MARCH 20, 1959

electronics

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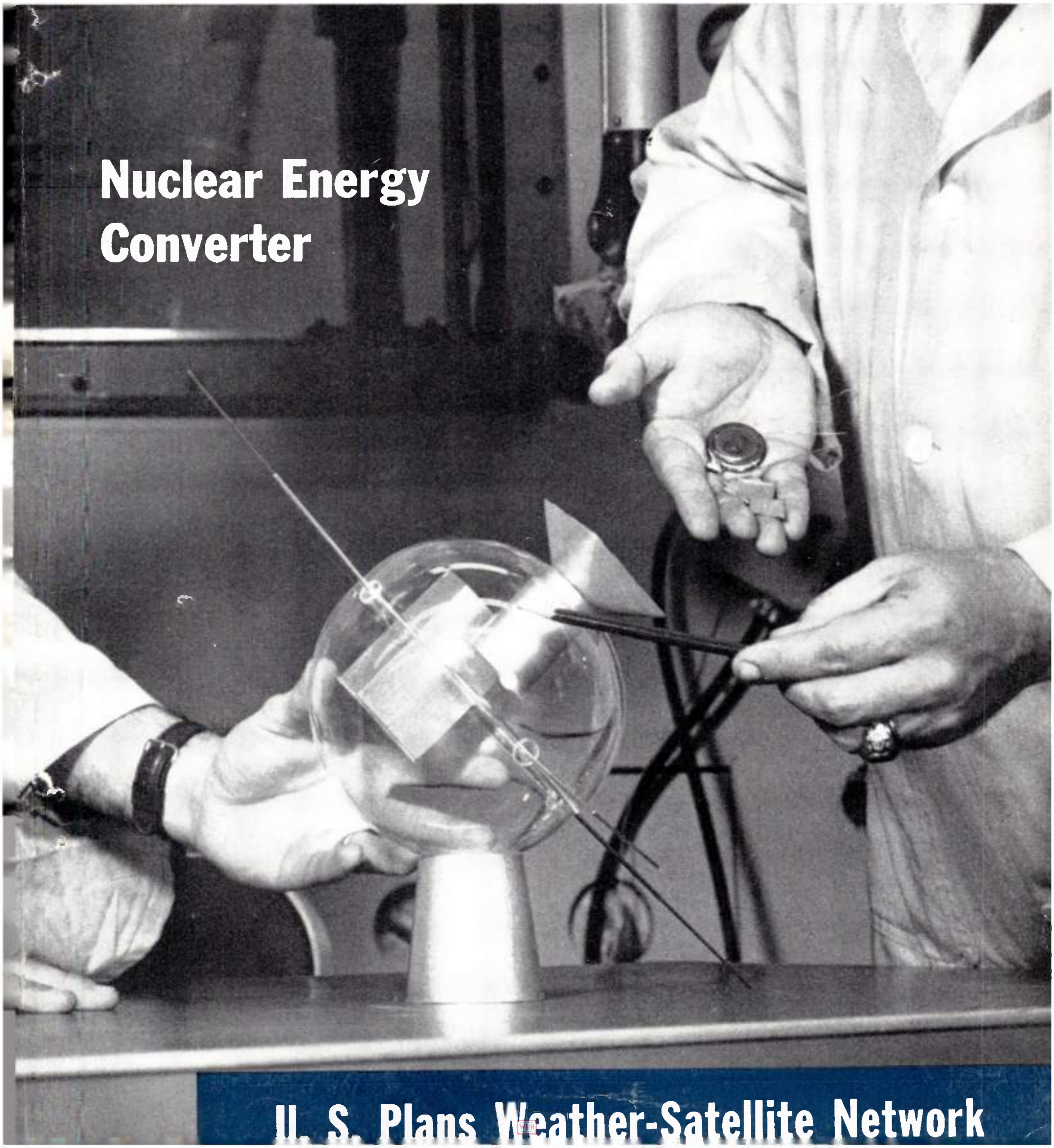

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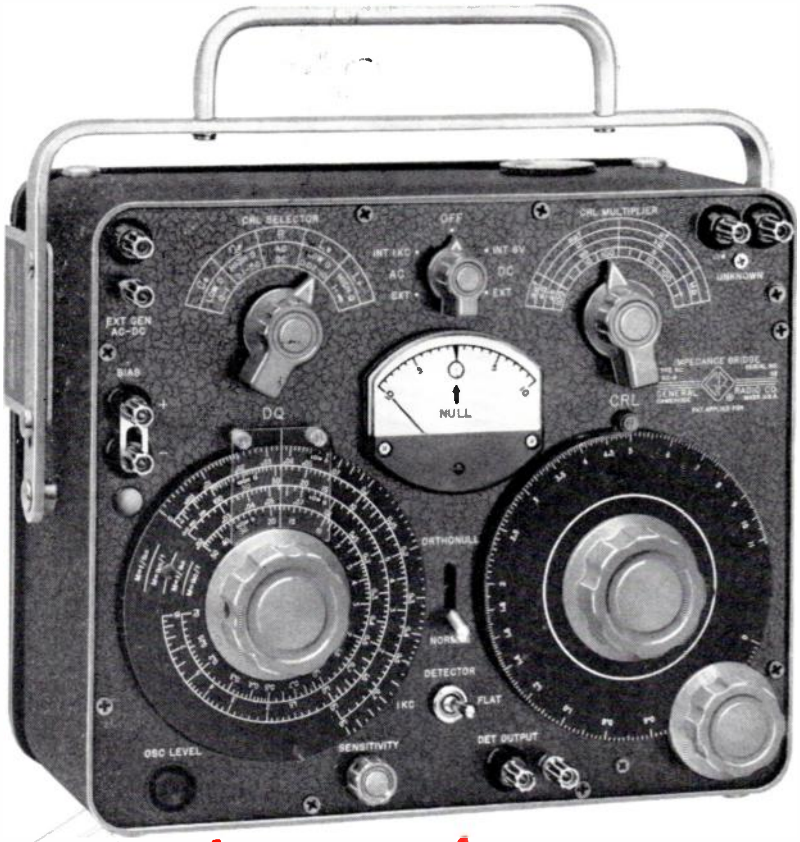

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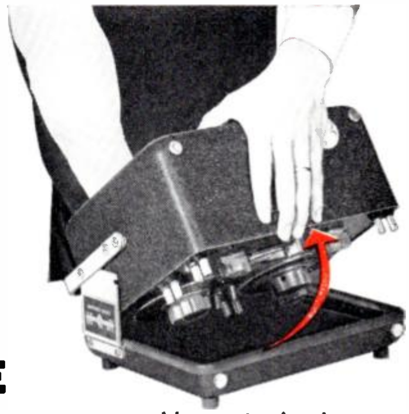

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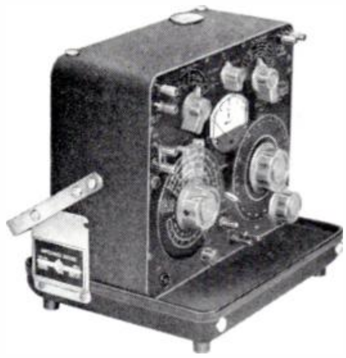

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Issue at a Glance

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Vol. 32 No. 12

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Paul G. Yewell is president of Yewell Associates, Inc., Burlington, Massachusetts — an electronics manufacturers' representative firm.

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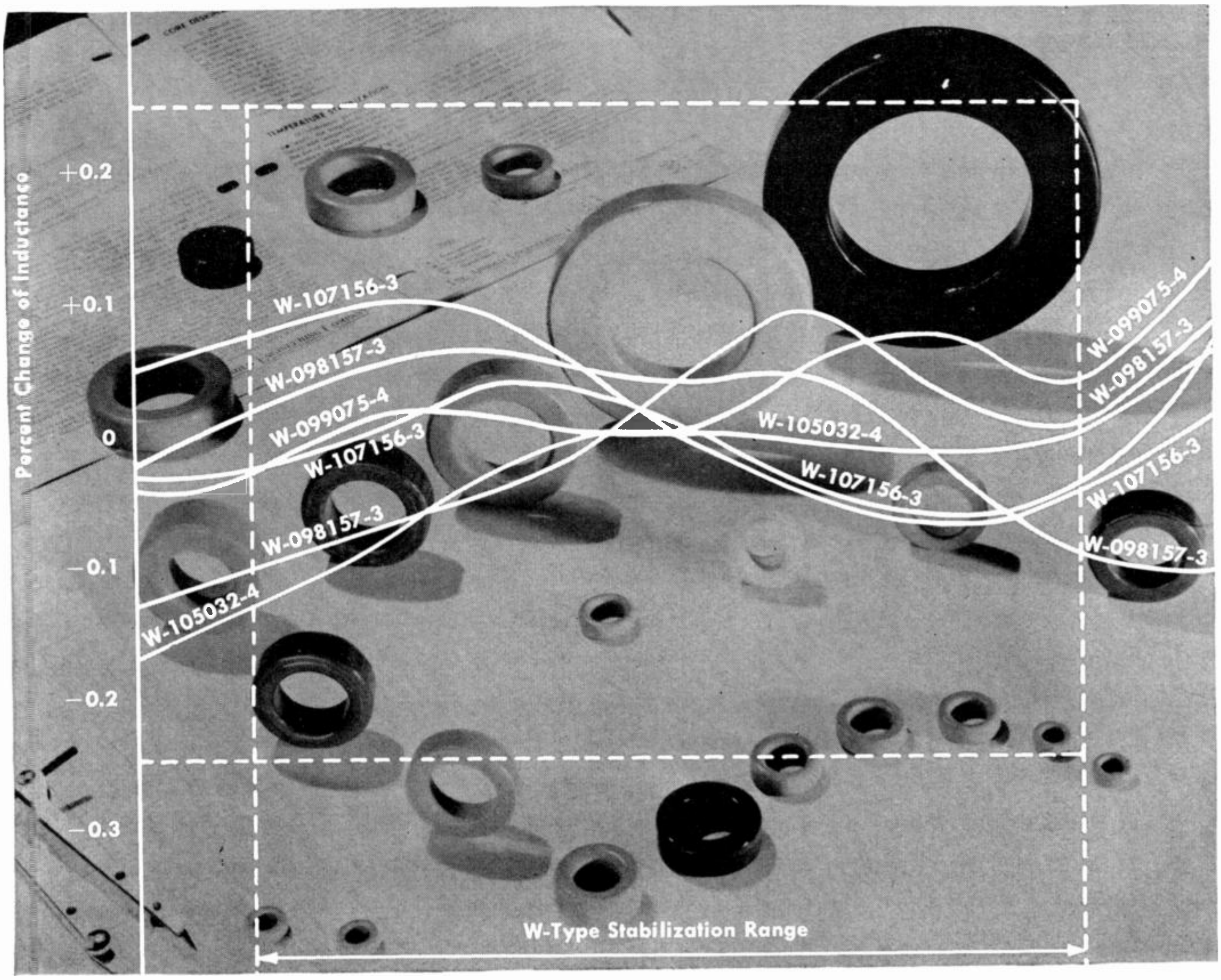

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NICE TO SEE YOU AGAIN. We expect to be saying this hundreds of times next week . . . and enjoying every time we do. We're really looking forward to this annual IRE convention and show.

As you know, this big electronics industry get-together is many things to many people. One of the nicest, to us, is seeing our many friends again and making new ones. How've you been? What's new with you? Can we help you?

See you at the show, booth No. 1117 on the first floor.

WEATHER ELECTRONICS. On a 4-day trip to Washington recently, Associate Editor Leary decided to check in with some old friends at the Weather Bureau. He uncovered a beehive.

Starting at the top—with Bureau chief F. W. Reichelderfer—he was passed down through Sigmund Fritz, head of the meteorological satellite section, to talk with a double handful of experts in all phases of meteorology, especially the new and promising area where meteorology ties to electronic measuring techniques, satellite platforms, and related advances.

It'll take a full technical feature—coming soon—to wrap it all up. Meantime, a quick preliminary report appears on p 26.

TOKYO FEEDBACK. In our Feb. 13 issue we ran a story from our McGraw-Hill World News Tokyo bureau headed "Japan Acts to Slow Licensing." It described how government research subsidies aim at reducing the dependence of the Japanese electronics industry on U.S. licenses, which are now more numerous than ever.

About a week later we were pleased to receive from our men in Tokyo a page one clipping from the English-language *Asahi Evening News*. It was an Associated Press story from New York quoting our story which originated in Tokyo.

Coming In Our March 27 Issue . . .

SPACE FLIGHT-TESTING. Some day soon, a huge B-52 will be flying over Wendover AFB in Utah with a strange cargo nestled in its belly. The event—initial flight test of North American's X-15—will signify man's first toddling steps into space.

Test range for the X-15, called High Range, extends 400 miles from Wendover to Edwards AFB in California. Test range instrumentation for gathering data from a manned missile traveling at Mach 5-plus and more than 100 miles up presents many special problems. Next week, R. Schock and R. F. Lander of the Electronic Engineering Co. of California, present the details of this new flight test facility.

PROTON TRACK SCANNER. In cyclotron experiments, protons from nuclear reactions are made to produce tracks on photographic emulsion strips. Studies of tracks yield valuable data about nuclei.

A unique method of scanning the emulsions and recognizing the presence of a proton track has been developed by P. V. C. Hough, J. A. Koenig and W. Williams at the University of Michigan. The recognition machine is equivalent to 15 human observers.

COMBUSTION STUDIES. One of the more difficult engine properties to measure is the instantaneous temperature of the unburned gases in the cylinder, according to R. R. Bockemuehl, of the General Motors Research Labs.

Bockemuehl has devised a method which involves measuring spectral radiation of the gases in an engine having a special quartz window in the cylinder wall. A gated amplitude ratio indicator yields the radiation intensity ratio as a function of engine crank angle.

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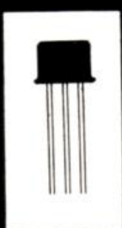

JETEC-30 Type	Punch through Voltage min.	f_{ab} ave. Mc	H_{FE_1} ave. $I_B = 1$ mA $V_{CE} = -0.25$v	H_{FE_2} ave. $I_B = 10$mA $V_{CE} = -0.35$v	I_{CO} at −12v µA	r_b' $I_C = -1$mA ohms	C_{ob} $V_{CB} = -6$v µµf
2N658	−24	5	50	40	2.5	60	12
2N659	−20	10	70	55	2.5	65	12
2N660	−16	15	90	65	2.5	70	12
2N661	−12	20	120	75	2.5	75	12
2N662	−16	8	30 min	50	2.5	65	12

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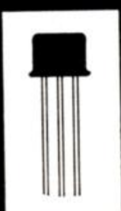

JETEC-30 Type	V_{CE} max. volts	f_{ab} ave. Mc	H_{FE_1} ave. $I_B = 1$ ma $V_{CE} = -0.25$V	H_{FE_2} ave. $I_B = 10$ ma $V_{CE} = -0.35$V	Rise Time* max. µsec
2N404	−24	12	30 min.	—	—
2N425	−20	4	30	18	1.0
2N426	−18	6	40	24	0.55
2N427	−15	11	55	30	0.44
2N428	−12	17	80	40	0.33

*I_C — 50 ma; I_{B_1} = 5 ma; R_L = 200 Ω; I_{B_2} = 5 ma; Grounded Emitter Circuit

SUBMIN Type	V_{CE} max. volts	f_{ab} ave. Mc	H_{FE_1} ave. $I_B = 1$ ma $V_{CE} = -0.25$V	H_{FE_2} ave. $I_B = 10$ ma $V_{CE} = -0.35$V	Rise Time* max. µsec
CK25	−20	4	30	18	1.0
CK26	−18	6	40	24	0.55
CK27	−15	11	55	30	0.44
CK28	−12	17	80	40	0.33

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THERMOCOUPLES MADE PRACTICAL

...or how a completely floating and isolated differential DC amplifier can be of assistance in obtaining over-all system accuracies of 1% to 0.1% when measuring the output of grounded thermocouples or strain gages.

Designers and users of data-handling systems, particularly systems for evaluating high-performance rocket or jet engines, are constantly under pressure to provide higher and higher measurement accuracies. According to recent statistics, a large percentage of these measurements involve narrow-band data from grounded thermocouples. Even on a bench, the measurement of temperature in a DC to 100-cycle bandwidth with 1% accuracy isn't too easy, and 0.1% measurements get pretty messy. Now, if you have fifty thermocouples and they happen to be or *have* to be grounded at the source, and the source is a rocket or jet engine separated from your amplifiers by, say, 300 feet of interconnecting cable, and the amplifiers are driving a load such as a large data-handling system that must be grounded, you are probably in trouble. In fact, with a system anything at all like this, it's likely that you had great difficulty getting 1% system accuracy and found 0.1% accuracy virtually impossible to obtain.

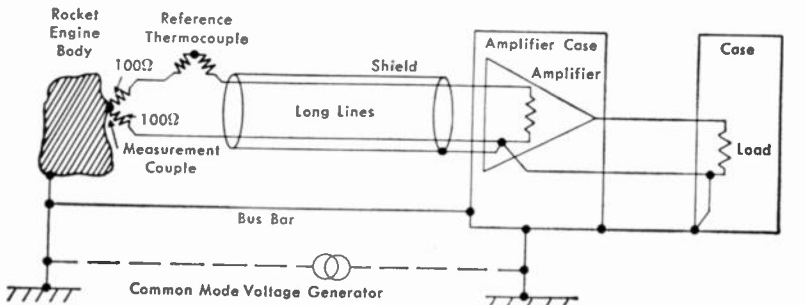

Figure 1

WHAT'S THE PROBLEM?

In *Figure 1,* we see a grounded thermocouple with a reference couple, 300 feet or so of shielded input leads from the couples to the amplifier, and a single-ended DC amplifier driving a grounded load. (For the moment, we will ignore the bus bar.) This is a typical system. It doesn't give very good accuracy. Nevertheless, it is a typical system. In our experience, the problem with such systems has always been noise, noise which results from ground loops. The troublesome part of this noise will consist of hum at the power line frequency. It will be random in magnitude and phase at the amplifier, precluding accurate cancellation. This noise, this difference in potential which exists between the thermocouple ground point and the amplifier ground point—since it is common to both input leads—is called common mode voltage, as shown in *Figure 1.* And any noise voltage appearing here will be applied directly to the input of the amplifier.

Let's examine the magnitude of the problem. A typical thermocouple will have a peak output of about 10 millivolts. If the system resolution is to be 0.1%, then the maximum peak error caused by noise, drift, non-linearity and what-have-you can't exceed 10 microvolts. Good single-ended amplifiers (such as KIN TEL's 111 series) will contribute less than 5 microvolts of equivalent input error from all of these causes. This means we can tolerate only 5 more microvolts of trouble from outside causes, or a little less than 2 microvolts RMS AC at 60 cycles. Can we expect 2 microvolts of trouble from ground loops? You bet we can! The normal, average common mode voltage at installations we know of is approximately 1 volt RMS at 60 cycles. In a number of cases, this common mode potential is as high as 4 volts at 60 cps.

In an attempt to better this situation by a rather common remedy, we shall tie a big fat bus bar between the rocket engine and the amplifier case ground, as shown in *Figure 1.* Our bus bar will be an eight-inch pipe filled with water, 300 feet long, with an impedance of about 0.2 ohms at 60 cycles. (An actual installation.) The common mode voltage generator shown in *Figure 1* will have some impedance associated with it, and the ratio of this impedance to the bus bar impedance will determine how much we reduce the common mode voltage. If the impedance of the common mode generator is 0.2 ohms, we will reduce 1 volt of common mode voltage to 0.5 volts. If the common mode generator impedance is 20 ohms, the common mode voltage will be reduced to 5 millivolts, or a little more than two thousand times greater than the 2 microvolts RMS we said we could stand. Even if the common mode voltage had been 1 millivolt instead of 1 volt, with 20 ohms of common mode generator impedance, the bus bar would reduce the common mode voltage to only 5 microvolts. This is still too much.

Unfortunately, most of the figures we have chosen are a little on the favorable side. More than likely, the common mode voltage will be 1 volt, more than likely the common mode generator impedance will be less than an ohm, and more than likely you won't have a bus bar with as little as 0.2 ohms impedance at 60 cycles. In fact, there's even more to the big bus bar fallacy than this, for if the generated common mode voltage is partly caused by electromagnetic pickup from high-voltage power lines or other sources, it may actually increase after the bus bar is installed. Admittedly, the bus bar may be far removed from power lines, but it's not even safe to be in the same world with high-voltage, high-current power lines when only 2μv of noise will ruin you. The bus bar may also short out part of the input signal. We show the thermocouple as a device with 100 ohms each side of the point at which it contacts the rocket engine. If this is true, and our bus bar is connected through the rocket engine to the exact center of the thermocouple, the input signal will be reduced to half. If the thermocouple impedance (or, more accurately, the emf generating part of the thermocouple) is all in series with the ground (low) side, the signal would be almost zero. You can see now why we said that obtaining 1% accuracy was difficult and 0.1% accuracy virtually impossible.

Are we completely whipped? Yes and no. If our system must look exactly like that of *Figure 1,* we probably are. If we can change the system somewhat, perhaps not. What we need to beat this common mode voltage problem is some impedance in series with our ground loop. If we can float the amplifier, or the thermocouple, we can solve or at least improve the situation. It's actually impossible to float a thermocouple bonded to a rocket or jet engine. Even if the whole stand sits on concrete, there will still be a big potential difference between engine and amplifier. This leaves the amplifier end to work on.

You have probably noticed that we show a grounded load, but not a grounded amplifier in *Figure 1.* This is realistic. It is possible, for example, to float our 111 series single-ended DC amplifiers by about 500 kilohms at 60 cps. This would be enough to keep us out of trouble with up to 10 millivolts of common mode voltage, since, in this case, we would produce only 2 microvolts of noise (100/500K x 10 mv). We are assuming that the load can be floated sufficiently so that the impedance of the low side of the amplifier to ground is the only consideration. However, if the load must be tied to ground as in *Figure 1,* either directly or through the low impedance of long cables between amplifier and load, then we cannot use a single-ended amplifier. Or, even with the load floated, if the common mode voltage is too high, we cannot use a single-ended amplifier.

THE DIFFERENTIAL AMPLIFIER

In the foregoing discussion we have pointed out that single-ended amplifiers can severely limit the performance of systems employing both grounded transducers and grounded loads. The differential amplifier (sometimes called floating amplifier), if it meets certain re-

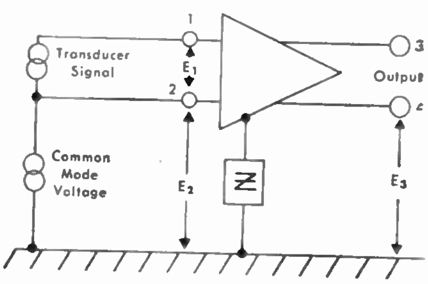

Figure 2

quirements, will permit the use of grounds at both ends of a long line without forfeiting adequate system performance. *Figure 2* is a diagram of the basic differential amplifier. Note that, unlike the single-ended amplifier in which voltages E_2 and E_3 would be equal, input terminal 2 and output terminal 4 are not common. The output of the true differential amplifier is only equal to the difference in potential between input terminals 1 and 2, times the gain of the amplifier, and is not affected by any voltage between terminal 1 and ground or terminal 2 and ground. Thus, E_2, the common mode voltage, does not affect the input. The major figure of merit of a differential amplifier is common mode rejection, or how much of the common mode voltage, E_2, is converted to normal mode voltage, transducer signal E_1. For example, if common mode voltage of 1 volt produces 1 microvolt of equivalent input signal, the common mode rejection is 1,000,000 to 1 (120 db).

There are two basic types of differential amplifiers. The most familiar is probably the balanced amplifier shown in *Figure 3*. This amplifier requires an exceptionally well-balanced input if common mode rejection is to be good. *Figure 3* can be redrawn as the bridge circuit shown in *Figure 4*. From this it

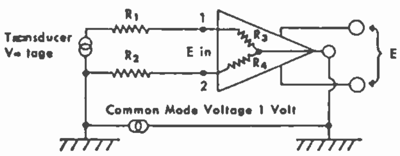

Figure 3

can be seen that the common mode rejection is determined by the equality of R_1/R_3 and R_2/R_4. With no transducer input signal and 1 volt of common mode voltage, an unbalance of only 2 ohms will introduce 20 microvolts of noise, which is a common mode rejection of 50,000 to 1. Even a simple system employing only a measurement thermocouple and a reference thermocouple may well have a resistive unbalance of a 100 ohms or more. Considering the reactive component of the impedances involved and the fact that most large installations employ calibration or level-setting potentiometers in the transducer circuit, it is *desirable* to have an amplifier that will provide high common mode rejection with up to several thousand ohms input unbalance. This the balanced-input differential amplifier cannot do. Internal limitations—such as the necessity of having carefully balanced feedback circuits —

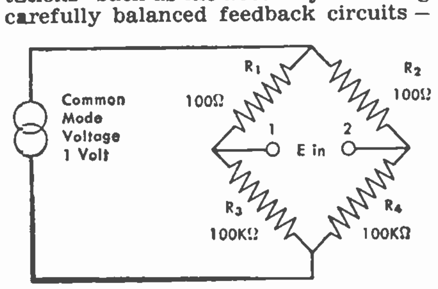

Figure 4

also conspire to limit the performance of balanced amplifiers.

If the balanced amplifier can be floated, that is, not tied to ground as it is in *Figure 3*, common mode rejection can be improved. Since good input to output isolation cannot usually be obtained in balanced amplifiers, the load must be floated too. Considering all of these factors, it is difficult in practice to obtain a common mode rejection of more than 1000 to 1 with the balanced amplifier. Nevertheless, it will improve system performance in the few cases where common mode voltage is low, but still too high to provide adequate performance with no common mode rejection at all. If common mode voltage is low enough, it is probably better to use a single-ended amplifier. Balanced amplifiers are generally more expensive than single-ended and, except for common mode rejection, their performance isn't usually as good.

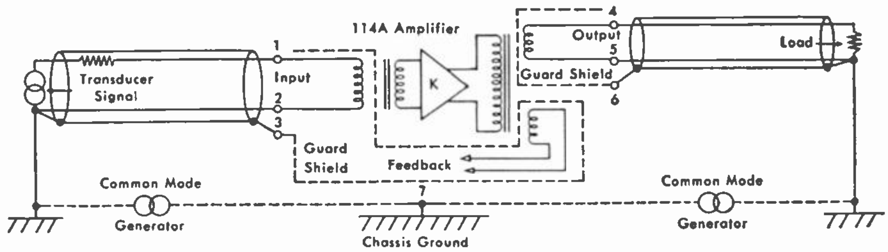

Figure 5

All of our common mode voltage problems could be solved with an amplifier that had nearly infinite impedance between input circuit and amplifier case or chassis ground, and, further, had only magnetic coupling between input and output with virtually no stray capacitance. Then the input would be isolated from the output and it wouldn't make any difference whether the load were grounded or not. Is there such an amplifier? Yes.

KIN TEL's 114A Differential DC Amplifier meets all these requirements and more. Common mode rejection of the 114A is 1,000,000 to 1 or better for 60 cps voltages, and practically infinite for DC. And it provides this rejection with up to 10,000 ohms unbalance in either input lead. To obtain this kind of performance, it can be seen that R_3 and R_4 in *Figure 4* would have to be 100,000 megohms, and, at 60 cps, leakage capacity to ground could not exceed about 0.3 micromicrofarads for each side of the input. In order to meet these tough isolation requirements, the KIN TEL 114A employs guard shielding similar to that used in fine AC bridges. These guard shields surround the entire input and output circuits and are extended out to the transducer and load by means of input and output cable shields. *Figure 5*, a considerably simplified version of the 114A, illustrates this principle. (The transformers are given DC response by means of input chopper and output demodulator circuits which are not shown.) If the guard shields were perfect, there would be no capacitance and therefore infinite impedance between input and output signal leads and chassis ground for the common mode voltage.

In practice, the KIN TEL 114A provides 10,000,000 megohms and less than 0.3 micromicrofarads impedance between each input signal lead and the amplifier case or chassis ground. Output circuit impedance to chassis ground is almost this high, and input and output are completely isolated from each other. In other respects—linearity, gain stability, noise, drift—the 114A closely equals the performance of the very best single-ended DC amplifiers. However, bandwidth is forfeited for common mode rejection. This is a penalty the present state of the art requires of all completely floating and isolated differential amplifiers that are capable of providing high common mode rejection with an unbalanced input. Fortunately, the 100-cycle bandwidth of the 114A is more than adequate for bonded thermocouples, which cause most common mode voltage problems, and is usually adequate for strain gage measurements. The advantage of using the 114A with strain gauges is that it eliminates the necessity of having exceptionally well-isolated power supplies and permits using one supply for a number of gauges.

IN SUMMARY

When you are designing a large, fairly complex narrow-band data-handling system with long lines between a grounded transducer and amplifier and/or amplifier and load, you will have ground loop problems. To determine the magnitude of the problem, measure the voltage, electromagnetic field strength, and earth impedance between transducer and amplifier ground points. From this information you can roughly calculate whether installation of an expensive bus bar between amplifier and transducer will provide enough reduction in common mode voltage. Examine power sources and loads that may be generating unwanted currents. Perhaps they can be ungrounded. If common mode voltage is still too high to provide desired system resolution (it probably will be), use a differential amplifier.

If you *have* a common mode voltage problem, and you *need* a differential amplifier, it *must* have very high common mode rejection at 60 cps. If 60-cycle rejection is only marginal, you may be in serious trouble at slightly higher frequencies. The amplifier *must* be capable of providing this common mode rejection with whatever input unbalance is present. If calibration or level-setting potentiometers are used to permit commutation of multiple channels, this unbalance can be several thousand ohms. To retain common mode rejection in the quite likely event that the load is grounded, the input circuit of the amplifier *must* be well isolated from the output circuit. And, if long output cables are used, the amplifier output circuit *must* be isolated from ground to almost the same degree as the input. Otherwise, the common mode voltage between output and load can cause trouble. All signal cables and shields must be arranged to provide both adequate shielding and maximum ground loop impedance for minimum ground loop current.

