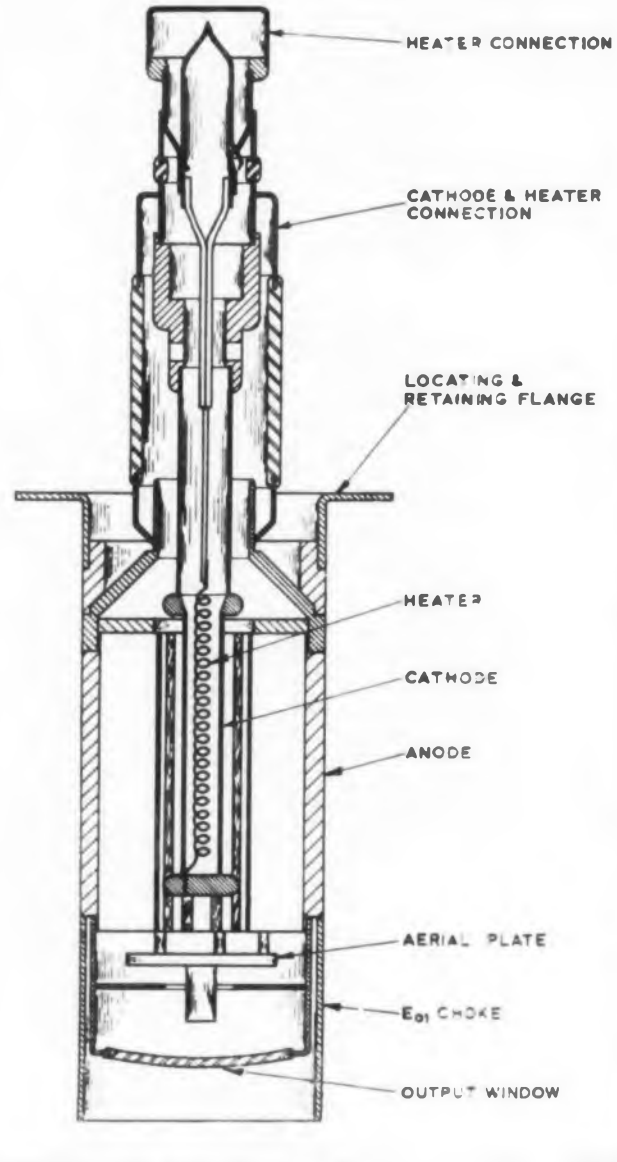
British S-Band Magnetron Combines High Power, Long Life

Peak power output of "well over five megawatts" and longevity up to 10,000 hours are claimed for a new British magnetron.

The component, the 7182 of English Electric Valve Co., Ltd., is also said to offer greater pulse length, lower missed-pulse count and less frequency change, either during a pulse or life.

Development of the "extremely stable" tube was described by the company as an outgrowth of the invention of the cavity magnetron, used extensively in narrow-beam radar during World War II for the precision tracking of aircraft. Dr. Henry Boot of the Services Electronic Research Lab at Baldock, Great Britain, and Prof. John Randall, professor of physics at the University of London, are credited with the development.

The 7182 is a water-and-forced-air-cooled, multi-resonator, pulse-operated magnetron, designed to operate at a fixed frequency within the limits of 2,750 and 2,860 megacycles a second. It is made for use with a separate water-cooled electromagnet and waveguide launching section.



Weather Satellite Will Send 500-Line Photos

Weather observations from space are scheduled to begin in early 1960 by means of a pair of U.S.-orbited 500-line television cameras.

The effort, called Project Tiros, will scan cloud formations over a large portion of the earth. The information is to be relayed to stations in Hawaii and Fort Monmouth, N.J.

An Air Force Thor-Able rocket combination will hurl the Tiros vehicle into space. The cameras are designed to produce far greater detail than any yet flown in U.S. Satellites—500 lines. One camera, aimed straight down, should cover about 490,000 square miles and show details one and a half miles or more in width. The other camera is to cover a smaller area but more in detail.

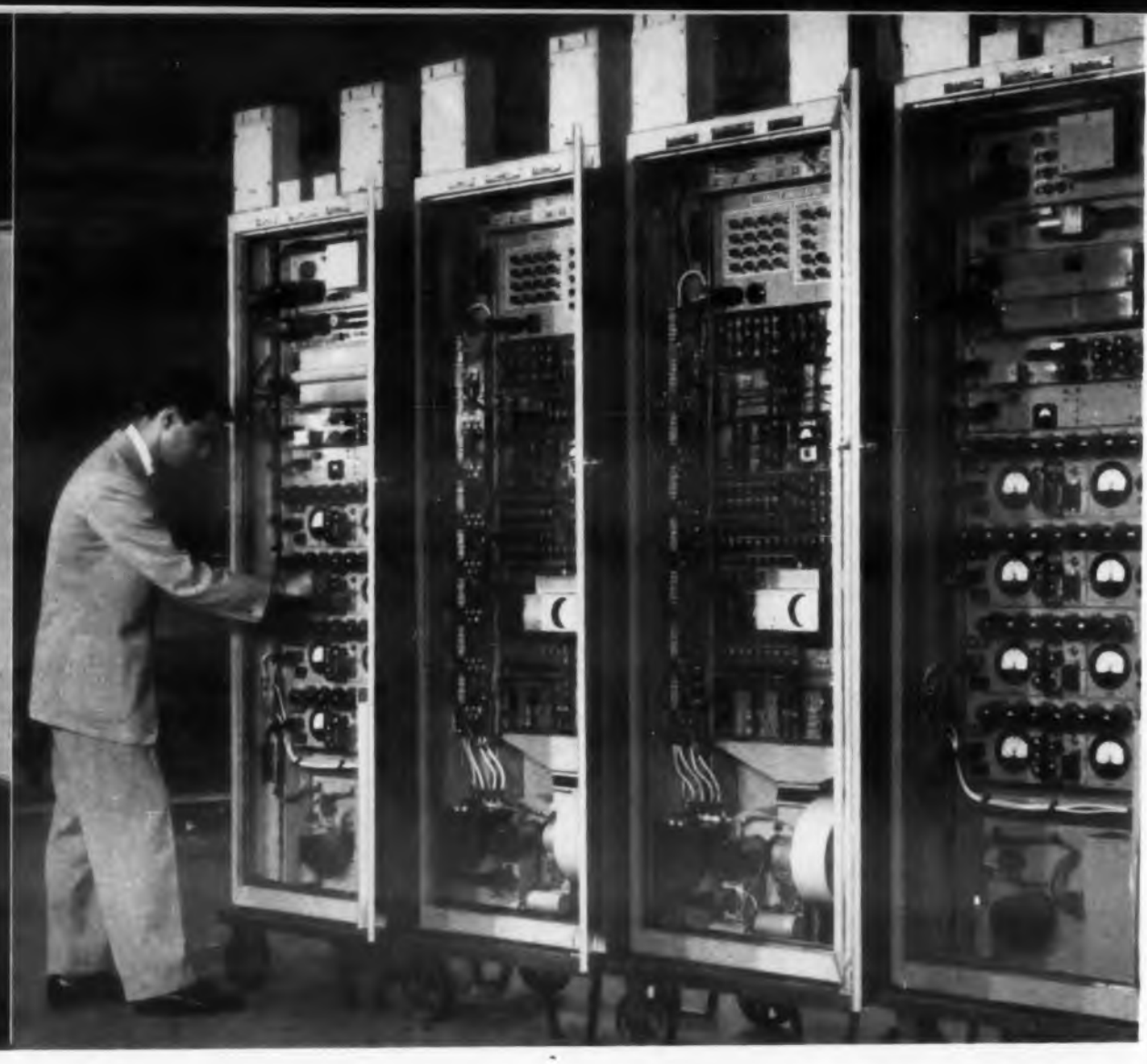
Shots taken by the cameras as the satellite whirls over the globe are to be stored on magnetic tape. Over the Hawaii or New Jersey stations, the images are to be broadcast on command. Pieced together, they will form a mosaic for the weatherman's reference.

NEWS BRIEFS . . .

. . . **DR. LEO ESAKI,** of Japan's Sony Corp., and inventor of the tunnel diode, recently visited the U.S. During his visit Dr. Esaki described plans for the 30-mc tunnel-diode computer he is helping design at Tokyo University.

. . . **WORLD's** largest solar-energy converter can be connected to provide 6 to 60 volts in 6-volt increments at from 0.5 to 5 amperes. The 4 by 8 foot panel holds 7800 silicon solar cells, automatically tracks sun.

Rear of monitor unit. Access door removed to show Tung-Sol / Chatham 6080 Series Regulator Tubes.



Exposed view of power supplies show battery of Tung-Sol/Chatham 6080 Series Regulator tubes in Budd Lewyt's AN/FST-1 Transmitter.

BUDD LEWYT links in SAGE system use Tung-Sol tubes to regulate power supplies

Defending America against air attack is the staggering job of SAGE. Daily, our radar network must locate, identify and track more than 30,000 aircraft in flight.

The Budd Lewyt CDT (Coordinate Data Transmitter System) helps do it automatically. CDT transmitters at unmanned Gap-Filler sites pick up, interpret, convert and then relay signals over telephone lines to CDT monitor units at SAGE Control Centers.

Handling 161,800 radar pulses per second, CDT verifies targets with 99.99% accuracy. Because this system must function with unfailing accuracy, Tung-Sol/ Chatham 6080 Series tubes are used to regulate vital power supplies in both the transmitters and monitors.

Whether your equipment is a critical link in national defense, or a new idea for furthering automation in business or production, your Tung-Sol Applications Engineer can be a big help in the planning stages of your projects. Call him with confidence, because Tung-Sol impartially produces both tubes and semiconductors . . . assuring you better quality, efficiency and dependability in your product. We'd welcome the chance to prove it to you. Tung-Sol Electric Inc., Newark 4, New Jersey. TWX: NK193.

TUNG-SOL

NEWS

220-lb Satellite Reactor Develops 3 kw

The Atomic Energy Commission has displayed what may well be the world's smallest nuclear reactor —a 220-pound unit, about the size of a five-gallon can. It will supply electrical power for advanced space vehicles.

Its output of three kilowatts is a hundred times as high as that of the solar-powered paddle-wheel satellite that the U.S. orbited last summer and hundreds of times in excess of a recently developed radioisotope power source.

The reactor, named SNAP II (Systems for Nuclear Auxiliary Power), uses enriched uranium fuel. Heat is carried by a liquid sodium to a mercury boiler, where vaporization occurs at high temperature. The mercury vapor turns a miniature turbine, which generates electricity in conventional fashion.

A full-scale model of the reactor has been built and successfully tested, the AEC said. Regular operation is scheduled within a year. Atomics International, a division of North American Aviation, Inc., is the manufacturer.

The A.E.C. estimated that development of the reactor system had cost about $6.5 million and that individual units would cost about $400,000.

A generator weighing 30 additional pounds is included in the system.

NEWS BRIEFS . . .

. . . **BERYLLIUM BALL** will be electrostatically supported in Minneapolis-Honeywell's Gyrostat-type gyroscope. A prototype has been built and promises accuracies beyond the range of present devices, according to the company.

◀ CIRCLE 17 ON READER-SERVICE CARD

New Inertial System Uses Digital Computer 'Platform'

An airborne intertial navigation system described as "a considerable departure from traditional concepts" is under development for the Air Force.

It shuns the use of a gimbal "platform" for accelerometers and gyros. The gimbal structure, with its large size and close tolerance parts, has been supplanted by a digital computer.

Basic details of the system have been disclosed by Ford Instrument Co. of Long Island City, N.Y., which announced receipt of a million-dollar contract to build and test an experimental model for the Weapons Guidance Laboratory at Wright Air Development Center. The system has been designated AJN-7.

Accelerometers and gyros, common to all inertial systems, are strapped down in this new version, the company reported. In conventional systems these units must have complete freedom of motion relative to the body of the airplane or missile. This calls for a "stable platform" inside a nest of free-swinging gimbal rings, in turn attached to a heavy base. In this arrangement the gyros force the accelerometers to conform to a predetermined orientation, independent of changes in heading, pitch or roll of the vehicle.

In the AJN-7 the gyros have no control over the accelerometers. Instead the accelerometers are free to follow any movement of the vehicle, while the gyros merely measure the deviations of the vehicle from its initial orientation. Signals from the accelerometers and gyros are fed into a digital computer, which integrates the data and provides continuous information on speed, direction and location. This information can be linked to an autopilot to keep the vehicle on course.

Japanese Transistor Imports Called Threat to U.S. Research

Japanese transistor imports are viewed by the president of the Electronic Industries Assoc. as a long-range threat to American electronic research.

The trade leader, David R. Hull, told the Mid-America Electronics Conference of the IRE that although Japanese sales were largely in the entertainment transistor field, that market "primarily has paid for the research and development programs which have been the industry's lifeblood."

The American electronics industry, he said, must support major expansion of research and production facilities to meet military transistor requirements. But, he warned, "This responsibility may some day go by default to a foreign power."

Biomedical Conference Stresses Effects Of Nonionizing Rays

"We know of no injury and no deaths from microwave energy," George M. Knauf of the Air Force told the 12th Annual Conference on Electrical Techniques in Medicine and Biology. This was his reaction to recent "scare" stories that reported persons had suffered from working in microwave fields.

The Conference, held in Philadelphia on November 10, 11, and 12, was sponsored by the IRE, AIEE, and ISA. This year's Conference dealt primarily with the interaction of predominantly nonionizing radiation with biological matter, explained H. P. Schwan, conference chairman. Both acoustic and electromagnetic radiation (from radio frequencies to ultraviolet) were covered.

The biological effects of microwave energy are getting more and more attention because of their increased use in industrial and military installations. Fourteen of the more than 40 papers delivered at the Conference dealt with the subject.

Thomas Ely, of the Office of Health and Safety, AEC, explained in his paper that today's research in microwaves includes work with several fundamental frequencies (both pulsed and continuous wave), use of rabbits, dogs, and men, and various ways of looking for and evaluating biological effects. An average field density of 0.01 watt per square centimeter has been accepted by the Department of Defense as being completely safe for man, regardless of exposure time.

The eye is very sensitive to microwave energy. Animal experiments have proved the cataractogenic effects of microwaves. Goggles fitted with common window-wire screen provide an effective shield for those in hazardous areas. In very strong microwave fields, like those in BMEWS, two layers of this screen are sufficient to protect the eye. Clothing coated with nichrome can be used to shield the body.

Some Highlights

■ The use of nuclear magnetic resonance for the measurement of blood flow was described at the conference. According to Robert L. Bowman and V. Kudravcev of the National Heart Institute, "preliminary experimental results encourage a belief in the feasibility and relative simplicity of the projected method."

■ The description of an instrument for measuring blood-cell concentration was provided by Robert H. Okada and Herman P. Schwan of the Moore School of Electrical Engineering, University of Pennsylvania. The instrument is based on

the fact that the resistivity of blood is a function of the volume concentration of the cells in the blood.

Rotating Anode in Line-Scan CRT

Line-scan tube uses an anode rotating at 1600 rpm to scan one line at a time with high resolution. CBS Labs asserts that tube's light source has pre-area brilliance comparable to brightest man-made light known.

Two Engineers Will Get Top Awards From IRE

The Institute of Radio Engineers will give its two highest awards in 1960 to Haraden Pratt and Dr. Harry Nyquist, consultant engineers.

Mr. Pratt, former telecommunications adviser to the President and now secretary of the IRE, has been named for the Founders Award "for outstanding contributions to the radio engineering profession and to the Institute of Radio Engineers through wise and courageous leadership in the planning and administration of technical developments, which have greatly increased the impact of electronics on the public welfare."

Dr. Nyquist, retired R&D scientist of Bell Telephone Labs, will receive the Medal of Honor "for fundamental contributions to a quantitative understanding of thermal noise, data transmission and negative feedback."

The awards will be presented March 23 at the 1960 IRE International Convention in New York.

NEWS BRIEFS . . .

. . . **THE THERMIONIC CONVERTER** being developed by RCA and Thiokol to convert waste rocket heat to electricity in solid propellant missiles is eventually expected to produce up to 175 watts per pound. Theoretical energy density is said to be more than 1000 watts per square centimeter.

. . . **AN EHF DATA LINK** for communication at above 30 kmc is being developed by Avco to solve difficulty of communicating during reentry into the earth's atmosphere. A prototype now being built will have 40 kw peak power.

. . . **AIRCRAFT** and electronic companies were briefed about the Army's long-range aviation needs at a meeting earlier this month at Ft. Monroe, Va. Among designs that the Army called for were improved surveillance aircraft heavily instrumented with electronic detection devices.

. . . **AN AUTOMATIC PILOT** with no moving parts is being developed by the Bendix Aviation Corp. The device is expected to result in all-electronic solid-state flight-control systems for operation of airborne digital computing systems.

. . . **THE FIVE SCIENTISTS** at Diamond Ordnance Fuze Labs who developed the Army's microminiaturization technique have been awarded $5,000 each under the government's award program for money-saving ideas. The Army estimates that the scientist's technique will lead to a $200,000-per-year-saving.

. . . **RESEARCH** in physiological instrumentation will be conducted in a new laboratory to be built at Iowa State. The research program involves the use and development of electronic devices in the measurement of bodily functions. It also will involve application of principles of feedback-controlled data systems.

. . . **TWO IDENTICAL GUIDANCE** and control systems were carried in a recent launching of a Jupiter intermediate range ballistic missile. The test verified the accuracy and reliability of the system developed by the Guidance and Control Laboratory of the Army Ballistic Missile Agency.

. . . **APPLICATIONS** for National Science Foundation Graduate Fellowships are being accepted now in subjects including information and communication theory, engineering sciences, and mathematical and physical sciences. Write: Fellowship Office, National Academy of Sciences, 2101 Constitution Ave. N.W., Washington 25, D.C., before 1960.

. . . **MICROWAVE TRANSMISSION** of computer data is now a reality. A communication system links together six large-scale IBM computers at North American's Los Angeles plant and the Rocketdyne facility 39 miles away. IBM and Pacific Tel and Tel developed the system for North American, which claims this is the first time information has been transmitted from one computer to another without a direct wire link. Transmission rate is 3000 words per second.

. . . **THE AMERICAN ROCKET SOCIETY** meeting, growing larger each year, will be held at the New York Coliseum in 1961.

. . . **THE CORNELL-DESIGNED** 1000-ft radar dish to be built in a Puerto Rican limestone sink (*ED*, 7/22/59, p8) will operate at only 400 mc. The aluminum mesh antenna, an ARPA project, is expected to be completed in 1961. Some targets: electron-density measurements to a 4000-mile height, radar echos from Mars and Venus and mapping of sun and moon areas, and probably studies on missiles using the Atlantic range.

. . . **SCANNING SYSTEM** in Samos (formerly Midas) surveillance satellite is being designed to take photos by starlight, and photos of seven-foot objects from 300-mile altitudes. Samos system will be ready in 1962. Advance versions, to be developed between 1965 and 1970 will photograph two-foot objects from same altitudes.

SIGNIFICANT CONTRACTS . . .

. . . **TO BURROUGHS CORP.**, Detroit, Mich., $35,000,000 from the Airborne Long Range Input (ALRI) for systems management work. ALRI is a radar station housed in an RC-121 reconnaissance aircraft to provide a seaward extension of SAGE.

. . . **TO SYLVANIA ELECTRIC PRODUCTS INC.**, New York, N.Y., $450,000 from the Communication and Navigation Laboratory of Wright Air Development Center for an experimental ultra-high-frequency receiver that will provide 10,000 hours (nearly 14 months) continuous operation and which will be adaptable to incorporation of micro-miniaturized electronic elements.

. . **TO COLLINS RADIO CO.**, Dallas, Tex., over $2,000,000 from the Air Force for the engineering, manufacture and installation of a microwave communication system for Fairchild Air Force Base.

MEETINGS

Calendar of Events

December

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

January

6-9 Institute of High Fidelity Manufacturers 1960 High Fidelity Music Show, Shrine Exposition Hall, 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

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, ISA, AIEE, Engineering and Scientific Center, Cleveland, Ohio.

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

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

*Includes meetings described herewith

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 plastics tooling, forming, extrusion, thermosetting molding, metals for plastics molds, and vinyl plastics. Conference chairman is Mr. Charles M. Wasugh of E. I. Du Pont de Nemours & Co., Inc., 7250 North Cicero Ave., Lincolnwood, Ill.

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

The 3rd International Electronic Parts Show, for electronic 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."

Technical sessions of the Conference will be devoted to the concepts, techniques and applications of the scientific equipment and methods utilized by various industries, with special attention being paid to the petroleum, chemical, aeronautical, missiles and electronic, and of process industries.

Papers scheduled for the technical sessions cover instrumentation progress and utilizing electronic principles for flow measurement, control and feedback in the chemical and petroleum industries. Reliability, testing and standards in the aeronautical and missiles industry will be covered in other papers, while presentations will be made on the development and economic justification of control systems in the Management and Economic sessions.

The Exhibit will include computers, measuring devices, transmission and telemetering instruments, data processing and information display equipment, control instruments and other elements and components of the newest products and services in instrumentation and automatic control.

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

Tours to the Pacific Missile Range and Naval Ordnance Laboratories, Corona, are among the many field trips offered to visitors at the 1960 Winter Convention on Military Electronics. The field trips are expected to offer a cross section view of the missile, defense and electronic industries in Southern California.

A visit to Space Technology Labs, Inc. will be held Wednesday, February 3. Visitors will be shown a film on current space probe activities and the company's Space Communications and Navigation Network (SpaN Net), headquarters for a vast intercontinental tracking station network.

February 3, from 7:30 to 10:00, an evening trip to the System Development Corp. of Santa Monica will be featured. Two tours will be offered February 5 to include a visit to the Pacific Missile Range, Point Mugu, Calif. to view a Regulus test launch and a tour to Consolidated Electrodynamics Corp.

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.

(Advertisement)

NEW PRODUCT

Rack and Panel Type Solderless Connector

Application of Burndy's HYFEN® principle to rack and panel type connectors has been announced by the company's Omaton Division. These connectors are also used as cable disconnects between electronic cabinets.

In addition to the crimp-type snap-locked pins and sockets characteristic of all HYFENs, this new version, the ME type connector, offers these distinct advantages: (1) interchangeability and compatibility with existing rack and panel solder-type connectors; (2) one-piece die cast aluminum shell and one-piece insulator block which eliminate one cause of moisture entrapment, reduce the possibility of lost parts, and allow interchangeability between shell and plug receptacles; (3) diversified installation tooling which allows extremely fast assembly either at bench or at equipment; and (4) use of only the number of contacts needed rather than all the contacts in the panel.

The HYFEN technique allows pins and sockets to be removed with a simple extraction tool and then to be re-inserted or changed as required. The ME also features closed entry type sockets which prevent damage from oversize test probes. In addition pins and sockets can take multiples of wire combinations where needed, and coaxial or shielded cable.

The crimp-type connection characteristic of HYFEN connectors eliminates the weaknesses of solder connections, including the introduction of corrosive elements in fluxes and dissimilar metals. The crimp provides a measurable indent for built-in quality control. In the assembly process, crimping means faster assembly. Dies are available for the M8ND HYTOOL® and Y8ND HYPRESS® which are ideal for close confined areas.

Burndy Corporation, Norwalk, Connect.

CIRCLE 24 ON READER-SERVICE CARD

EDITORIAL

Relief From Measurement Pinch Found in Action

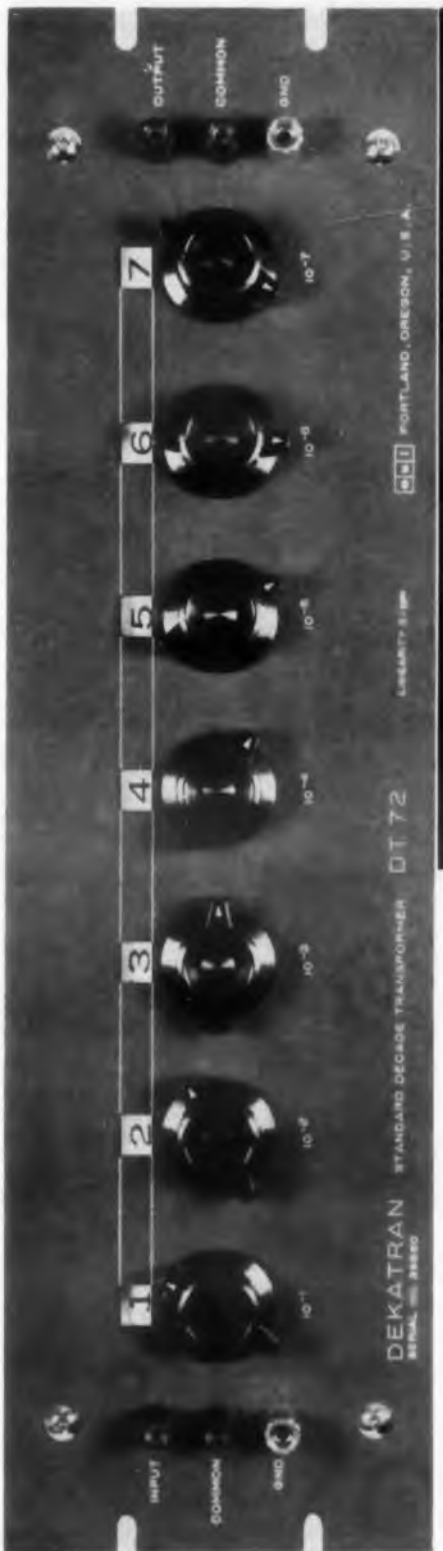
Eighty-five per cent of today's precision measurement problems involve electronic and electric quantities. There are no national standards for many of these quantities. The lack of a standard for measuring microwave power to calibrate radars is but one example. This and other lags between measurement need and measurement capability were pinpointed recently for the Aerospace Industries Association in a survey by a team of engineers of the Sperry Gyroscope Co.

The conclusions and suggestions that L. B. Wilson of Sperry drew from the survey merit the support of every engineer. Mr. Wilson asserts that although the National Bureau of Standards has standards with accuracies adequate for today's problems, these accuracies should be ten times better to allow for deterioration in getting from NBS's primary laboratories to industry test benches. He warns, too, that the total of critical measurements is mushrooming and that minor problems now may plague the entire industry as advanced R&D go into production. Mr. Wilson concludes:

- There must be more basic research and accelerated research in the technical problems of measurement. NBS should lead the attack, but industry and academic institutions must help.
- Training and education in calibration deserve attention; better dissemination of information is needed. A glossary of calibration terms and definitions should be drawn up and industry-wide calibration procedures circulated.
- Regional calibration standard centers should be set up throughout the U.S. to relieve the overload on current NBS facilities, to speed service, and to reduce the problem of transporting standards over long distances.
- Calibration and standards should be considered early in the design phase to ensure manufacturing capability and reliability.

Congratulations to all who have sounded this early warning on measurement standards! The Air Force, in particular, has been conspicuous in establishing this year many precision calibration laboratories across the country. Navy BuOrd has set many standards for equipment testing. NBS's facilities for radio frequency measurement at Boulder, Colo., are providing helpful knowledge. We applaud the Electronic Engineering Representatives for calling a symposium on this subject and the General Radio Company for conducting a three-and-a-half-day seminar last month on standards and measurements. Such action will enable us to master our problem.—*JAL*

ELECTRONIC DESIGN is proud to act too. Last month's Calibrating Frequency Standards by K. Jaensch (Nov. 11, ED, p50) is but one example. Our Feb. 3 issue will carry a special report on control of radio frequency interference.



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Anthony Paolantonio
New York Naval Shipyard, Brooklyn, N. Y.

How to Design Deposited Film Coaxial Attenuators for VHF

Anthony Paolantonio wrote this article to help eliminate the trial-and-error approach which is so prevalent in the design of film attenuators. He proposes, instead, a simple yet practical design procedure.

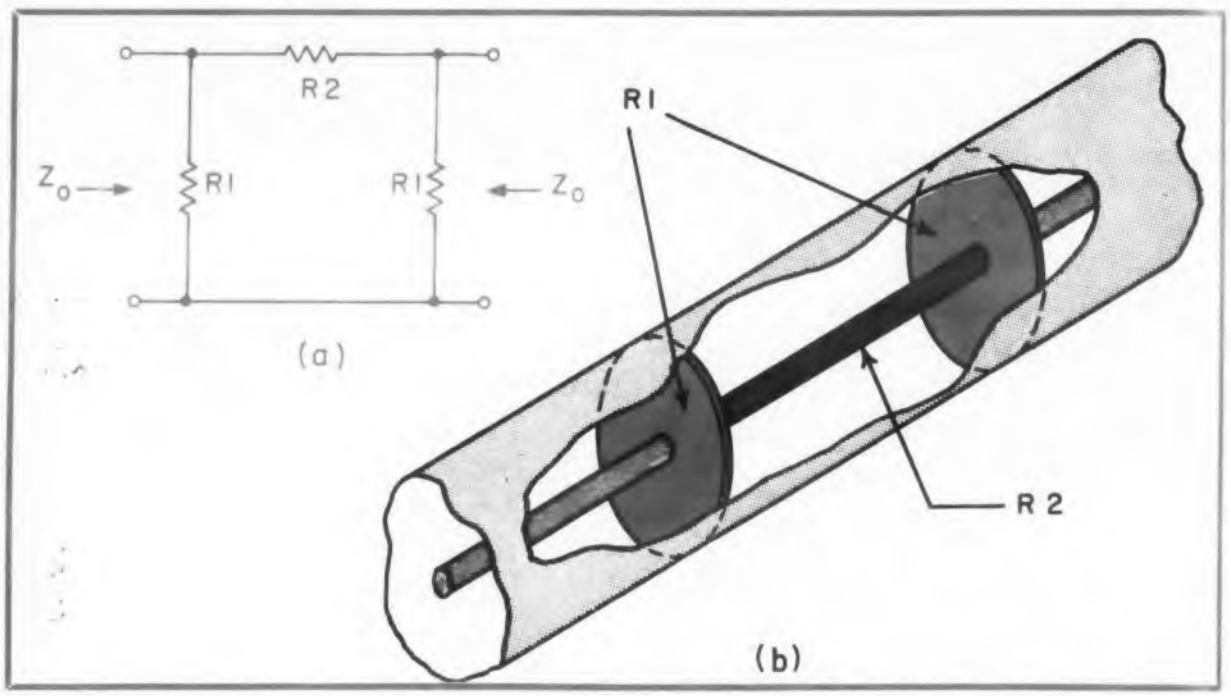
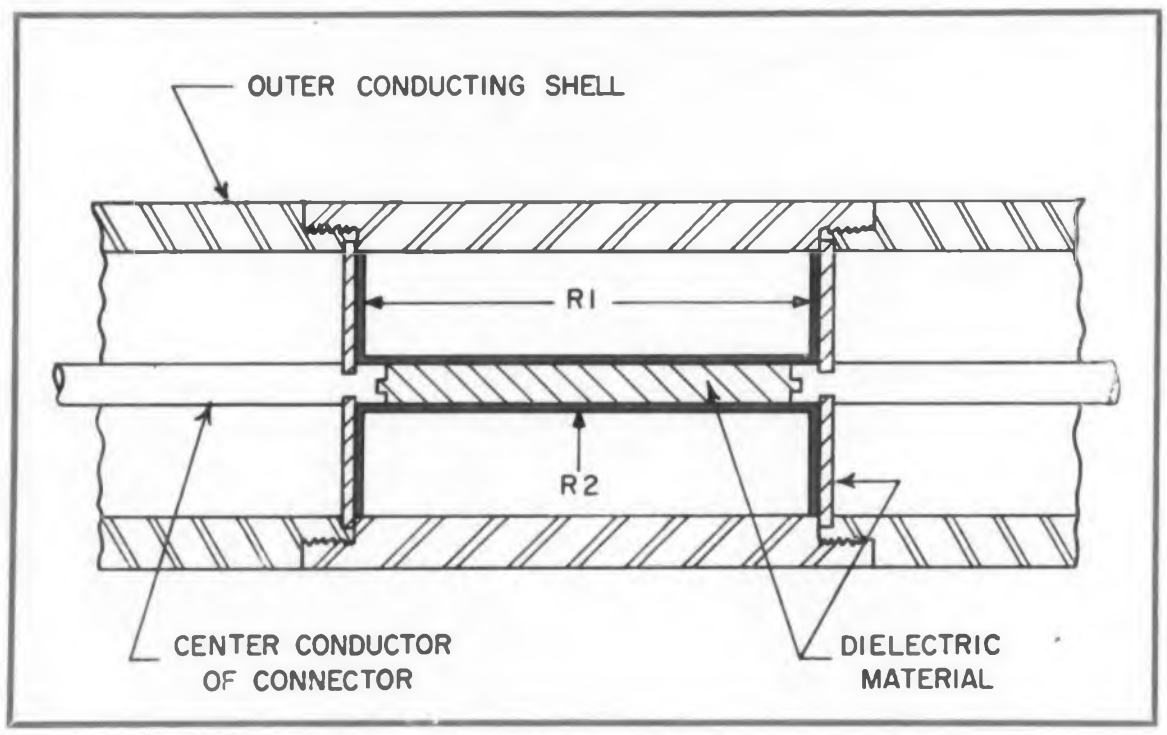


Fig. 1. (right) The "pi" attenuator network, showing the equivalent circuit and a phantom view of the construction.

Fig. 2. (below) Assembly drawing of coaxial attenuator. (The film thickness is exaggerated for clarity).



DEPOSITED film coaxial attenuators are almost always designed and constructed by trial and error—a very time-consuming technique. These networks, which introduce a desired loss in a coaxial transmission line, can be produced, following a practical design procedure.[1, 2, 3]

Such resistive attenuators can be used in very high frequency coaxial transmission line systems. Beyond 300 or 400 mc, they yield much better performance than the easier-to-design "lumped parameter" attenuators, whose shunt capacitance limits their usefulness to relatively low frequency lines.

Deposited Film Takes Many Forms

Before outlining a design procedure, it is useful to review the nature of deposited film resistance materials. Resistors, in the form of sheets or cards, circular discs, and other special shapes are available commercially. They are manufactured by bonding a thin layer of carbon or composition material to an insulating wafer.

In addition, aquadag solutions may be used to "paint" the surface of an insulator to form a re-

sistor. A still further method calls for evaporating a metallic substance, say borocarbon, and depositing the condensate on an insulating surface.

With the improved techniques now available for depositing thin resistive films on glass and plastic materials, it is desirable, from a production standpoint, to be able to make a deposited film attenuator in "one piece" rather than several (as is the present practice). The advantages of such "one piece" construction are twofold: (1) Excellent high-frequency characteristics, and (2) Economical quantity manufacturing.

In the design procedure here, it is assumed that the deposited film attenuators will be fabricated by either the "paint-on" technique or by deposi-

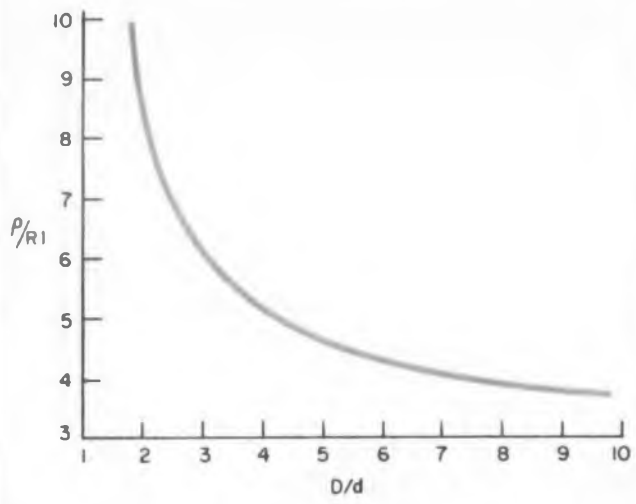


Fig. 3. Variation of ϱ/R_1 with D/d for a disc resistor.

tion of evaporated metal.[4, 5, 6, 7]

The analysis will be carried out for a symmetrical "pi" type attenuator. Other network configurations can be analyzed in a similar fashion.

Equations for "Pi" Parameters

The equations for calculating the "pi" parameters (shown in Fig. 1) are:

$$R_2 = \frac{(N-1)\,Z_0}{2\sqrt{N}} \tag{1}$$

$$\frac{1}{R_1} = \frac{1}{Z_0}\left(\frac{N+1}{N-1}\right) - \frac{1}{R_2} \tag{2}$$

Here R_1 and R_2 refer to the resistance in ohms of the shunt and series arms of the "pi" respectively. N is the ratio of the power at the attenuator input to that at the output. Z_0 is the characteristic impedance of the transmission line.

The physical form for R_1 and R_2 is shown in the phantom view included in Fig. 1. A mechanical assembly of the completed attenuator is illustrated in Fig. 2. R_1 assumes the shape of a disc

resistor, and R_2 that of a tube of resistance material.

In this design a uniform film of resistance material, a few thousandths of an inch thick or less, is deposited on the dielectric "spool" to make the attenuator in one piece. With the values for R_1 and R_2, as determined from Eq. (1) and (2), it is possible to solve for the dimensions of the disc resistor portions and also the length of the central tube of resistance material.

The resistance of the disc resistor, R_1, is related to its physical dimensions by the following equation:

$$R_1 = \frac{\rho}{\pi}\left(\frac{D-d}{D+d}\right) \tag{3}$$

where ρ is the surface resistivity of the resistance material to be used—in units of ohms-per-square. D is the outer diameter of the disc resistor and d is its inner diameter (which is equal to the diameter of the tubular series arm of the "pi"). Eq. (3) can be arranged in a more useful form as follows:

$$\frac{\rho}{R_1} = \pi\left(\frac{D+d}{D-d}\right) \tag{4}$$

A plot of the normalized, ρ/R_1, as a function of the dimensions of the disc resistor, D/d, is shown in Fig. 3.

The outer diameter of R_2 is the same as the inner diameter of R_1, hence the remaining unknown dimension for R_2 is its length L. This dimension is determined from the expression:

$$R_2 = \frac{L}{\pi d}\,\rho \tag{5}$$

Design Procedure

1. Knowing the characteristic impedance, Z_0, of the transmission line, and the desired attenuation, find R_2 by using Eq. (1).
2. Similarly, find R_1 by using Eq. (2).
3. The inner diameter of the outer wall of the attenuator holder determines the dimension D. Make d equal to the diameter of the attenuator connector pin.
4. Calculate ρ by using Eq. (4).
5. Use Eq. (5) to find L for R_2.

Sample Design

Problem.

It is desired to insert a 20 db attenuator in a 70 ohm transmission line system. A length of brass tubing with an inside diameter of 1/2 in. is to be used for the outer shell of the attenuator; and the connector pin has a diameter of 5/32 in. Determine all parameters and dimensions of the attenuator.

Solution.

1. Find N from the given attenuation: Attenua-

tion = 10 $\log_{10}N$. Solving, $N = 100$, which is the power ratio between input and output terminals for an attenuation of 20 db.

Use Eq. (1) to find R_2:

$$R_2 = \frac{(N-1)\,Z_0}{2\sqrt{N}} = \frac{(100-1)\,70}{2\sqrt{100}} = 346.5 \text{ ohms}$$

2. Using Eq. (2), find $R_1 = 85.5$ ohms.

3. Using Eq. (4) find $\rho = 512$ ohms per square inch.

4. Using Eq. 5, find $L = 0.331$ in.

The complete design parameters and dimensions for the attenuator are:

$Z_0 = 70$ ohms	$R_2 = 346.5$ ohms
Attenuation = 20 db	$R_1 = 85.5$ ohms
$D = 1/2$ in.	$\rho = 512$ ohms per squar
$d = 0.156$ in.	$L = 0.33$.

The attenuator may now be fabricated. Either the "paint-on" techniques or the evaporation process may be used to deposit the resistive film material on the "spool" used for the "pi" network supporting form.

Power Dissipation

Because the deposited film resistance material is very thin, at most only a few thousandths of an inch thick, this device can only be used for low power applications. The power dissipation capability of deposited film attenuators is in the order of one watt or less, except for special designs.

In addition, it is shown[8] that the distribution of the power dissipation between the several parts of the attenuator is not uniform. Other factors to be considered, to minimize hot spots caused by this non-uniform distribution of power dissipation, are the physical shape and size of the shunt and series arms, ambient temperature, and temperature characteristic of the deposited film resistance material. ■ ■

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1 *Some Basic Rules*

Handling Nodes And Loops

Two-Port Networks, The Topology Equation

Interpretations And Examples

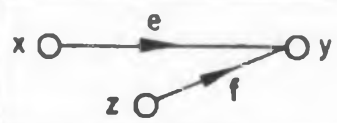
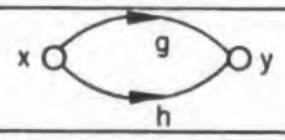
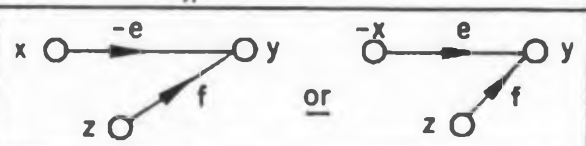
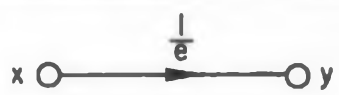
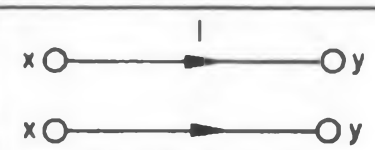
Visual Engineering Mathematics

A Self-Contained Course

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

The authors wrote this serialized, self-contained course in flow graph analysis—a visual form of engineering mathematics—"to provide a basic understanding of the subject after about two hours of study." The value of the flow graph technique is its ability to provide both a general view of the interdependence of variables, and a particular view of any required aspect. Rules are developed from the simplest possible mathematical structures. Although transistor engineering (to which flow graph analysis is particularly suited) is used in some specific examples, the main work is treated in general terms which are applicable in many branches of engineering. Flow graph analysis has been treated by many authors in many different ways. In many respects, this series differs from other writings on the subject, particularly with reference to the use of the topology equation which this series introduces for the first time. This course is divided into four parts.

Table I
BASIC RULES

ADDITION		$y = ex + fz$
		$y = gx + hx$
SUBTRACTION		$y = fz - ex$
MULTIPLICATION		$y = ex$
DIVISION		$y = \frac{x}{e}$
IDENTITY OR UNIT TRANSMITTANCE		$y = x$ $y = x$
NEGATIVE UNIT TRANSMITTANCE		$y = -x$ $y = -x$

FLOW GRAPH analysis is basically a way of writing equations. Flow graphs need not be related to any block diagram or circuit—though they often yield valuable benefits when so associated.

These benefits are similar, in nature, to those accruing from continued working with the equations of a particular system: for example, a

acuum-tube engineer may become so familiar with the standard equations relating μ, g_m, R_a, and R_L that, in considering any new question (say the influence of output capacitance on voltage gain) he will select a suitable standard equation for his analysis. Flow graphs yield this kind of benefit because they simultaneously display all the equations of a system. And a flow graph can be read in a general way to get a broad picture of the functional dependence before it is read in detail for precise information.

A flow graph is not a kind of block diagram. Its main purpose is merely to list the equations in an orderly form. The equations themselves *are* the flow graph.

A flow graph is not reduced piece by piece until an elemental flow graph results. This operation *can* be performed; but much more commonly the flow graph is left intact, as originally drawn.

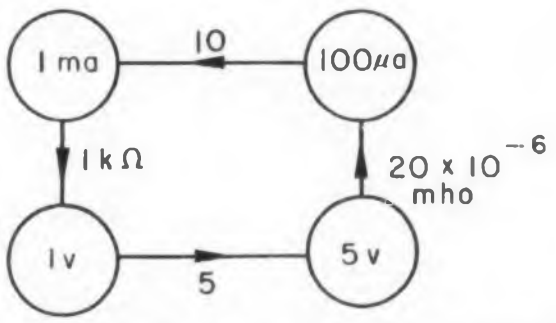
Flow Graph Notation

To understand the general method used in flow graph notation, assume that equations may be written either vertically or horizontally, so that:

$$\left.\begin{aligned} w &= ax \\ x &= by \\ y &= cz \\ z &= dw \end{aligned}\right\} \equiv \begin{aligned} w &= a \cdot x \\ d &\quad \| \\ \| &\quad b \\ z \cdot c &= y \end{aligned}$$

We may insert quantities to help illustrate the method, and replace the equal signs by arrows:

$$\begin{aligned} 1\ \text{ma} &= 10 \times 100\ \mu\text{a} \\ x &\quad \| \\ 1\ \text{k}\Omega &\quad 20 \times 10^{-6}\ \text{mho} \\ \| &\quad x \\ 1\ \text{v} &\times 5 = 5\ \text{v} \end{aligned}$$



On the right the flow graph notation shows the rather strict distinction made between dependent and independent variables.

In this particular case, a loop has been formed and the product of the transmittance around it ($a \cdot b \cdot c \cdot d \cdot$ or $1\ \text{K} \cdot 10 \cdot 20 \cdot 10^{-6}$ mho $\times 5$) equals

unity. This is the general topological equation for a closed flow graph, and it can sometimes be used to advantage in writing a set of equations and solving them for a particular unknown.

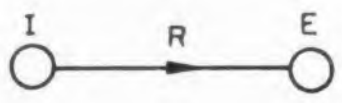
Many subjects lend themselves to flow graph notation; some do not. The mathematical proof of the formula for an infinite series can be written in two lines from a simple flow graph. Transistor "*h*" parameters can be converted to "*z*" parameters by a single manipulation of the flow graph. Amperes, ohms, volts, and watts, however, cannot be embodied simultaneously in the same flow graph.

Flow Graph Rules Simply Stated

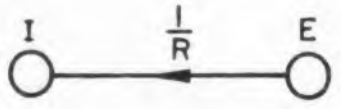
The various flow graph rules can be stated swiftly and simply. Almost the entire subject is covered by the rules shown in Tables 1 and 2. To yield a reasonable fluency, the subject should be covered in a series of steps, with some practice at each step and with some attention to the "don'ts" and "do's."

Addition, Multiplication, Path Inversion

A flow graph such as:



says that I multiplied by R equals E. I and E are the *nodes*, which are the variables in the equation. R is the *transmittance*, which represents the relationship between variables. The arrow's direction is important. It shows that the taking-off node, I, experiencing the influence of the transmittance, R, becomes the terminating node, E. If the direction of the arrow were reversed, the flow graphs would become:



Reversal of the arrow's direction means changing the transmittance to its reciprocal. Note the distinction made between the dependent and the independent variable in the two equations

$$E = I\,(R)$$
$$I = E\,(1/R)$$

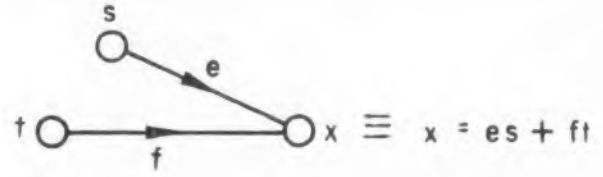
This distinction is required in flow graph analysis more than in other mathematical methods.

Although any equation could be written as a flow graph, there is little advantage in this unless the equation can also be *manipulated* as a flow graph. (As an example, Eq. 3 can be manipulated to form Eq. 4.) To this end it is generally desirable to represent voltages and currents by nodes (dependent or independent, as the case may be) and the interrelating factors by transmittances. Most electronic circuits are concerned with the conditions when voltages and currents vary but transmittances remain constant.

The transmittance is the ratio of the dependent to the independent variable. The relationship between the nodes will usually be in ohms or mhos for transmittances which relate voltages and currents. Or, transmittances will be dimensionless (amplification or attenuation factor) if they represent the relation between nodes of the same dimension.

(Reactances—or immitances, generally—may take the place of the ohms and mhos as the dimensional nature of transmittances. Also, Laplace transforms of voltage or current may be represented by nodes in a flow graph, with the related transfer functions represented by transmittances.)

When two transmittances terminate at a node, the quantity represented by each of them contributes to the value of the node. To evaluate a particular node, the contributions by the various transmittances are added as in the following equation:

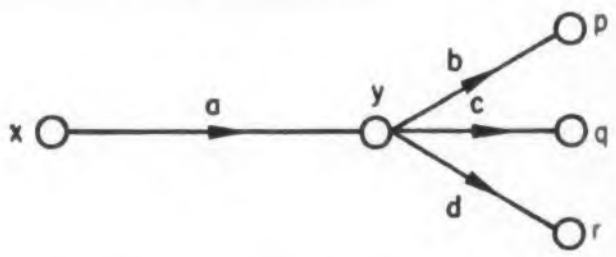


It is in this sense of "making a contribution" that the idea of "signal flow" must be interpreted. The description "oriented graphs," which is sometimes applied, also catches the idea of information being conveyed in one direction (that of the arrow) but not in the other. The strict distinction between dependent and independent variables, too, is in keeping with this concept.

Writing A Node Equation

In writing the equation for a node, we specify, by assumption, that the node in question is the dependent variable. The same node may also be an independent variable in some other area of the flow graph; i.e., arrows may enter and leave any node in a flow graph. Very often such a node can be omitted in describing the functional dependence (e.g., node y in Eq. 6 below).

In a flow graph such as Eq. 6, the siganl must not be thought of as being apportioned among the three branches. As far as p, q, and r are concerned, y is truly independent.

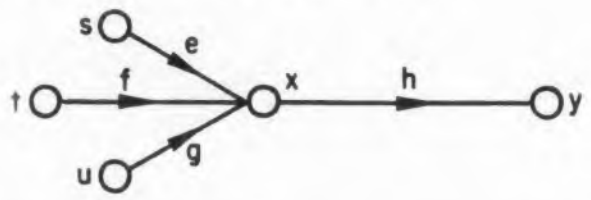


No matter what other variations may take place in r, there is no effect on y. One cannot travel, as it were, in a direction against the arrow. But any variation in x will cause a variation in all three de-

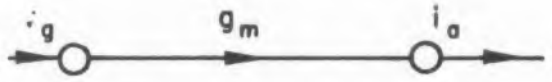
pendent variables, for $p = abx$, $q = acx$, and $r = adx$.

In Table 1 are shown the various rules which form the basis of flow graph construction and interpretation.

The equation for a node is the sum of all the transmittances entering it. In the following graph, x as a dependent variable equals $es + ft + gu$, while x as an independent variable makes a contribution through h to the dependent variable, y. That is, $y = hx = hes + hft + hgu$.



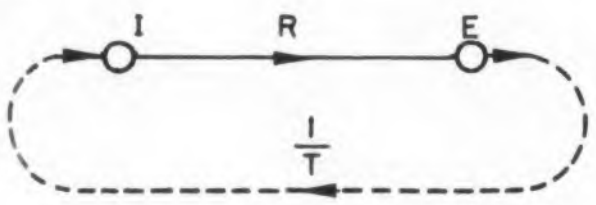
Flow graphs may be open or closed. Most of those illustarted above are open and it is sometimes desirable to show this by drawing arrows entering and leaving the flow graph, thus:



Giving the symbols their conventional definitions, Eq. 6 is the flow graph of a vacuum-tube amplifier in which the anode current equals the grid voltage multiplied by the transconductance. This example illustrates a point which is not always so clearly in evidence. The input and output of a circuit are, respectively, the independent and dependent variables.

Remember: the INput, represented by an arrow INto the network, is the INdependent variable.

When looking at an open flow graph, mentally tie the vacant ends together; this helps provide the background for the flow-graph picture, since an open flow graph can always be transformed into a closed one in this manner, should the need arise. Closing an open flow graph involves joining the output to the input by a transmittance $1/T$, thus:



T represents the transmittance of the network involved.

Since the flow graph is now closed, we can make use of the topological fact that the product of the transmittances around the loop is unity. In a complicated flow graph, it is sometimes a neat mathematical trick to use this technique, solving the topological equation for T to establish an otherwise elusive transfer function. ■ ■

Parts two, three, and four of this course will follow.

How to Drive the Beam Switching Tube

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The beam switching tube looks, at first glance, like a very complex device. In this article, Arpad Somlyody, shows how relatively easy it is to design the input and output circuit for this unusual tube.

THE BEAM switching tube, in the basic circuit shown in Fig. 1, forms a ten-position stepping device. It advances an electron beam sequentially or at random, one step for every negative voltage change applied, alternately, to the two inputs.

Applications of this type of circuit include decade counting, distributing, multiplexing, sampling, dividing, gating, coding, memory, and other digital functions.

The basic circuit for use with beam switching tubes comprises six functional sections, the input circuit, the output circuit, the spade circuit, spade and cathode degeneration, the zero-set circuit, and the bias circuit. This article treats the two most important circuits, the input and output.

There are several variations of the basic circuit, the differences being either in the output circuit or in the input circuit.

The Input Circuit

One input circuit, most frequently employed as shown in Fig. 2, is used to ac couple a rectangular waveform, such as the outputs of a multivibrator, in push-pull fashion to the even and odd sets of grids of the beam switching tube. It also provides the two sets of switching grids with the appropriate bias voltage V_g, which is about +25 to +30 v with respect to the cathode.

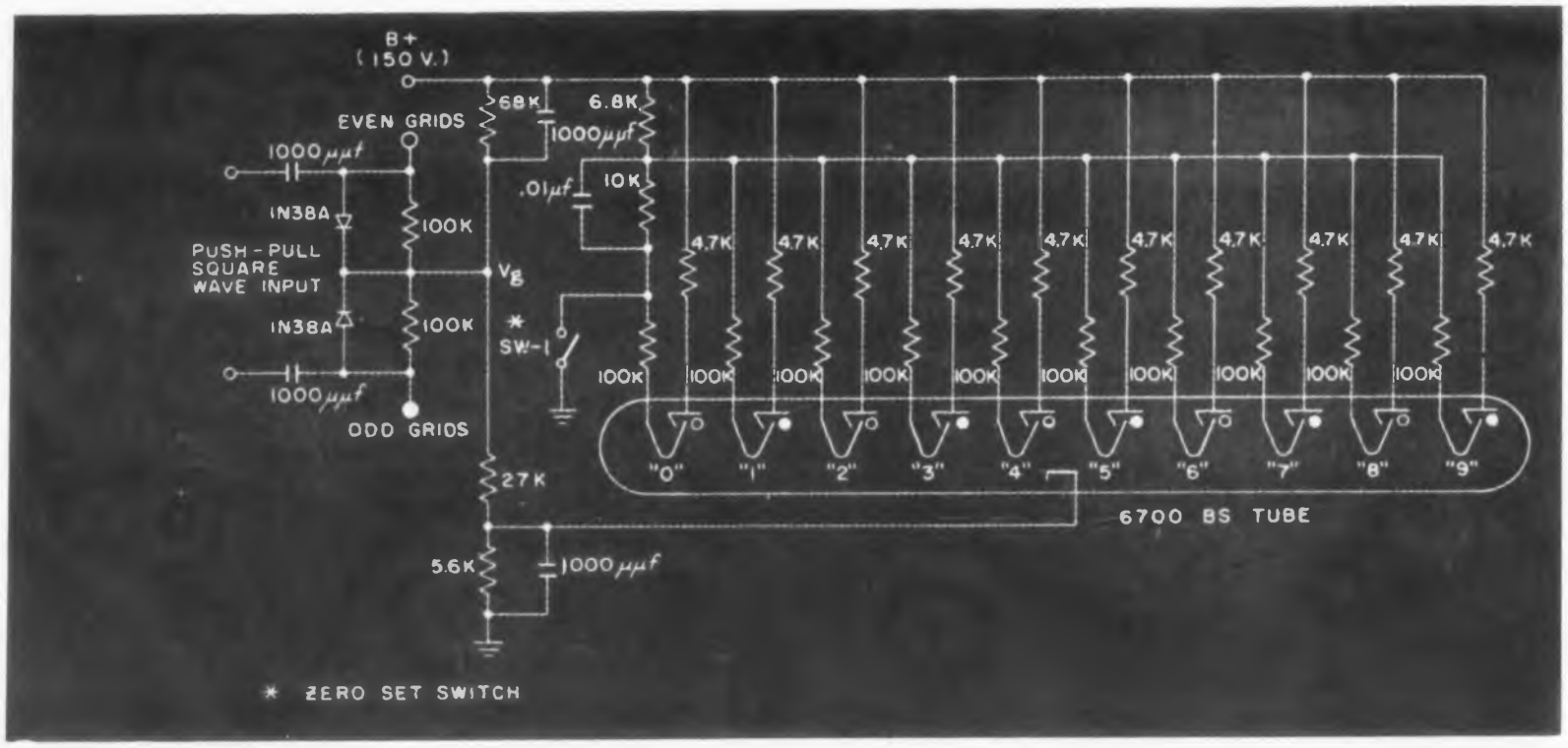


Fig. 1. (left) The basic circuit for the beam switching tube.

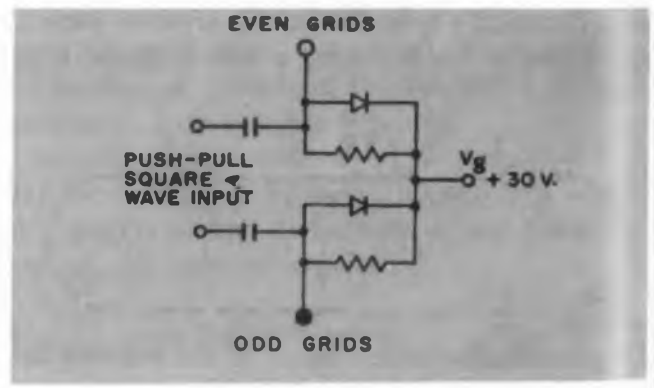


Fig. 2. Input circuit used to ac couple a square wave to the bs† grids.

The value of the resistors between the bias point V_g and either set of grids is 100 K. This value is not critical. However, a very low value of resistance causes too much attenuation through this differentiating network and loads the driving source unnecessarily. On the other hand, excessively high resistance values should be avoided to eliminate the effects of grid current that tend to lower the grid potential and thereby cause switching instability.

The beam switching tube is generally considered to have a high input impedance, but when the targets are at low potential, grid current of several hundred microamperes may flow.

The value of the coupling capacitors is generally between 100 μμf and 1000 μμf or greater, depending on the rise time of the negative going edge of the driving waveform. A fast rising waveform requires smaller capacity to couple through with negligible loss in amplitude.

When the amplitude of the available driving waveform is known, the coupling capacitors are chosen to obtain an amplitude at the grids in excess of the minimum requirement of the beam switching tube. This minimum requirement is a direct function of counting frequency, spade time constant and "on target" potential. It should generally exceed 50 v.

Diodes As DC Restorers

The diodes across the two resistors serve as dc restorers. They are only required at high repetition rates, that is, when the period of input waveform T_i is less than 5 RC where R and C are the resistance from grid to the bias point and the coupling capacitance respectively.

When no diodes are used and the period of the input waveform is greater than 5 RC, the time T_i is long enough to allow the capacitor to charge and discharge back to the grid bias level after every change in input voltage. (Fig. 3.) Therefore, the useful output amplitude E_o is very nearly equal to the amplitude of the input waveform E_i.

If the period of the input waveform is less than 5 RC, and no diodes are used, a different condition exists. For an initial voltage step E_i at the input of the circuit in Fig. 4, the voltage appearing across R after time T_i is given by the equation

$$e_o = E_o\, \epsilon^{-T_i/RC}$$

By rearranging this equation, we can show that the percentage discharge of capacitor C is purely a function of the period of the input waveform and the time constant of the circuit.

$$\frac{e_o}{E_o} = \epsilon^{-T_i/RC}$$

In a similar manner

$$\frac{e_o}{E_o} = \frac{e_1}{E_1} = \frac{e_2}{E_2} = \cdots \frac{e_n}{E_n} = \epsilon^{-T_i/RC}$$

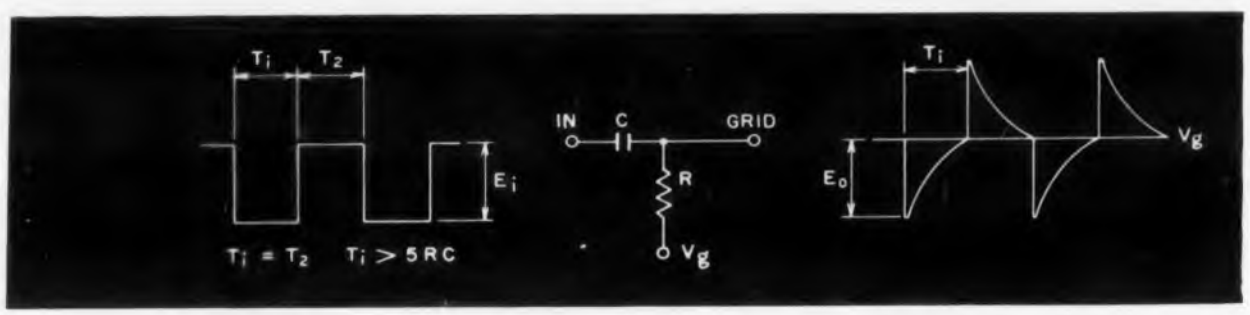


Fig. 3. With no input diode, at low repetition rates, there is ample time for the capacitor to return to the grid bias level.

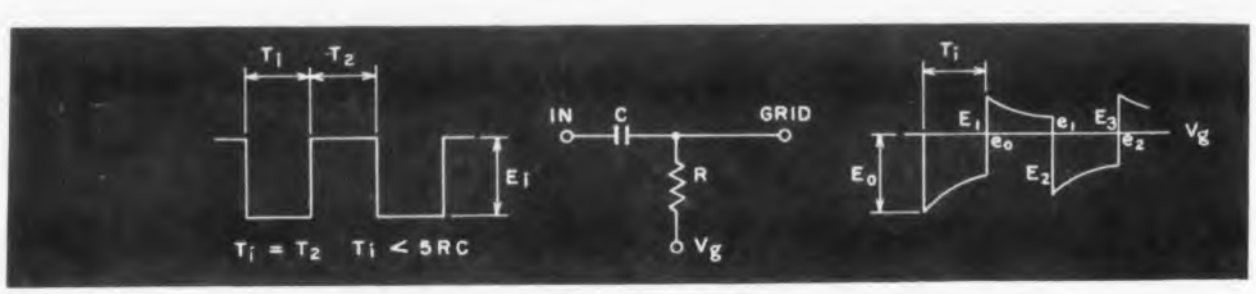


Fig. 4. With no input diode, at high frequencies, the amplitude of the grid voltage waveform is a function of frequency.

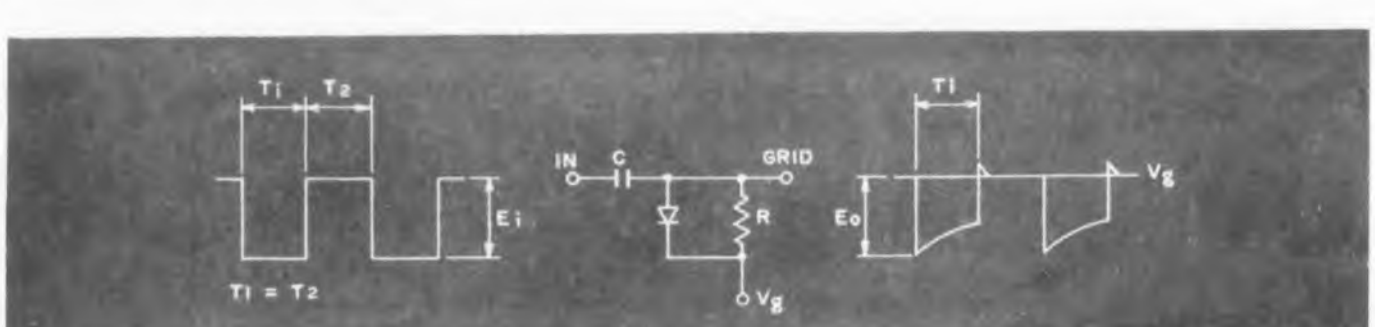


Fig. 5. With a diode shunting the input resistor, the capacitor will discharge during every positive input swing.

where $n = 0, 1, 2, 3, \ldots$
But we can say

$$\epsilon^{-T_i/RC} = K$$

where K is constant as long as R, C, and T_i are constant.
Therefore

$$e_n = KE_n \qquad 0 < K < 1$$

After the initial period, the input waveform changes in the positive direction and

$$E_1 = E_o - e_o$$

In time $2T_i$, E_1 decreases to

$$e_1 = KE_1$$

The input waveform now changes in the negative direction again and

$$E_2 = E_o - e_1$$

After time $3T_i$

$$e_2 = KE_2$$

The amplitude of the successive negative swings, as also seen in Fig. 4, diminishes

$$E_o \cong E_i$$
$$E_2 = E_o - K\,(E_o - K\,E_o)$$
$$E_4 = E_o - K\,[E_o - K\,(E_o - K\,E_o)]$$

until equilibrium is reached and the negative and positive swings at the output are equal in amplitude. This amplitude is a function of K and may be anywhere between E_o and $E_o/2$.

Therefore, if diodes are not used and the operating frequency is high, then the amplitude of the driving waveform at the grids of the beam switching tube is a function of the frequency. The peak-to-peak amplitude of the driving waveform then exceeds twice the negative switching amplitude required by the beam switching tube.

If a diode is used across the resistor R, as in Fig. 5, with its cathode connected to the bias point V_g, the capacitor will discharge completely during every positive swing of the input waveform through the forward impedance of the diode.

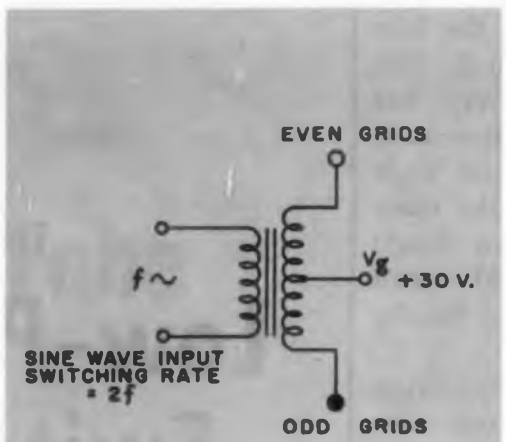


Fig. 6. Input circuit for sine wave drives.

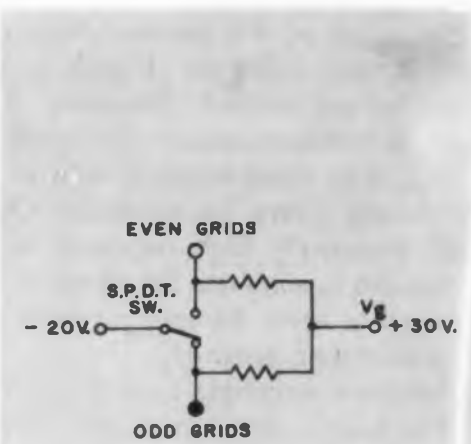


Fig. 7. A mechanical switch can drive the beam switching tube.

The bias point V_g can be considered a low impedance point in this case.

As seen in Fig. 5, the input and output voltages remain nearly equal regardless of the period of the input waveform.

Input For Sinewave Drive

Another form of input circuit, shown in Fig. 6, is used when sine wave drive is available. The turns ratio of the transformer is selected to provide, across each half of the secondary, a peak-to-peak amplitude greater than twice the minimum requirement. This gives a peak-to-peak amplitude, between the two sets of grids in excess of four times the minimum requirement. Grid bias voltage is applied at the center tap of the secondary.

A relay or a manually operated switch can also be used to produce the step waveform necessary to drive the beam switching tube. Fig. 7 is a circuit of this type where −20 v is applied alternately to the grids by a spdt switch.

The Output Circuit

The output circuit of the beam switching tube affords great flexibility of design. Voltage swings in excess of 200 v can be obtained from the ten targets, each reperesenting a 5.5 ma constant current source. In special tubes, this output voltage swing can exceed 1000 v.

Beam switching tubes exhibit a knee in their target characteristics as seen in the I_T-E_T plane of Fig. 8. This knee in the Type 6700 tube begins approximately 50 v above cathode potential. Below this potential, part of the excess electrons are collected by the grid and part of them by the leading spade. This is the spade immediately following the beam holding spade in the direction the beam advances. The resultant current flow lowers the potential of these two electrodes, causing the beam to switch to the next position.

If the same condition exists in all ten positions,

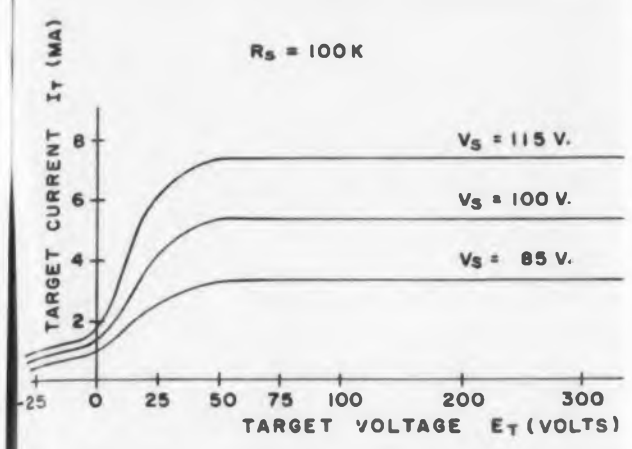


Fig. 8. The bst's target characteristics. Note the knee at about 50 v.

hat is, the target potential drops below the knee f the I_T-E_T curve when target current flows, he beam will not be stable in any position and ill skip around the tube erratically. Therefore, n designing the output circuit, the target potenial should never be allowed to drop as low as the alue given by Eq. (1) and (2).

$$E_T = V_T - (I_T R_T) \quad (1)$$

$$E_T > V_s/2 \quad (2)$$

here V_T = target supply voltage

E_T = conducting target voltage (voltage etween the beam collecting target and the athode)

I_T = target current

R_T = target load resistance

V_s = spade operating voltage (voltage beween the spade buss and the cathode)

A wide variety of resistive load lines and suply voltages can be used if the relationships in (1) nd (2) are observed.

The circuit in Fig. 1 yields approximately 26 v utput across the 4.7 K target loads.

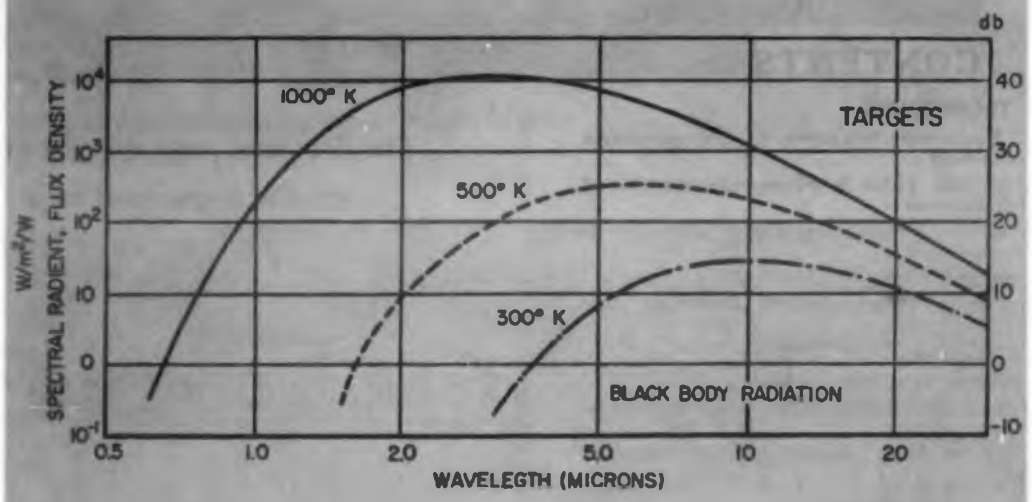
Relays requiring no more than 5 ma of pull-in urrent can also be used in the target circuit. By-ass capacitors or diodes are generally used to revent the inductive overshoot of the relay from using target switching instability by momenarily driving the target below the knee of its haracteristic curve.

A negative transient may appear on adjacent pades every time the beam advances if the target wings more than 100 v. This is due to coupling rough interelectrode capacity and may cause ipping and erratic operation. A small by-pass pacitor across each spade resistor (5 μμf or ore) will eliminate the effect of this coupling. imilar results are obtained by padding the tarets with somewhat larger capacity.

Using this basic circuit and the principles outned here, the beam switching tube can be dapted to the majority of its applications. ■ ■

Author George Rayl feels there exists a need for understanding the physics involved in the detection of an object at a distance. In this article he discusses problems applying to infrared systems. A thorough understanding of these problems forms a sound basis for working with improved infrared components in the future.

IR As A Passive Method Of Target Detection And Identificatio



WHEN confronted with the problem of target detection and identification at a distance, the objective system design engineer must choose initially the spectral interval with which he intends to work in the design of a passive detection and identification system. This spectral interval might conceivably be in the ultraviolet, visible, infrared, or microwave portions of the electromagnetic spectrum. Proper choice of one or more spectral intervals is dependent on a thorough knowledge of:

- Spectral distribution of both target and background.
- Spatial distribution of the background if scanning is employed.
- Transmissivity of the intervening atmosphere.
- Availability and transmissivity of optical materials.
- Limiting sensitivity (noise equivalent power) of the detector in the spectral interval.

The post-detection data processing circuits are very similar for a given class of detection equipment; i.e., search or track, and will be covered in another article.

Target Spectral Power

Spectral distribution of target radiant energy is the first factor to be considered in most applications. Fig. 1 (top) shows the relative distribution of radiant energy as a function of wavelength for several complete radiators (blackbody). Note the log scale on the ordinate. Fig. 1 also shows the desirability of matching the spectral response, or passband, of the detection equipment to the peak radiation of the target. It also excludes the use of photomultipliers for all but the 1000 K target.

Fig. 2 gives the radiant energy distribution of the carbon dioxide emission band at 4.3 microns and water vapor bank at 2.9 microns. This non-

Fig. 1. Typical infrared system parameters. Note how target radiation can be related to other system factors.

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complete radiation distribution arises from the products of combustion found in the exhaust of hydrocarbon fuel mixtures and as such represents the radiant energy emission from an important class of targets.

Background radiation can be described by two characteristic parameters, spectral and spatial distribution. Both of these parameters are a function of the time of day, elevation and azimuth angle of line of sight, and the point of observation. Figs. 3 and 4 are a plot of these parameters for the circumstance indicated.

Sunlight and Sky Radiation

Fig. 3 is a spectral plot of the two sources of background radiation; i.e., scattered sunlight and sky radiation. The shape of the clear sky curve demonstrates two characteristics of scattered sunlight: (1) the increased ineffectiveness of scattering by air molecules, dust and haze with wavelength and, (2) the effective cutoff of scattered sunlight at approximately 3 microns. The notches in the curve at 1.4 and 1.9 microns represent absorption by atmospheric water vapor. The curve on the right shows the distribution of sky radiant energy as recorded on the earth on a cloudy day. The curve is drawn smooth without the water vapor, carbon dioxide, or ozone absorption bands. Under these conditions, this radiant energy distribution approximates a complete radiator of a temperature of 22 C.

Cloud Background

Fig. 4 gives a typical spatial distribution for cloud background. The second curve of slope 2 is drawn in for comparison purposes. Average power density from clouds then falls off approximately 40 db per decade. The abscissa units of waves per radian imply that there is a measurable spatial frequency associated with sky radiance. These two parameters singularly and together point out the advantages of working in the infrared as compared to the visible.

Atmospheric Attenuation

Having defined the target and background radiation on a spectral and spatial basis, the next step is to quantitatively describe the transmissivity of the atmosphere. The Rayleigh theory of scattering by small particles is adequate for atmospheric scattering by particles less than or equal to 1/2 the wavelength of the radiant energy involved. This theory indicates that the magnitude of the scattering loss is inversely proportional to λ^4. Fig. 5 shows that up to the critical Rayleigh wavelength, the scattering losses are constant and double, approximately 40 db per decade of particle size. This scattering loss relationship means that during conditions of fair weather scattering losses are down by 24 db at 1.0 from the visible. This course is again a strong argument for the infrared spectral interval.

The second factor in the atmospheric attenuation of radiant energy is the loss by molecular absorption. Fig. 6 shows the absorption bands contributed by the various atmospheric constituents. Examination of the 1-13 micron interval shows that the principal absorbers are water vapor, carbon dioxide, and ozone. Total absorption over a given range with a given altitude of observation, target altitude and water vapor, relative humidity is found by the super-position of narrow band spectra of the three major absorbers. Fig. 7 shows the resultant spectral transmission of a one-mile path at sea level.

External Systems Factors

The external systems factors then may be listed as follows: target spectral power, sky noise background, and atmospheric attenuation. A thorough quantitative knowledge of these factors enables the engineer to predict the spectral power density of radiation above the background falling on the irdome, or first element, of the receiving equipment. If we assign the symbol $H(\lambda)$ to the spectral power density on the irdome, the following relation can be set up:

$$H(\lambda) = N(\lambda)A_T\,\tau_A(R, \lambda)r^{-2} = J(\lambda)\,\tau_A(R, \lambda)\,r^{-2}$$

where

$H(\lambda)$ = radiant flux density per micron, (watts cm^{-2})
$N(\lambda)$ = radiance per micron, (watts cm^{-2} ster^{-1})
A_T = area of the target, (cm^2)
$J(\lambda)$ = radiant intensity watts ster^{-1}
$\tau_A(\lambda)$ = radiant transmittance of the atmosphere
r = range, (cm)

Integrating over the spectral interval of interest

$$NEI = \int_{\lambda_1}^{\lambda_2} H(\lambda)d = A_T r^{-2} \int_{\lambda_1}^{\lambda_2} N(\lambda)\,\tau_A(\lambda)d\lambda \quad (1)$$

This quantity can also be considered as the noise

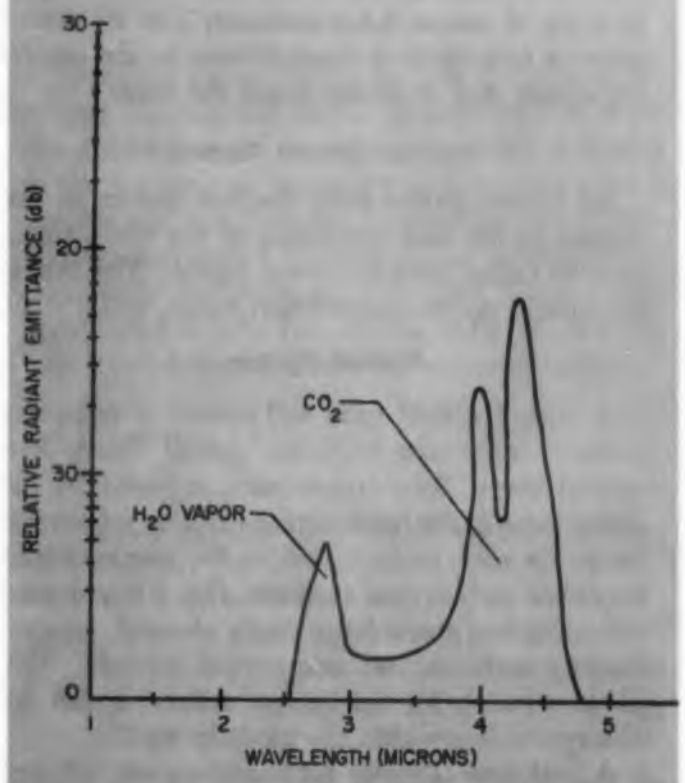

Fig. 2. CO_2 and H_2O emission from combustion of hydrocarbons in air.

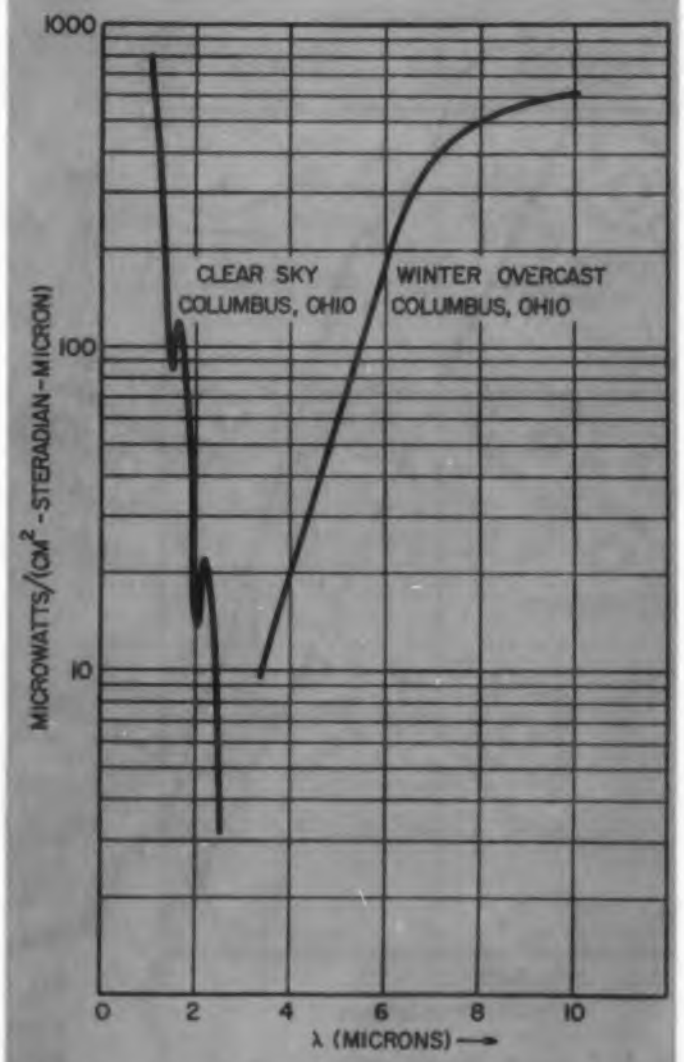

Fig. 3. Spectral plot of background radiation of scattered sunlight and clouds.

equivalent input (*NEI*) at the irdome for a signal to noise of one at the transducer. This statement assumes non-selective transmittance by the receiving optics, and generally is not the case.

Internal System Factors

All system factors from the first surface of the irdome to the final processing of the video signal may be called internal system factors. The first is the optical system transmission factor, $\tau_0\,(\lambda)$.

Optical System

A typical optical train will consist of reflecting surfaces, refracting surfaces, optical filters, and spatial filters. Total transmission is found by the convolution of the transmittance and/or reflectance curve for each surface besides the transmittance curve for each optical medium. Fig. 8 is a typical transmittance curve for a single element, two refracting surfaces, and one optical medium. This curve accounts for the Fresnel reflection and the absorption loss within the medium itself.

A final optical factor for consideration is image spread. This is usually specified as a certain percentage of the incident energy falling within a blur circle of a given dimension. The exact meaning of this specification, of course, is dependent on the grid size in the spatial filter, if there is one, or the transducer element size. Any obscuration of the blur circle by the spatial filter during the "on" part of the cycle must be charged against the system as a loss. Similarly, if the coded, or uncoded energy "spills over" the sensitive area of the transducer, an energy loss will occur. The product of all these efficiencies is called the optical transmissivity.

Target to Background Noise

The second internal system factor is the target signal to background noise ratio at the transducer. Detection of a target in the presence of noise background is a statistical problem involving many factors. Analysis can be simplified by assuming that the noise associated with the transducer; shot noise, excess noise (f^{-1}) and Johnson noise, is the limiting noise of the entire detection system. All other noise sources such as background noise, tube shot noise, flicker noise, and ambient noise are to be considered of secondary importance.

The next step is to assign a noise distribution to the transducer. With few exceptions, the transducing element will be of the photoconductive variety. Within the photoconductive class of transducers, the lead salts (lead sulfide, lead selenide and lead telluride), are the most commonly used transducers. Limiting noise of this class of transducers is excess noise following a $1/f$ dependence. The output signal in volts to radiant flux in watts incident on the transducer is known as the responsivity of the transducer. When the peak signal voltage is measured equal to the rms noise over a particular bandwidth and center frequency, the incident radiant flux is designated as the noise equivalent power (*NEP*) of the transducer. *NEP* is a function of wavelength of the incident radiant flux, chopping frequency, area and temperature of the sensitive surface and follows the relationship for $1/f$ noise, for the previously named transducers:

$$NEP(\lambda) = S(\lambda)\,(A_d)^{1/2}\left(\Delta\frac{f}{f}\right)^{1/2}$$

$$R(\lambda) = 1/NEP\,(\lambda)$$

where

$S(\lambda)$ = constant for a given transducer in cm²

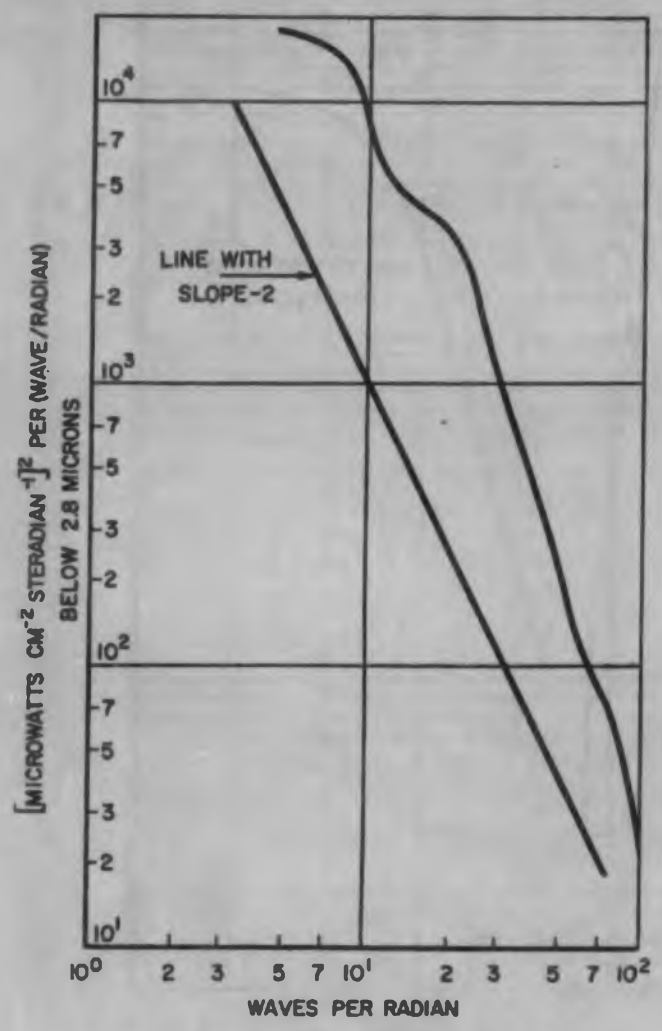

Fig. 4. Average power density for clouds.

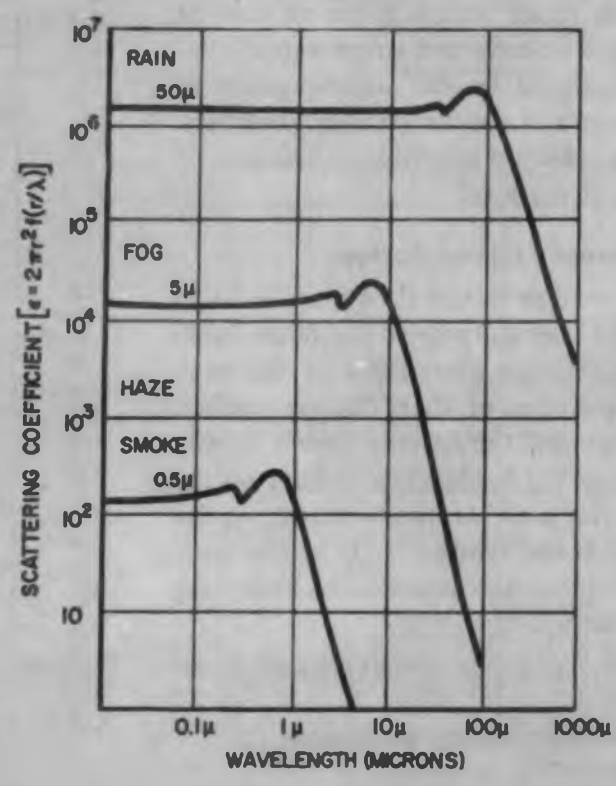

Fig. 5. Scattering coefficients for various particles.

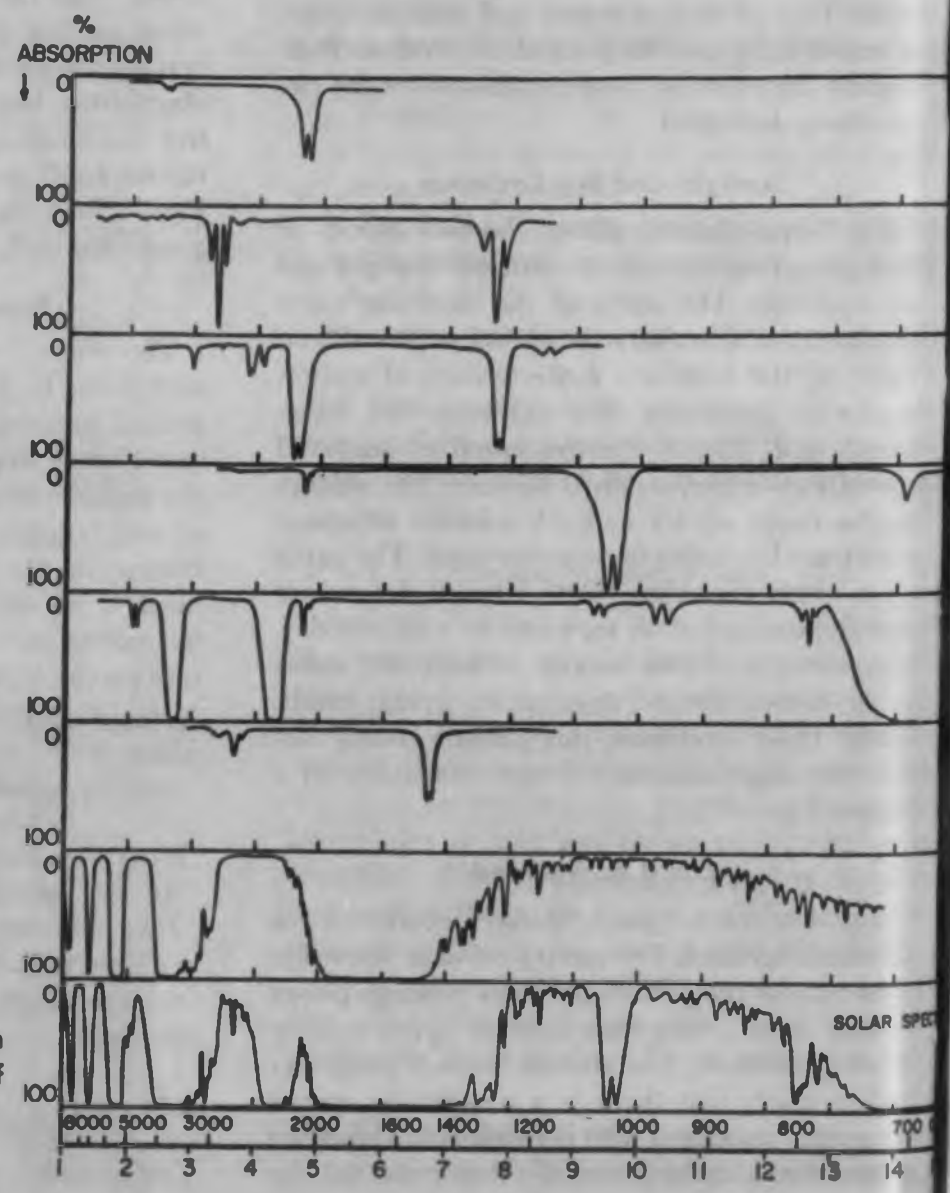

Fig. 6. Near-infrared solar spectrum (bottom curve). Other curves are laboratory spectra of the molecules indicated.

A_d = sensitive area of the transducer
Δf = passband in cps
f = modulation frequency in cps

Transducer Time Constant

An equally important parameter involved in the specification of an infrared transducer is the time constant of that transducer. By definition, the time constant is the time in seconds that it takes for the output voltage to reach 0.7 (−3 db) of maximum after a step input irradiance. Similarly, a critical frequency is reached, as the modulation frequency is raised, when the output voltage falls to −3 db below maximum. This is the optimum modulation frequency for those tranducers exhibiting a single time constant and is related to the time constant by $f_c = 1/2\,\pi\,\tau$, where τ is the time constant in seconds.

Most systems are designed around this critical frequency or time constant limit by setting the dwell time, or time per instantaneous field of view in the case of a search set, equal to the time constant. The general case for responsivity as a function of frequency is found from the transfer function of an *R-C* circuit:

$$R = R_{max}\,[1 + (2\pi f_c\,\tau)^2]^{-1/2}$$

The dwell time, t_d, instantaneous field of view, ω, total field of view, Ω, are related to the scan time, t_f, as follows:

$$t_d = t_f{}^{n\omega/(1+\gamma)\Omega}$$

where

$NEI = [1 + (2\pi f_c\,t_d)^2]^{1/2}\,(S/N)\,A_o{}^{-1}$
n = number of transducer elements
ω = instantaneous field per element in steradians
Ω = total field of view in steradians
γ = scan redundancy factor
t_f = time per complete scan in seconds

Experience has shown that signal to noise is maximum when the passband and dwell time of the video pulse are related as follows:

$$\Delta f(t_d) = 1.2$$

With these internal systems factors in mind, it is then possible to write the relationship

$$\int_{\lambda_1}^{\lambda_2} NEP(\lambda)\,\tau_o{}^{-1}\,(\lambda)\,d\lambda \quad (2)$$

where:
A_o = effective area of the collecting optics
S/N = peak signal to rms noise required to give the desired probability of detection and false alarm rate.

Practical Application

Using the procedure outlined in this article, the system designer can fix the parameters that enter into the problem of the remote detection of targets in the presence of background. There remain the problems of detail design to transform the specifications enumerated by these parameters into practical workable hardware. Equations 1 and 2 may be equated to solve for any one of the related factors. Two of the more common expressions are:

$$r = \left[A_T A_o\,(S/N)^{-1}\,[1 + (2\pi f_c t_d)^2]^{-1/2} \int_{\lambda_1}^{\lambda_2} N\,(\lambda) t_A\,(R, \lambda) t_o\,(\lambda) NEP^{-1}\,(\lambda) d\,\lambda \right]^{1/2}$$

for range, r in centimeters, or,

$$A_o = (S/N)\,[1 + (2\pi f_c\,t_d)^2]^{1/2}\,r^2\,A_T{}^{-1} \int_{\lambda_1}^{\lambda_2} NEP(\lambda) N^{-1}\,(\lambda) t_A{}^{-1}\,(R, \lambda) t_o{}^{-1}\,d\lambda$$

All of the preceding systems factors may be tabulated and organized for ease of calculation. A chart form may be easily devised for this purpose. ■ ■

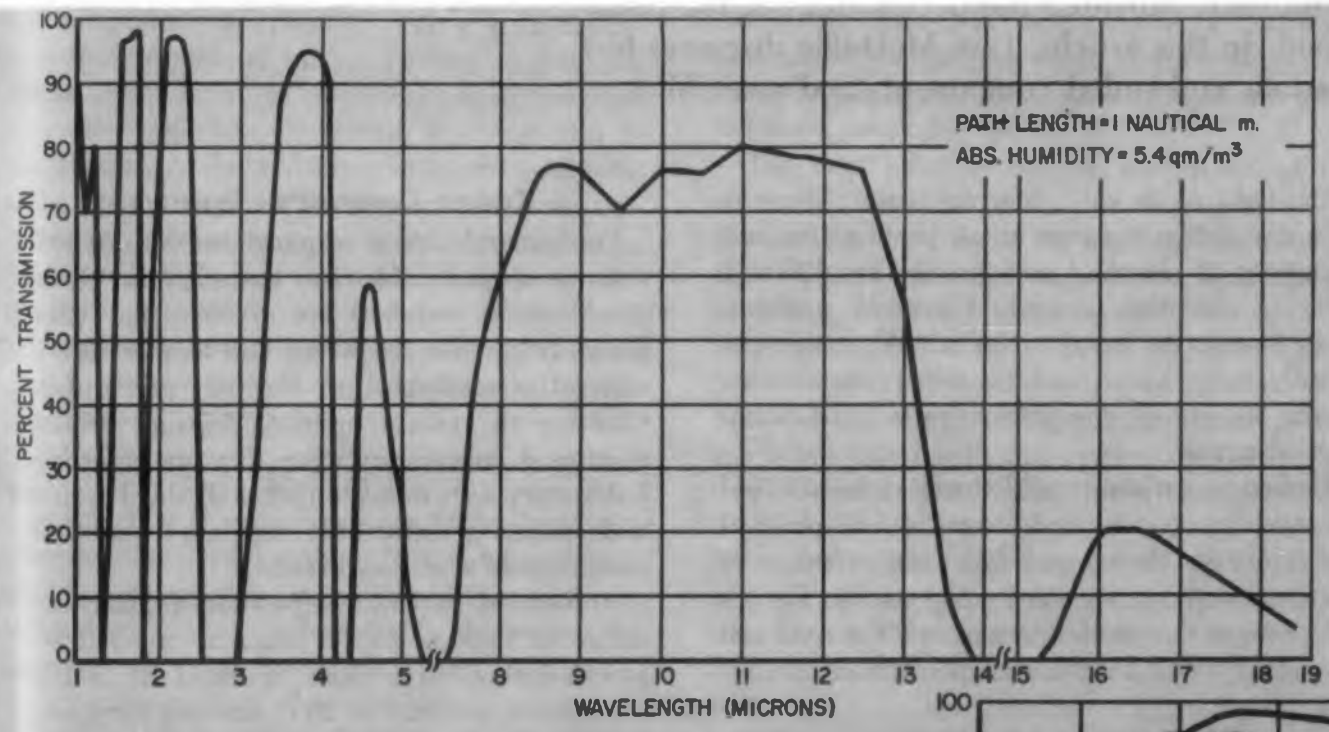

Fig. 7. Infrared atmospheric absorption at sea level.

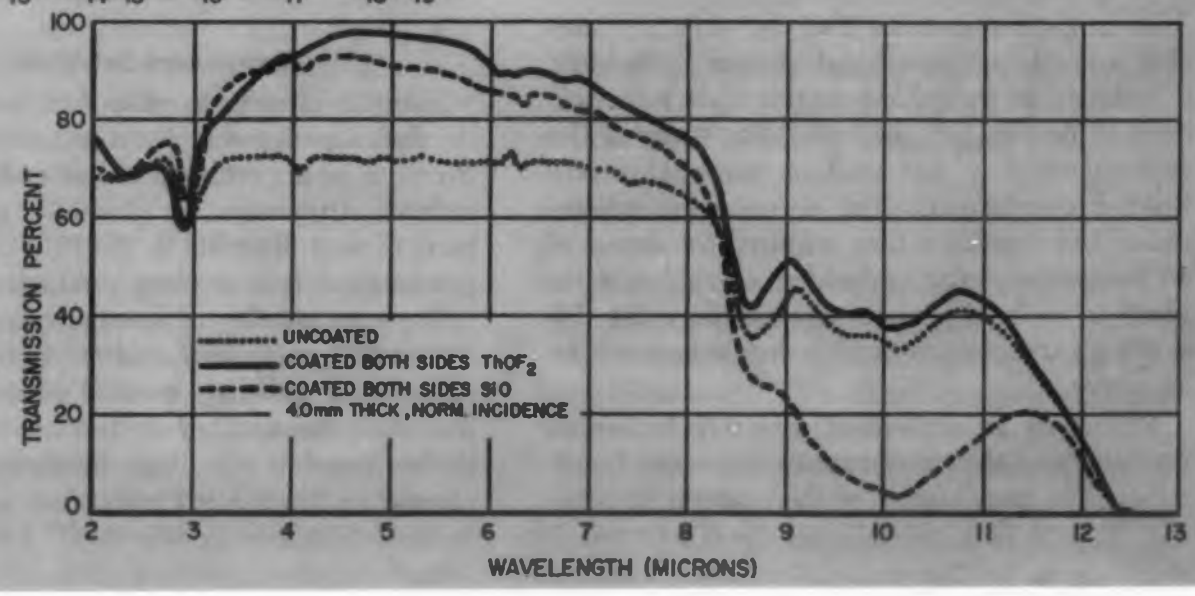

Fig. 8. Infrared transmission of arsenic trisulfide plate.

Fig. 1. How the 10 mc oscillator assembly was imbedded. Sample second from right shows thermocouple leads.

Embedment and Performance of Electronic Components

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Embedment of components offers the greatest support to increased reliability, provided the peculiarities of the resins are understood. In this article, Tom McDuffie discusses test results of various embedded components and assemblies.

PREDICTIONS of failure-rate for embedded electronic components do not conform with predictions which have been evolved for standard unembedded components. Differences in environments for the two types of components alter the criteria by which deterioration of a component is promoted. Remove the environment, and a different set of conditions effecting component deterioration will appear. Embedment virtually effects displacement of natural environments for electronic components, leaving heat as the prime source of destruction. This heat, in the absence of air and moisture, becomes less violent in its role as a destructive agent.

Investigations indicate that by utilizing suitable embedding resins and proper embedding techniques, an embedded electronic assembly will excel in performance and reliability many of the conventional low and medium powered unembedded counterparts. The decrease in maintenance and shutdown time required for repair of an equipment using embedded assemblies seem likely to overcompensate any necessity for discarding a complete assembly when it becomes inoperative.

Failure of an embedded assembly to sustain continued reliable performance can often be attributed to peculiarities of the embedding resin, in the light of its environmental usage. There is little correlation between these peculiarities and deviations of electrical performance for different types of electronic circuits. Electrical performances have been found to be related, more specifically, to the nature and functional requirements of the individual component parts of the embedded circuit.

Embedding resins should therefore be selected for stability of measured electrical and physical characteristics during and following exposure to adverse environments, since compensation for initial changes due to the presence of the resin can be accomplished by the design engineer.

Component Selection

Selection of suitable component parts to satisfy the design parameters of an embedded electronic circuit is an important phase of embedment procedures. Utilization of presently manufactured parts is most desirable in the light of economical procurement from existing production runs.

The compatibility of existing components with embedding resins are based on controlled studies of low and medium powered electronic circuits and components. They do not necessarily reflect the performance which may be encountered when other than the implied criteria are satisfied.

Carbon Composition Resistors

For general circuit applications, this type of resistor is preferable for embedment. Normal consideration required for conventional circuit design (e.g. noise, frequency and temperature coefficient of resistance) are the only prerequisites. Contrary to general opinion, derating of these resistors is unnecessary when they are embedded. Laboratory tests indicate that embedded resistors will outlast unembedded resistors even under conditions of severe overloads.

Embedded carbon composition resistors with values as high as 50,000 ohms at one-half watt power rating, have been operated at 600 per cent power overload at 25 C ambient for seventy hours. Other embedded resistors have been operated with overloads of 400 per cent in ambient temperatures from 100 C to 125 C for 90 hours.

The maximum changes in resistance during these investigations were approximately 15 per cent of nominal value as against open circuits which develop in unembedded resistors under similar conditions. These observations do not suggest the use of these components under such strenuous conditions; they are presented to support the contentions that derating of embedded carbon composition resistors under normal usage is not necessary.

Fixed Film Resistors

These resistors are equally suitable for embedment purposes where close resistance tolerances and stability are required. Electrical properties of these resistors are affected very little by the presence of the compound and the internal heat generated by embedded subminiature vacuum tubes. The necessity for derating film resistors under embedment has not been explored. However, they may be more susceptible to excessive temperatures than the composition variety. This supposition is based on variations in the method of fabrication of the resistance element, where the mobility (migration) of the resist deposit is in question.

Capacitors

No special procedures have been required for embedding any of the ceramic, mica or paper varieties of capacitors. Abnormal leakage currents of embedded paper capacitors have been observed when they were exposed to ambient temperatures of 150 C and higher. This condition is inherent to the dielectric of these capacitors and as such become critical when they are used as dc blocking components which work into a high-impedance load. Abnormal leakage current tends to decrease under aging at elevated temperatures but is never completely eliminated. It occurs also in unembedded mica and ceramic type capacitors[1] and is temporary in nature, since the insulation resistance returns to normal at room ambients. Under normally encountered equipment temperatures (85 C), conventional paper, mica, and ceramic capacitors are quite suitable for reliable circuit performance in embedded assembly applications.

RF Coils

In selecting these components for embedment, consideration must be given to the type of protective coating that is covering the winding. Molded type coils or uncoated coils are preferable, since it was found that certain other coatings react chemically with the embedding resin and inhibit "through-curing." Inductance and "Q" of coils are altered after embedment. Nevertheless, these changes can be closely predetermined by experimental embedment of the coil in the associated embedding resin prior to fabrication of the prototype circuit assembly.

Vacuum Tubes

This component is the part most sensitive to embedment. Variations in the degree of expansion and contraction of the vacuum tube and the resin invariably result in cracking of the tube. Precoating the vacuum tube with silicone resins was effective for counteracting the effects of shrinkage of the compound during the curing cycle. However, when the completed assembly was exposed to thermal shock, the majority of the embedded tubes would fracture. (Tube fracture can be ascertained by measurement of the tube's filament resistance: the value of resistance being related inversely to the degree of vacuum within the tube envelope).

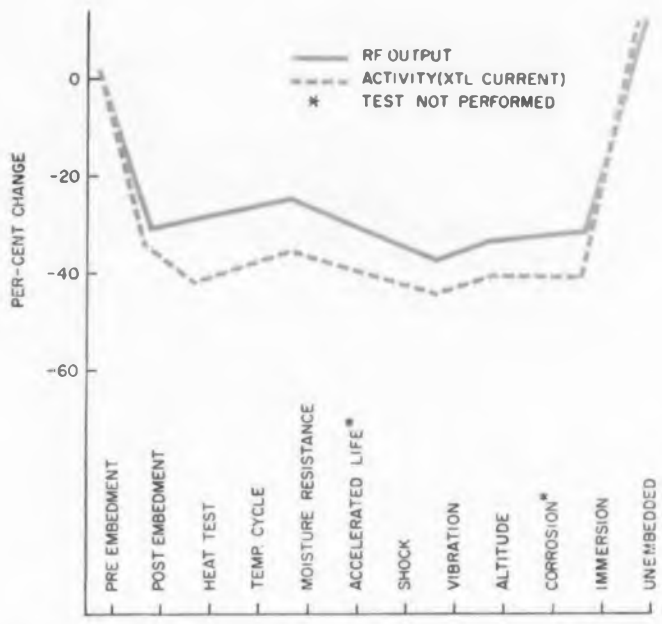

Fig. 2. Typical effects of embedment on 10 mc oscillator, effects of environment testing and final unembedded characteristics.

The most effective method for protecting the embedded vacuum tube was accomplished by pre-coating the tube with an Engelhard Industries' type CA-9R silicone cement. This cement provides excellent cushioning and maintains its resilience under a wide range of temperatures (manufacturer's thermal shock specification: —320 to 950 F). Ten type 5719 subminiature vacuum tubes precoated with this cement, and each embedded in an epoxy resin, survived exposure to the thermal shock test: method 102, condition C (modified at the high temperature to 95 C) of MIL-STD-202, while maintaining normal emission current. The method of coating these tubes involves a single dip of the tube into the cement whereas the degree of coating is controlled by the cohesive action of the compound and its adhesion to the tube envelope. Although double dips have been performed, the single dip appears equally effective for the temperatures involved.

Fabricating the Circuit

Embedded circuit assemblies are designed to perform a primary function such as: sine wave generator, pulse generator, audio amplifier, if or rf amplifier, etc. Whenever possible, all of the components of a functional circuit are included in a single embedment; with this technique, simplification of dynamic testing of each completed unit is achieved. Each unit is also made to be plugged into a suitable polarized socket to facilitate maintenance and repair of equipments in which they are utilized. Preference in component placement is given to location of the vacuum tubes; utilization of the subminiature type of tube is preferred in order to minimize space requirements.

Generally, it will be unnecessary to use hookup wire, since the leads of the components provide adequate lengths for electrical connections within the assembly. Where an interconnecting lead is required, solid bare or enameled covered wire or its equivalent is preferable. Where insulation of any lead is required, materials highly inert to chemical and thermal reactions should be used. It has been observed that vinyl insulation reacts with some compounds so that "through-curing" of the resin is inhibited.

Electrical connections are made with conventional resin-cored solder; assurance being made that the exothermic reaction of the embedding resin does not cause melting or undue softening of the solder. If the embedded assembly is to be exposed to temperatures above the melting point of conventional solder, the external pins of the mounting base should be sealed with high temperature solder to insure contact of the leads inserted within the pins. If solid pins are used, and connections to these pins are made within the embedded area, conventional solder is suitable since the cured resin will restrict its flow.

Selecting The Embedding Compound

Selection of a suitable embedding compound cannot be overstressed. Quite frequently it will be found necessary to consult with the materials engineer on peculiarities of a particular assembly requirement, lest the purpose of embedment is defeated. The major concerns of prospective users of embedding resins generally involve its thermal conductivity, stability of physical dimensions in the curing cycle, insolubility, and dissipation properties. Over-emphasis on the foregoing characteristics arises more from academic thinking than from empirical determinations of prevailing reactional phenomena.

Embedding compounds should be basically assessed for:

- Stability of electrical parameters
- Resistance to moisture
- Resistance to attack by chemical agents of deterioration
- Resistance to heat and thermal shock
- Resistance to mechanical stresses

Having obtained a resin which satisfies these basic requirements, the circuit designer must then determine the compatibility of the resin with the circuit components and their electrical functions: pour temperature, exothermic reaction, and curing temperature may react either singly or in combination to mutate the components of the em-

bedded circuit. The shape of the mold for the assembly depends on several factors and as such is left to the discretion of the design engineer. Care should be taken, however, to keep the components as far from the surface of the embedment as possible, in order to retain the strength of the resin.

Effects of Embedment

Three prototype assemblies were used in a study of the effects of embedding resins on the performance of each circuit. These circuits were chosen in order that some concepts may be evolved regarding the effects of resins on representative circuits which are found in presently designed electronic equipments. Four Epoxy resins and three polyester resins were used to embed the assemblies for this study.

A ten-megacycle crystal controlled oscillator was tested to reveal effects of resins on high-frequency circuits (Fig. 1). Electrical measurements made prior to and following embedment of this circuit revealed changes in operating parameters which were fairly uniform for each of the resins employed. As expected, the amplitude of the generated rf voltage decreased subsequent to embedment. The magnitude of this reduced output (Fig. 2) was found predictable and satisfactory as an electrical function.

An Eccles-Jordan type bi-stable multivibrator, similar to designs used in computer applications, was checked in the same manner. The performance of this circuit is dependent on the maintenance of close tolerances on the embodied components of the system. Important parameters of the circuit are: pulse width, pulse rise-time, and capable switching rate of the system. Embedment of this circuit produced negligible effects on the aforementioned electrical parameters. Decreases in the minimum and maximum plate supply voltages by which the units could operate were observed. However, these changes never encroached upon the design-center value for the circuit.

A trigger amplifier circuit, similar to one used in the Navy type AN/PDR Radiac set, was also tested. This circuit is used to convert input pulses of variable amplitude and duration to output pulses of constant amplitude and duration. Included is an electronic voltage regulator which compensates for aging of the B+ supply battery. Embedment of these units (Fig. 3) was of little consequence to changes in the electrical functions which were measured prior to embedment.

Fig. 3. Imbedded trigger amplifier assembly showing density and placement of components.

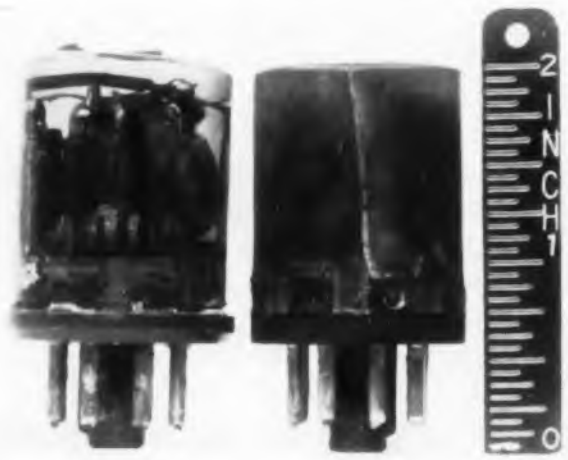

Fig. 4. Accelerated life test was performed on the samples of two different resins. Components were not damaged.

Environmental Testing

Embedment of electronic circuit components is intended to provide protection against humid ambients, corrosive and fungus attack, and mechanical shock. In order to benefit fully from the embedment, the circuit must be highly reliable and free from the necessity of maintenance and repair. It is apparent that embedded components react differently than unembedded components when exposed to chemical and physical agents of deterioration. The deleterious effects of moisture on circuit components are known to be influenced by temperatures of the environment. Deterioration of components is also known to be accelerated by other environmental agents. A practical solution is to establish procedures whereby simulated environmental studies may be performed on functional embedded assembly circuits. This approach will reveal effects from which some ideas may be formulated for the proper use of embedment techniques.

Table 1 outlines procedures which were used for evaluating these embedded assemblies. It will be noted that each assembly is energized in every test where feasible; the purpose being to simulate as closely as possible, actual field usage of the units. Laboratory data reveal this approach to be the most reliable method for assessing the quality of an embedding resin and the reliability of its associated circuit elements.

Two of the seven resins used in this study were found to meet the environmental test requirements of Table 1. Stability of the electrical and physical characteristics of these two resins, and the degree of protection they provided for the embedded components, were evident by the acceptable performance of each assembly during and following exposure to each of the environmental tests. The remaining five resins were found unsuitable for embedment purposes after the assemblies, on which they were used, failed to meet the specified test requirements. Although the initial characteristics for each of these resins were found acceptable, the lack of stability of these characteristics under adverse environments

Table 1
Environmental Test Requirements

Test	Procedure	Comment
Heat Test	Exposed to 85 C ambient for 24 Hrs.	Energized
Moisture Resistance	Method 106 of MIL-STD-202A	Energized
Altitude	½ inch of mercury for 1 hour	Energized
Corrosion	50 hours per MIL SPEC QQ-M-151A	Unenergized
Shock	400g at ¾ millisecond duration, (6 blows)	Energized
Vibration	Method 201, MIL-STD-202A	Energized
Immersion	Method 104, Condition A, MIL-STD-202A	Unenergized
Accelerated Life	Para. 4.5.13, MIL-E-16400	.....
Temperature Cycle	Thermal Shock Method 107, Condition A, MIL-STD-202A	Operated in final cycle

rendered them useless for embedment.

Peculiarities associated with unacceptable resins illustrate precaution which must be taken in order to avoid selection of other resins which may react similarly when placed in actual field usage. One factor which accelerated changes in the characteristics of these resins was found to be the generation of heat internal to the compound. Some of the resins were found to have physical characteristics whose stabilities are dependent upon whether the embedded circuits were energized or unenergized during an environmental exposure; cracking or softening of the resin being affected thereby. Another conclusion evolved from environmental testing of these assemblies is that internal heat accelerates the absorption of moisture in approximately four times greater in an energized state for the first 24 hours of exposure, this rate of absorption tapering off to comparable rates for unenergized units.

Heat and Moisture Problems

A more aggravated condition of resin deterioration occurs if the input power of the energized units is cycled as required in the accelerated life test (Test 8, Table 1). Variations of input power apparently increase the effective breathing of the resin and readily reveal its resistance to the combined effects of heat and moisture. It was also established that this phenomenon predicates the source of heat originating from within the assembly; exposing unenergized assemblies (at equal humidities does not produce similar results[2].

Changes in volume resistance of the resins in the presence of moisture was another factor which influenced the operation of some of the assemblies. There appears to be little correlation between the moisture absorption rate and the volume resistance change among the resins. With some resins, it was found that a small percentage of absorbed moisture effected a much larger percentage of moisture. The change in volume resistance had the effect of increasing the dissipation factor of the resin and effectively altering the performance of the embedded circuit. It is possible that this phenomenon is due to hydrolytic action or dissolution of the resin. If this is true, then the low moisture absorption characteristic, which is determined by per-cent of weight increase, may be a false value resulting from the countereffect of loss in weight through hydrolysis or dissolution of the resin. This point, however, remains to be proved.

Structural stability of each resin was best revealed by the thermal shock test (Test 9, Table 1). Two of the unacceptable resins invariably cracked when exposed to the temperature of this test. Precluding the vacuum tube, the embedded components were unaffected in spite of the structural failure of these resins.

Supplementary Investigations

The resins of two of the 10 mc oscillator assemblies were successfully disintegrated without incurring physical damage to the embedded components, Fig. 4. Operation of these two units following unembedment revealed conclusively that changes in the electrical performance of each unit are due mainly to changes in the electrical characteristics of the embedding resin, and not to changes in electrical values of the embedded components (Fig. 2).

Four of the bistable multivibrators have operated over 15,000 hours under life test, and to the present time have shown negligible changes in electrical functions. The internal temperature of these assemblies is approximately 85 C as indicated by embedded thermocouple elements.

Five samples of the trigger amplifier assembly were stored in ambient temperatures from 100 C through 150 C for a combined total of 54 hours without incurring changes in normal operating characteristics. Short time exposure at 240 C produced fissures in the resins of four of the five samples; subsequent operations of the units revealed no deleterious effects to the embedded components except for a cracked vacuum tube in one of the voltage regulator circuits. Following this exposure, the remaining unfissured assembly was successfully operated in ambient temperatures from 100 C through 200 C (24 hours at 200 C) for a combined total of 52 hours.

A prototype embedded audio amplifier assembly was also operated in an ambient temperature of 175 C for 240 continuous hours; the only change observed was a slight loss in gain at the high frequency end of the response spectrum. This was attributed to changes in the characteristics of the resin, since separate measurement of component parameters revealed ineffectual deviations from nominal values.

None of the components of either of these assemblies possesses high-temperature design. They were obtained from stock and were rated at 85 C ambients. ■ ■

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Acknowledgements

Acknowledgement is made to Messrs. Michael Pizzino and Phil Randino of the Materials Engineering section, whose cooperation and interest have contributed to the success of this study. Thanks are due to Messrs. George C. Neuschaefer, Albin M. Snadyc and Murray Silverman, of Electronic Components, Communications and Acoustics Branch, for their constructive criticism of this article.

Acoustic Noise . . . Its Effects on Components

Electronic components in today's guided missiles are subject to severe dynamic environments during missile flight. One of the environments that can affect the component's performance is high-intensity acoustic noise. Merwin Anderson, section chief, reliability, at Avco, describes tests and discusses effects of acoustic noise on shock-mounted, rigidly mounted and foam-potted components.

ACOUSTIC testing facilities utilizing electromagnetic loudspeakers are capable of simulating the noise environments experienced by components in rocket powered missiles. Extremely high reliability is required for missile systems. Therefore, components, assemblies, and complete missile systems should be evaluated with this type of laboratory equipment to prove that acoustic noise environments will not affect the operation of the missile.

A typical test facility is a progressive wave tube (Fig. 1). In this facility, the acoustic energy, or sound wave produced by the loudspeakers, progresses down a long tube past the test specimen and is absorbed at the end. An exponential horn is used to couple the noise from the low frequency loudspeaker to the tube. A midrange or high frequency unit is mounted in the opening of the exponential horn where it joins the progressive wave tube so that the two loudspeakers form a coaxial drive unit for the facility.

The progressive wave tubes are used for testing small parts and assemblies because the noise in this type of facility is well defined with either sinusoidal or random excitation. It is an excellent facility for performing development tests since the angle of incidence of the noise can be specified for one or more axes of the component. Progressive wave tubes are less practical for testing large specimens because of the large amount of power required to produce the desired noise levels.

Large specimens are tested in reverberant or enclosed chambers (Fig. 2) which are more efficient than progressive wave tubes with respect to sound pressure levels produced for a specific amount of power input. The angle of incidence of the noise in this type of facility is random. However, many of the internal parts of a missile will be mounted in an enclosed compartment bounded by the missile's external structure and the bulkheads; therefore, the internal acoustic noise environment will be similar to the noise produced in a reverberant chamber.