Finally, call your nearest KIN TEL Engineering Representative, you'll want a demonstration of the 114A Differential DC Amplifier.

KIN TEL
A DIVISION OF
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Write today for descriptive literature or demonstration. 5725 Kearny Villa Road, San Diego 11, California

CIRCLE 5 READERS SERVICE CARD

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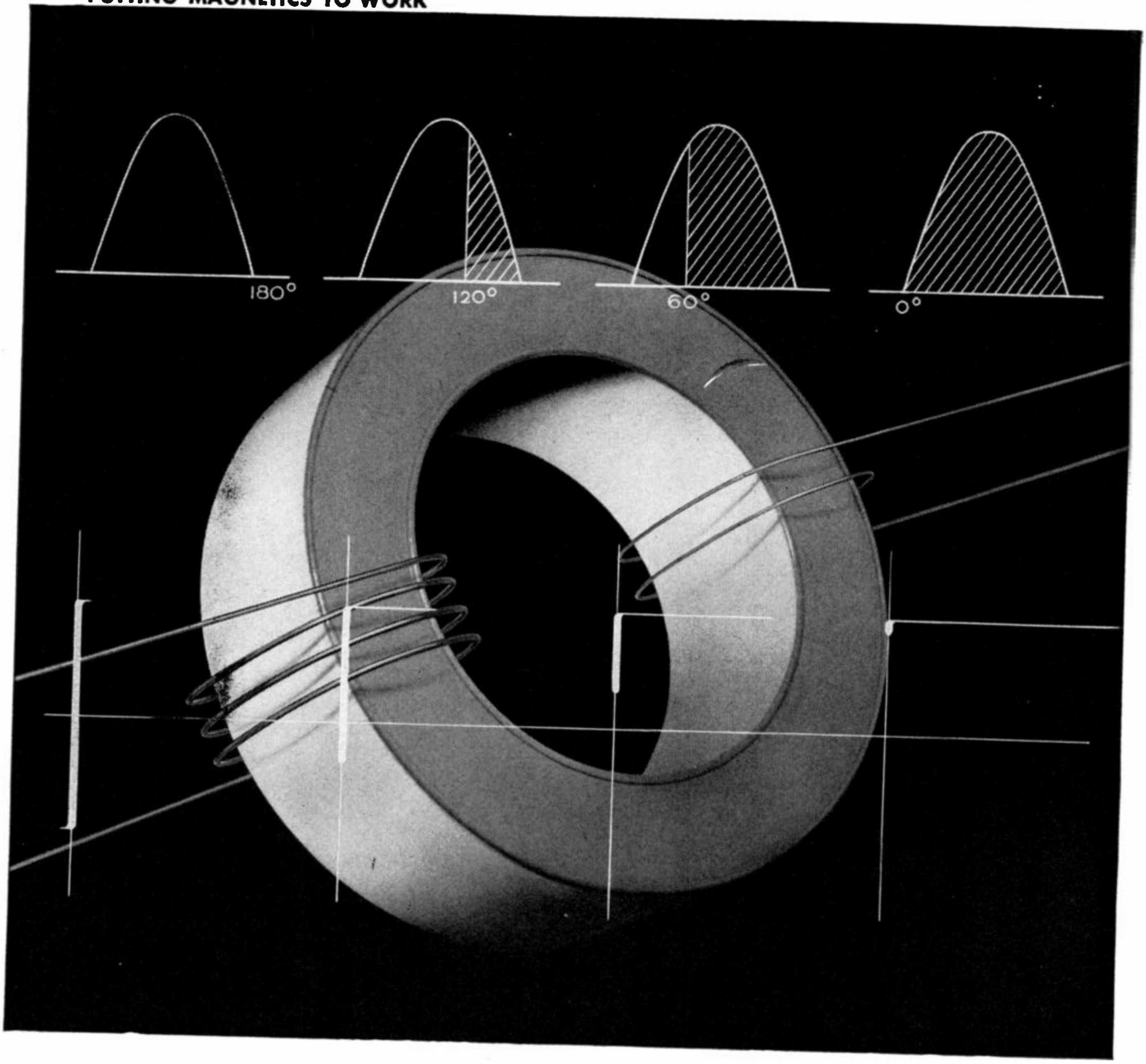

Want a billion-position switch?

Magnetic amplifier manufacturers turn to Orthonol® tape cores for precise proportioning control or switching action

Orthonol is a switching material that can be turned all the way on—or part way on—with vast precision.

The rectangular B-H loop of the 50% nickel, grain-oriented alloy provides an amplifier output which is linear and directly proportional to control (reset) current. This response is so linear that the amplifier acts as a valve with an infinite (at least a billion) number of steps from full off to full on.

Full off and full on can be achieved with snap action, because the horizontal saturation characteristic of the B-H curve means a very low saturated impedance. Thus, when the amplifier is on, it is *on;* when it is off, it is *off*. On-to-off impedance ratios of at least 1000 to 1 provide complete assurance of this absolute characteristic.

Should your manufacturing facilities prevent the use of Orthonol in tape wound core form, you can still take advantage of this excellent material in laminations. An Orthonol laminated core has characteristics almost identical to those in toroidal form.

Like all Magnetics, Inc. products, Orthonol tape wound cores and laminations are Performance-Guaranteed. Full details await your inquiry. *Magnetics, Inc., Dept. E-60, Butler, Pennsylvania.*

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CIRCLE 8 READERS SERVICE CARD

ELECTRONICS NEWSLETTER

DOPPLER RADAR PROXIMITY WARNING device is being tested by General Motors in its experimental Cadillac Cyclone and might foreshadow a commercial breakthrough by automotive radar devices on the cars of all U.S. manufacturers. The Delco Radio device consists of two 10-in. aluminum reflectors mounted four feet apart on the front of the car, and a transmitter and receiver concealed in the front fenders. Reflex klystron puts out 16,140 mc through waveguides to one reflector which focuses beam. Microwaves that bounce off an object ahead of the car are collected by the other reflector, piped through waveguides to a crystal detector for comparison of outgoing and incoming frequencies. Frequency difference is amplified by a transistor amplifier to hearing level over an inside speaker; signal strength thus depends on the speed with which the car closes in on the object in front of it. Another circuit can switch off a green light and flash on a red one for the driver in case of danger.

SATELLITE to relay radio and tv and help mariners chart their courses was described last week by NASA engineers at an aviation conference of The American Society of Mechanical Engineers. They said a plastic sphere would be hurtled 1,000 mi into space with a covering of vapor-deposited aluminum to make it brighter than all but two stars and four planets and give it a good reflecting surface. Power needed to beam radar to the satellite: between 10 kw and 10 mw.

Meteorological rocket radio transmitter smaller than a teacup and weighing a few hundred grams has been developed by Soviet engineers; it uses transistors and printed circuits.

STEREO RADIO transmission system developed by EMI Electronics of Britain was shown last week at the National Association of Broadcasters' convention. System depends on separation of directional information from the normal left and right signals in an encoder. Left and right signals are then recombined in the correct ratio as a single audio signal for transmission. Decoder in receiver inserts required directional information into the audio channels.

PROPOSALS for construction of better but inexpensive science instruction equipment for U.S. high schools are invited by the National Science Foundation. Course Content Improvement Section of NSF's Division of Scientific Personnel and Education, Washington 25, D. C., will consider limited grants for this fiscal year before April 15.

TITAN ICBM TESTING will be accelerated by the electronic Master Operations Control just announced by Martin-Denver. The equipment automatically monitors countdowns of R&D firings, checks out missile systems as well as electronic payload devices. Countdown procedures are programmed into a unit which verifies the sequence of functions as related to countdown time. If a malfunction occurs in any subsystem during countdown, the gear initiates a "hold fire" or shuts down the engine. Pen recorders monitor the functions operated through this master sequencer; time pips, 10 per second, pinpoint the time of malfunction, enabling the area in which it occurs to be determined.

Missile guidance radars, AN/SPG-55, for ships equipped with the latest surface-to-air Terrier missiles will be produced by Sperry Gyroscope under a $51.9-million contract from Navy BuOrd.

INTERNATIONAL CIVIL AVIATION Organization expects to put a trans-Atlantic cable system into operation by 1962 to solve communications problems involved in air traffic control over the North Atlantic. System will provide four duplex teletypewriter channels and one speech channel, permitting traffic controllers to talk across the Atlantic by telephone.

Prototype English-to-Japanese translating machine has been built by a Japanese government electronics laboratory. Memory of 2,000 words will be increased to 10,000 by year's end. Magnetic drum has 820,000-bit capacity.

PHOTOELECTRIC SCANNER in automatic letter handling machine being tested in the Main Post Office, Washington, D. C., locates the stamp on each envelope so that all pieces may be oriented before they pass through a cancelling station at the end of the machine. Gear was designed and built by American Machine & Foundry.

ANTISUBMARINE AIRCRAFT RADAR, AN/APS-80, has been delivered by Texas Instruments to the Navy BuAer for test and evaluation. With an indicator it weighs 550 lb; parabolic reflector antennas can be used for either continuous rotation or sector scanning.

GYRO PLATFORM to give precise reference data to the new B-70 intercontinental bomber will be developed and manufactured by Sperry Gyroscope, says North American Aviation, weapon system contractor for the triple sonic bomber.

WASHINGTON OUTLOOK

AIR FORCE GENERALS have told the House Defense Appropriations Subcommittee in closed session that the ballistic missile program could be effectively stepped up with the addition of some $700 million to the fiscal 1960 budget.

In view of the widespread Congressional dissatisfaction with the Administration's defense policy, it is a foregone conclusion that Congress this year will once again appropriate more military funds than have been requested. The additional funds will probably add up to the $700 million figure cited by the Air Force generals.

Indeed, Rep. George Mahon (D.-Tex.), chairman of the Appropriations Subcommittee, has already used this sum in forecasting an increase for the new defense budget.

The Pentagon's current ballistic missile plans call for nine Atlas and 11 Titan squadrons—10 missiles per unit. The extra $700 million would not necessarily mean an expansion in these plans. But the additional funds could result in accelerating production schedules, putting the 20 ICBM squadrons into operational status one year earlier than now planned.

The Defense Dept.'s top echelon is still reluctant to invest in liquid-propellant ballistic missiles beyond the present program. The Pentagon's top strategists are looking to the solid-fuel Minuteman ICBM, now under development, as the major missile component in the future U.S. arsenal of nuclear delivery systems.

Actually, the Pentagon considers present production plans for Atlas and Titan exceedingly tentative. The ICBM mix is still subject to change as a result of missile tests and technological developments. This state of flux is reflected in the vigorous Washington politicking some companies are conducting on behalf of certain missiles.

The producers and their respective teams of associate contractors are putting on an active sales campaign. The present missile competition seems likely to attract Congressional attention in upcoming months.

- **Twelve companies** have organized an Electronics Small Business Council here to push for a greater volume of military subcontracting to smaller firms. Prime movers are Thomas L. Thomas of Polytronic Research, Inc., Rockville, Md., who heads the Council, and George Estock of Park City Electronics Laboratory, Bridgeport, Conn., who is chairman of the Council's legislative liaison committee.

  The Council plans a vigorous lobbying campaign in Washington, claims that a Congressional committee has already become interested in its two major complaints:

  1. Alleged limitations on little firms to get subcontracts to make replacement or maintenance parts on big electronic end-items.

  The Council claims that end-item prime contractors hold back on parts specifications so long that military procurement agencies are forced to depend on the primes for production of replacement parts under negotiated supply contracts. The Council wants the primes' proprietary rights limited so smaller firms can competitively bid for replacement part orders well before the end-item becomes obsolete.

  2. Alleged advantages for larger companies in landing prime R&D contracts and exploiting the technology developed at military expense in the commercial market. The Council seeks a bigger role for small contractors in research and development.

  The Council claims that some 150 smaller electronics companies have already expressed an interest in joining the new organization. The group has set up offices at 1000 Vermont Ave., in Washington, plans to hold a general meeting in New York during next week's IRE show.

For utmost accuracy, these new Precision Attenuators depend on mathematical law instead of resistivity

New "barrel" design (shown) on K and R band models; time-tested original design (same principle) on G through P band models. Phase shift constant with attenuation. Attenuates 0 to 50 db; SWR less than 1.5 full range. High stability; unaffected by frequency, temperature or humidity changes. Direct reading; no charts or interpolation. Up to 15 watts capacity; simple, one-control tuning; large dial.

The new ·hp· 382A series attenuators provide a completely reliable, true standard of attenuation for calibration or comparison measurements. Unlike waveguide-below-cutoff or resistive-film attenuators, no frequency correction is required. Attenuation is a function of mathematical laws of rotating electrical fields and is precisely accurate under all ambient conditions. Extremely compact, sturdy. For full details, call your ·hp· representative or write direct.

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	G382A	J382A	H382A	X382A	P382A	K382A	R382A
Frequency Range, KMC:	3.95 - 5.85	5.3 - 8.2	7.0 - 10.0	8.2 - 12.4	12.4 - 18.0	18.0 - 26.5	26.5 - 40.0
Waveguide Size:	2 x 1"	1½ x ¾"	1¼ x ⅝"	1 x 1.2"	0.702 x 0.391"	½ x ¼"	0.36 x 0.22"
Power-handling capacity, watts:*	15	10	10	10	5	3	2
Price:	$500.00	$350.00	$350.00	$275.00	$275.00	$425.00	$450.00

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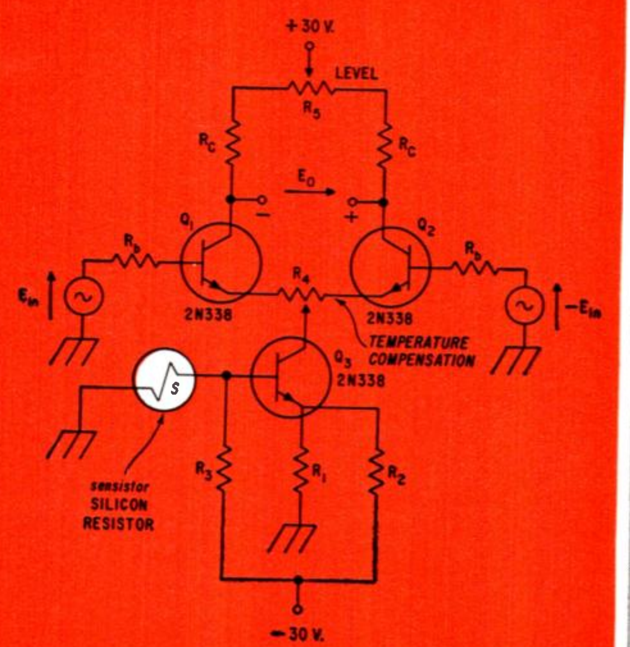
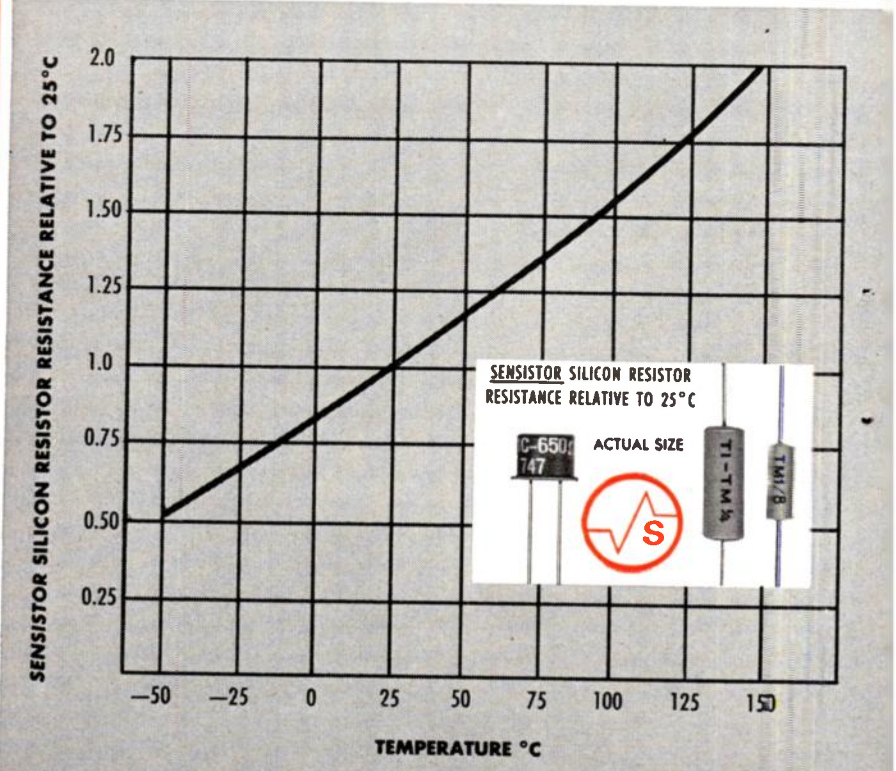
TI APPLICATION NOTE



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



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

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

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

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

DESIGN CONSIDERATIONS

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

For optimum performance keep $(2R_b + R_4)$ as small as possible, preferably less than 2000Ω, and the collector currents of Q_1 and Q_2 should remain below 100 μA.

*TRADEMARK OF TEXAS INSTRUMENTS

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

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

CIRCUIT OPERATION

Sensistor resistor S and its biasing resistor R_3 serve as a voltage source which has an output linearly related to temperature . . . level potentiometer R_5 adjusts output voltage E_0 to zero when E_{in} is zero . . . potentiometer R_4 adjusts for minimum output drift due to ambient temperature changes. As temperature increases, the resistance value of S also increases causing the base of Q_3 to go more negative, thereby reducing the collector current of Q_3. This temperature-dependent current is fed into the differential amplifier through R_4.

Depending on the wiper position of R_4, the correcting signal may be positive, negative or zero. When the wiper is centered, zero correction results. As temperature increases, output voltage E_0 tends to go more positive if the R_4 wiper is placed nearer the Q_2 emitter and negative if the wiper is placed nearer Q_1. The optimum setting for R_4 can be determined by cycling over the desired temperature range to give a minimum drift for changes in ambient temperature.

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New Merger Plans Disclosed

FINANCIAL ACTIVITY in the electronics industry is continuing at a brisk pace with the onset of spring. Here are some items making news:

• **Servomechanisms Inc.**, Los Angeles, and **Laboratory for Electronics**, Boston, have jointly announced a merger plan on the basis of 2¾ shares of Servomechanisms to one share of Lab for Electronics. No date has been set for submission of the plan to stockholders.

• **Merger plans** have been released by **Radiation Inc.**, Orlando, Fla., telemetry and data-processing firm, and **Levinthal Electronic Products**, Palo Alto, Calif., manufacturer of radar, electro-surgical, medical and nucleonic equipment. Levinthal will become a wholly-owned subsidiary of Radiation and will continue operation under present management.

• **Thompson Ramo Wooldridge Inc.**, Los Angeles, announces that 1958 sales and earnings exceeded expectations. TRW, formed last October by merger of Thompson Products and Ramo-Wooldridge, says sales came to $340,621,767 and net income totalled $8,979,232.

• Stockholders of **U. S. Semiconductor Products** and **U. S. Electronics Development Corp.**, Phoenix, Ariz., have been advised formally that directors of both firms have voted to accept the offer of **Topp Industries**, Los Angeles, to acquire the two companies. Both firms manufacture diodes and other semiconductor devices for infrared applications. Acquisition by Topp would be in the form of a stock exchange.

• **Douglas Aircraft**, Santa Monica, Calif., announces that its missile business for last year shows an increase of 109 percent over 1957. The firm's output of missiles, components and ground support equipment came to $415.6 million, as compared with the previous yearly total of $199.1 million. Douglas finds it significant that its missile business total almost equals its $536.8 million figure for military aircraft.

• **Fairfield Engineering Corp.**, Springdale, Conn., announces election of two new directors. Both men are officials of Payson & Trask, a New York venture capital firm which is providing additional working funds for FEC's continued growth. The Springdale firm specializes in power controls.

OVER THE COUNTER

1958 BIDS LOW	1958 BIDS HIGH	COMMON STOCKS	WEEK ENDING Feb. 27 BID	WEEK ENDING Mar. 6 BID	WEEK ENDING Mar. 6 ASKED
3¾	20½	Acoustica Assocs	22½	22¾	27¼
1⅝	3	Advance Industries	3⅞	3⅝	4⅜
3⅛	6⅝	Aerovox	6⅞	7	8
16¾	24¼	AMP Inc	26	25	29
5½	15	Appl'd Sci Princet	12	12	15¾
1⅛	8⅞	Avien, A	8¾	8⅛	9¼
6¾	24	Baird-Atomic	26	26½	29⅜
9¾	13⅜	Burndy	16	17¼	18¾
6¾	9	Cohu Electronics	7	7	9½
11	22½	Collins Radio, A	26¾	27¾	32
10¼	22¼	Collins Radio, B	26½	27¾	32
4	7	Craig Systems	7¼	7¾	8¾
30	50½	Dictaphone	44	44	49¼
17⅝	25⅜	Eastern Industries	20	19¾	23⅞
10½	21	Electro Instr	23¾	24¾	27
34	49	Electronic Assocs	44½	45	50⅜
5	11	Electronic Res'rch	14¼	15	20⅜
8½	12¾	Electronic Spec Co	12⅝	12⅜	13⅝
15¼	49½	Epsco, Inc	33	34	39⅞
5½	9⅜	Erie Resistor	10	9⅞	11
10	17½	Fischer & Porter	14¼	14½	16¼
36¾	50	Foxboro	49½	49½	54
5½	10½	G-L Electronics	12½	12	14⅛
12	27	Giannini	27½	28¾	32½
30	39½	Hewlett-Packard	40¾	41½	45⅛
23¼	48	High Voltage Eng	54	60	71½
1¾	3	Hycon Mfg	3⅛	3	3⅝
1⅛	5⅛	Industro Trans'tor	2¾	3	3⅞
1½	4¾	Jerrold	4¾	5⅜	6⅝
21	30	D. S. Kennedy	31¾	34	39
3¾	29	Lab For El'tronics	27¼	34½	40¾
19¼	28	Leeds & Northrup	28	28	30⅜
2	3⅛	Leetronics	2½	2½	3¼
5	18¾	Ling Electronics	18⅝	18¾	25
16	20½	Machlett Labs	27½	26¼	29⅜
3¼	8¼	Magnetic Amplifiers	7⅝	8	10¾
2⅞	4½	Magnetics, Inc	4	4⅛	5¼
4⅝	12	W. L. Maxson	12½	13⅜	15¼
10⅝	29	Microwave Assocs	29	31½	39⅞
5¼	11¾	Midwestern Instr	13¾	12¼	15
1⅛	7	Monogram Precis'n	8⅝	10	12⅜
3½	7¼	Narda Microwave	6⅞	6	7¾
9¾	16	National Company	21½	21¼	25⅛
14¼	56	Nuclear Chicago	34	37	43
14½	29¾	Orradio Industries	32	38	42¾
4½	7⅜	Pacific Mercury, A	11⅛	11¼	12⅝
10⅛	27½	Packard-Bell	34	34½	38
4¼	9⅜	Panellit, Inc	6½	7¼	8½
21	53¾	Perkin-Elmer	48¾	50¼	55¾
11⅜	19½	Radiation, A	18¼	21½	23⅞
2⅛	7⅜	Reeves Soundcraft	7⅜	7¾	8⅝
13	32½	Sanders Associates	29½	32½	35⅝
7	12	SoundScriber	15	15	20⅝
22¾	40	Sprague Electric	39	40½	45⅛
26	35	Taylor Instruments	34¾	37	42
5½	15	Technical Operat'ns	20	20½	25⅛
5½	15¾	Telechrome Mfg	16¾	16¾	19⅛
3¼	7¾	Telecomputing	8⅝	9⅜	11⅜
1⅛	2¾	Tel-Instrument	2¾	2¾	3¼
8¾	16¼	Topp Industries	13¼	12¾	14⅜
3¾	10¾	Tracerlab	10¾	11	13⅛
1⅛	3⅜	Universal Trans'tor	⅞	⅞	1¼
14¼	40	Varian Associates	45	47¼	53¼
12½	18½	Vitro Corp. Amer	15⅞	16	19⅝

The above "bid" and "asked" prices prepared by the NATIONAL ASSOCIATION of SECURITIES DEALERS, INC., do not represent actual transactions. They are a guide to the range within which these securities could have been sold (the "BID" price) or bought (the "ASKED" price) during preceding week.

ANALAC is a true production-line wire. This film-insulated solderable magnet wire does away with pre-stripping before soldering, lends itself to gang soldering, to iron, gun and dip soldering.

Now, just one step! Analac lets you solder without pre-stripping!

Anaconda's Analac* magnet wire saves time and money on the production line. This film-insulated, solderable magnet wire can be used just as you use Formvar or Plain Enamel—with this plus advantage . . . it is solderable without pre-stripping the insulation.

Analac cuts down labor-time where many solderable connections are to be made. It's ideal, too, where removal of the insulation is a hazard to the wire. Soldering Analac by dipping, iron or gun produces a perfect joint.

It performs well in high-speed winding! Analac has the excellent abrasion-resistance and other mechanical advantages of the enamel wire you're now using.

Distinctive red color simplifies identification . . . is highly visible, helping operators turn out higher quality work.

Analac, 105°C (AIEE Class A) wire, is available in sizes from 15 Awg to 46 Awg.

The Man from Anaconda will be glad to give you more information. See "Anaconda" in your phone book—in most principal cities—or write: Anaconda Wire & Cable Company, 25 Broadway, New York 4, N. Y.

*Reg. U. S. Pat. Off. 58362

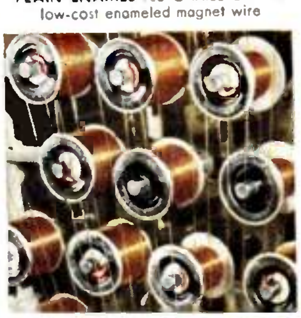
SEE THE MAN FROM ANACONDA®

FOR READY-TO SOLDER ANALAC MAGNET WIRE

For details on how you can save with Analac, and for engineering data—please turn the page!

ANATHERM 155°C (AIEE Class F) high temperature resistance

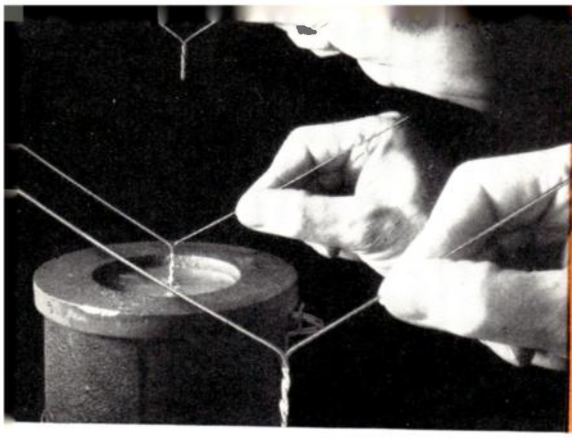
PLAIN ENAMEL 105°C (AIEE Class A) low-cost enameled magnet wire



FORMVAR 105°C (AIEE Class A) established dependability

VITROTEX 130°C (AIEE Class B) glass-insulated, high heat resistance

EPOXY 130°C (AIEE Class B) general compatibility



MAGNET WIRE DATA SHEET

from

Anaconda Wire & Cable Co.

TEAR OUT FOR YOUR FILE

IMPORTANT FACTS FOR YOUR WORK...

about Analac 105°C (AIEE Class A) Magnet Wire

SOLDERABILITY. Anaconda's Analac can be used to overcome high cost of insulation stripping by adapting your present system to automatic soldering techniques. Your Anaconda sales representative can arrange for cooperation from Anaconda's Research Laboratories to help you take full advantage of Analac's cost-saving possibilities.

Analac is versatile; lends itself to gang soldering, to iron, gun and dip soldering. Anaconda's Analac Booklet contains full information on soldering methods, fluxes, temperature control. Use the coupon below for your copy.

WINDABILITY. Analac is abrasion-resistant . . . has excellent lubricity and surface characteristics which make it readily adaptable to automatic high-speed winding operations. Can be used on your present equipment—no retooling is necessary to adapt solderable Analac.

COMPATIBILITY. Analac is compatible with most insulation varnishes presently being used.

TECHNICAL PROPERTIES

MECHANICAL PROPERTIES

Analac has excellent mechanical properties. The film possesses superior abrasion-resistance and flexibility under a number of varied conditions—such as heat, cold and moisture. The wire shows no cracks when elongated rapidly to the breaking point. It will also withstand 3 times diameter wrap after 20 percent elongation.

MOISTURE-RESISTANCE

Analac's moisture-resistance is excellent, particularly in size range 25 and heavier. It offers moisture-resistance superior to most other film-type insulations.

ELECTRICAL PROPERTIES

Analac has superior dielectric strength both in a dry condition and after exposure to high humidity. Meets NEMA twist test requirements. Analac has unusually low dielectric losses at high frequencies, which are only slightly affected by high humidity. Thus Analac is particularly suited for electronic uses.