A practical and economical laboratory arrangement for performing acoustic noise tests would include an 18 in. diameter progressive wave tube and a 200 cu ft reverberant chamber. The progressive wave facility can be used to perform development tests on components and small assemblies (less

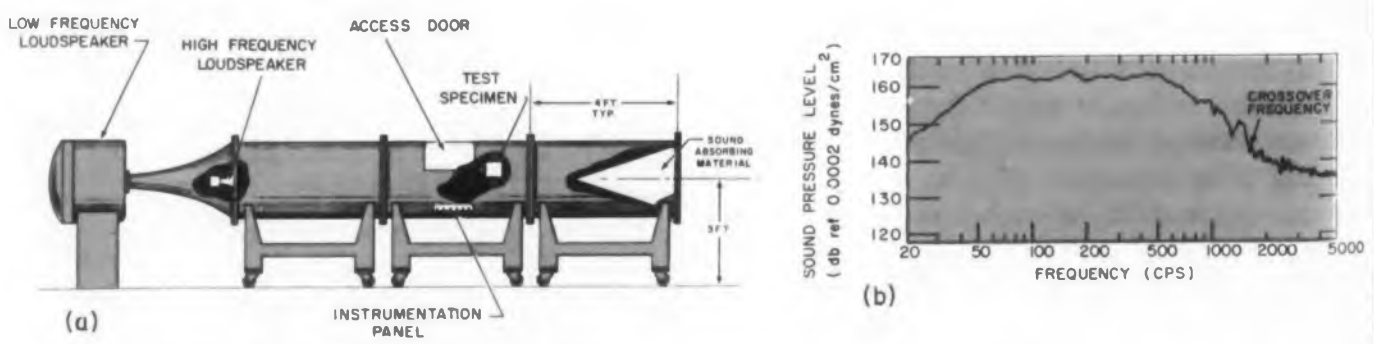


Fig. 1. Typical test installation using progressive wave tube (*a*). Frequency response curve (*b*) of the Avco loudspeaker and on Altec-Lansing speaker in a 10-in. dia tube. Maximum sound pressure level of 163 db is developed with 1000 w of acoustical power available.

than 100 sq in. cross-sectional area) to determine the behavior of the individual components in acoustic noise environments. The reverberant chamber can be used to perform qualification and acceptance tests on large assemblies, and complete systems (less than 27 cu ft in volume) to demonstrate that the systems will operate properly in acoustic noise environments.

With these two chambers, it is possible to satisfy requirements for testing the internal components and systems of most missiles. Sound pressure levels from 152 to 155 db at frequencies to 10,000 cps can be produced in the chambers and the cost of the complete facility including both chambers is less than a 1500 g-lb vibration system.

Acoustic noise and mechanical vibration environments excite resonant frequencies to different levels. Since components will experience mechanical vibrations from the structure to which they are attached simultaneously with acoustic noise environments, the best simulation of dynamic environments experienced in flight would be a combined acoustic noise-mechanical vibration environment.

This combined environment could be produced by utilizing a mechanical exciter with the reverberant facility described in the preceding paragraph. The exciter can be oriented so as to vibrate in a horizontal plane and the reverberant chamber positioned so that the exciter head extends through one wall of the reverberant chamber. Test specimens may be mounted directly to the exciter or suspended in the reverberant chamber and vibrated through push rods by the exciter. With this arrangement it is possible to vibrate the specimens in each of three mutually perpendicular axes while simultaneously subjecting them to an acoustic noise environment.

Results of Tests

During the past two years, there has not been a single failure in our laboratory of small parts such as subminiature relays and transistors when the parts were tested independently in a 155 db progressive wave field with a frequency spectrum as shown in Fig. 1. Since this type of part has a small surface area and a high mass density, vibrations induced by the acoustic noise are at a relatively low level, and the parts are not affected by the noise environment.

Malfunctions have occurred in electronic and electromechanical devices such as dc gyroscopes, dc accelerometers, power supplies and switch assemblies during acoustic noise tests. Intermittent operation, noise and high ripple voltage, and changes in operating levels are some of the failures experienced with these components. A potentiometer wiper arm making intermittent contact with the potentiometer coil is a typical cause of the component's failure.

In many instances components that failed in acoustic noise environments were previously exposed to severe mechanical vibration tests without the failure occurring. This would be expected because of the difference in exciting forces between the two environments. Mechanical vibration is transmitted to the component through the mounting points. Any vibration isolation provided by shock mounts or structural members in the component would attenuate high-frequency excitations before they reached parts in the component.

Acoustic noise excites the component housing and each part in the component with a distributed force; the magnitude of the force is a function of the sound pressure level and the area of each part of the component. Vibration isolators that are effective for mechanical vibrations may be completely ineffective for acoustically induced vibrations.

Tests described in this article illustrate the effects of acoustic noise on a shock mounted component, and a foam potted component. Each of the components was evaluated in a 155 db acoustic noise environment and, for comparison, in a 5 g random vibration environment.

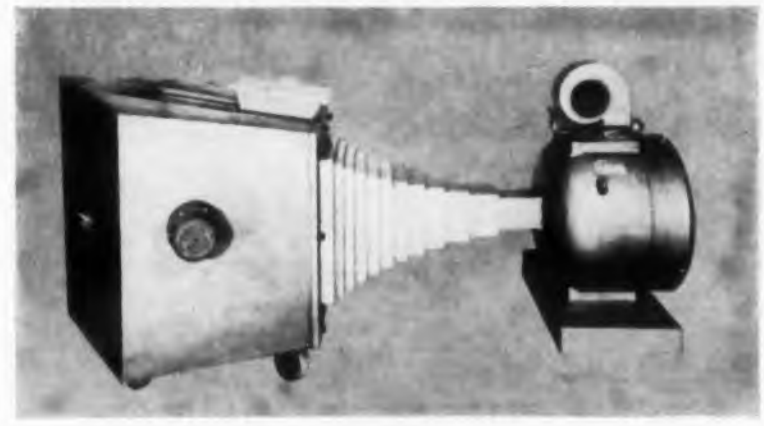
The acoustic noise tests were performed in the 8 cu-ft reverberation chamber and the noise spectrum was, as shown in Fig. 3, from 150 to 4000 cps. The frequency distribution of the mechanical vibration was essentially white from 20 to 2000 cps. All of the units evaluated were mounted on a cylindrical structure which simulated the internal structure of a missile.

During the acoustic noise tests, the cylindrical structure was suspended in a reverberation chamber and during the vibration tests the cylinder was mounted directly to an exciter. For each evaluation accelerometers were mounted on the cylinder in the vicinity of the assemblies. The vibration level at most points on the structural cylinder was approximately 5 g (rms) during the mechanical vibration test and between 1 and 3 g (rms) during the acoustic noise test.

Results of the tests are presented on a log-log paper to show up resonant points which would not appear significant on a semi-log graph. For the tests, the excitation was random and the data is one-third octave plotted at the center frequencies. It should be noted that on a one-third octave band curve, the same level of spectral density at higher frequencies is equivalent to a much higher overall vibration level than at the lower frequencies because the over-all g level in each band is equal to the square root of the product of spectral density and the bandwidth.

Baroswitch (Shock-Mounted)

The baroswitch consists of four altitude sensitive switches mounted in a 1.5 x 5 x 6-in. housing



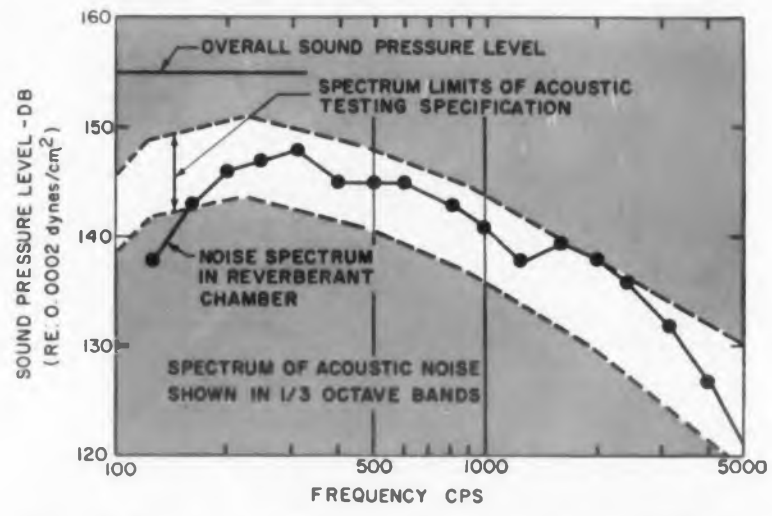


Fig. 2. Reverberant or enclosed chamber for testing large specimens (a). Noise spectrum produced (b) in this chamber is from 150 to 5000 cps.

which acts as a smoothing chamber for the pressure sensitive switches. The complete assembly, shown in Fig. 3, is shock mounted at three points.

As shown in the curve (Fig. 3) resulting from mechanical excitations, the natural frequency of the shock mounts is in the 200 cps frequency band and attenuation of the higher frequencies reduces the amplitude of the 1250 cps resonant frequency of the structure to a relatively low level.

The same resonant frequencies appear on the spectrum due to the acoustic excitation, however, the amplitudes developed at each resonance are very different. The component resonance at 1250 cps is the most predominant frequency component and the amplification of the shock mount resonance at 250 cps is at a relatively low level. The over-all rms vibration amplitudes due to the mechanical and acoustical excitation are 8.2 g and 27.5 g, respectively.

This data demonstrates the ineffectiveness of the shock mounts in an acoustic environment. Since the acoustic exciting force is applied directly to the structure, high-frequency resonances, which would be attenuated by the shock mounts in mechanical vibration environments, are excited to high amplitudes in acoustic environments. The most critical test for this component would consist of a combined vibration-acoustic noise environment since both the low-frequency resonance

Fig. 3. Baroswitch assembly tested and its response characteristics.

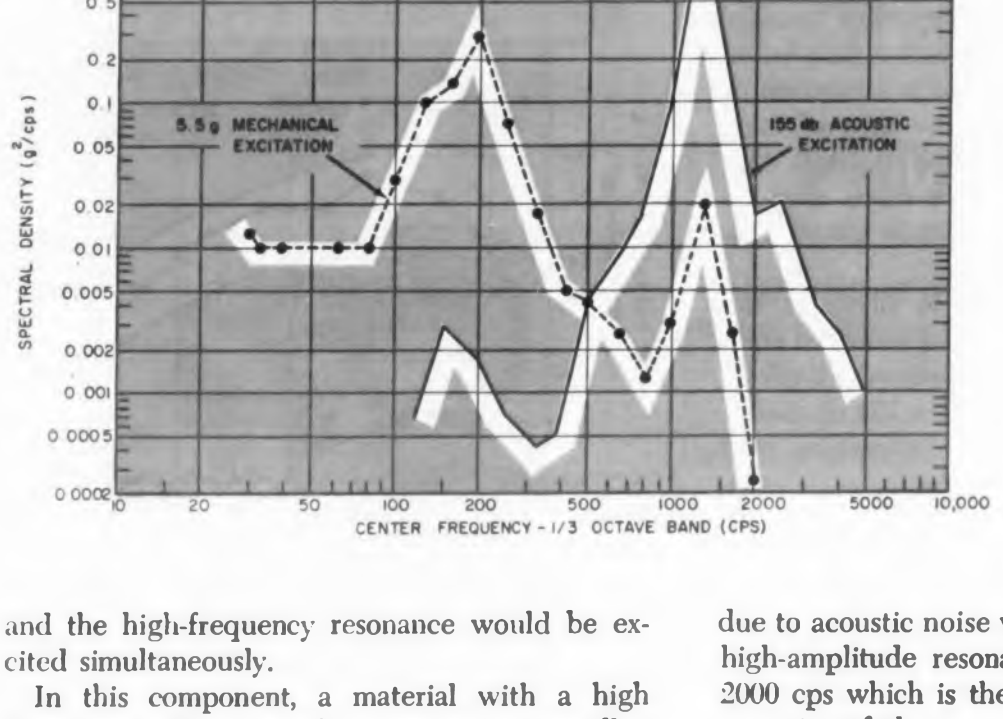
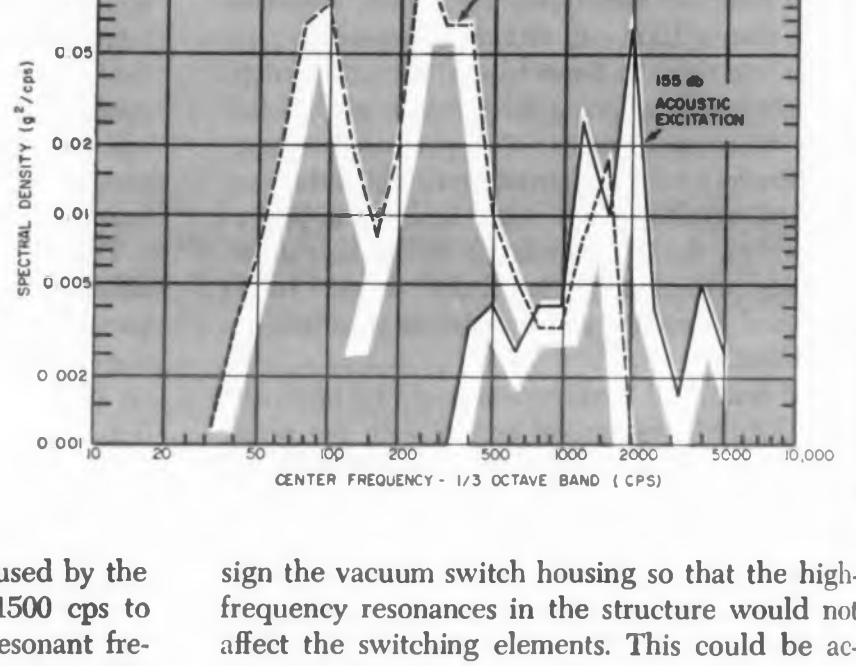


Fig. 4. Vacuum switch assembly with its test results.



and the high-frequency resonance would be excited simultaneously.

In this component, a material with a high damping coefficient such as a magnesium alloy should have been used to fabricate the housing in order to reduce the amplification factor associated with the high-frequency resonance. For the vibration isolators to be effective in the acoustic noise environments, they would have to be placed between the parts and the housing rather than between the housing and the structural member.

Vacuum Switch (Rigidly Mounted)

The vacuum switch assembly (Fig. 4) consists of two pressure sensitive elements mounted in a 3 x 4 x 5-in. housing which acts as a smoothing chamber for the switches. The complete assembly is rigidly mounted at four points to the internal structure of the missile.

The results, which are shown in Fig. 4, demonstrate the different effects of the acoustic and mechanical excitation on the housing. During the mechanical excitation, the major portion of the energy was concentrated at the lower frequencies, whereas with acoustic noise, there was very little excitation below 500 cps. A predominant resonance occurred in the 2000 cps range. The change in closure altitude of the switches was only 6000 feet due to the mechanical vibration. However, due to the acoustic noise environment the closure altitude changed 45,000 feet. The large change due to acoustic noise was probably caused by the high-amplitude resonances between 1500 cps to 2000 cps which is the range of the resonant frequencies of the pressure sensitive switches. The pressure fluctuations of the acoustic noise could also have affected the switches.

As in the previous case with the baroswitches, attenuation of the high-frequency excitation was present in the assembly structure when the vibration was applied at the base. However, the acoustic noise, which was applied at the housing, excited the high-frequency resonances leading to a large change in the operating point of the switches, which must be classified as a failure.

In this assembly, it would be necessary to redesign the vacuum switch housing so that the high-frequency resonances in the structure would not affect the switching elements. This could be accomplished by changing the resonant frequency of the housing so that it does not coincide with any critical frequencies of the switches, or by using a material for the housing which has a high damping coefficient like a magnesium alloy, or each switching element could be mounted in the housing with suitable vibration isolators.

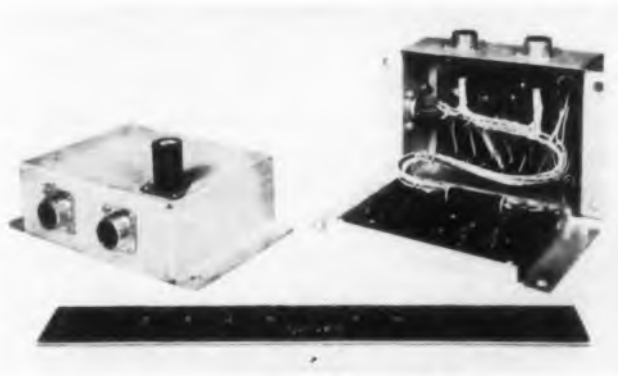


Fig. 5. Relay chassis tested showing mounting of parts before potting.

Relay Chassis (Foam Potted)

The relay chassis (Fig. 5) consists of thermal relays, and a sensitive relay mounted on printed circuit boards which are potted in the chassis. In addition, a time delay is mounted on the top of the sheet-metal chassis. The assembly is the control center for an operational missile system handling all the signals for the operation of the functional components in the system.

During the test program, the top plate of the chassis broke away from the potting compound resulting in high-amplitude vibrations. These vibrations caused the time delay relay to fail which resulted in the disqualification of the complete chassis. The remaining parts were unaffected by both the acoustic noise and mechanical vibration environments.

All the parts, except the time delay relay, were protected from acoustic noise as well as mechanical vibrations by the potting. The error in this

design was in placing the time delay relay on the chassis housing and the inability of the potting compound to adhere to the sheet metal plate. Since the time delay relay was a thermal type, the relay was not placed in the potting because it was necessary to dissipate heat from the relay housing. This thermal energy could have been dissipated by a suitable heat sink inside the chassis where the part would not have been subjected to the high-level vibrations of the top plate.

Recommendations

The majority of component failures due to acoustic noise environments are caused by the acoustically induced vibrations on the housing and structural members of the component. Small integral parts of the component such as transistors or subminiature relays experience vibrations well above the design levels that result in erratic operation of the component or failure of an electrical or mechanical connection. This type of failure is due to poor packaging of the component and/or poor design of the component structural members. In the design of electronic components which must function in acoustic noise and mechanical vibration environments, the following should be considered in order to minimize the effects of the environments:

- Component assemblies should be subminiaturized and made as small as possible.
- Materials that have high damping properties should be used for the major assembly structure and for supporting members and housings of the component assemblies. By doing this, the vibration level on small parts due to both mechanical vibration and acoustic noise environments would be minimized.
- Sandwiched printed circuit boards should be used in component assemblies. Conductors between terminals are subjected to much less stress on a sandwiched printed circuit board during vibration. Components mounted on the printed circuit board should be rigidly attached with an epoxy resin, or a suitable mechanical attachment.
- Vibration isolators utilized in components should be attached so that any resonance vibrations excited by acoustic noise will be attenuated by the isolators.
- Potting compounds should be used in the component if it is possible. The potting compound will reduce the intensity of the acoustic noise field inside a package and the assembly will be less susceptible to induced vibration.

If these items are considered during the design of an electronic component, the unit will be less susceptible to mechanically induced vibrations as well as acoustically induced vibrations. Failures that might occur in the laboratory or during flight will be "designed-out" of the component, resulting in a more reliable unit. ■ ■

Low Thermal Soldering Procedures For Copper Junctions

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Bruce K. Smith demonstrates his low-thermal soldering technique to engineers and technicians. Although he has always been vitally concerned with packaging and electromechanical problems, Mr. Smith is primarily known for his development of advanced digital techniques and magnetic amplifier design. He did all of the logical design of the FLAC and RADAC digital computers, and was project engineer on the UNIVAC and LARC programs.

LOW THERMAL soldering techniques can reduce undesired thermo-potentials generated in solder junctions between copper wires. Such voltages created are inconsequential in most electronic circuits because they are usually in the order of μv and will cancel one another in circuits whose junctions are at equal temperature. However, in low-level circuits, such as found in data systems for example, the numerous thermocouple voltages may not be completely self-cancelling and can seriously affect the accuracy of the low-level signals being monitored.

Reducing Thermo-Potentials

If the copper conductor from a resistor is joined to the copper of a circuit board by ordinary lead solder, the two junctions (copper-to-solder and solder-to-copper) may not be at the same temperature due to the fact that heat from the resistor flows through the connection. If the connection is at room temperature, but the drop across it is 1 C, the difference voltage will be about 3 μv.

The three factors which can be controlled to minimize this voltage are:

- The amount of heat passed through the junction. It is often possible to provide alternate paths for heat condition, such that the thermal "current" at the junction is only a fraction of the total flowing to or from a component.
- The resistance of the solder path at the junction. The temperature drop in a circuit is directly proportional to the thermal resistance of the circuit and may therefore be reduced by decreasing the length of the solder path or increasing the cross-section area of solder which is actually between the two conductors. This says, really, that the mechanical considerations which are ordinarily a part of good soldering technique have an additional significance in low thermal soldering in reducing the thermal gradient across the junction.
- The thermal electric potential of a copper-solder junction. Cadmium forms a thermocouple with copper which has only about one-tenth the output of a lead-copper junction. Consequently, the difference potential produced by a cadmium soldered joint will be lower than a lead solder joint for a given thermal gradient. A special solder is available for making low thermal connections. This consists of cadmium 70.44 per cent by weight and tin 29.56 per cent by weight. Note that this is a "thermal free" solder for copper wires, but is not necessarily useful for joining other metals.

Any of the procedures listed above may be sufficient for the requirements of a particular thermally sensitive connection. Part of the job of production engineering will be to find the way, or combination of ways, which does each job most economically. Until such times as procedures are more closely defined for each critical application, it will be assumed that any joint which is specified as thermally sensitive will be given all of the mechanical and metallurgical considerations noted in the section on production practice.

Poor Joint Invisible

Observation of these procedures is especially important, inasmuch as an improper joint will usually be visually indistinguishable from one which is proper, and expensive areas of circuitry may have to be discarded when the circuits are tested.

These procedures apply only to the soldering of bare copper parts to one another, or to copper parts which have been electrolytically plated with tin, cadmium, gold, or other protective metals. Engineering must specifically interpret a thermally sensitive junction when it applies to metals other than copper, or to copper parts which have been tinned by dipping.

Production Practices

Solder

- All low thermal soldering should be done with "thermal free solder," procured from Liston Becker or other approved source in 1/16th inch square wire stock.
- Immerse spare solder stock, i.e., that stored in the stockroom, in alcohol in a closely capped glass container. This is not required for solder in active line use, but the "open" supply should be minimized.

Flux

- The flux used must be pure resin mixed with sufficient isopropyl alcohol to form a free flowing fluid.

- Replace alcohol lost through evaporation as needed.
- Block resin and alcohol reserved for making flux should be carefully contained to avoid contamination.
- The flux mixture should be contained in non-metallic bottles, and used for no other purpose than low thermal soldering.
- Apply flux with a non-metallic applicator which is maintained free of contamination. Applicators which are integral to the flux bottle caps are ideal for this purpose.
- Flux bottles should be emptied, rinsed with alcohol, and replenished whenever the purity of their contents is suspect, or whenever three months have elapsed since their last cleaning.

Iron

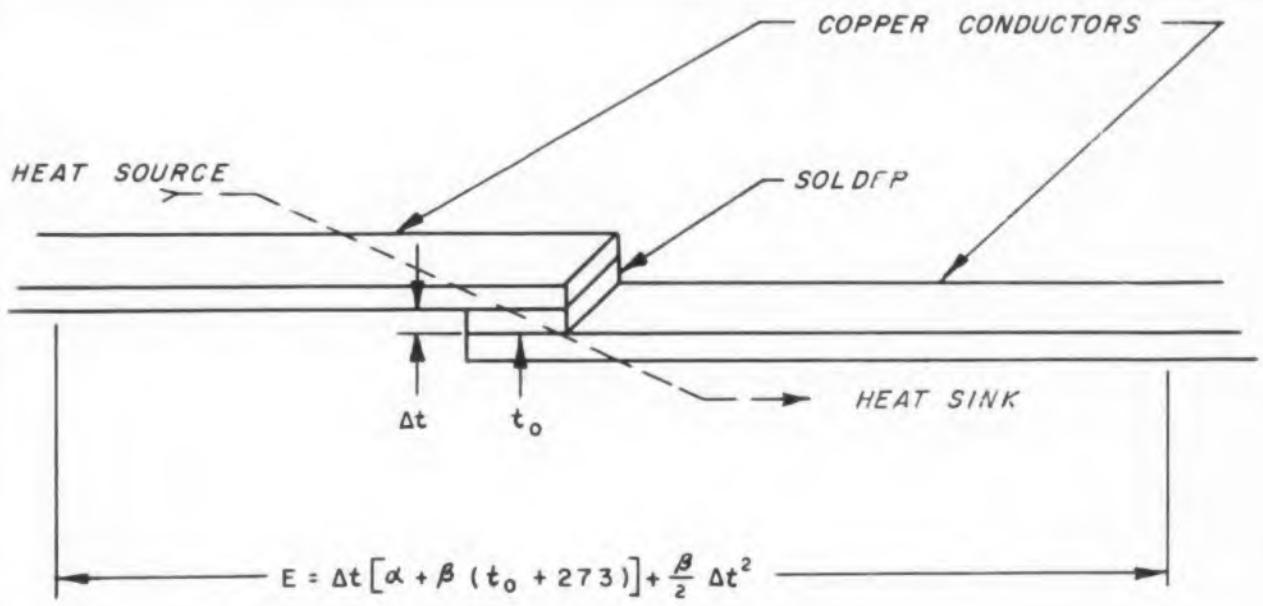
- Use only Weller 135 w soldering guns for low thermal soldering in production, and these should not be used for other purposes. If similar units are used elsewhere in the area for conventional soldering, those reserved for low thermal work should bear boldly distinguishing markings.
- The soldering tips used on the Weller irons should be plain copper with reinforced chisel tips, tinned with thermal free solder using the rosin flux. Tips which are purchased pre-tinned, or which are tinned by any other method are not acceptable.
- File and re-tin tips after each 15 minutes "on" time of the iron, or whenever the tips show obvious signs of contamination.

Wire Preparation

- The wires and/or terminals must be of pure copper, and must not have been tinned by any method other than electrolytic plating. Gold or silver plating is acceptable.
- The areas to be soldered should be free of grease and present a bright, uncorroded appearance. Filing and/or scraping may be required on old stock items.
- Tin the parts with "thermal free" solder before they are joined together. The procedure for tinning is:
- Brush part with rosin flux.
- Heat the part with the Weller iron until the part (not the iron) will melt solder.
- Flow solder evenly over the area of interest. Avoid excess solder.

Soldering

- Use tinned parts in production as soon as possible.
- Apply flux to the parts to be joined together.
- Wrap the wire around the terminal, lug, or joining wire; forming at least one complete turn.
- Crimp the connection, using long nose pliers, so that the parts to be soldered are firmly together, over as much area as possible.
- Heat with the Weller iron until the tinning melts and presents a bright appearance. Remove heat immediately.
- Do not use additional solder to form a low thermal connection.
- Paint the finished joint with green lacquer. ■ ■



Analysis of the thermocouple potential developed at the junction of a copper-to-solder-to-copper joint.

Fifteen different circuits can be built with this Erec-Tronic tube kit featuring Jiffy connectors and text type schematics. Transistor Kit is described on opposite page.

Today's Electronic Toys Helping Build Tomorrow's Engineers

Christmas counters this year are displaying many toys that teach electronics. In addition to the one-shot construction projects, there are some well-thought-out kits designed to encourage experimenting. The engineer-father who gives one of the "learn electronics" toys instead of a six-shooter may find that he's a bigger hero in his son's eyes than even Hopalong Cassidy.

ELECTRONIC TOYS today are not just boxed collections of surplus parts. They are, for the most part, kits designed to teach the curious child. They range from the relatively simple—radios and other one-project kits—to the complex—breadboards, with quick connect-disconnect leads, that can form the basis for a veritable junior experimental "laboratory."

Improvements, paralleling somewhat progress in the adult electronic world, are evident in many of the kits. Radio building sets have transistors and various kinds of tubes. Some inexpensive experimental kits still use Fahnstock clips, but the specially designed connect-disconnect leads are gaining in favor.

Which kit is best? It depends, of course, on the child who is to use it. An easy-to-build radio can be an excellent introduction to electronics for the youngster who is inexperienced. And since the project is completed once the set is built, it can also give him a feeling of achievement, which can be the springboard for further exploration in electronics.

For the child interested in challenge, there are a variety of experimental kits. A breadboard with a few components can give such a youngster a laboratory of his own, where his scientific abilities and interests can begin to flourish.

Following is a sampling of kits representative of each category.

Erec-Tronic Transistor Set

Instructive but easy to use, the No. 11051 Erec-Tronic Transistor Set comes with printed templates for four individual projects. The templates, which resemble actual schematics, are placed on a pegboard, and the youngster mounts the components in their designated spots. Electrical connections are made with Jiffy clips, which an inexperienced and not-so-strong hand will have no trouble using. Each template presents a more challenging circuit for the child to build. For each circuit, he mounts the components in different positions on the board.

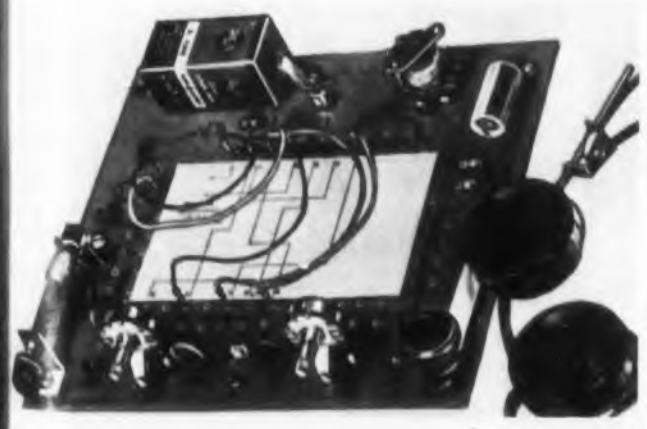
After a little practice, an apt youngster will want to put away the templates and repeat the circuit designs by himself. Finally he may try projects of his own—a good test of how much he has learned.

The instruction manual, which gives actual schematics and some simple theory, also shows how to test the components for failure. The kit includes a crystal diode, a 250-μμf capacitor, code-sending key, tuner, transistor, a one-and-a-half volt battery and 25 feet of antenna wire. Priced at about $10.98, the kit is made by A. C. Gilbert Co., which also offers, at somewhat higher prices, models with more components, connect-disconnect leads and a pegboard for mounting.

10-Circuit Transistor Lab Kit

Offering more complex projects, the 10-Circuit Transistor Lab Kit made by Knight-Kits, Allied Radio Corp., requires a little more work. The youngster first learns how to solder with the aid of an instruction manual. Once he has the components in their places around the edge of the board, he can build different circuits by changing the wiring. A printed diagram on the board shows where the wires go. Electrical connections are made with connect-disconnect leads.

The 20-page manual gives schematic diagrams,



Allied Radio Corp. experimental kit has wiring diagram to show how to interconnect fixed components.

an explanation of what each circuit does, and step-by-step instructions. Such projects as an am radio, broadcaster and electronic timer are possible with the kit. Two transistors, a battery and dual headphones that also serve as a microphone are provided. The kit sells for about $15.75.

12-In-1 Electronics Lab Kit

The 12-In-1 Electronics Lab Kit, also made by Knight Kit, is aimed at the beginner who is willing to put more time into his experimenting. It provides for building 12 different circuits and includes a 40-page book of instructions, diagrams and explanations. The components are soldered into place permanently, but the wiring must be resoldered for each new project. This kit sells at about $14.95.

7-In-1 Multi-Circuit Electronic Kit

The 7-In-1 Multi-Circuit Electronic Kit made by Educational Electronics offers seven projects and also needs soldering. Made to operate from a 110-volt outlet, the kit is said by the manufacturer to be safe to use. The price is about $15.95. Company also has simpler pre-wired kits.

Heathkit EK-1 Educational Kit

As a separate gift, or better still, with one of the experimental kits, the Heathkit EK-1 Educational Kit is a volt-ohm-milliammeter that first must be assembled, then can be used to measure voltage, resistance and current in circuits that the youngster has built. A detailed text-workbook is included. The kit sells for about $19.95.

Simple Crystal Radios

Selling at about $3, radio kits made by Aurora Plastics Corp. and Educational Electronics have crystal detectors and cat's whisker selection. Also made by Aurora, Model 1618 Crystal Diode Radio Kit uses a germanium diode and ball-type

Typical construction kit by Educational Electronics Company also makes simple experimental breadboards.

Crystal kit by Aurora for beginners. Company offers complete line of tube and transistor kits.

tuning. Included with the instructions in Aurora kits is a page of simple radio theory. Remco Industries also supplies a radio kit using a fixed crystal.

Radios With Transistors

Also offered are tube radios. Educational Electronics provides the No. 204 One-Tube Portable Radio Kit, pre-wired for building with screws. the list price is $12.98.

Aurora's one- and two-tube radios (No. 1617 and No. 1615) mount with screws, washers, and Fahnstock clips. Furnished with plastic cases, these sell for about $9.98 and $16.98, respectively.

Among the many transistor radios available is the Philmore TR9 Portable Transistor Battery Kit, which uses one transistor and a germanium diode. The radio is packaged in a transparent plastic case, which permits the child to recall visually how he put it together once it is completed. Connections are made with Fahnstock clips, and a printed template placed on the board shows where each part goes. This kit sells at about $9.75.

Made for very easy construction, the Remco Transistor Radio No. 107 sells at about $6.98. Components are placed directly in a plastic case and connected by color-coded wiring.

A complete line of transistor radio kits, with up to six transistors, is made by Superex. Prices range from about $5.75 to $25.95. The sets come in varying degrees of difficulty: some require soldering, and others are made more quickly with nuts, screws and washers. All have attractive cases and booklets with pictorial diagrams, schematics and step-by-step instructions.

The Lafayette KT-135 Explor-Air receiver kit covers from 550 kilocycles to 30 megacycles. This kit calls for soldering and includes a 110-volt, 50-to-60-cycles-per-second power supply. It sells for about $18.50. An instruction manual is furnished. Arkay offers a five-tube broadcast radio. ■ ■

New Wafer Modules . . . for versatile telemetering systems

WAFER-SHAPED telemetry components provide an unconventional, yet logical way of assembling a complete telemetry system. This new approach is inherently versatile and consequently more universal in application than standard mounting methods. Its cylindrical shape also facilitates mounting in small rockets or missiles.

Essentially, this wafer fm/fm telemetry system consists of a series of individual plug-in modules with integral connectors. The connectors contain common bus lines required for system interconnections. Designed by Vector Manufacturing Co., Inc., Southampton, Pa., the system is designated the XPS-26.

The standard approach for interconnecting individual plug-in components is based upon the use of a mounting assembly or mounting brackets. This approach has many severe limitations, notably the inability to readily expand or reduce an initial system design without replacement or addition of mounting assemblies or brackets as requirements change. In addition, interconnecting harness changes become a costly process. When replacement harnesses must be made, instruction book and wiring dia-

Complete cylindrical telemetry system, upper right, is made up of the wafer modules shown. Subcarrier oscillators can be readily added or removed as desired.

grams must also reflect these changes.

A typical airborne telemetry transmitting system consists of a number of subcarrier oscillators, voltage regulator, mixer amplifier and a transmitter. The number of subcarrier oscillators used in any one system is a function of the number of individual information functions which are telemetered and transmitted.

Since the subcarrier oscillators are identical in function, circuitry and size and are the basic building blocks for system integration, they proved to be readily adaptable for Vector's new design concept.

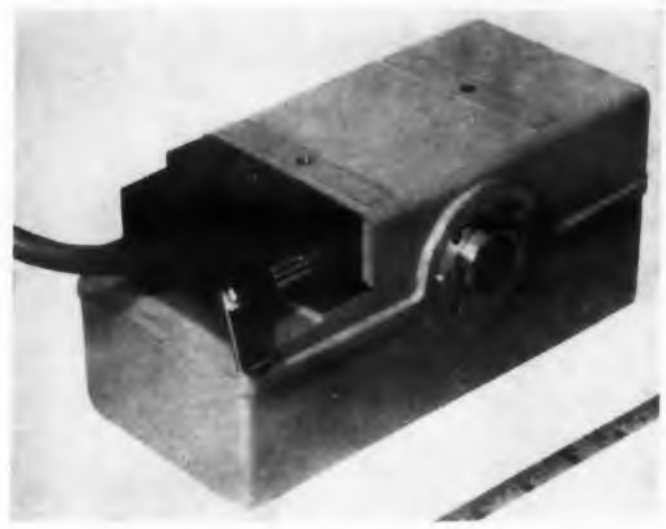
As shown in the photograph, the subcarrier oscillators were designed in a wafer-type form factor, 2.6 in. in diameter by 3/8 in. thick. Two floating connectors are provided, one on each face of the wafer, which have identical pin functions. One is a male and the other is a female. The center of the wafer contains a hub with 18 holes around the circumference of a master hole. Information input lead of each subcarrier oscillator is brought out through one hole in this center. The hub can be removed and the input lead can be fed through any one of eighteen holes. This feature enables any output lead to be rotated to another position to avoid interference with already occupied holes. Greater flexibility in assembly of a system is thus possible.

The common electrical connections to all of the subcarrier oscillators, such as B+, ground and the mixed signal output are contained in the two connectors which are jumped together internally. The only variable electronic function is the information input signal for each of the subcarrier oscillators. Since there are only a total of eighteen different subcarrier oscillator center frequencies available for use in any one system, each channel is assigned one hole which is used for feeding through the information input lead.

To assemble a system the oscillator wafers are strung together, like beads, by feeding the information leads through the matching holes in the adjacently stacked wafers. Mechanical interconnection is then accomplished by the mating of the floating connectors, the interlocking of the lip and shoulder provided on each wafer, and finally by three through bolts. The result is one rigidly assembled cylinder which conforms to the configuration of the smaller rockets.

The eighteen information leads are then terminated in a connector for accepting the information inputs. In order to increase or decrease the number of subcarrier channels, it is only necessary to unsolder the one master information input connector and either add or remove the required number of subcarrier oscillator wafers.

For further information on this Vector XPS-26 telemetry system, turn to the Reader-Service Card and circle **101.**



Heavy-Duty A/D Converter Memorizes Shaft Position

WITH ITS INPUT shaft rotating at up to 250 rpm, a new analog-digital converter, the Mem-O-Tizer, can read out a previous shaft position in the form of switch closures. Where very fast operation is not essential, this shaft-position encoder provides many advantages in addition to its memory feature.

Manufactured by the Automation Div. of Telechrome Manufacturing Corp., 26 Edison St., Amityville, N. Y., the Mem-O-Tizer was designed primarily for industrial environments. Hence, it should be rugged and reliable, if not particularly small and light.

Among its unusual features are:

- Memory of a previous shaft position.
- Low break-away torque requirement—as low as 0.003 in. oz.
- Direct operation of external equipment through one amp, 60 vdc contacts.
- Nonambiguity with any available output code.
- High resolution—to one part in almost 2.1 million.

These features result from the unusual design of the encoder. It has an integral input shaft and first stage code drum. Additional drums, as required, are geared to the first drum.

Each drum is composed of concentric cams, profiled with a series of high, intermediate, and low faces. Solenoid-operated sensors, each with a simple, posi-

tion-locking device, follow the drum profile and close high- or low-position switches.

Sensors are positioned, switches operated and locked into position, and the sensors retracted in 50 milliseconds—regardless of the duration of the read signal. A half-second duty cycle allows plenty of time to actuate external devices.

An electromechanical interlock eliminates readout ambiguity by locking a detent between the teeth of a gear ring on the perimeter of the first code drum.

Unless this detent is positively seated and locked, no readout can result; an incremental movement is required. This positive definition works in either direction of rotation of the bidirectional Mem-O-Tizer.

The input shaft drives the main drum through a lost-motion coupler. Hence, the detent can stop the drum for a reading, on command, while the input shaft keeps turning. When the drum is released, the spring-action coupler helps it catch up with the shaft.

No brushes or other electrical contacts are made or broken during rotation. Switch contacts close only when the drum is stopped to read; the input shaft need not be stopped.

The converter is available with a wide variety of output codes: decimal, binary, modified binary, binary decimal, or Grey, with five, six, seven, or eight bits. Through proper choice of output codes and number of coding drums, input information can be resolved to one part in 2,097,152.

For more information on this A/D, shaft position encoder, turn to the Reader-Service Card and circle **102.**

Touch of a feather overcomes the breakaway torque of this shaft position encoder with a memory.

Precision Thermistor Bridge Calibrates RF Generators at 1.000 Mw

COMPLETELY self-contained except for an external thermistor mount, the TB-2 thermistor bridge provides a precise calibration point for rf signal-generator output monitors. Using only dc for substituted power as well as bias power, the bridge provides 1.000 milliwatt of substituted output power.

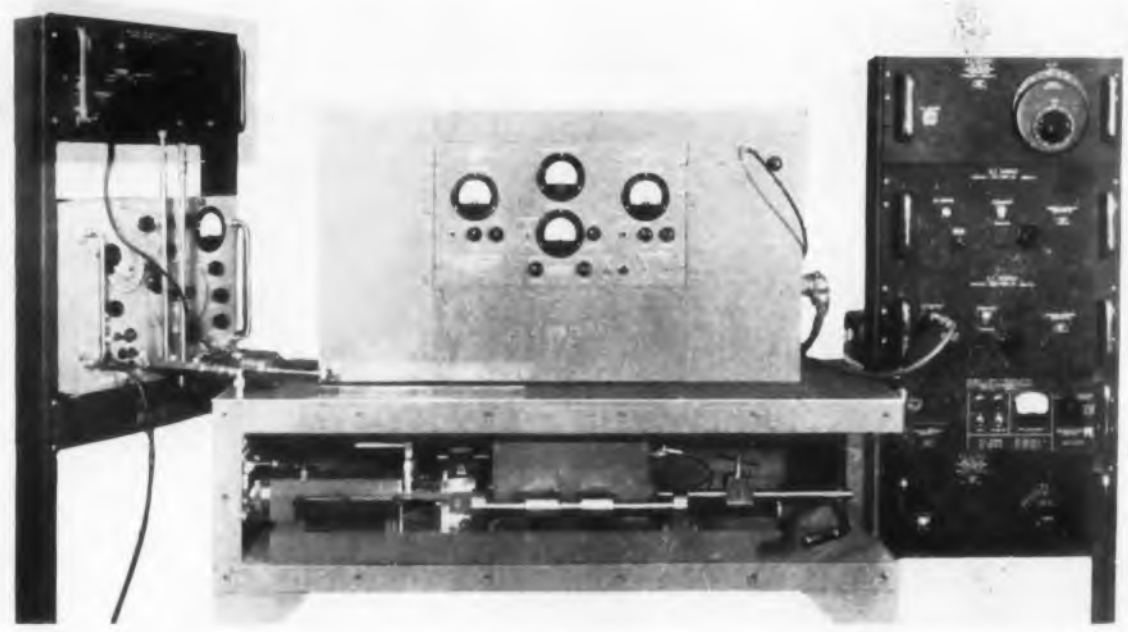
To provide this precision, the substituted dc power is accurate to within 0.1 per cent for thermistor mount temperatures from 18 to 28 deg C.

Manufactured by Weinschel Engineering, 10503 Metropolitan Ave., Kensington, Md., the bridge can serve as a companion instrument to relative rf voltmeters like the Weinschel VM-1A, which can directly calibrate output attenuators of signal generators from –15 to –87 dbm.

Though the TB-2 measures only at a fixed level of 1.000 mw of average rf, it can be used for higher power levels as well. Higher powers must be applied to the thermistor mount through precisely calibrated attenuators or directional couplers.

The bridge uses dc power for biasing the two thermistors in the mount so their series resistance is 200 ohms, as well as for substitution in the absence of rf.

Its single, self-contained pointer-



Thermistor bridge (upper left), in a typical application, calibrating the absolute output of one milliwatt of the signal generator beneath it. Centered in the photo is the VM-1A, used to calibrate the signal generator's output attenuator. Rf sources, at right, cover frequencies from 50 to 10,500 mc.

galvanometer, used as a null-detector, is the only indicator and measuring device required. After initial adjustment, its sensitivity can be varied in steps to provide sensitivities of 100 μw per division, 10 μw per division, and a maximum (uncalibrated) sensitivity of about 3 μw per division.

A self-contained standard cell serves as reference for all internal voltages. These are standardized by internal potentiometer adjustments, using the galvanometer as null detector.

In using the TB-2 thermistor bridges, the operator must know the calibration factor of the thermistor mount accurately. This factor is set on the direct-reading "calibration factor" dial to change the dc substitution power of the bridge. Then the bridge will be in balance for exactly 1.000 mw of incident rf.

Knowing the calibration factor is essential, as even very stable X-band waveguide mounts can have calibration factors as low as 0.81. Without correction, they can yield a 19-per-cent error.

To realize the full accuracy of the TB-2, the calibration factor of the mount should be obtained from the Electronic Calibration Center of the National Bureau of Standards.

NBS now provides this calibration for X-band waveguide at 9.0, 9.8, and 11.2 kmc to an absolute accuracy of 1.0 per cent. NBS has scheduled the extension of this service to other frequency ranges.

For more information on this precision thermistor bridge, turn to the Reader-Service Card and circle **500.**

NEW PRODUCTS

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

Slip Ring Assembly Measures 0.777 in. 535

This slip ring micro-capsule, for use in miniature stable platforms, contains 61 gold slip rings in a total length of 0.777 in. The diameter of the assembly is 0.248 in. Currents up to 400 ma can be adequately handled. Hi-pot ratings exceed 500 v and circuit to circuit resistance is 100 meg, minimum. The unit has Teflon insulated leads.

Rotary Devices Corp., Dept. ED, 40 Jay St., Englewood, N. J.

Time Delay Relay Weighs 1/2 Oz 536

Weighing 1/2 oz, the type E404 time delay relay has an operating temperature range of —65 to +85 C or ±125 C. The hermetically sealed unit has a voltage range of 18 to 32 v dc; it can operate up to an altitude of 150,000 ft. The maximum reset time is 10 μsec and the delay ranges from 0.1 to 10 sec. Output of the unit is spst, normally open. It will stand a shock of 100 g for 11 ±1 msec, and an acceleration of 100 g. It can be mounted in any position.

Wheaton Engineering Corp., Dept. ED, 920 Manchester Rd., Wheaton, Ill.

Tunnel Diodes Made Available For Engineering Evaluation 537

Twelve tunnel diodes designed for operation up to 1000 mc with power consumption ranging from 0.75 to 3 mw are now available for engineering evaluation purposes. Nominal peak or tunnel currents range from 1.8 to 6.8 ma. For maximum usefulness of the negative resistance characteristic, the ratio of peak current to minimum current is maintained in excess of 4.5 to 1. The diode consists of a pn junction 1/1000 of an inch in diameter and 80 A in width. This unit is mounted in a miniature ceramic case that has an inductance of 0.4 mμh.

Radio Corporation of America, Dept. ED, Commercial Engineering Dept., Semiconductor Div., Somerville, N.J.

Volume Of Subcarrier Oscillator Is 1.5 Cu In. 539

The model TOE-300 transistorized, voltage-controlled subcarrier oscillator has a volume of 1.5 cu in. It is applicable to FM/FM telemetering systems for missiles, space vehicles and aircraft. Total power required is 20 v dc at 5 ma; input ranges from 1 v total min. to 5 v total max. The input impedance is 100,000 ohms per volt. Temperature range is 25 to 85 C and it can stand ±25 g. Its stability is 1% and its linearity is 0.5%. The oscillator is available in all standard IRIG numbered and lettered bands.

Bendix Aviation Corp., Bendix–Pacific Div., Dept. ED, 11600 Sherman Way, North Hollywood, Calif.

Commutator Designed For PAM Systems 538

Designed for use in PAM systems, this 30 x 10, 2 pole telemetering commutator measures 2.5 in. sq by 4 in. long including a self-contained motor, gear box and switching section. Total weight of the unit is less than 1.5 lb. Displaying less than 0.3% noise levels with millivolt input signals, the life of the switch is in excess of 1000 hr. It is powered by a 400 cycle, single ac phase, 115 v motor. The complete unit is capable of meeting missile environmental conditions.

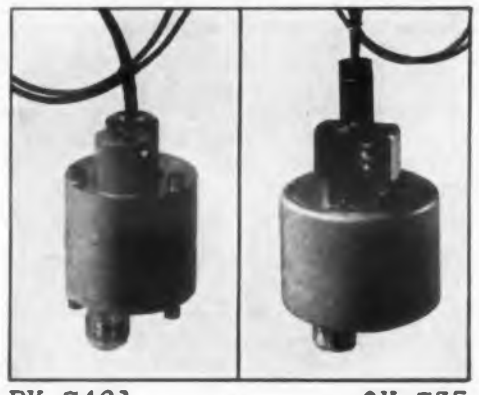
Instrument Development Laboratories, Inc., Dept. ED, 67 Mechanic St., Attleboro, Mass.

Creative Microwave Technology

Published by MICROWAVE AND POWER TUBE DIVISION, RAYTHEON COMPANY, WALTHAM 54, MASS., Vol. 1, No. 5

NEW RAYTHEON MICROWAVE TUBE DEVELOPMENTS

Miniature pulsed magnetrons for missile beacon applications are ruggedly constructed with integral magnets. The RK-7461 is tunable from 9,300 to 9,500 mc and has minimum peak power output of 60 watts. It is 1¼" in diameter and 2½" long, and weighs only 6 ounces.



RK-7461 QK-735

The QK-735 is tunable from 5,400 to 5,900 mc with minimum peak power output of 400 watts. 1½" in diameter and 3⅛" long, it weighs 8 ounces.

CIRCLE 771
Reader Service Card

* * *

permanent magnet, and can be mounted in any position.

CIRCLE 772
Reader Service Card

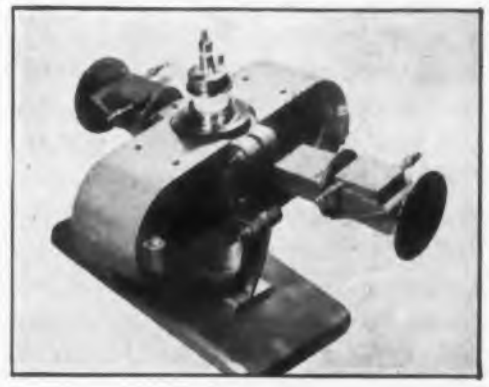
* * *

Small-signal gain of up to 35 db in microwave relay links is achieved by means of a new compact traveling wave tube amplifier -- the QK-542. This permanent-magnet focused CW tube has nominal saturated power output of 5 watts over 5,900 to 7,400 mc. An integral UG 344/U waveguide-type flange is supplied as standard. With an optional coaxial output coupler the QK-542 covers 4,000 to 8,000 mc.

CIRCLE 773
Reader Service Card

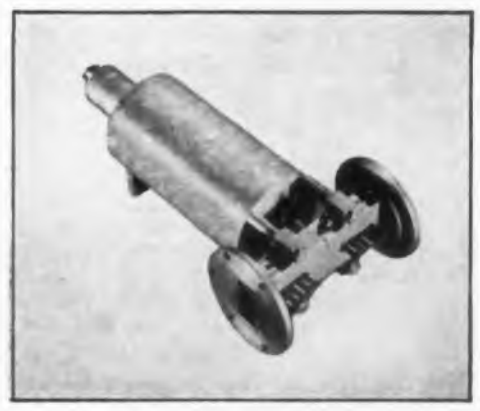
Ideal for linear accelerators and high-power radar systems. The QK-783 and QK-622 Amplitrons operate over the 2,700-2,900 mc and 2,900-3,100 mc bands, respectively, at a peak power of 3 megawatts and a typical efficiency of 75%. Because no heater is required, these tubes are capable of exceptionally long life. RF gain is 8 db under rated conditions, and as high as 12 db at lower peak power outputs. Phase pushing figure is less than 0.5 degrees for a 1% variation of anode current.

CIRCLE 774
Reader Service Card



* * *

Designed for electronic countermeasures and FM/CW operations, the QK-625 BWO provides a minimum CW power output of 180 watts and a nominal CW power output of 250 to 350 watts over the 2,500 to 3,000 mc band. The tube is voltage tunable over the entire range with tuning sensitivity of approximately 0.4 mc/volt. Liquid-cooled, the QK-625 BWO is equipped with an integral



Compiled as a Raytheon service to the field, new Consolidated Data Booklet contains comprehensive information about principal unclassified magnetrons, klystrons, backward wave oscillators and special purpose tubes manufactured by Raytheon. Characteristics presented include maximum ratings, typical operating values, band or frequency ranges and other essential data for microwave engineers and purchasing departments.

CIRCLE 775
Reader Service Card

A Leader in Creative Microwave Technology RAYTHEON

NEW PRODUCTS

Pulse Controllers 528

Adjust from 30 to 500 msec

Designed to extend or shorten the duration of an electrical impulse, models PC-600, PC-601, and PC-602 pulse controllers are all available in three ranges from 30 to 500 msec. Longer time periods are provided on special models. Other features are: an output pulse of up to 5 amp at 115 v ac, 15 msec recharging time, and 5 msec lag from start of input to start of output pulse. Typical uses are with counters and with hydraulic-pneumatic machinery.

Warco Industries, Inc., Dept. ED, 6625 Delmar Blvd., St. Louis, Mo.

Diode 532

For use at 1 to 12.4 kmc

Type 1N639 tripolar coaxial diode is a replacement for the 1N358 diode in microwave video receivers used in the frequency range of 1 to 12.4 kmc. The input impedance is 65 ohms, the figure of merit is 15, and the video impedance is 4500 to 18,000 ohms. The tangential signal sensitivity is —40 dbm min. The diode operates over the temperature range of —40 to +150 C.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.

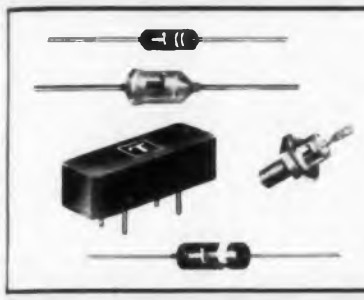
Mixer Diode 527

Noise figure is 6 db max

Type 1N21F silicon microwave mixer diode has an over-all receiver noise figure of 6 db max when measured with a 1.5-db, 30-mc if amplifier. Made for use with superheterodyne receivers at 100 to 4000 mc, the diode has a vswr of 1.3 max and if impedance limits of 350 to 450 ohms. Reversed polarity and matched pairs can be supplied. Applications include use in mixers following parametric preamplifier stages, vhf-uhf scatter communications, and navigational receivers.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.

SILICON REGULATORS AND REFERENCES



	Voltage Range (Volts)	Maximum Dynamic Resistance (ohms)	Maximum Current @ 25°C (ma)	Maximum Current @ 125°C (ma)	FEATURES
Subminiature — SV-5	4.3-5.4	55	50	10	• Long-term stability • Operation up to 150°C • Small size, easy mounting • Hermetically sealed
Miniature — SV-815	13.5-18	120	40	8	
Power — SV-924	20-27	8	55°C (amps)* .4	(ma)* 100	
Stabistor — SG-22	.64	40	150	25	
Reference — SV-3176	8-8.8	15	Temp. Coefficient ±.001%/°C		
Ref-Amp — 3N44	8.3-9.8		±.002%/°C		

*Case temperature ratings

Write for Bulletin TE-1352

SILICON CAPACITORS

	Ultra High Frequency Types — Ratings @ 25°C						FEATURES
	Cut-off Freq. (mc)	Capacity (μμf) @ V Max.	@ −0.1V	Q @ −4V @ 50Mc	@ 100Mc	Maximum Working Voltage	
SCH-51	5000	.35	2	100	50	10	• Subminiature Size • High Q • High Temperature Operation
SCH-52	5000	.8	4	100	50	7	

	High Frequency Types					
				Q @ −4V At 5mc	At 50mc	
SC-1		4.4	24	350	35	22
SC-5		25	120	350	35	11
SC-15		120	360	350	35	6

Write for Bulletin PB-45

GERMANIUM DIODES

Specifications and Ratings at 25°C		Forward Current @ +1V (ma)	Inverse Current at Specified Voltage (μa @ V)	Max. Oper. Voltage (volts)	Description
	JAN-1N270	200	100 @ −50	80	JAN TYPES
	JAN-1N277	100	250 @ −50 @ 75°C 75 @ −10	100	
	JAN-1N281	40	500 @ −50 30 @ −50	60	
	JAN-1N126	5	500 @ −50 30 @ −10	60	
	JAN-1N198	5	250 @ −50 @ 75°C 75 @ −10	50	
	1N283	200	20 @ −10	20	COMPUTER TYPES
	T16G	40	100 @ −50	60	
FEATURES • Milli Microsecond Switching • Superior Forward Conductance • High Inverse Resistance • Uniformity and Stability • Gold Bonded Construction	1N278	20	125 @ −50 @ 75°C	50	HI-TEMPERATURE TYPES
	T22G	40	20 @ −10 @ 75°C	15	
	T9G	100	20 @ −50 2 @ −10	60	HI-RESISTANCE TYPES
	1N67A	5	50 @ −50 5 @ −5	80	
	T8G	100	20 @ −100 5 @ −10	100	
	S570G	10	30 @ 6	Recovery Time .002 (μsec)	MILLI-MICROSECOND SWITCHING

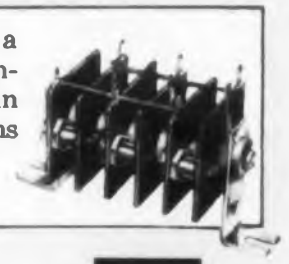
Write for Bulletin TE-1300 & TE-1319

GERMANIUM COMPUTER TRANSISTORS

	Minimum Current Gain (B)	Maximum Collector Voltage (volts)	Typical Cutoff Freq. (MC)	FEATURES
2N427	40	15	8	• High FrequencySwitching • Low Saturation Resistance • Uniform Input Characteristics
2N428	60	12	13	

Your local authorized TRANSITRON DISTRIBUTOR now carries in-stock inventories for immediate delivery.

Transitron's TD series of rectifier stacks offer a wide range of ratings in seven standard circuit configurations. High voltage cartridges, quads, plug-in assemblies, and many other special encapsulations are also available. Your inquiries are invited.
Write for Bulletin TE-1342.



Transitron
electronic corporation • wakefield, massachusetts

Frequency Meters 531

Ranges are 48 to 62 cps and 338 to 412 cps

For measuring frequencies normally used in power distribution, these frequency meters have ranges of 48 to 62 cps and 388 to 412 cps. Other ranges can be furnished. The meters consist of a converter, which translates input frequencies into dc signals, and an indicator, which uses the output of the converter to indicate corresponding frequencies on a linear scale. Input of the meter is 105 to 135 v ac of the frequency being measured; no auxiliary power is required. The temperature range is −65 to +130 F. Suitable for aircraft or missile support equipment, the meters meet Mil specs for shock and vibration.

Consolidated Controls Corp., Dept. ED, Bethel, Conn.

Metal Film Resistors 526

Range is to 2.5 meg.

These metal film resistors are available in 2-w units in semi- and full-cylindrical shapes with a range to 2.5 meg, and in a 0.25-w unit measuring 5/8 in. long and 15/64 in. in diam. Consisting of a thin film of metal alloy bonded to glass, these precision units have low reactance at high frequencies and operate in high ambient temperatures. They are sealed in a high temperature plastic case.

Ohmite Manufacturing Co., Dept. ED, 3655 W. Howard St., Skokie, Ill.

Grid Board 533

For prototype work

The Fotoceram grid board, designed for prototype work, is clad on both sides with copper that can be etched away as required. Components can be installed by hand or dip soldering. The 0.052-in. round holes are spaced 0.1 in. apart. The board is 1/16 in. thick and is offered in three sizes: 3 x 5, 6 x 8, 9 x 12 in.

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

◀ CIRCLE 48 ON READER-SERVICE CARD

NEW PRODUCTS

Metal Consoles 529

Come in modular units

These cabinet and desk assemblies come in the following modular types: single, double, or triple assemblies with short or full depth tabletops and with or without desk top control cabinets. A pedestal rack provides for panel mounting angles, shelves, detachable side panels, and other accessories. The units are suitable for housing electronic equipment. Formica tabletops are used.

Par-Metals Products Corp., Dept. ED, 32-62 49th St., Long Island City 3, N.Y.

Two-Circuit Switches 530

Life is 10,000,000 operations

Designed for use on machine tool limit and control mechanisms, series 3MN switches have a median mechanical life of over 10,000,000 operations at full overtravel. Three of these snap-action switches have a combined stacking width of 2.03 in. The arc-resistant plastic case allows extra space between the integral terminals to prevent shorting. A minimum of 0.08 overtravel is provided. The contact arrangement is single-pole two circuit, double-break. The switches are rated at 15 amp, for 120, 240, 480, or 600 v ac.

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

Laminated Plastic 523

Heat resistant

Type N-104-84-2 laminated plastic, made by impregnating graphite fabric with phenolic resin, is for use in missiles and in other applications requiring exceptional heat resistance. Available in sample quantities to companies having a DX-A2 Ballistic Missile Program priority, it comes in two forms: laminated 6-in. squares in thicknesses up to 0.5 in., and 3-in. diam cylindrical moldings, made from macerated impregnated fabric, in depths to 2 in.

Continental - Diamond Fibre Corp., Dept. ED, Newark, Del.

◀ CIRCLE 49 ON READER-SERVICE CARD

Photoconductive Cell 480

Handles to 100 v dc

The Mullard ORP11 cadmium sulphide photoconductive cell handles to 100 v dc and has maximum response in the red/infrared region. The temperature range is —40 to +70 C. At 10 v dc, 5 lumens per sq foot, and 2700 K, the average cell current is 6 ma and the minimum cell current is 3 ma.

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

Flow-Control Servo Valve 517

Weighs 9-½ oz

Weighing 9-1/2 oz, model 40 electromechanical, flow-control servo valve is for airborne applications. It can be used as a connecting link between the electrical system and the hydraulic system in rockets, missiles, and aircraft. It can also be used in test vehicles and other devices where electrical signals are converted to hydromechanical action. The unit has a rated flow to 5 gal per min at 1000 psi valve drop. The current rating is 8 ma and the power, 0.06 w. The maximum internal leakage is 0.09 gal per min and there is no external leakage. Linearity is ±3% and hysteresis is 2%.

Midwestern Instruments, Dept. ED, P.O. Box 7186, Tulsa, Okla.

NEW PRODUCTS

Gear Motor 522

Is 0.1 hp

Model 31R48R73 azimuth drive geared motor operates from 200 v ac, 400 cps, three-phase, and provides 0.1 hp. The motor speed of 11,000 rpm is geared down to 290 rpm continuous duty operation in accordance with MIL-N-969A. The unit is 2 in. in diam and 4 in. long.

Western Gear Corp., Electro Products Div., 132 W. Colorado Blvd., Pasadena, Calif.

Insulation Material 520

Flame-retardant

Type 225FR flame-retardant insulation material, using a cellulose base fiber, has a dielectric strength of up to 350 vpm when dry and to 200 vpm at 7% moisture content. The arc resistance is 75 to 100 sec. This material has a tensile strength of 17,000 psi lengthwise and 6000 psi crosswise. Standard thicknesses are 0.031, 0.062, 0.093, and 0.125 in.

Rogers Corp., Dept. ED, Rogers, Conn.

Nylon Film 524

Abrasion and vapor resistant

This nylon film is abrasion and vapor resistant and can be steam sterilized. It has a low coefficient of friction and a low permeability factor. Offered in thicknesses of 0.002 to 0.06 in., and in widths to 18 in., the sheets can be supplied in any length required.

U. S. Gasket Co., Dept. ED, Camden 1, N.J.

Zener Diodes 521

Have 5% tolerance

For such uses as high power voltage regulators, limiting and clipping devices, and over-voltage protective devices, these 35-w Zener diodes have a tolerance of 5% in single

◀ CIRCLE 51 ON READER-SERVICE CARD

units. Zener voltages are from 8.2 to 100 v at 500 or 50 ma, dynamic impedance is low, and breakdown is abrupt over the entire Zener voltage range. Matched coefficients of expansion and the diffused silicon junction provide resistance to vibration, plus thermal and mechanical shock. The units are reliable under adverse environmental conditions.

U. S. Semiconductor Products, Dept. ED, Phoenix, Ariz.

Bevel Gear Boxes 519

Shaft sizes are 1/8 to 1/4 in. in diam

Type BA-5 heavy-duty gear boxes come in a variety of configurations and in shaft sizes from 1/8 to 1/4 in. in diam. Ball bearings or oil-less bearings or both are available. Ratios are from 1:1 to 3:1. The units can have variable shaft outputs and inputs.

Pic Design Corp., Dept. ED, 477 Atlantic Ave., E. Rockaway, L.I., N.Y.

Servo Valves 525

Consist of two moving parts

Type 6103 electrohydraulic servo valve consists of only two moving parts, a spool and a sliding fork integral with the armature of a torque motor. The input power is 300 mw, the rated current is ±10 ma, and the dc coil resistance is 3000 ohms per coil. It operates over the temperature range of −65 to +275 F.

Kearfott Co., Inc., Dept. ED, 1500 Main Ave., Clifton, N.J.

Disc Capacitors 540

Have values from 3.3 μμf to 0.05 μf

For industrial use, the ID series of 500 wvdc disc capacitors are offered in 86 capacitance values ranging from 3.3 μμf to 0.05 μf. The size varies from 1/4 to 7/8 in. in diam.

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

CIRCLE 52 ON READER-SERVICE CARD ➤

NEW PRODUCTS

DC Tester and Sorter 518

Handles 4000 pieces per hr

Model AB-6-2 dc resistance tester and sorter can sort resistors into nine groups automatically at the rate of 4000 pieces per hr. The instrument has an accuracy of ±0.3% for 10 to 100 ohms, ±0.1% for 100 ohms to 2 meg, ±0.2% for 2 to 10 meg, and ±0.3% for 10 to 100 meg. A built-in seven-dial resistance decade is set to the nominal value of resistance being tested. Tolerance limits for the nine bins are set by means of plug-in units. Electromechanical counters tally the number of pieces in each bin.

Industrial Instruments Automation Corp., Dept. ED, 89 Commerce Rd., Cedar Grove, Essex County, N.J.

Speaker Cross-over Network 478

Measures 1-5/8 x 1-3/16 x 7/8 in.

Designed for use with two-speaker installations, type CN-8 crossover network measures 1-5/8 x 1-3/16 x 7/8 in. with two tabs for mounting. Insertion loss in the pass region is negligible. The unit may be used with 8 or 16-ohm tweeters and woofers.

Vidaire Electronics Manufacturing Corp., Dept. ED, 44 Church St., Baldwin, N.Y.

Strain Gages 481

Temperature range is −350 to +850 F

These temperature compensated strain gages operate over the range of −350 to +850 F. A platinum wire compensating element is contained in a prestabilized, strain sensing grid to minimize inaccuracies caused by rapidly changing temperatures and high thermal gradients. An external circuit permits adjustment of the temperature response characteristics of the gage. Model FNB-50-12E is sealed in a phenolic carrier and may be bonded with epoxy or phenolic cements. Model FNH-50-12E has a strippable backing and uses ceramic cement. Both units have a gage length of 0.5 in.

Baldwin-Lima-Hamilton Corp., Electronics and Instrumentation Div., Dept. ED, 42 Fourth Ave., Waltham 54, Mass.

Dynamic Rectifier Analyzer 486

Has to 20 amp dc forward current

For incoming inspection, on-line testing, and laboratory testing, model 141A dynamic rectifier analyzer has a forward current range of 0 to 1, 10, and 20 amp dc. The piv is 0 to 1000 v. The instrument measures a forward drop of 0 to 1/5 v and a reverse current range of 0, 0.05, 0.5, 5, and 50 ma. Forward current and reverse voltage controls are independently adjustable. An external oscilloscope provides for monitoring all four parameters. The power input is 120 v, 60 cps, 600 w. The unit measures 21.25 x 20 x 16 in., weighs 80 lb, and needs no auxiliiary equipment.

Wallson Associates, Inc., Dept. ED, 912-914 Westfield Ave., Elizabeth, N.J.

NEW PRODUCTS

Panel Meters 505

Movements range from 100 μa to 1 ma

These panel meters come in seven basic models, any of which can be modified to meet individual requirements. Movements range from 100 μa to 1 ma with zero left or zero center. Sizes are 1, 1.5, and 2 in. A slip-on metal grip is used in mounting; no brackets or bolts are needed. The units are made in Japan.

Mura Corp., Dept. ED, P.O. Box 224, Great Neck, L.I., N.Y.

Radiators 506

For power transistors and rectifiers

Able to radiate surfaces of 35 to 65 sq in., these heat radiators are for power transistors and rectifiers. They can be used for both convection and forced-air cooling. No insulating washer is required for most applications. Of compact, lightweight aluminum construction, they have a hard, anodized insulating finish. Aluminum constructed manifolds are also available.

Relco Products, Dept. ED, Box 8327, University Park Sta., Denver 10, Colo.

Terminals 507

Dielectric strength is 5000 v

Designed for AWG wire sizes 10 to 22, these terminals meet commercial pull requirements and hold a dielectric strength test of 5000 v. Available in the standard ring and forked-tongue design, they have an internally serrated barrel section into which the conductor is permanently staked. When strip feeding is used, these terminals can be attached at speeds to 1200 per hr.

The Thomas and Betts Co., Dept. ED, 36 Butler St., Elizabeth, N.J.

Resistance Comparators 514

Three types available

These resistance comparators come in three different types. Model 1406 6-dial universal ratio set, shown here, permits comparison of odd-valued resistors with a known standard. It handles ratios up to 10:1 with a ratio limit of error of 0.1%. Functionally equal to a long slide wire with movable contact, the device has a constant resistance between external terminals of 2,111.11 ohms for all settings. Potential contact may be set at any point along the wire to the nearest 0.001 ohm. The unit is useful in calibrating laboratory potentiometers and has a maximum limit of error of 0.0002%. Model 1414 4-dial set offers a range of 0.994445 to 1.005555 in steps of 0.000001. Also available, model 1413 3-decade set has a range of 0.99445 to 1.00555 in steps of 0.00001.

Minneapolis-Honeywell Regulator Co., Rubicon Instruments Div., Dept. ED, Ridge Ave. at 35th St., Philadelphia 32, Pa.

Oscilloscope Camera 482

Records full-sized patterns

Model 196A oscilloscope camera records full-sized oscilloscope patterns without distortion. The object-to-image ratio is 1:0.9 to show a full 10-cm graticule width. Lens adjustment may be made without removing the camera from the scope. The lens can be moved through 11 detented positions by means of a knob while the camera back remains fixed. Standard camera bellows are used to eliminate light leakage. The unit weighs 9 lb.

Hewlett-Packard Co., Dept. ED, 275 Page Mill Rd., Palo Alto, Calif.

NEW PRODUCTS

DC Power Supplies 513

Cover a range of 18 to 300 v

The ME series of 60 power supplies covers the range of 18 to 300 v dc, including dual outputs. These transistorized units have a line regulation of 0.05% or 5 mv and a load regulation of 0.1% or 10 mv, from zero to full load. Down to 5 v, a 0.01% line and load regulation can be obtained on special units. Ripple is less than 0.01% for typical units having 1 mv rms. Recovery time is less than 50 μsec and overshoot is less than 1% af full current and voltage. All units are equipped for remote load change sensing and have completely floating outputs. Incorporated in this line are modular plug-in units.

Mid-Eastern Electronics, Inc., Dept. ED, 32 Commerce St., Springfield, N.J.

Go/No-Go Measuring Set 501

Handles to 1000 v dc input

Type DY-5344 go/no-go measuring set handles input voltages to 1000 v dc in four decade ranges. A complete testing system, it measures and compares dc voltages against preset limits, displays the measured value, and records the test results. The input signal is converted to frequency and is compared digitally with high and low limits determined by front panel controls. Indicating lamps show HI, GO, or LO, and a five-place display indicates the measured value. A digital recorder records the comparison result, the measured value, the channel number selected, and the test serial number. The over-all accuracy of measurement is 0.1% of the input ±1 count.

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

Digital Test Equipment 389

Operates at speeds to 500 kc

The 3000 series digital test equipment is designed for operation at speeds to 500 kc. Included in the series are type 3101 inverter, type 3110 diode NOR, type 3201 flip-flop, type 3301 delay, type 3401 clock, type 3410 pulse generator, and type 3601 pulse amplifier. The units have graphic front-panel construction and are packaged in aluminum housings. All logical interconnections are made with banana-jack patch cords on the front panels, and standard power connections are made through the plug-in back panels. Accessory equipment includes power supplies, power cables, mounting panels, and patch cords.

Digital Equipment Corp., Dept. ED, Maynard, Mass.

Aircraft Battery Substitutes 391

Delivers 0 to 30 v dc at 20 amp

Model KM88 aircraft battery substitute delivers from 0 to 30 v dc at the full load rating of 20 amp. The maximum rms ripple is 0.5% of the average dc output. Input is 115 v ac, 60 cps, single-phase. The unit can be used for marginal checking, over-voltage testing as well as normal operation of 28-v airborne equipment.

Opad Electric Co., Dept. ED, 43 Walker St., New York 13, N.Y.

Test Chamber 390

Temperature range —100 to +250 F

For use in the missile component field, this environmental test chamber, called ValuMite, offers temperatures from —100 to +250 F. The temperature control is to within 1 deg C. Made of stainless steel, the chamber has 2 cu ft of test space. Input is 208 or 230 v, 60 cps, single-phase. The unit is designed for bench mounting.

International Radiant Corp., Dept. ED, 577 E. 156th St., New York 55, N.Y.

NEW PRODUCTS

Encapsulation System 353

Consists of three parts

This mass-encapsulation system consists of these three parts: an all-epoxy header with embedded leads and, a round or rectangular molded, cured, epoxy shell, and pre-metered epoxy pellets. After the components are attached to the mounting board, the finished module and a pre-metered pellet are inserted into the shell and heated. The pellet melts and cures, embedding the module and forming a single, epoxy-encapsulated unit. The entire system meets temperature cycling of −55 to +200 C, altitudes of 50,000 ft, and the salt spray, vibration, fungus, and humidity requirements of MIL 202A and MIL-E-5272A.

Epoxy Products, Inc., Dept. ED, 137 Coit St., Irvington, N.J.

DC Motors 354

Have ratings to 1/100 hp

Type GJ dc motors have continuous duty ratings to 1/100 hp and can be wound for series, split-series, shunt, or universal operation. Torques to 6 oz-in. can be obtained for intermittent duty. The integral brakes are capable of full load speed stops in 2.9 revolutions. Integral planetary gear speed reducers are available in many ratios. The motors can use from 6 to 75 v dc and provide output speeds from 6000 to 13,000 rpm. The unit shown is 5 in. long and weighs about 16 oz.

Globe Industries, Inc., Dept. ED, 1784 Stanley Ave., Dayton 4, Ohio.

AC-DC Comparator 355

Readings are within ±0.05% of true value

This ac-dc comparator measures ac current, voltage, and power at ±0.05% of true value at frequencies to 1000 cps. It offers a basic ac standard for calibration and testing with ranges to 125 amp, to 500 amp with special transformer; 600 v, to 1500 v with a special voltage divider; and power to 100 amp and 600 v. The double light spot scale gives direct readings of 1 part in 10,000.

Physics Research Labs., Inc., Dept. ED, P.O. Box 555, Hempstead, N.Y.

Metallized Paper Capacitor-Resistor 362

Capacitance is 0.25 μf

Type RC metallized paper capacitor-resistor has a capacitance rating of 0.25 μf and has resistances of 200, 250, and 600 ohms. It is for operation to 200 v dc. The resistance is in the metal layer which is used as a series resistance to the capacitance. The package is molded in a humidity-resistant thermosetting resin. The unit measures 1 in. in length and 1/2 in. in diam.

Presin Co., Dept. ED, 2014 Broadway, Santa Monica, Calif.

Microwave Tubes 356

For use at 67,000 to 73,000 mc

Types QKK837 and QKK838 mechanically-tuned velocity variation oscillators are for use in the range of 67,000 to 73,000 mc with a minimum output of 10 mw. The rf output is through a waveguide sealed by a mica window. The output flange mates with a standard UG385/U cover-flange.

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

NEW PRODUCTS

AC to DC Power Supplies 35

Rated at 85 to 300 v

These ac to dc power supplies are available in 11 models with ratings from 85 to 300 v and from 10 to 40 ma. Required input is 117 v, 60 cps. All models are housed in metal drawn cases and are furnished with filtering circuits. They are designed to be plugged into standard octal sockets.

Acopian Technical Co., Dept. ED, 927 Spruce St., Easton, Pa.

Beam Power Tubes 360

Have piv ratings of 24 w max

Types 7551 and 7558 beam power tubes have maximum piv ratings of 24 w for rf power-amplifier and oscillator service. Type 7551 is made for use in mobile communications equipment operating from 6-cell storage-battery systems; type 7558 is made for use in fixed-station and other communications equipment using 6.3-v heater supplies. Both tubes can be operated at full ratings to 175 mc. Each tube supplies a useful power output of about 10 w for a driver power of 1.5 w. Both types are of the nine-pin miniature design.

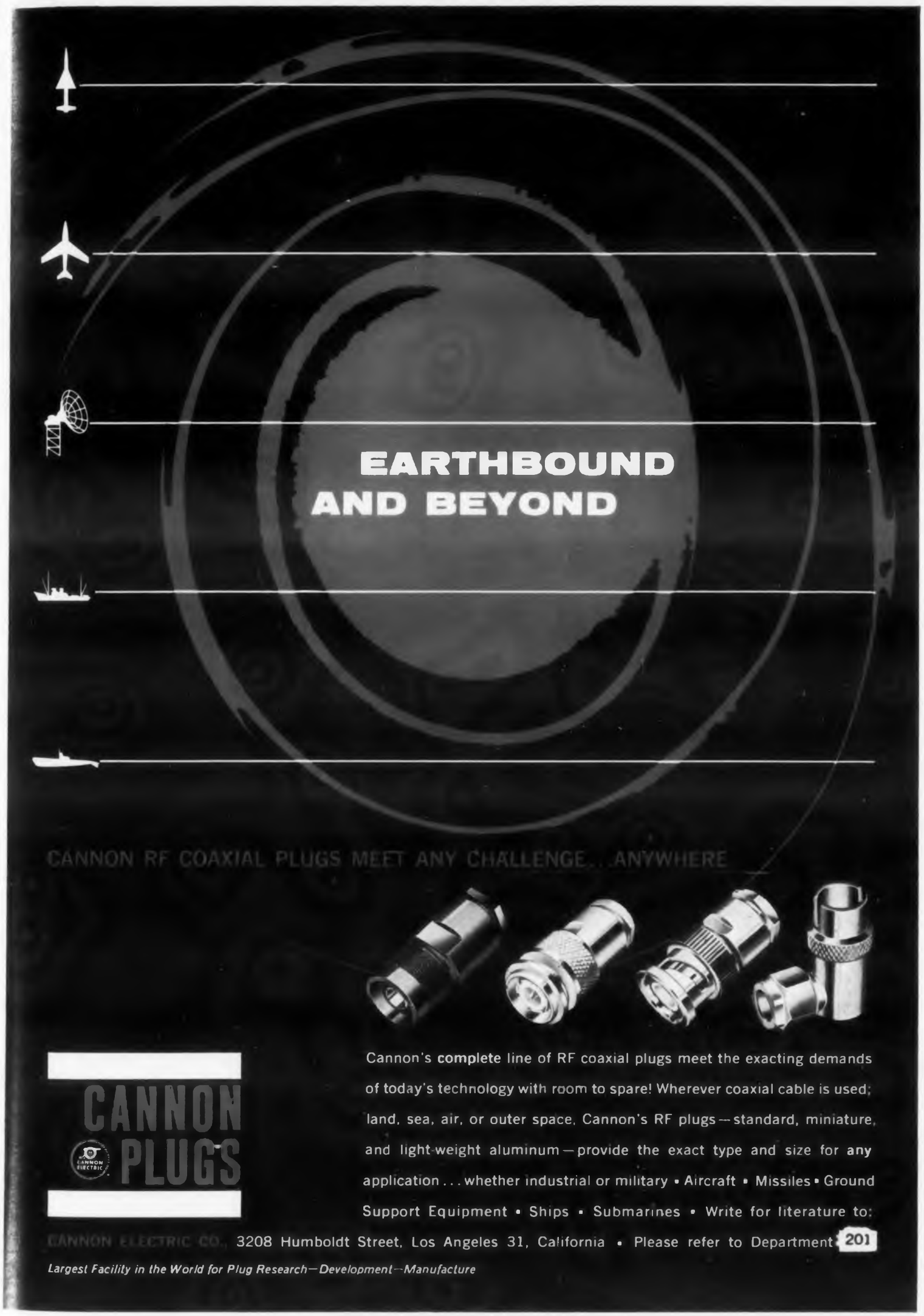
Radio Corp. of America, Electron Tube Div., Dept. ED, Harrison, N.J.

Capacitors 358

Capacitances are 0.01 to 10 μf

Type 26MM metallized Mylar capacitors are available in capacitances of 0.01 to 10 μf, with diameters from 3/8 to 1 in., and with lengths from 5/8 to 2-1/3 in. The temperature range is —55 to +125 with no derating. In addition to a moisture-resistant phenolic case, epoxy resin encapsulation is used. Typical uses are in dc filters and airborne equipment.

Wesco Electrical and Manufacturing Co., Dept. ED, 27 Olive St., Greenfield, Mass.



CIRCLE 62 ON READER-SERVICE CARD

CANNON PLUGS

Schweber

FOR IMMEDIATE LARGE QUANTITY DELIVERY AT FACTORY PRICES

2500

Yes! You can now order up to 2500 each of such popular Cannon Connector types as Miniature D, KO, DPD, DPA, DPX, etc. Immediate shipment at factory prices.

Schweber ELECTRONICS

60 HERRICKS ROAD, MINEOLA, L.I., N.Y.
PIONEER 6-6520 TWX G-CY-NY-580

CIRCLE 63 ON READER-SERVICE CARD

NEW PRODUCTS

Inductors 365

Provide 18 to 1000 μh

This line of inductors, designated Mini-Stab, offers 22 standard inductance values from 18 to 1000 μh with tolerances of 2, 5, and 10%. High stability is obtained by means of a powdered iron coil form with axial leads to form an open magnetic circuit. The typical induction variation with temperature is ±2% from —55 to +125 C. Inductance variation over the range from zero to rated current is a typical —1%. A molded thermosetting plastic jacket provides protection against environmental conditions and physical damage. The units stand a 300% overload for 5 min.

Speer Carbon Co., Jeffers Electronics Div., Dept. ED, DuBois, Pa.

Parametric Amplifier 366

Tunes from 220 to 400 mc

Model MA-1-350 parametric amplifier tunes from 220 to 400 mc. It has a noise figure below 2 db for up to 20 db gain and about 1/4% bandwidth. In typical operation, pump power of 100 mw is required at a pump frequency of about four times the signal frequency. The input and output impedance matches a 50-ohm line. In the non-amplifying condition, insertion loss of the cavity is about 0.2 db. Type N fittings are provided for injection of rf pump power, and connection of signal input and output to receiver. The unit is supplied with two Varactor diodes and is also available with auxiliary equipment including pump oscillator, pump power supply, and interconnecting cables. The over-all cavity dimensions are 10-7/8 in. high and 4 in. in diam.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.

Mesa Transistors 367

Dissipate 2 w at 25 C

For medium power and small-signal amplifier use as well as switching applications, types TI 2N696 and TI 2N697 silicon mesa transistors dissipate 2 w at 25 C and

◀ CIRCLE 64 ON READER-SERVICE CARD

are available with a collector-base voltage of 60 v. Type 2N696 has a beta spread of 20 to 60 and type 2N697 has 40 to 120. Both have a maximum saturation resistance of 10 ohms.

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

Strain Indicator 368

Direct Reading

Model DR-20 direct reading strain indicator is for use with all commercial strain gages and strain gage transducers. The adjustable gage factor control is from 0.5 to 10 providing the instrument with sensitivities of 2 to 100 μv per v per division. For low strains, the sensitivity can be set to provide a readability of 1 μin. per in. Strains as high as 50,000 μin. per in. can be read directly. Transducers will drive the meter full scale for capacity output or for about 5% of capacity output to provide readability as high as 0.1%. Automatic polarity reversal permits reading from full tension to full compression with no adjustment. The instrument operates from four self-contained flashlight batteries and is housed in a case measuring 11 x 8-1/2 x 6 in. It weighs 9 lb.

Bytrex Corp., Dept. ED, 50 Hunt St., Newton 58, Mass.

Analog Computer 369

Measures 35.5 x 21 x 23 in.

Measuring 35.5 x 21 x 23 in., type AR-2 analog computer is furnished with 12 amplifiers, 16 potentiometers, a pulse generator, and a stepping function generator. Six of the amplifiers can be used as integrators with three different ratios of integration. Impedance-matching design eliminates the need to compensate for loading effects between amplifiers. The solution to physical and mathematical problems appears as a time-variable voltage curve that can be viewed on any dc oscilloscope or direct-writing oscilloscope. An x-y plotter can also be used to plot one variable against another.

Boonshaft and Fuches, Inc., Dept. D, Hatboro Industrial Park, Hatboro, Pa.

CIRCLE 65 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Connectors 363

For use to 1200 F

Using a boron-free ceramic, these connectors are for high temperature use to 1200 F. The pin and case are No. 303 stainless steel. Capacitance from one pin to ground is 2 μμf.

Technical Industries Corp., Dept. ED, 389 N. Fair Oaks Ave., Pasadena, Calif.

EIR Meter 352

Has 5 dc voltage ranges

Model 109 volt-ohm-milliammeter has 5 dc voltage ranges to 3000 v at a sensitivity of 20,000 ohms per v, and 5 ac ranges to 3000 v at a sensitivity of 10,000 ohms per v. It has 3 ac and dc current ranges and 3 resistance ranges to 20 meg. A 40-μa 4.5-in. meter is used. The unit is housed in a molded bakelite case and is available wired or as a kit.

Electronic Measurements Corp., Dept. ED, Eatontown, N.J.

Miniature Capacitors 359

Capacitances are 0.1 μμf to 500 μf

Designed for applications where space is limited, these capacitors are available with capacitances from 0.1 μμf to 500 μf and in capacity tolerances from 0.1% to 20%. The following types can be furnished: paper, metallized paper, electrolytic, mica, ceramic, and film dielectrics such as Mylar, Teflon, polystyrene, and polyethylene. Voltages are 3 to 1000 v. The operating temperature ranges are from —65 to +350 C. Units can be supplied cased or uncased, flat, or round. Leads can be positioned radially, axially, for plug-in connections, and others. The leads in all types are plastic anchored. The capacitors are supplied in steatite, bakelite, plastic-treated paper, in metal tubes, cans, and plastic encapsulated, dipped, or molded.

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

Density Meter 361

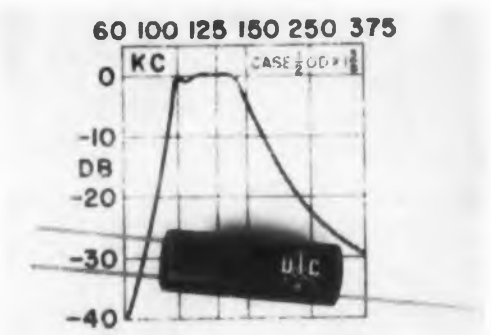
Covers the range of 200 to 10,000 mc

Covering from 200 to 10,000 mc, model 1200 battery-operated density field meter indicates the presence of radiated energy above or below the safe level of 10 mw per sq cm as well as the intensity of the energy. The instrument provides direct readings. The accuracy and the sensitivity are ±1 db. The frequency range is divided into five steps. Without antenna, the unit measures 5-3/4 x 2-7/8 x 2 in.

Radar Measurements Corp., Dept. ED, Hicksville, L.I., N.Y.

HF Filters 393

Miniature



These hf Minifilters are available in band pass types for frequencies of 50 kc to 1 mc, low pass types with cut-off frequencies from 75 kc to 1 mc, and high pass types with cut-off frequencies of 100 kc to 1 mc. The units weigh 1/3 oz, have a 1/2-in. diam, and are 1-3/8 in. long. The unit shown is a 15,000-ohm band pass filter with a center frequency of 120 kc, flat within 3 db from 95 to 145 kc. Attenuation is greater than 40 db below 60 kc and greater than 30 db above 375 kc.

United Transformer Corp., Dept. ED, 150 Varick St., New York 13, N.Y.

Thermocouple Wire 364

Temperature range is 1800 to 2300 F

This base metal thermocouple wire provides true temperature readings in the range of 1800 to 2300 F. The emf values meet standard emf curves. The oxidation-resistant negative leg is a nickel alloy containing about 2.5% silicon. This highly magnetic material has a negative emf against most other alloys and metals. The positive leg is a nickel alloy containing 10% chromium and controlled traces of other metals. It is non-magnetic and has a highly positive emf against other alloys and metals. Standard tolerances for these couples in the temperature range of 32 to 530 F is ±4 deg F or ±0.089 mv; in the range of 531 to 2300 F, it is ±3/4%.

The Kanthal Corp., Dept. ED, Amelia Place, Stamford, Conn.

NEW PRODUCTS

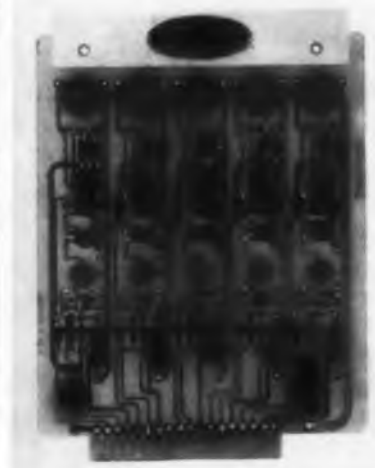
Phase Shifter 39

Range is 360 deg

These 360-deg phase generators, designated models PG1-, PG-3, and PG-5, provide continuous phase shift of a carrier without amplitude change. The units can be used as single-frequency phase meters, references for demodulator circuits, and position-phase transducers. The range is 360 deg, and the phase accuracy is 30 sec of arc. The input voltage is 115 v and the output voltage is 32 v.

Theta Instrument Corp., Dept. ED, 520 Victor St., Saddle Brook, N.J.

Pulse Delay Module 412



Has five delay circuits

Model 304 pulse delay module contains five independent, all semiconductor, delay circuits. Each section provides a delayed pulse output and a square wave output for the delay duration. Each delay circuit includes a high gain regenerative delay stage, a dc pulse amplifier which provides a square wave, and a differentiating circuit. For each delay section, the delay range is adjustable from 3 to 30 μsec. The delayed pulse output is a differentiated pulse of −3 v unloaded with a capability of 1 ma. The square wave output is −12 v switching to −2 v. Rise and fall times of 3 μsec remain constant for the full range with adjustments. The unit is a 5 x 6-in. glass-epoxy printed circuit card, measuring 1/16 in. thick. It is for use with an 18-pin P.C. receptable.

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

Electronic Battery 388

Delivers 5 amp at 6 v

Model 175 electronic battery delivers 5 amp at 6 v with a line regulation of 0.01% for changes from 105 to 125 v and a load regulation of 0.05% from no load to full load. Output noise and ripple are less than 1 mv rms and recovery time for either line or load transients is 0.001 sec. This transistorized unit replaces storage battery or a storage battery and floater combination. Applications include use as a low voltage source for strain gages, bias supplies, and precision filament supplies.

American Electronic Labs., Inc., Dept. ED, 121 N. Seventh St., Philadelphia 6, Pa.

Scanning Machine 414

For industrial and laboratory use

Model T-24 FZ floating zone machine produces semi-conductor materials and highly purified metals. Made for both industrial and experimental use, it has an extremely narrow molten zone which traverses the length of the vertically supported impure bar. Purification is by means of induction heating. The machine handles bars up to 1.25 in. in diam and 24 in. long. Scanning speed is continuously variable to 12 in. per hr, and return speed is continuously variable over the range of 40 to 800 in. per hr. The control panel includes up and down speed controls, a manual-automatic selector switch, and rotation motor switches.

Induction Heating Corp., Dept. ED, 181 Wythe Ave., Brooklyn 11, N.Y.

CIRCLE 71 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Plate and Filament Transformers 357

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 type 5Y3GT rectifier for models MVRP-40 and 70 or type 5U4GA/GB for the MVRP-185.

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

Power Supplies 409

Input is 12 to 14 v dc

Made to operate from an input of 12 to 14 v dc, this line of power supplies includes dc converters in 25, 60, and 120-w models and a 25-w inverter which delivers 115 v or 26 v at 400 cps. The units are for use under extreme environmental conditions and are transistorized. Applications of the converters are in mobile communications, marine radio-telephones, and aircraft radios. The inverter is suitable for synchro position indicators, gyro instruments such as turn and bank indicators and artificial horizons, remote indicating compasses, and other aircraft and marine instruments.

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

Servo Motor-Brake 410

Stall torque of motor is 0.48 oz-in.

This servo motor-brake combination has a stainless steel housing, end bells, and shaft, and can be made with size 10, size 11, or 1-in. mounting. The stall torque of the motor is 0.48 oz-in. A brake range of 0.03 to 0.1 ±0.01 oz-in. is offered. It is designed for 115 v, 400 cps operation in both phases. The nominal impedance is 1450 +j1600. The brake does not change linearity of the speed torque characteristics. The unit meets MIL-E-5272. A unit including an integrally mounted gear box with ratios to 8000:1 is also available.

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

Power Amplifier 394

Delivers 20 w from a 10-mw input

Operating from an input signal of 10 mw, model ATMS-2001 power amplifier provides 20 w over the frequency range of 30 cps to 150 kc. Attenuation is 0.5 db. Input impedance is about 10 K and the input circuit is provided with a step attenuator to control the amplitude of the input signal. The harmonic distortion is less than 1.5% and the output impedance is a balanced or unbalanced resistive load of 135 ohms. Model ATMS-2002 transformer is available for use with the amplifier permitting an output impedance selection of 4, 16, 64, 600, or 2400 ohms. Frequency response of the transformer is 30 cps to 150 kc ±2 db at extreme impedance levels.

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

NEW PRODUCTS

Miniature Acceleration Switch 404

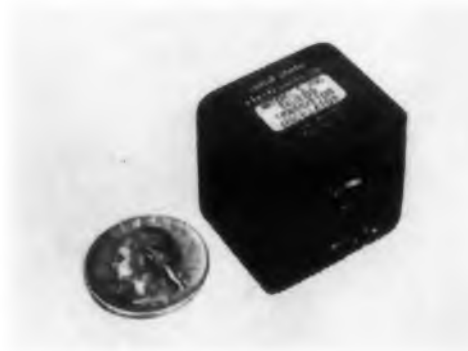
Temperature range is −65 to +250 F

Operating in the temperature range of −65 to +250 F, type 174 miniature, unidirectional, single-axis switch closes a circuit in response to a preset acceleration level and resets itself when the acceleration drops below a preset level. The unit consists of a gas-damped seismic system with a range of 5 to 60 g, an accuracy of ±5%, a repeatability of ±0.25 g, and a damping ratio of 0.8 of critical. The switch is spst type, normally open with a contact rating of 100 ma. The unit is hermetically sealed, weighs 3/4 oz, and measures 1-3/16 x 7/16 in. OD. It is suitable for use in aircraft and missile control for measuring and indicating devices.

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

Transistor Sinusoidal Oscillator 401

Frequency range is 25 cps to 100 kc



Designed to create a sine wave signal source, model S-200 silicon transistor sinusoidal oscillator covers a frequency range of 400 cps to 70 kc or of 25 cps to 100 kc. The unit withstands 500 g shock for 11 msec, 35 g vibration from zero to 2500, and acceleration of 700 g. The required input is +28 v at 2 ma. Distortion is less than 5%. The output impedance is a nominal 2.5 K. Output amplitude is greater than 2 v rms for a load impedance of more than 35 K. Suitable for use in missile instrumentation, telemetering, carrier systems, guidance systems, magnetic tape biasing, and other uses, the unit weighs about 2 oz, depending on frequency of operation.

Solid State Electronics Co., Dept. ED, 15321 Raven St., Sepulveda, Calif.

Power Supply 408

Has adjustable output of 2.5 to 13 v dc

Operating from an input of 115 v ac ±10%, 60 ±1 cps, single-phase, type 7197 power supply has an adjustable output of 2.5 to 13 v dc. Load current is 0 to 10 amp, continuous duty. The dynamic regulation is provided for a ±90% load change and a step function of ±5% line change. Slow regulation is provided for no load to full load and a ±10% line change. Total regulation including slow, dynamic, and ripple will not exceed ±1%. The ripple voltage is 10 mv max. The supply has short circuit protection over the entire range and meets all electrical specifications to 35 C. The voltage reference is stabilized in two stages. The pass circuit, consisting of six parallel transistors, is controlled by a current amplifier and a voltage amplifier transistor.

The Daven Co., Dept. ED, Livingston, N.J.

Sweep Generator 403

Flatness is ±0.05

Model 707 sweep frequency generator has a flatness of ±0.05 over its highest octave of coverage. The unit can be furnished with plug-in oscillator heads covering any part of the spectrum from 0.5 to 250 mc. An electronic saturable reactor permits a maximum deviation of about 4.5 to 1, with sweep rates adjustable from 0.5 sweeps per min to 60 sweeps per sec. The instrument can be used with X-Y recorders where permanent records are required. Sawtooth or pyramid sweep shapes may be selected by front panel controls. The output power exceeds +20 dbm and is monitored by a front panel meter. The unit operates from a 115 v, 50 or 60 cps supply built on a 13 × 17-in. chassis for cabinet or rack mounting.

Jerrold Electronics Corp., Industrial Products Div., Dept. ED, 15th and Lehigh Ave., Philadelphia 32, Pa.

NEW PRODUCTS

Switching Transistor 397

Dissipates 45 w at 25 C

Type 2N1120 switching transistor dissipates 45 w at 25 C mounting base temperature. Maximum collector current rating is 10 amp dc and collector-emitter voltage rating is 70 v dc. Designed to meet MIL-T-19500/68, the unit has a high reliability.

Bendix Semiconductor Products, Dept. ED, Long Branch, N.J.

Electromagnetic Counter 392

Measures 2.092 x 2.401 x 2.25 in.

Measuring 2.092 x 2.401 x 2.25 in., this electromagnetic counter displays six digits. Characters are 0.188 in. high. Operation may be on 115 v ac or other voltages, if requested. Power consumption is about 6 w. Maximum constant speed is 700 counts per min.

Veeder-Root Inc., Dept. ED, Hartford 2, Conn.

Synchro Control Transformer 402

Temperature range is −55 to +125 C

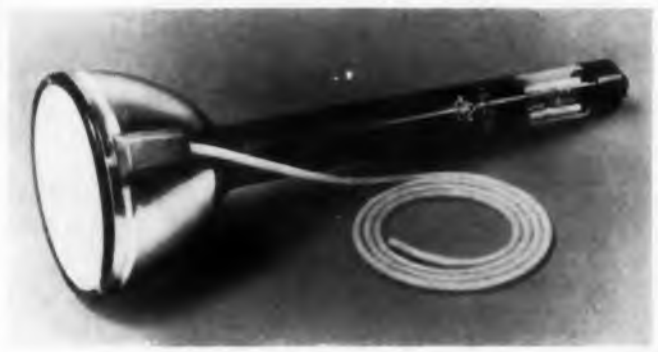
Type 4227-01 400-cps synchro control transformer has minimum error variations from −55 to +125 C. The input voltage is 11.8 v, the input current is 0.03 amp, and the input wattage is 0.073 w. The output voltage is 22.5 v, the phase

shift is 8.5 deg, the rotor resistance is 316 ohms, and the stator resistance is 67 ohms. All molded parts are made from material with high impact strength, good dimensional stability, and heat resistance. The unit has stainless steel housing.

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

Cathode Ray Tube 400

Has 3000 lines

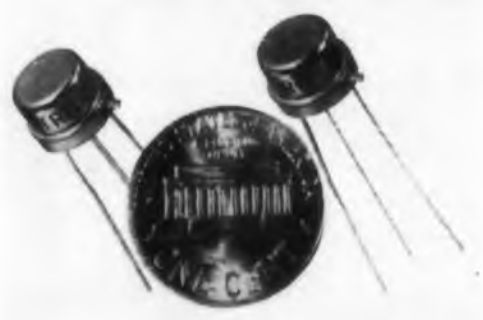


Type SC-2782 cathode ray tube is made for high resolution photographic recording and has a definition range of 3000 lines with a spot size of 0.0013 in. at currents of 5 μa. This 5-in. tube has a flat, clear non-browning optical glass faceplate. An integral encapsulated high voltage connector minimizes corona at high altitudes. The tube is aluminized and uses a non-ion trap construction with magnetic deflection and focus.

Sylvania Electric Products, Inc., Dept. ED, 730 Third Ave., New York 17, N.Y.

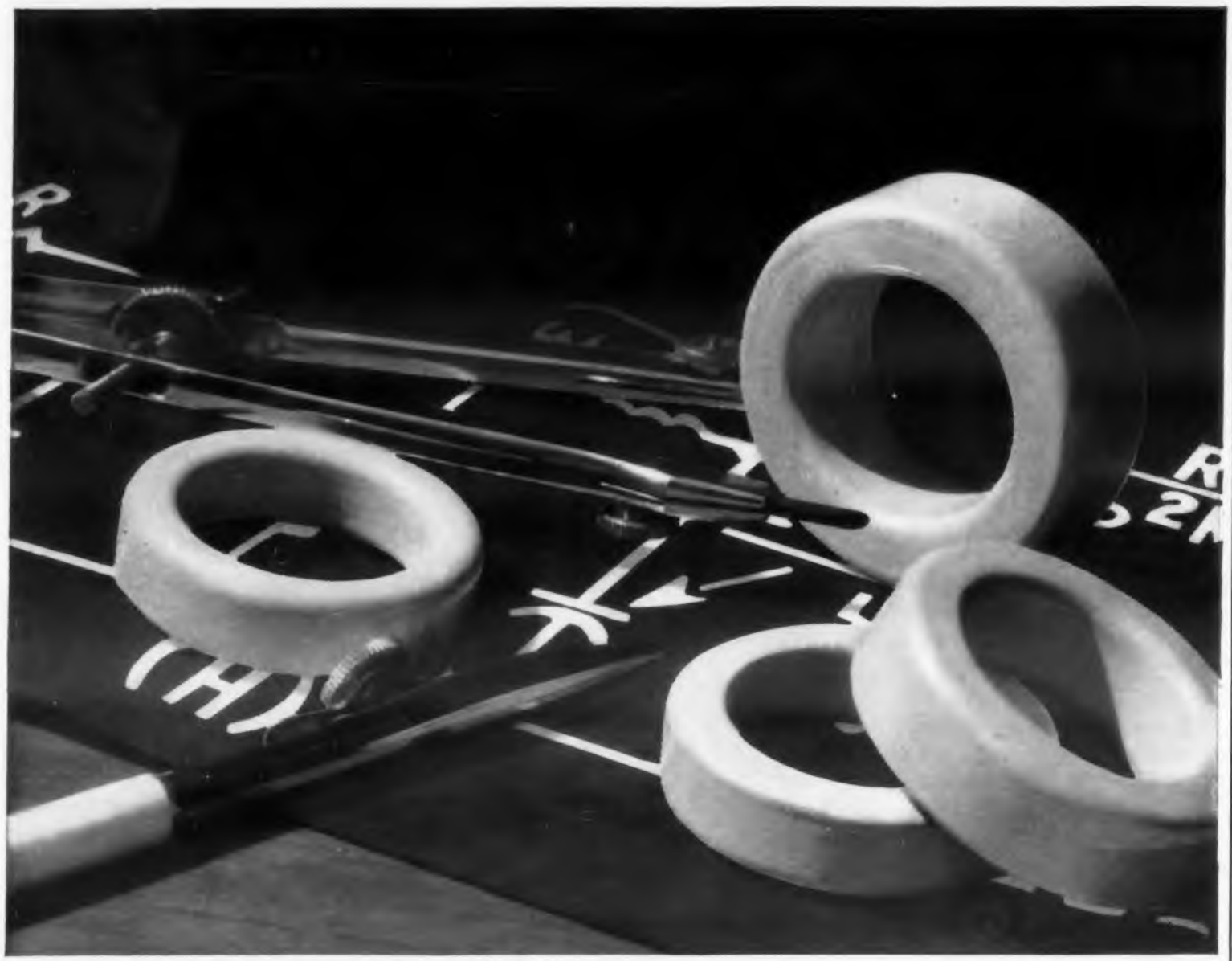
PNP Germanium Alloy Junction Transistor 406

For military and industrial computer use



Type 2N1356 pnp germanium alloy junction transistor is for military and industrial computer use where extreme reliability is required. Made to replace type 2N3596A, the unit has a floating base construction with the three leads insulated from the case. Types 2N1353, 2N1354, 2N1355, and 2N1357 are similar replacements for types 2N384, 2N395, 2N396, and 2N397. All units meet the requirements of MIL-T-19500A and MIL-S-19500B.

Industro Transistor Corp., Dept. ED, 35-10 36th Ave., Long Island City 6, N.Y.



NEW PRODUCTS

Delay Line

413

Delay time is 0.5 μsec

Designed for printed wiring assembly techniques, model 15-52 delay line has a delay time of 0.5 μsec, tapped at 0.1-μsec intervals. The impedance is 100 ohms and the rise time is 0.1 μsec. The unit has raised-bearing surfaces to prevent moisture trapping. Its dimensions are 0.375 x 2 x 2.28 in.

ESC Corp., Dept. ED, 534 Bergen Blvd., Palisades Park, N.J.

Pulse Generator

396

Rise time is 0.4 mμsec

Model PG-3 pulse generator has a rise time of better than 0.4 mμsec. Repetition rates can be fixed at 60 cps, variable from 20 to 300 cps, or externally triggered. The calibrated pulse amplitude is 0 to ±100 v and the calibrated pulse widths are 1.7, 5, 10, and 20 mμsec. Other pulse widths can be produced by using additional cables. Transistorized drive circuits provide for stable operation. The unit measures 12-7/8 x 7 x 10-1/2 in.

Lumatron Electronics, Inc., Dept. ED, Westbury, L.I., N.Y.

Correction Notice

The magnetic tape transport described on page 54 of the October 28th issue is model 906, Mark II, and not model 908, Mark II, as reported. It is manufactured by Potter Instrument Corp. of Plainville, L.I., N.Y.

Limit Stop Assembly 371

To meet Mil specs, type X2 is available in ball bearings or oil-less bronze bearings with a wide range of mechanical stop limits from 30 to 4530 deg. Made for stopping torques to 500 oz-in., the units are self-adjustable for fine zero adjustment.

Pic Design Corp., Dept. ED, 477 Atlantic Ave., E. Rockaway, L.I., N.Y.

Gold 372

For silicon transistors and diodes used in computers, aircraft, and missiles, this gold contains 10 parts per million impurity.

American Silver Co., Inc., Dept. ED, 36-07 Prince St., Flushing 54, N.Y.

Hermetic Magnetic Wire 373

Made of a Formvar material, it has low extractions, good blister-resistance, and does not soften in Freon-22. Called Hermeteze, it also has good resistance to heat and pressure at crossovers.

Phelps Dodge Copper Products Corp., Inca Mfg. Div., Dept. ED, Fort Wayne, Ind.

Resistance Paints 374

These seven types, offering from 10 to 10,000 meg, can replace resistors in non-precision applications and can be applied directly to insulating surfaces. Rods or sheets can be coated by spraying, dipping, flooding, or brushing.

Micro-Circuits Co., Dept. ED, New Buffalo, Mich.

Switches 375

Types BZE6-2RN28 and BZV6-2RN28 one-way roller arm actuators provide electrical actuation in one direction and are made for either side or bottom mounting. Types BZE6-2RQ62 and BZV6-2RQ62 side and bottom enclosed switches have a low force 6-in. rod actuator. Ratings are 15 amp at 120, 240, and 480 v ac, 0.5 amp at 125 v ac, and 1/4 amp at 250 v ac.

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

Neon Noise Sources 376

Designed to operate in the range of 1120 to 26,500 mc, these neon tubes provide 18 db of excess noise.

Kay Electric Co., Dept. ED, 14 Maple Ave., Pine Brook, N.J.

Ceramic Bushings 377

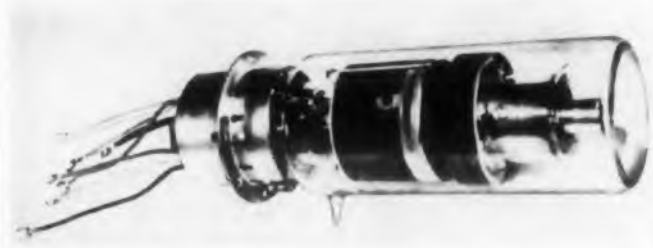
For use in electrical insulators and semiconductor tooling, they withstand temperatures to 2000 F. Diameter sizes are from 0.028 to 12 in. OD. Standard tolerances are held to ±0.5%.

Ceramic Products, Inc., Dept. ED, 426 Commercial Ave., Palisades Park, N.J.

NEW PRODUCTS

Hydrogen-Thyratron 407

Average pulse power is 75 kw

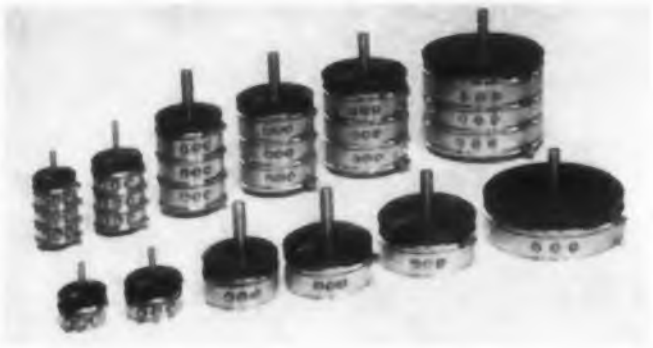


Type GHT4 Genalex hydrogen-thyratron has a peak pulse power of 50 megawatts, and an average pulse power of 75 kw. Tube life is 3000 hr or more. Constant gas pressure can be maintained with variations of up to 7.5% of supply voltage. The ambient temperature range is —5 to +70 C. Jitter is less than 1 mμsec and pulse lengths are 5 μsec at maximum peak current. The unit measures 15 in. long and 4.5 in. in diam.

British Industries Corp., Dept. ED, 80 Shore Rd., Port Washington, N.Y.

Servo Potentiometers 411

Operate from —55 to +150 C



Designed for military applications under severe environmental conditions, the PVR series of servo potentiometers operate over the temperature range of —55 to +150 C. Offered in diameter sizes from 0.5 to 3 in., they have mandrel construction to provide maximum resolution and preloaded stainless steel ball bearings to eliminate end play.

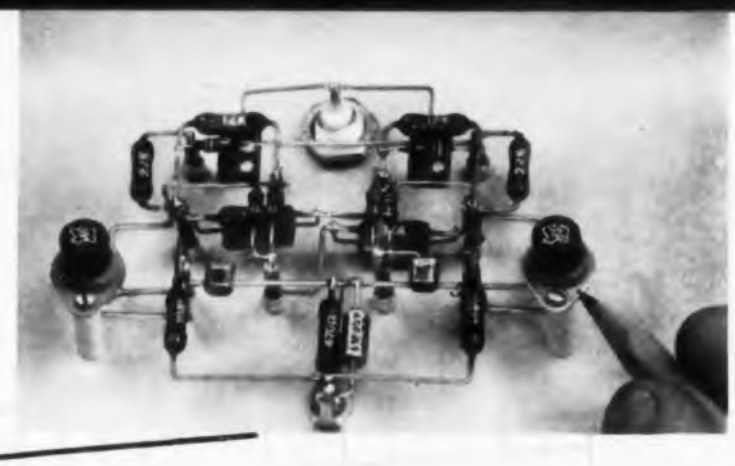
Technology Instrument Corp., Dept. ED, 531 Main St., Acton, Mass.

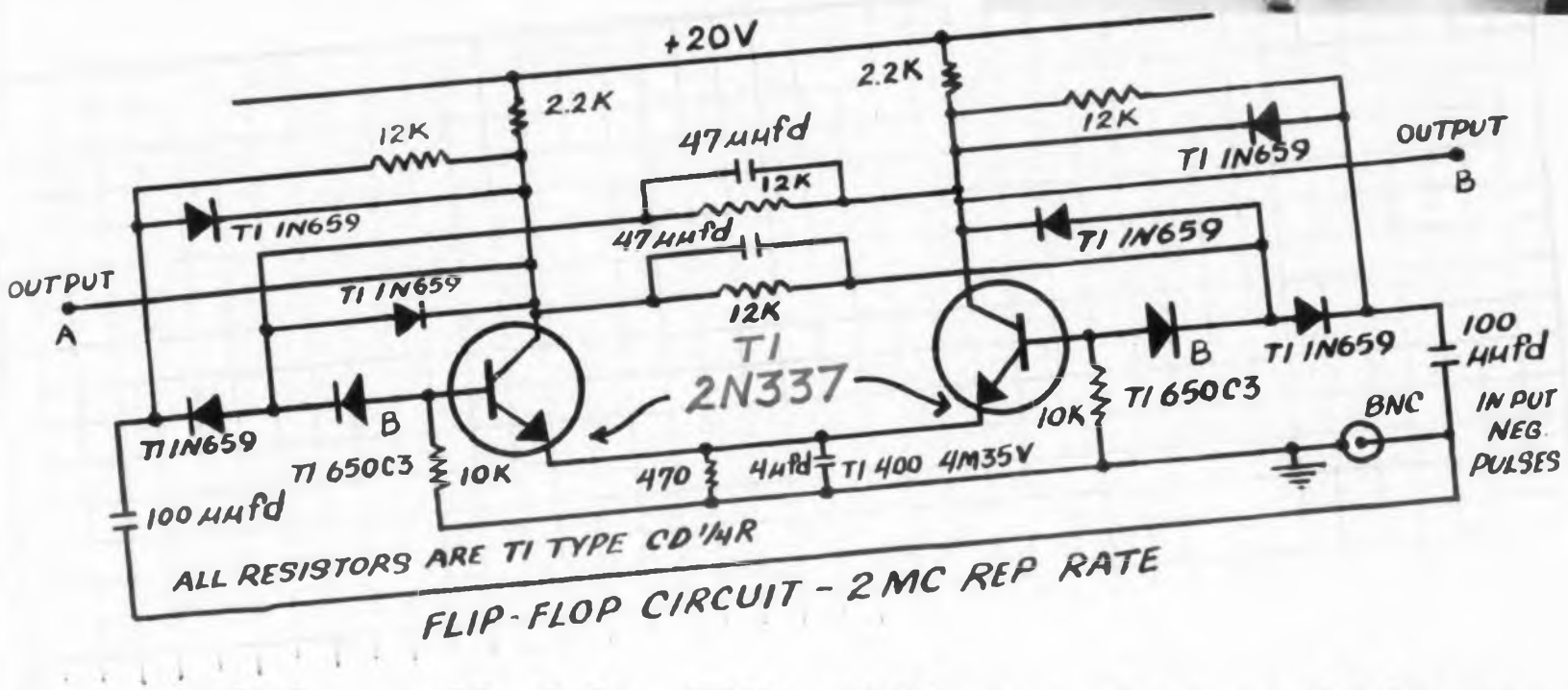
Correction Notice

Model LS-2 focusing light source can provide a light spot at any distance from 12 ft to 5 in., and not from 1 ft to 5 in. as reported in the July 22nd issue. The light source is made by Farmer Electric Products Co., Inc., 2300 Washington St., Newton Lower Falls, Mass.

CIRCLE 83 ON READER-SERVICE CARD ➤

HIGH SPEED SWITCHING





. . . with reliable T/I silicon transistors

New improved TI 2N337 and 2N338 specifications provide greater design flexibility for your switching circuits . . . nuclear counters . . . pre-amplifiers . . . RF amplifiers . . . 455 KC IF amplifiers . . . and many other high frequency applications.

You get high gain at low current levels with TI diffused silicon transistors. High alpha cutoff . . . 10 mc min for 2N337, 20 mc min for 2N338 . . . and extremely low collector capacitance assure optimum performance in your switching and high frequency amplifier applications.

Over four years of mass production and successful use in the most advanced military and industrial applications have proved the value of the TI 2N337 series. Consider TI's guaranteed specs when you select devices for your next transistor circuit. These units are immediately available in production quantities or from large stocks at all authorized TI distributors.

design characteristics at 25° C ambient (except where advanced temperatures are indicated)

		test conditions		2N337 min	2N337 design center	2N337 max	2N338 min	2N338 design center	2N338 max	unit
I_{CBO}	Collector Cutoff Current	V_{CB} = 20V	I_E = 0	—	—	1	—	—	1	μA
	at 150°C	V_{CB} = 20V	I_E = 0	—	—	100	—	—	100	μA
BV_{CBO}	Breakdown Voltage	I_{CB} = 50μA	I_E = 0	45	—	—	45	—	—	V
BV_{EBO}	Breakdown Voltage	I_{EB} = 50μA	I_C = 0	1	—	—	1	—	—	V
h_{ib}	Input Impedance	V_{CB} = 20V	I_E = −1mA	30	50	80	30	50	80	Ohm
h_{ob}	Output Admittance	V_{CB} = 20V	I_E = −1mA	—	0.2	1	—	0.2	1	μmho
h_{rb}	Feedback Voltage Ratio	V_{CB} = 20V	I_E = −1mA	—	200	2000	—	300	2000	X10⁻⁶
h_{fb}	Current Transfer Ratio	V_{CB} = 20V	I_E = −1mA	0.95	0.985	—	0.975	0.99	—	—
h_{FE}	DC Beta	V_{CE} = 5V	I_C = 10mA	20	35	55	45	80	150	—
$f_{\alpha b}$	Frequency Cutoff	V_{CB} = 20V	I_E = −1mA	10	20	—	20	30	—	mc
C_{ob}	Collector Capacitance*	V_{CB} = 20V	I_E = −1mA	—	1.2	3	—	1.2	3	μμf
R_{cs}	Saturation Resistance†	I_B ‡	I_C = 10mA	—	75	150	—	75	150	Ohm
h_{fe}	Current Transfer Ratio	V_{CB} = 20V	I_E = −1mA, f = 2.5mc	14	22	—	20	24	—	db
t_r	Rise time§			—	0.05	—	—	0.06	—	μsec
t_s	Storage Time			—	0.02	—	—	0.02	—	μsec
t_f	Fall time			—	0.08	—	—	0.14	—	μsec

* Measured at 1 mc † Common Emitter ‡ I_B = 1mA for 2N337, 0.5mA for 2N338 § Includes delay time (t_d)

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MA 2-1661

CIRCLE 84 ON READER-SERVICE CARD

◀ CIRCLE 85 ON READER-SERVICE CARD

NEW PRODUCTS

Nylon Screws 378

For use in electronic assemblies, these precision molded nylon screws come in these thread sizes: No. 0-80, No. 1-72, and No. 4-90.

Gries Reproducer Corp., Dept. ED, 125 Beechwood Ave., New Rochelle, N.Y.

Oscillator Packages 379

This complete line has a frequency range of 400 cps to over 100 mc. The units are transistorized and are made to withstand extreme environmental conditions.

Monitor Products Co., Dept. ED, 815 Fremont, S. Pasadena, Calif.

Silver Solder Preforms 380

For automatic soldering at 1600 to 1800 F, they are available as rings, discs, washers, pellets, castings, balls, and special shapes.

Alloys Unlimited, Inc., Dept. ED, 21-01 43rd Ave., Long Island City 1, N.Y.

FM Telemetry Radio Link 381

Operates in the 400 to 406-mc band. Model KT transmitter has 2-w rf output. Model KR receiver has a low noise rf stage and automatic frequency control. An airborne version is also available.

Amtron Corp., Dept. ED, 17 Felton St., Waltham 54, Mass.

Socket 382

For tube type 7462, it occupies 27/32 x 7/16 x 11/64 in. Able to stand temperatures to 400 F, it has five contacts made of beryllium copper and plated with both silver and gold.

Jettron Products, Inc., Dept. ED, 56 Route 10, Hanover, N.J.

Winding Tube 383

Class H type, is made of silicone bonded glass cloth and mica mat. It has high dielectric characteristics, is low in moisture absorption, and is easily handled. Square, rectangular, and round tubes are available in sizes from 3/16 x 3/16 in. to 10 x 10 in.

Accurate Paper Tube Co., Inc., Dept. ED, 806 N. Peoria St., Chicago 22, Ill.

Seismic Switches 384

Series 29000 senses any pattern of accelerations occurring in a missile. Made for use where two or more switches would ordinarily be required, they have a current capacity of 1 amp dc resistive, a leakage resistance of 250 meg min, and operate in the ambient temperature range of −40 to +250 F.

Aerodyne Controls Corp., Dept. ED, 1783 New York Ave., Huntington Station, N.Y.

Power Supply 395

Output is 250 v max

Model HCVS-250-20 power supply, providing a maximum output of 250 v at 20 amp, is used primarily for tantalum capacitor production, precision electroplating, and battery charging. When on constant current operation, the supply will automatically switch to constant voltage operation upon reaching a predetermined voltage due to load resistance buildup.

Matthew Labs., Dept. ED, 3344 Fort Independence St., New York 63, N.Y.