ELECTRICAL PROPERTIES

		Number of Tests Averaged	Volts per Mil at Breakdown
Dielectric strength.	NEMA twist test, room condition	145	3500
	NEMA twist test, dry.	30	4050
	NEMA twist test after 6 hours exposure at 100F and 100% relative humidity.	30	4000
	Layer test—double layer wind on 1 inch diameter mandrel, apply voltage between layers	30	2840

		Frequency			Dissipation Factor—Cotangent of Angle of Lag (Temperature—Deg C)			
		cps	kc	mc	Room	85	125	15[illegible]
Dielectric loss	Dissipation factor at room temperature.	100			1.00	—	—	—
		1000			0.92	—	—	—
			10		1.38	—	—	—
			100		1.90	—	—	—
			1000		1.97	—	—	—
				10	1.93	—	—	—
				40	2.79	—	—	—
	Dissipation factor at elevated temperature.	100			—	1.08	1.73	15.[illegible]
		1000			—	1.32	1.48	11.[illegible]
			10		—	1.72	1.62	6.[illegible]
			100		—	1.40	1.40	[illegible]

		Frequency			Dielectric Constant K			
		cps	kc	mc	Room	85	125	15[illegible]
Dielectric constant.	As measured by bridge and Q meter at room temperature.	100			3.00	—	—	—
		1000			2.96		—	—
			10		2.93		—	—
			100		2.55	—	—	—
			1000		2.54	—	—	—
				10	2.42	—	—	—
				40	2.90	—	—	—
	As measured by bridge and Q meter at elevated temperature.	100			—	3.63	3.85	3.6[illegible]
		1000			—	3.57	3.80	2.9[illegible]
			10		—	3.51	3.69	2.4[illegible]
			100		—	3.40	3.63	2.3[illegible]

CHEMICAL PROPERTIES

Analac has good resistance to the action of solvents, water, and dilute acids and bases. Analac will withstand 24 hours' immersion at room temperature in most varnish solvents including naphtha, toluol, xylol, and ethyl alcohol. Shows excellent resistance to 5% sulfuric acid and 5% potassium hydroxide.

THERMAL PROPERTIES

Analac is offered as 105°C (AIEE Class A) magnet wire, although its thermal stability shows it is capable of performance at much higher temperatures. Analac's thermoplastic flow cut-through data, obtained on basis of MIL-W-583A methods, has been above 200°C.

DELCO POWER TRANSISTORS

NEW TYPES

MILITARY
COMMERCIAL

TYPICAL CHARACTERISTICS AT 25°C

EIA	2N297A*	2N297A	2N665**	2N553
Collector Diode Voltage (Max.)	60	60	80	80 volts
HFE (I_c=0.5A) (Range)	40-100	40-100	40-80	40-80
HFE (I_c=2A) (Min.)	20	20	20	20
I_{co} (2 volts, 25°C) (Max.)	200	200	50	50 μa
I_{co} (30 volts, 71°C) (Max.)	6	6	2	2 ma
F_{ae} (Min.)	5	5	20	20 kc
T (Max.)	95	95	95	95°C
Therm Res. (Max.)	2	2	2	2° C/W

*Mil. T 19500/36 (Sig. C.)
**Mil. T 19500/58 (Sig. C.)

NOTE: Military Types pass comprehensive electrical tests with a combined acceptance level of 1%.

Delco Radio announces new PNP germanium transistors in 2N553 series — the 2N297A and 2N665, designed to meet military specifications. These transistors are ideal as voltage and current regulators because of their extremely low leakage current characteristics. All are highly efficient in switching circuits and in servo amplifier applications, and all are in *volume* production! Write today for complete engineering data.

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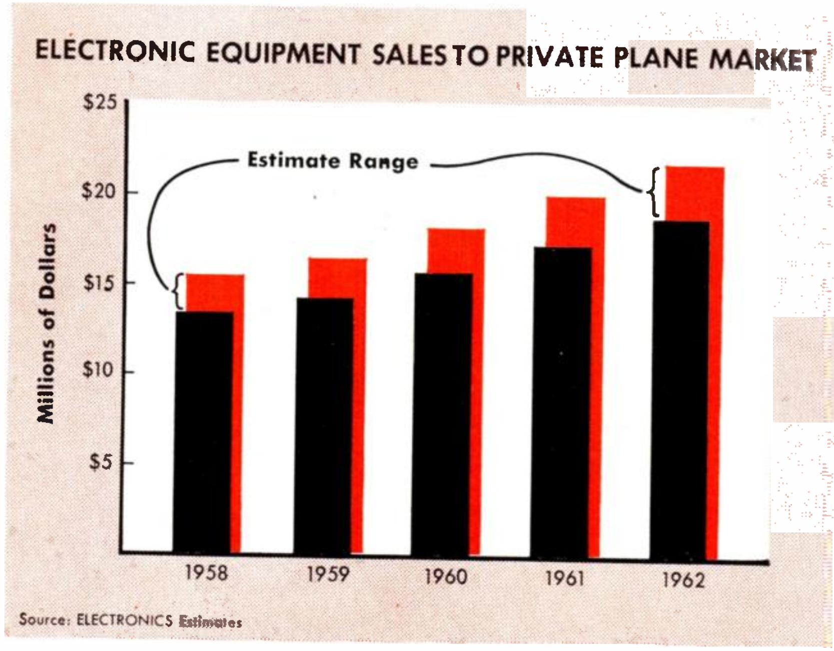
MARKET RESEARCH



More Sales to Private Planes

GROWING USE of private planes by business firms is building the market for communication, navigation and other electronic equipment.

Last year private plane electronic gear sales were about $13.5 to $15.5 million, manufacturers estimated. Total 1958 sales showed little change from 1957. But sales are expected to mount at average rate of at least 10 percent a year through 1962.

Annual sales at that time should top $20 million. Range of estimates is $19 to $22 million.

Many equipment manufacturers in our industry use total value of private planes as a rough measure of the market for electronic gear. Consensus of opinion is that value of electronic items is between 13 and 15 percent of private plane sales at manufacturers' prices.

Electronic equipment sales forecast rests on expectation that private plane sales will increase at annual rate of 10 percent throughout the 1958-1962 period. Total value of private plane sales at manufacturers' prices amounted to some $102 million in 1958. By 1962 such sales will increase to at least $146 million, estimates by plane manufacturers indicate.

Average cost of electronic gear is about $2,000 per private plane. On smaller planes the equipment may cost only a few hundred dollars. For larger planes, cost may be $30,000 or more. One manufacturer reports some executive planes have $100,000 worth of electronic equipment.

The largest sales category is transmitting and receiving radio gear, while radar is in second place, manufacturers report. Other equipment sold for private plane use includes direction finders, automatic pilots, instrument landing systems, radar altimeters, omni-range and dme-receivers, rho-theta computers, intercoms and electronic fuel gages.

FIGURES OF THE WEEK

LATEST WEEKLY PRODUCTION FIGURES

(Source: EIA)	Feb. 27, 1959	Jan. 30, 1959	Change From One Year Ago
Television sets	96,248	129,745	+7.6%
Radio sets (ex. auto)	282,163	295,036	+59.5%
Auto sets	112,336	95,323	+106.2%

STOCK PRICE AVERAGES

(Standard & Poor's)	Mar. 4 1959	Feb. 4, 1959	Change From One Year Ago
Electronics mfrs.	77.65	72.74	+46.2%
Radio & tv mfrs.	93.67	79.03	+104.1%
Broadcasters	86.80	81.08	+57.7%

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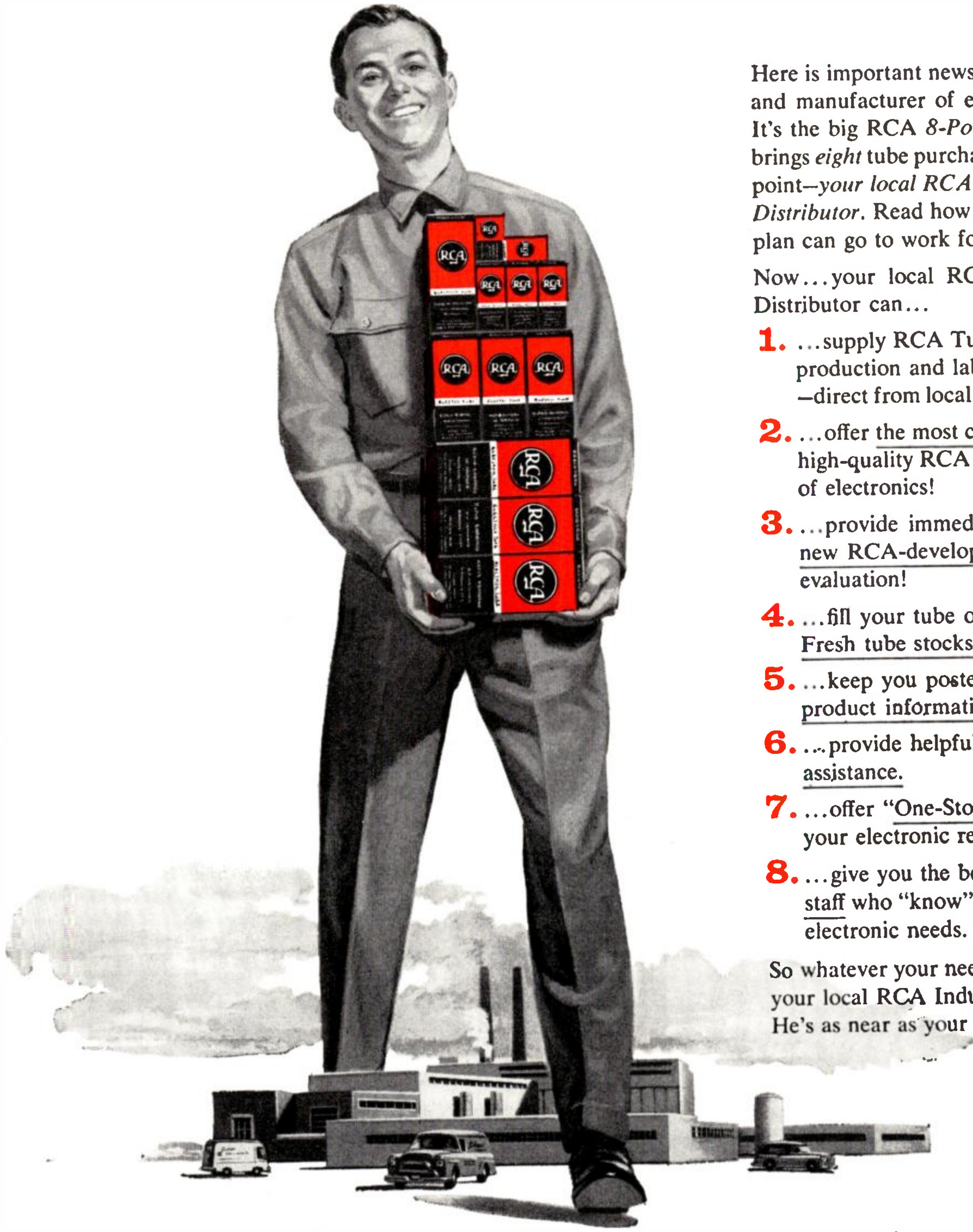

Here is important news for every designer and manufacturer of electronic equipment. It's the big RCA *8-Point-One* plan that brings *eight* tube purchasing benefits from *one* point—*your local RCA Industrial Tube Distributor*. Read how the big 8-Point-One plan can go to work for you—right now.

Now...your local RCA Industrial Tube Distributor can...

1. ...supply RCA Tubes for your pre-production and laboratory requirements—direct from local stock at factory prices.
2. ...offer the most comprehensive line of high-quality RCA Tubes in the history of electronics!
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7. ...offer "One-Stop" order service on your electronic requirements.
8. ...give you the benefits of a specialized staff who "know" electronics and your electronic needs.

So whatever your needs in electronics, call your local RCA Industrial Tube Distributor. He's as near as your telephone.

RADIO CORPORATION OF AMERICA
Electron Tube Division Harrison, N. J.

For the name of your nearest RCA Industrial Tube Distributor, call Western Union by 'phone number and ask for Operator 25.

Paul Odessey takes the stand for electronics

"We are our own best customer," is a phrase heard often in the electronics industry. This means that electronics equipment manufacturers buy component parts, materials and services from fellow suppliers in the field.

Polarad Electronics Corporation is an electronics equipment manufacturer producing microwave signal generators, receivers, spectrum analyzers, test equipment, microwave accessories and antennas and is a major government supplier for research and development. Paul H. Odessey, Executive Vice President of Polarad, is a graduate engineer who has been with the firm since 1945.

How long have you been reading electronics, Mr. Odessey?

Since 1935.

Over the past ten years electronics has passed through a remarkable period of growth and development. Would you comment on electronics magazine's contribution to the expansion of the industry it serves?

Well, it has brought together the products of the entire industry in an integrated organized fashion so that engineering or management could know what the progress of any aspect of their industry was at the time. For example, in transistors, the appearance of new manufacturers in the magazine brought attention to management of many new sources of supply not known. For the small company it became important to be seen in **electronics** *in order to become known in the industry. For the big company it is a matter of maintaining prestige and position and calling attention to the product lines. To the individual engineer, it is a matter of personal accomplishment to have a paper published, or a news item appear relevant to his standing in the field.* **electronics** *is the important source for purchasing electronic components, materials and services.*

If it's about electronics, read it in electronics

electronics

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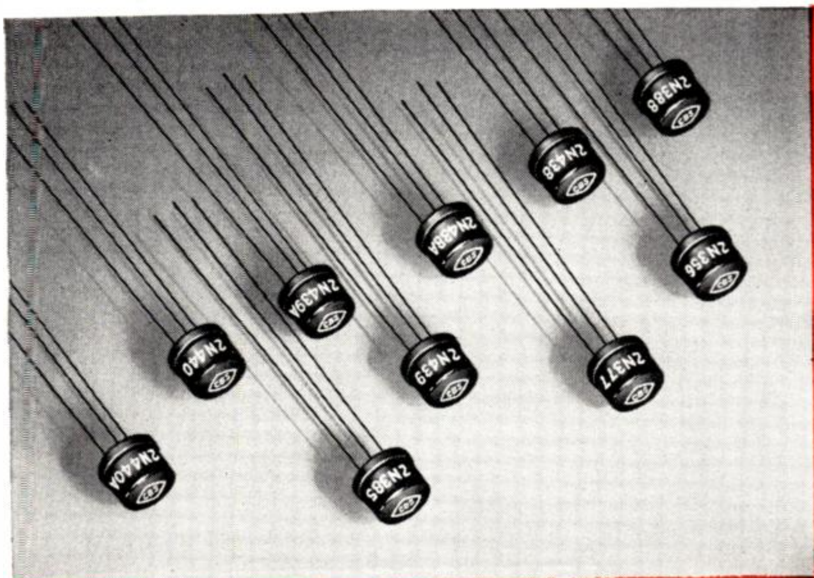
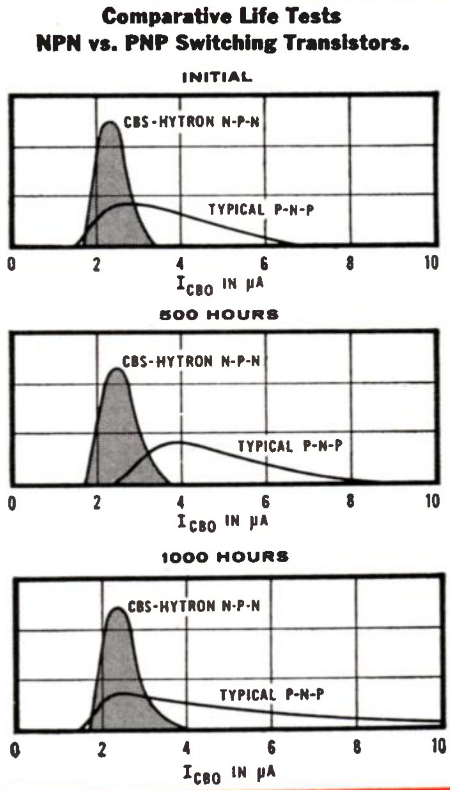
ABC

NPN switching transistors PROVE MORE RELIABLE than PNP

Some design engineers specify PNP switching transistors because they consider them inherently more reliable. Actually NPN transistors can give you superior reliability along with their well-known higher speed. Life tests covering hundreds of thousands of CBS-Hytron NPN alloy-junction germanium switching transistors proved this during the past year. See graphs comparing these transistors with typical military-approved PNP transistors.

The superiority of CBS-Hytron NPN transistors is achieved by special processing: For example, advanced surface chemistry techniques seal out moisture and contamination. Precise control of alloying produces high back voltages. Thorough bake-out stabilizes gain. The result is reliable NPN computer-type switching transistors featuring fast switching . . . high voltage . . . low cutoff current . . . and low saturation resistance . . . in a welded JETEC TO-9 package.





CBS-Hytron NPN Switching Transistors

Type	Minimum BV_{CBO} (Volts)	Dissipation @ 25°C (Milliwatts)	Minimum h_{FE}	@ I_C (Ma)	Typical $f_{\alpha b}$ (Megacycles)	Application
2N356	20	100	20	100	3	Core Driver
2N377	25	150	20	200	6	Core Driver
2N385	25	150	20	200	6	Core Driver
2N388	25	150	30	200	8	Core Driver
2N438	30	100	20	50	4	Logic Circuit
2N438A	30	150	20	50	4	Logic Circuit
2N439	30	100	30	50	8	Logic Circuit
2N439A	30	150	30	50	8	Logic Circuit
2N440	30	100	40	50	12	Logic Circuit
2N440A	30	150	40	50	12	Logic Circuit

Operating and storage temperature, $T_j = -55$ to $+85°C$

A comprehensive line of these reliable CBS-Hytron NPN high-speed switching transistors is available now in production quantities. Check the table. Order types you need . . . or write for Bulletin E-293-302 giving complete data...today.

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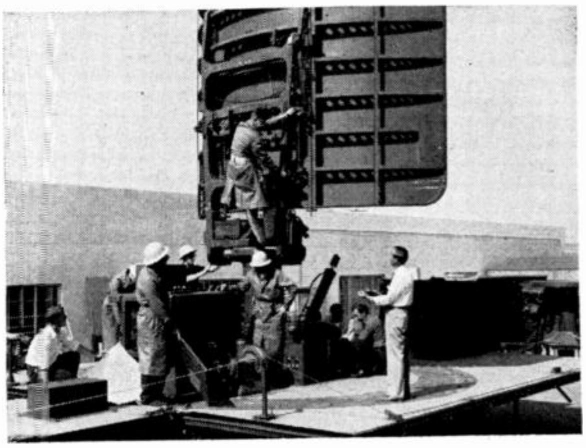
CIRCLE 20 READERS SERVICE CARD

Packing circuits to circle

the world



New Electronic Scanning radar antenna—Frescanar—developed by Hughes at Fullerton, positions beams in space by electronic rather than mechanical means.

Purity Plus—Hughes Products Division engineer checks semiconductor materials to insure purity.

"Project Cordwood" is a new Hughes Communications project which has produced low-cost, widely interchangeable circuit modules *(see photo on left-hand page)*. Other projects under way at the Hughes Communications Division involve the development of systems which deflect their signals from meteors and artificial satellites. Allied to this is the Hughes adoption of the wire-wrapping technique to obtain compact, reliable and automatically applied wiring.

Because of the dynamic growth in communications, Hughes has established a separate, major Communications Division. Already, work has extended past the *transfer* of information to the *use* of information to supplement man's abilities where human resources are inadequate.

From the discovery of basic scientific knowledge through the creation of working hardware, the systems approach is typical of Hughes activities... in Airborne Electronics Systems, Space Vehicles, Plastics, Nuclear Electronics, Microwaves, Ballistic Missiles and many others.

This atmosphere offers creative engineers and scientists the widest possible scope of opportunity for personal and professional growth.

Similar opportunities are open at Hughes Products, where Hughes developments are translated into commercial products—semiconductors, specialized electron tubes, and industrial systems and controls.

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HUGHES

HUGHES AIRCRAFT COMPANY, *Culver City, El Segundo, Fullerton and Los Angeles, California; Tucson, Arizona*

I.R.E. CONVENTION: Visit the Hughes Recruiting Center at The Waldorf-Astoria Hotel or Booth Numbers 2801-2807.

Newly instituted programs at Hughes have created immediate openings for engineers experienced in the following areas:

Communications	Circuit Design
Semiconductors	Test Engineering
Field Engineering	Systems Analysis
Industrial Dynamics	Technical Writing
Digital Computer Eng.	Electron Tubes
Microwave Engineering	Industrial Systems

Write in confidence, to Mr. Tom Stewart, Hughes General Offices, Bldg. 6-D3, Culver City, California.

'Moons' Aid Weather Research

Satellites will help weathermen keep tabs on the atmosphere. Ultimate aim: a satellite network to look everywhere all the time

CURRENT research program into what makes the weather is being aided by the rocket and satellite technology.

Vanguard II, launched late last month, was the first of the weather satellites. It carried an infrared sensing device, was meant to provide a good first approximation of a cloud-cover map. Two miscalculations interfere with its operation: its orbit is too far out and too elliptical to do the job, and its spin is slower than anticipated—15 rpm instead of near 50. Despite these flaws, it is collecting hitherto inaccessible data, and weathermen are enthusiastic about future satellite use.

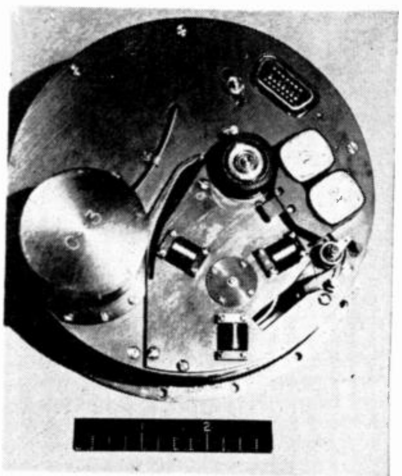
Chief advantage of satellites is that they get up where they can see the earth panoramically and stay there for protracted periods. Sounding rockets get up there, but come right back down again. Balloons can sample only a small vertical column of air at a time, can't get above the atmosphere.

The Weather Bureau has established a meteorological satellite section to plan best use of the little moons. The MSS works closely with National Aeronautics & Space Administration (which has designated the Weather Bureau as its special meteorological research arm), with the Federal Aviation Agency and the Air Force.

The first series of weather satellites includes experiments held over from the International Geophysical Year. There were six Vanguard shots originally planned for the IGY, of which three were to have contained meteorological experiments. One was the cloud-cover mapping experiment carried aloft in Vanguard II.

Another was to measure the earth's heat balance. This experiment will fly later this year, is to measure the heat budget by finding the difference between incoming visible radiation and outgoing infrared radiation. More heat is received than lost in the equatorial regions, and more is lost than received in the polar regions. The imbalance causes the atmosphere to behave as a heat engine, with overall air-mass movement from low to high latitudes.

Three more weather satellites are definitely scheduled for firing this year. One is a NASA satellite, one of the leftover Vanguard vehicles, which will measure heat balance and certain radiation levels. One is a vehicle developed by Army Ballistic Missile Agency for the IGC (International Geophysical Cooperation, a continuation of certain IGY studies), which will also make the heat-budget study. The third is an Advanced Research Projects Agency vehicle which will carry a tv camera and make more sophisticated experiments.



Heart of communications system in Vanguard "Cloud Cover Satellite" now orbiting is basic tape recorder (left). Unit is 5½-in. wide, weighs 1 lb, 5 oz, and records weather on global scale. Right: 75-ft tape is checked by engineer from Army Signal Lab, which developed recorder, and official of Minnesota Mining & Mfg., developer of the special instrumentation tape

Instrumentation

Instrumentation currently planned for the satellite program includes various types of infrared sensors, tv cameras and radar.

Since most of the energy in which the meteorologists are interested is in the ir spectrum, the researchers plan many types of detectors in the various bands. Besides mapping cloud cover, infrared sensors can take the temperature of the earth's surface and the tropopause, and perhaps also measure other important air interfaces.

The tropopause measurement makes use of the fact that water vapor absorbs almost all ir energy at 6.3 microns. An ir sensor in this band therefore senses the temperature at the top layer of water vapor in the atmosphere, which is effectively the tropopause, the boundary between troposphere and stratosphere.

An infrared detector in the 10-12 micron band, on the other hand, sees clear through water vapor to sense either surface temperature or the top layer of cloud cover.

Television camera currently planned—an RCA 500-line vidicon—will sweep a path 6,000 miles long and 1,200 miles wide on the surface each revolution. It will take 10 pictures 1,200 miles on a side each time the satellite revolves; the pictures overlap to make the finished map. Ground resolution will be about 2½ miles.

Picture information will be stored on magnetic tape. Data from a 90-minute orbit will be dumped in four minutes on interrogation from a ground station.

The ARPA satellite is scheduled to carry such a camera aloft this year. The satellite will also carry infrared equipment for backup cloud-cover measurement, and to take readings on the heat budget.

Long-range plans also include radar to pick up storm centers and precipitation that might escape visible-light and infrared sensors.

Satellite Network

Big problem in the accumulation of weather data is the extreme "perishability" of the information. "We can make forecasts today," says a meteorological analyst, "that are quite valid for 24 hours—measured from the time when the data are taken on which the forecast is based." Currently it may take several hours to take enough data, then more time elapses while the data is processed into a forecast.

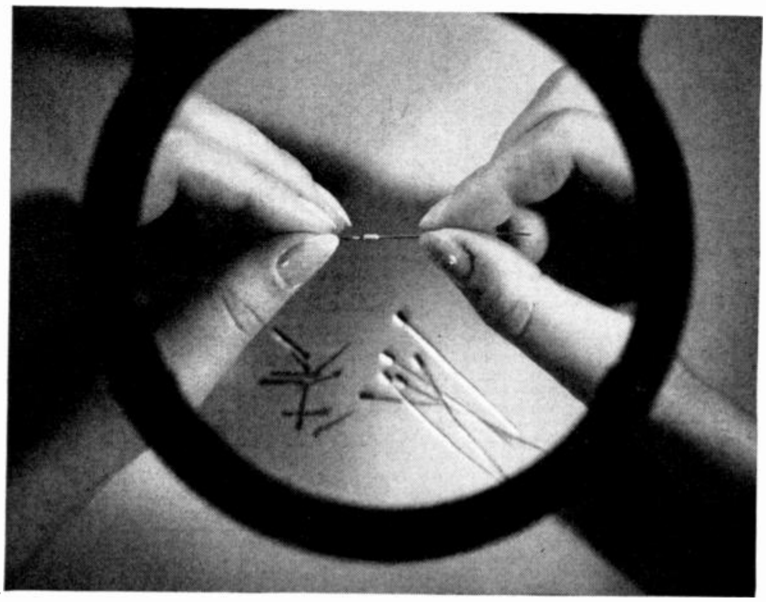
Another big problem is the sparsity of data points. Over most of the earth's surface—ocean areas and vast uninhabited areas of Asia, Africa and South America—there are few points where information about the atmosphere can be collected. The United States operates one of the densest networks of meteorological-data collection points—yet three spiral storm-centers of the type normally associated with hurricanes moved into Texas from the Gulf of Mexico in the spring of 1957 without being tagged as cyclonic. The storms were ultimately to cause the serious floods of April 19-27, 1957.

The storms were photographed, coincidentally, from a rocket fired over White Sands, N. M., and a close scrutiny of ground records permitted weathermen to analyze the data correctly—after the fact.

Ground data points are not feasible over water or uninhabited areas. But a satellite is an acceptable substitute for whole networks of ground observation posts.

A satellite making a 90-minute polar orbit would process about 20 deg. of longitude each orbit, effectively covering the globe once a day. Six such satellites chasing each other at equal intervals would provide practically a synoptic view of the atmosphere and cloud cover in any four-hour period.

It is such a network of space-borne observation posts that the Weather Bureau is ultimately striving for.



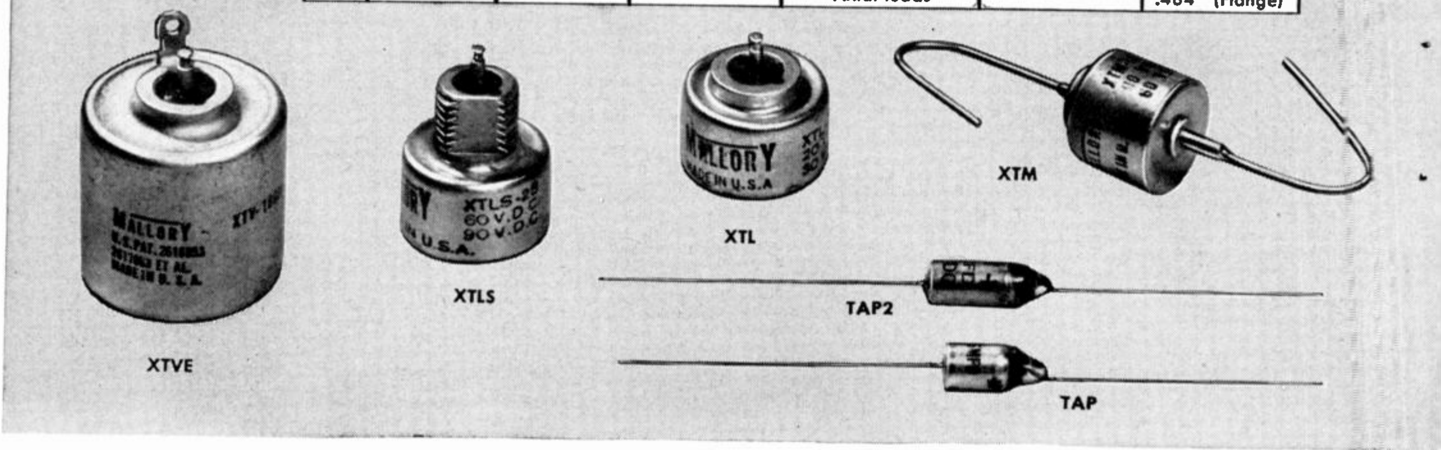
The Mallory

Newest capacitor member of the Mallory Micro-miniature Family

This is the latest example of continued progress in Mallory Tantalum Capacitors—the type HAT. This micro-miniature design sets a new standard of compactness and performance for hearing aids, instruments, and other ultra-miniature electronic components. It features the famous sintered-pellet anode—has a DC leakage of less than 1 micro-amp—is priced for commercial service—is so small that an ordinary pin looks *big* beside it. This new Type HAT delivers premium service at a commercial price.