Cathode Ray Tube 398

For use at altitudes to 35,000 ft

Type 3ASP7 cathode ray tube is rated for use at altitudes to 35,000 ft. Designed to give good pulse display at low duty cycles, it has sensitivities of 33 v per in. vertical and 80 v per in. horizontal, under a typical anode voltage of 2000 v. The anode is brought out separately. Length is less than 9 in.

Waterman Products Co., Inc., Dept. ED, 2445 Emerald St., Philadelphia 25, Pa.

NEW PRODUCTS

Spectrum Analyzers 370

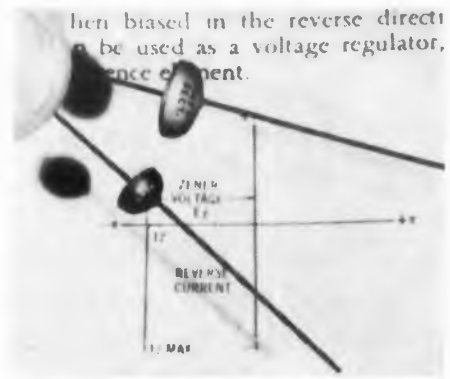
Sweep linearity ±1%

These three models of transistorized spectrum analyzers cover frequency ranges of 25 to 10,000 cps, with bandwidth resolutions of 20, 95, and 290 cps, and a sweep linearity of ±1%. Made for use in airborne telemetry applications, they are compatible with IRIG telemetry systems. The requirements of MIL-E-8189 for vibration, shock, and altitude are met and the operating temperature range is 0 to 160 F. The adjustable sweep period is 1 to 22 sec. Power required is 25 to 29 v. The devices occupy less than 25 cu in. and weigh less than 16 oz.

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

Silicon Zener Diodes 405

Come in ratings of 500 mw and 1 w



Designed specifically for commercial equipment applications, these silicon Zener diodes are available in ratings of 500 mw and 1 w. They have standard RETMA 10% voltage steps from 5.6 to 27 v. A three-layer seal is used to provide resistance to humidity, shock, vibration, and temperature extremes. The diodes have low Zener impedance values and sharp Zener knees.

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

Permeance Transducers 387

Temperature range is −325 to +1000 F

These variable permeance transducers have a temperature range of −325 to +1000 F. The sensing slug is a high temperature compensated alloy with a Curie point of 1580 F. The phase change is 180 deg at the null point. Full scale senstivity is 0.2 to 0.4 v per v. The linearity is ±0.3% to ±0.75% and the linear ranges are ±0.04 to ±1 in. The thermal coefficient of sensitivity is less than 0.003% of full scale per deg F.

Technical Industries Corp., Dept. ED, 389 N. Fair Oaks Ave., Pasadena, Calif.

CIRCLE 92 ON READER-SERVICE CARD ▶

Leveler Amplifier 430

Gain is 6 x 10^6

Model 700 dc leveler amplifier has a gain of 6×10^6. Used with an external crystal detector and directional coupler, it can hold rf output from single frequency or swept microwave sources constant to ±0.1 db. With proper rf components, power varies less than ±0.5 db over L, S, C, and X bands at slow and fast sweep speeds. The unit can also be used as a broadband attenuator with a 30-db dynamic range. The unit operates with cw signals and an internal square wave generator will modulate the rf signal. Input is 3 mv to 1 v and output is 100 v max in the range of −50 to +100 v. Frequency response is dc to 100 kc.

Alfred Electronics, Inc., Dept. ED, 897 Commercial St., Palo Alto, Calif.

Servo System 431

Has a linearity of ±0.1%

Designed to provide servo controlled attenuation of signal level for a specific input function, model 801 servo motor has a linearity of ±0.1%. Resistances are 1000 to 100,000 ohms, resolution is as low as 0.03%, and power rating is 1.5 w per element. The unit operates in the temperature range of −65 to +200 F. Rotary potentiometers with straight windings instead of curved resistive elements are used. Each potentiometer can be supplied with its own independent function so that simultaneous control, feedback, and telemetry signal can be provided. The instrument provides a network of up to seven gangs of servo driven potentiometers. The environmental requirements of MIL-E-5272A are met.

Bourns, Inc., Dept. ED, P.O. Box 2112, Riverside, Calif.

CIRCLE 92 ON READER-SERVICE CARD

NEW PRODUCTS

Pressure Transducer 450

Delivers to 1.5 v ac or to 100 mv dc

The Compu-tran low pressure transducer delivers high level output signals, up to 1.5 v ac or up to 100 mv dc, with accessory demodulator. Standard ranges are from 0 to 1.5 psi to from 0 to 60 psi, with four intermediate ranges. Accuracies are to ±0.15% of full range. The sensing element has excellent hysteresis characteristics, and allows close-tolerance performance over a wide temperature range. The instrument is sealed in a NEMA class IV housing, permitting operation in humid or corrosive environments. Various forms of the instrument are available, for the measurement of gage, differential, and absolute pressure.

International Resistance Co., Dept. ED, 401 N. Broad St., Philadelphia 8, Pa.

Voltage Standards 448

Two standard models offered

The Evenvolt constant voltage unit can be a temperature-compensated model which replaces the dry cell, the standard cell, the stand-

CIRCLE 94 ON READER-SERVICE CARD

...dizing rheostat, and the standardizing mechanism. Also available, the non-compensated model is used to replace the dry cell in instruments having standardizing circuits. In both models 110 v ac at 60 cps is converted to dc with a 20% input voltage variation reflected in a maximum output variation of ±0.04%. Potentiometers which ordinarily use dry cells are easily converted to utilize this unit. Since there are no tubes or other short-life components, the service life is estimated at 10 yr or more.

InstruLab, Dept. ED, 1205 Lamar St., Dayton 4, Ohio.

Microwave Switches 452

Cover the range of 8.2 to 12.4 kmc

Models X-160 and X-160R X-band switches cover the frequency range of 8.2 to 12.4 kmc and provide, respectively, 40 and 50 db isolation over the entire band. Model X-160R also includes an internal relay that permits remote, low current energizing of the actuating solenoid. Both models meet a wide range of applications in microwave systems, including the elimination of interference and ground returns in testing several radars at the same location and insuring radar silence while a radar transmitter is in operation. Insertion loss is less than 0.2 db and vswr is 1.1:1 max. Peak power capacity is 350 kw at atmospheric pressure and switching time is 0.05 sec. Both units measure less than 6 x 3 in. and weigh about 2 lb.

Radar Measurements Corp., Dept. ED, 190 Duffy Ave., Hicksville, N.Y.

CIRCLE 95 ON READER-SERVICE CARD

NEW PRODUCTS

Slip Ring And Brush Assemblies 436

For rotary antennas

This line of slip ring and brush assemblies is made for use in rotary antenna arrays. Of modular construction, these units can be furnished with 3 to 40 circuits to fit shafts from 1/4 to 1 in. in diam. The assemblies include Teflon-insulated leads, silver graphite brushes, and stainless steel bores.

Rotary Devices Corp., Dept. ED, 40 Jay St., Englewood, N.J.

Totalizers 445

Modular type

For applications such as multiple-lap coil winding, length cutting, and periodic thickness measurement, series 550 preset totalizers provide accuracies to 100,000 events per sec. Of modular construction, the units have in-line thumb-wheel switches for adjustment of count totals. Transistors and cold-cathode tubes are used throughout. A batching register is optional with the unit.

Iconix, Inc., Dept. ED, 945 Industrial Ave., Palo Alto, Calif.

Ferrite Isolator 446

Frequency range is 2.1 to 4.3 kmc per sec

Made for use in telemetry, radar systems, and transponders, model WD-2106 S-band ferrite iso-

lator has a frequency range of 2.1 to 4.3 kmc per sec. Isolation is 20 db min, insertion loss is 2 db max, and the input vswr is 1.5 max with a type N connector. Peak power is 1000 w max and average power is 5 w max. The unit operates in ambient temperatures to 65 C.

Kearfott Co., Microwave Div., Dept. ED, 14844 Oxnard St., Van Nuys, Calif.

Decimal Digitizer 415

Has 3, 4, 5, or 6 decades

Available in 3, 4, 5, or 6-decade units, this decimal digitizer is a nonambiguous electromechanical shaft position encoder of the absolute positional, multispeed type. It provides straight decimal contact output. Able to make 10, 40, 100, 400, and 1000 counts per rotation, the unit has continuous or demand readout. It operates parallel entry printers directly.

Coleman Electronics, Inc., Dept. ED, 133 E. 162nd St., Gardena, Calif.

High Temperature Capacitors 440

Size is 0.1 x 0.1 x 0.1 in.

The K2R and K2T capacitors measure 0.1 x 0.1 x 0.1 in. and offer good performance in temperatures to 150 C. Capacitances are from 10 to 18,000 μμf with 5%, 10%, and 20% guaranteed minimum values. The dielectric strength is tested to 800 v.

King Electronics, Inc., Dept. ED, S. Pasadena, Calif.

NEW PRODUCTS

Temperature Chamber 432

Range is −100 to +500

Series 1060 portable temperature chamber offers temperatures of −100 to +500 F controlled to within ±0.2 F.

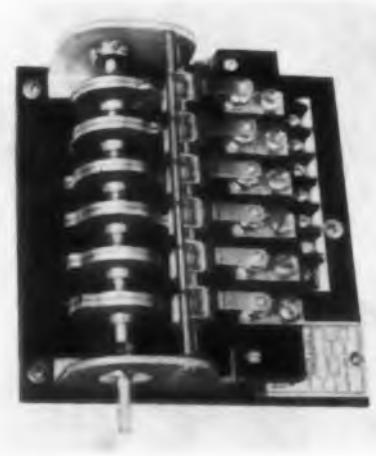
Control is maintained by a meter-relay in conjunction with a copper-constantin thermocouple. The unit operates on 117 v ac and contains a centrifugal blower to assure temperature uniformity throughout the test space.

The series includes a rack mounted model with a test volume of 10 x 7 x 7 in., two bench models with the same test volume, and a wide drawer model with a test volume of 16 x 7 x 7 in.

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

Rotary Cam Limit Switches 433

With 2 to 16 individual circuits



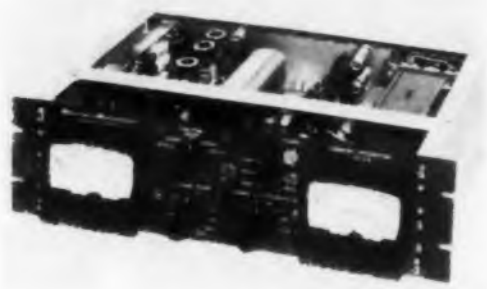
These rotary cam limit switches having from 2 to 16 individual circuits will operate at speeds up to 300 rpm. Of heavy duty construction, they have 3/8-in. coin silver contacts rated at 15 amp, ball bearing supported cam shaft, nylon roller cam followers, and 2-in. diam nickel-plated cams with assured accuracies to 0.5%.

The 1/4-in. cam shaft extends beyond the bearing mounting for connection to an external drive.

Eagle Signal Co., Dept. ED, 202 Twentieth St., Moline, Ill.

Current Integrator 434

Current Range is 10^{-9} to 10^{-3} amp dc



Having a current range of 10^{-9} to 10^{-3} amp dc, model CI-110 current integrator measures the amplitude of an input current or voltage and simultaneously integrates this input with respect to time. The charge range is from 0.045 μa-sec to 50 amp-sec. The integrating capacity is 0 to 50 coulombs. Accuracy on all ranges is better than 1%. Modular packaging is used with all basic elements counted on plug-in circuit cards so the instrument can be modified to meet specific requirements.

Eldorado Electronics, Dept. ED, 2821 Tenth St., Berkeley 10, Calif.

Servo Indicator 437

Input impedance is 100,000 ohms to 1 meg

Model 20-200-4 aircraft servo indicator has an input impedance of 100,000 ohms to 1 meg. Completely contained in a MS-33639 hermetically-sealed case 2 in. in diam and 5 in. long, the indicator operates in a ambient temperature range of −55 to +70 C. Sensitivity is 0.1%, gain is 10,000, and slewing time is about 4 sec for full scale. Silicon transistors are used and the self-contained power supply requires an input of 115 v at 400 cps. The unit is suitable for use when it is necessary to drive several indicators from the output of a variable inductance transducer.

Servo Development Corp., Dept. ED, 567 Main St., Westbury, L.I., N.Y.

CIRCLE 99 ON READER-SERVICE CARD

CIRCLE 100 ON READER-SERVICE CARD

NEW PRODUCTS

DC Power Supply 438

Regulation is better than ±0.1%

Type PS4022 transistor-regulated power supply provides 4.5 to 9 v dc with load currents from 0 to 10 amp. Total regulation is better than ±0.1% change in set output voltage for any combination of input voltage or load current conditions. Ripple and noise are less than 2 mv rms. Input is 105 to 125 v, 57 to 63 cps or 380 to 420 cps. Temperature stabilization insures minimum drift in the output for operating temperatures from −20 to +65 C. Output impedance is less than 0.02 ohms from dc to 1000 cps. Voltage across the output is set by a three-step range switch and a vernier potentiometer.

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

Inertia Damper 435

Viscous-coupled

Designed for use where high velocity and high torque constants with good stability are required, this viscous-coupled inertia damper replaces tachometers, networks, and other servo stabilizers. Performance is not affected by line frequency shift. Two models are available with diameters of 1.52 or 1.79 in., and with ten time constants ranging from 0.02 to 1.2 sec. Damping action is factory set.

Feedback Controls, Inc., Dept. ED, 8 Erie Drive, Natick, Mass.

Lever Switch 449

For multicircuit control

Type Ma-12-L miniature lever-actuated switch provides multi-circuit control for low power and electronic circuits. The assembly can be furnished in one or two sections, giving up to 12-pole switching. The electrical ratings are: 3 amp continuous current at 115 v ac; interrupting rating, 1.2 amp at 115 v ac; and voltage breakdown, 1000 v rms. The insulation of both stationary and movable contacts is molded of alkyd type MAI-60 as per MIL-M-14E.

Electro Switch Corp., Dept. ED, 167 King Ave., Weymouth 88, Mass.

Refrigeration Equipment 453

Provides temperatures to —120 F

These one-piece mechanical refrigeration assemblies, called Kold-Pak, provide low temperature mediums to an enclosure through heat exchangers that can be connected to the required flow lines. They can be the direct expansion type, with freon refrigerants passing through a separate heat exchanger, or the brine chiller type with a liquid acting as a secondary cooling agent. Twelve standard models are offered with the following capacity span: at —40 F brine temperature or —60 F evaporator temperature, the capacity is 3240 to 34,000 BTU per hr; at —100 F brine temperature or —120 F evaporator temperature, capacity ranges from 660 to 7000 BTU per hr.

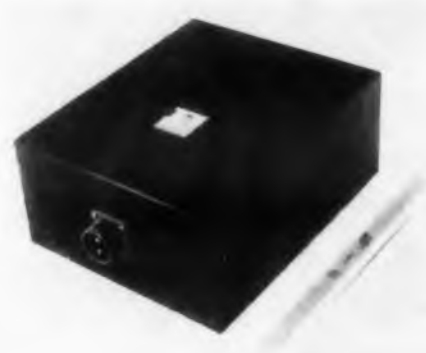
Tenney Engineering, Inc., Dept. ED, Union, N.J.

CIRCLE 105 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Inverter 447

Efficiency is 82% at full load



This 2-kva static inverter has an efficiency of 82% at full load and of better than 77% at half load. Regulation is ±2% from 30% of load to full load. A three-phase unit, it has no moving parts, vacuum tubes, or transistors in high current circuits. Silicon semiconductor elements are used. The output is a nearly perfect sine wave. The input voltage is 26 to 29 v dc and the output is 115 v ac ±2%. The power factor is unity to 0.85. The inverter will supply 150% of rated current for 15 min and 200% for 5 min. Designed for missile and aircraft use, it meets all the MIL-E-5272 requirements.

Kinetics Corp., Dept. ED, 410 S. Cedros Ave., Solana Beach, Calif.

Microwave Cavities 441

For frequencies from 5925 to 7759 mc

These microwave cavities, tunable over a 10% frequency range, are available for frequencies from 5925 to 7750 mc. They can also be designed for frequencies from L-band through Ku-band. When used with a waveguide discriminator, they control the frequency of transmitting klystrons to conform to FCC specs.

Portchester Instrument Corp., Dept. ED, 114 Wilkins Ave., Port Chester, N.Y.

Polystyrene Capacitors 454

Maximum drift is ±0.1%

These polystyrene dielectric capacitors have a maximum drift of ±0.1% under long-term, fully rated operating conditions. The capacitance range is 0.002 to 5 μf at voltage ratings of 100 to 1000 wvdc. The operating temperature range is −55 to +85 C, and the dielectric absorption is 0.1% max. The dissipation factor is 0.02% at 1 kc, the temperature coefficient −120 ±15 ppm per deg C, and the standard tolerance ±5%.

Arco Electronics, Inc., Dept. ED, 64 White St., New York 13, N.Y.

Electromechanical Timer 455

Ranges are 100 to 1000 msec

Type TMC-PG-2 electromechanical timer is independently variable for both on and off time, with on-time ranges of 100 to 1000 msec and off-time ranges of 50 to 100 msec. This transistorized unit is designed for use with stepping motors and stepping switches, for sequence timing and as a high-power, square-wave generator. It is built for free-running or triggered operation with a power requirement of 50 ma over an ambient temperature range of −55 to +125 C.

Timech Corp., Dept. ED, 13866 Saticoy St., Van Nuys, Calif.

Magnetic Amplifier 456

Furnishes 0 to 1 ma dc

Model 1532 magnetic amplifier furnishes 0 to 1 ma dc for any signal input from 0 to 1 μa through 0 to 60 μa. The unit uses signals derived from a photo-multiplier tube, thermocouple or other sensing device and drives an ink recording device. Ranges are overlapping to permit continuous adjustment. Amplifier ranges can be set by adjusting the potentiometers. The excitation voltage is 115 v ±10%, 60 or 400 cps.

Lumen, Inc., Dept. ED, P.O. Box 965, Joliet, Ill.

CIRCLE 108 ON READER-SERVICE CARD ➤

NEW PRODUCTS

DC Power Supply 418

Is rated at 40 kv at 1 ma

This dc power supply is rated at 40 kv at 1 ma and 35 kv at 5 ma. The output is varied over the full range by varying the input. Ripple is 0.5% per ma. The unit uses selenium rectifiers immersed in insulating oil. Filled with oil, the supply weighs 70 lb. Its dimensions are 10 x 12 x 11 in.

Del Electronics Corp., Dept. ED, 521 Homestead Ave., Mt. Vernon, N.Y.

Reversible Decade Counter 419

Rise time is less than 1 μsec

Applicable to industrial operations such as flow, tally, and computing, this reversible decade counter requires a positive input transistion of 2 to 3 v in amplitude with a rise time of less than 1 μsec or a pulse greater than 0.25 μsec in width. It operates at counting rates of 100 kc or better in either direction. The input pulse trains may be derived from a single source, or multiple sources for addition and subtraction. Isolated output signals are provided for driving external output devices such as printer drives, predetermined count detectors, and digital-to-analog converters. Binary coded decimal indication may be self-contained or separate in-line decimal indicators can be furnished. The components are

mounted on a card measuring 4-1/2 x 8 in.

Victor Adding Machine Co., Dept. ED, Chicago 18, Ill.

Neutron Detector Tube 417

Is photosensitive

Type K-1578 neutron detector tube is used with standard multiplier phototube circuitry. It can be used as a quantitative detector and can differentiate between thermal neutrons, gamma radiation, and high speed neutrons. The cathode is a cascade type with a neutron sensitive coating deposited internally on the window. The tube is an end-window multiplier type having ten stages. Its diameter is 2 in.

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

DC Power Supplies 416

Provide 1000, 3000, and 5000 v

This line of dc power supplies includes units which provide 1000, 3000, and 5000 v with current ratings at 2 ma. Required input is 105 to 125 v ac, 60 or 400 cps. Line or load regulation is better than ±0.5% and ripple is less than 1% rms. Units which operate from an input of 26 to 29 v dc are also available. Made for high voltage applications, including cathode ray indicators, klystron and microwave tube powering, and scintillation counters, these power supplies employ static semiconductor designs.

Era Pacific, Inc., Dept. ED, 1760 Stanford St., Santa Monica, Calif.

NEW PRODUCTS

Miniature Solenoid 444

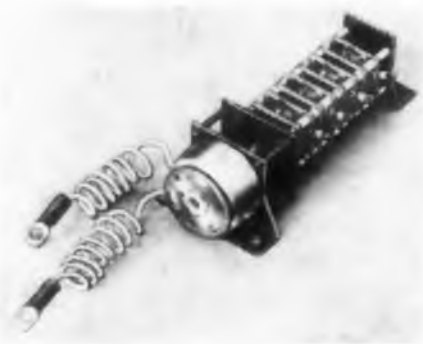
Ac or dc type available

No. 28 Midget solenoid, ac or dc, intermittent or continuous duty, has over-all dimensions of 1-1/8 x 1 x 1-3/16 in. and weighs about 3.5 oz. It has a tapered plug and plunger for greater power. Plunger strokes are from 1/16 to 1/2 in. with a lift of over 41 oz.

Guardian Electric Manufacturing Co., Dept. ED, 1621 W. Walnut St., Chicago 12, Ill.

Solenoid-Operated Switches 442

Have up to five poles



Type MA-12-S solenoid-operated rotary switches provide for remote control of multiple circuits. Up to five poles, in a tap switch arrangement having 12 taps per pole, can be supplied. The solenoid coil is for dc voltages from 6 to 230 v. Self-interrupting contacts as well as rectifiers for ac operation are also available. Insulation is molded alkyd type MAI-60 as per MIL-M-14E. The basic switch is designed to meet MIL-S-3786. The following characteristics are supplied to meet customer specifications: pulsing method, frequency of operation, number of operations, and ratio of energized time to de-energized time.

Electro Switch Corp., Dept. ED, 167 King Ave., Weymouth 88, Mass.

ACTUAL SIZE

Amazing, New, High Inductance WEE-DUCTOR

The R.F. Choke that's so small you can pack 200,000 to a cubic foot

Tiny, new, WEE-DUCTOR covers a full range of inductances from 0.10 μH to 56,000 μH yet it measures only 0.157" x 0.375".

Unique ferrite sleeve and core construction provides 560,000 to 1 inductance range in a tiny package . . . and yet when assembled side-by-side, exhibit less than 2% coupling.

Essex WEE-DUCTORS are available immediately from stock. WEE-DUCTORS are the latest addition to Essex's broad line of Standard R.F. Choke Coils.

Essex Electronics Standard Line of R.F. Chokes

ESSEX PART NO.	WEE-DUCTOR	RFC—S	RFC—M	RFC—L
L μH	.1-56,000	.1-100	1.0-1,000	1.0-10,000
Max. Res. Ω	.035-499	.02-6.0	.04-21	.03-80
I Max. mA	3000-26	4000-220	2700-125	4000-80
Dia.	.157	.188	.250	.310
Length	.375	.440	.600	.900

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CIRCLE 112 ON READER-SERVICE CARD

Dual Potentiometers 439

Diameters are 7/8 to 3 in.

These dual potentiometers have diameters from 7/8 to 3 in. and are 53/64 in. thick. They are precision single-turn units with linearity to 0.05%, low torque, and a life in excess of 2,000,000 operations. They operate to 150 C and have good electrical characteristics with a resistance of 200 K. Made to meet Mil specs, they are gangable to 30 units. A sixed-ganged unit is shown here.

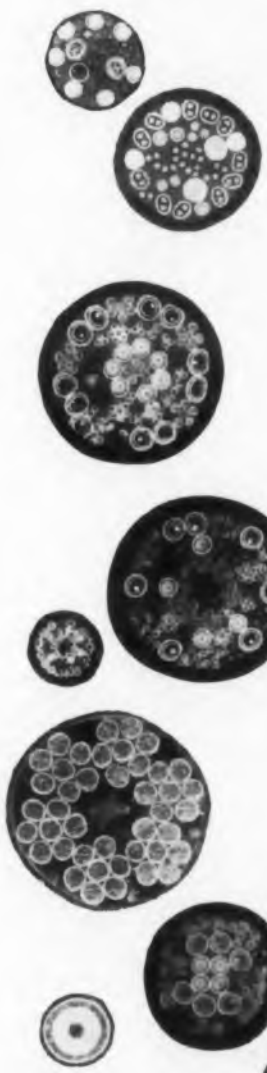
Me-Mar Electronics Corp., Dept. ED, 2176 E. Huntington Drive, Duarte, Calif.

Magnetic Tape Tensiometer 443

For 1/2 and 1/4-in. tapes

Designed to measure and record steady-state and transient tensions of magnetic tape during use in tape recorder transports, model K-44 magnetic tape tensiometer handles 1/2 and 1/4 in. tapes. The tensiometer may be inserted at any point in a tape path having a clear area of 3/4 x 3/16 in., and a minimum clearance between the recorder deck and the inner tape edge of 1/4 in. The instrument has a useful range to 8 lb. When properly installed and balanced, the tensiometer has a useful dynamic range of better than 60 db. The instrument responds to tension transients having rise times of 1 msec or less.

General Kinetics, Inc., Dept. ED 555 23rd St. S., Arlington 2, Va.



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Pacific Division: 1516 N. Gardner St., Los Angeles, California

® Du Pont

CIRCLE 113 ON READER-SERVICE CARD

NEW PRODUCTS

Static Inverter 458

For airborne use

Designed for airborne use, model 4312 500-va static inverter has special sealing for high altitudes. Operating from 28 v dc, it produces both single and three-phase power. Single-phase voltage output is regulated to ±5% for input and load changes. A phase adapter converts some of the single phase output to three-phase power for operating gyros. The frequency regulation is ±0.1% and the maximum harmonic content is 5%. The unit measures 5 x 8 x 10.5 in. and weighs 15 lb.

Varo Mfg. Co., Inc., Dept. ED, 2201 Walnut St., Garland, Texas.

Peak Accelerometer 459

With ranges to 1000 g

Designed to measure true peak gravity in shock and vibration tests, this accelerometer has four ranges for accelerations to 1000 g. A barium titanate transducer is connected to an amplifier and an indicator unit. It retains the peak reading for 15 sec for shock measurements, or follows peak acceleration reading when the instrument is measuring vibration. The instrument has a 3.5-in. meter with a mirror scale and a knife-edged pointer. Dimensions are 13.25 x 10.25 x 6.5 and the weight is 15.75 lb.

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

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.

Grid Dip Meter Kit 386

Covers the range of 1.5 to 300 mc in six overlapping ranges. Called Knight-Kit model G-30, its applications include adjusting wave traps, pruning antennas to proper length, detecting parasitic oscillations in transmitters, and modulation monitoring. It operates from 110 to 120 v ac, 50 or 60 cps.

Allied Radio Corp., Dept. ED, 100 N. Western Ave., Chicago 80, Ill.

Volt-Ohm Meter 385

No. 83 Y 708 Knight-Kit reads in 13 ranges at a sensitivity of 1000 ohms per v dc. Ranges are: 0, 5, 15, 50, 150, and 500 v dc; 0, 15, 50, 150, and 500 v ac; 0, 1, 10, and 100 ma dc; and 0 to 30,000 ohms. Supplied with battery and test leads, the unit is portable.

Allied Radio Corp., Dept. ED, 100 N. Western Ave., Chicago 80, Ill.

Transistorized Interval Timer 420

Type 308 has heavy-duty dpdt control contacts rated for 15 amp at 115 v ac, 10 amp at 230 v ac, and 4 amp at 115 v dc. Made for industrial use, it requires no warm up time and mounts in a 3-3/16-in. diam panel cut-out.

Automatic Timing and Controls, Inc., Dept. ED, King of Prussia, Pa.

Electronic Thermometer 422

Provides direct readings in deg F and has push-button selection of 12 ranges from −425 to +800 F. Accuracy is 1/2 deg F over most of the range. Power supply can be a self-contained C battery or a 110 v ac 60 cps source. The instrument weighs 12 lb and measures 10 x 9 x 6 in.

Trans-Sonics, Inc., Dept. ED, Burlington, Mass.

Silicon Solar Cells 423

Have thin, optically-coated coverglass. They are claimed to provide optimum reflection properties and high thermal emissivity.

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

Torquemeter 424

Measures torque from several shafts on the same indicator. Up to five torque pickup heads are used. Covering the range of 0.1 to 500 oz-in., the instrument has an accuracy of ±2% full scale. Torque readings are independent of shaft speeds from 50 to 24,000 rpm.

Metron Instrument Co., Dept. ED, 432 Lincoln St., Denver 3, Colo.

NEW PRODUCTS

DC Power Supply 472

Ripple is 100 mv rms max

Model KM75B power supply has a ripple of 100 mv rms max throughout the range of 0 to 32 v dc and 0 to 5 amp. Input is 115 v ac, 60 cps, single-phase. The voltage regulation provides a maximum change of 3 v when the load current changes from 0.5 to 5 amp.

Opad Electric Co., Dept. ED, 43 Walker St., New York 13, N.Y.

Paper Tape Perforator 473

Operates at 60 characters per sec

Designed to accept tape of varying widths up to 8 channels, this tape perforator punches tapes at rates of 60 characters per sec. It prepares tape from keyboards, tape reproducers, digital counters, and digital data handling systems. Two models are offered: model 420PF panel-mounted unit for fan fold tape handling, and model 420PR which uses reels.

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

Shift Register 474

Has 3 inputs and 8 outputs

Model 1801 4-stage shift register has 3 inputs and 8 outputs and may be cascaded to form a multistage shift register. The unit replaces 4 standard flip-flop units.

Harvey-Wells Electronics, Inc., Research and Development Div., Dept. ED, E. Natick Industrial Park, Natick, Mass.

Indicator Lights 451

Neon and incandescent types

Type 1BG1, 3, and 4 neon and type 1BF1, 3, and 4 incandescent lamps are available with round and with short or long flat lenses. The incandescent lamps are rated at 2.5 to 60 v. The neon units may have encapsulated resistors and can be supplied with or without insulated leads. All types mount in a 0.316-in. diam hole in panels with up to 1/8 in. maximum thickness.

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

Frequency Meter and Counter 457

Has time periods of 0.1, 1, and 10 sec

For production or laboratory use, model WE-120L frequency meter and counter has time base periods of 0.1, 1, and 10 sec. It has a maximum sensitivity of 75 mv over the range of 10 to 100,000 cps. Stability is ±0.001% ±1 count. The unit has a variable display time of 0.5 to 5 sec. It uses cold-cathode decade glow transfer tubes for both digital presentation and digital division of the 100-kc crystal controlled time base frequency. For mounting on a 5-1/4 x 19 in. rack, the unit is 6-1/2 in. deep. Model WE-120 measures 6 x 11 x 9 in. and is portable.

Westport Electric, Dept. ED, 149 Lomita St., El Segundo, Calif.

CIRCLE 118 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Pump Motor 460

Sizes are 0.5 to 5 hp

Made in sizes from 0.5 to 5 hp, this stainless steel canned pump motor handles nuclear contaminated, highly corrosive, and highly volatile liquids. Typical characteristics for the 0.75-hp motor are: rated speed, 1100 rpm; voltage, 220 v, three-phase; efficiency at full load, 60%; locked rotor torque, 180% at full load; and maximum breakdown, 250% of full load.

H. K. Porter Co., Inc., Peerless Electric Div., Dept. ED, Warren, Ohio.

Blower 461

Delivers 51 cfm free air

Model BT2910B high pressure blower delivers 51 cfm of free air at 7.6 in. of water SP. It operates over the temperature range of −55 to +85 C and meets Mil specs for humidity, salt spray, sand, dust, shock, and vibration. Operating speed is 11,250 rpm and input is 85 w at 0.33 amp. The standard unit is designed for an input of 208 v, 400 cps, three-phase; a 115 v, 400 cps, single-phase unit is also available. The temperature range may be extended to 125 C. Weight of the unit is 3.1 lb.

Induction Motors Corp., Dept. ED, 570 Main St., Westbury, L.I., N.Y.

Circuit Breakers 462

Provide tripping action in 25 msec

Series 500-1 electromagnetic circuit breakers provide tripping action in 25 msec on overloads of 150% of rated current. Having current ratings of 50 ma to 10 amp, the units are miniature and hermetically sealed. Designed for use at 50 v dc and 120 v ac rms max at 40 or 400 cps, they can be supplied in ganged assemblies to automatically trip two or three circuits when an overload occurs.

Airpax Electronics Inc., Cambridge Div., Dept. ED, Cambridge, Md.

Silicon Rectifiers 463

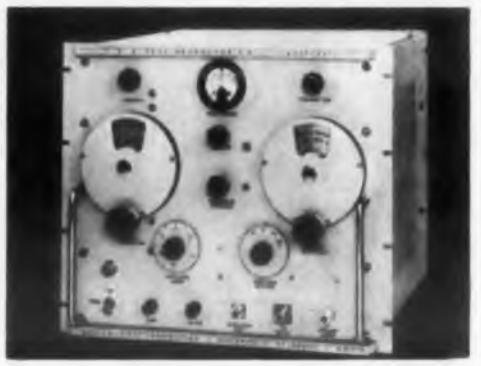
Are rated at 13.5 amp at 25 C

Type 21 silicon power rectifiers are rated at 13.5 amp avg at 25 C on a 3 x 3 x 1/16-in. copper sink. The piv range is 50 to 400 v, in steps of 50 v. Typical forward dynamic resistance is 0.009 ohms.

Syntron Co., Dept. ED, Homer City, Pa.

FM Signal Generator 464

Covers 1300 to 2500 mc



Developed for telemetry and data transmission applications, model 201B fm signal generator covers the frequency range of 1300 to 2500 mc in one band. Having a 1% deviation linearity, it can be frequency modulated by applying external signals with modulation bandwidths to 500 kc. A nominal deviation of 2 mc, peak-to-peak, is made by external-modulation signals having an amplitude of 1 v, peak-to-peak.

Sierra Electronic Corp., Dept. ED, 3885 Bohannon Drive, Menlo Park, Calif.

Vibration Tester 465

Operates at 420 to 1200 rpm

Used to determine errors in vibrating assembled products as they come from the production lines, type 400-U-SP vibration tester operates at a fixed displacement of 1/8 in. in the speed range of 420 to 1200 rpm.

The vibrations delivered will dislodge solder splatters, separate poor electrical connections, and detect improperly tightened fasteners. Uses include testing radio and TV assemblies, instruments, and electronic equipment.

L. A. B. Corp., Dept. ED, P.O. Box 278, Skaneateles, N.Y.

◀ CIRCLE 119 ON READER-SERVICE CARD

NEW PRODUCTS

High-Vacuum Pumps 466

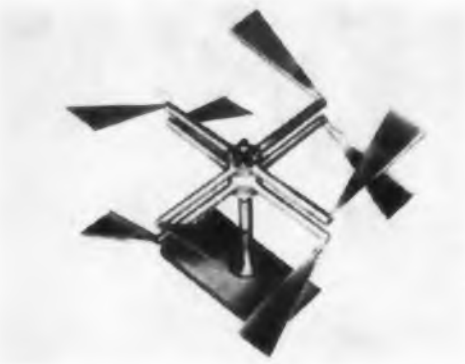
Produce vacuums below 1 x 10^{-9} mm Hg

Able to produce clean vacuums below 1 x 10^{-9} mm Hg, the 150 series of vacuum pumps weigh 13 lb, including magnet, and measure 6-1/4 x 7-3/4 x 5 in. For such applications as vacuum-tube processing and thin-film work, they have a pumping speed of 5 liters per sec. Model 150E has a pumping speed of 10 liters per sec and contains a replaceable multifilament evaporator which permits the injection of additional titanium.

Ultek Corp., Dept. ED, 920 Commercial St., Palo Alto, Calif.

Telemetry Antenna 467

Covers 216 to 260 mc



This circularly-polarized, omni-directional telemetry antenna covers 216 to 260 mc. For both transmitting and receiving, it has an impedance of 51 ohms and less than 2:1 vswr. For airborne applications, the antenna is supplied with a fiberglass radome measuring 1/8 in. thick. It is suited for ground use as well.

Dynatronics, Inc., Dept. ED, Box 2566, Orlando, Fla.

Converters 468

Replace dynamotors

These transistorized dc to dc and dc to ac converters replace dynamotors in both military and commercial equipment. The input voltage is 22 to 30 v dc. Input current is less than 25 amp. The output voltage is 1000 v dc at 0.5 amp or any ac voltage with 1500 w max power. The operating temperature is −55 to +85 C. Ripple is less than 6 v rms and regulation is 14% max from zero to full load. The units withstand an overvoltage to 34 v dc for 5 min. Operation life is better than 2500 hr continuous duty.

The Daven Co., Dept. ED, Livingston, N.J.

Epoxy Resin Equipment 469

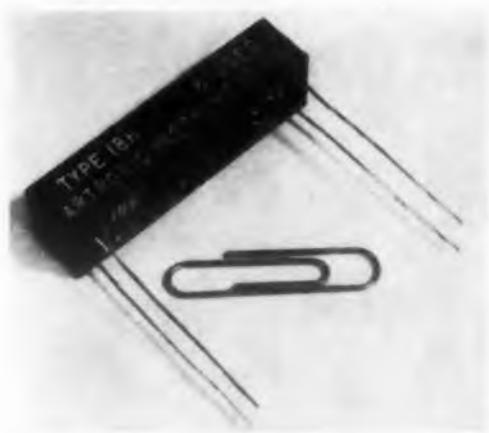
For potting coils and assemblies

Called the Auto-Rez-Mixer, this unit proportions, meters, mixes, and dispenses multicomponent reactive resins. Sharp cut-off of highly viscous or filled resins is provided, adjustable measured shots are dispensed on signal, and short pot-life resins can be easily handled.

C.P.M. Special Machinery Corp., Dept. ED, 324 Butler St., Brooklyn 17, N.Y.

Delay Lines 470

Delay time is 0.05 to 10 μsec



Type 18H and 18L lumped-constant delay lines have a delay time of 0.05 to 10 μsec. Delay tolerance is ±3% or ±0.01 μsec and rise time is 20% to 25% of delay time. Made to operate over the temperature range of −65 to +125 C, they have a temperature coefficient of delay of 0.005% per deg C. Offered in both high and low impedance types, they are designed for excellent pulse performance and for linear phase shift vs. frequency characteristics. Having leads of No. 22 gage wire and spaced on a 0.1-in. grid, the delay lines are to be plugged into printed circuit boards and dip-soldered into place. Test voltage is 600 v dc, working voltage is 300 v dc, and pulse voltage is 300 v peak. Epoxy resin construction is used and requirements of MIL-STD-202A are met.

Artronic Instrument Co., Dept. ED, 11232 Triangle Lane, Silver Spring, Md.

Silicon Rectifiers 471

Provide to 240 amp

Type 439 silicon power rectifiers provide up to 240 amp of forward current per cell with maximum piv ratings up to 600 v. The maximum reverse leakage current is 50 ma at rated piv. For operation to 190 C at the junction, they have solid copper bases and are a maximum of 3 in. long. A 3/4-in. stud permits mounting the cell in any position.

Westinghouse Electric Corp., Dept. ED, P.O. Box 2088, Pittsburgh 30, Pa.

NEW PRODUCTS

Diode 475

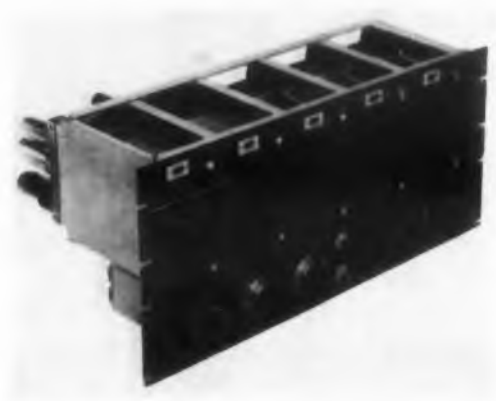
Germanium alloy type

Type 1N2326 germanium, alloy-junction diode is designed to compensate for the effects of temperature and supply voltage changes in the operation of class B push-pull af power amplifiers. The diode matches such transistors as types 2N217, 2N270 and 2N408. It withstands input variations up to ±40% and ambient temperature changes within the range of −20 to +71 C. Sealed in a metal case, the diode has a length of 0.405 in. and a diameter of 0.24 in.

Radio Corp. of America, Semiconductor and Materials Div., Dept. ED, Somerville, N.J.

Voltage Comparator 476

Has go/no-go indication



For automatic component testing, system checkout, or process monitoring, type DLI-205 dc voltage comparator has go/no-go indication. Operating time is 20 msec and absolute accuracy is 0.1%. The input voltage range is ±1 mv to ±100 v. The power requirement is 115 v at 60 cps.

Electro Precision Corp., Dept. ED, P.O. Box 669, Arkadelphia, Ark.

Pressure Switch 477

Life is 100,000 cycles

Type 95000 pressure actuated switch incorporates a snap action switch mechanism that is actuated by a piston, spring loaded against the pressure system. High overload pressure will cause complete close-off to protect the switching element. The switch has a life operation of 100,000 hr. Suitable for aircraft and missile use, it is applicable in systems having to 4000 psi. The weight is less than 7 oz.

Hydraulic Research and Manufacturing Co., Dept. ED, 2835 N. Naomi St., Burbank, Calif.

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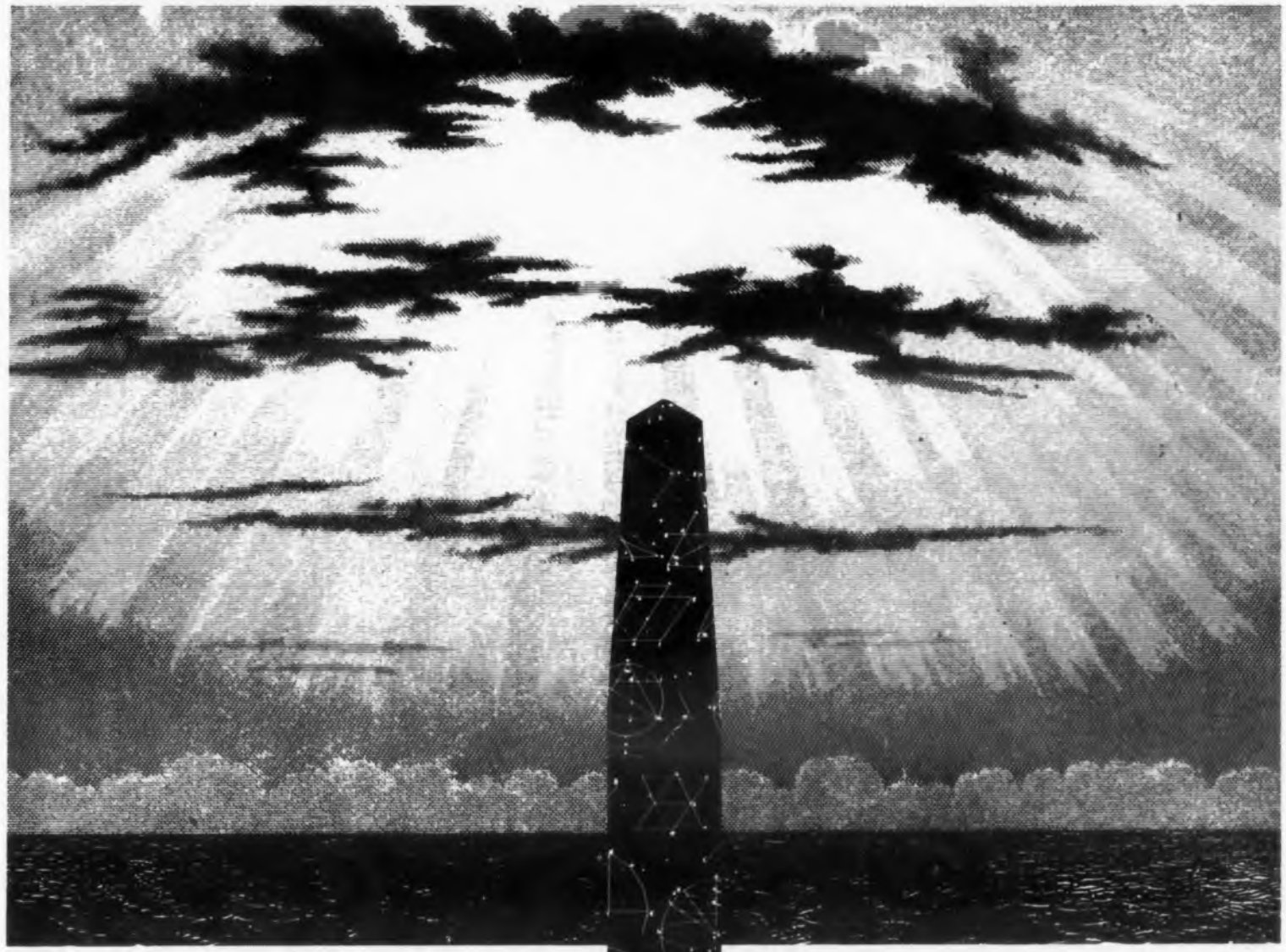
For full information
write to:

Mr. C. C. LaVene
Box 601-E
Douglas Aircraft Company, Inc.
Santa Monica, Calif.



The care and feeding of a missile system

It takes more than pressing a button to send a giant rocket on its way. Actually, almost as many man-hours go into the design and construction of the support equipment as into the missile itself. A leading factor in the reliability of Douglas missile systems is the company's practice of including all the necessary ground handling units, plus detailed procedures for system utilization and crew training. This complete job allows Douglas missiles like THOR, Nike HERCULES, Nike AJAX and others to move quickly from test to operational status and perform with outstanding dependability. Douglas is seeking qualified engineers and scientists for the design of missiles, space systems and their supporting equipment.

Alfred J. Carah, Chief Design Engineer, discusses the ground installation requirements for a series of THOR-boosted space probes with Donald W. Douglas, Jr., President of DOUGLAS

MISSILE AND SPACE SYSTEMS ■ MILITARY AIRCRAFT ■ DC-8 JETLINERS ■ CARGO TRANSPORTS ■ AIRCOMB ■ GROUND SUPPORT EQUIPMENT

NEW PRODUCTS

Ultrasonic Cleaner 487

Tank is 10.5 x 8.5 x 6 in.

Model 120 ultrasonic cleaner has a 2-gal tank which measures 10.5 x 8.5 x 6 in. and has rounded corners. For all standard applications, the unit has 24 sq in. of actual radiating surface and 27% of the tank bottom covered with driving elements. The generator is 115 v, 60 cps, and is designed for continuous operation.

National Ultrasonic Corp., Dept. ED, 111 Montgomery Ave., Irvington, N.J.

Silver-Zinc Battery 488

Provides two-level output voltage

The two sections in model P46A silver-zinc battery provide a heavy peak current as well as a steady power supply. A 20-cell section provides 25 amp at 28 v. Maximum current is 100 amp with a discharge time of 35 min at 25 amp. Capacity is 15 amp-hr. The 4-cell section supplies 6.3 v at 19 amp. Maximum current is 100 amp, discharge time is 35 min at 19 amp, and capacity is 11 amp-hr.

The temperature range is 40 to 80 F. The battery measures 7.25 x 9.75 x 10 in. and weighs 30 lb. It is suitable for missile use.

Cook Batteries, Telecomputing Corp., Dept. ED, 3850 Olive St., Denver 7, Colo.

Sub-system for the ground support equipment on the B-58 **Hustler** program. Measures AC and DC single-ended voltages and ratios, and AC and DC differential voltages and transients. Chosen for its excellent operating characteristics under adverse environments.

stems shown here are typical of more than 200 designed d built by EI and now in use. They range in complexity m data logging systems for automatic scanning, measement and recording of data from multiple transducers... high speed, automatic checkout systems for missile and craft... to systems for automating industrial processes.

Because of the EI modular design approach, many of se systems can be delivered on virtually an off-the-shelf is, eliminating the long delivery times usually associated h system development. This approach also results in a cost system because the modules are manufactured in e quantities. Cost is almost a linear function of permance capabilities desired.

ou get MORE with EI systems!

ORE VERSATILITY

and DC voltages, AC and DC voltage ratios, ohmic stances, capacitance, frequency, phase, inductance, time, combinations of these basic input quantities can be epted by the EI system.

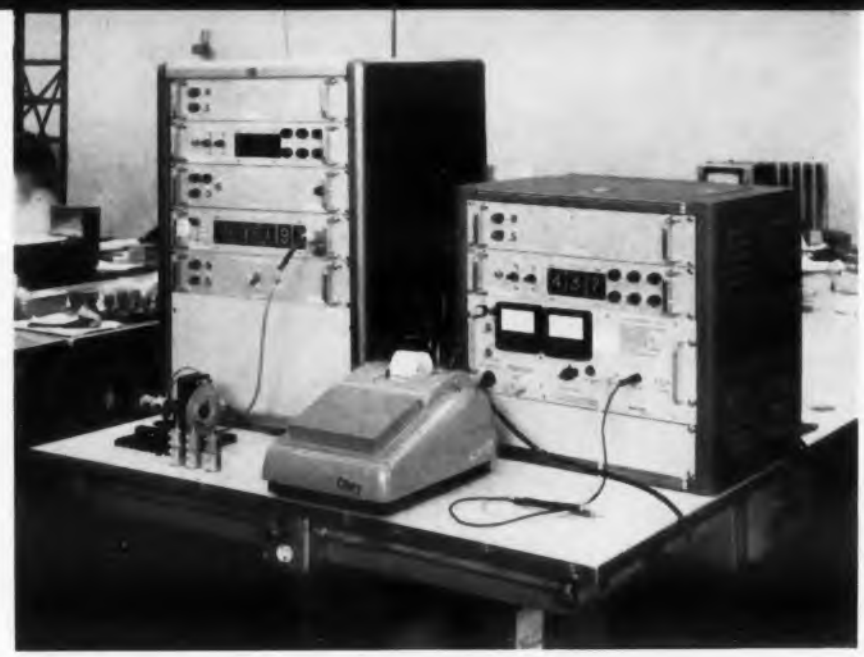
ORE RELIABILITY

ximum use is made of solid-state and MIL-type coments which are designed into conservatively-rated, fieldven circuits. All vendor-supplied parts are exhaustively ted and evaluated.

ORE FLEXIBILITY

pansion of the EI system can be made by simply adding propriate new modules. This approach eliminates new ineering development costs each time needs change; imizes system obsolescence.

Why not talk over your digital system requirements with r EI Sales Engineer? His system experience will be a able help in solving your problem.



Resistance measuring system – Used as a secondary standard to make accurate, resistance measurements required for checking linearity of multi-turn potentiometers.

Multi-purpose digital measuring and recording system measures AC volts, DC volts, ohms and ratios. Prints and punches information for immediate reading by the operator and subsequent data reduction.

Resistor scanning unit – Scans large numbers of resistors, measures values from 0.1% to 0.01% and records the information on punched cards. Operation is automatic and operates entirely unattended.

Electro Instruments, Inc.

3540 AERO COURT, SAN DIEGO 11, CALIFORNIA

AL INSTRUMENTS FOR MEASURING AC/DC VOLTAGES, AC/DC RATIOS, RESISTANCE, CAPACITANCE, AND FREQUENCY • X-Y RECORDERS & ACCESSORIES • DC AMPLIFIERS

Sound and Vibration Analyzer 489

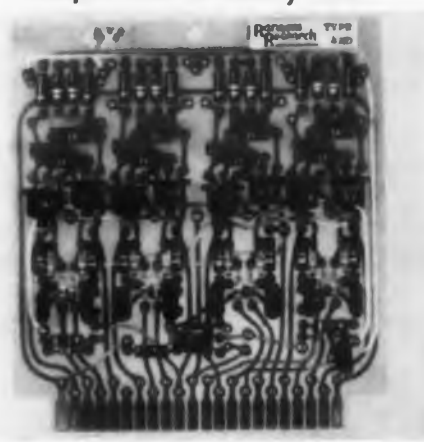
Range is 2.5 cps to 25 kc

Type 1554-A portable sound and vibration analyzer has a range of 2.5 cps to 25 kc. It has a 10:1 span on each of four ranges, a 1/3-octave bandwidth, a narrow bandwidth, and an all-pass response. It is used to measure both single-frequency and noise components. The narrow-band maximum response is flat ±2 db over the tuning range, the 1/3-octave maximum response is flat ±4 db, and the all-pass response is flat from 2.5 to 25,000 cps ±2 db.

General Radio Co., Dept. ED, West Concord, Mass.

Decade Counter 490

Outputs are in binary code



Type 4XD decade counter has standard 1-2-4-8 binary code outputs. This plug-in, solid-state computer element consists of four binary flip-flops and a transistor gate, which resets at the tenth count. both outputs are provided from each flip-flop. Assembled on a standard 4.5 x 5-in. printed card, the unit is provided with a 22-pin PC connector.

Ransom Research, Dept. ED, 323 W. Seventh St., San Pedro, Calif.

◀ CIRCLE 126 ON READER-SERVICE CARD

NEW PRODUCTS

Contact Switch 491

Mercury-wetted type

Type HGX-1003 mercury-wetted contact switch is for use as a limit switch, float switch, pulse generator, stepping switch, time base, or in other applications where actuation is by means of a permanent magnet. The switch capsule is sealed in glass, pressurized with hydrogen, and potted in an impregnated paper tube. It handles a contact load of 5 amp max, 500 v max, and 250 va.

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

Chopper Input Transformer 492

For use with frequencies of 60 to 500 cps

Model G-24 chopper input transformer is for use with frequencies of 60 to 500 cps and with an impedance ratio of 40,000 ohms, center-tapped, to 40,000 ohms, center-tapped. The primary and secondary coils are completely reversible. Each winding uses the box shielding method which reduces capacitive coupling to less than 0.05 μμf.

Triad Transformer Corp., Dept. ED, 4055 Redwood Ave., Venice, Calif.

◀ CIRCLE 127 ON READER-SERVICE CARD

NPN Silicon Transistors 493

Minimum cutoff is 15 mc

Designed for amplifier and switching use in military and industrial equipment, these npn silicon transistors have a minimum alpha cutoff rating of 15 mc. Type 2N1276 has an ac gain of 9 to 22; type 2N1277, 18 to 44; type 2N1278, 37 to 90; and type 2N1279, 76 to 333. They have typical 1000-cps power gain ratings of 37, 39, 44, and 45 db.

General Electric Co., Semiconductor Products Dept., Dept. ED, Charles Bldg., Liverpool, N.Y.

Pulse Generator 350

Regulation is ±1%

Model 402 laboratory pulse regulates line voltage within ±1% for a ±10% line change. For such uses as a high voltage power supply, a pulse forming network tester, a charging choke tester, and a pulse transformer tester, the unit provides 0 to 5 kv dc at 120 ma and 2% max peak-to-peak ripple. Voltages to 6 kv may be obtained at lower currents. Required power is 95 to 130 v, 60 cps, 1700 w.

Furmac Electronics Co., Inc., Dept. ED, 142 S. Long Beach Rd., Rockville Center, L.I., N.Y.

CIRCLE 129 ON READER-SERVICE CARD ➤

REPORT BRIEFS

Harmonic Generation and Frequency Mixing

The present report in part extends the earlier work of Pippin on second-harmonic generation and frequency mixing to include the effects of longitudinal components of rf magnetic fields. In addition, demagnetizing factors and loss in the Landau-Lifshitz form are simultaneously considered in the second-order calculations. A special case of third-harmonic generation is also treated. One result of importance has to do with the effectiveness of longitudinal components (in conjunction with the usual transverse components) of rf magnetic fields in producing magnetizations in second order and higher. *Harmonic Generation and Frequency Mixing in Ferromagnetic Insulators, R. L. Jepsen, Gordon McKay Laboratory of Applied Science, Harvard University, Cambridge, Mass., May 25, 1958, 86 pp, Microfilm $4.80, Photocopy $13.80. Order PB 137479 from Library of Congress, Washington 25, D. C.*

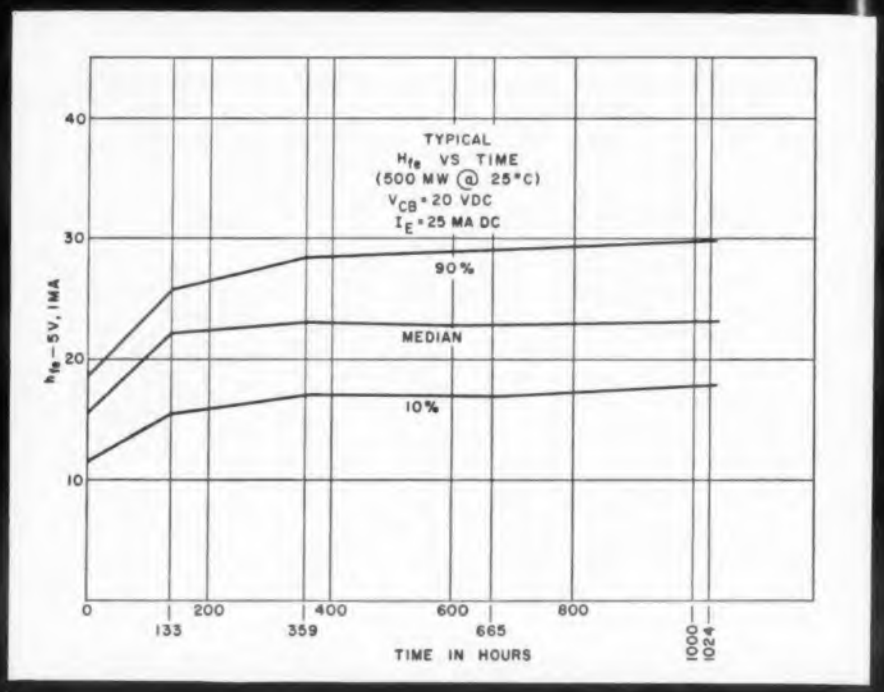
Crystal Oscillator Circuits

A complete design method is presented for the grounded grid crystal oscillator, operating in the frequency range of 75 to 150 mc. Design information is presented in the form of graphs and tables. A reference circuit, having a single set of values for the frequence range covered has been devised, and by varying the circuit component values measurements of performance have been made and plotted. The resulting graphs are normalized with respect to the reference circuit component and performance figures. In this way, output and crystal drive voltage variations were determined for specific changes in circuit parameters. The accuracy of performance prediction is 20 to 25 per cent for output voltage and 35 to 40 per cent for crystal drive voltage. A review and discussion of four crystal oscillators using subminiature filament-type tubes is presented. These are the grounded grid, feedback, or Heegner, the capacitance transformer coupled and the bridged "T" circuits. Work on the capacitance transformer coupled oscillator at 75 mc has been completed and performance characteristics are given. Since this oscillator has more desirable performance figures than the other oscillators tested, future-work will be confined to obtaining information for this circuit at higher frequencies. *Study of Crystal Oscillator Circuits, H. E. Gruen and A. O. Plait, Armour Research Foundation, Chicago, Ill., Aug.-Nov. 1956, 51 pp, Microfilm $3.60, Photocopy $9.30. Order PB 142169 from Library of Congress, Washington 25, D. C.*

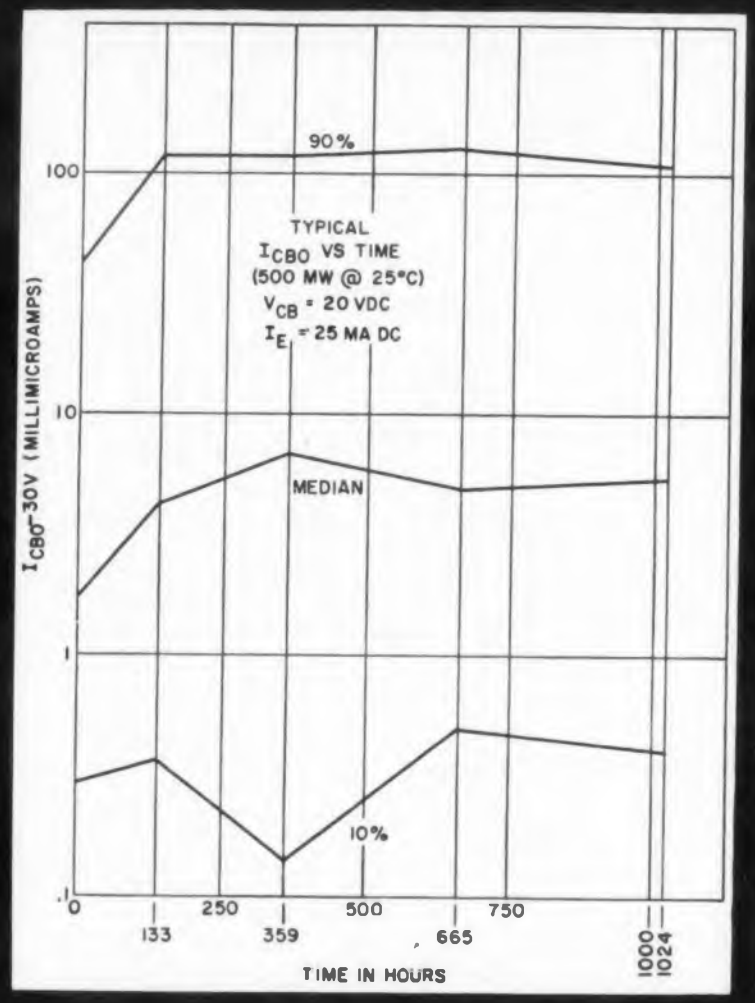
GENERAL ELECTRIC SEMICONDUCTOR NEWS

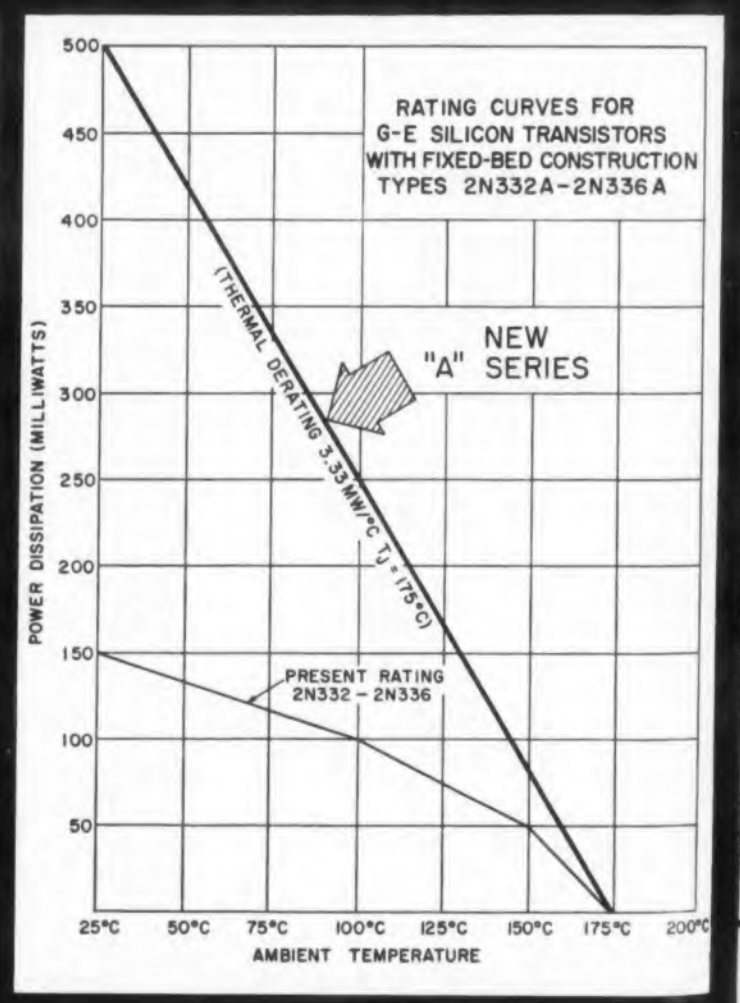
New silicon triodes dissipate

Greatly magnified photo of silicon transistor showing Fixed Bed Construction. All parts are firmly fastened, with no suspended parts except wire lead. Transistor reacts as a solid block in resisting shock and vibration. Power dissipation is inherently higher.