Type	Cap. Range	W. Volts DC Rating at *85°C	Temp. Range	Case Style	Body Length	Body Dia.
HAT	1-16 mfd.	16-1 v.	0 to 50°C	Insulated Metal Case Axial leads	.200"	.070"
TAP	2-30 mfd.	90-6 v.	−55 to +100°C	Miniature Axial leads	.500"	.225"
TAP2	11-140 mfd.	90-6 v.	−55 to +85°C	Metal Case Axial leads	.625"	.225"
TAS	.33-330 mfd. .33-68 mfd.	25-6 v. 35 v.	−80 to +125°C −80 to +85°C	Miniature Axial leads Solid Electrolyte	.250" to .625"	.125" to .313"
TNT	8-80 mfd.	50-3 v.	−55 to +85°C	Miniature Axial leads	.375"	.145"
STNT	4-40 mfd.	50-3 v.	−55 to +85°C	Subminiature Axial leads	.250"	.145"
XTM	4-40 mfd.	340-35 v.	−55 to +175°C	Miniature Axial leads or Solder tabs	.566" to 1.800"	.625"
XTL	3.5-120 mfd.	630-18 v.	−55 to +200°C	Metal case Solder terminals	.500" to 2.594"	.875" min.
XTH	7-240 mfd.	630-18 v.	−55 to +200°C	Metal case Solder terminals	.688" to 2.750"	.875" min.
XTO	7-240 mfd.	630-18 v.	−55 to +200°C	Metal case Solder terminals	.565" to 2.750"	1.125"
XTV	18-1300 mfd.	630-30 v.	−55 to +175°C	Metal case Solder terminals	1.125"	1.125"
M2	11-140 mfd.	90-6 v.	−55 to +150°C	Metal case Axial leads	.500"	.287" (body) .484" (Flange)

*WVDC at 50°C for HAT only.
WVDC at 125°C for 25VDC and lower voltage.



Tantalum Capacitor Line...

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You get the most complete line of Tantalum Capacitors . . . for research—for prototype—for production—from Mallory. This broad selection of types and ratings can supply both military and industrial needs with the very best . . . with Tantalum Capacitors capable of withstanding the toughest temperature and shock environments.

Mallory pioneered the development and manufacturing of the first and only tantalum capacitor capable of withstanding ambient temperatures of 200°C in military equipment. Unique sintered pellet anode construction, the heart of Mallory tantalum performance, is now applied in a broad series of capacitors for both military and commercial uses . . . ranging from the micro-size new HAT capacitor to the high capacity XTV. Mallory pioneers, too, in true hermetic sealing, and in designs suitable for extreme shock and vibration.

Mallory's manufacturing facilities and know-how have enabled continued production of these capacitors at the highest quality level. This improved quality level means longer shelf life as well as longer circuit life—enables them to be *stocked* for immediate delivery.

You may obtain complete technical data and specifications on any or all of these Mallory Tantalum Capacitors by asking the man from Mallory—or by writing. Skilled application engineers are always at your service to assist in the selection of the type best suited for your own circuit requirements.

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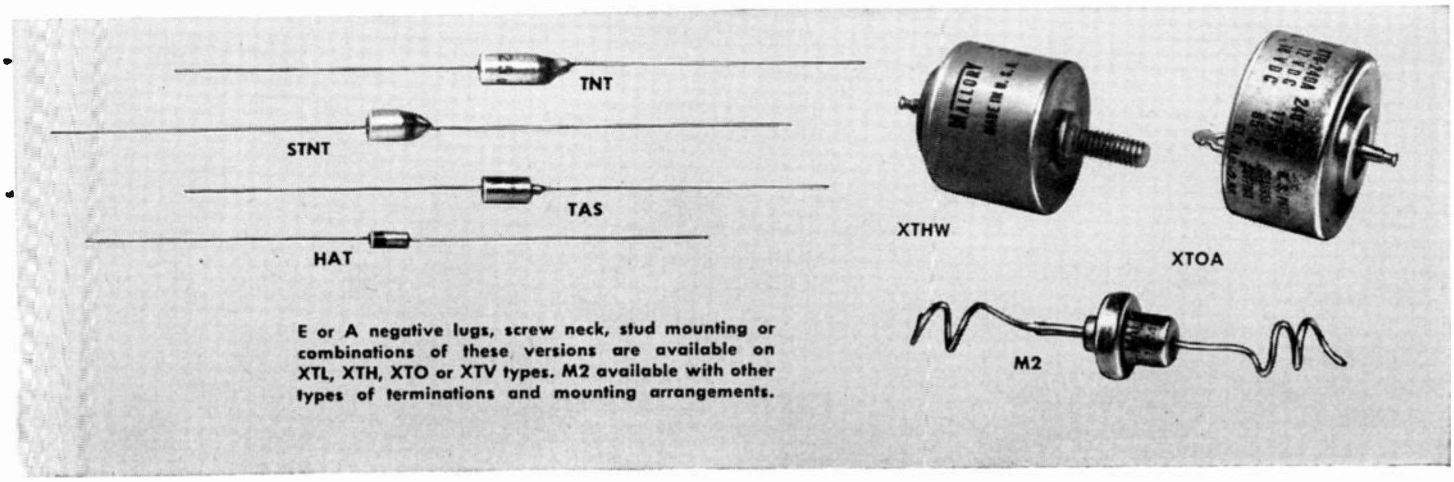


CIRCLE 25 READERS SERVICE CARD

What Does Russia Fish For?

Ifs, ands, and halibuts surround the damage to five undersea cables by a Soviet trawler. Many small Red ships carry sophisticated gear

CONVERTED FISHING TRAWLERS and oceanographic ships under the Soviet flag are plying the seas with electronic equipment to collect data that could be as useful in warfare as in fishing.

The skipper of the U. S. radar picket ship which recently put a party aboard the 1,670-ton Soviet trawler *Novorossisk*, following damage to five submarine cables, reported tersely that there was "no indication of intentions other than fishing."

Why U. S. Watches

However, the unusual step of invoking an 1884 treaty to board the Soviet trawler, and subsequent interest in examining damaged ends of cable brought back by a cable company ship, indicate Washington's concern over Soviet activities in the area. Here's why:

- Caesar, the hush-hush sonar antisubmarine project whose East Coast defense curtain, ranging past the Newfoundland fishing grounds, is already in place, would be a likely object of snooping and electronic ferreting by Soviet submarines and surface ships—quite possibly, by small, fish-laden trawlers.
- If a surprise attack were launched against the U. S., a simultaneous attempt would probably be made to cripple all submarine cables. This would mean reliance on radio communications between the U. S. and NATO, which could be monitored and decoded more readily than multiplexed messages sent through Western Union's Telecrypton coders and telegraph cables.

First evidence indicates that the five cables were not broken in the same manner. In some instances, the cable was apparently hauled aboard the Soviet trawler and cut with a hacksaw to free the trawling gear; in other cases, the cable was damaged on the bottom.

Fishing fleets have been informed for years by Western Union, and by the A.T.&T. Co. since the laying of the telephone cable in 1956, of the whereabouts of the cables so that they could be avoided.

Information about the location of the cables was presented at the International Fishing Gear Congress in Hamburg, West Germany, in October 1957. Cablemen say Russians were present. Also, cable companies have promised fishing fleets compensation for their trawling gear if the trawlers would cut off their own lines instead of the submarine cable in the event of fouling.

Although Western Union suffers cable damage from trawlers about 20 times a year anyway, the damage to four out of ten cables within 26 hours is believed to be a record. These four plus the telephone cable, damaged three days earlier, cover 50 mi from the northernmost to the southernmost. The ocean bottom is about 1,200 ft in each case.

During the IGY the Soviets reported that a converted fishing trawler, the *Sevastopol*, which has a displacement of 2,800 tons and a speed of 10 knots, carried:

- Two electric winches and one trawling winch designed by the State Institute for the Design and Planning of the Fishery Fleet. The trawling winch may be used with dredges, bottom scoops and for anchoring the ship in depths of more than 1,000 meters, and for other "special purposes." The ship has four fathometers, two of which are described as "deep-water, powerful fish detecting apparatus." It accommodates 30 scientists besides the crew. (The *Novorossisk*, displacing 1,670 tons, with a speed of 12 knots, carried a total of 54 men and women). It is believed that at least 30 Russian fishing trawlers were similarly equipped.

A new submarine laboratory, the *Severyanka*, belonging to the All-Union Scientific Research Institute of the Fish Economy and Oceanography, recently completed its first oceanographic expedition. Among other electronic equipment that it carries is measuring gear to provide data on salinity, pressure and temperature.

Important in Sonar

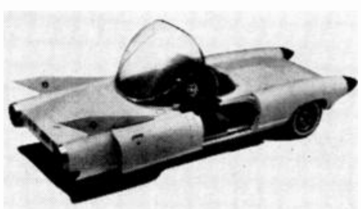
Besides being of interest to fishermen and oceanographers, these salinity, pressure and temperature variation factors are of great concern to designers of sonar detection and sonar interception gear. Such factors cause sound waves to bend in sea water. As stated in ELECTRONICS (p 15, June 27 '58), the nature of sound is the greatest challenge that sonarmen have had to meet in designing Caesar. It follows that plumbing of oceanographic data near our continent by the Soviets would give them militarily useful information.

The Soviet oceanographic ship *Vityaz*, says a Hungarian technical journal, carries photographic equipment for taking detailed pictures of the ocean floor. One exposure covers 3 sq meters; a series makes a detailed map of the ocean bottom.

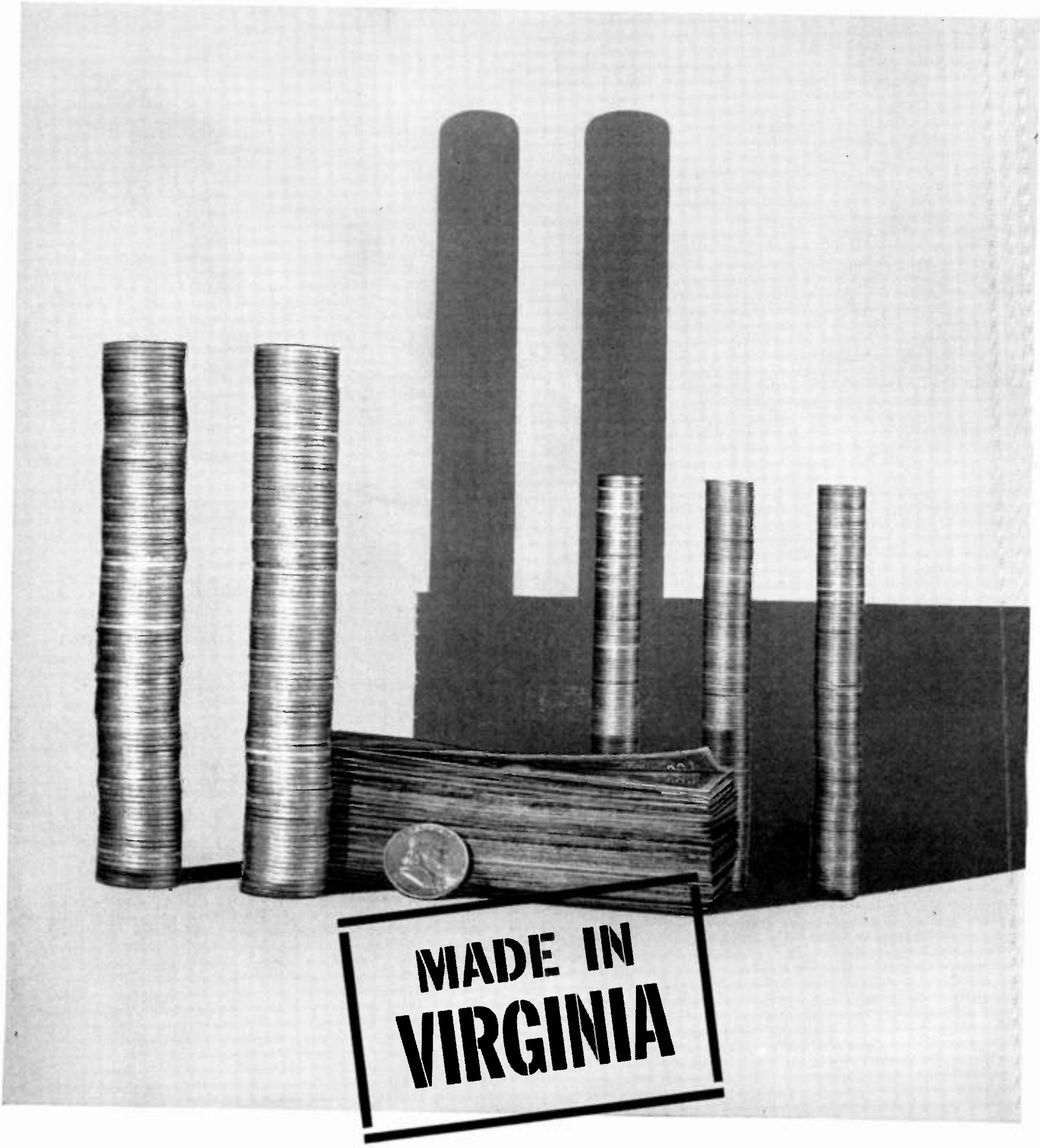
On an IGY voyage the *Vityaz* has also taken stereoscopic pictures as far down as 6,000 meters and other photographs down to 10,000 meters, using electronic controls. A new automatic underwater camera for submerging with a trawl operates by means of an electronic relay and can make 750 exposures.

Underwater tv apparatus built at the Laboratory of Marine Electronics of the Institute of Oceanology, USSR Academy of Sciences, has a circular scanning mechanism controlled from a panel.

Car With Radar



Radar locating device placed in front nose cones of GM's newest experimental car, Cadillac Cyclone, scans highway and warns driver of objects ahead



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Business Is Brisk at

Recruiters at this year's IRE show find growing competition between East and West coasts as rise in business creates more jobs

JOB OPPORTUNITIES being presented at this year's IRE convention indicate an increased degree of competition between East and West coast recruiters.

Expanding activity on the West coast in missile and aircraft work has created increased need for experienced engineers. On the other hand, the East coast region contains the majority of engineering schools and electronics firms from which experienced help may be drawn.

Eastern firms are continuing to establish Western installations, but are keeping transfers at a minimum, preferring to recruit new personnel for the West coast plants.

A personnel man for a major eastern communications corporation admits frankly that his firm is willing to pay junior engineers a slightly higher salary in California than in New Jersey. Difference ranges between $5 to $20 a month. Variations in pay scales decline, however, as higher engineering echelons are reached. "Once a man has joined us, we feel it would cause trouble if his counterpart back East were making less," the personnel man points out.

Willing to Pay

A recruiter for a large California aircraft and missile manufacturer says his firm is much more willing to pay travel and relocation expenses for westbound personnel than for those hired in the West to work in Atlantic coast divisions of the company.

Without exception, recruiters say they will make relocation easy for the men they really want, because of a growing tightness in the specialized labor market.

An engineer who relocates usually has his household moving expenses paid. Most firms also say they will pay family travel and per-diem expenses. Further inducement is often made in the form of relocation allowances while the newly-arrived man seeks housing.

Although recruiting emphasis for next week's convention is placed on hiring trained specialists, several recruiters say they are interested in speaking with newly-graduated holders of engineering

Radio Sextant Guides Ship

First photo of Collins AN/SRN-4 radio sextant installed aboard USS *Compass Island*, Navy's experimental navigation ship. Gear automatically tracks thermal radiation from both sun and moon. (See ELECTRONICS, p 24, June 10, 1957)

Job Marts

degrees. In these cases, firms say they want men who can be trained within the company.

Average salaries, judging by talks with recruiters, range between $5,500 and $6,300 a year for new grads. Increases of $500 can sometimes be had if the applicant has military or other experience in electronics.

In general, recruiters are reluctant to comment in detail on the market value of experienced specialists. They do admit that competition is keen for missile experts, semiconductor engineers, and some instrument specialists.

Less 'Fringe' Talk

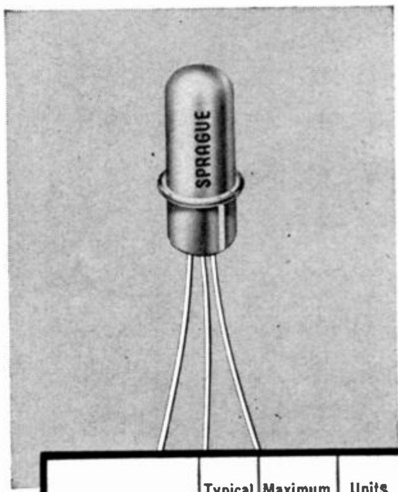
"Under present conditions, almost any job change an engineer makes is bound to mean higher pay," says one recruiter. "This is a time when a man with talent and background can afford to do some pretty selective shopping around."

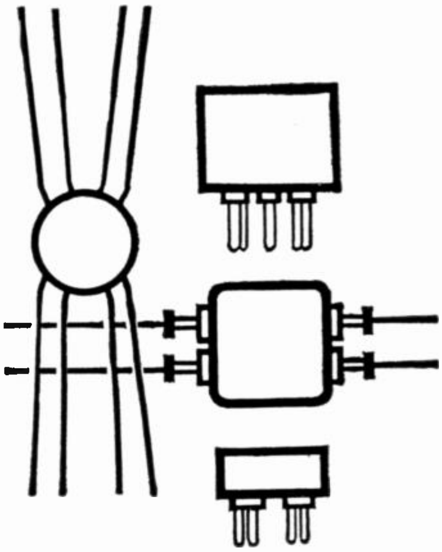
Another personnel aspect noted by convention recruiters is a reduced number of questions centered around fringe benefits. Most side benefits are similar from one electronics firm to another. Personnel men say competition caused the similarity and helps keep it that way

Recruiters say young graduates are more interested in career opportunity and company educational benefits than they are in insurance and medical privileges, but older men are more prone to ask about things auxiliary to salary scales.

Western electronics manufacturers seem to accept job-hopping as a fact of life and attach no particular stigma to a job applicant with several hops in his career. Eastern firms are not nearly so tolerant of job-hopping.

A Los Angeles personnel man says this is because West coast firms have been more subject to fluctuations in manpower requirements. Western engineers, as a rule, have had to cope more often with layoffs, contract cancellations and other conditions which left them no choice but to take frequent job changes as a matter of course.





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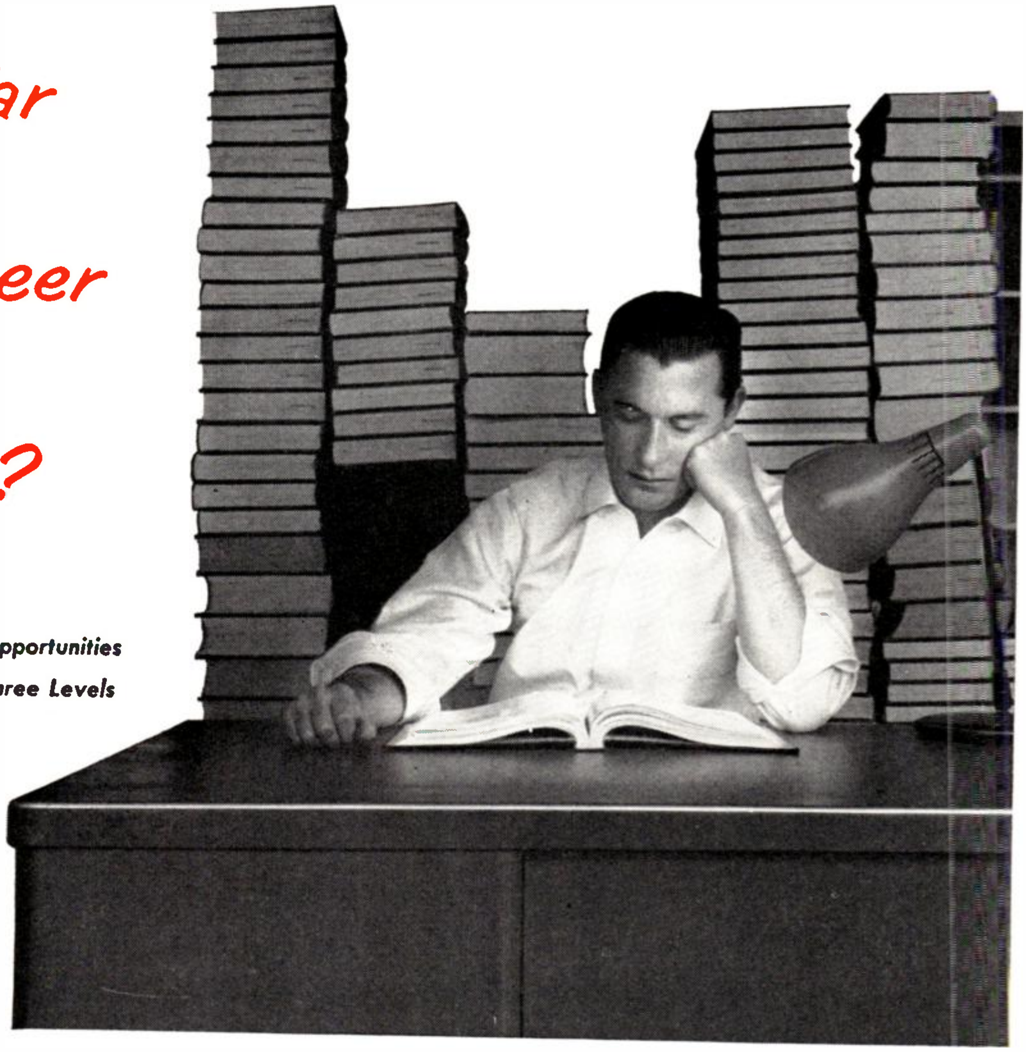

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*** *That martyred, hands-tied feeling you get when your specification is loaded.***

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Don't feel bad. Lots of circuit designers are in the same quandary. But why not *do* something about it? Summon your manly courage, and go ask this specifier whether he wants novelty (at an awful price), or:

...known performance, known reliability, safe design, good logistics, systems flexibility, and economy (all of which you can prove). In short...a design that doesn't apologize!

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P. S. **Come on over to Booth 2908 at the IRE Show, and we'll show you tubes doing things that make other devices blush. Look for the 7-foot tube!**

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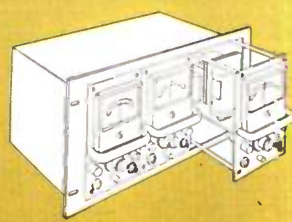

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Russian 'Sputnik X' in Orbit?

Both United States and Soviet Union might soon have reconnaissance satellites in operation

NEW EVIDENCE that both East and West are making big strides toward achieving operational reconnaissance satellites is exciting interest in both camps—and indignation from the Communists.

East Berlin radio accuses Discoverer I of "spying." On the other hand Bochum Observatory in West Germany claims to have picked up new signals from Sputnik III or else from a new, unannounced Soviet vehicle, apparently orbiting the earth. The signals on a frequency of 20.05 mc were picked up at 104-minute intervals, each time several minutes after the end of Sputnik III's signals.

Discoverer I, an outgrowth of USAF's Sentry project, is the initial vehicle in a program for perfecting a global reconnaissance satellite, as well as for testing the reactions of mice and monkey passengers in space.

The vehicle was launched under heavier-than-usual security wraps on Feb. 28 from Vandenberg AFB, Calif. Due apparently to tumbling, and thereby spraying its signals in all directions, fact that Discoverer I was in a polar orbit was not announced by the Advanced Research Projects Agency until March 5.

Standard Thor guidance in Discoverer I was replaced by a tape-fed programmer and an autopilot for attitude stabilization.

The 40-lb payload includes a vhf low-power beacon transmitter for initial acquisition by tracking stations and a radar beacon transmitter with transponder allowing the satellite to receive commands, as well as facilitating accurate long-range tracking. Telemetry equipment operates on 15 channels, 10 continuous and five commuted. Equipment allows for over 100 pieces of information to be continuously relayed to ground stations. Most of the instrumentation is designed to provide data on the operation of the vehicle's components.

Guidance and stabilization technique involved gimballing the main engine during orbital boost period and releasing high pressure nitrogen through a series of external jets. Intelligence for both is provided by an infrared horizon scanner which sends signals to guidance equipment.

Plans for the rest of 1959 call for one Discoverer launching a month.

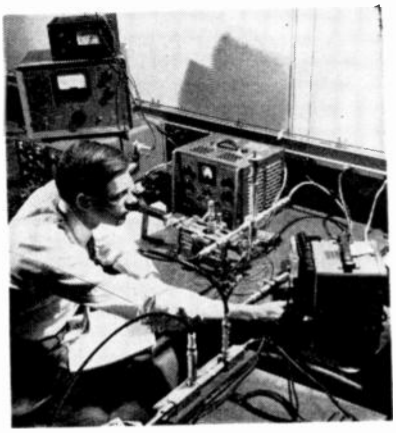
Army's space probe, Pioneer IV, also revealed developments in electronics for space:

It carried a voltage-measuring germanium diode to report on performance of the radio transmitter at the source. By comparing received power level with transmitted power as measured by the diode, it was possible to tell whether excessive power loss was due to equipment malfunction or some unknown condition existing in space.

One of the sun planet's three subcarrier channels used for telemetering data back to earth was "time-shared" by the monitor and the shielded Geiger-Mueller tube.

Information from the latter was transmitted during the first 5½ hrs of flight when the earth's band of intense radiation was penetrated. Then the channel was switched over to report data from the diode monitor.

Transmitter's antenna was a fiberglass cone washed with a thin coating of gold to provide conductivity. Over this golden surface a striped pattern is painted to control inner temperature.



Low-noise parametric amplifier developed at GE received Pioneer IV's signals beyond 400,000 miles

MEETINGS AHEAD

Mar. 23-25: Flight Testing Conf., American Rocket Society, Daytona Plaza and Princess Issena Hotels, Daytona Beach, Fla.

Mar. 23-26: Institute of Radio Engineers, IRE National Convention, Coliseum & Waldorf-Astoria Hotel, New York City.

Mar. 31-Apr. 2: Millimeter Waves Symposium, Polytechnic Inst. of Brooklyn, USAF, ONR, IRE, USA Signal Research, Engineering Societies Bldg., New York City

Apr. 1-May 6: Transistor Circuits Workshop, Six Weekly Evening Sessions, IRE, John Hancock Hall, Boston.

Apr. 5-10: Nuclear Congress, sponsored by over 25 major engineering and scientific societies, Public Auditorium, Cleveland.

Apr. 6-7: Astronautics Symposium, Air Force Office of Scientific Research, Sheraton-Park Hotel, Washington, D. C.

Apr. 6-9: British Radio and Electronic Components Show, Great Hall, Grosvenor House, Park Lane, London.

Apr. 13-15: Protective Relay Conf. A & M College of Texas, College Station, Tex.

Apr. 14-15: Industrial Instrumentation & Control Conf., PGIE of IRE, Armour Research Foundation, Illinois Inst. of Tech., Chicago.

Apr. 16-18: Southwestern IRE Conf and Electronics Show, SWIRECO Dallas Memorial Aud. & Baker Hotel, Dallas.

Apr. 20-21: Analog & Digital Recording & Controlling Instrumentation, AIEE, PGIE & PGI of IRE, Bellevue-Stratford Hotel, Phila.

Apr. 20-22: Instrument Society of America, Southeastern Conf. & Exhibit, Gatlinburg, Tenn.

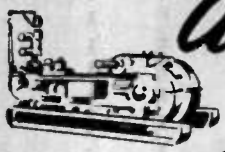
Apr. 20-22: Man-in-Space Conf. American Rocket Society, Hotel Chamberlain, Hampton, Va.

Apr. 21-22: Electronic Data Processing, IRE Section, Engineering Society Building, Cincinnati.

Apr. 22: Medical Electronics, The Electro-Medical Program at the Moore School, PGME of IRE, Univ. of Penn., Philadelphia.

There's more news in ON the MARKET, PLANTS and PEOPLE and other departments beginning on p 78.

INDUSTRIAL INSTRUMENTATION



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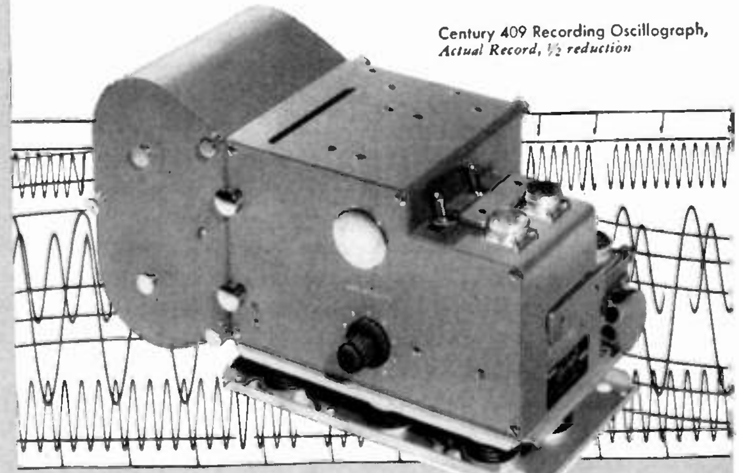

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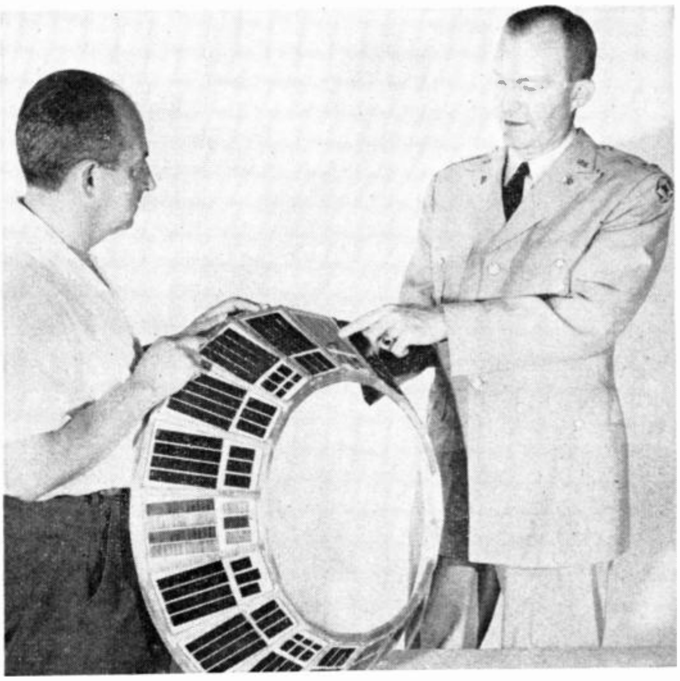

Interior view of thermoelectric generator SNAP 111. Unit delivers 5 watts at efficiency of 8-10 percent with 3,000 charge of Po^{210}

Experimental solar cell ring is under development for a future Army satellite application. Each section of windows generates 5 watts

New Power Sources For Space-Age Electronics

Trend to miniaturization and transistorization has accelerated development of chemical, nuclear and solar energy as the three prime sources expected to fulfill requirements for portable electrical power in space

By DAVID LINDEN and ARTHUR F. DANIEL, U. S. Army Research and Development Lab., Fort Monmouth, N. J.

THE FRONT COVER. Technician at the GE Vallecitos atomic laboratory places jar over cylinder containing small thermionic converter, used successfully in eight-day experiment to produce electricity directly from a radioisotope. Unit is designed primarily for application in space vehicles as auxiliary power source.

Strip of radioactive gold about 1/16 by 4 by 6 inches produced enough power to operate a small transmitter. Present estimates are that a power pack capable of producing 100 watts and lasting more than a year would weigh less than 25 pounds.

PORTABLE ELECTRICAL POWER sources are being used in increasing numbers for a variety of applications both on the ground and in outer space. Transistorization, miniaturization, and other advances in electronics have served to accelerate this trend, and have resulted in the design of many electronic devices that heretofore were not practical. These equipments are dependent on the availability of portable power sources for their successful operation.

PRIME SOURCES—Chemical, nuclear and solar energy are the three prime sources of energy which

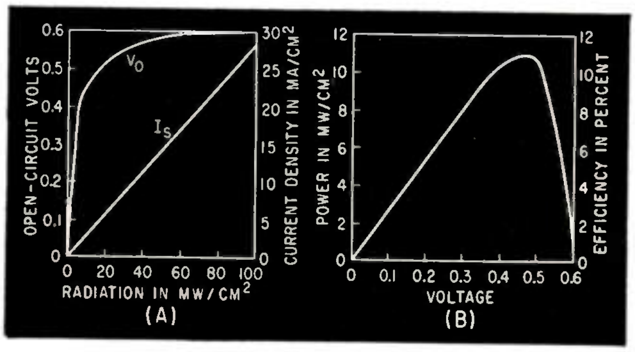

FIG. 1—Typical curves showing current, voltage and power relations of silicon solar batteries

fulfill the new power requirements. Each of these sources has attractive characteristics. These are indicated in Table I.

SOLAR ENERGY—The energy to weight ratio of a solar energy power source can become quite high, especially if it is used for a long period, as its life is limited only by the converting device and not by the availability of fuel. Solar energy reaching the earth each year amounts to 3 $\times$ 10^{21} Btu under conditions of full sunlight at the earth's surface. This is equivalent to 1,000 w/m^2. Above the earth's atmosphere, the radiation is equal to about 1,400 w/m^2; at Venus, 2,650 w/m^2; and at Mars, 600 w/m^2.

The most satisfactory and simplest means for converting solar energy into electrical energy at the present time is the silicon solar cell. This solid-state converter has no moving parts and, as nothing is consumed or destroyed during the conversion process, has a long reliable operating life. The cell consists of a *p* and an *n* type silicon layer, placed one above the other, to form a *p-n* junction where the conversion of radiant energy to electricity takes place.

Development of the silicon solar cell has now reached the point where a conversion efficiency of about 10 to 11 percent has been attained compared to a theoretical efficiency of 22 percent. Thus, at full sunlight at the earth's surface, the output of a solar cell is about 10 to 11 mw/cm^2 and about 40 w/lb. Current and voltage characteristics of the solar cell are shown in Fig. 1A.

Figure 1B shows the power output and efficiency at full sunlight for a varying voltage due to the variation of load resistance. The output of the solar cell can be increased by concentrating the sunlight. At the equivalent of 5 suns, 35 mw/cm^2 have been obtained, and if the cells are cooled, this value can be increased to 50 mw/cm^2.

The most publicized application of the solar cell to date has been the power supply on the Vanguard satellite. The Vanguard employs six solar clusters, mounted under protective glass. This number is used to assure that at least one will be fully oriented to the sunlight and provide the necessary power.

A larger power supply, having a 5-watt output, is being designed for a new satellite application. Each group of 6 sections (there will be a total of 36 sections) can supply the required 5-watts; 2.5 watts to power the electronic equipment and 2.5 watts to charge a group of nickel-cadmium batteries which supply the power when the satellite is in darkness.

PHOTOGALVANIC DEVICES—Light energy can also be converted into electrical energy by chemical means. Photogalvanic devices, however, are still in the research and development phase, and only low conversion efficiencies have been reported.

A typical system utilizes a photosensitive metal oxide or metal halide which under radiation is reduced to the metal and the related oxidant. These two materials form the anode and cathode of the battery and deliver electrical energy when they are reconverted to the original material. Conversion efficiencies reported to date using these techniques are less than 1 percent, but it is not unreasonable to expect a conversion efficiency as high as 40 percent when this system is fully developed.

Photogalvanic devices have the advantage of containing their own built-in storage devices. The battery, once charged by solar radiation, can be discharged at will and not only during periods of radiation as with photovoltaic devices. Also, the discharge rate is determined by battery design and not by the level of radiation.

NUCLEAR ENERGY SYSTEMS—Nuclear energy systems provide a source of electrical energy in a compact form capable of yielding over 1,000 times the energy of a chemical source of the same weight. Performance is generally independent of temperature and other external influences.

On the negative side, nuclear power sources have the disadvantage of radiating continuously or being difficult to shut off. Thus, the full energy capabilities of the system are not realized unless the power

Table I—Comparison of Energy Sources

	Chemical	Nuclear	Solar
Advantages	High power/wt ratio; reliability; controllable discharge rate and time; low cost	High energy density; independent of temperature and other environment factors	Free, inexhaustible power source; long life; high energy-weight ratio
Disadvantages	High wt/energy ratio; temperature dependent; limited shelf-life	Require heavy shielding; heat dissipation problems; high cost	Needs light orientation; requires energy storage for continuous operation; low power density
Mechanism of energy conversion	Electrochemical (batteries, fuel cells); thermal energy	Direct conversion; nucleogalvanic; thermal energy	Light energy (photoelectric, photogalvanic); thermal energy

Table II—Characteristics of Nuclear Batteries

Battery Type	Constant Current Charging			Contact Pot'l Difference	Junction	Photo-Junction	Thermo-Junction
Radioactive Mat'l	Sr^{90}	H^3	Kr^{85}	H^3	Sr^{90}	Pm^{147}	Po^{210}
Half-Life.	25 yrs	12 yrs	10 yrs	12 yrs	25 yrs	2.6 yrs	138 days
Quantity	10 mc	1 cu	1 cu	1.5 mc/cell	50 mc	4.5 cu	3,000 curies
Size	1 $in.^3$	1 $in.^3$	5 $in.^3$	1 $in.^3$	———	0.2 in.×0.7-in. dia	5.5 in.×4.75-in. dia
Weight	6 oz	1 oz	14 oz	1.5 oz	———	0.6 oz less shielding	5 lb
Current, Amps	10^{-12}	6×10^{-10}	10^{-9}	10^{-10}	5×10^{-6}	0.25–1 v 20 μw	5 watts
Voltage	14 kv	1 kv	1 kv	100 v (66 cells)	0.2 v		
Development status	Sr batteries in production; prototypes of H, Kr batteries under test			Development complete, but not in production	Development complete, but not in production	Development complete	Prototypes completed; larger units being investigated
Manufacturers	Radiation Research Corp.; Patterson Moos Div., Universal Winding Co.			Tracerlab, Inc.	RCA	Elgin National Watch Co.	Mound Laboratory; Martin Company

source is used continuously and at full output. Nuclear sources also create a secondary environment of nuclear and thermal radiation which requires heavy shielding and a means of dissipation of the waste heat.

Nuclear power sources can be classified into two types: those using the energy released in the decay of radioactive isotopes, and those employing a reactor source.

The power output of a nuclear reactor is relatively constant and its thermal energy can be converted to electrical energy by a number of methods. These units are not efficient from the standpoint of power/weight ratio, in sizes smaller than about 3 kw.

The power of a radioisotope is determined by the rate of decay and the energy per decay. Power output decreases exponentially with time and falls off to one-half the original output in a period of a half-lifetime.

NUCLEAR BATTERIES—Direct conversion nuclear batteries, employing radioisotopes, are being used in extremely low power applications of the order of 10[illegible] watts. The characteristics of several of these are shown in Table II.

One of the more promising of these batteries is the constant-current charging type. High-speed electrons from the radioactive isotope penetrate an insulating medium and are collected by an outer conducting electrode, which then becomes negatively charged. The advantage of this battery is its unique ability to develop high voltages in a single small unit.

In the contact potential difference type, the radioactive material irradiates a gas contained in a space between two dissimilar metallic electrodes. The gas is ionized and the resultant gas ions migrate to the electrode of opposite charge when these electrodes are connected through an external conductor. The electrical energy output depends on the ionizing energy of the radioactive material and the potential depends on the electrode materials.

In the junction-type battery, the radioactive source irradiates a *p-n* silicon junction, and its operation is similar to the solar cell. This battery has extremely short life as the radiation destroys the silicon junction in several weeks. This is overcome in a fourth type of nuclear battery, where the radioactive material irradiates a phosphor which converts the nuclear energy into light and this, in turn, is converted to electrical energy by a small silicon junction.

THERMAL ENERGY CONVERSION—Solid state devices are most attractive because they provide a means for the direct conversion of heat into electrical energy without the use of moving parts, and result in a long-life noiseless system, free of maintenance. They also offer the possibilities of high conversion efficiency, (in the order of 30 percent) high watt-hours per pound, and opportunities for miniaturization. There are two methods of conversion under serious study at the present time. One utilizes the thermoelectric or Seebeck effect, and the other the thermionic emission or Edison effect.

It has been known for some time that an emf is produced when a temperature differential exists between electrically connected junctions of dissimilar materials. The power output depends on the materials used and the temperature differential. This is known as a thermo-electric effect. Systems employing this principle have been designed in the past, but they had low conversion efficiencies primarily from large thermal losses and the nonavailability of thermoelectric materials having favorable physical properties. The radioisotope heat source has renewed interest in this type of conversion, since a concentrated source of heat is now available that can be readily fitted into a design which will minimize thermal losses.

An early prototype 50-mw battery has been fabricated by the Mound Laboratory. This device consists of a chamber in which the nuclear capsule is placed. Polonium 210 is the heat source and Chromel P and constantan are the thermocouple materials.

The state of the art has been greatly advanced by recent announcement of a 5-watt unit designated SNAP III by the Atomic Energy Commission. This device was developed jointly for the AEC by the Martin Company and Minnesota Mining and Manufacturing Company. The thermal-electric material used is lead telluride alloyed with other substances and the radioisotope is again Polonium 210.

With 3,000 curies of radioactivity, SNAP III will generate electricity at the rated capacity of 5 watts with an efficiency of 8-10 percent.

THERMIONIC EMISSION—Thermionic emission is the liberation of electrons from the surface of a material resulting from the kinetic energy imparted to the electrons by the application of heat. This phenomenon has been known for some time. Only recently, with the announcement of the development of devices capable of converting more than 8 percent of the applied heat to electrical energy, has it been seriously considered as a means of energy conversion. The reported power output is in the order of 0.3 w/cm² of electrode surface, or 20 w/lb with a temperature differential of 450 C.

The thermionic diode consists of two electrodes made of materials of different work functions which are separated by a narrow gap and placed in an evacuated container. One of the electrodes, the emitter, is heated to a temperature which is high enough for effective electron emission. A high percentage of these emitted electrons are collected by the outer cylinder, which becomes negatively charged, creating a potential difference between the two electrodes. A large difference between emitter and collector work functions and their respective operating temperatures is necessary to obtain maximum output power. With a tungsten emitter operating 100 C below its melting point, a theoretical limit of 1,000 w/cm² is computed with a maximum conversion efficiency of 65 percent.

PYROELECTRIC PHENOMENA—When the temperature of oriented crystals such as the titanates is changed, a potential is generated between two faces of the crystal. This pyroelectric effect is similar to the piezo-electric effect, except that in the latter the potential is developed mechanically instead of thermally. Another similar effect, the pyromagnetic effect, depends on alternate heating and cooling of a magnetic material to produce changes in magnetic permeability, inducing an emf in a coil. These devices are still in their infancy, but power output in the order of 50 w/lb may be obtainable.

BATTERIES—Electrochemical batteries have many characteristics and advantages which cannot be equalled by other energy systems. They are among the best energy sources that exist for short-time applications with proven performance and low cost. Their power-to-weight ratio is among the highest known; in this respect the chemical systems are superior to the solar and nuclear devices which perform best in long-term discharges service.

An important use of chemical batteries is in conjunction with other systems where it is used as a storage device or for handling short-term peak power requirements. Chemical energy systems

Table III—Characteristics of Fuel Cells

Type of Cell	Low-Pressure H_2-O_2	High-Pressure H_2-O_2	High-Temperature	Redox
Features	Construction relatively simple	Higher output/unit wt or volume than low-pressure cell	Permits use of industrial fuel gases	Separate reaction compartment simplifies gaseous electrode problem
Fuel: Oxidant:	H_2 of commercial purity O_2 gas or air	H_2 gas of high purity O_2 gas of high purity	Fuel gases of high purity Air or O_2	Fuel gases Air or O_2
Operating pressure " temp	1 atm 60–65 C	40–55 atm 200–250 C	1 atm 700–800 C	1 atm 85 C
Cu ft/kw	3.5–5	0.25–1.2 (est)	———	5
Lbs/kw	250–500	40–90 (est)	———	50–75
Development status	Prototype models being fabricated	In development stage	In experimental stage	Development work near completion
U. S. manufacturers	National Carbon Co. General Electric Co.	Patterson, Moos Div. Universal Winding Co.	Pittsburgh Consolidation Coal Co.	General Electric Co., Lockheed

have the disadvantage of an extremely high weight to energy ratio. A maximum value of about 100 watt-hours per pound can be expected with these systems.

CHEMICAL CONVERSION—Heat energy can be converted to electrical energy by using a chemical system as the conversion device. One such system is based on the formation and decomposition of ionic hydrides. The cell reaction for a system involving a metal hydride such as lithium hydride is $2M + H_2 \rightarrow 2MH$. Electricity is produced in this fuel cell reaction. The product is then decomposed into the original reactants by heating in the regenerator.

Conversion of the fuel cell reactants to electrical energy can be accomplished with high efficiencies associated with chemical systems, with the overall efficiency limited by the Carnot cycle. The system also has the advantage of providing a means of energy storage. Thermal energy can be used to produce the chemical fuel reactants which can be stored until electrical power is required.

FUEL CELLS—Another means for the conversion of chemical energy into electrical energy is the fuel cell.

The fuel cell eliminates the intermediate step of conversion to heat that is necessary with Carnot-cycle devices, thus offering the possibility of overall fuel conversion efficiencies in the order of 70 percent. No moving parts are required, except for auxiliary functions. This results in quiet operation, long life and a minimum of maintenance.

Many fuel-cell systems have a low operating temperature and are thus relatively immune from infrared detection. The energy/weight ratio of the fuel cell, while not comparable to nuclear energy systems, is attractive, and most of the problems associated with handling of nuclear fuels are non-existent.

One of the most significant of the fuel cells being developed is the low-pressure hydrogen-oxygen cell. This cell has been widely investigated and units have been operating on a laboratory scale for over two years. Field type units in the 150-w to 2-kw category are now being built.

The cell employs a number of gas electrodes in a cell containing a solution of potassium hydroxide as the electrolyte. These electrodes are porous carbon tubes which are treated chemically. Hydrogen and oxygen are fed into alternate electrodes and diffuse through to the surface where they come in contact with the electrolyte. Electrical power is produced as part of the chemical reaction.

Hydrogen can be supplied using tanks, hydride fuels (calcium or lithium hydride which are decomposed to hydrogen with water) in hydrogen generators or, ultimately, by conversion of kerosene or carbonaceous fuels. Air can be used as the source of oxygen, but improved performance is obtained using pure oxygen.

The high-pressure version of the hydrogen-oxygen cell is similar in principle. A solution of potassium hydroxide is used as the electrolyte and the gas electrodes are of sintered-nickel powder. The higher

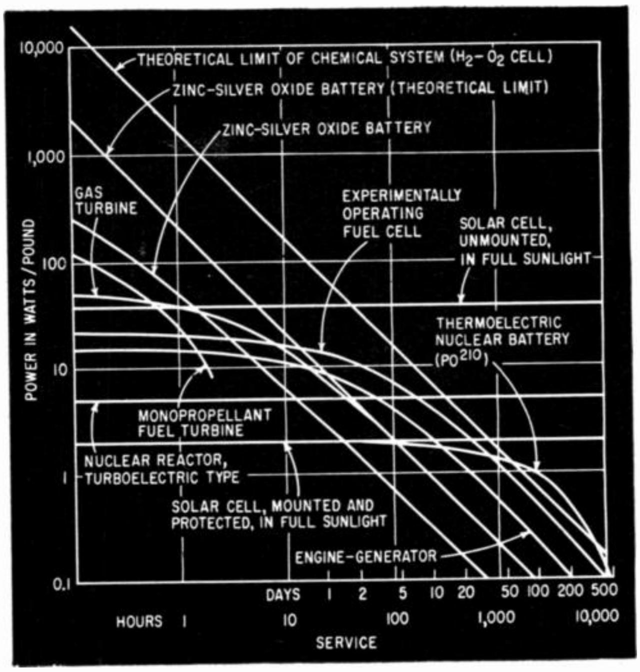

FIG. 2—Typical performance curves of new energy sources compare power output. In practice, wide variations are produced depending on power level, shielding and other design factors

operating temperatures of 200 to 250 C and pressure of about 40 atm result in more efficient performance.

HIGH TEMPERATURE FUEL CELL—Another type, the high-temperature fuel cell, permits the use of cheaper fuels such as industrial fuel gases, and cheaper oxidants. The porous gas electrodes are made from metals or metal oxides. A solid electrolyte in the form of a molten salt (usually a carbonate) in a porous solid matrix made from a refractory oxide is used. The electrolyte has adequate ionic conductivity at the operating temperatures of 700 to 800 C.

REDOX FUEL CELL—This fuel cell avoids the difficulties associated with gaseous fuel electrodes by separating the fuel reaction from the electrochemical reaction. In the redox cell, suitable atoms or ions are alternately oxidized and reduced, generally in room-temperature aqueous solutions, to produce electrical power. The discharged reactants in solution are circulated through auxiliary apparatus where the oxidant is regenerated by reaction with oxygen, and the reductant regenerated by reaction with hydrogen. The overall reaction is still oxidation of the fuel gas, but the various reactions are carried out independently and under optimum conditions.

The characteristics of fuel cells are summarized in Table III.

The output of many new types of electrical power sources for the space age are summarized in the comparison chart of Fig. 2.

The authors acknowledge the assistance of the members of the Power Sources Division, U. S. Army Signal Research and Development Laboratory, and the industrial organizations who supplied information and photographs used in this article.

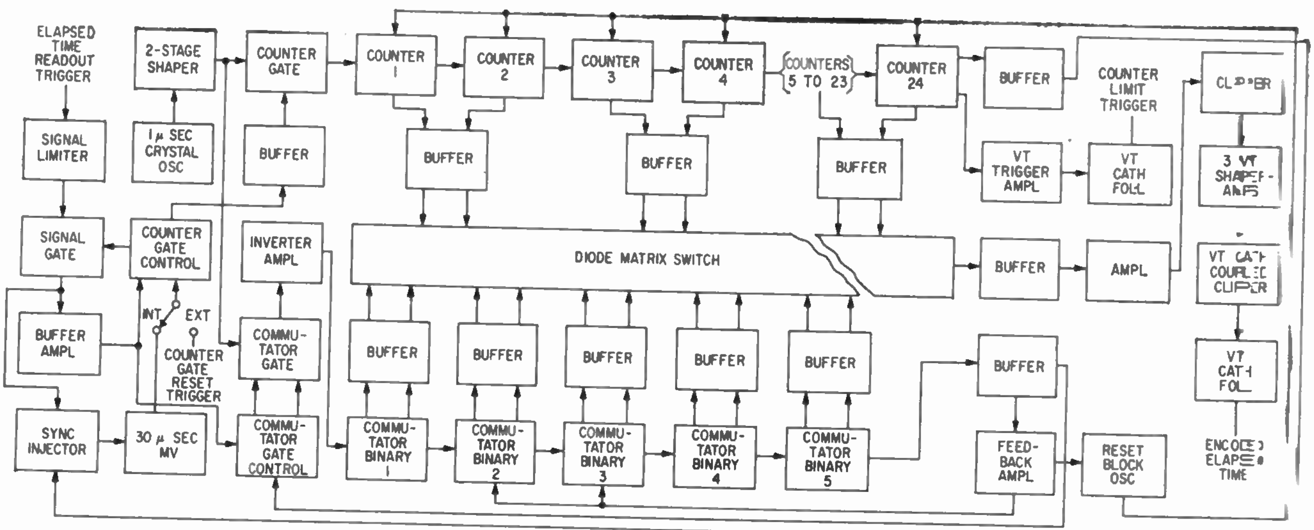

FIG. 1—Size, weight and power consumption of encoder are minimized by using semiconductors in all circuits not identified as VT (vacuum tube). Device will operate reliably over a temperature of —40 to +55 C

Encoder Measures Random

ANALYSIS AND CONTROL of pulse period jitter in pulse-time and pulse-code modulation communication systems are simplified using the high-resolution random event encoder to be described. The device can also be used to form statistical distributions as in the investigation of variations in period between

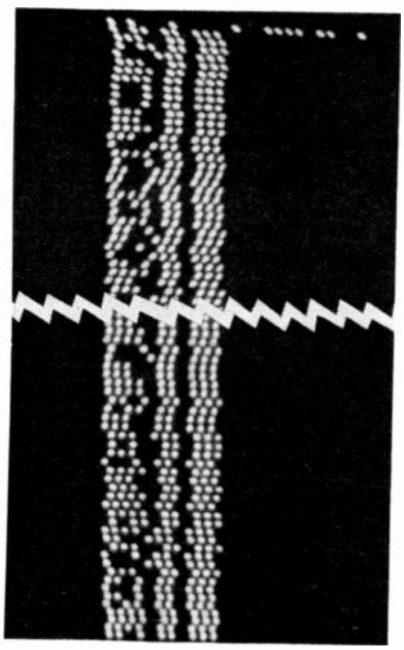

FIG. 2—Encoded elapsed time record on single-frame 35-mm photograph

counts produced by a scintillation counter used for nuclear radiation studies.

A block diagram of the encoder is shown in Fig. 1. A one-mc oscillator is used as a time reference. Output of the oscillator is shaped and used to drive a 24-stage binary counter which stores elapsed time.

When a signal appears at the input indicating the end of the desired storage period, the output of the oscillator is switched from the counter to a commutator circuit. The commutator together with a diode matrix reads out the state of the counters in serial form. Upon completion of readout, a reset pulse is applied to each counter stage returning it to the original state.

Reset

Counter reset technique permits the time required for readout to remain as a stored count. Elapsed time, therefore, is actually the time from the start of the previous readout to the start of the present readout. Thus, the time required for readout (approximately 30 μsec) is not subtracted from the time between the events being studied.

If the period timed is longer than the capacity of the counters (approximately 16 sec), a trigger pulse

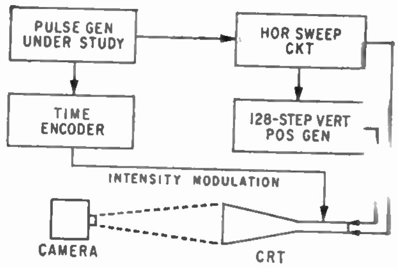

FIG. 3—Circuit used to produce elapsed time record shown in Fig. 2

is generated which initiates the readout process when the limit of the counter is reached. In this instance, only an index pulse is read out. Storage of elapsed time is resumed after the counters have been reset to the time required for this readout.

Output of the diode matrix switch is amplified and shaped for use in intensity modulating the horizontal sweep of a crt. Resulting patterns are then photographed. For a recording of approximately 100 elapsed time readouts, the film is held stationary while successive horizontal sweeps are positioned vertically by a direct-coupled step generator.

Record Analysis

A record made of the jitter in a pulse train generated by a pulse

Transistorized encoder stores and reads out elapsed time between consecutive but randomly occurring events. One-mc oscillator triggers 24 elapsed time counters until end of storage period. Oscillator is then switched to an electronic commutator controlling a diode matrix switch. Counter data is read out serially through the switch, converted to traces on a crt screen and recorded photographically

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Event Time Intervals

generator operating at approximately 1 kc is shown in Fig. 2. The circuit used to produce the photograph is given in Fig. 3.

Each horizontal line of dots is an elapsed time readout. The first dot at the left hand side is an index dot. Remaining dots are weighted in binary fashion, that is, the first dot to the right of the index represents one μsec (2^0), the second dot two μsec (2^1), and third dot four μsec (2^2), the fourth dot eight μsec (2^3) and so on.

Addition of time represented by the visible dots indicates total elapsed time. As an example note the dots visible on the bottom line: the index, 2^0, 2^2, 2^4, 2^5, 2^7, 2^8 and 2^9. The elapsed time is the sum of these figures or 949 μsec.

Consecutive horizontal sweeps are not in exact vertical alignment because the one-mc oscillator and the external signal trigger pulse that starts the sweep were not synchronized. Readout, therefore, begins within the one μsec period following the initiation of the sweep. Long time readout indicated at the top of the photograph results from the random state of the counters at the start of the testing period. To study a greater number of consecutive periods, the vertical positioning can be held constant while the film is moved at a rate determined by the minimum period expected.

A schematic of the one-mc crystal oscillator and shaper circuits is shown in Fig. 4. An emitter coupled crystal oscillator is

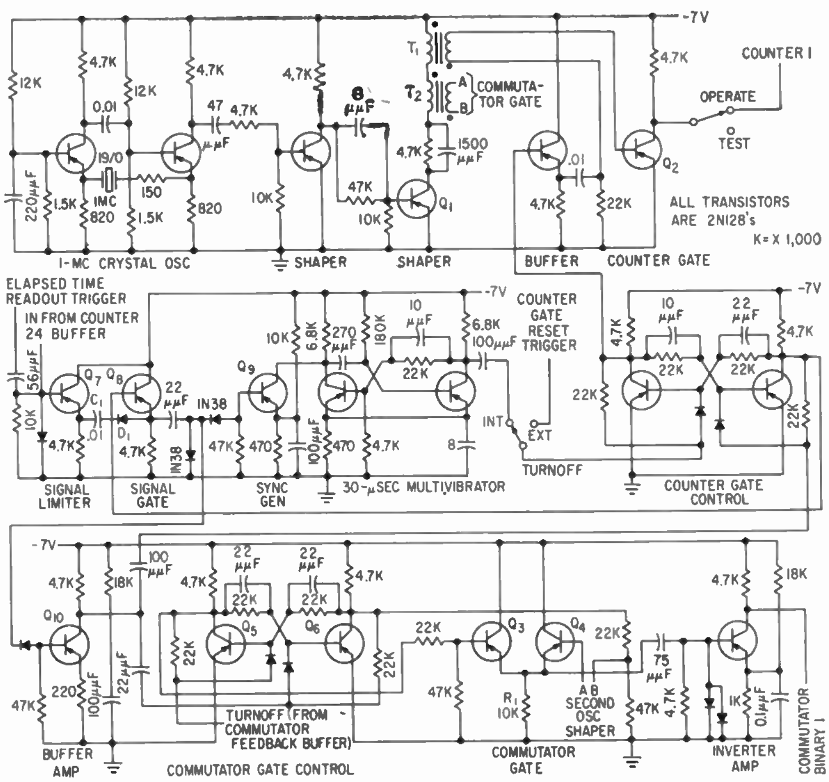

FIG. 4—Oscillator, shaping and gating circuits of encoder. Crystal in oscillator is principal frequency determining element. Gates are designed to maintain amplitude of trigger pulse at one-half the supply voltage or more within —40 to +55 C range

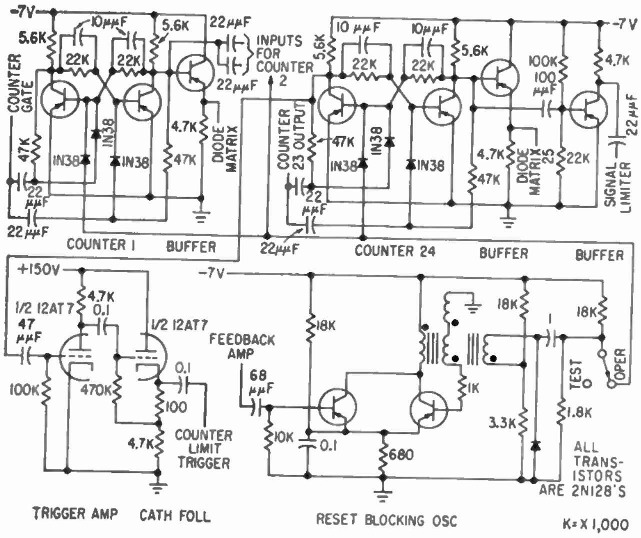

FIG. 5—Counter, limit trigger and blocking oscillator circuits of encoder. Counters 2 through 23 are identical to counter. Similar multivibrators are used in commutators and gate control circuits shown in Fig. 6

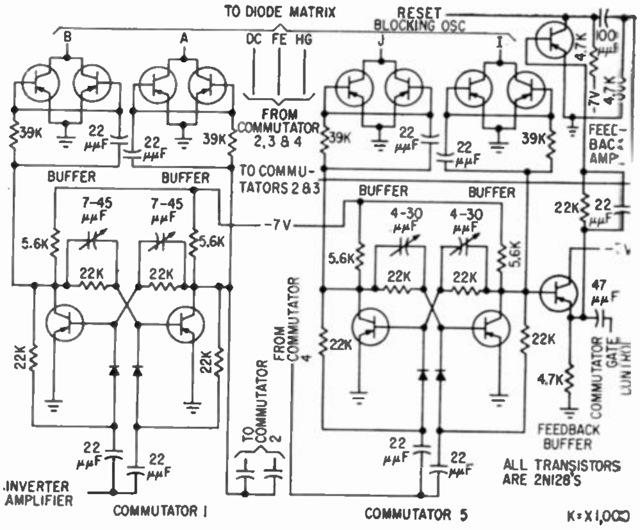

FIG. 6—Commutator, buffer and feedback circuits of encoder. Commutators 2, 3 and 4 are identical to commutator 5 except that value of variable capacitor in commutator 3 associated with output F is 7-45 $\mu\mu f$

used as the time reference. If the crystal ceases to function, oscillations will stop rather than continue at some uncontrolled frequency as might happen in a stage containing additional tuned circuits. Output of the oscillator is amplified and shaped to produce synchronizing pulses or triggers.