Power dissipation of the 2N332A-through-2N336A silicon transistors (see chart below) ranges from 500 mw at 25°C to 83 mw at 150°C without heat sink. Note also (see chart below, left) the extremely low I_{CBO} throughout 1000 hours of testing. Nearly 90% of units fall within 100 mμa. Beta spread (chart above) is stable out to 1000 hours.





Active Networks

The Linvill configuration is used to synthesize second-order, nonpositive-real, driving-point functions. Synthesis is accomplished by the use of a surplus factor. With the arbitrariness of the surplus factor, one is able to control the driving-point function. The existence of the solution in all cases is demonstrated and the minimum number of elements property of the solution is proved. It is shown that only five elements are required besides the negative impedance converters (NIC). RC networks are used in some cases and RL networks are used in the remaining cases. *Synthesis of Active Networks With Negative Impedance Converters, Robert T. Chien, Electrical Engineering Research Laboratory, University of Illinois, Urbana, Ill. 5 May 1958, 66 pp, Microfilm $3.90, Photocopy $10.80. Order PB 137068 from Library of Congress, Washington 25, D.C.*

Transistorized Radar Target Tracker

Airborne vehicles must be tracked in ground environment systems for area defense, air traffic control, and terminal area control. When many aircraft are involved, tracking radars is not practical, and the necessary data must be obtained by automatic trackers from a scanning radar. All critical parts of a transistorized cartesian coordinate tracker have been designed and tested. The results indicate that it should perform as well as the latest vacuum-tube trackers, but with much greater reliability. *A Transistorized Radar Target Tracker, Thomas C. Horth, Air Force Cambridge Research Center, Bedford, Mass., Mar. 1959, 42 pp, Microfilm $3.30, Photocopy $7.80. Order PB 142196 from Library of Congress, Washington 25, D. C.*

Design Radomes

This report considers radome design requirements and construction and the manner in which absorption losses affect radome performance. Equations for lossy radomes are given, and a number of transmission curves are computed for lossy sandwich panels. The report also contains the design procedure for lossy high-incidence radomes, methods for obtaining optimum core thickness for maximum transmission, and a discussion of the effects of dimensional tolerances on transmission. *Electrical Design of Lossy High-Incidence Radomes, S. Wolin, Aeronautical Electronic and Electrical Laboratory, Naval Air Development Center, Johnsville, Pa., July 11, 1959, 139 pp, Microfilm $6.90, Photocopy $21.30. Order PB 142015 from Library of Congress, Washington 25, D. C.*

REPORT BRIEFS

Pulse Width Modulated Relay Control

This report investigates the application of pulse width modulation as a control method for relay controlled systems with sampling. The limit cycles which occur in relay control systems with sampling are discussed and two methods of design employing pulse width control which eliminate these limit cycles are developed. Experimental results are presented for a second order system. Application and extension of the results are discussed. *Pulse Width Modulated Relay Control of Systems Subject to Sampled Data, Winston L. Nelson, Columbia University, School of Engineering, New York, N. Y., 1957, 72 pp, Microfilm $4.50, Photocopy $12.30. Order PB 142367 from Library of Congress, Washington 25, D. C.*

Crystal Oscillator Circuits

Performance information for the cathode coupled and grounded grid oscillators for the 10 to 75 mc frequency range is reported. Reference circuits and their performance as a function of frequency have been established. Effects of component variation have been determined, and shown to be adequately described by the normalized curves developed for higher frequency operation. Initial problems of frequency and crystal voltage correlation have been resolved. These are shown to be caused by the effect of the plate-to-cathode capacitance. Correction is obtained by the addition of an inductor in series with the crystal in the feedback path. The design information for the grounded grid circuit in this frequency range has been found to be essentially an extension of the results obtained in the higher frequency range. A discussion of the problems encountered with the cathode coupled circuit is given. However, its performance at the lower frequencies is compared with that at the higher frequency range and differences are noted. Temperature characteristics and oscillator output harmonic content measurements for the two series resonant circuits in the 75 to 150 mc frequency range are reported. Extension of the antiresonant circuit design information to 20 mc has been completed for the Colpitts circuit, and work on the electron coupled Colpitts is in progress. The previously developed design information is shown to be useful to 20 mc without any loss of accuracy over that originally specified. *A Study of Crystal Oscillator Circuits, H. E. Gruen and A. O. Plait, Armour Research Foundation, Chicago, Ill., Feb. 15-May 15, 1957, 35 pp, Microfilm $3.00, Photocopy $6.30. Order PB 142400 from Library of Congress, Washington 25, D. C.*

UHF Amplifiers

This report will present the synthesis considerations, design procedures, and constructional features of uhf amplifiers described in Technical Report No. 11, "A 400-Mc IF Amplifier," June, 1952. The reader is referred to this report, which serves as an introduction to the present report and indicates the results that can be obtained. *The Synthesis and Design of Grounded-Grid Staggered-Triples at UHF, Donald O. Pederson, Electronic Research Laboratory, Stanford University, Calif., Sept. 30, 1952, 60 pp, Microfilm $3.60, Photocopy $9.30. Order PB 142433 from Library of Congress, Washington 25, D. C.*

10-Kilowatt VHF Air Borne Transmitter

A general discussion is presented of the development of a 10-kw VHF airborne radio communications transmitter occupying only 4 cubic feet of space. The transmitter may employ either frequency shift keying or frequency modulation. The transmitter may be remotely controlled. The system employs an external liquid cooling system. *Development of a 10-Kilowatt VHF Air Borne Radio Communications Transmitter, Henry A. Tackett, Continental Electronics Mfg. Co., Dallas, Texas, Mar. 1959, 28 pp, Microfilm $2.70, Photocopy $4.80. Order PB 142349 from Library of Congress, Washington 25, D. C.*

Electromagnetic Antenna Coupling

The properties of a dipole antenna coupled electromagnetically to a two-wire transmission line are studied experimentally. It is found that the coupling of the antenna to the transmission line can be maximized by a proper choice of (1) the angular position of the antenna with respect to the transmission line, (2) the length of the antenna, and (3) the separation of the antenna from the transmission line. The effect of the spacing between the wires of the transmission line on the optimum parameters is investigated. Measurements of (1) the current in the antenna as a function of its angular position and (2) the unbalanced component of current on the transmission line are also reported. It is found that the optimum angular position of the antenna is not noticeably altered if instead of a single antenna, an array of properly located antennas is used as the load. The advantage of an antenna array built on this coupling principle is discussed. *A Dipole Antenna Coupled Electromagnetically to a Two-Wire Transmission Line, S. R. Seshadri and Keigo Iizuka, Cruft Laboratory, Harvard University, Cambridge, Mass., Oct. 31, 1958, 47 pp, Microfilm $3.30, Photocopy $7.80. Order PB 142139 from Library of Congress, Washington 25, D. C.*

REPORT BRIEFS

Cascade-Circuit Traveling-Wave Tubes

A study is made of the saturation characteristics of cascade-circuit traveling-wave tubes. Measurements made on several tubes indicated that the saturation efficiency of these cascade-circuit tubes was much lower than that for comparable single-circuit tubes. In order to explain these unusual results, a series of calculations is carried out using approximate expressions which are based on simple physical pictures of the interaction process. It is possible to explain the measured results by using these simple physical pictures. The low saturation efficiency of the cascade-circuit backward-wave amplifier is found to tie due to the nature of the boundary conditions which must exist on the demodulator section. The cascade-circuit forward-wave amplifier, if properly designed, would appear to have a saturation efficiency approaching that of a single circuit tube. *Some Results from the Large-Signal Behavior of Cascade-Circuit Traveling-Wave Tubes, W. H. Watson, Electronics Research Laboratory, University of California, Berkeley, Calif., Oct., 1958, 33 pp, $1.00. Order PB 151607 from OTS, Washington 25, D. C.*

Microwave Resonant Cavities

This report describes the design and testing of two types of resonant microwave cavities operating near 9435 megacycles per second in which the end plates are replaced by terminations which leave the cross-sections of these cavities essentially unobstructed. *Design of Open-Ended Microwave Resonant Cavities, Donald C. Thorn, Electrical Engineering Research Laboratory, University of Texas, Austin, Texas, Aug. 25, 1958, 23 pp, Microfilm $2.70, Photocopy $4.80. Order PB 142035 from Library of Congress, Washington 25, D. C.*

Traveling Wave Tube Devices

The work described includes theoretical and experimental studies on backward-wave interaction, light weight focusing systems and space-charged waves in periodic beams, crossed-field interaction, and dc and rf tests on novel high-density emitters. Supporting work on electron beams and large-signal studies is also described, as well as a preliminary study of variable parameter amplifiers. *Electron Physics of Traveling Wave Tube Devices, J. R. Whinnery, D. H. Sloan and others, California University (Berkeley), Aug. 15, 1957, 24 pp, $0.75. Order PB 151888 from OTS, Washington 25, D.C.*

Synthesis of Multipole Control Systems

This report is concerned with obtaining the optimum system in the Wiener sense for a multipole system. Earlier literature has shown how to obtain the mean-square value of the error when the multipole system transfer function has been specified, but thus far no published work has shown how to solve the synthesis problem, in general, for this case. The principal reason that this problem has appeared to be impossible of analytic solution for cross correlation between the inputs, is based on the fact that the usual variational approach results in a set of untractable simultaneous integral equations involving many complicated cross products of the desired weighting functions and the variational functions. *On the Optimum Synthesis of Multipole Control Systems in the Wiener Sense, H. C. Hsieh and C.T. Leondes, California University, Los Angeles, Calif., Mar. 1959, 63 pp, Microfilm $3.90, Photocopy $10.80. Order PB 142298 from Library of Congress, Washington 25, D.C.*

Designing Crystal Filters

A set of convenient insertion loss equations is derived, which is applicable to the design of multisection, reactive, symmetric filters. Specific network designs for quartz crystal bandpass filters with sharp cutoff characteristics, and more than 60 db attenuation in the stop bands, are presented for two categories of fractional bandwidths: (1) less than or equal to 0.4 per cent; (2) equal to or larger than 1.5 per cent. Several network structures for each of these two categories are worked out and the corresponding insertion loss characteristics are plotted. Element values are given for a filter with a 6 db bandwidth of 40 kc with respect to a center frequency of 11.5 mc. A design for a filter with a bandwidth of 400 kc with respect to a center frequency of 24 mc is included. This design makes full allowance for the effects of coil dissipation. In an appendix, a general approach is outlined to the formation of lattice-type filters with 4, 6, and 8 peaks of infinite attenuation (i.e., zeros of transmission) and with image impedances suitable for (1) quartz crystal-capacitor filters possessing the maximum possible bandwidth for a given crystal cut and (2) quartz crystal-capacitor-inductor filters with a constant-k image impedance. Recent design progress is announced, which took place subsequent to the close of the first quarter and promises to lead to a very satisfactory filter design in the fractional-bandwidth region between 0.4 per cent and 1.5 per cent. *High Frequency Crystal Filters, Leo Storch, Hughes Aircraft Co., Culver City, Calif., Oct. 1-Dec. 31, 1956, 84 pp, Microfilm $4.80, Photocopy $13.80. Order PB 142388 from Library of Congress, Washington 25, D. C.*

REPORT BRIEFS

Detection of Signals in Noise

A detection criterion is formulated which leads to the design of detectors on the basis of much less a priori information. These non-parametric detectors are proposed as possible alternatives to the detectors studied in those situations where little a priori information is available. A concept known as asymptotic relative efficiency is employed to compare nonparametric detectors with some of the detectors investigated in the past. Using this criterion the efficiency of non-parametric detectors is found to be quite high. The application of the nonparametric detection criterion to the detection of nonstationary signals in noise is discussed. Nonparametric detectors are shown to possess certain advantages in detecting such signals. *Nonparametric Methods for the Detection of Signals in Noise, Jack Capon, Columbia Univeristy, School of Engineering, New York, N. Y., Mar. 12, 1959, 234 pp, Microfilm $10.20, Photocopy $36.30. Order PB 142327 from Library of Congress, Washington 25, D. C.*

Crystal Oscillator Circuits

A complete design method is presented for the grounded grid crystal oscillator, operating in the frequency range of 75 to 150 mc. Design information is presented in the form of graphs and tables. A reference circuit, having a single set of values for the frequency range covered has been devised, and by varying the circuit component values, measurements of performance have been made and plotted. The resulting graphs are normalized with respect to the reference circuit component and performance figures. In this way, output and crystal drive voltage variations were determined for specific changes in circuit parameters. The accuracy of performance prediction is 20 to 25 per cent for output voltage and 35 to 40 per cent for crystal drive voltage. A review and discussion of four crystal oscillators using subminiature filament-type tubes is presented. These are the grounded grid, feedback, or heegner, the capacitance transformer coupled and the bridged "T" circuits. Work on the capacitance transformer coupled oscillator at 75 mc has been completed and performance characteristics are given. Since this oscillator has more desirable performance figures than the other oscillators tested, future work will be confined to obtaining information for this circuit at higher frequencies. (See also PB 142168) *Study of Crystal Oscillator Circuits, H. E. Gruen and A. O. Plait, Armour Research Foundation, Chicago, Ill., Aug. 15-Nov. 15, 1959, 51 pp, Microfilm $3.60, Photocopy $9.30. Order PB 142169 from Library of Congress, Washington 25, D. C.*

RC-RL Curves and Nomograms — II

Donald Moffat
Motorola, Inc.
Western Military Electronics Center
Phoenix, Ariz.

To simplify the time-consuming calculation of transfer function, Donald Moffat presents a series of nomograms. Many of the most common circuits have been analyzed, and their transfer functions, curves and nomograms are shown.

In Part I four single-section configurations were described. Some discussion on the effects of loading was included and exact equations used where approximations are not valid.

Part II continues with a discussion of phase manipulation.

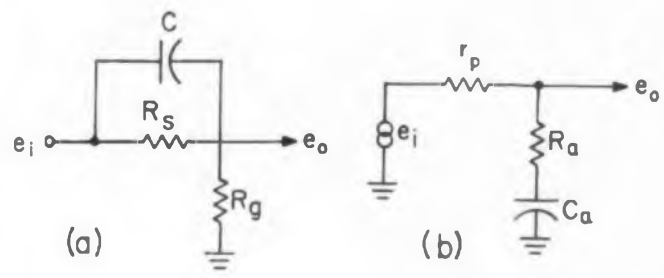


Fig. 1. Single sections for varying phase response.

MANIPULATION of the phase response of this simple RC circuit is often accomplished by a variation of the single section, as shown in Fig. 1a. Phase response of this circuit is

$$\varphi = \arctan \frac{\omega R_s C_s}{1 + x\,(1 + \omega^2 R_s^2 C_s^2} \qquad (1)$$

where $x = R_g / R_s$.

There is zero phase shift at dc and at infinite

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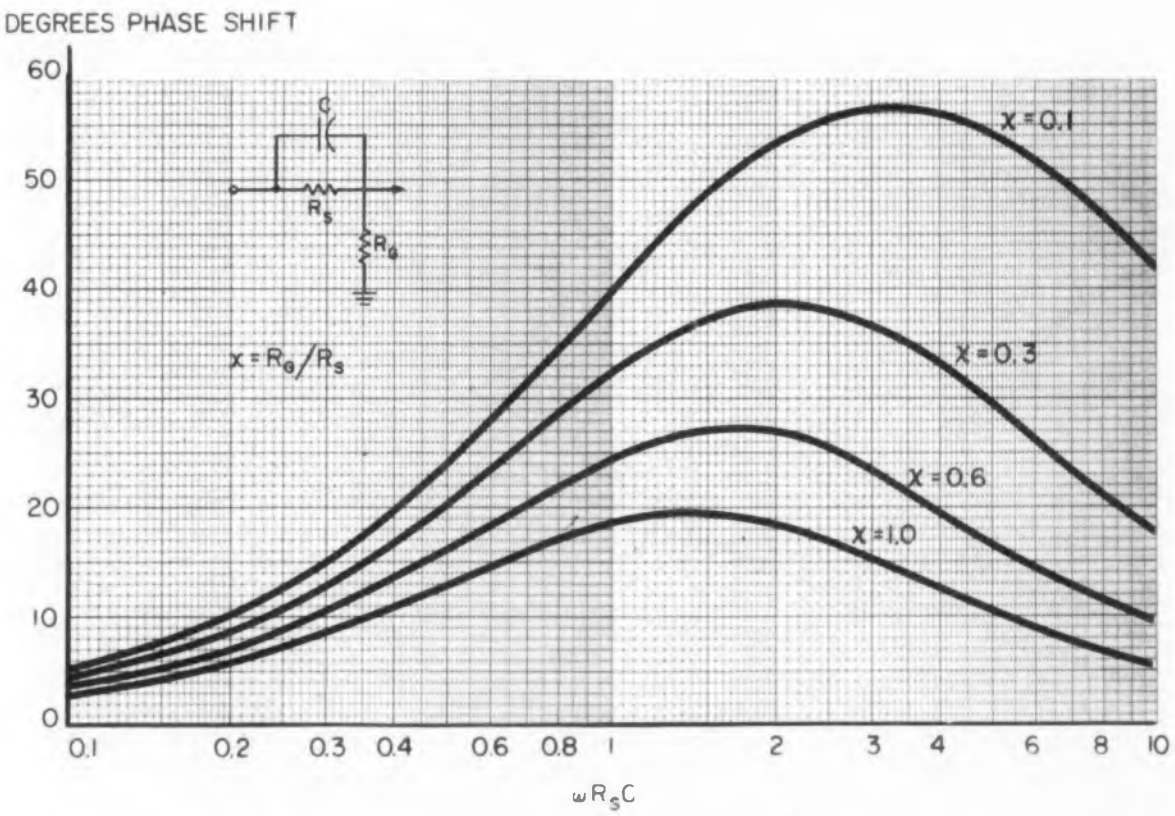

Fig. 2. Phase shift of circuit of Fig. 1a. Parameter is resistance ratio.

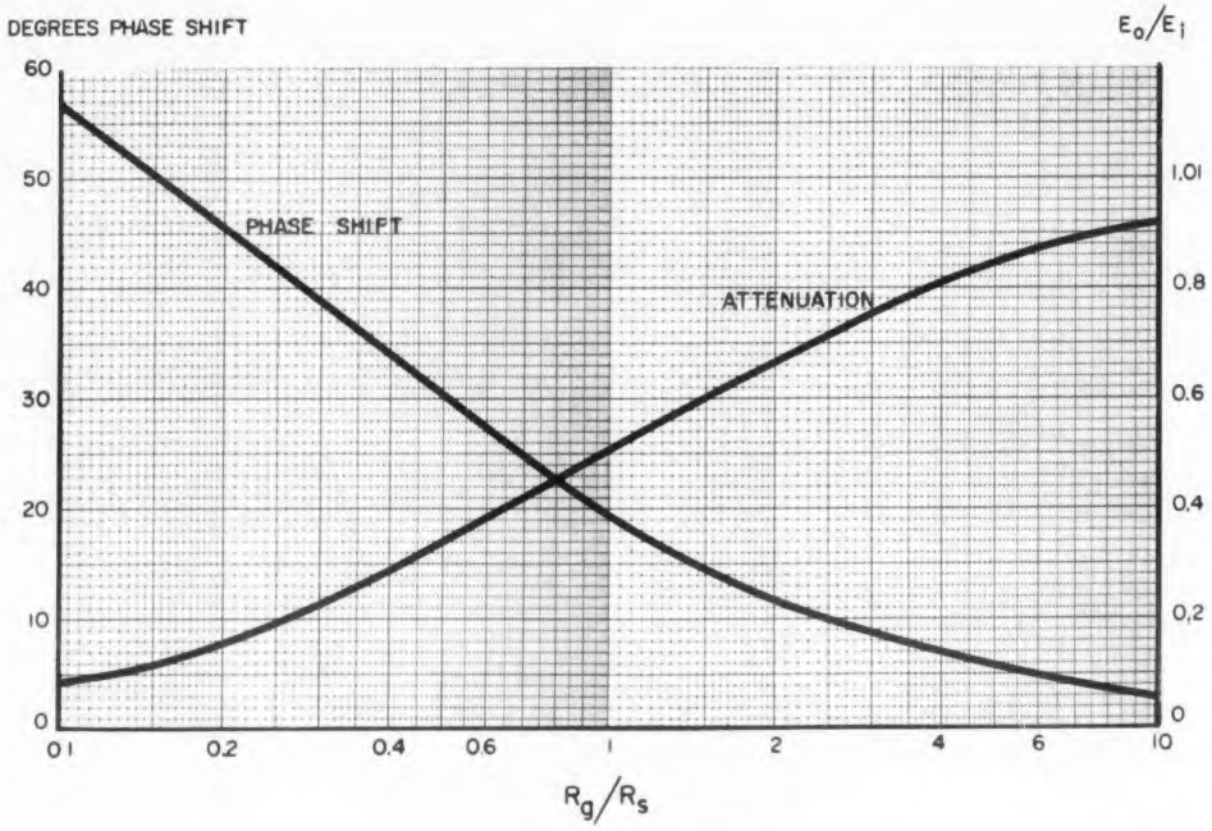

Fig. 3. Maximum attenuation and maximum phase shift as a function of resistance ratios in Fig. 1a.

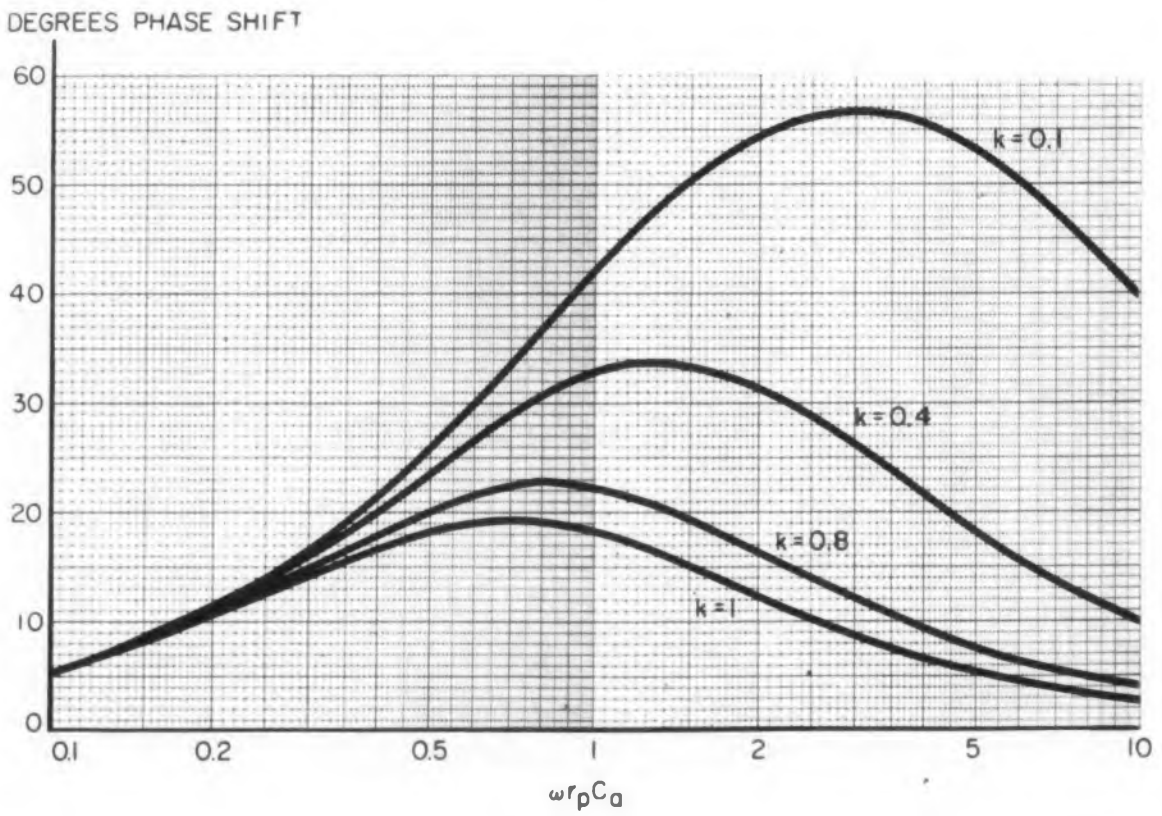

Fig. 4. Phase response as a function of normalized impedance, with k (R_a/r_p) as the parameter, for circuit of Fig. 1b.

frequency, and maximum phase shift when

$$\omega = (1/R_s C_s)\sqrt{(1+x)/x}\,. \qquad (2)$$

Location of the maximum phase shift is seen to depend on all components. However the amplitude of the maximum depends only on the resistance ratios, according to

$$\varphi_{max} = \text{arc tan}\,\sqrt{1/x\,(1+x)}/2 \qquad (3)$$

Nomograms

The above results are shown graphically in Figs. 2 and 3, and as *Nomograms 1* and *2*. To use the nomograms, draw a line between the resistor values in *Nomogram 1* and read ϕ_{max} where the line crosses the center scale.

Nomogram 2 is used to find a value of capacitance to place the maximum at a particular frequency. Extend a line from x (also found on the center scale of *Nomogram 1*) through f, the frequency where ϕ_{max} is to occur, to the *Turning Scale*. From that point on the *Turning Scale* draw a line to R_s and read C where the line crosses that scale.

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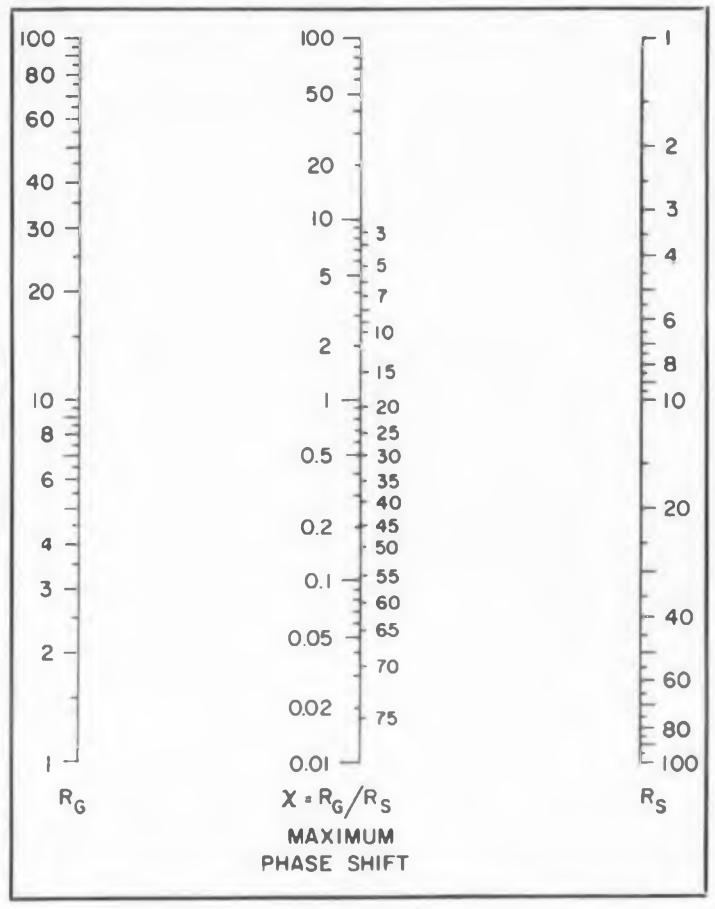
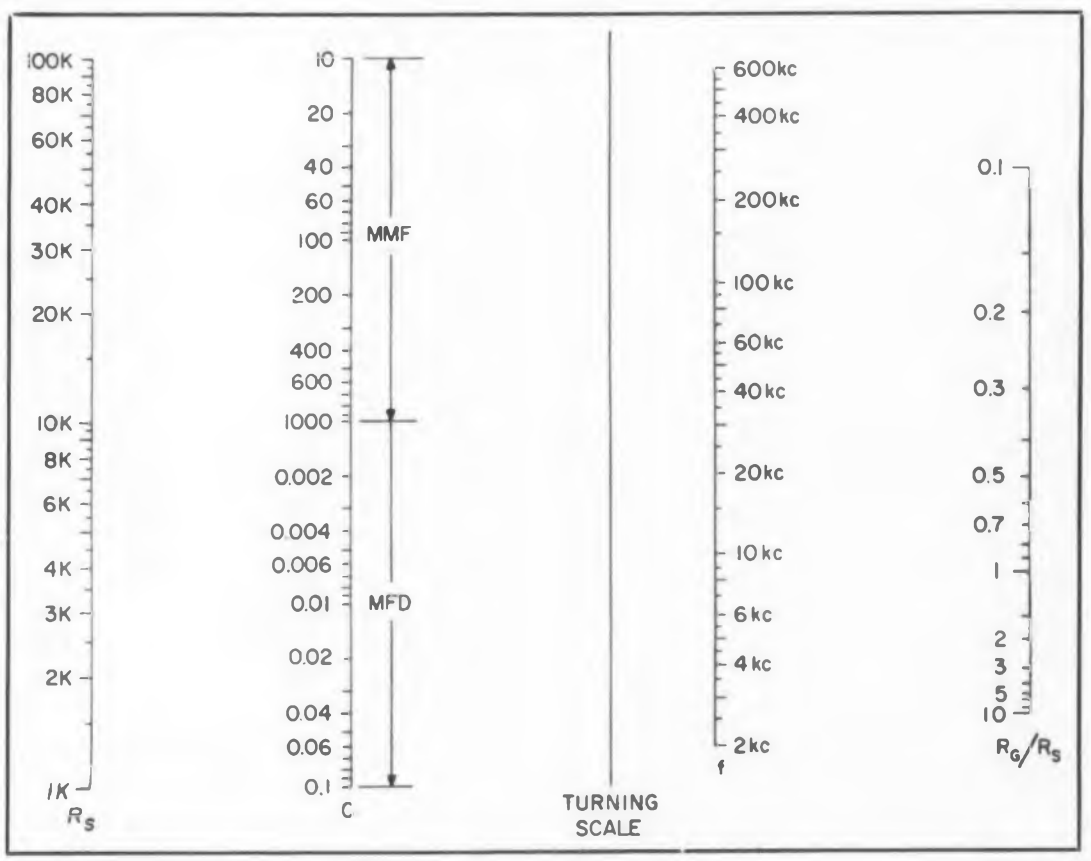
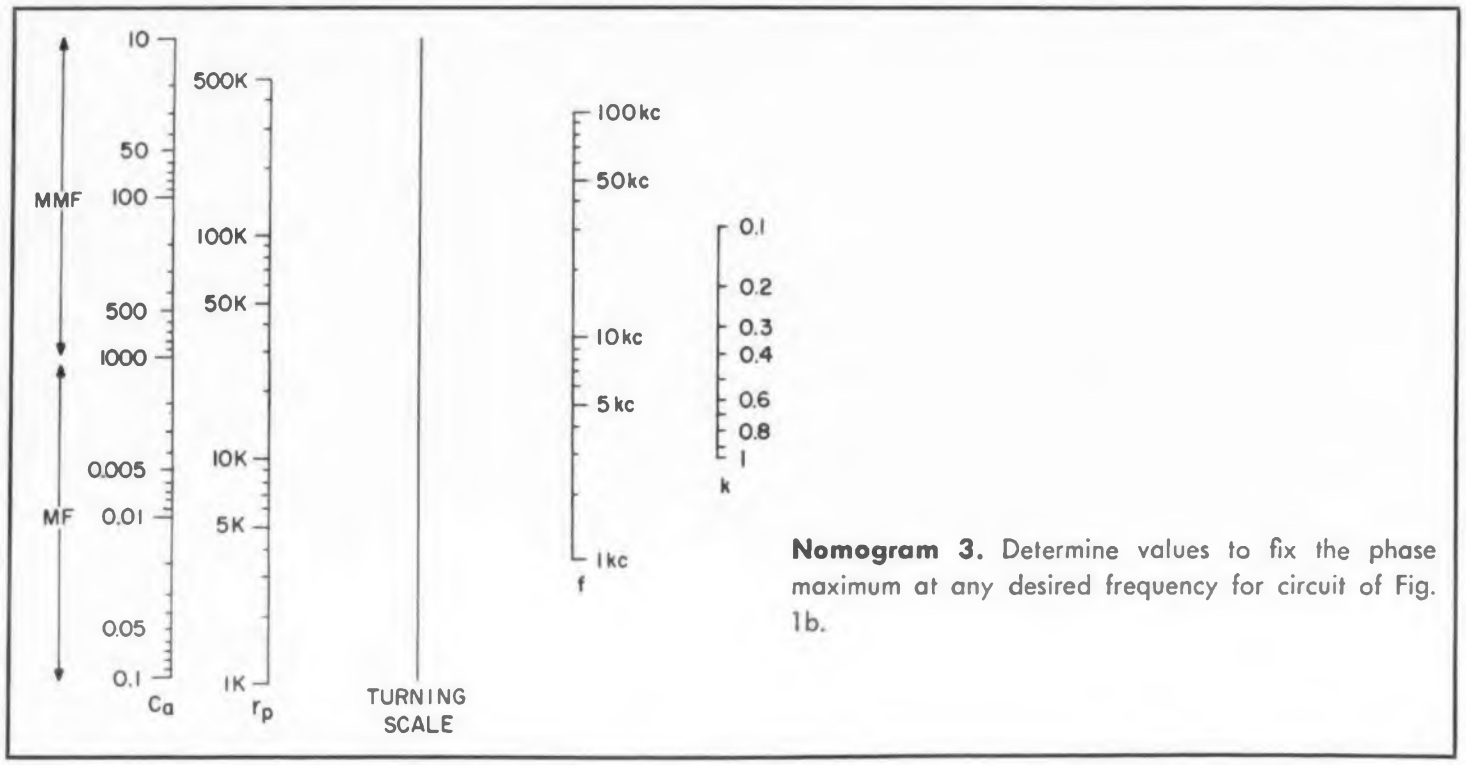


Nomogram 1. Given parallel and series resistances, find φ_{max} for circuit of Fig. 1a.



Nomogram 2. Use this to find a capacitance value to fix maximum phase shift at a desired frequency.

RC-RL Curves and Nomograms — II



Nomogram 3. Determine values to fix the phase maximum at any desired frequency for circuit of Fig. 1b.

Shunt Capacitance

Another circuit that has a peak in its phase response is shown in Fig. 1b. The phase response is

$$\varphi = \arctan \frac{\omega r_p C_a}{\omega^2 r_p^2 C_a^2 k (k+1) + 1} \qquad (4)$$

where $k = R_a/r_p$. Once again there is no phase shift at high and low frequencies. There is a maximum of

$$\varphi_{max} = \arctan (1/2 \sqrt{k (k+1)}) \qquad (5)$$

at

$$\omega = 1/r_p C_a \sqrt{k (k+1)} \qquad (6)$$

The phase response is plotted in Fig. 4, as a function of normalized impedance and with k as the parameter. *Nomogram 3* is included so the designer can quickly select values to locate the phase maximum at any desired frequency. This nomogram is used in the same way as *Nomogram 2*; a straight line between r_p and f should cross the *Turning Scale* at the same point as a line between C_a and k.

Part III of this series will discuss multiple sections and the attendant non-negligible loading. The optimum number of sections for best phase response, minimum attenuation, selectivity and rate of change of phase will be described. A section on the RC differentiator will be included.■■

NEW LITERATURE

Pulse Generator 137

One-page bulletin 3450C describes and illustrates the firm's megacycle pulse generator which features modular plug-in design. Repetition rate, pulse delay, pulse output, power, accessories furnished, standard modules, and a physical description of the device are included. Electro-Pulse, Inc., 11861 Teale St., Culver City, Calif.

Electric Motors 138

Features of the firm's extreme precision hysteresis synchronous electric motors, for use in such applications as transports, turntables drives, and missile and aircraft instrumentation, appear in this four-page illustrated brochure. A table of performance characteristics and dimensional diagrams is included. Construction, design features, and reliability are also covered. Hysyn Electromotive, Subsidiary of Telecomputing Corp., 915 N. Citrus Ave., Los Angeles 38, Calif.

Recording System 139

An automatic multipoint digital data recording system is described and illustrated in bulletin 350-8, two pages. System components and specifications are given; operation of a typical system is discussed with the aid of a diagram. Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

Pulse Transformers 140

"The Design and Usage of Miniature Pulse Transformers," an 18-page catalog, covers the history of low-level pulse transformers, their chief differences compared to other transformer types, methods of measurement, and theory of application. Information on pulse transformer equivalent circuit, transformer polarization, and methods of degaussing a core is included. Circuit diagrams, pulse width charts, electrical specifications, and case types also appear. PCA Electronics, Inc., 16799 Schoenborn St., Sepulveda, Calif.

Precision Resistor Wire 141

This 12-page illustrated catalog introduces the firm's low-density high-resistivity precision resistor wire. A graphic evaluation of physical and electrical properties necessary for the manufacture of precision wirewound resistors and potentiometers is presented. Special tables and graphs cover the material's corrosion and wear resistance properties, its strength and ductility, the effects of winding tension on electrical characteristics, and the stability of resistance during a road life test. Hoskins Manufacturing Co., 4445 Lawton Ave., Detroit, Mich.

NEW LITERATURE

Electronic Instruments 149

Technical data on the firm's line of electronic instruments are contained in this two-page data sheet. Included are descriptions of a transistorized, regulated power supply series, a portable series, plug-in models, and a system-engineered sealed series. Two instruments for the accurate measurement of resistance up to 5000 million megohms with accessories for measuring volume resistivity at elevated temperatures are described. A wide range ohmmeter and an automatic relay tester are also covered. Mid-Eastern Electronics, Inc., 32 Commerce St., Springfield, N.J.

Cable Marker Tags 150

Bulletin 804, two pages, describes the firm's cable marker tags. They are manufactured in light gage aluminum, brass, copper or zinc. Illustrations in this bulletin show standard stock shapes and sizes available for prompt shipment. Seton Name Plate Co., 431 W. Rock Ave., New Haven 15, Conn.

Functional Modules 151

This four-page brochure with additional data sheets describes and illustrates the firm's line of functional modules. Features, applications, specifications, circuit descriptions, and schematic diagrams appear. Vitro Labs, 200 Pleasant Valley Way, W. Orange, N.J.

Subminiature Fuses 152

Complete technical information on subminiature fuses is provided in this two-page data sheet. Dimensional data and photographs are included, and the sheet is punched for insertion in any binder or file. Littelfuse, Inc., Des Plaines, Ill.

Preset Variable Resistors 153

A data sheet is available illustrating a new line of 3/4 in. diameter, miniature preset wirewound 1/2 to 500 ohm resistance range variable resistors. Chicago Telephone Supply Corp., Elkhart, Ind.

Aluminum Electrolytics 159

Illustrated bulletin 3441A, 12 pages, describes power supply filter capacitors which meet 85 C operating conditions. Dimensional diagrams, tables of standard ratings, typical curves of impedance, and a list of performance characteristics are included. A guide to application and operation also appears. Sprague Electric Co., North Adams, Mass.

Electrical Contacts 160

Materials, properties, forms, uses, and illustrations of the firm's line of electrical contacts appear in catalog 601, four pages. Discussed in the folder are contacts manufactured from fine silver, coin silver, palladium, gold, platinum, silver alloys, and many powdered metal compositions. Electrical contacts for various applications such as contactors, instruments, circuit breakers, and switches are shown in outline form. Gibson Electric Co., Box 596, Delmont, Pa.

Electronic Multiplier 161

This 16-page illustrated brochure includes a general description, features, and performance specifications of an electronic multiplier which provides four quadrant multiplication of input variables at 500 cps. In addition to a discussion of the theory of operation, a section is devoted to a new type of discriminator which provides an exactly linear relationship between am and fm outputs. Diagrams show how the multiplier can be converted to perform division and square root functions. Computer Systems, Inc., 611 Broadway, New York 12, N.Y.

Rotary Switch 162

An actual size photograph plus a dimensional diagram of the firm's high precision rotary switch appear in this one-page bulletin. In addition to a description of the switch, electrical, mechanical, and environmental specifications are also given. Waters Manufacturing, Inc., Wayland, Mass.

Power Connectors 163

Four series of miniature rectangular power connectors designed for heavy duty applications are covered in this 20-page catalog. Complete specifications, outline dimensions, illustrations, and general information are included. Among the power connectors featured are those with closed entry contacts, polarizing screwlock, aluminum hoods, and quick release. De-Jur Amsco Corp., Electronic Sales Div., 45-01 Northern Blvd., Long Island City 1, N.Y.

NEW LITERATURE

Tube Types 170

This revised pamphlet on tube types, eight pages, lists entertainment types including TV picture tubes, vacuum types for rf and af power applications, vacuum types for pulsed-power applications, voltage-regulator, glow-discharge, and computer types, thyratrons, power rectifiers, oscillograph tubes, storage tubes, phototubes, and photoconductive cells. Applications and descriptions are given. Radio Corp. of America, Electron Tube Div., Harrison, N.J.

Digital Tape Handler 171

A three-color, eight-page brochure is available which gives complete specifications on the FR-400 Digital Magnetic Tape Handler. Included also are illustrations showing the mechanical highlights and construction of the machines. Ampex Corp., Instrumentation Div., 934 Charter St., Redwood City, Calif.

Wide Range Ohmmeter 172

A two-page bulletin gives application data and specifications on the Model 701 Wide Range Ohmmeter. Applications include measurement of forward and back resistance of semiconductors, thermistors, low resistance copper paths, and determination of resistance of moving coils in electrical indicating instruments. Mid-Eastern Electronics, Inc., 32 Commerce St., Springfield, N.J.

High Temperature Connectors 173

A new catalog sheet is available describing the line of high temperature connectors. The technical bulletin points out the type of applications for which the connectors were designed and offers complete information regarding standard sizes, types, contact patterns, MS cross refernce numbers and insert data. Harco Laboratories, New Haven, Conn.

Capacitors 178

The firm's complete line of ceramic disc and plate capacitors is described in this eight-page catalog. Mechanical as well as electrical specifications are provided. Some of the data is covered in graphs. One section of the catalog covers capacitors for military purposes. Electra Manufacturing Co., 4051 Broadway, Kansas City, Mo.

C-Band Radar Beacon 179

Publication WCP59-0812, eight pages, describes General Electric's C-brand radar beacon, a 9.8 lb, airborne, pulse-type missile tracking and identification aid designed particularly for operation with AN/FPS-16 radar and also compatible with the AN/MPS-26 and several other C-band radars. Beacon characteristics such as its 400-w output capability, application, flexibility and compact size are discussed. A full product description, development history and complete specification are included. General Electric Co., Schenectady 5, N.Y.

Precision Resistors 180

Performance data, net price, and military decade values of deposited carbon precision resistors appear in this six-page bulletin. Illustrations, wattage, length, and diameter of various types of resistors are included. Campbell Industries, Inc., Dover, N.H.

Recorders 181

A 12-page, two color bulletin, No. GEA-6933, provides buying information on the complete line of the firm's recording instruments, including dimensions and chart speeds, operating specifications, applications, features and accessories. Recorders are grouped by accuracy class for convenient selection. Photographs of all models discussed are included. The bulletin also describes specialized recording instruments available, such as spectrophotometers, recording vibrometers, automatic oscillographs, self-balancing potentiometers, and speed recording systems. General Electric Co., Schenectady 5, N.Y.

NEW LITERATURE

Alnico Permanent Magnets 189

An improved version of alnico permanent magnets, especially suited for core type meters and instruments, is the subject of this two-page bulletin. In addition to magnetic and material characteristics of the oriented and nonoriented forms, a demagnetization and energy product curve also appears. Applications for this improved permanent magnet material are given. The Indiana Steel Products Co., Valparaiso, Ind.

Metal Housings 190

Catalog 600, 20 pages, describes standard metal housings for the electronics industry. It features the firm's new line of modular console systems including heavy duty transmitter racks, pedestals, writing desks, turrets, and other accessories. The regular line of chassis, cabinets, racks, and panels also appears. Premier Metal Products Co., New York 59, N.Y.

Current Generators 191

Two-channel and four-channel millimicrosecond current generators are featured in this one-page bulletin. Input, output, power, accessories, standard modules, and physical descriptions are included. A photograph of the two-channel model appears. Electro-Pulse, Inc., 11861 Teale St., Culver City, Calif.

Injection Molded Parts 192

Detailed engineering information on injection molded Delrin parts is provided in this eight-page bulletin. Outlines of established and potential uses are also included. Illustrated with photographs, charts and tables, the bulletin offers data on the mechanical, chemical and physical properties of Delrin. Performance data for this plastic is compared with that of several cast ferrous and non-ferrous materials. Gries Reproducer Corp., 400 Beechwood Ave., New Rochelle, N.Y.

Potentiometers 193

This supplement to the firm's current potentiometer catalog contains complete electrical, mechanical and environmental specifications and drawings of four new single-turn precision potentiometers. The 1-7/16-in. diameter series 5410 and 5420 have standard temperature ranges of −65 to +125 C and −65 to +150 C, respectively. The 1-3/4 in. diameter series 5510 and 5520 also have the same choice of temperature range. Beckman Instruments, Inc., Helipot Div., 2500 Fullerton Road, Fullerton, Calif.

Electronic Gaging 199

A complete description of electronic gaging systems and of each of the modules comprising them is given in this 12-page brochure. Typical applications are shown. The principal advantages of electronic gaging are 100 per cent repeatability, instantaneous response, high reliability and accuracy to 0.00005 in. Radio Corporation of America, Industrial and Automation Div., 12605 Arnold Ave., Detroit 39, Mich.

Caps and Terminals 200

Bulletin No. 59-4, four pages, two colors, describes and gives specifications for many sockets, plate caps, grid grips, terminal components and assemblies available for numerous radio and electronic applications. Data is provided in tabular form and photographs are included. National Radio Co., Inc., 37 Washington St., Melrose 76, Mass.

Miniature Delay Lines 201

Two-page illustrated bulletin DL1159 describes a standard line of miniature lumped constant delay lines. Electrical specifications, packaging, and the unique construction techniques are covered. Design factors that should be considered when establishing specifications for special delay lines are also explained. Valor Instruments, Inc., 13214 Crenshaw Blvd., Gardena, Calif.

Dials, Drives and Mechanisms 202

Descriptions and specifications of an assortment of dials, rim and planetary drives, and vernier mechanisms appear in this eight-page bulletin. Photographs show the dimensions of the various models. National Radio Co., Inc., 37 Washington St., Melrose 76, Mass.

Power Supplies 203

Featured in this two-page bulletin is the firm's complete line of transistorized power supplies, including more than 60 off-the-shelf models and dual output types. Design, special features, prices, and general specifications of standard models are given. One model is illustrated. Mid-eastern Electronics, Inc., 32 Commerce St., Springfield, N.J.

Magnetic Shields 204

Data sheet 150 decribes the problems extremely low-level magnetic fields encounter with backward wave tubes. It explains how these problems can be eliminated by low-leakage magnetic shields. A photograph of the magnetic shield appears. Perfection Mica Co., Magnetic Shield Div., 1322 N. Elston Ave., Chicago 22, Ill.

NEW LITERATURE

Power Supplies 210

Bulletin 422, 12 pages and three color, includes specifications on the Regatron Mark II series of high precision, chopper-stabilized calibrators. Also covered is the entire line of Regatron programmable, nonprogrammable and general utility power supplies. Photographs are supplied and the data provided in tabular form. Ordering information is given. Electronic Measurements Co., Inc., Eatontown, N.J.

Pulse Discriminator Filter 211

A pulse width discriminator filter that is applicable to a wide variety of pulse and video type electronic systems is described in this six-page brochure. Graphs and photographs are included. One section of the brochure presents the electrical, mechanical and environmental features, including actual measured data such as wave forms and transfer characteristics of a typical unit. Mini-Rad, Inc., 7416-E Varna Ave., N. Hollywood, Calif.

Relay Definitions and Testing Procedures 21[illegible]

This 70-page progress report covers dry circuits, measurements of electrical characteristics, contact life testing, environmental testing, vibration testing, shock, acceleration and tumbling. The report presents suggested definitions and test procedures, discusses test equipment and precautions, outlines work yet to be done and solicits comments and suggestions on work accomplished to date. National Association of Relay Manufacturers, P. O. Box 6, Stillwater, Okla.

Chassis Punches 213

Information on chassis punches for electronic applications and other uses are provided in this four-page folder. It covers a line of more than 20 different sizes and types of punches which require 50 per cent less torquing effort than is customary due to an exclusive electrocoating process used on the cutting edges. Walsco Electronics Mfg. Co., Div. of Textron Inc., 100 W. Green St., Rockford, Ill.

Magnetic Thyratron Controls 218

Bulletin MTC 558 gives operational data on a line of magnetic thyratron controls. These units are basically magnetic amplifiers with a continuously phase-variable pulse having a rise time of less than 500 μsec and a pulse amplitude up to 140 v. Typical application circuits included are: high voltage regulated power supply; low voltage, high current, regulated power supply; two-phase ac servo motor position control; dc series motor; dc shunt motor; and split field dc servo motor controls. Fairfield Engineering Corp., 934 Hope St., Springdale, Conn.

Acoustic Noise Generator 219

A 166 db acoustic noise generator is described in this four-page bulletin. The generator uses an electro-mechanical transducer of moving-coil type producing 166 db of random noise and 170 db at discrete frequencies. Photographs, graphs and applications are included. Avco Corp., Research and Advanced Development Div., 201 Lowell St., Wilmington, Mass.

Strip Conductor 220

Specifications, availability and descriptions are given in these data sheets on aluminum electrical strip conductor. The product description section provides a general explanation of the product, both bare and anodized, and the technique of its production. The availability section defines standard strip conductor items, manufacturing limits, minimum quantities, shipping tolerances, and standard packaging procedures. In the specified requirements portion, chemical composition limits are listed, plus electrical and anodic film properties and a description of testing which the product undergoes before shipment. Reynolds Metals Co., Richmond 18, Va.

DC Power Supplies 221

Features, specifications, and a description of dc power supplies appear in this two-page illustrated bulletin. A circuit for hot wire operation and a circuit for thermistor operation are also included. Gow-Mac Instrument Co., 100 Kings Road, Madison, N.J.

IDEAS FOR DESIGN

Thyratron Gates, Stores, And Drives Punched Paper-Tape Output

TO ACCELERATE the nuclear research program at our laboratory, a system was designed to punch binary data from an RCL pulse-height analyzer (PHA) on paper tape concurrent with the printing of decimal information.

In the PHA, a 20-bit word is stored in a magnetic core memory. There are 256 (2^8) such words stored. When the PHA is in the print mode, the 20-bit word is read out of storage into a flip-flop register. The eight-bit address is available in a similar register. Approximately eight μsec after being read into the word register, a binary-to-decimal conversion routine begins which destroys the binary data.

A total of 300 milliseconds is required to punch the 28 bits of data and address on paper tape, so that storage external to the PHA is necessary. In addition, 60 ma at 50 v are required to operate the punch coils.

The usual method of achieving the required results is shown in Fig. 1. Information is gated to storage flip-flops on store command. Storage flip-flops are gated to punch drivers, which drive paper-tape punch coils. For this system 56 gates, 28 flip-flops, and 6 punch drivers are required.

Our requirement called for a minimum number of components, resulting in greater reliability and economy. The basic element in our solution is the tetrode thyratron, which has the following desirable characteristics:

1. Conduction may be inhibited by either grid (gating).
2. Once the thyratron conducts, grids lose control (storage).
3. Thyratrons may safely pass large amount of current (driver).

The final circuit is shown in Fig. 2. Twenty-eight thyratrons and a stepping switch are required. The output of a PHA flip-flop is connected to grid *2* of the thyratron; it is slightly positive for a "1" and at −40 v for a "0."

When the 20-bit word is set up in the PHA register, a 4-μsec store pulse is applied to grid *1*. Those thyratrons connected to flip-flops in the "1" position will not fire. Since grid *1* is normally biased negative, changes in the PHA flip-flops before or after the store pulse will not affect the thyratrons.

These thyratrons conduct through a 50 K plate resistor until selected by a stepping switch connected to the punch coils. When this selection is made, five bits per cycle are punched. In six punch cycles, the binary word and address are punched. The thyratron memory is then cleared, and the unit is ready for another channel. The channel is advanced when both paper-tape punch and PHA printer have completed the cycle.

Robert M. Walker, Electronics Engineer, Lawrence Radiation Laboratory, University of California, Livermore, Calif.

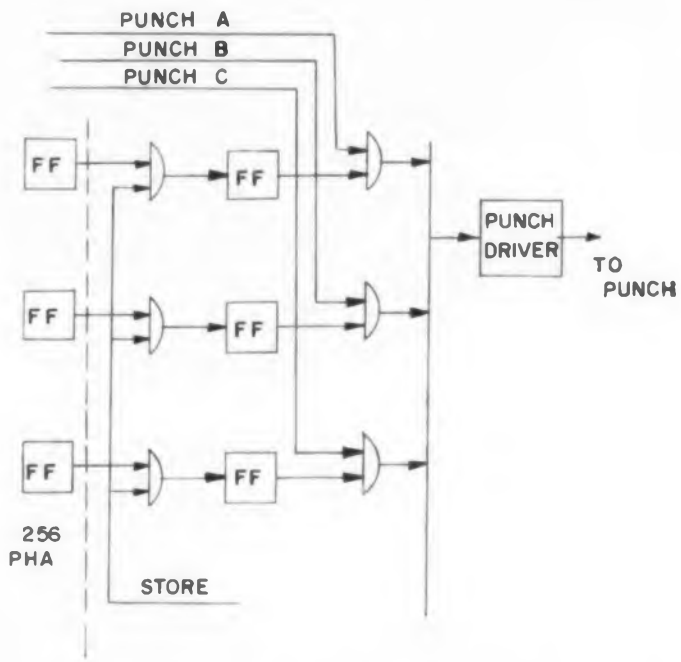


Fig. 1. Conventional circuit uses 56 gates, 28 flip-flops and 6 punch drivers.

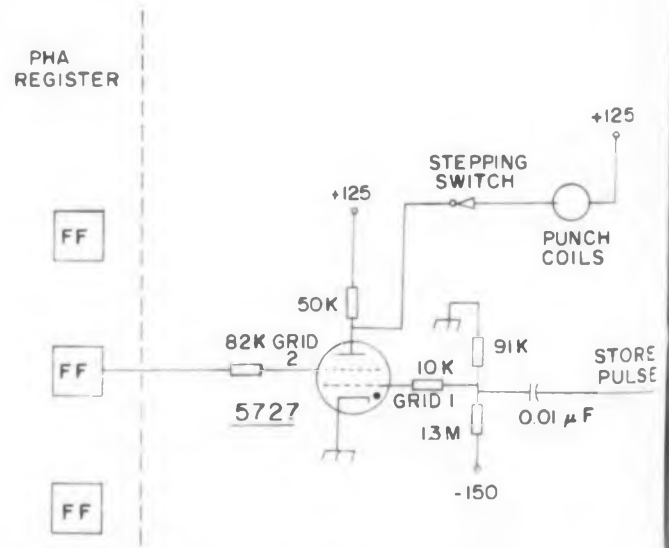


Fig. 2. Thyratron circuit uses 28 thyratrons and a stepping switch to accomplish the same gating, storage and driving functions.

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CIRCLE 228 ON READER-SERVICE CARD

IDEAS FOR DESIGN

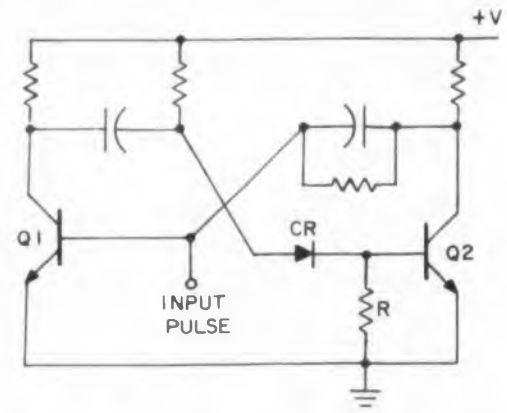
Diode Protects Transistor Junction in Monostable Circuit

In many transistorized monostable applications, the cut-off pulse applied to the base of the transistor *Q2* will exceed the maximum cut-off voltage and destroy the junction. The use of diodes to solve this problem might be overlooked.

A diode *CR* having a peak inverse voltage greater than the cut-off pulse will act as a voltage divider because of its high back resistance. In the normal conducting state of the transistor there will be no effect because of the low forward resistance of the diode.

Resistor *R* prevents I_{co} from turning *Q2* on.

Walter V. Billin, Engineer, The Martin Co., Baltimore 3, Md.



Diode in series with transistor base prevents destruction of Q2 junction by cut-off pulse.

Transistorize A One-Shot Phantastron Circuit

Transistorization of a phantastron circuit has often baffled designers. Here is a means by which it can be done.

Fig. 1 is a simple one-shot pentode phantastron.