Gating Circuits

Gating circuits used are shown in Fig. 4. Ground reference is removed from the triggers by pulse transformers T_1 and T_2 in the collector of Q_1. The secondary windings of the transformers are applied to the inputs of the counter and commutator gates respectively.

The gating circuits are designed to minimize the effects of leakage and gain resulting from temperature variations. These circuits operate satisfactorily over a temperature range of -40 to $+55$ C.

The gate which controls the triggers to the counter blocks the triggers only during the 30 μsec readout period. This gating action makes it possible to a-c couple the control waveform from the counter gate control multivibrator thereby removing the d-c reference level. The control waveforms are then permitted to go positive with respect to ground and effectively bias off gate transistor Q_2. Thus, trigger pulses present in the base circuit are prevented from appearing at the collector circuit and triggering the counters.

The commutator gate is normally off and is turned on to pass triggers only during the readout period. If a pedestal appears at the collector of this gate when it is turned on, the leading edge of the pedestal produces a false trigger in the output.

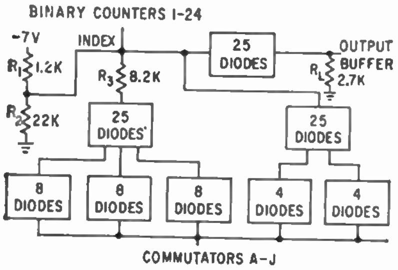

FIG. 7—Diode matrix switch of encoder. Gold-bonded germanium 122G diodes are used throughout

Push-Pull Gate

To prevent the generation of a pedestal, a push-pull gate is used which consists of two emitter followers Q_3 and Q_4 and common emitter resistor R_1. The bases are connected to opposite collectors of the commutator gate control multivibrator. Trigger pulses present in pulse transformer T_2 do not appear at the emitter of Q_4 if sufficient base current is supplied to Q_3 by the gate control multivibrator.

Base current is supplied to Q_3 when the multivibrator is triggered to place transistor Q_5 in a nonconducting state. When this occurs, the voltage developed at the emitter is sufficient to bias Q_4 to a point where the negative pulses present in the base circuit do not appear at the emitter. When the multivibrator is triggered to place Q_6 in a nonconducting state, the d-c level at the emitters of Q_3 and Q_4 does not change appreciably, but the negative triggers present at the base of Q_4 now appear at the emitter. These triggers are amplified and inverted to drive the commutator.

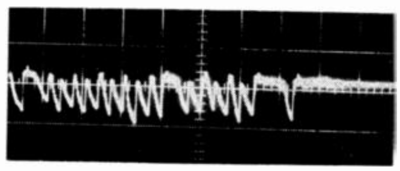

FIG. 8—Encoded elapsed time at diode matrix output

The external trigger that is supplied to the encoder to start the elapsed time readout passes through a gate before it reaches the 30 μsec multivibrator and the two gate-control multivibrators. Thus, triggers that may appear during the readout period are prevented from affecting the timing of the 30 μsec multivibrator. The gate consists of two emitter followers Q_7 and Q_8 coupled by a capacitor in series with a diode. Emitter follower Q_7 acts as a clipper and limits the external trigger pulse amplitude to approximately -7 v. When this gate is off, the base and, therefore, the emitter

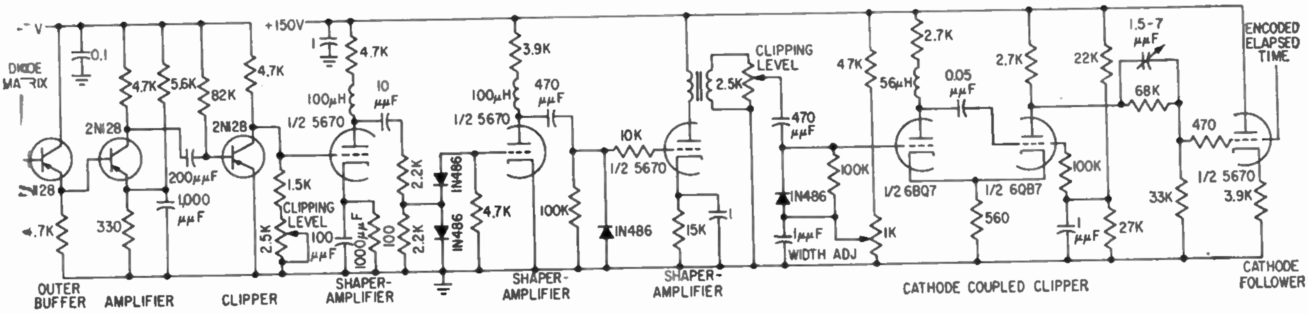

FIG. 9—Output circuits of encoder. Cathode follower stage provides low output impedance

of Q_8 are at approximately −7 v because of the state of the counter gate control multivibrator.

Back resistance of diode D_1 limits the charging of capacitor C_1. The time constant formed by the diode back resistance and the capacitance is made large in comparison with the gate off time of 30 μsec. If a trigger pulse appears during this time, the pulse amplitude appearing at the emitter of Q_7 is limited to the voltage present at the emitter of Q_8 resulting in no signal current passing through capacitor C_1. This action prevents the trigger pulse from reaching the sync injector Q_9 and the buffer amplifier Q_{10}. When the gate is on, no current is supplied to the base of Q_8, therefore, any trigger pulse appearing at the emitter of Q_7 also appears at the emitter of Q_8 with practically no attenuation.

Counters

Counter and associated circuits are shown in Fig. 5. The counters consist of 24 identical bistable multivibrator stages. Capacity of the counter is 2^{24} or 16,777,216 μsec.

In theory the operation of a stage is closely analogous to that of a vacuum-tube multivibrator. One transistor is supplied with sufficient base current to cause saturation which causes the voltage drop across the resistor in the collector circuit to become almost equal to the supply voltage.

Since the voltage at the collector is practically zero, negligible current is supplied to the base of the opposite transistor which is, therefore, in a nonconducting state. Voltage at the collector of the opposite transistor is equal to the supply voltage minus the small voltage drop resulting from the leakage current and plus any small base current supplied by the saturated transistor.

Interchange of the state of the two transistors can be done by supplying a positive trigger to the base circuit through triggering diodes. The diode that is connected to the base of the nonconducting transistor is back-biased by the voltage present at the collector. A positive trigger will therefore act only to turn off the transistor that is conducting. As the conducting transistor is turned off, its rising collector voltage acts to turn on the opposite transistor thereby permitting the use of positive going triggers to change the state of the multivibrators.

Readout Switch

The commutator shown in Fig. 6 when used with a diode matrix shown in Fig. 7 forms a single-pole, 26 position switch to obtain serial readout of the count stored in the counters. Normally, this switch is in the off position. When the commutator gate opens allowing the commutator to be triggered, a readout is obtained of an index pulse, produced by the voltage divider formed by resistors R_1 and R_2 shown in Fig. 7, followed in sequence by the state of counters 1 through 24. After readout, the switch returns to the off position.

The commutator is a five stage binary counter that employs two feedback paths to obtain a count of 25[1]. With the switch in the off position, all buffers connected to the commutator are supplied with sufficient base current to cause saturation. Shunting effect of the collector saturation resistance acts to prevent the voltage present at the switch input terminals from appearing across output resistor R_L of the diode matrix. Saturation resistance of 2N128 transistors is less than 100 ohms. When the commutator is driven by trigger pulses, the shunting effect of the buffers is sequentially removed from the 25 diode matrix inputs allowing a portion of the voltage, determined by the voltage divider action of R_3 and R_L, to appear across R_L.

Readout Waveforms

A typical digital readout waveform appearing at the output of the switch is shown in Fig. 8. A rapid decrease in voltage occurs at the output after the readout of each on counter, but the rate at which the output voltage increases because of an on counter is limited by the minority carrier storage time of the buffer transistors. Results of this minority carrier storage action are desirable because the slow on and fast off action produces a separation in the readout between adjacent on counters. In certain positions, it is necessary to supplement the minority carrier storage effect by adding integrating capacitors to further reduce the counter on transition time.

The output circuits used to obtain the desired output waveform are shown in Fig. 9.

The authors wish to acknowledge the assistance of John D'Aiuto in designing and testing the circuits and of Arthur Walter, John VanderHorn and Norman Tirpak in laying out the circuits and constructing the encoder.

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A-C Computing Resolvers

Characteristics of typical size 8, 10 and 11 resolvers that have two stator and two rotor windings are tabulated below. Next issue of ELECTRONICS will list typical size-15 resolvers and the following issue will list sizes 18, 23 and 25

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SINCE RESOLVER manufacturers do not present data in a standardized way, the tabulation below can only serve as a general guide to electrical resolvers. For example, some data is obtained by testing units that are representative of current production and other data are obtained by testing units that represent the optimum in performance.

When the tuned input impedance, Z_{it}, is not listed, it may be computed from Z_i, the input impedance measured when the secondary is open. The input current and power can then be calculated from Z_{it} and the input voltage.

The stator is the input winding unless the notes column specifies the rotor. The transformation ratio, TR, is the ratio of the output to the input voltage (rotor to stator for stator input and stator to rotor for rotor input).

When either of the two compensator winding ratios, TR_{sc} or TR_{cr}, is given, the other can be calculated from the relation $TR = TR_{sc} \times TR_{cr}$.

An x in a tabulation space indicates the column head does not apply. A blank space indicates the information was unavailable or that it can be calculated.

KEY

AE	American Electronics
CPP	Clifton Precision Products
Kear	Kearfott
Kol	Kollsman
M	Muirhead
NK	Norden Ketay
V_i	maximum input voltage
Z_i	input Z, secondary open
Z_{it}	tuned input Z
Acc	accuracy in % of function deviation or minutes of spread
Axis	interaxis error
TR	transformation ratio, output/input voltage
TR_{sc}	TR, stator/compensator voltage
TR_{cr}	TR, compensator/rotor voltage
θ	phase shift
Comp	compensator winding

Table I—Typical Commercial

Mfr, Model No.	Size	Diam (in.)	Length (in.)	Test f (cps)	V_i (v)
AE, IR8N4–600	8	0.750	1.281	400	26
AE, IR8N4–601	8	0.750	1.281	400	26
AE, IR8W4–602	8	0.750	1.281	400	26
CPP, CSC8A1	8	0.750	1.241	400	26
CPP, CSC8A4	8	0.750	1.241	400	26
Kear, R1031	8	0.750	1 9/32	400	26
Bendix, AY520–3	10	0.937	1.241	400	26
Bendix, AY520-12-A1	10	0.937	1.241	400	10
Bendix, AY520–25	10	0.937	1.241	400	26
Bendix, AY540–5	10	0.937	1.241	400	26
CPP, CSC10–AS1	10	0.937	1.281	400	26
CPP, CSC10–AS4	10	0.937	1.281	400	26
NK, 100D2C	10	0.937		400	26
NK, 100D2B5	10	0.937		400	26
Oster, 10–4061–01	10	0.937		400	11.8
Oster, 10–4065–02	10	0.937		400	11.8
AE, 1R11W4–127	11	1.062	1.97	400	26
AE, 1R11N4–147	11	1.062	1.97	40,000	26
AE, 1R11N16–148	11	1.062	2.5	1,600	150
AE, 1R11W4–150	11	1.062	1.85	400	26
AE, 1R11W4–156	11	1.062	1.86	400	60
Bendix, AY192A1	11	1.062	1.682	400	26
Bendix, AY909A1	11	1.062	1.682	400	26
CPP, CS11B2	11	1.062	1.640	400	26
CPP, CS11B5	11	1.062	1.640	400	26
CPP, TSC11E1	11	1.062	1.640	400	26
CPP, TSC11E2	11	1.062	1.640	400	26
CPP, TSC11E3	11	1.062	1.640	400	26
CPP, TSC11E4	11	1.062	1.640	400	26
CPP, TSC11E5	11	1.062	1.640	400	26
CPP, CYC11B2	11	1.062	1.640	400	26
Diehl, B11R1–1	11	1.062	2.528	400	
Diehl, B11R1–4	11	1.062	2.528	400	
Diehl, B11R1–5	11	1.062	2.528	400	
Diehl, B11R1–6	11	1.062	2.528	400	
Diehl, B11R1–8	11	1.062	2.528	400	
Kear, R230–2	11	1.062	1.739	400	26
Kear, R235–1	11	1.062	1.739	400	11.8
Kear, R235–3	11	1.062	1.739	30	26
Kear, R4–235–3	11	1.062	1 45/64	400	0.36
Kear, R980–01	11	1.062	1 49/64	400	60
Kear, R980–41	11	1.062	2.800	400	60
Kol, A25420–00410–0	11	1.062	1 45/64	400	26
M, F11M6–A/1	11	1.062		400	26
NK, 101D2A	11	1.062		400	26
NK, 101D2C	11	1.062		400	26
Oster, 11–4117–03	11	1.062		400	11.8
Reeves, R110–102F	11	1.062	1.907	400	26
Reeves, R110–102G	11	1.062	1.907	400	26
Reeves, R111–102	11	1.062	1.907	400	40
Reeves, R111–102E	11	1.062	1.907	400	26
Reeves, R111–102F	11	1.062	1.907	400	40
Reeves, R111–102G	11	1.062	1.907	400	26

Sizes 8, 10 and 11

Resolvers for Analog Computation—Sizes 8, 10 and 11

Z_i (ohms)	Z_{it} (ohms)	Acc. (% or min)	Axis error (min)	TR	TR_{sc}	TR_{cr}	θ (deg)	Null (mv)	Low f (cps)	High f (kc)	Res Stator (ohms)	Res Rotor (ohms)	Res Comp. (ohms)	Notes
1[illegible]0 + j370	1,180	0.1%	5	0.91	x	x	14	26	105	190	97	185	x	
4[illegible]7 + j1,580	5,787	0.1%	5	0.47	x	x	14	26	105	190	390	185	x	
[illegible]20 + j370	840	0.1%	5	0.87			26	26	210	190	195	185	195	Compensated
2[illegible]0 + j630		14′		0.415	x	x	20	30			27	230	x	Rotor input
2[illegible]0 + j630		14′		1	x	x	20	30			170	230	x	Rotor input
[illegible]20 ∠69°		5′		1.00	x	x	18	60			145	140	x	Rotor input
[illegible]08 + j570		18′		0.455	x	x	18.5				42	200	x	Rotor input
[illegible]00 + j660		5′		1.22	x	x	19				400	240	x	Rotor input
[illegible]58 + j620		18′		0.455	x	x	17				41	200	x	Rotor input
[illegible]30 + j2,260		18′		0.455	x	x	12				170	530	x	Rotor input
[illegible]70 + j670		15′		0.435	x	x	5	26			28	215	x	Rotor input
[illegible]70 + j670		15′		0.985	x	x	8.5	26			166	215	x	Rotor input
[illegible],380 ∠67.7°		30′	5		x	x		200					x	
[illegible]60 ∠62°		30′			x	x		50					x	
[illegible]52 + j843		24′		1	x	x	14.6	50			44	240	x	Rotor input
[illegible]53 + j2,740		24′		1	x	x	6.8	30			165	450	x	Rotor input
[illegible]85 + j1,960	10,000	0.1%	5	0.975			8.5	26	70	50	305	350		Compensated
		0.1%	5	0.98	x	x		26	75	250	20	36	x	
[illegible]00 + j1,870	9,140	0.1%	10	0.488	x	x	1		175	300	47	26	x	Null 700 mv at 115 v
210 + j850	10,000	0.1%	5	0.98	x	x	10	26	60	100	165	100	x	
420 + j2,340		0.1%	5	0.975			8				340	350		Null 3,000 mv at 125 C; Comp.
95 + j420		12′		0.455	x	x	5				18	45	x	Rotor input
315 + j1,500		20′		0.800	x	x	6.6				160	170	x	Rotor input
128 + j503		12′		0.485	x	x	8.5	26			13.6	80	x	Rotor input
610 + j1,690		12′		0.85	x	x	13	30			140	400	x	Rotor input
128 + j503		14′		0.485	x	x	8.5	26			13.6	80	x	Rotor input
140 + j600		14′		0.485	x	x	7.5	26			13.6	80	x	Rotor input
450 + j1,960		14′		0.85	x	x	7	26			140	240	x	Rotor input
460 + j1,850		14′		0.50	x	x	7.4	26			80	240	x	Rotor input
460 + j1,210		14′		0.85	x	x	15	26			160	360	x	Rotor input
370 + j1,400		12′		1.08			9	30			225	415		Compensated
750 ∠77°	3,000	0.03%	4	0.975	x	x	6	1.5/v	45	100	70	70	x	
800 ∠75°	2,800	0.03%	4	0.965	0.975		9	1.5/v	70	100	107	70	220	Compensated
3,000 ∠77°	12,000	0.03%	4	0.985	x	x	6.5	1.5/v	40	50	275	300	x	
1,500 ∠70°	4,100	0.03%	4	0.950	0.950		13.5	1.5/v	90	80	300	122	300	Compensated
2,200 ∠72°	6,500	0.03%	4	0.970	0.960		11	1.5/v	70	55	385	240	385	Compensated
292 ∠79°		20′		0.123	x	x	5.1	10			1.13	28.5	x	Rotor input
131 ∠79°		20′		1.83	x	x	7	60			15.5	65	x	
183 ∠28°		20′		0.5	x	x	90	5			150	400	x	
1,320 ∠78°		20′		0.86	x	x	7	70			150	385	x	
629 + j2,510		7′		0.98	0.985		8.5	25						Compensated
450 + j2,200		5′		0.98	0.985		7.5	25						Compensated
240 ∠78°		20′		0.095	x	x	7	10			1.14	34	x	
		0.2%		1	x	x							x	
1,510 ∠71°		10′	15		x	x		60					x	
440 ∠76°		10′	15		x	x		60					x	
127 + j550		10′		1.06	x	x	6.3	30			16	75	x	Rotor input
410 + j2,770	19,000	0.1%	5	0.980	x	x					260	430	x	
130 + j750	4,300	0.1%	5	0.980	x	x					75	120	x	
400 + j2,100	10,000	0.1%	5	0.980	0.985						250	300		Compensated
760 + j3,830	19,000	0.1%	5	0.980	0.985						500	460		Compensated
525 + j2,770	12,000	0.1%	5	0.980	0.985						350	430		Compensated
150 + j760	4,000	0.1%	5	0.980	0.985						93	120		Compensated

High-Speed Switching

Beam-switching tube pulses bridges sequentially. Each bridge has a pressure-sensitive capacitance transducer which unbalances the bridge in proportion to changes in pressure. Output pulses of the bridges are displayed pulse pattern corresponds to the pattern of pressure imposed on an auto seat

By **ARIEL STIEBEL,** Electronic Engineer, Rockwell-Standard Corporation, Birmingham, Michigan

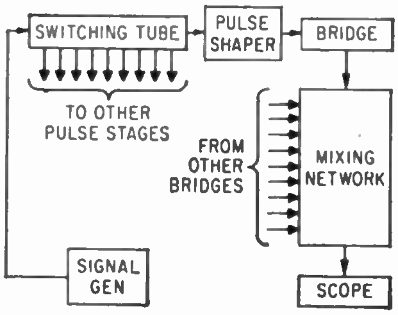


FIG. 1—Capacitance transducers in the bridges pick up pressure data

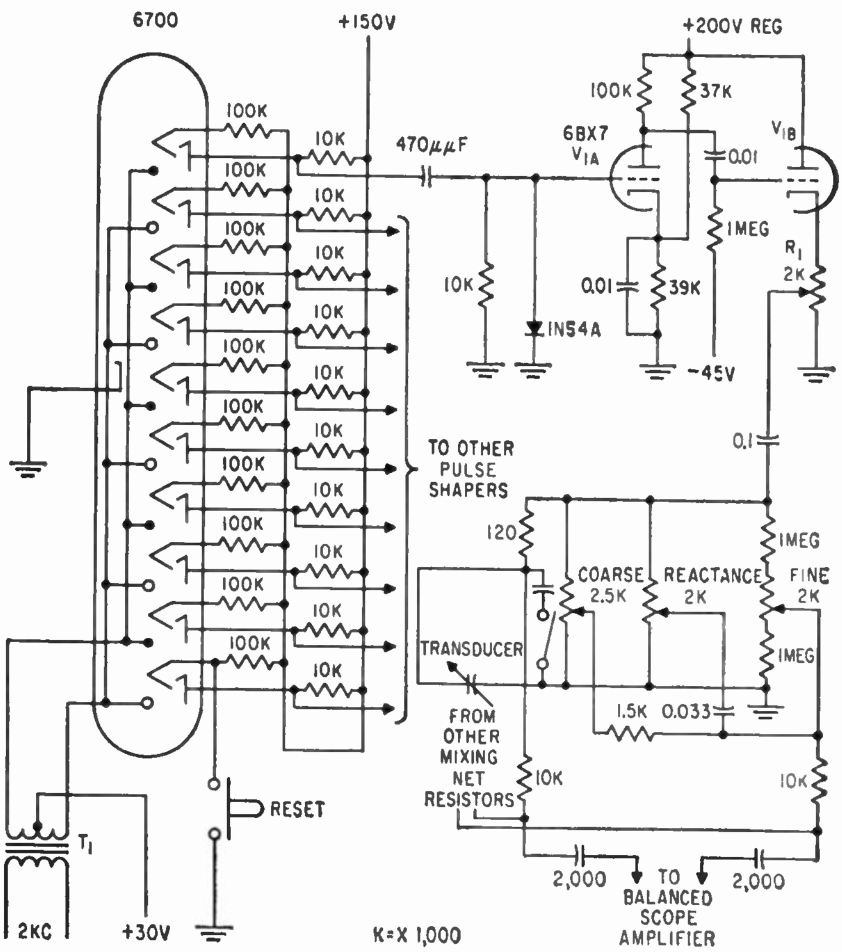


FIG. 2—A pulse from the 10th plate of the beam-switching tube drives the pulse shaper that is shown. The output of the bridge that is pulsed by V_B is applied to the scope

HIGH-SPEED switching is employed in an instrument that measures and records data on the application of pressure to an automobile seat. The information obtained is valuable in the study of present, as well as future seating designs.

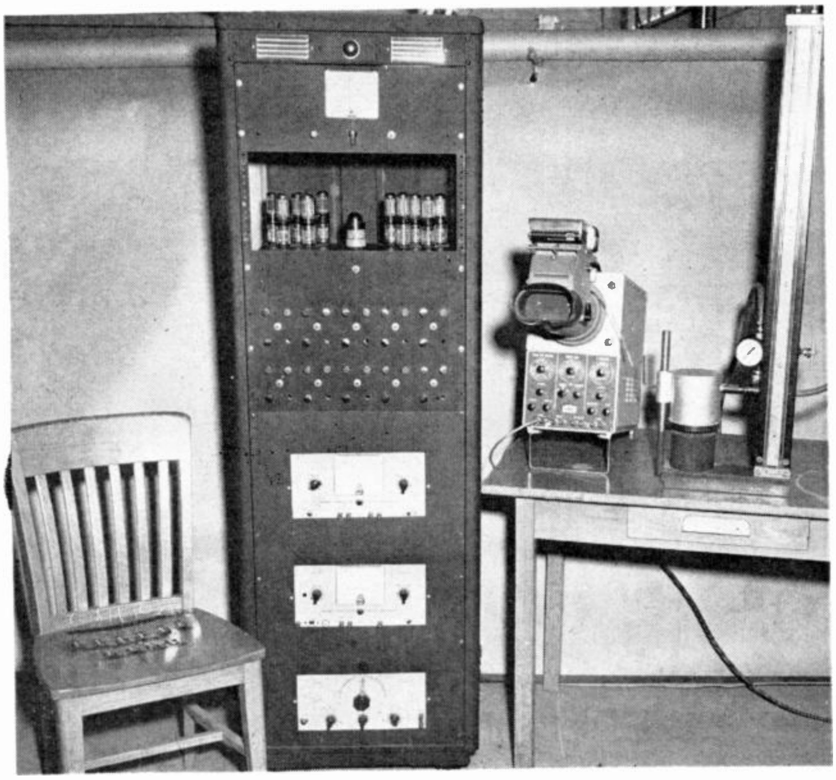
Capacitance transducers ascertain the pressure at ten locations on a seat, and produce low level signals in bridges. A beam-switching tube pulses the bridges sequentially, and the bridge outputs appear on a cathode-ray oscilloscope (cro). Switching occurs at a high speed, and the noise introduced by the beam tube is negligible compared to mechanical or diode switching devices.

The instrument uses ten capacitance transducer cells, but can be easily enlarged to switch hundreds of cells. Switching speed is 4 kc, but speeds up to 1 mc are possible. Each capacitance cell is one sq cm in area and 0.030- to 0.040-in. thick. These dimensions provide a relatively high geometric resolution, so that accurate pressure contours can be drawn, especially in the neighborhood of bony prominences. The cells have a useful pressure-sensitivity range from 0 to 10 psi. A high degree of sensitivity is obtained by using the cells in bridge circuits.

Overall Operation

The beam-switching tube, Fig. 1, operates at a frequency which is determined by the signal generator. The resulting pulses from the beam-switching tube are applied to ten

# of Low Level Signals



Set up for pressure testing. The pressure cells are mounted on the chair. The calibration device is at the extreme right

pulse shapers. Each shaper excites one bridge.

Since switching occurs at a high level and the low level outputs of the bridges are not affected by switching, inherent disadvantages of low level scanners, such as noise, etc., are eliminated. Only one amplifier is needed for any number of bridges and the operation is reliable and accurate.

The bridge output is applied through a mixing network to a high-gain differential amplifier and finally appears on the scope as a pulse whose height depends on the pressure detected by the capacitance transducer.

Pulse Switching and Shaping

The beam of the beam-switching tube (bst), Fig. 2, is rotated at a rate of 4,000 cps when a 2-kc sine-wave input is applied to transformer T_1.

Each of the plate tragets of the bst produces a square wave across its load resistor, which drives a pulse shaper. After differentiating the square wave, the positive peak is clipped and the negative pulse applied to V_{1A}. This pulse drives the normally conducting V_{1A} into cut-off. Thus all output pulses of V_{1A} and of the corresponding tubes of the other bridge circuits are reduced to the same height. The positive output pulse of V_{1A} is coupled to V_{1B} which is operated at cutoff. The output pulse of V_{1B} is taken from potentiometer R_1 to provide the right impedance matching for the bridge. The setting of R_1 determines the sensitivity.

Balancing

The bridge circuit has course and fine balancing potentiometers and a potentiometer which balances out reactive components.

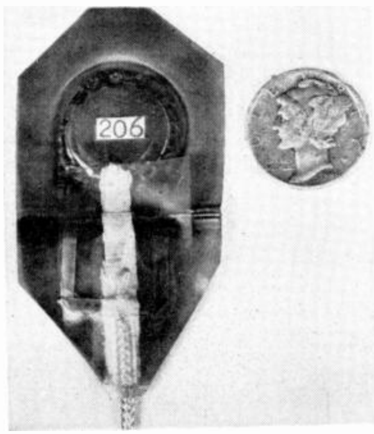
Since all the bridge outputs are fed into one common amplifier, isolation resistors are used to eliminate interaction between the various bridges.

A special device calibrates each capacitance cell. This device consists of a cylinder capped at one end by a rubber diaphragm. The capacitance cell is inserted beneath the diaphragm and loaded with a known pressure. Calibration produces a curve of pressure in terms of the corresponding pulse amplitude out of the capacitance cell.

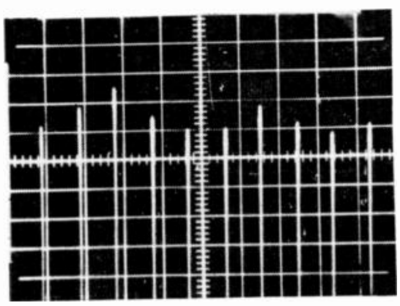
Operating Procedure

A typical operation consists of balancing the various cells to a common zero line, submitting the cells to the load under investigation, and taking a photograph of the changes in amplitude of the pulses at any instant.

The author appreciates the assistance of M. G. Rigby and E. A. Herider, chief engineer, in developing the instrument.



Pressure-detecting capacitance cell



Typical pattern of pressure exerted by person on a seat

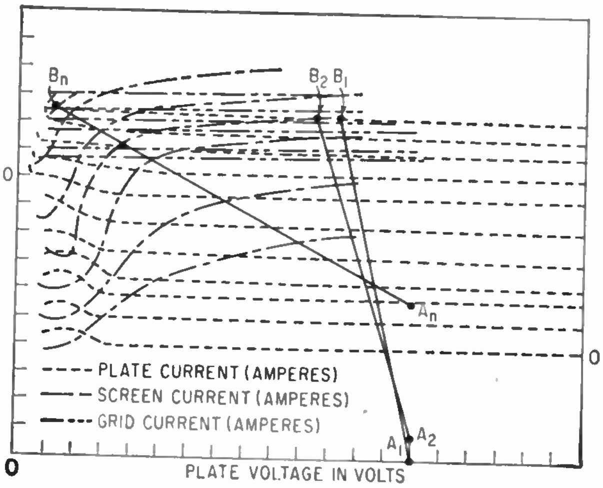


FIG. 1—Operating lines of tubes 1, 2 and n drawn on constant-current characteristics

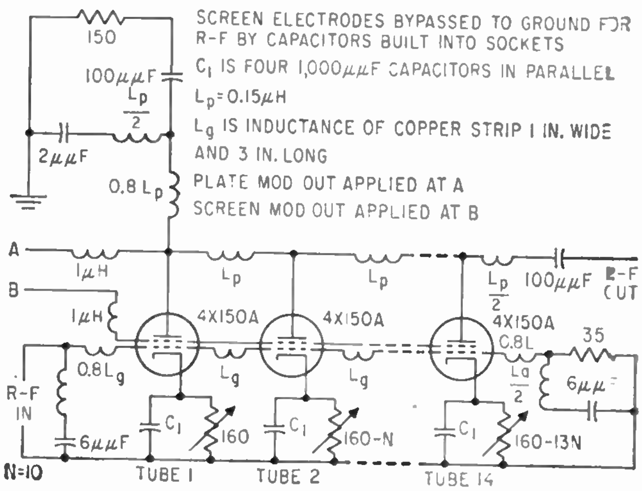


FIG. 2—Schematic diagram of distributed power amplifier designed to operate around 200 mc

How to Design Pulsed

DISTRIBUTED-AMPLIFICATION principles are well known. Considerable progress has been made in recent years in establishing design criteria for voltage amplifiers employing this principle.

The basic distributed-amplifier circuit with low-pass, constant-K filter sections is shown in the accompanying box. This type of filter exhibits a fairly linear relationship between phase shift and frequency within the lower 80 percent of its passband. Variation of its mid-shunt impedance with frequency is not rapid in this region. For these reasons, a cutoff frequency is chosen such that its desired operating frequency will fall within the lower 80 percent of the filter passband. If the operating range is held between 0.5 and 0.8 f_c, the possibility of second-harmonic transmission is eliminated also.

Elementary design equations are given in a box. Also included is a glossary of terms to be used throughout this article.

Design Procedure

To obtain maximum efficiency and output power of a distributed amplifier, it is necessary to use a sufficient number of tubes to generate an r-f current wave traveling in the forward direction with a peak value of E_{pm}/Z_p. The following procedure is used to determine the number of tubes required.

A reasonable bias voltage for class-C operation is selected for tube 1. This voltage, together with the pulse voltages applied to the plate and screen electrodes, determines point A_1 in Fig. 1. In practice, it will be found advisable to have a degree of variability in the bias voltages of all tubes so that they can be adjusted empirically for optimum operation.

Having chosen a value of bias voltage and determined E_{g1}, the required driving power is calculated from Eq. 5. Disregarding any effect contributed by backward-flowing currents from other tubes in the amplifier, tube 1 sees an impedance Z_p in either direction along the plate transmission line or a total plate load of $Z_p/2$.

Point B_1 in Fig. 1 is determined by calculating the voltage drop across this load impedance when i_{pm} is flowing through it. An operating line for tube 1 is drawn between A_1 and B_1. Using a graphical method of harmonic analysis, the fundamental and d-c components of current are determined.

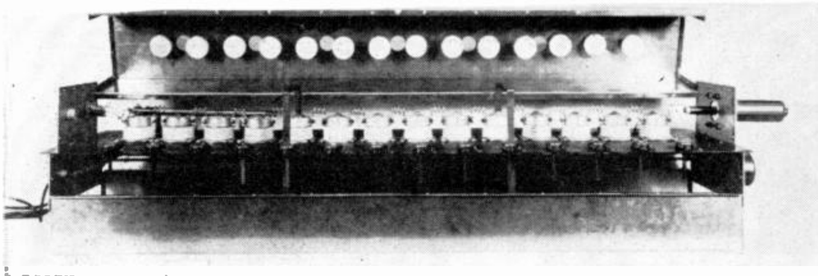
Dissapation

Power dissipation by the tube elements is calculated in the usual manner. If a low duty cycle is used, over-dissipation will probably be of no concern. However, the initial tubes in a distributed amplifier operate inefficiently and care must be exercised to avoid damaging them.

The grid signal is attenuated as it passes the first tube. Power loss is given by Eq. 6. Driving power arriving at tube 2 is given by Eq. 7 and peak driving voltage at the grid of tubes 2 and 3 by Eq. 8.

Using the value of peak voltage at the grid of tube 2 calculated by Eq. 8, the bias voltage of tube 2 is set at a value which will just allow the tube to be driven to its maximum emission current. The bias on tube 2 is reduced from that of tube 1 by the amount $E_{g1} - E_{g2}$. Thus point A_2 (Fig. 1) is established.

Half the fundamental r-f current wave generated by the first tube will travel toward the output end of the amplifier. It will arrive at the plate of tube 2 in such a phase as to produce a voltage drop which adds to the voltage drop at the plate



Amplifier with shields raised. Grid compartment is pressurized by high-volume blower

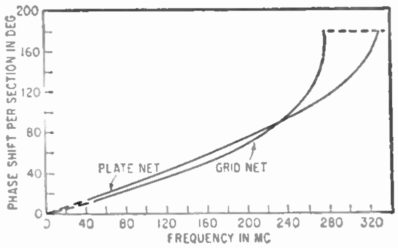


FIG. 3—Phase shift versus frequency for grid and plate networks

Applications for these amplifiers include output stage of moderate-power radars, final drive of high-power radars or high-level amplification of pulses

By S. K. MEADS, U. S. Naval Research Laboratory, Washington, D. C.

Distributed Amplifiers

of this tube created by the current flowing through it. The total peak voltage drop across the transmission line is given by Eq. 9.

Point B_2 (Fig. 1) is now established by subtracting V_{L2} from the applied plate voltage. This process is continued, the forward-traveling current wave contributed by each tube being added to the forward-traveling wave, until a sufficient number of tubes has been added so that the nth tube has an operating line terminated at point B_n in Fig. 1. Plate voltage on the nth tube varies through the maximum possible range. The negative peak reaches the diode line of the tube. Any additional tubes would not make a significant contribution to the r-f current wave. Their addition would serve merely to decrease the efficiency of the amplifier.

Backward Currents

The current waves which flow in the backward direction along the plate line have thus far been ignored. These do not add in phase except at zero frequency and at the cutoff frequency where the filters produce a phase shift of 0 and π radians per section, respectively.

That part of the backward power which is not dissipated at the various tube plates is dissipated in the reverse termination. The backward-traveling voltage wave may have the effect of displacing the individual points, Fig. 1, to the right or left. Since the tubes used will probably be tetrodes, this slight displacement will have little effect on plate current generated.

Experimental Amplifier

The 4X150A tetrode was chosen for use in an amplifier designed to operate in the region of 200 mc. Input and output capacitances of the tube, when used with air system socket and chimney, were found by measurement to be 19 $\mu\mu$f and 6.5 $\mu\mu$f, respectively. A cutoff frequency of 311 mc was chosen. Operation up to about 250 mc should be permitted.

From Eq. 1, 2 and 3, Z_g and Z_p at 200 mc are computed to be 70.3 and 205 ohms, respectively.

Maximum pulse voltage which can be applied to the plate of the 4X150A is 7,000 v. Pulsed characteristics for the 4X150A were obtained by extrapolating the published c-w curves using the Child-Langmuir Law. The c-w voltages were multiplied by five and the c-w currents by $5^{3/2}$. This method of extrapolation is valid as long as the currents plotted do not exceed the emission capability of the tube. From these characteristics, a value of about 6,500 v for E_{pm} is obtained. From Eq. 4, the maximum output pulse power to be expected is found to be 105,000 w.

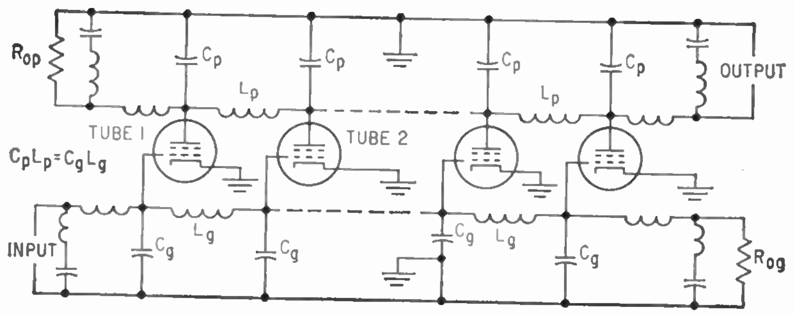
Within a 20-percent bandwidth centered at 200 mc, Z_p will not change from its center-frequency value by more than nine percent. This variation will lead to a variation in maximum power output of less than 0.5 db.

Final Approach

Using the design procedure described previously, it was determined that 13 tubes would be required to generate a voltage wave with peak value of 6,500 v on the plate line at 200 mc. These tubes would provide the maximum output power of 105,000 w at this frequency. One extra tube was added, both to compensate losses in the plate line and to supply the additional current required to generate the 6,500-v wave at the lower frequencies of the band where Z_p has a lower value.

From the pulse characteristics

WHAT IS DISTRIBUTED AMPLIFICATION?



Distributed amplification is a method whereby transconductances of a number of tubes are added without adding the detrimental effects of their input and output capacitances. Tube capacitances are used as shunt elements in two artificial transmission lines of ladder-type configuration. The input line connects the grids; the output line, the plates. A large number of tubes can be made to operate effectively in parallel over a wide frequency band.

Bandwidth obtainable is independent of number of tubes used. Input transmission line is designed to have same phase characteristic as output line so that current contributions from each tube add in phase at the output

BASIC DESIGN EQUATIONS

$$R_{op} = 1/\pi f_c C_p \quad R_{og} = 1/\pi f_c C_g \qquad (1)$$
$$Z_p = R_{op}/(1 - f^2/f_c^2)^{1/2} \qquad (2)$$
$$Z_g = R_{og}/(1 - f^2/f_c^2)^{1/2} \qquad (3)$$
$$P_m = E_{pm}^2/2Z_p \qquad (4)$$
$$P_d = E_{g1}^2/2Z_g \qquad (5)$$
$$P_{L1} = I_{c1}E_{g1} \qquad (6)$$
$$P_{d2} = P_{d1} - P_{L1} = E_{g1}^2/2Z_g - I_{c1}E_{g1} \qquad (7)$$
$$E_{g2} = E_{g1}(1 - 2I_{c1}Z_g/E_{g1})^{1/2} \qquad (8)$$
$$E_{g3} = E_{g2}(1 - 2I_{c2}Z_g/E_{g2})^{1/2}$$
$$V_{L2} = i_{pm}Z_p/2 + Z_pI_{p1}/2 \qquad (9)$$

GLOSSARY OF SYMBOLS

C_g—grid-to-ground C of tube
C_p—plate-to-ground C of tube
E_{g1}—peak grid volts needed for tube 1 to draw max emission plate current
E_{g2}—peak driving volts, grid tube 2
E_{pm}—max r-f voltage swing attainable on tube plates; derived from characteristic curves of tube
f—amplifier operating frequency
f_c—cutoff frequency
I_b—average plate current
I_c—average grid current
I_p—peak fundamental plate current
i_{pm}—max emission plate current
L_g—inductance/section, grid filters
L_p—inductance/section, plate filters
P_d—required driving power
P_{d2}—power arriving at tube 2
P_{L1}—power loss, grid circuit tube 1
P_m—max power output of amplifier
R_{og}—zero-frequency surge impedance, grid filters
R_{op}—zero-frequency surge impedance, plate filters
V_{L2}—total peak voltage drop across transmission line at tube 2
Z_g—mid-shunt impedance, grid-line filters
Z_p—mid-shunt impedance, plate-line filters

for the tube type, a value for E_{g1} of 605 v was obtained. Equation 5 then gives the required driving power of 2,590 w. Power gain at this frequency (P_m/P_d) is 105,000/2590 or 40.5 or about 16 db. Power gain tends to decrease with frequency owing to the decreasing characteristic of Z_g (Eq. 3). But the increased output power obtainable at the lower frequencies might partially compensate this effect.

Physical Structure

Figure 2 is a schematic diagram of the amplifier which was built. The 4X150A air-system sockets were set in a copper sheet which served as a shield between the grid and plate filters.

Bias voltage is developed in each tube as cathode self-bias. Each of the four cathode leads in the air socket is bypassed to ground for r-f with a 1,000-$\mu\mu$f capacitor. Cathode pulse current flows through a resistor in parallel with these capacitors, developing the required bias.

Capacitive disks were suspended above each of the tube plate connections. They were used to trim the plate-line filter so as to compensate for any phase variation between the various sections of the grid filter and the corresponding plate-filter sections. This trimming is accomplished by adjusting each capacitor for maximum power output from the amplifier.

These capacitors can be used also to slightly shift the crossover point of the grid-line and plate-line functions of phase shift against frequency. At this crossover point, the two lines have identical phase characteristics.

Figure 3 is a plot of the phase shift against frequency functions of the grid and plate lines measured with the metal compartment shields removed. When the shields were replaced, the crossover point C appeared to shift downward to about 200 mc.

Performance

To drive the amplifier over a 53-mc frequency band from 166 to 219 mc, a 4X150A tube was used in a coaxial tank oscillator circuit. The driver would not operate below 166 mc.

Performance of the amplifier at 219 mc had deteriorated sufficiently to limit interest in higher frequency operation.

Plates of the amplifier tubes were driven with a pulse which was five μsec long with a nominal amplitude of 7,000 v. Screens were pulsed to 1,250 v. Pulse repetition rate of 200 pps was used giving a duty cycle of 0.001 for the amplifier plate circuit.

Performance deteriorates from the maximum level which occurs at crossover point C (Fig. 3) with either an increase or decrease in frequency due to divergence of the grid-line and plate-line phase functions. The more rapid divergence of the phase functions at the higher frequencies is reflected in a rapid deterioration of performance.

Bias voltage on each successive tube in the amplifier is decreased to compensate attenuation of the drive signal. When this bias is adjusted for optimum operation of the amplifier, the values vary from approximately 600 v on tube 1 to 120 v on tube 14. Mode of operation in the tube array thus ranges from class C, with a fairly narrow angle of current flow, in the initial tubes to class AB_2 in the later tubes.

Deflection Yoke Cores

Table lists characteristics of four materials used in deflection yokes for high-precision displays and military applications

By W. W. H. CLARKE and T. A. RILEY, Cossor (Canada) Ltd., Halifax, Nova Scotia, Canada

DEFLECTION YOKES for high-precision displays and military applications differ from most other electronic components in that they are not mass-produced. This is consistent with the requirement which is almost always different for each application, while no application requires quantities suitable for mass production.

Until recently, designers of precise display systems have had to complicate their deflection yoke drive circuits to compensate yoke imperfections. Use of new materials and design techniques has resulted in performance improvement to almost an order of magnitude. (See p 74 next week)

WIDE-ANGLE TUBES—While best performance is not to be expected with wide-angle tubes, yoke design methods which have achieved 0.1 percent accuracy for 15-degree tubes are capable of providing improvements for wider angles too.

Precision yokes generally conform to the motor stator concept and generally use a slotted core inside which the current-carrying coils are placed. Four types of cores offer distinctive performance characteristics, summarized in Table I.

Mu-metal cores are formed of thin magnetic laminations spaced by similar laminations of fiberglass laminate. Ferrite cores use three or more standard parts with slots spaced by accurately made washers. Coscanite cores are formed entirely of the magnetic material and require no supporting parts. Nonmagnetic cores are toothed formers taking advantage of external wire placement. They are designed to facilitate encapsulation and are generally made of Phenolite.

CONSTRUCTION ERRORS—For practical yokes there are errors of construction to be taken into account; they are included in Table I. There are two values given in the table: the figure obtainable with negligible reject rate and normal quality content, and that achievable for special applications demanding best available geometry and some 40 percent rework at an interim stage of manufacture.

Additional error in nonrepetitive scan applications arises from magnetic remanence or memory of the core material. Reduction of this in materials acceptable for yoke cores is of prime importance to yoke designers. It may be seen that Coscanite which was developed from the point of view of low memory initially, offers exceptional geometry and good sensitivity. Memory is not generally important in applications with repetitive scans, although for ppi displays it can cause the well-known phenomenon known as hole-in-the-center.

Table I—Core Characteristics of Precision Deflection Yokes

Core Material	Sensitivity, for given inductance, in degrees/ma	Sensitivity, for given settling time,[1] in degrees/ma	Geometric Accuracy[2] in percent		Orthogonality[3] in degrees		Memory in percent	Advantages
			25-deg tubes	15-deg tubes	Case 1	Case 2		
Nonmagnetic	0.6	0.76	0.5	0.2	0.25	0.1	nil	For multiple yokes and where sensitivity must be sacrificed
Mu-metal	1.08	1.08	0.2	0.1	0.25	0.1	0.4 max	Good for geometrical adaptability and sensitivity
Ferrite	1	1	0.5	0.2	0.5	0.25	0.5 max	Used for high speed and economy
Coscanite	0.92	0.97	0.5	0.2	0.25	0.1	<0.1	Low memory and good response

[1] Settling time is calculated including a driver circuit capacity of 30 $\mu\mu$f for standard yoke types where heavy silicone enamelled wire is used
[2] Geometrical accuracy is quoted as a percentage of screen dia for flat screens
[3] Case 1 is normal standard; case 2 involves a high rework percentage

Digital Recorder Holds

Recorder memorizes instantaneous magnitude of parameters when triggered by a predetermined set of conditions. Data are stored in ferrite cores that can retain the data even after a 6,000-g shock. Subsequent interrogation of the cores releases the stored information for processing

By **CHARLES P. HEDGES,** Santa Barbara Division, Curtiss-Wright Corporation, Santa Barbara, California

MAGNITUDE of any measurable parameter can be recorded quickly and stored indefinitely by a member of a family of recorders termed didmop. This terminology refers to the ability of this type of recorder to record *d*iscontinuously the *i*nstantaneous *d*igital *m*agnitude *o*f *p*arameters.

Magnitudes of parameters are presented in digital form and recorded on command, rather than continuously. When a parameter varies continuously, an analog-to-digital converter is used to supply digital information to the recorder.

Didmop recorders use the coincident current principle to store information in ferrite cores. The magnetic state of a core may be changed by passing half-write current pulses through it in the same direction and time. The information thus stored can be released by pulsing the core to its former magnetic state and reading the resulting pulse delivered by the sense

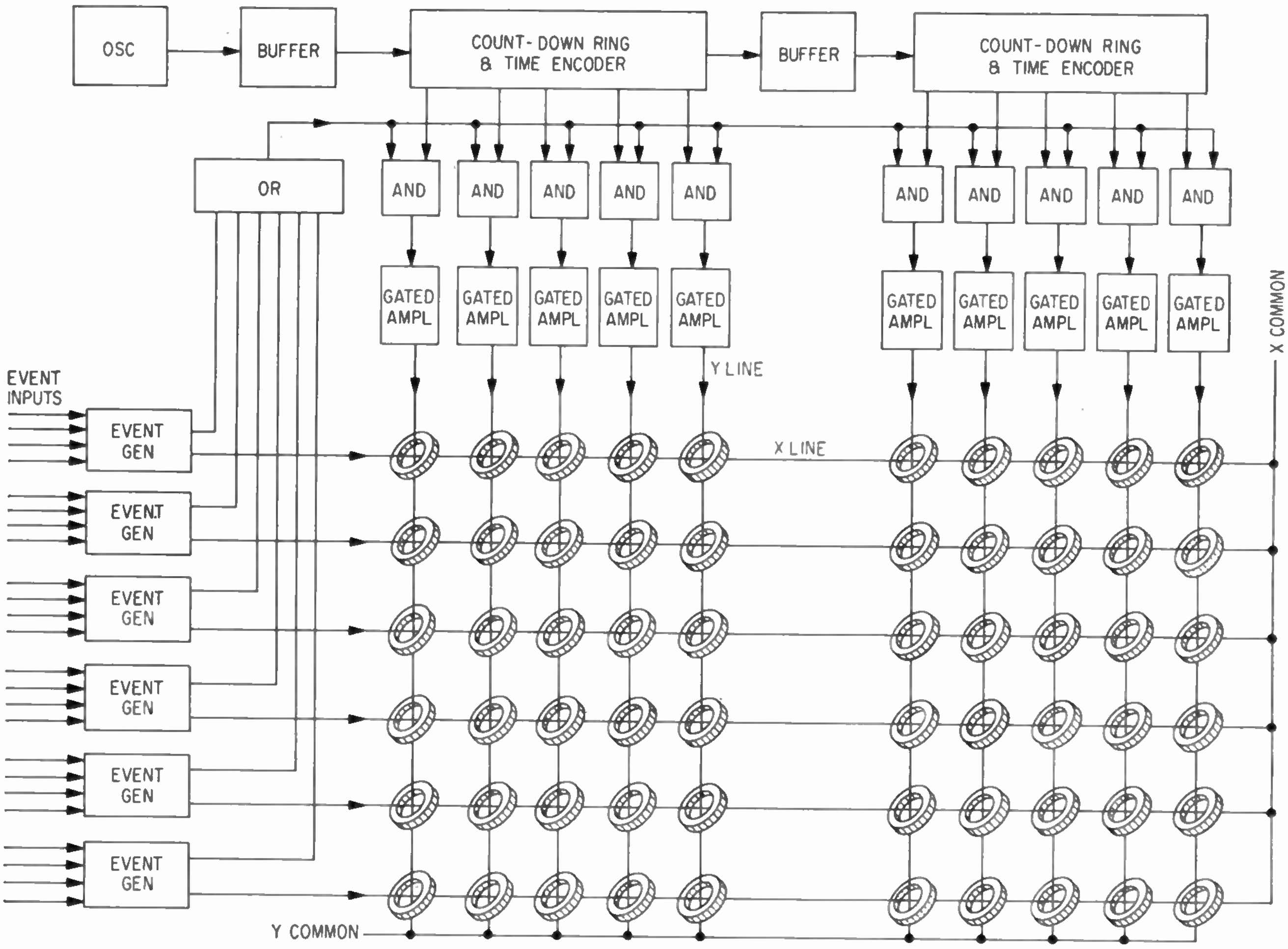


FIG. 1—Time of events recorder. The core windings in each X and Y line of cores are in series. Sense windings are not shown

Data After Shock

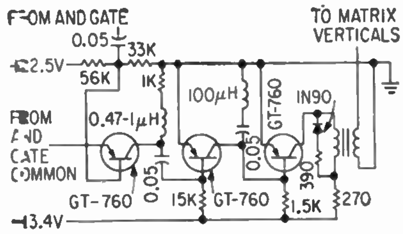


FIG. 2—When pulsed, a gated amplifier drives six toroids

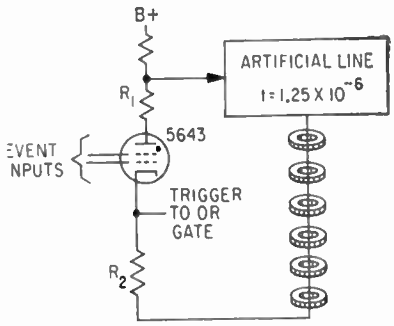
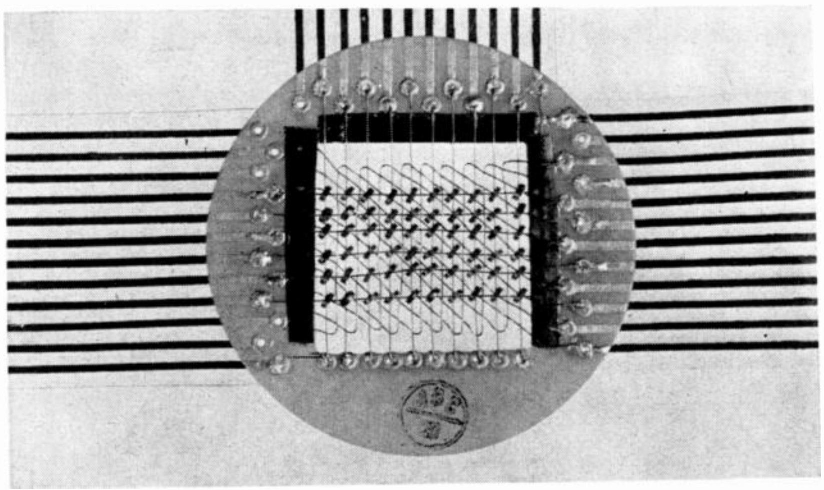


FIG. 3—Only two event inputs to the event generator are indicated. The impedance of the artificial line equals $R_1 + R_2 + e_p/i_p$

winding that threads the core.

The time-of-event recorder, shown in Fig. 1, is a member of the did-mop family. Before recording, the core matrix is erased by passing a current pulse through the cores which has an opposite polarity to the polarity of the write current. The erase current brings the cores to the ZERO state. To record a digit, a core is pulsed to its ONE state.



The Y inputs of the matrix are at the left, X on top and sense inputs are at right

The oscillator drives a count-down ring and time encoder. Each output of the encoder supplies one input to an AND gate. The gate opens if a pulse is applied at the same time to its other input.

When all event inputs to an event generator are present, the event generator pulses an X line of tor-

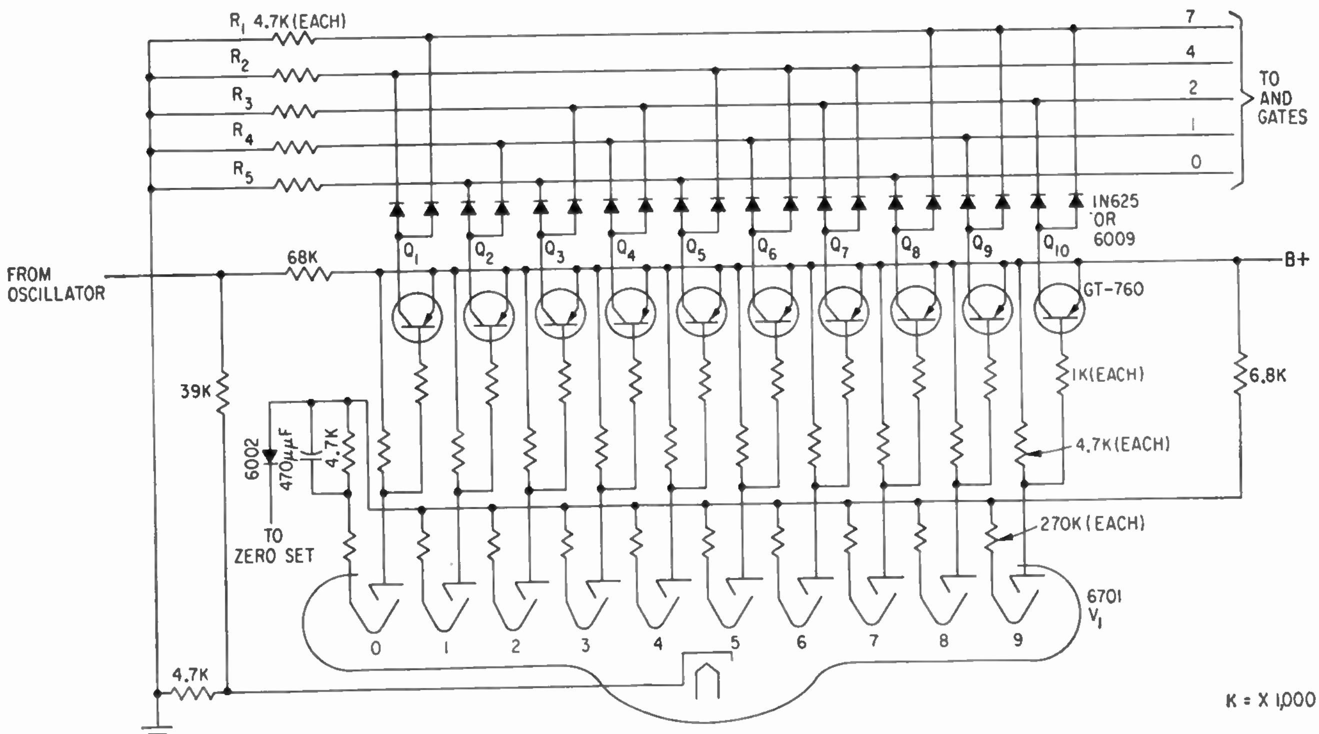


FIG. 4—Each transistor encodes a decimal digit into two binary digits. Voltages at the output terminals represent terminal numbers. The switching grids of V_1 are not shown

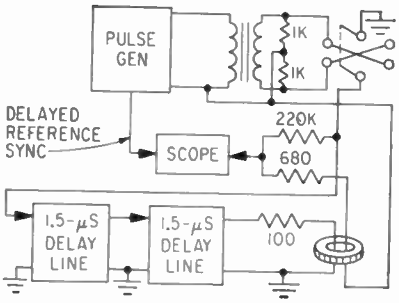


FIG. 5—Read-out circuit. The generator pulses a core with a full-select current. If the core is in the one state, its sense winding pulses the scope

oids, and generates a trigger pulse. The trigger pulse passes through the OR gate to the common input of the AND gates, opening the AND gates that simultaneously receive time encoder pulses.

The AND gate pulses a gated amplifier, Fig. 2, which drives a line of Y toroids. The cores that receive both X and Y half-select currents go to the ONE state. These cores now hold a word that indicates the time corresponding to a specific set of conditions established by the event inputs.