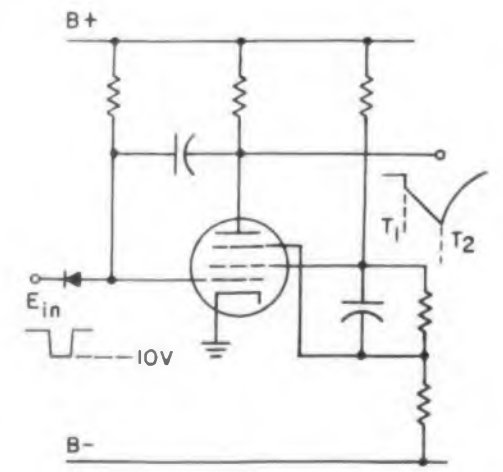


Fig. 1. A conventional pentode one-shot phantastron circuit.

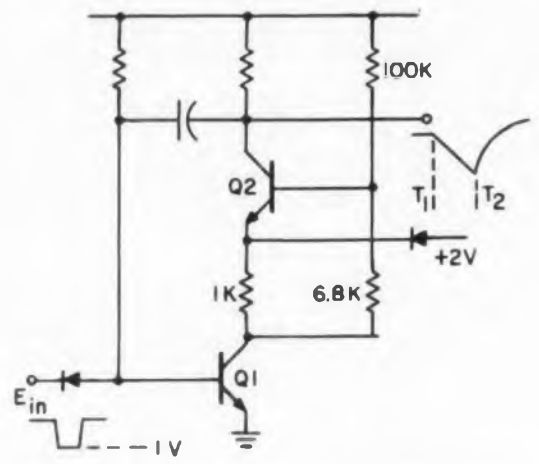


Fig. 2. Transistorized version of the phantastron.

Fig. 2 is the transistorized version.

The circuit may be triggered at several points. During standby, the plate is cut off in the pentode circuit of Fig. 1. In the transistorized version of Fig. 2, *Q2* is cut off during standby, by means of the drop across the 1-K resistor. The sweep is initiated by momentarily cutting off *Q1* or relieving the drop across the 1-K resistor. The linearity of the sweep voltage is comparable or better than the pentode equivalent.

Tom Kitaguchi, Electrical Engineer, Martin Co., Baltimore 3, Md.

Zener Diodes Avert Transistor Derating

The high-voltage switching transients present in saturating-core-type transistorized power supplies frequently cause transistor failure. For this reason, the transistors must be operated at voltages lower than those for which they were designed.

This circuit allows operation at full ratings of the transistor. It also affords protection against any transients on the supply, *E*.

The Zener voltage of the diodes should be 2*E*. *R* is only necessary to limit the Zener current to safe values and will be very small (1-2 ohms). This circuit is also applicable to the grounded emitter and grounded base configurations.

Robert A. Durand, Electrical Engineer, Martin Co., Baltimore 3, Md.

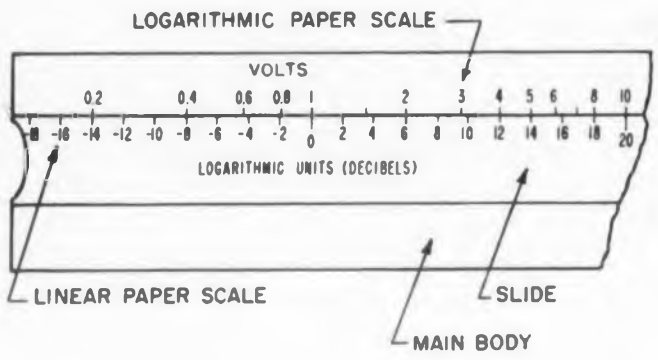
Symbol Dropped In Head

A symbol was dropped out of the head for an Ideas For Design article by Charles Gage (*ED*, Nov. 11, p. 174). The head should read "Power Supply Delivers Low Z, High I, Low Cost." Apologies to Mr. Gage and readers.

Modified Slide Rule Converts Volts to Logarithmic Scale

Voltage readings obtained from meters or from oscilloscopes must often be converted to logarithmic values in order to plot on semilog graph paper. A cheap slide rule can be quickly modified to perform these conversions with the help of a little graph paper.

First determine the maximum number of decimal digits in the numbers which you ever expect to convert (i.e., units, tens, hundreds, thousands, etc.). Select a semilog graph paper with this number of cycles.



Graph paper past-ons modified this inexpensive slide rule to a handy lin-log converter.

Select a linear graph paper with lines that form integral increments of this log scale. If an exact match is not available, hand rule the proper scale on plain paper. (Let the space between the numbers 1 and 2 of the log scale equal six graduations on the linear scale).

Now calibrate the log scale in volts and calibrate the linear scale in logarithmic units (decibels if the reference voltage is proper).

R. Fred Pfost, Ampex Corporation, Redwood City, Calif.

Special Glass Prevents RF Leakage Through Test Equipment Window

A problem existed in maintaining rf shielding across a glass window in test equipment. The application required viewing a tape transport unit and yet reduced radio noise emanating from the window area.

Successful results have been obtained using glass with a thin transparent conductive coating applied. Such glass is manufactured by Pittsburgh Plate Glass Co. The hardened glass window has

an area 12 in. x 10 in. and a coating resistance of 15 ohms per inch square.

Connections are made to the glass by means of silver plating buss strips around the edge of the conductive coating. Attenuation figures range from 30 db at 30 mc to 20 db at 10,000 mc. At frequencies below 30 mc the glass becomes more opaque. Best shielding properties are obtained with lowest resistance coatings, but below 15 ohms per inch square the reduction in transparency may become noticeable.

J. R. Marchant, Electronics Engineering Dept., Stromberg-Carlson Co., Div. of General Dynamics Corp., Rochester 3, N.Y.

More On Dimensioning PC Boards

The thought had not occurred to us that the dimensioning of printed circuit boards plagued other companies as it has our own. After reading Mr. Baltayan's article on the subject (*ED*, Sept. 2, p. 30) we would like to tell you of our solution to the problem, one which appreciably reduces the work involved on the part of everyone connected with the drawings.

Stated briefly, we make our drawings to the same degree of accuracy as a layout and then lend our vellum to the printed circuit manufacturer, who may scale the vellum or even use it for a direct over-lay. This method eliminates the designer's problems of creating and specifying dimensions and the manufacturer's problems of interpreting and applying them, all of which are burdensome jobs. At present we still dimension critical hole patterns, special cut-outs, and the outlines of the board itself. These dimensions are relatively few and fill three needs:

1. Control of critical dimensions is assured within specified limits.

2. Our file prints continue to show all dimensions we are concerned with.

3. The printed board manufacturer has a method of detecting dimensional changes in the vellum and setting up his enlarger.

We protect our vellums in transit by use of cardboard mailing tubes. A reproducible copy is made of the vellum before it leaves the plant as insurance against possible loss or mutilation. This copy is destroyed when the original is returned.

So far, we have had no trouble of any kind with this extremely simple system nor can we detect any change in product quality. I might add that this system evolved from a discussion with the manufacturer and is as desirable to him as it is to us.

R. D. Reid, Flight Test Engineer, Dept. 6-7, Zone 6, Box 5, Convair, Fort Worth, Tex.

IDEAS FOR DESIGN

Idea For Design—True, But With Explanations

Dear Sir:

In the article on the modified cathode follower by Mr. John A. Mooney (*ED*, June 24, 1959 p50), there are some misleading conclusions which appear to be due to incomplete analysis of the circuit. The following remarks may help to clarify the operation of the circuit.

(1). The circuit cannot make the plate voltage look larger than the supply voltage. This can be seen by examining the last paragraph of the article for the case of a positive swing on the grid of V_1: "When the grid of V_1 swings positive (away from cutoff) the cathode of V_2 becomes more negative, thus lowering the effective plate voltage of V_1".

From this it will be noted that the apparent source voltage is being raised for one-half cycle and lowered for one-half cycle, so that the net dc change is zero. As far as V_1 is concerned, it thinks that the supply voltage has very poor regulation, since every time it draws less current the supply voltage rises, and vice versa for the attempt to draw more current. This, of course, is a direct consequence of the action by the cathode follower in reducing the voltage drop across RL by having the cathode follower supply some of the signal current drawn by V1.

(2). R (the parallel combination of the plate load and grid leak) is not affected in any way by the gain of the driver stage, since the driver gain does not appear in the feedback loop. For simplicity, let's assume that all capacitive reactances are small in comparison with the resistances connected to them; circuit analysis then shows the gain of V1 to be given by

$$\frac{e_{p1}}{e_i} = \frac{-\mu_1}{1+\frac{r_{p1}}{R_e}\left[1-\frac{1+R_e g_{m2}}{1+R_e\left(g_{m2}+\frac{1}{r_{p2}}+\frac{1}{R_s}+\frac{1}{R_2}+\frac{1}{K}\right)}\right]}$$

while the gain of V1 and V2 combined is

$$\frac{e_o}{e_i} = -\frac{\mu_1}{1+\frac{r_{p1}+R_e}{1+g_{m2}R_e}\left(\frac{1}{r_{p2}}+\frac{1}{K}+\frac{1}{R_s}+\frac{1}{R_2}\right)}$$

and the output impedance of the combined circuit is

$$Z_o = \frac{1}{g_{m2}+\frac{1}{r_{p2}}+\frac{1}{K}+\frac{1}{R_s}+\frac{1}{R_2}+\frac{1-g_{m2}r_{p1}}{R_e+r_{p1}}}$$

where $$R_e = \frac{R_L R_g}{R_L + R_g}$$

R_s = resistor between R_L and supply voltage
$R2$ = resistor between R_g and ground
K = impedance of output transformer
Subscripts $_{on}$, etc, refer to $V1$ and V_2 as indicated.

If Eq. 1 is compared with the gain of a conventional driver stage, it is found that the apparent impedance that V_1 sees is increased over its actual value (R) by the reciprocal of the coefficient of r_p/R_L in Eq. 1 rather than being multiplied by the stage gain as stated in your article (actually stated as $A + 1$). However, this circuit does provide improved gain over a conventional driver direct-coupled to a cathode follower.

Using typical values for a 6SL7 driver and 6SN7 cathode follower, for example, and assuming 10 K impedance for the output transformer (it should be as high as reasonably practical) the circuit should produce an overall gain of 62 with an output impedance of 380 ohms whereas the conventional circuit yields a gain of 50 with an output impedance of 308 ohms. The apparent load that V_1 sees, using the same parameters, is about 11 times the actual value.

Richard A. Wall
Motorola, Inc.
Riverside, Calif.

Dear Sir:

I have to fully agree with Mr. Richard A. Wall on point (1) of his letter explaining why the dc operating point does not change. However, since the dc operating point is the same and the loadline slope is much more nearly horizontal because the tube is looking into a high impedance, the effect is a much higher plate voltage feeding the driver through a much higher load resistor.

But the plate swing of the driver is limited to somewhat less than the supply voltage for peak-to-peak voltage output due to boundary conditions. On the extreme negative swing of the driver grid, the cathode follower cathode cannot go more positive than its plate or it would be cut off. On the extreme positive swing of the driver grid, the plate voltage cannot go below zero. So the effect is like a choke coupled stage feeding the cathode follower.

But this is enough swing, or at least very nearly enough swing, to fully drive the cathode follower without the use of the driver transformer.

It is very interesting to note that a very similar circuit appeared in ELECTRONIC DESIGN, July 8, 1959, by Andrew S. Williams at Stromberg Carlson. He was interested in getting high gain from a pentode by virtue of the high impedance. I am primarily interested in a great voltage swing and can, of course, use a pentode as a driver, though linearity will suffer slightly.

Mr. Wall's formulas given on point (2) are very

(Continued on p 158)

IDEAS FOR DESIGN

(Continued from p 157)

helpful to determine gain and other parameters within the operating region and are admittingly more thorough than my analysis. They are presented in a very useful form.

There is one problem with this circuit: the stray capacitances associated with the driver plate to ground will have a greater effect than before because they see a high impedance.

John A. Mooney
Lockheed Aircraft Corp.
Marietta, Ga.

Reverse Two-Phase Ac Motors Without Power Waste

Occasionally, it becomes necessary to use a two-phase ac motor to provide a reversible source of rotary mechanical power. Conventional switching methods can cause over-heating and single-phasing problems.

Reversing a two-phase motor is accomplished by reversing the electrical connections of one of the two field windings. This is usually done by using the circuitry shown in Fig. 1. In applications requiring only momentary power, switch "S" is a spring-loaded, momentary dpdt switch. By using the circuit of Fig. 1, electric power is always applied to the nonreversed winding. This causes undue heating during the periods when the motor is idle.

What can be more troublesome, when medium or larger sized two-phase servo motors are connected as shown in Fig. 1, single-phasing is possible. That is, after the motor has started, one phase winding is sufficient to keep the motor turning at reduced speed even though power in

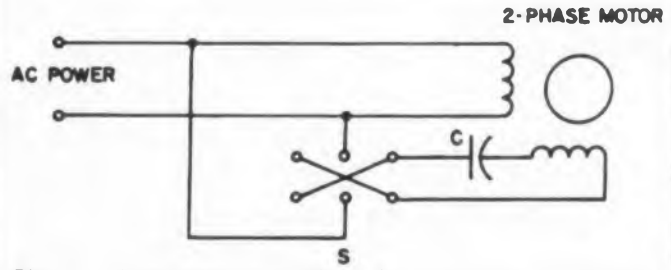


Fig. 1. Conventional method for reversing a 2-phase motor. Power is always applied to one winding.

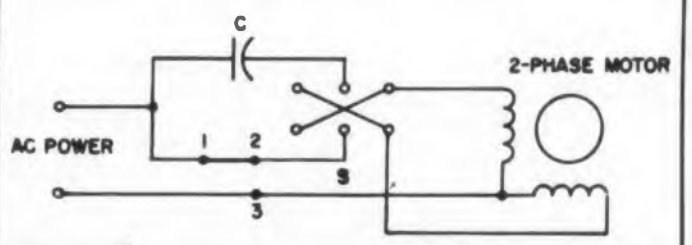


Fig. 2. Circuit showing a momentary dpdt switch used for motor reversal and power shut-off.

the second winding is disconnected.

The circuit shown in Fig. 2 can provide both reversible motor operation and complete power disconnection to both phases simply and without increasing the number of required parts. Here the reversing is accomplished by switching the motor capacitor "C" into either of the two-phase windings. When the dpdt switch returns to its center off position, power is then removed from both windings.

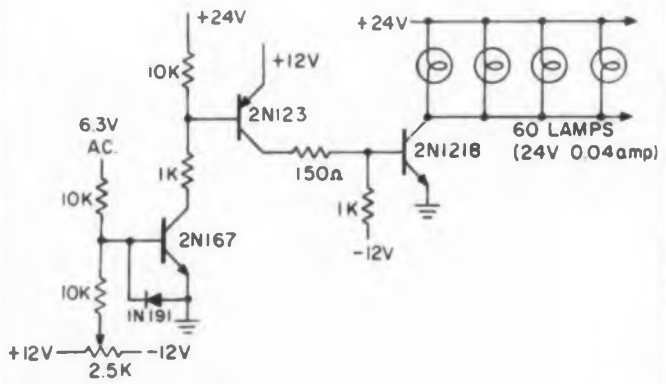
The motor rotational speed can be varied by opening the lead between points *1* and *2*. A variable voltage output power auto-transformer is connected between *1* and *3*. Its variable output is connected to point *2*. The motor speed is then changed by varying the voltage applied to one winding.

William B. Turner, Senior Engineer, Fairchild Astrionics Div., Fairchild Engine and Airplane Corp., Wyandanch, L.I., N.Y.

Panel Light Intensity Varied By Duty-Cycle Control

A control was needed for varying the intensity of the back lighting of a display consisting of 60 electromechanical readouts. The lack of available space and the relatively large current involved (2.4 amp maximum), as well as the desirability of keeping dissipation to a minimum suggested that a unique solution was warranted.

In the solution illustrated, the lights are pulsed at a 60 cps rate by a power switching transistor.



INTENSITY CONTROL

Unusual approach to light intensity control employs this variable duty cycle circuit.

The duty cycle of the resulting square wave is varied by a potentiometer adjustment. The variation in intensity is controllable over a range from full brightness to complete extinction. Control is smooth and there is no flicker. Dissipation in the control circuit is kept to a minimum and the circuit occupies a small space.

Jim Curry, Engineer, Tasker Instruments Corp., Hollywood 28, Calif.

PATENTS

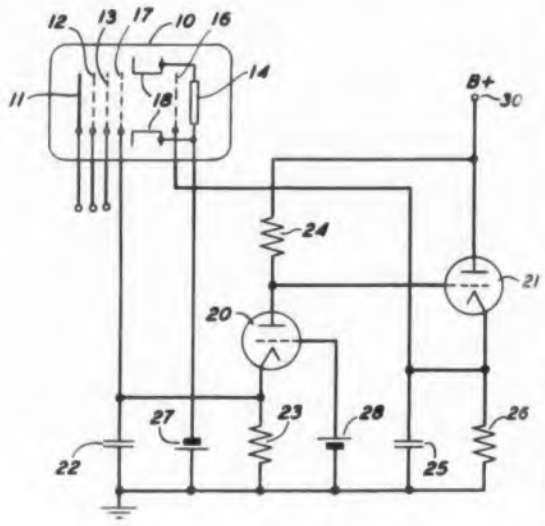
Virtual Cathode Stabilization Means

Patent No. 2,903,580. George H. Robertson. (Assigned to Bell Telephone Labs., Inc.)

A stabilized virtual cathode circuit permits the control grid to operate at low temperature and the output is substantially independent of aging, deterioration or movement of the cathode.

A virtual cathode exists between electrodes *13* and *17* since the triode comprising cathode *14*, grid *16* and grid *17* generates an electron beam subject to control by the negative potential applied to control grid *13*. Electrode *18* serves to focus the beam.

Triodes *20* and *21* stabilize the virtual cathode as follows: If screen grid *17* goes positive, the grid-cathode bias of amplifier *20* decreases, and the voltage applied to amplifier *21* is reduced. The cathode of this stage couples the lower voltage to grid *16* and thereby the current collected by screen grid *17* is made less. Should, by contrast, the voltage on screen grid *17* decrease below the reference level, the degenerative network will make the proper adjustment.

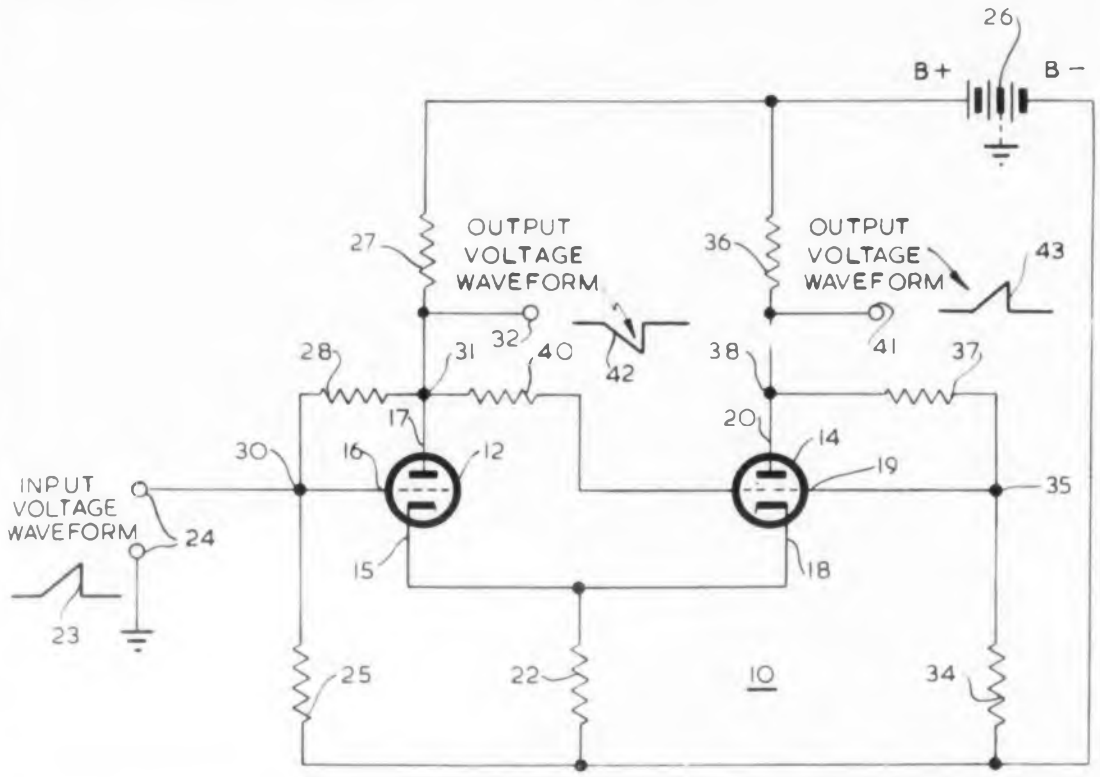


Phase Inverter

Patent No. 2,903,525. Claude W. Cooke, Jr. (Assigned to Hughes Aircraft Co.)

Equal values of plate impedance in a

cathode-coupled phase inverter may be used when tube circuits are balanced. In the schematic shown, cathode resistor *22* couples to amplifier *14* which contains feedback resistor *37* to correct distortion; similarly amplifier *12* contains feedback through resistor *28*. Cross-connecting resistor *40* modulates the voltage on grid *19* to compensate for the reduced grid to cathode swing due to resistor *31* and thereby allows equality of plate resistors *27* and *36*.



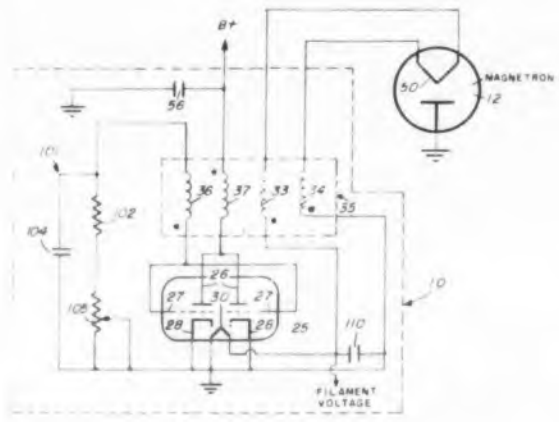
PATENTS

Generation of Very Short Microwave Pulse

Patent No. 2,908, 870. Clyde D. Hardin, James Salerno. (Assigned to USA)

Millimicrosecond, high repetition rate pulses are generated by a blocking oscillator employing a ferrite-core transformer to drive an x-band magnetron directly. The driving pulses are of proper shape for the π-mode.

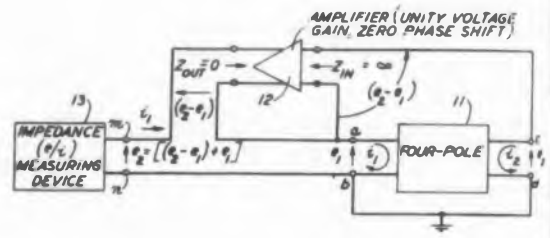
A circuit typical of the invention is shown. The transformer core consists of 1.25 in. toroid of Ferramic G and he plate-grid, as well as the output windings, are wound bifilar to further reduce the capacitance. With a 500 v plate supply, the oscillator output impedance is 600 ohms for 35 μsec pulse repeated at 100 kc.



Measurement and Simulation of Transfer Parameters

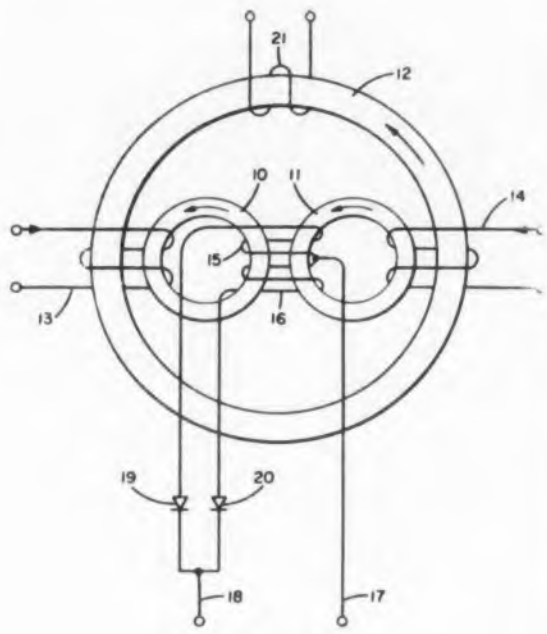
Patent No. 2,907,950. Gordon Raisbeck. (Assigned to Bell Telephone Labs, Inc.)

A unity gain, zero phase shift cathode



follower amplifier simplifies measurement of the transfer impedance of a four-pole network.

As illustrated, amplifier *12* is connected between the four-pole output and input such that the voltage across the measuring device is e_2, the four-pole output voltage. In addition, since the cathode follower input impedance is very high, $i_2 = 0$ and four-pole input current is i_1. Thus, the transfer impedance is measured directly.



Magnetic Core Half Adder

(Patent No. 2,872,667. Mao Chao Chen. Assigned to General Dynamics Corp.)

The magnetic core device generates a first output when either of two inputs is pulsed and a second output is developed when the two inputs are pulsed simultaneously.

In the array of cores physically dimensioned and polarized as shown, a pulse applied to input *13* sufficient to switch core *10* develops an output across terminals *17* and *18*. The flux linking core *12* is insufficient to flip this larger element; also, diodes *19* and *20* assure that core *11* does not reverse. A pulse separately applied to input *14* flips core *11* exclusively. However, pulses to both inputs *13* and *14*, of the correct sense, change the magnetization of core *12* to flip coil *21*.

BOOKS

The Theory of Numbers and Diophantine Analysis

Robert D. Carmichael, Dover Publications, Inc., 180 Varick St., New York 14, N. Y., 212 pp, $1.35

These are two complete works, bound together in one volume. Though no previous training is necessary beyond a firm foundation in high school mathematics, the material will be found useful by teachers and students at all levels of ability.

"Theory of Numbers" deals with one of the most extensive and elegant disciplines in the whole body of mathematics. It includes Prime Numbers, Eratosthenes' Sieve, the Fundamental Theorem of Euclid, the Unique Factorization Theorem, G.C.F. and L.C.M. of Two or More Integers, the Indicator of an Integer, Congruences, Theorems of Fermat and Wilson, the Converse of Wilson's Theorem, Linear Congruences, Primitive Roots Modulo m, etc. The last chapter indicates directions of further studies, such as Theory of Quadratic Residues, Analytical Theory of Numbers, Diophantine Equations, Pythagorean Triangles. Included in the text are 76 carefully chosen exercises which further the collection of useful results.

"Diophantine Analysis" is organized around the notion of a multiplicative domain. The exposition is supplemented by 222 exercises, on three levels of interest practice material for developing facility an indication of special results already obtained and problems found amenable t

...ek; and unsolved problems of particu... interest. Partial contents: Rational Tri...gles; Method of Infinite Descent; Pythagorean Triangles; On Numbers of the Form $x^2 + axy + by^2$; Quadratic Equations of the Second Degree in Two Variables, in More Than Three Variables, of a Higher Degree; Equations of the Third Degree, of the Fourth Degree, Higher Than the Fourth Degree; the Fermat Problem, the Method of Functional Equations.

Space Technology

Edited by Howard S. Seifert, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1100 pp, $22.50

This book is the first collection of serious analytical treatments of all phases of space technology by 38 top men in their respective specialties. It is a thorough quantitative exposition of those natural laws which are uniquely related to space flight.

The subject of ballistics and flight dynamics—the foundation of space travel—is treated in an especially complete and analytical way, with eleven authors presenting much new material.

The next most vital subject, propulsion, is treated by seven authors and covers both present-day and future systems. Major sections are also included on communications and guidance (six authors), man in space (four authors), and scientific uses of space (four authors).

To add to the completeness of the discussion, the same area of subject matter is occasionally treated from separate points of view by different authors. The book's 500 selected references form a guide to the significant parts of a vast literature.

The book is based on a series of lectures presented by the Department of Engineering and Physical Sciences, University Extension, University of California, in cooperation with Space Technology Laboratories, Inc.

This series codified significant laws and pointed out many important new problems with the enormous development of space technology yet to come.

BOOKS

Classification and Definitions of Diagrams and Charts Used in Electrotechnology (IEC Publication, 113)

American Standards Association, 70 E. 45 St., New York 17, N.Y., $1.20

This new publication providing internationally-accepted standard definitions and classifications of diagrams and charts in the field of electrotechnology has become available through the American Standards Association.

American interests in IEC work are represented through the U. S. National Committee of the IEC, an arm of the American Standards Association.

There are 34 nations in the IEC, which was founded in 1904 to coordinate national standards in electrotechnology.

Diagrams and charts are defined and classified in this publication to explain or picture electrical and electronic connections.

Two kinds of classifications have been adopted: according to purpose, and according to method of presentation.

Handbook of Automation, Computation and Control

Drs. Eugene M. Grabbe, Simon Ramo and Dean E. Wooldridge, John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N. Y., 1093 pp, $17.50

Design and use of the computers is explored in detail in the second volume of this monumental "Handbook of Automation, Computation and Control."

Contributors to the volume are high-ranking scientist-engineers and educators affiliated with America's top electronic organizations. They have furnished practical material on design of computing elements and equipment operation; explored new developments such as magnetic cores and transistors; functions of data processing systems as well as techniques; equipment and applications; an entire section on advanced programming and coding and many allied fields.

Under way for several years, the project will be completed in 1960 with Volume 3 on Systems and Components.

A Treatise On Algebraic Plane Curves

Julian Lowell Coolidge, Dover Publications, Inc., 180 Varick St., New York 14, N. Y., 513 pp, $2.45

The text treats such topics as the topological properties of curves, the Riemann-Roch theorem, and all aspects of a wide variety of curves including real, covariant, polar, containing series of a given sort, elliptic, hyperelliptic, polygonal, reducible, rational, the pencil, two parameter nets, the Laguerre net, nonlinear systems of curves; etc.

It is almost entirely confined to the properties of the general curve rather than a detailed study of curves of the third or fourth order. Algebraic procedure is generally used, with large portions written according to the spirit and methods of the Italian geometers.

However, there is much use of geometric methods, especially those involving the projective geometry of hyperspace.

The reader will find that this volume will carry him far enough to appreciate the symbolic notation of Aronhold and Clebsch.

Partial content:

The Fundamental Properties of Curves: Asymptotes; Real Circuits of Curves; Nesting Circuits; Elementary Invariant Theory; Projective Theory of Singular Points; Plucker's Equations; Klein's Equation; The Genus; Metrical Properties of Curves; The Singular Points; The Reduction of Singularities; Development in Series; Clustering Singularities; Systems of Points on a Curve; General Theory of Linear Series; Abelian Integrals, Moduli and Limiting Values; Singular Points of Correspondences; Nonlinear Series of Groups of Points on a Curve; Higher Theory of Correspondences; Parametric Representation of the General Curve; Postulation of Linear Systems by Points; Ternary Apolarity; The Cremona Transformation; much more.

BOOKS

Processing of Thermoplastic Materials

E. C. Bernhardt, Reinhold Book Co., 430 Park Ave., New York 22, N.Y., 706 pp. $18.00

Here is a definite, and extensive handbook on the engineering problems involved in extrusion, injection molding, calendering and other thermoplastics processing operations.

The book reviews the engineering fundamentals on which the design of plastics processing equipment is based and demonstrates the practical application of these fundamental concepts in the analysis of thermoplastics processing problems.

The text is developed simply and clearly, and is designed to help fill the need for a basic book on processing of thermoplastics.

The book is aimed at engineers, but does not require the reader to possess previous knowledge of plastics processing technology.

Nineteen technical authorities have contributed to this volume from first-hand experience, and fourteen plastics firms and universities have supported it by providing information, editors and authors.

Contents of the book includes:

- Fundamentals of flow behavior, heat transfer and thermodynamics, mixing and dispersing.
- Applications including extrusion, injection molding, sheet forming of hollow articles, sealing and welding.
- Processing properties.

Laplace Transforms For Electronic Engineers

James G. Holbrook, Pergamon Press, Inc., 122 E. 55 St., New York 22, N.Y., 238 pp. $8.50

This book fills a long-felt need for a graduate level text on the Laplace Transformation that can be used either in classroom instruction or for self study by the practicing electronics engineer.

Though it has been carefully edited to eliminate the heavily abstract, non-electronic terminology of pure mathematics, it will be found rigorous and thorough enough to satisfy the most critical instructor for classroom use.

This book will be particularly valuable to the graduate electronic engineer who wishes to develop and expand his knowledge of circuitry and networks by a careful program of study, formally or informally, of the modern methods of Laplace transform theory and applications.

The very complete set of Laplace transform tables, and transform function tables, together with a bibliography which includes references as recent as 1958, make this a valuable reference work.

Taking a new approach to the subject, the author begins with enough of the fundamentals of complex variable theory to enable the engineer without previous training in the theory to follow the more rigorous developments of the Laplace transform.

Recent advances covered, other than the formal Laplace transform theory itself, include much very recent material on modern filter networks and synthesis, oscillator networks, special integrating and differentiating networks and other feedback circuitry, methods of solving the transfer function of iterative networks by Pascal's triangle, and the new process of summing infinite series by using the Laplace transform method.

Few of these topics have even been mentioned in previous treatments of the subject; their inclusion, and the chapters devoted to practical applications of the theory of today's problems, will be welcomed by electronic engineers who wish to familiarize themselves with modern developments in the field.

A Six-Stage, Low Frequency Logarithmic Amplifier

A. N. Sus and G. V. Ratanov

Saratov State University,
U.S.S.R.

THIS ARTICLE describes a six-stage low-frequency amplifier with a logarithmic relationship between the input and output voltages. Developed at the request of the Semiconductor Institute of the U.S.S.R. Academy of Sciences, the amplifier operates from 20 to 5,000 cycles.

It will accept input voltages from 10 microvolts to 10 volts. Its input impedance is one megohm.

To obtain a logarithmic relationship between the input and output voltages in an amplifier, use is usually made of the method of successive detection. This method, compared with others, is most effective with respect to the range of the input voltages within which logarithmic dependence can be insured.

The idea of the method of successive detection is based on the following:

A detector is used after each stage of amplification. The outputs of all the detectors flow through a common resistor, from which the output signal is picked off. As the input signal is increased, the last tube overloads first and its output voltage stops increasing with increasing input voltage.

Then, upon further increase in input voltage, the next-to-last tube saturates. As a result, the increase in output voltage is slower than the increase in input voltage.

It is difficult to carry out an exact quantitative analysis of such a circuit. The circuit characteristics are computed graphically, using an experimental curve of the dependence of the output voltage on the input voltage in a single stage. Such a calculation shows that the better the use of the amplifying stage and the less the gain of each stage, the closer to logarithmic is the characteristic of the amplifier. The amplitude characteristic of each stage should be similar to that shown in Fig. 1.

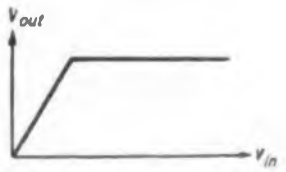


Fig. 1. Amplitude characteristic of a single amplifying stage.

The upper limit of acceptable input voltages is determined by the value of the input voltage at which grid current starts flowing in the first tube. The lower limit of the input voltage is determined by the level at which the last stage of the amplifier overloads.

The limiting value of the minimum input signal is determined by the noise level of the amplifier. With a noise level of a broadband amplifier of about one microvolt, the minimum value of the input voltage is approximately 10 microvolts.

Thus, the method of successive detection, without using voltage dividers at the input, insures a continuous measurement of input voltages in a range of five or six orders of magnitude. Measurement of the voltages over so broad a range without the need for any switching devices at the amplifier input is the principal advantage of this type of amplifier. It makes it possible to use it for continuous investigation of widely varying electronic quantities.

Description of the Amplifier

The amplifier circuit, shown in Fig. 2, consists of six identical stages, each built around the triode portion of a 6G2 double-diode triode. The gain of each stage is approximately 10 and the total gain is approximately 10^6. Decoupling filters are connected in the plate circuits and a 6Kh6 dual-diode is connected at the output of each amplifying stage.

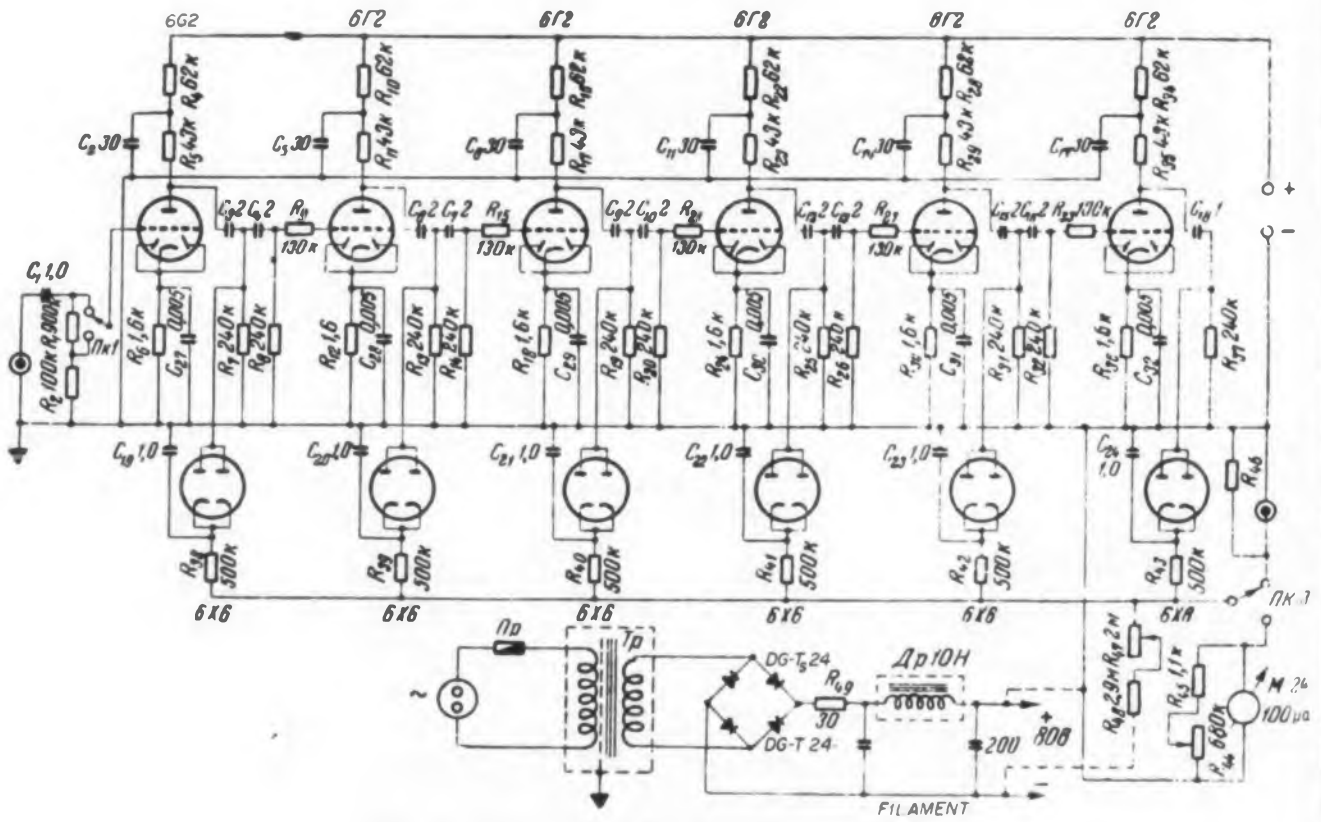


Fig. 2. Schematic of the logarithmic amplifier.

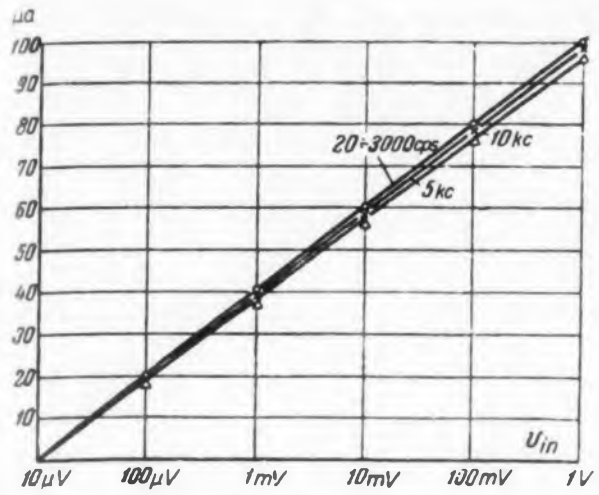


Fig. 3. Calibration curves of the amplifier at 20 to 3000 cps, 5 kc and 10 kc.

Connected to the output of the amplifier is a microammeter or an EPP-09 automatic recording potentiometer. A voltage divider is connected to the input. With the voltage divider in position *1*, the amplifier makes it possible to measure input voltages from 10 microvolts to one volt, and in position 2, from 100 microvolts to 10 volts.

The filaments of the tubes are fed in series from a separate rectifier, consisting of DG-Ts 24 germanium diodes connected in a bridge circuit. The filter insures high ripple suppression. At a rectifier output of 80 volts, the ripple voltage is approximately 150 millivolts. The rectifier circuit is shown in the lower portion of Fig. 2.

Calibration of the Amplifier

The amplifier is calibrated in such a way that when an alternating voltage of 10 microvolts is applied to the input, the output instrument reads zero. This is done by passing a bucking signal through the output instrument when 10 microvolts appear at the input.

The compensation is effected by connecting the output instrument through a large resistor $R_{47}R_{48}$ at the terminals of the supply to the filament circuit.

Calibration curves for the amplifier for various frequencies are shown in Fig. 3. ■ ■

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GERMAN ABSTRACTS

E. Brenner

Low Leve

IN MEASUREMENT and control applications, it is frequently necessary to convert low-level dc voltages or currents into corresponding ac signals for drift-free amplification, as indicated by the block diagram of Fig. 1. For the most part, the modulators (choppers) which are used for the purpose of inversion consist of a voltage divider in which one element varies synchronously with the carrier frequency. The characteristics of eight different types of modulators are shown in the accompanying table.

In mechanical choppers (Fig. 2a), drift arises from thermal and electrostatic noise as well as through capacitive and inductive coupling to the moving contact.

For measurement of thermal voltages at extremely low frequencies, a thallium wire at the temperature of liquid helium is used. An ac magnetic field periodically modulates the superconductivity.

For high input impedance level, the voltage divider of Fig. 2b, where a mechanically driven time varying capacitor furnishes the carrier variations, is well suited. In this circuit, the average input time constant must be large compared with the carrier period. The rms ac output, V, is related to the dc input, V, by the formula $V/V_0 = 0.71\Delta C/C$, resulting in small values of transfer constants.

In modulators which employ photoresistors, Fig. 2c, drift is caused by the fact that not only does the modulated light source produce

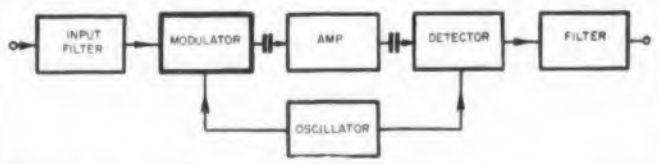


Fig. 1. Block diagram of chopper stabilized dc amplifier.

resistance variation but it also produces temperature dependent photo-voltages. Further difficulty is encountered in attempting to modulate sufficiently intense light sources. This situation can be improved by using glow tubes whose spectral distribution matches the spectral sensitivity characteristics of the photoconductor (for example, argon is preferable to neon for cadmium sulfide).

Diode modulators (Fig. 2d), when compared to the preceding circuits, have the disadvantage of not isolating electrically the dc signal circuit from

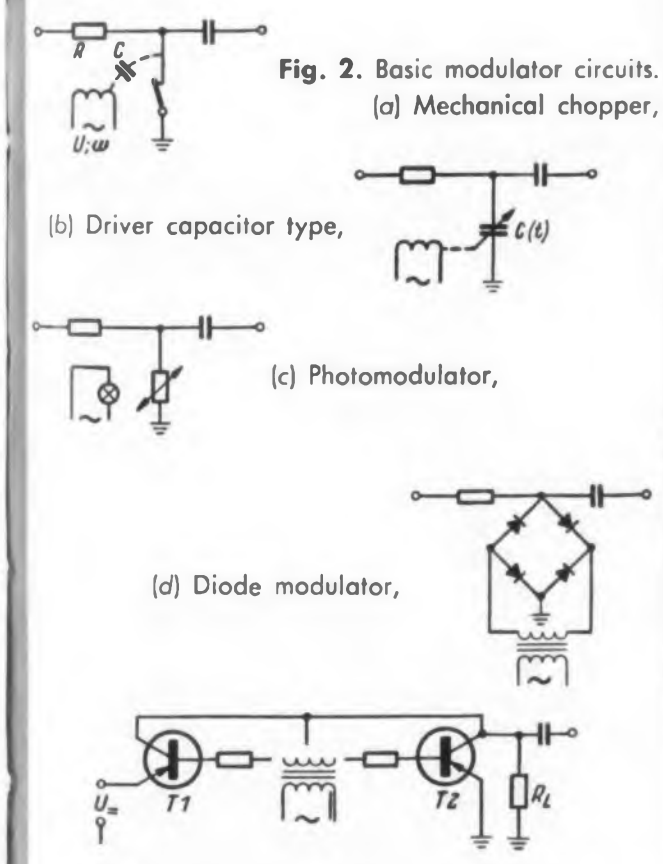
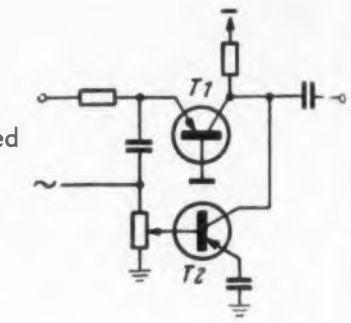
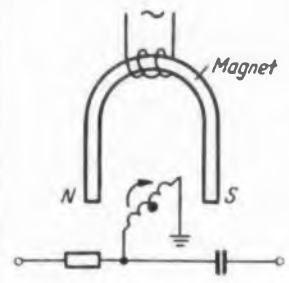


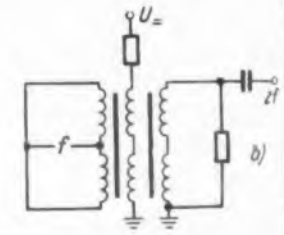
Fig. 2. Basic modulator circuits. (a) Mechanical chopper, (b) Driver capacitor type, (c) Photomodulator, (d) Diode modulator, (e) Voltage compensated transistor circuit,



(f) Current compensated transistor circuit,



(g) Moving coil induction-type modulator,



(h) Magnetic modulator.

Peak Reading Voltmeter for Pulses

IN LABORATORY work, nonrecurrent microsecond voltage waveforms may be analyzed by using cathode-ray oscillography with resistent screens. When peak values only are desired, this elaborate method can be replaced by use of a direct reading instrument which consists of cascaded peak detectors. Even with the use of electrometer tubes, a single stage peak detector cannot be used for microsecond pulses; no special tubes or components are needed in the cascaded circuit, yet pulses as short lived as three μ sec can be measured with adequate precision.

The principle of the cathode-follower coupled cascade is shown in Fig. 1. For the first stage, the charging time constant is $R_{L1}C_1$ and the discharge time constant is $R_{E1}C_1$; successive stages have progressively longer time constants ($R_{E1} = R_{E2}$, $C_2 > C_1$). The peak output voltage of the second stage, V_{2max}, is given approximately by $V_{2max} = V_o\epsilon^{n \ln n}$ where $n = R_{L2}\ C_2/R_{E1}C_1 \ll 1$, and the cathode follower gains were taken as unity. The voltage v_2 rises to this maximum in negligible short time and then decays with the time constant $R_{E2}C_2$.

...ne ac circuit. Carrier suppression is achieved by ...pending on bridge balance. On the other hand, ...he possible use of high carrier frequencies permits ...nstruction of relatively broadband dc amplifiers.

A variety of switching transistor modulators is possible. Either the residual voltage in the "switch closed" condition (Fig. 2e) or the residual current in the "switch open" condition (Fig. 2f) may be compensated.

On moving coil (induction) modulators (Fig. 2g), the zero-signal error is determined by the feasible decoupling between the exciting and moving coil.

Magnetic modulators require comparatively large carrier power, are sensitive to stray fields and are comparatively bulky. In the example shown (Fig. 2h), the second and other even harmonics provide a measure of the dc voltage; the presumed symmetry of the magnetic characteristics is relied on to balance out the fundamental frequency components.

Abstracted from an article by G. Meyer-Broetz Telefunken Zeitung, *Vol. 32, No. 125, September 1959, pp 189-195. A 32-item bibliography, referring chiefly to the U.S. literature, is included in the original paper.*

...or Nonrecurrent ...Pulse Measurement

If more stages are used, a sufficiently long discharge time constant for the final stage can be prescribed together with a sufficiently short time constant for the input stage. Setting $n = R_{L(n+1)}C_n/R_{En}C_n$ and $a = R_{En}/R_{Ln}$, the number of stages required for discharge time constant τ_m is

$$m = \frac{lg \dfrac{R_E\, C_m}{R_{L1}\, C_1} \cdot n}{lg\ a \cdot n}$$

Abstracted from an article by K. F. Heine, Elektronische Rundschau, *Vol. 13, No. 10, Oct. 1959, pp 365-366.*

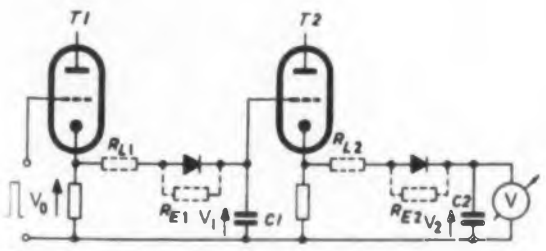


Fig. 1. A cascade of peak detectors with progressively increasing time constants.

Variable Capacitance Paramp For Low Noise Without Refrigeration

IN THE RACE for lower and lower noise, we presently find the maser far in the lead, since the noise associated with its basic amplifying mechanism is negligibly small. Many applications, however, do not require and cannot benefit from this ultimate in noise performance.

For these applications, the variable-capacitance "parametric" amplifier offers the advantage of simplicity. Its noise performance lies somewhere between that of vacuum tubes and masers yet, in contrast to masers, neither refrigeration nor a magnetic field are required. If we are willing to introduce a moderate amount of refrigeration, that is, refrigeration to liquid nitrogen temperature, further improvements in noise performance can be obtained.

There are two basic types of variable-capacitance amplifiers: the negative-resistance amplifier and the up-conversion amplifier. Both types were first demonstrated at Bell Laboratories.

The two types of amplifiers have in common the use of a variable-capacitance diode as the active element and a high frequency ("pump") signal as the principal energy source. They differ, though, in their mode of operation, in the applicable frequency range, and in several other respects.

Negative-Resistance Parametric Amplifier

Let us first examine the physical principles involved in the negative-resistance amplifier. Suppose we have at our disposal the simple resonant circuit of Fig. 1.

This circuit is unconventional only in that one of the plates of the capacitor is movable. A small sinusoidal signal voltage of frequency s (top left in drawing), applied to the terminals of this circuit, would cause the charge on the capacitor to vary sinusoidally also.

Next, imagine that the upper capacitor plate is

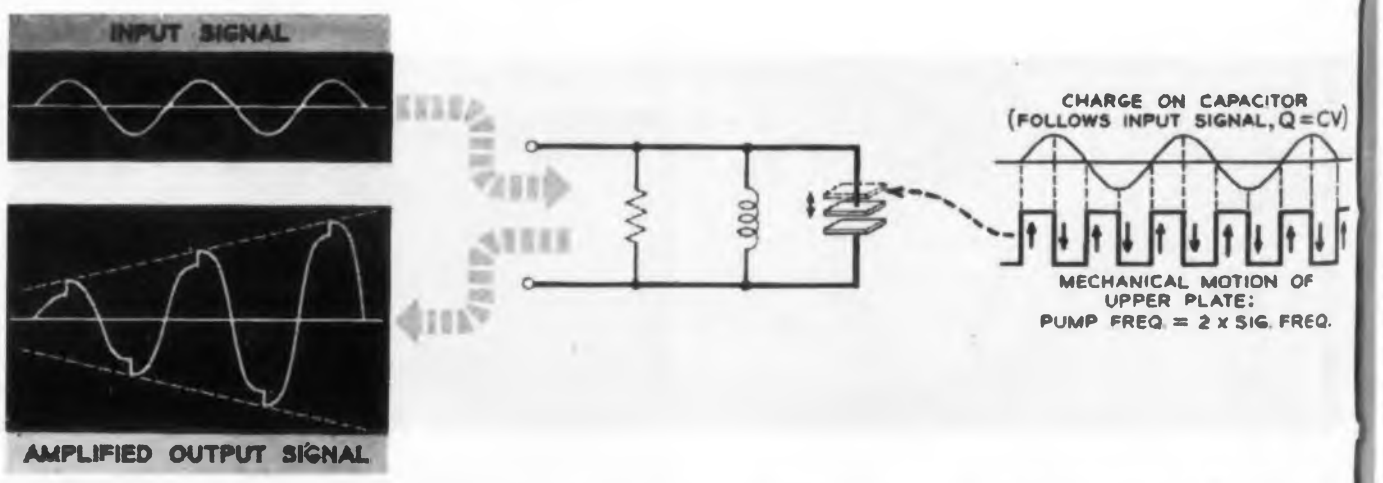


Fig. 1. Mechanical analogy to variable-capacitance amplification. The top plate of the capacitor is "pumped" up and down at twice the signal frequency. Capacitance is decreased when voltage increases.

pulled upward a small amount whenever the charge is at a maximum, regardless of polarity. This maximum, of course, occurs twice every cycle. The plate is returned to its original position whenever the charge is zero—again twice every cycle.

In other words, we are performing, with the upper capacitor plate, a square-wave "pumping" motion at twice the frequency of the applied signal. The phase relationship has been so chosen that the capacitance is always decreased during that part of the cycle which finds the charge relatively constant.

But for constant charge, the $Q = CV$ relation states that the voltage across the capacitor is inversely proportional to the capacitance. Hence, whenever we decrease the capacitance, we increase the voltage and obtain gain. This "pumping-up" of the signal voltage is shown as an amplified output signal at the bottom left in Fig. 1.

Another way to look at this amplification process is to note that we always have to do work *on* the circuit whenever we separate the plates in the charged condition, since we have to overcome the attractive force between the opposite charges on the capacitor plates.

No work is expended, however, in restoring the original plate-separation, since this occurs whenever the charge on the capacitor plates, and hence the attraction between them, is zero. The energy transferred from the external pump (not shown in sketch) to the circuit provides the signal gain and internal amplifier losses.

Why do we call this type of gain "negative-resistance" gain? Because, like a resistor, this type of parametric amplifier is a two-terminal or single-port device. In the case of *positive* resistance, the power reflected is always less than the incident power. Conversely, we speak of a *negative* resistance if the reflected power exceeds the incident.

Like a Child on a Swing

A well-known example of this kind of amplification is a child pumping-up the excursions of a swing. Twice during each complete cycle—that is, at both extremes of the swing—the child will raise his center of gravity and lower it during both downward phases of the swing.

Let us now turn to a practical high-frequency amplifier. Here, of course, our capacitance is varied electronically and the capacitance itself is not a parallel-plate capacitor, but rather a special kind of semiconductor diode—one in which the terminal capacitance varies with the applied voltage.

Depending on the operating frequency, the environment of this diode may either be coaxial or stripline circuitry or, in the microwave range, a waveguide cavity.

DIGEST

(Continued from p. 177)

The Pump and the Signal

Another important difference between the idealized analog treated earlier and a practical situation pertains to the pump and signal frequencies.

For maximum energy transfer from pump to circuit, the signal frequency must precisely equal half the pump frequency and must bear a definite and fixed phase relation to the pump. This frequency and phase relation is very difficult, if not impossible, to maintain, since the incoming signal ordinarily varies in both frequency and phase in a way which is beyond the control of the receiver.

If, however, we are willing to settle for something less than maximum energy transfer, such exact control is not required. In part (*a*) of Fig. 2, the frequency of an incoming signal is marked *s* and the frequency of the pump is marked *p*. As shown, *s* is somewhat less than half the pump frequency, *p*/2.

As a result of this frequency difference, the signal and pump will no longer interact favorably all the time, but rather will drift periodically into and out of the condition for favorable interaction.

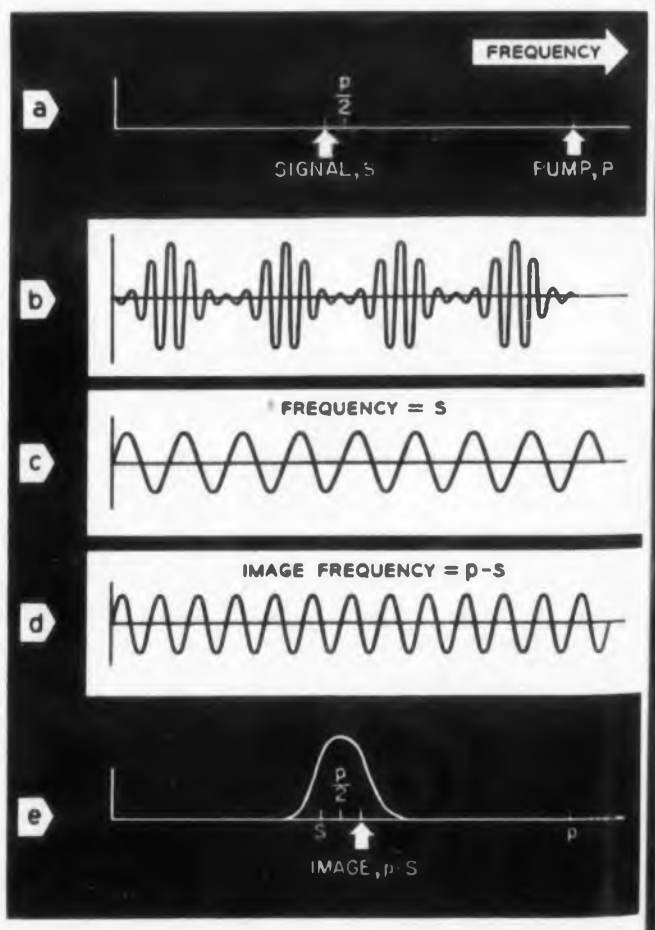


Fig. 2. When the signal is displaced from half the pump frequency, as in (*a*), a modulated output, (*b*), results with the components shown in (*c*) and (*d*). The image frequency is symmetrical around *p*/2 as in (*e*).

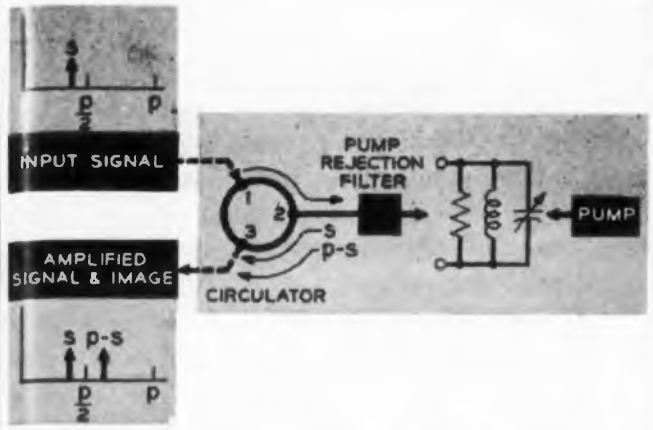


Fig. 3. In the three-terminal ferrite circulator, the signal is introduced at *1* and enters the amplifier through *2*. The amplified signal, together with its image, returns through terminal *2*, and the output appears at terminal *3*.

Hence, the amplified signal emerging from the amplifier will be modulated as shown in part (*b*). Separated into its component sinewaves, this modulated signal is the sum of two uniform signals, (*c*) and (*d*)—one at the signal frequency, *s*, and the other at the frequency *p-s*.

In (*e*) we have repeated the frequency scale but have added the new frequency, *p-s*. We note that *p-s* is as far above *p/2* as *s* is below. Because of this symmetry, *p-s* is called the "image" of the signal.

The Inevitable Image

The generation of this third frequency is a very important characteristic of the negative-resistance amplifier: by introducing a signal which differs in frequency from half the pump frequency, we get back not only an amplified signal at the signal frequency but an equally strong signal at *p-s*.

Two important facts to bear in mind with this image signal—or as some call it, the "idler"—are these: First, the image signal is an inevitable by-product of this type of amplification. Suppressing it would also suppress the desired amplification of the signal. Second, the closer the signal is to half the pump, the closer the image will be to the signal, and the more difficult it will become to separate signal and image by filtering. Consequently, the amplifier must have enough bandwidth to encompass both the signal and its image.

In contrast to conventional amplifiers, this type of variable-capacitance amplifier must have twice the bandwidth occupied by the signal. It therefore accepts and amplifies twice the normal input noise. All the more surprising that, in spite of this handicap, the over-all noise performance of the variable-capacitance amplifier is still better in some cases than the best we can do with vacuum tubes. This is primarily due to the small amount of noise contributed by the semiconductor diode.

The reader may justly wonder at this point how

DIGEST

the various signals we have encountered so far—namely the input signal, the amplified output signal, the image and the pump—are unscrambled and put to use. One neat method makes use of another solid-state element, the ferrite circulator, illustrated in Fig. 3.

The signal to be amplified is introduced at terminal *1*, and by the circulator action is guided to terminal *2*. Here, it enters the parametric amplifier, is amplified and re-emerges at terminal *2*, together with its image. Again, by the circulator action, these two signals are guided to terminal *3*, which thereby becomes the effective output terminal.

Prior to detection, the two signals are separated in a suitable filter network. The pump signal is confined to the variable-capacitance diode and is prevented from leaking into the output by means of a sharp pump-rejection filter placed between the parametric amplifier and terminal *2* of the circulator.

Variable-Capacitance Effect

Until now we have assumed, without explana-

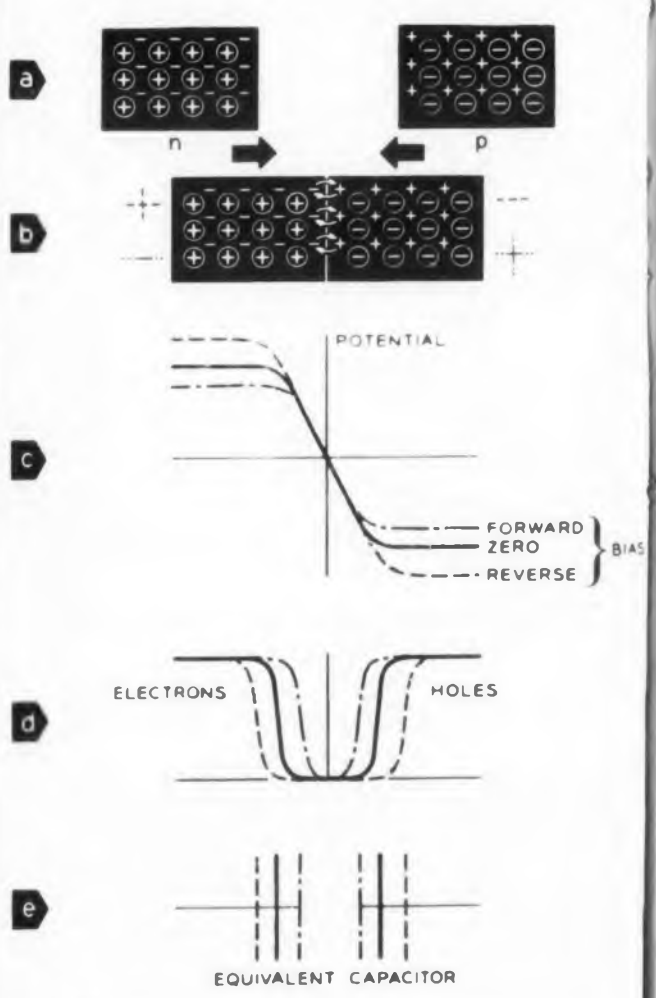


Fig. 4. At a p-n junction, the region swept free of charge carriers can be varied by changing bias voltage. This action is equivalent to varying the space between the plates of a capacitor.

tion, the existence of an electronically variable capacitance. Since this really is the heart of the parametric amplifier, an explanation will next be given of the variable-capacitance effect in semiconductor diodes.

At the top of Fig. 4, we see two sections of semiconductor material. In the *n*-type section on the left, the circled plus signs represent fixed positive charges due to donor impurities, and the minus signs represent mobile negative charge-carriers or electrons. In the *p*-type section, the circled minus signs represent fixed negative charges due to acceptor impurities, and the plus signs represent mobile positive charge-carriers or holes.

By themselves both slabs are electrically neutral —that is, in the *n*-type material the fixed positive charges are neutralized by precisely the same number of electrons, and similarly in the *p*-type material the fixed negative charges are exactly neutralized by the same number of holes.

Let us now go through the fictitious process of forming a *p-n* junction by bringing the two slabs into contact, as in part (*b*) of the drawing, and observe in slow motion the events leading to the establishment of equilibrium.

With the *p* and *n* section in contact, electrons will diffuse from a region of high to one of low electron density—that is, from left to right. Similarly, holes will diffuse across the junction from right to left. As this diffusion proceeds, the loss of electrons will render the previously neutral *n*-type section increasingly positive.

Also, the diffusion of holes from the right to left will render the *p*-type section increasingly negative. The resulting potential difference between the two halves will set up an electric field at the interface, as shown by the solid curve in part (*c*). This field is so directed as to oppose and finally bring to a halt the diffusion of electrons and holes across the junction.

In addition, the field will sweep clear of electrons and holes a narrow region about the interface, thus giving rise to the equilibrium distribution of electrons and holes shown by the solid curve of (*d*).

The central layer—also called the *depletion layer* because it is devoid of mobile charge carriers —may be thought of as a nonconducting or dielectric region. Since it is bounded on both sides by regions containing mobile charge-carriers—that is, conducting regions—we may compare the diode to a parallel-plate capacitor with a plate separation equal to the width of the depletion layer.

Suppose, next, that the junction is given a slight reverse bias—a bias so directed as to increase the potential difference between left and right—the dashed curve in (*c*). The positive potential applied to the *n*-side will then urge the electron distribution toward the left, and the negative potential applied to the *p*-side will urge the hole

distribution to the right.

This will cause a widening of the depletion layer and a decrease in terminal capacitance. Similarly, a forward bias (dash-dot curve) will urge the electron and hole distributions toward each other, the depletion layer will shrink, and the capacitance will increase. Thus we have a capacitor, the terminal capacitance of which will vary with the applied voltage.

It is very important to note that this variation in capacitance results from a very minute motion of electron and hole distributions, and that an actual flow of these charge carriers across the junction is not involved. These are the principal reasons why both the high-frequency and low-noise performance of the variable-capacitance diode are superior to that of the transistor.

Negligible Transit Time

In fact, the motion of charge carrier distributions under the influence of the applied voltage is so minute—only a few millionths of an inch—that transit-time effects are completely negligible. These, of course, constitute basic limitations in the high-frequency response of transistors and many other electron devices.

What does limit the high-frequency performance of the diode is an inevitable fixed capacitance, which appears in shunt with the useful variable capacitance. This fixed capacitance depends on the contact area of the diode, the width of the depletion layer, the type of encapsulation, and the applied bias. Together with the series resistance of the diode, it determines the upper frequency limit for amplification. At present, this limit lies in the 30-60 kmc range for silicon *p-n* junction diodes of good quality.

The series resistance of the diode, the value of which depends primarily on the composition and geometry of the bulk of the semiconductor material, is the principal source of internal noise in the parametric amplifier. Recent experiments at Bell Laboratories by Uenohara have shown that this noise can be considerably reduced by refrigeration of the diode to liquid nitrogen temperature.

An experimental amplifier combining these ideas and principles was built by M. Uenohara of Bell Laboratories. As illustrated in Fig. 5, it uses a variable-capacitance diode in a simple waveguide cavity. For this amplifier, Uenohara specifies a useful signal band (thickened portion of response curve) 4 mc wide with a midband gain of 20 db. This signal band is well separated from half the pump frequency.

Because of the presence of the image band, there is no one number which fully describes the noise behavior of this amplifier. Rather, we must

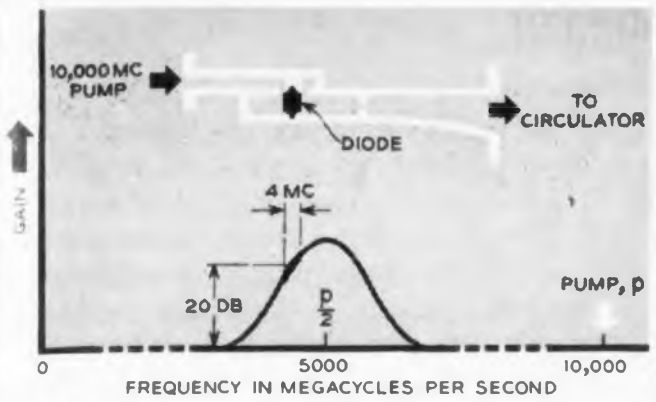


Fig. 5. Structure of a 5000 mc variable-capacitance paramp. The response curve shows that the operating region, slightly off the center frequency of 5000 mc, gives a 4-mc bandwidth with a gain of 20 db.

know whether the signal is coherent, as in communications, or noise, as in radio astronomy.

Also we must have information on the source temperature. For instance, when a coherent signal originating from a room-temperature source is introduced in the signal band only, Uenohara's amplifier will exhibit sensitivity equal to that of traveling-wave tube having a 5 db noise figure.

However, when this same amplifier receives signals from the *cold* sky, such as from satellites, it will exhibit noise performance equal to that of a traveling-wave tube having a noise figure of 3.7 db.

In still another case when the signal itself is noise, as in radio astronomy, the same amplifier will have the sensitivity of a 2 db traveling-wave tube. Here, the "signal" may be introduced in both the signal and the image band, so that the effective bandwidth is now equal to the signal band, and not twice this band as in single-sideband reception.

By placing the diode in a resonant cavity, it is apparent that we can extract the highest gain per diode, but we are at the same time paying the penalty of a restricted bandwidth. This restriction can be eliminated by mounting the diode in a nonresonant environment.

Gain per diode is thereby sacrificed, but overall gain can be recovered by using large numbers of diodes in suitable arrays. These diodes then become part of a transmission line and interact with traveling signal and pump waves. R. Engelbrecht of Bell Laboratories has built such an "iterated" amplifier using 16 pairs of diodes in a modified coaxial line. This amplifier has a bandwidth of 200 mc at an operating frequency of 600 mc.

The Up-Conversion Amplifier

The second major type of parametric amplifier is the so-called "up-converter." It differs from the negative-resistance amplifier in these respects:

1. The frequency involved here, in addition to the signal frequency, s, and the pump frequency, p, is the upper sideband, $p + s$. In con-

trast, the negative-resistance amplifier uses only the lower sideband, $p - s$.

2. In a well-known theorem, J. M. Manley and H. E. Rowe of the Bell Laboratories have shown that gain in the up-converter is proportional to the frequency ratio $(p + s)/s$. Hence, to achieve reasonable gain, the pump frequency must be many times greater than the signal frequency, whereas a ratio of only two was required for the negative-resistance amplifier. This requirement for a large ratio of pump to signal frequency has restricted experimental up-converter work to signal frequencies in the uhf band.

3. In the up-converter, the signal frequency is inevitably shifted in the amplification process, while in the negative-resistance amplifier the amplified signal may be used either at the original frequency or at the lower sideband frequency.

4. The up-converter is a true two-port amplifier having unconditional stability, whereas the negative-resistance amplifier, being a single-port amplifier, requires a circulator for stable operation.

With up-converters, over-all system noise figures of less than 2 db have been achieved in the uhf band. Such amplifiers have been built at Bell Laboratories by Uhlir and at Airborne Instruments Laboratories.

The Manley-Rowe theorem, incidentally, suggests still another type of parametric amplifier.

Design Considerations for Power

MANY FACTORS must be considered carefully when designing square-wave oscillators for use in power conversion. The relative importance of each factor must be weighed in the light of the specific application of the particular power converter. The relationship between efficiency, stability, reliability and cost must be kept in mind in any design.

The desired maximum power output level is probably the principal factor in the design of a power converter. Important considerations in this

It is a hybrid between the negative-resistance and the up-conversion types. In common with the former, it uses the lower sideband, $p - s$. In contrast to the negative-resistance amplifier, however, and in common with the up-converter, the pump frequency is chosen many times higher than s. The lower sideband signal at $(p - s)$—now also much higher in frequency than the input signal—is the useful amplified output.

This operation has the advantage of higher gain and better stability than the negative-resistance amplifier. Uhf amplifiers of this type have been built at Bell Laboratories by H. Seidel and G. F. Herrmann and also by Workers at Federal Telecommunication Laboratories. The application of these low-noise amplifiers in scatter propagation systems should offer attractive economies.

This review of variable-capacitance amplifiers has been restricted to a description of broad principles and a small number of representative experiments. The intense industry-wide attention these amplifiers have received testifies to their great potential. It is only a matter of time before they will be extensively introduced into the communications industry.

Abstracted from The Variable-Capacitance Parametric Amplifier *by E. D. Reed, which appeared in the October 1959 Bell Laboratories Record.*

...ation...r Square-Wave ...Powe...pplies

...d care... ...cillators ...ive im... ...l in the ...rticular ...en effi... ...be kept

...level is ...gn of a ...s in this

respect are available source current and source voltage. If the available dc source voltage is too high for safe operation of the transistors, it may be necessary to use circuits with transistors connected in series. If the input voltage is low and the required output power is high, it may be necessary to operate transistors in parallel.

Efficiency and Rated Output

For most power converters, the efficiency falls off rapidly as the output power level deviates

upwards or downwards from the rated maximum output power. In view of this, it is desirable that the output load be as constant as possible and preferably within 20 per cent of the rated output of the converter.

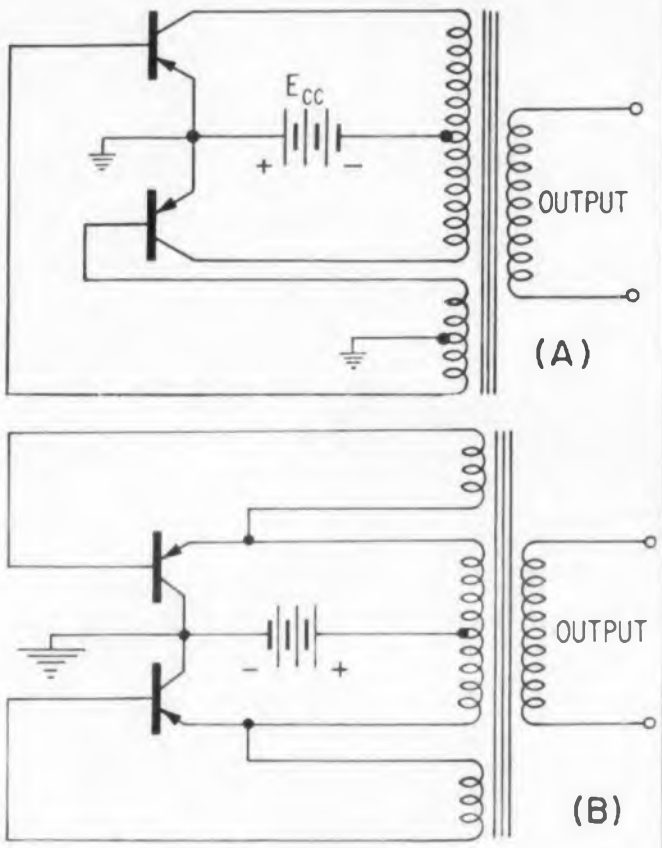


Fig. 1. Two types of square wave oscillators. The conventional common emitter circuit of (*A*) is more efficient than common collector types, but the latter allow the advantage of mounting transistors directly on a metal heat sink. The grounded-collector, common emitter circuit of (*B*) provides both advantages, efficiency and direct grounding.

There are two basic modes of output transformer core operation in square wave oscillator applications. The output transformer itself may be excited to saturation, or a winding of the output transformer may drive a small additional transformer to saturation to switch the transistors. Although the first method is the more widely used, the second method has distinct advantages.

Single Transformer Square Wave Oscillators

The type of core material used in the transformer is important. The core configuration also has an effect on transformer performance from the standpoint of leakage inductance. Interleaved and bifilar windings will help reduce these flux losses. Leakage inductance should be minimized because it contributes to the formation of dangerous voltage spikes on the leading edge of the output waveform. Leakage inductance will also

hinder load-current reversal.

Transformer core materials with narrow hysteresis loops give best efficiency because of lower core losses. Some of these materials have relatively low saturation flux densities which require that their cross-sectional areas be relatively large.

Transistor Operating Modes

In designing a square wave oscillator, one must consider the relative merits of the possible modes of transistor operation—common emitter, common collector, and common base. The overall circuit efficiency may change appreciably from one type of circuit to another because of the differing amounts of power which must be diverted from the output circuit and dissipated as copper losses in the feedback winding.

For example, the common emitter type of the square wave oscillator circuit shown in Fig. 1A requires less input power, for a given output power, than common collector types. This is because the transformer efficiency for the latter circuit may be lower due to greater copper loss in the additional turns of the feedback winding.

Offsetting this disadvantage, common collector operation will frequently permit mounting the transistors directly on the chassis or uninsulated heat sink. However, the same result can be achieved in the grounded-collector common-emitter circuit in Fig. 1B.

Transformer efficiency in a common base circuit is lower than that in a common emitter circuit because the same V_{be} at a higher current must be transformed. Most of this power is recovered because the supply voltage is effectively higher. The additional copper required to transform this current may not only increase copper losses, but can also require a larger core window to accommodate the additional bulk of the winding.

Feedback Windings

Considerable care must be taken in designing the feedback windings. When the transistor is forward biased, enough current must be supplied to maintain the transistor in the saturated condition under full load. Similarly, if the transistor is reverse biased, enough voltage must be supplied to bias the transistor to cutoff.

For Delco transistors a minimum value of two volts will be sufficient if the resistance of the drive circuit is small enough to allow proper base current for the collector current needed.

At the same time it is important that feedback voltage be as small as practical. In particular, high cutoff voltages (above four volts) will increase the possibility of secondary breakdown and should be avoided.

Excessively large base currents during conduction will increase the switching transients. These

DIGEST

high-voltage switching transients constitute a major problem. A transistor switching off an inductive load is subjected to a very high voltage spike. This spike is generated when one transistor switches "off" while the other switches "on."

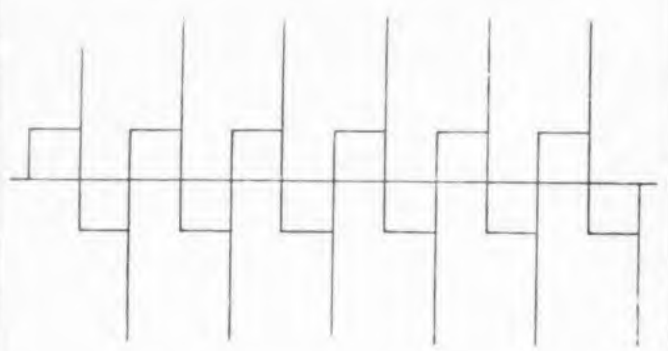


Fig. 2. Leading-edge voltage spikes across the primary of an oscillator transformer can cause heating at the transistor junction.

An oscilloscope with good frequency response will show the voltage spike at the leading edge of square waves. It is believed that these spikes (Fig. 2), though of low energy, cause localized heating at the transistor junction.

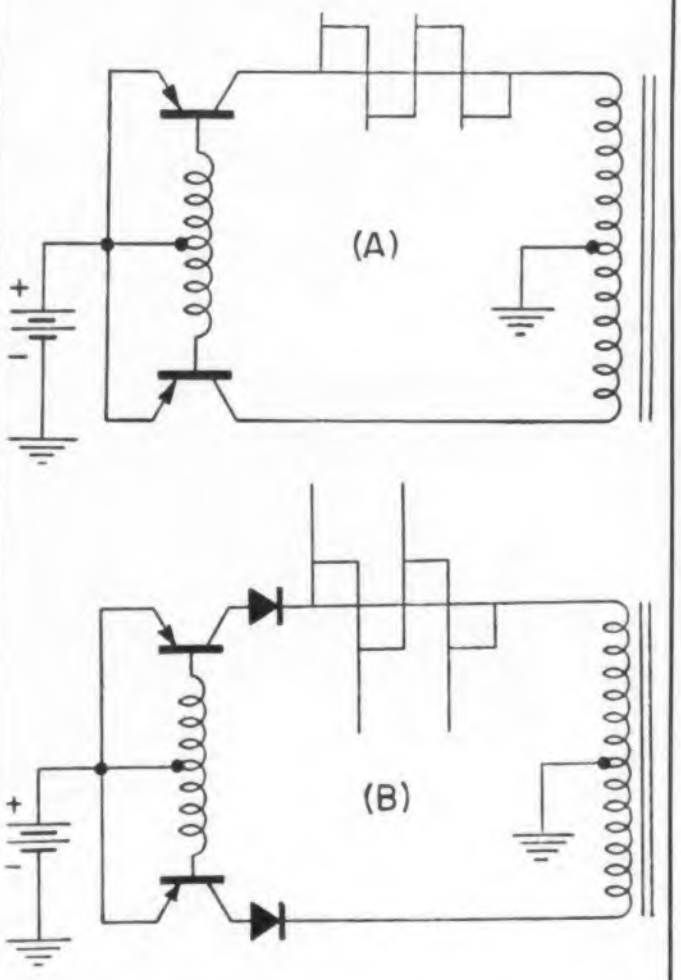


Fig. 3. Push-pull oscillators tend to reduce voltage spikes due to collector clamping as at (*A*), but series diodes disable the clamping and the spikes remain, as at (*B*).

Push-Pull Oscillators

A push-pull square wave oscillator is self-protecting to some extent since the voltage spikes are reduced somewhat, as first one end of the collector winding, and then the other clamps itself to the B supply by forward conduction through its collector diode. Through transformer action, this also reduces the spike at the other collector.

Fig. 3A shows how the voltage spikes normally appear across the collector leads of an oscillator. Note that in Fig. 3B, diodes in series with the collectors, prevent clamping. The spikes are increased, since the collector windings cannot clamp to the B supply.

Two-Transformer Square-Wave Oscillators

Another means of decreasing switching transients is by use of a two-transformer saturating-core oscillator such as that shown in Fig. 4. In this circuit, the output transformer operates in the nonsaturated region of the hysteresis loop of the core. Because the output transformer operates in this linear region, the coupling between halves of the primary and from primary to secondary is optimum. The total leakage flux and the inductance associated with it are reduced. Thus, the transient voltage generated during switching is reduced.

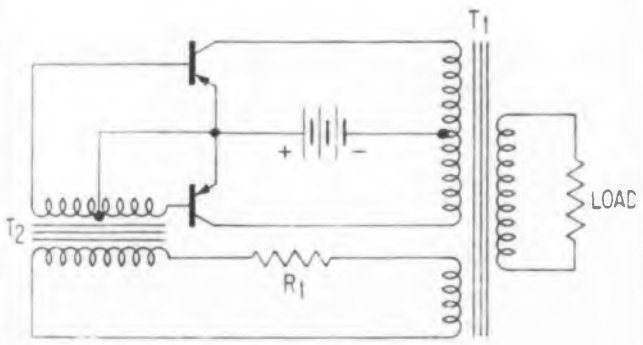


Fig. 4. The two-transformer saturating-core oscillator reduces switching transients by reducing leakage flux.

The switching in Fig. 4 is effected by means of a small saturating transformer T_2 with a series resistor R_1 in the base drive circuit. T_2 is designed to saturate before T_1. As T_2 saturates, the magnetizing force will first increase, dropping more voltage across R_1 until all of the voltage appears there. Then it decreases, generating a voltage transient.

The amplitude of this transient can be much lower than that developed in a single transformer circuit. This is because the leakage inductance of T_2 can be made smaller, due to its reduced size as compared to that of the output transformer.

DIGEST

Other Methods of Transient Reduction

If a core shape other than toroidal is used, it may be necessary to use external components for despiking. As alternatives to the use of special transformer core shapes, the following methods may be used to limit excessive switching voltages.

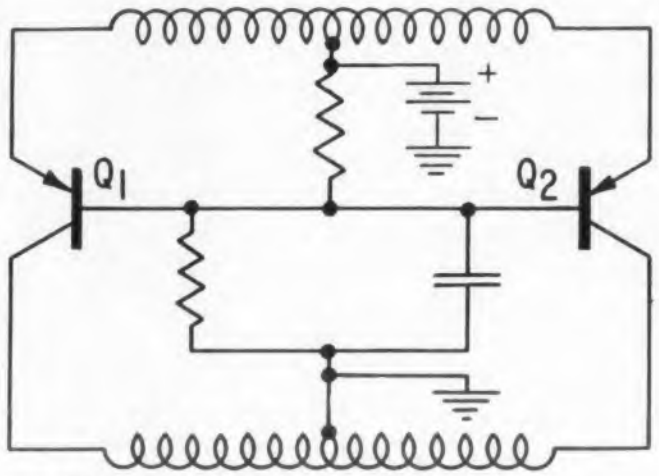


Fig. 5. A common-base despiking network.

Fig. 5 shows a despiking network consisting of a capacitor and a resistor in a common base circuit. As transistor Q_1 switches off, the collector of Q_2 tries to go positive. Current flows from collector to base and the capacitor absorbs this sudden voltage surge with a negligible increase in charge. By discharging through the bias network, the capacitor is then ready for the next voltage spike.

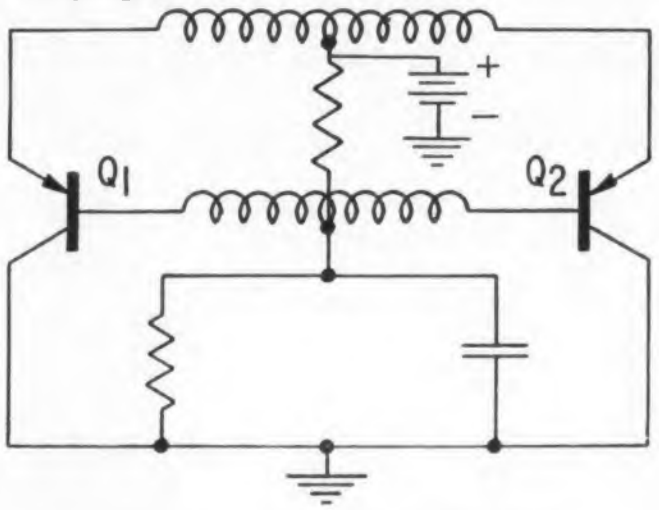


Fig. 6. A common-emitter despiking network.

Fig. 6 represents a similar common-emitter despiking network. As conduction of Q_1 stops, Q_1 collector tries to go positive. It is clamped to the voltage that appears across the capacitor. As the transistors switch, one collector diode clamps and then the other.

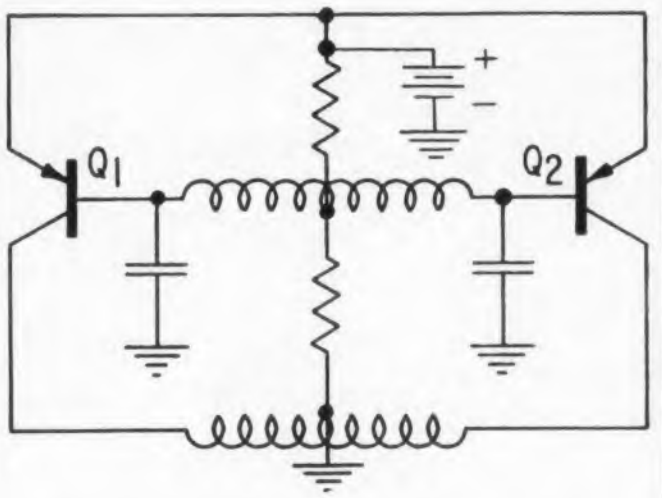


Fig. 7. A common-collector despiking network.

Fig. 7 shows the despiking network that might be used with a common collector circuit. As transistor Q_1 switches off, the Q_2 base tries to go negative with respect to ground. It is clamped through the collector diode to the despiking capacitor. Between spikes, the resistor bleeds off some charge from the capacitor and keeps the voltage from building up.

The magnitude of the capacitance used in these clamp circuits depends on the amount of leakage inductance and magnetizing force involved. For example, the capacitors used with high nickel toroidal cores would be smaller than a tenth of those used with silicon iron "C" cores.

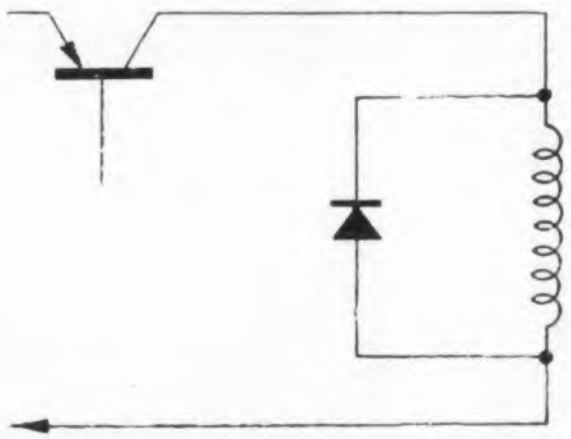


Fig. 8. A diode will remove spikes across an inductive load.

Fig. 8 shows how the spike can be removed from an inductive load as it is switched off, by placing a diode across the load.

Abstracted from Application Note 9-A, Design Considerations for Square Wave Oscillator Power Supplies. *Delco Radio Div., General Motors Corp., Kokomo, Ind.*

STANDARDS AND SPECS

Sherman H. Hubelbank

Electronic Industries Standards

Six new standards have been released by the Engineering Department of the Electronic Industries Association. Copies of each may be obtained from EIA, 11 W. 42nd St., New York 36, N.Y.

RS-211-A, Dimensional Characteristics of Monophonic and Stereophonic Disc Phonograph Records for Home Use, August 1959 (60 cents)

RS-222, Structural Standards for Steel Transmitting Antennas, Supporting Towers, August 1959 ($1.10)

RS-226, Television Picture Area—35mm and 16mm Motion Picture Film, October 1959 (25 cents)

RS-227, One-inch Perforated Paper Tape, October 1959 (25 cents)

RS-152-A, Minimum Standards for Land-Mobile Communications FM or PM Transmitters 25-470 mc, October 1959 (80 cents)

RS-228, Fixed, Tantalum Electrolytic Capacitors (Polarized), October 1959 ($1.65)

Transistors

MIL-STD-701A, Preferred and Guidance Types of Transistors, dated 25 September 1959, supersedes limited coordination standard MIL-STD-701 (Navy). The newly issued standard consists of a list of preferred types and guidance types of transistors. These types have been chosen jointly by the Department of the Army, the Navy and the Air Force. These transistors are for use in the design and manufacture of military equipment. Seven preferred types and 43 guidance types of transistors are listed. Preferred types are those transistors that have been in production and on a QPL list. Guidance types are those that have general application for use in military equipment.

Nomenclature

Once again the Navy has revised the technique of requesting nomenclature. This spec applies to the procurement of electronic production systems, sets, groups, units, and accessories. It is also intended to cover equipment procured for research and development, application engineering, service test, and evaluation. The full title of this specification is: MIL-E-21981 (SHIPS), Requirements

for Electronics Type Designations, Identification Plates and Markings, 1 July 1959.

TV Luminance Signal Levels

Methods of measuring the significant levels of a monochrome or color TV signal, either composite or noncomposite are described in this standard. The standard is concerned with measurements in transmission systems where the signals are at video frequency. These methods are limited to those involving the use of oscilloscopes. Copies of this standard are available from the American Standard Association, 40 E. 45 St., New York 17, N.Y., at 60 cents per copy. Specify C16.31-1959.

Relays

This ASA standard (C83.16-1959) covers definitions, classifications, terminology, notation, and performance characteristics of relays for general switching purposes. It also includes military relays, relays for use in electronic circuits, relays for unusual environmental conditions, and relays for airborne equipment. Copies may be obtained from the American Standards Association, 70 E. 45 St., New York 17, N.Y., at $2.00 per copy.

Interelectrode Capacitance

A revision of American Standard Measurement of Direct Interelectrode Capacitance, C60.6-1959, has been approved and published by the American Standards Association. The Standard describes test methods used by manufacturers and laboratories for designing, testing, and controlling electron tube quality. It covers the measurement of direct interelectrode capacitance of five classes of tubes: receiving, cathode ray, gas, phototubes and multiplier phototubes, and high-power vacuum tubes. Included are definitions of parts and principles for making connections for measurements. Also included are standard test conditions and capacitance measuring circuits. Copies of this standard entitled Measurement of Direct Interelectrode Capacitance are available from American Standards Association, 70 E. 45 St., New York 17, N.Y., for $1.50 per copy.

Measuring TV Receiver Interference

ASA has published a second supplement to the American Standard Methods of Measurement of Interference Output of Television Receivers in the Range of 300 to 10,000 kc. The supplement has been issued to describe a new procedure for delivering an rf input signal to a TV or fm broadcast receiver to measure conducted interference. The network formerly used has been responsible for some inconsistency. ASA C16.25b-1959 is available at 30 cents per copy from the American Standards Association, 70 E. 45 St., New York 17, N.Y.

Switching Circuit Works, But Whose?

An article entitled "Switching Circuit Works, But How?" (*ED*, Oct. 14, p. 201) presented a simple neon-tube circuit whose principle of operation had eluded the contributor (and some of our editors). An appeal was made to the readers of ELECTRONIC DESIGN to shed some light on how and why it worked as a flip-flop.

In the first two weeks following publication, dozens of letters were received. There was a remarkable basic agreement among the many circuit explanations, but an equally remarkable disagreement concerning its origin and use. To top it off, the circuit seems to be covered by a patent issued in 1955, 20 years after the first-mentioned application of the circuit!

The following extracts from letters give one circuit analysis, and a cross-section of the application and origin comments of our readers.

It Works Like This

Dear Sir:

The switching circuit (Fig. 1) discussed by M. D. Bedrossyan may be explained in the following manner.

When the supply voltage is initially applied, one of the neon bulbs will conduct first. Assume it is the one connected to point *A*. Since there is no initial charge on the capacitor, the firing of

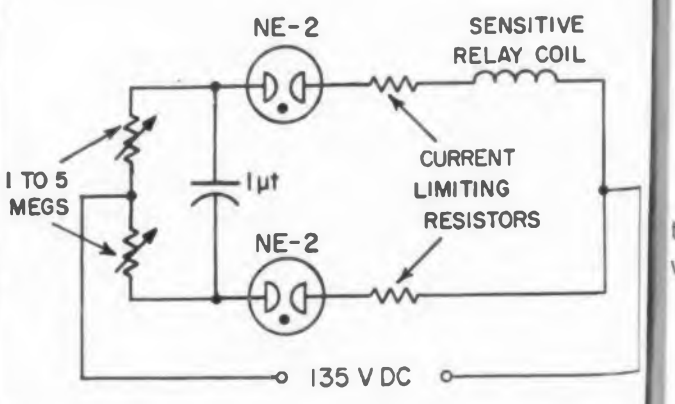


Fig. 1. Switching circuit should not work—but does

bulb *A* will clamp both points *A* and *B* to approximately ground potential. (This neglects the voltage drop across bulb *A*.) Now the current through the conducting bulb will consist of one component passing directly through a resistor and a second component passing through the other resistor and the capacitor. This second current component will tend to charge the capacitor to the supply voltage value and increase the voltage of point *B*. Eventually, the voltage at point *B* will be sufficient to fire the bulb connected to point *B* and point *B* will be clamped to ground potential. Since the capacitor had been charged to approximately one hundred volts and the capacitor voltage cannot change instantaneously, point *A* will be driven to approximately minus one hundred volts and bulb *A* will cease conduction. Now point *A* will tend to charge to the supply voltage. The current path is through the conducting neon bulb. Thus, the circuit acts exactly like a monostable multivibrator.

R. Nitzberg, Development Engineer
Adv. Radar & Countermeasures Engineering
General Electric Co.
Advanced Electronics Center
Ithaca, N.Y.

It's Novel, And Clever . . .

. . . The switching circuit that Mr. Bedrossyan discovered is most certainly novel, but not impossible to analyze. . . .

Glen K. L. Mulligan
Polytechnic Institute of Brooklyn
333 Jay St.
Brooklyn 1, N.Y.

. . . The circuit . . . is quite clever and probably useful. Its operation, apparently puzzling to the originator, is readily explained and easily designed for various on-off times. . . .

Max Kramer
Senior Engineer
Equipment Development Div.
Aluminum Co. of America
2210 Harvard Ave.
Cleveland 5, Ohio

. . . The switching circuit . . . has every right to be considered legitimate and there is no reason why it should not work. . . .

Eric Bajars
Simpson Electric Co.
5200 W. Kinzie St.
Chicago 44, Ill.

(Continued on following page)

LETTERS

. . . Mr. Bedrossyan's problem was indeed interesting and his circuit has many practical applications. . . .

I. M. Salzberg/C. L. Cohen
Electrical Design Groups
Nuclear Products-Erco
Div. of ACF Industries Inc.
Riverdale, Md.

But We Thought Of It Years Ago

. . . We realized that the basic circuit (minus relay) was familiar to both of us but through completely independent work. Use as a waveform generator was investigated by Mr. Dowdell in 1955 with the voltage across the capacitor being used as a triangular wave generator of surprisingly good linearity. A novel use of this circuit by Mr. Rudin in 1956 was as a "decision maker" by adding a switch across the capacitor. Operating at a high repetition rate where both lamps appeared continuously on, the switch was closed, stopping the circuit but leaving one light on. With the lamps labeled YES & NO, a decision was made, the ideal Christmas present for the harried executive. . . .

V. L. Dowdell
N. A. Rudin
Electronics Div.
Stromberg-Carlson Co.
A Div. of General Dynamics Corp.
Rochester 3, N.Y.

. . . This basic circuit used in a toy appearing as a construction project in my article "Electronic Toys for Christmas" in the December, 1955 issue of *Popular Electronics*. The article includes a description of how the circuit works. . . . Interestingly enough, this type of circuit may be extended to include a number of interlocked "stages" which can be made to fire in order.

E. G. Louis
P. O. Box 1727
Wheaton, Md.

. . . Some years ago I experimented with this circuit and found it possible to trigger with a pulse, as I recall, as narrow as 5 microseconds. As a matter of fact, the free running low frequency version of this circuit usually forms a Christmas decoration on my breadboard chassis. . . .

Art Goldschmidt
506 Devon Road
Moorestown, N.J.

LETTERS

. . . In Fact It's Quite Old, And Well-Known . . .

. . . Needless to say these circuits have been with us some time, having enjoyed their peak of application as desk ornaments during the 1940's. . . .

T. C. Penn
Member of Technical Staff
Data Systems and Earth Science Research
Texas Instruments Inc.
Dallas 21, Tex.

. . . The NE-2 circuit shown has been used for several years as an indicator. . . . This circuit is but the simplest of any many similar types. As many as six NE-2's can be arranged in a ring with careful selection of NE-2's. . . .

August E. Munich
Engineer
Airborne Instruments Lab.
160 Old Country Road
Mineola, N.Y.

. . . The circuit is actually quite old when used with thyratrons instead of neon lamps. In the case of thyratrons, the control elements are tied together and controlled by a series of pulses. The result is a form of flip-flop capable of driving relays or other counting or control mechanisms at 1/2 the pulse frequency. . . .

Lawrence C. Kelsey
Project Engineer
W. M. Welch Manufacturing Co.
1515 Sedgwick Street
Chicago 10, Ill.

. . . This manner of operation (using a pulse to turn off a device) is common in circuits involving thyratrons or silicon controlled rectifiers. . . .

J. E. Rathke
Sperry Utah Engineering Lab.
Salt Lake City, Utah

. . . I had come upon this circuit about 10 years ago, and have used it several times since. . . .

D. A. Kerr
235 S. Harrison
E. Orange, N.J.

What's More, It's Patented!

. . . In connection with the article . . . I be-

(Continued on p. 198)

LETTERS

lieve the enclosures will be of interest. (*ED*, Sept. 1, 1956, p. 86.)

Frequency Divider Apparatus

Patent No. 2,728,030. R. G. Green. (Assigned to North American Aviation, Inc.)

A circuit is described and illustrated which generates an oscillation or pulse by successive firing of two or more glow discharge tubes. The tubes fire in succession and at a constant frequency so that a frequency division or a pulse of

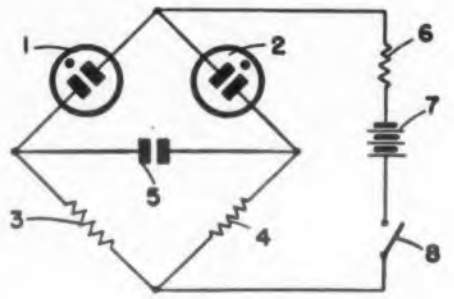


Fig. 2. Patented circuit dating from late 1955.

predetermined frequency may be secured.

The circuit in its simplest form is shown in the figure. The circuit parameters are selected so that the discharge tubes will not fire from the current applied by power source 7 alone. When switch 8 is closed, the full potential of the power source is applied to the discharge tubes. One tube only fires because of a lack of equal characteristics of each tube and its circuit.

Assume that tube 1 fires, whereupon the current is supplied from the power source through resistor 3 and also from capacitor 5. The current supplied from the capacitor passes through resistor 4, which reduces the potential across discharge tube 2 and assures that it does not fire. The current supplied to the discharge tube from the capacitor decreases exponentially so that a point is reached where the current is insufficient to support the discharge. Tube 1 then becomes extinguished. When this occurs the potential across discharge tube 2 becomes such that it fires and transmits current until the decrease in current is insufficient to support conduction. When this

LETTERS

occurs, discharge tube 1 again fires and the cycle repeats.

W. C. Lane
Staff Engineer
ITT Federal
Clifton, N.J.

▶ (Of probable interest to the Patent Office is a "search" made by Mr. Richard Wall, Project Engineer at Motorola Inc. Systems Research Lab, Riverside, Calif. Mr. Wall turned up eight references to this circuit in the literature, going back to 1951, and including the above patent in ELECTRONIC DESIGN.)

. . . I wish to express my sincere appreciation to the many engineers and others, including two college professors, who, in response to my query, took time and trouble to analyze my switching circuit and offered helpful explanations. . . .

Mark D. Bedrossyan
Atlantic Electronics Labs.
P. O. Box 918
Asbury Park, N.J.

How About This Puzzler?

. . . Theoretically, extension may be made to n bulbs, as in Fig. 3. (In fact, the circuit of Fig. 1

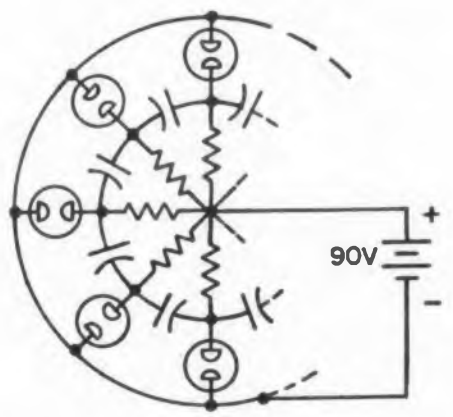


Fig. 3. N-lamp version of switching circuit.

is the direct result of setting $n = 2$.) However, the experimental fact is that odd numbers of bulbs can be made to fire in sequence, but even numbers seem to run at random.

Can anyone explain this? . . .

William E. Koeblitz
Keithley Instruments, Inc.
12415 Euclid Ave.
Cleveland 6, Ohio

Any More Puzzlers?

▶ We are quite impressed with the response

(Continued on p. 200)

LETTERS

shown to this puzzle circuit, and would like to encourage this exchange of problems and solutions. If any of our readers have a circuit or design which has been mystifying him, send it along, and we will submit it to our readers for a solution.

References Cited

Dear Sir:

With reference to the article on "Inside-Out Twin-T" p 198 in the October 14, 1959 issue of ELECTRONIC DESIGN, I would like to point out that a complete analysis of this network was made in 1952 by Messrs. C. F. White and K. A. Morgan of the Naval Research Laboratory and a paper presented at the National Electronics Conference in Chicago. The paper entitled "The Dual-Input Parallel-T Network" can be found in the Proceedings of the NEC Vol. 8 1958 pp 588-597.

A naval Research Report No. 4011 on the subject is also available.

K. A. Morgan
Convair
San Diego 12, Calif.

Great at WESCON Too

Dear Sir:

The Electronic Circuit Tolerances article that appeared in the October 28 issue of ELECTRONIC DESIGN is great, many thanks for the manner in which you treated it.

For the record, we feel that it should be mentioned that the article is based on a paper which was presented at WESCON in August, 1959.

Harold Hechtman
Director of Public Relations
Airborne Instruments Lab.
Mineola, N.Y.

Russians Denounce Plagiarism

Contrary to popular notions in the United States, the Russians have no more use for plagiarism than we do. The following letter was written by a leading member of the Russian Academy of Sciences to the editor of the authoritative journal Radiotekhnika i Elektronika (Radio Engineering and Electronics).

As background, it should be known that the author of the letter, Dr. V. A. Fok, had presented a paper by R. G. Mirimanov for publica-

LETTERS

tion in the Transactions of the Academy of Sciences. Mr. Mirimanov could not present his paper for publication in that journal as he was not a member of the Academy.

In connection with the letter by R. G. Mirimanov, published in your journal,[1] I consider it necessary to report the following.

Some time ago I obtained from Professor Keller (Joseph B. Keller, New York University, Institute of Mathematical Sciences) a letter in which he calls attention to a plagiarism, perpetrated by Mirimanov with respect to many works by Keller. Keller's letter was directed to me because one of the articles by Mirimanov,[2] printed in the Doklady Akademii Nauk SSSR (Transactions of the Academy of Sciences, U.S.S.R.) was presented by myself (this article is also recalled in the letter by Mirimanov[1]).

Actually, after comparing the text in the formulas of Mirimanov's article,[2] we detect some formulas of the article by Primakoff, Klein, Keller, and Carstensen[3] (which Mirimanov naturally does not mention in his letter[1]). It can be established that all of Mirimanov's formulas and explanations of these formulas are contained in the work by Keller and his co-authors, with the only difference being, that the sought function is designated by the letter ϕ instead of p.

All that Mirimanov did was to replace (in the heading and in the text) sound waves by electromagnetic waves; he also thanked corresponding member A. N. Tikhonov of the Academy of Sciences. Part of the material from the article by Keller et al. was omitted by Mirimanov.

Thus, Mirimanov's article is a plagiarism, and I regret that I was misled by Mirimanov when I presented it for publication.

As to the remaining publications of Mirimanov, listed by him in his letter to the editor, they are an unreadable set of formulas, a considerable portion of which was copied from Keller and his co-authors, and furthermore copied without understanding the remaining.

References

1. R. G. Mirimanov, Radiotekhnika i Elektronika, 1958, No. 3, 7, 971.
2. R. G. Mirimanov, Doklay ANSSSR, 1948, Vol. 61, 4, 617.
3. H. Primakoff, M. Klein, J. Keller, E. Carstensen, Journal of Acoustic Society of America, 1947, Vol 19, No. 1, p. 132.

V. A. Fok

BLOCKS

This is the third of a series of articles on blocks to creativity. The first article discussed perceptual blocks, and the second, cultural (ED, Nov. 11 and 25). A final article will offer hints on overcoming the obstacles to creativity.

A. L. Simberg has lectured extensively on creativity before professional engineering and collegiate groups. At AC Spark Plug he is in charge of all research affecting the selection, training and morale of employes.

EMOTIONAL BLOCKS to creativity lie within ourselves, partly determined by the stress of everyday living. To help understand their effect upon our creative thinking processes, picture a balance scale with emotions on the one side and clear thinking, or intellect, on the other. We find that as one side goes up, the other goes down. In other words, when emotion is maximum, the intellect is minimum. Overpowering amounts of emotions–such as fear, love, hate and anger–can be blinding, make us "freeze." They can be completely debilitating.

Probably at the root of most emotional blocks is insecurity, whether on the job or in other areas. Whatever the cause, however, their effects can be just as devastating as the perceptual and cultural blocks.

All individuals feel insecure to some extent. The main thing to keep in mind is that a good deal of insecurity is groundless. Most people are at least a little apprehensive about tackling a new assignment, about trying to adjust to a new situation. But most seem ultimately to meet the challenge fairly successfully. However, the fears and anxieties accompanying new situations are sometime

Fear of making a mistake or making a fool of yourself.

A. L. Simberg, Supervisor
Personnel Research & Development,
AC Spark Plug Division,
General Motors Corp., Flint, Mich.

to creativity
ll Emotional Hazards

sufficient to block creativity.

Let us look at some of these emotional blocks and see how they affect our creative behavior.

■ ***Fear of making a mistake or making a fool of yourself.***

Probably more good ideas have been stifled for this reason than for any other. There is a natural reluctance of anyone, particularly the new engineer in an organization, to say anything that might be considered "foolish" by one's fellow workers or supervisors. The sad part of it is that in many cases the idea would not seem foolish at all to others; the individual only thinks that it might.

■ ***Over-motivation to succeed quickly.***

Anyone who takes his job seriously and is intent upon advancement aims to be "the best." It is only natural, therefore, that the young engineer in this situation will find himself very highly motivated. He will not have too much patience. When he does not immediately see a solution to a problem, he may become frustrated and either give it up or continue to butt a stone wall.

Patience is very often required for the solution of complicated problems. We have to learn to allow time for meditation, for the continued mulling over of a problem in our minds (sometimes at a level below awareness). Just as "nothing succeeds like success," so very often lack of progress serves only to block progress.

CAREERS

■ ***Neurotic desire for security.***

Everyone has a natural desire for security. But overconcern with security can be neurotic. Such a person may refuse to take a chance on anything that is new or untried. A young engineer with this attitude is in a severely handicapped position to try to develop new ideas.

Quite often such an attitude is instilled through association with senior company employes who may have had unfortunate experiences many years before. There should be no realistic reason for a young person, starting in an organization—with his entire career ahead of him—to retreat into a foxhole of security.

■ ***Fear of supervisors and distrust of colleagues.***

Another example of an emotional block is when the engineer distrusts those with whom he works and fears those for whom he works. In some few cases, of course, these fears may be based on reality. Perhaps, through improper placement, the individual is "over his head," either technically or because of administrative inexperience. Ordinarily these fears are not related to reality. They are primarily a lack of confidence within the individual or a fear of supervisors generally—or any authority, for that matter.

Whatever their basis, they are a definite deterrent to creative activity.

■ ***Grabbing the first idea that comes to mind.***

This emotional block is a failure on the part of many young engineers to reject a workable solution and to continue to search for a better one. A good rule to follow is always to have more than one solution to a problem. You can easily see that this will help your supervisor. With only one idea to judge, he must say either "yes" or "no." With alternatives, you give him a choice. ■ ■

Fear of supervisors and distrust of colleagues.

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A two-page division chart is given, designed to inform the applicant where his specialty is needed. Subsequent pages are devoted to brief histories, present projects and aims, products, available positions and community facilities for each Bendix division. Company policy and employe benefits, including education assistance, are listed.

Charles Cleveland, Director of Scientific Recruitment, Bendix Aviation, Dept. ED, Fisher Building, Detroit, Mich.

CIRCLE 870 ON READER-SERVICE CARD

Polarad

Engineers at Polarad Electronics Corp. are engaged in projects that cover automatic checkout equipment, classified electronic reconnaissance systems, countermeasures systems and systems engineering. Required skills for particular jobs are outlined.

Ullman Rosenfield, Director of Industrial Relations, Polarad Electronics Corp., Dept. ED, 43-20 34th St., Long Island City 1, N.Y.

CIRCLE 871 ON READER-SERVICE CARD

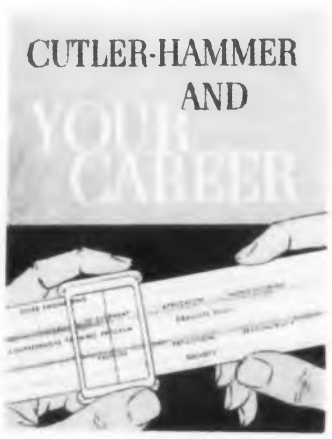
ITT Laboratories

ITT, a research division of International Telephone and Telegraph Corp., has openings in all phases of electronic research and development. Areas covered in this brochure are missile and space systems, avionics, communications systems, physical sciences, components and instrumentation and electronic countermeasures. Employe benefits are listed.

T. C. Allen, Manager, Professional Staff Relations Department, ITT Laboratories, Dept. ED, 500 Washington Ave., Nutley, N.J.

CIRCLE 872 ON READER-SERVICE CARD

Cutler-Hammer



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Opportunities and company facilities, including on-the-job training programs, are discussed under the following headings: sales, development, systems and production engineering and business administration. The company's advertising program and a graph depicting sales growth are given. Employe benefits and community facilities are listed.

Cutler-Hammer, Inc., Dept. ED, 315 N. 12th St., Milwaukee 1, Wis.

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Packaging Engineers . . . with a knowledge of packaging and production techniques in sheet metal and electronic equipment. Will design electronic portions of guided missiles, radars, computers, test equipment. Should have thorough knowledge of circuitry.

Electromechanical Designers . . . will design electromechanical equipment and electronic portions of guided missiles, including coordination of effort through the shop. Will work closely with Design Engineers in developing electronic packaging philosophies. Knowledge of electronics, electronic components, and ability to read schematics required. Should have experience in sheet metal equipment design and knowledge of current "state of the art" in electronic equipment.

RAYTHEON MISSILE SYSTEMS DIVISION

CIRCLE 903 ON CAREER INQUIRY FORM

YOUR CAREER

NEWS AND NOTES

One way to better relations between management and scientists and technicians in research is offered by E. H. Schulz of the Armour Research Foundation, Chicago, in a paper, "The Individual Case in Research Management." He says:

"The research director must be careful to avoid the substitution of cookbook approaches for the realistic combination of a thorough understanding of the subject matter to be administered, a familiarity with management principles and an understanding of human behavior."

By "cookbook approaches" Mr. Schulz means the use by management of mechanical devices–"staff members are interviewed, psychoanalyzed, sent to AMA courses, appraised, and are made members of committees to study staff morale, working environments, incentives, Christmas parties and everything else under the sun"–in place of the human touch.

Mr. Schulz traces the evolution of company management policies in three stages:

1. Inadequate management control.
2. Excessive management control and paper work.
3. Minimum control and red tape consistent with company objectives.

"Our aim as managers in the research world of today," Mr. Schulz says, "must be to minimize the magnitude and duration of the second stage of this growth pattern and arrive at the mature third stage as rapidly as possible."

The paper notes several areas where managerial improvements can be achieved. Two sensitive areas: merit evaluation and salary administration.

"That people should be regularly evaluated as to their performance and that they should know where they stand cannot be denied," Mr. Schulz concedes. "However, the insertion of a formal system including checks on printed forms followed by a formal interview with the man can be quite harmful, particularly when applied by the inexperienced.

"First, an inept job of discussing a man's so-called good and bad points can do more harm than good. Further, the research supervisor can easily lull himself into the false feeling of having accomplished his staff development job well by filling out a form periodically and promptly forgetting the subject, while he should actually be developing his staff in day-to-day contact–largely by example.

"Wasn't the supervisor put in his position first and foremost because of his ability to guide his

(Continued on p 210

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CAREER NEWS

staff? Would it not be a more direct approach to correct the supervisor instead of applying more or less dangerous medicine to 5 or 25 confused subordinates?"

Of salary administration—"another process highly susceptible to over-mechanization"—Mr. Schulz comments:

"The average scientific manager feels uneasy in his role of playing God, so to speak, in determining what each individual's compensation should be. He would love to hide behind some mechanical scheme where a man is given points for attitude, attendance record, potential, etc., and a score is arrived at which automatically determines his salary, while the significant factor is the supervisor's fair judgment of the contribution of the individual."

The hope for good management, Mr. Schulz concludes, lies in competent personnel rather than any "system."

"Unfortunately," he reminds management, "there is no approach short of: (1) understanding the subject matter to be administered; (2) a familiarity with management principles; (3) an understanding of human behavior, and (4) the realistic combination of this information in application to each individual management consideration."

° ° °

Once upon a time, before man-made satellites went whizzing into space, engineering schools in this country began teeming with students. Young men were responding to the pleas of industrialists, educators, and patriots for more engineers to match the growing enrollments in the Soviet Union.

Then the Russians launched a "sputnik"—the world's first—and today the trend in American engineering schools may be reversing—at least temporarily—a Cornell University dean suggests.

"Sputnik fever," says Dean Dale R. Corson of Cornell's College of Engineering, drove many potential engineers to study science instead of engineering when it swept the country two years ago.

"In the fall of 1958 freshman engineering enrollments were down 11 per cent on the average all over the country." he reports. "This year the number of applications was down again."

Moreover, Dean Corson says, engineering schools are finding it increasingly vexing to attract and hold talented teachers.

But at least a couple bright spots remain. Though the quantity of undergraduate engineering students is down," the quality is higher than normal this year," the dean says. And the graduate program has been increasing about 15 per cent a year.

ENGINEER–IMPROVEMENT COURSES AND SEMINARS

One-Day Course In Increasing Sales Through The Technical Staff, IEI, Boston, Philadelphia, New York

The IEI has developed this course for research and development men, technical specialists and project, application and sales engineers to show how the technical man can help increase his company's sales and what techniques improve customer relations and make the technical specialist a part of the marketing team. The program outline is as follows: The Technical Man's Role in Selling Function, Industrial Purchasing Habits, Practices and Policies, Analyzing the Customer's Requirements, Developing Sales Presentations, Negotiation and Following-up After the Sale. The program will be conducted by Louis J. De Rose, President of De Rose & Associates, and Executive Director, Materials Management Institute. The seminar will be held Dec. 8, Sheraton-Plaza, Boston, Mass., Dec. 10, Hotel Sheraton, Philadelphia, Pa., and Dec. 11, Hotel Park-Sheraton, New York, N.Y. For further information write to: Industrial Education Institute, 25 Huntington Ave., Boston 16, Mass.

Research Administration Workshop Seminar, IEI, December 14-16

This seminar is open to research administrators, particularly those charged with the administration of a research laboratory or laboratories. The key areas to be covered include: responsibilities of research administrator; translating broad management objectives into specific research items; public relations; research facilities inside and outside company; laboratories, design and maintenance; library; consultants and other outside sources; research personnel; technical administrative functions; communications; assignment of problems; procedures for reporting results to all concerned; and problems in research administration.

Market Research Orientation Seminar, IEI, December 14-16, New York

The creative market researcher, product planner, or product designer who attends this seminar will learn that certain approaches have proved more effective than others in uncovering new product opportunities in which the consumer-goods company can capitalize on its resources in a profitable market. Far from being a pure analytical job, this is a quest that requires as much creative insight and conceptual ability as it does analytical skill. Topics under discussion will include: (1) identifying product trends; (2) identifying market trends and latent market demands;

(Continued on p. 212)

CAREER NEWS

(3) use of creative techniques to determine alternate ways of "marrying" company resources with current market opportunities.

Course In Organizing The Engineering Project, IEI, December 14-16, New York

The objective of this workshop seminar is to show the importance of proper organization in project engineering and how to achieve it. Sound organization not only takes into consideration preliminary planning but programs of controls and goals that extend through the life of the project as well as consideration of criteria that can be used to measure the results in the final analysis. This seminar will be of interest to those who are concerned with: execution of engineering projects; reviewing outside requests; determination of project personnel and facility requirements; balancing workload with capacity; establishment of controls; and evaluating performance.

Product And Package Design Forum, IEI, December 14-18, New York

Products and packages are inseparably linked together. This seminar will analyze the fundamentals of this relationship to help develop both products and packages that capitalize on inherent profit opportunities. From planning to promotion of the final product, opportunities for improving function and affecting savings will be explored. Emphasis will be placed on developing the ability to see the product and its package as a distinct design element throughout the planning, production and promotion process to the profit-producing phase. For additional information for this course and the following three write to: Industrial Education Institute, 25 Huntington Ave., Boston 16, Mass.

PAPER DEADLINES

Convention Program Chairmen have issued the following deadlines to authors wishing to have their papers considered for presentation.

December 15: Deadline for abstracts of 150-200 words for the **1960 Electronic Components Conference** scheduled for **May 10-12** in Washington, D.C. Please send in triplicate to: *Gilbert B. Devey, Technical Program Chairman, Sprague Electric Co., N. Adams, Mass.*

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