Event Generator

Each event generator, Fig. 3, is a miniaturized version of an artificial-line type of radar modulator.

The event inputs to the generator establish the operating conditions which generate half-current and trigger pulses. These conditions include a suitable cathode temperature, plate supply voltage, screen-grid bias, and an adequate control-grid voltage.

The impedance of the artificial line, resistance of R_1 and R_2, and the supply voltage determine the magnitude of the half-current pulse. The duration of this pulse is 2.5 μsec, twice as long as the minimum core switching time.

Count-Down and Encoding

The oscillator continuously drives tube V_1, a beam-switching decade counter (Fig. 4). Transistors Q_1 to Q_{10} conduct in succession, switching currents through combinations of resistors R_1 to R_5. The voltages at terminals 0, 1, 2, 4 and 7 thus represent one decimal digit.

If the AND gates that receive time voltages from the time encoder are also pulsed by an event generator, they open and pulse their gated amplifiers. The cores that receive half-currents from both the gated amplifiers and an event generator change state and now store the time of an event.

Oscilloscope equipment is used to obtain photographic records of the data. The read-out circuit, Fig. 5, consists of a low impedance pulse generator, an artificial delay line, a core sensing lead and an oscilloscope. The pulse generator triggers the oscilloscope and interrogates a core with a select pulse. An oscilloscope sweep first shows the amplitude and polarity of the core drive signal and then the presence or absence of core response.

Conventional ferrite memory matrices use one sensing wire which threads all of the cores in a plane. Thus the minor changes of core flux produced by half-select currents contribute noise to the sense winding. The time-of-event recorder matrix uses as many sense windings as time digits. Thus the noise produced by other cores in a row that is pulsed does not add noise to the core-turnover-signal sought.

Application

Figure 6 shows a design of a didmop recorder. With auxiliary circuits, this recorder could be used to obtain a record of an airplane's operation during a midair collision. Flight data such as throttle settings, manifold pressure, engine rpm, flap and landing gear positions, aircraft elevation, etc., would be monitored continuously. When various collision phenomena are sensed such as the closing of an impact switch or the opening of a conductor along the skin, logical gating and selecting circuits would then trigger a recording. With careful packaging, the information stored in the cores can and has been recovered after a 6,000-g shock.

The author acknowledges the contributions of P. M. Cruse, V. Alvarez, W. Johnson, K. Wasserman, and R. L. Williams and the cooperation of P. Escher, A. P. Bridges and D. L. Baker.

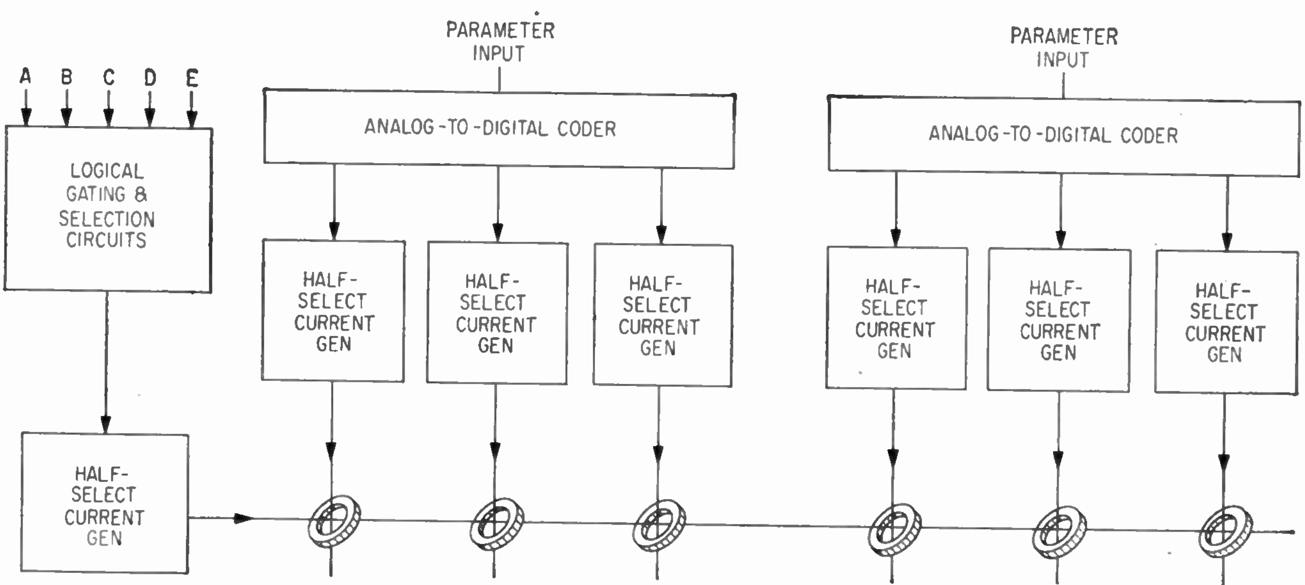


FIG. 6—Many variations of this didmop design are possible. Inputs *A, B, C, D* and *E* can be events, magnitudes or other parameters

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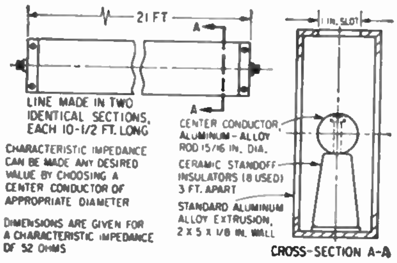
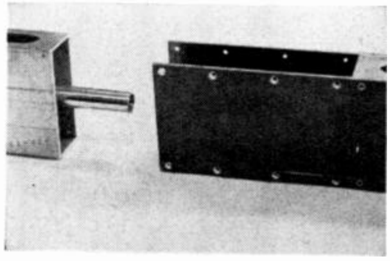
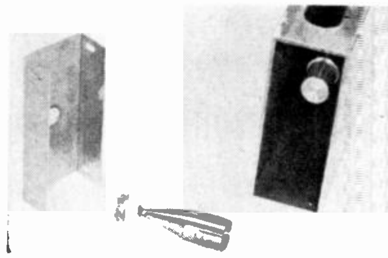


FIG. 1—Slotted-line construction used to measure the vswr of a transmission line at high frequencies



Two sections of the line are joined by splice plates and a telescoping center connector



Transition adapters at each end of the line connect the center conductor to standard BNCs

Slotted Line for 100 Mc

Inexpensive slotted line uses a vtvm as a standing wave indicator and measures impedances between 10 and 100 mc

By LESTER ZUKERMAN,
United Electrodynamics, A Division of United Geophysical Corporation, Pasadena, Calif.

OCCASIONALLY it is necessary to measure impedances from 10 to 100 mc, where some bridges will not operate with precision. An inexpensive slotted line can be constructed from standard aluminum-alloy extrusion and bar stock, Fig. 1. The Q and coupling coefficient of a resonant circuit can be determined, or the magnitude and phase angle of an unknown impedance can be measured.

The line uses a H-P model 410B vtvm as a standing-wave indicator. This instrument has a sufficiently high impedance to be placed directly across the line without introducing any perceptable error.

Machining

For convenience, the line is made in two sections. Each section has five slots, one by 24 inches, machined in one of the narrow faces of the extrusion. All machining operations were performed on a small vertical mill. Transition adapters at each end of the line have a 20-deg taper, which reduces reflections for ordinary work up to 100 mc. Careful redesign could further reduce reflections at the discontinuity for highly accurate measurements.

The design equation used was for a trough transmission line[1]. If the diameter of the central conductor is D, the width of the trough is W, and the height is H, then the characteristic impedance with the dimensions given in Fig. 1 is 52 ohms. When H/W is greater than 2, the characteristic impedance is essentially independent of the height. Thus slots can be cut in the short side of the rectangular extrusion without noticeably changing the chracteristic impedance.

A great advantage of this line is that the characteristic impedance can be calculated with great accuracy from the cross-sectional dimensions. Thus accuracy of impedance measurements depends only on the calibration of the voltmeter used as a probe.

The characteristic impedance was measured by terminating the line in a 100-ohm one-percent deposited carbon resistor and measuring the standing wave ratio when the other end of the line was fed from a matched load at 21 mc. For this condition the vswr measured 1.925, so the characteristic impedance is 100/1.925 = 52 ohms exactly. Another measurement with a 51-ohm resistor gave a vswr of 1.044, giving a value of $Z_o = 51 \times 1.044 = 53.3$ ohms. This still differs by only 2½ percent, from the design value.

Discontinuity contributed by the transition adapters at the ends of the line had no serious effect until the frequency used was above 250 mc, at which point the error was 4 percent.

Testing

To test for probe error, the voltage was measured along the line and the values of V/V_{max} compared with sine $2\pi l/\lambda$ where l was measured from a minimum. The difference between these two values at 21 mc was less than two percent in every case. Considering that the shunt reactance of the HP 410B vtvm is 1,000 ohms at 100 mc, no correction would be necessary in the region of a minimum at that frequency, but a correction would be necessary in the region of a maximum for standing wave ratios greater than three. All ordinary precautions for slotted-line measurements should be observed.

REFERENCE

(1) "Reference Data For Radio Engineers", p 593, 4th edition, Federal Telephone & Radio Co.

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Strontium 90 May Produce Electricity

RESEARCH and development has begun on a method to transform Strontium 90 into a source of additional power, the Atomic Energy Commission reveals. The Nuclear division of Martin is working on a ground-based 100-watt generator.

Heat liberated by the spontaneous decay of the radioisotope would be changed into electrical energy by a highly efficient thermoelectric conversion system. Because of the 28-year half-life of Strontium 90, the generator could be expected to produce continuous power for almost a decade without servicing or refueling. If it were linked to an energy-storage system, it could provide intermittent bursts of much higher energy than 100 watts (for a high-powered radio transmitter which might be required to broadcast for only a few minutes each hour).

Design

Several designs are being considered, but the final generator will probably use more than 200,000 curies of Strontium 90 and be about the size of a kettle drum. The country's supply of refined Strontium 90 could be multiplied readily if additional separation facilities were set up. Martin scientists estimate that by 1975 the normal radioactive waste products of the nation's nuclear energy industry will be great enough to supply 50 million watts of heat energy. Assuming a conversion efficiency of five percent, this would amount to 2½ million watts of electrical power.

Because of present-day cost, the most practical uses of radioisotopic power appear to lie in unattended power sources, where long life and reliability are vital factors. Remote weather stations, aircraft warning beacons and sea buoy markers are possible civilian uses.

Parametrons Cut Computer Cost

DEVELOPMENT of a large-scale digital computer has been completed by the Nippon Telephone and Telegraph Corp. The computer, which uses 5,000 Parametrons, is said to offer unusually high reliability and small size.

Power requirements are about one-third those required for vacuum-tube types of the same size. Cost of construction is claimed to be only about 10 percent of the cost of a vacuum-tube counterpart.

Great reduction in cost is attributed to the Parametrons, which are used in place of vacuum tubes. These units, a set of small magnetic toroids, capacitor and resistor, were invented in Japan in 1954.

The designers say that the original idea for the computer came from the fact that it takes two strokes of the human body for a a child to make one pendular movement of a swing. Instead of the two strokes, a-c excitation at a frequency $2f$ induces oscillation of a frequency f in the Parametron circuit by inductance variation in its magnetic toroids. Oscillation can take either one of two phases which are 180 degrees apart. Phase depends on a control signal coupled from other Parametrons. Phases represent either a zero or a one of the binary digits.

The computer uses a pure binary system and has a 40-bit word length. The number of its operation commands is about 130. Commands of an addition take an average of 2.5 milliseconds and of a multiplication 10 milliseconds. It can process alphanumeric information by conversion first into binary numbers, then back into either number or alphabet after data is processed.

Memory

The machine has core memory with a present capacity of 256 words. The memory cores are ferrites with nonrectangular hysteresis curve. Writing and reading of the information into and from the memory cores are done by superposition of two alternating currents of frequencies f and $f/2$. Magnetic

Foresters Use Recorder

Twenty-pen recorder by Esterline-Angus monitors weather variables in burn area of forest in state of Washington. Replacing large numbers of instruments previously required, recorder supplies wind-current data need in study of forest-fire control

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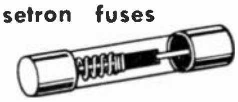

dual-element — slow blowing type

These fuses avoid needless blows from starting currents or surges. Yet protection is afforded against short-circuits or continued overloads.

Test specifications — carry 110%, open at 135% within 1 hour.

Voltage	Amperes
250 or less	up to 2
125 or less	up to 7
32 or less	up to 30

For Signal or Visual indicating fuses . . . *specify* . . . **Fusetron FNA fuses**

13/32 x 1½ inch.

Fusetron fuse with indicating pin which extends when fuse is blown. Can be used in BUSS fuseholders to give visual signal or, if desired, pin can be used to actuate a light or audible signal by using fuses in BUSS Signal fuse block.

0 to 2½ ampere sizes and 12 to 15 ampere sizes listed as approved by Underwriters' Laboratories.

Voltage	Amperes
250 or less	1/10 to 30.

For fast acting fuses for protection of instruments *specify* **BUSS AGC fuses**

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In sizes up to 2 ampere, for circuits of 250 volts or less, they provide high speed action necessary to protect sensitive instruments or delicate apparatus.

Listed as approved by Underwriters' Laboratories.

Test specifications — carry 110%, open at 135% in 1 hour or less. 1/500 to 2 ampere sizes also will open at 200% load in 5 seconds or less.

For high interrupting capacity fuses . . . *specify* . . **BUSS KTK fuses**

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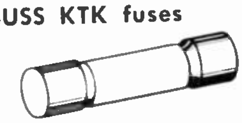

Capable of safely interrupting 68,000 amperes at voltages of 500 or less, AC or DC.

Test specifications — Carry 110%, open at 135% in 1 hour or less.

Voltage	Amperes
500 or less.	1/10 to 30.

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drum and magnetic tape will be installed soon as auxiliary memories.

Programs and data are perforated on paper tape and fed into the computer through a photoelectric reader. The paper tape has a 6-hole position, and each character is always represented by an odd number of holes, which are checked by the input of the computer.

Solid-State Thyratron Control

CONTROL of solid-state thyratrons can be accomplished with a unit developed by Control division of Magnetics, Inc. Called a Control Amplifier, it provides the necessary signal to control solid-state thyratron systems, which, in turn, can drive inductive loads as well as resistive loads without complicated circuitry.

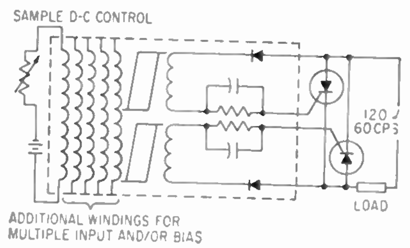


FIG. 1—Low-power magnetic amplifier adjusts to input needs of solid-state thyratrons

Combined with solid-state thyratrons, the unit shown in Fig. 1 provides circuit designers with a complete solid-state system from logic input to power-handling output. It substantially reduces components required to control solid-state thyratrons in proportioning applications, where phase-adjustable control pulses are required.

It offers proportioning and switching control. At the same time, it provides isolation of multiple logic inputs.

Circuits may be used for static switching, temperature control, automatic welding control, variable d-c supply, constant current supply and pulse-width modulation.

Essentially a low-power, high-speed magnetic amplifier, the unit self-adjusts to input needs of the solid-state thyratron.

Unlike conventional magnetic-amplifier controls, the device is self-clipping. Output cannot burn out the solid-state thyratron.

Infrared Missiles May Fight Forest Fires

INFRARED detectors and fire-fighting missiles have been suggested as a means of combating forest fires. "Applied as a team to fight fires, such devices could within 25 years eliminate 90 percent of the disastrous fires in our forests," believes Tom Linton, project engineer at California Institute of Technology.

Linton was formerly with the Forest Service, working on fire detection, suppression and experimental control. "The apparatus is already at hand to make a start," he said. "It's strictly an engineering and professional job to put the pieces together."

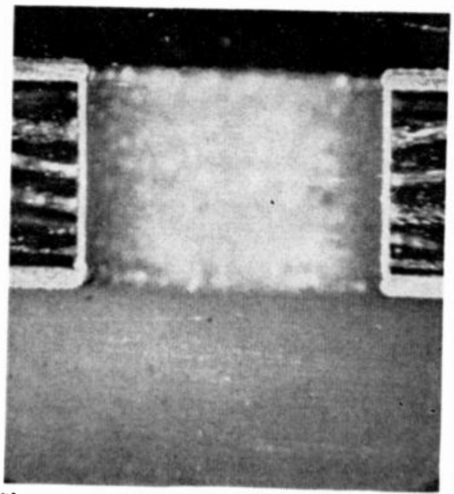
Time is the vital factor in detecting a fire. Too many of them are well advanced before they are spotted. An infrared-sensing device that could pick up a heat source within a range of 20 miles could, from a hilltop vantage point, detect heat even without tell-tale smoke. It could transmit an alarm from a small transistorized radio powered by a combination of solar and storage batteries.

The device would scan a critical fire area 24 hours a day. It could direct and trigger a fire-supressing missile, provided safety controls were a part of the system.

The Forest Service has found that it would be feasible to use the Navy Sidewinder missile. In tests, it was launched from a helicopter and unerringly sought out the fire. It would carry fire suppressing chemicals which it would spray over the flames.

The missiles could be backed up by jet planes and helicopters carrying anti-fire bombs. The combination of quick detection and quick attack could go far toward knocking out the forest fire menace. It also would tend to discourage arsonists by increasing their chances of being caught on the spot.

A network of the sensing devices supplementing lookout stations and eventually combined with television scanning could effect a breakthrough in subduing forest fires.



Photomicrograph of plated-through hole as used in printed armature

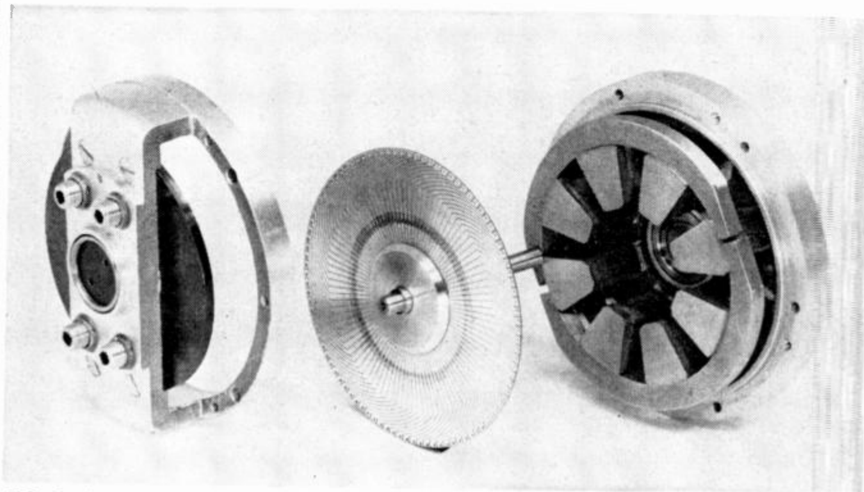


FIG. 1—Armature is mounted so that straight radial portions of each conductor lie within field flux

D-C Motor Has Printed Armature

CONVENTIONAL wire windings are replaced by a two-sided printed circuit in a d-c motor invented in France and patented in the United States by Printed Motors, Inc. Printed circuits and base material are being supplied in this country by Photocircuits Corp.

Armature

Armature of the new motor presents the appearance of a thin perforated disk mounted on a shaft by means of bearing flanges. Flat, ribbon-like copper conductors are printed on each face of the disk. The armature is mounted in a planary air-gap machine so that the straight radial portions of each conductor lie within the field flux as shown in Fig. 1. Curved portions of the conductors near the edge and center of the disk are connected to corresponding sections on the opposite face by plated-through holes.

Silver-graphite brushes ride directly on the bare surface of the armature conductors of which there are usually 100 or more. Winding layout may be arranged easily to avoid simultaneous commutation. The supporting disk contains no iron core. As a result, the armature produces a smooth torque output and is almost completely free from conventional armature reaction. Absence of iron leads to a small value of winding inductance. Commutation is quiet and free from sparking.

Both thermal conduction to the hub and thermal radiation to the adjacent pole pieces cool the flat armature disk. Machine structure is not limited to temperature rises tolerated by conventional organic insulators. Base materials for printed windings may consist of glass or other ceramic compositions.

Magnetic Circuit

Figure 2 shows the magnetic circuit of the new motor. It is an eight-pole structure excited by Alnico 6 permanent magnets. The arrangement makes the most efficient use of the flat armature winding.

For some servo system applications, direct coupling is desirable. It reduces cost and eliminates back-

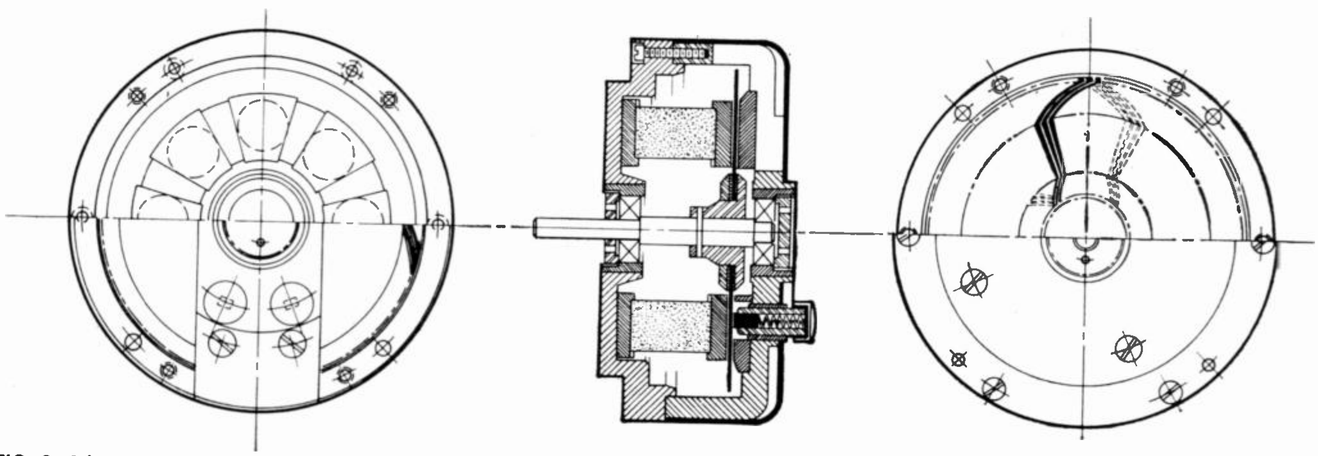


FIG. 2—Schematic view of the printed-circuit d-c machine

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lash. At the same time, however, good viscous damping is needed to provide stable operation because inertia of the load on the motor shaft is increased. To accomplish the necessary damping, the insulating core of the armature winding can be replaced with a conductive one such as aluminum. Eddy-current braking then provides braking torque proportional to speed. In a typical motor, this torque is five oz-in per 100 rpm.

Input Signal Response

Time required for a damped machine to respond to an input signal may be extremely small if damping factor and associated circuitry are carefully chosen. With an aluminum core for the armature windings, the armature inductance and the electrical time constant of the armature become essentially zero. Since input impedance of the machine is then resistive, large armature current and corresponding torque may be established effectively in phase with a step-wave voltage drive from a simple driving system such as a power transistor. A servo motor using these techniques has been designed with a stall torque of 60 oz-in. and a mechanical time constant of four millisec.

Torque

Torque available from constant-speed printed motors increases rapidly with armature size. Theoretically, permissible input power varies about as the 4.5 power of armature diameter. Armature inertia varies about as the fifth power of the diameter. Efficiency increases with armature diameter.

Applications

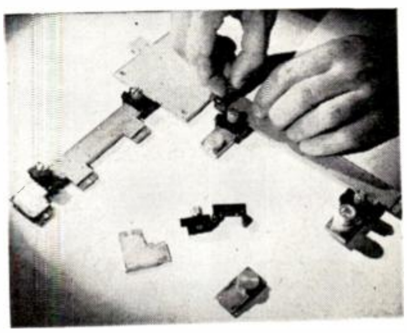
Printed-circuit d-c motors are logically applied to servomechanisms. Large, smooth torque output at low speeds and excellent angular resolution eliminates necessity for inserting a gear train to smooth motor torque at the servo load. Incorporation of damping in the servo motor produces a machine whose electrical transfer time constant is essentially zero. Feedback loop design for the servo is, therefore simplified.

Variation of the armature voltage of the printed d-c motor enables it to be applied as a variable speed motor. Excitation of the field by permanent magnets reduces copper losses at stall while high thermal transmission of the machine structure permits continuous operation at low speeds and high torques. In machine-tool applications, speed change gear boxes can be simplified or even eliminated.

Stepping Motors

In intermittent motion applications such as stepping motors and paper tape transports, the printed machine is useful. Incorporation of damping reduces the mechanical time constant to about four millisec, as mentioned previously. This time constant is virtually unaffected by electrical impedance of the driving source and brings the motor to a stop rapidly in a repeatable and predictable manner when driving voltage is removed. If, at the same time, average shaft velocity is low, the amount of power dissipated in damping torque is small.

In-Stock Modular Strip Components



New line is designed to give broadband operation from 250 to 4,000 mc

BUILDING-BLOCK construction of uhf and microwave circuits is possible with new modular Tri-Plate strip transmission-line components manufactured by Sanders Associates, Inc.

Available Components

Components available include directional couplers, hybrid mixers, variable and fixed attenuators, power dividers, bends and special fittings for interconnecting individual units or adapting them to coaxial line and crystal mounts.

Pegboard Makes Prototype P-C Card

By A. R. PEARLMAN, Transistor Products Div., Clevite Corp., Waltham, Mass.

DELAY AND EXPENSE in designing and producing transistor printed circuit cards can be circumvented by hand wired cards. Only simple hand tools are needed, materials are inexpensive and readily available and the same layout can be used for printed circuits later.

The circuit is conveniently laid out on graph paper with 5 squares to the inch (Fig. 1). Grid line intersections represent holes. The primary layout rule is that all crossovers are effected by components crossing conductors.

Adherence to the rule makes the wired circuit topologically identical to a printed circuit board bearing conductors only on 1 side. It can be used to design an interchangeable printed circuit card.

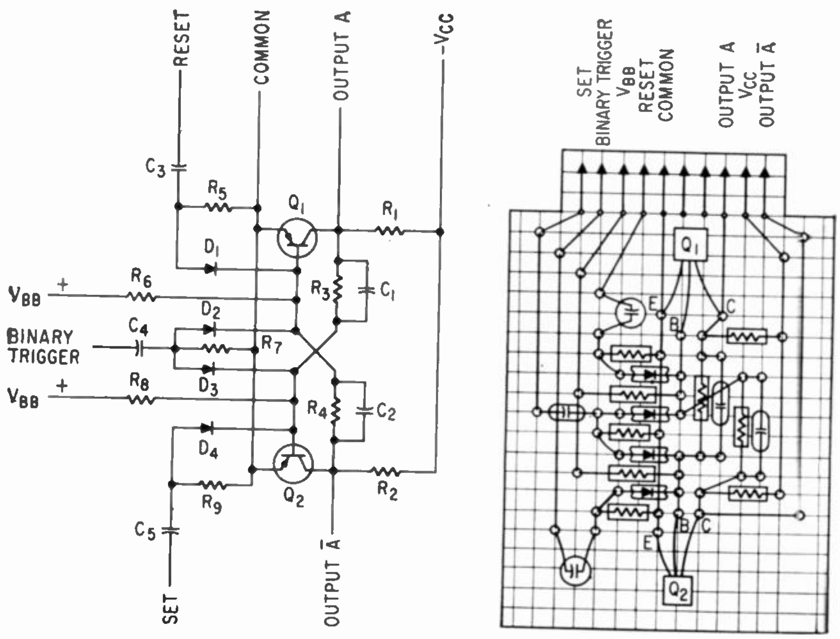
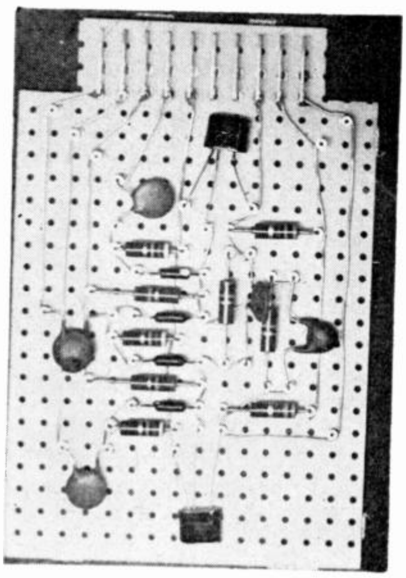


FIG. 1—Transition from schematic to completed circuit board. Board layout is done on graph paper. Author sketches component symbols into component outlines for clarity

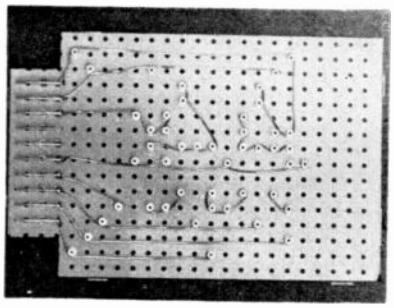
No Wire Stripping

In addition, the rule eliminates the need for insulated wire and the labor of wire stripping. Keeping all components on the same side of the card makes the circuit easy to trace for testing and servicing.

Card material is 1/16 inch epoxy-paper insulating board with 1/16 inch diameter holes on a 0.200 inch grid. This pegboard is also available in XXXP phenolic and epoxy-fiber-glass, but the writer prefers the epoxy-paper. The board is supplied in sheets 17 by 4 7/8 inches. The sheets are sawed or sheared into smaller sizes suitable for plug-in modules.



Completed hand wired board. Components make all crossovers



Circuit is wired with bare wire. Component leads go into lugs

A variety of connectors are available. The type used by the writer (see parts list) has a chassis-mounting receptacle and mating contacts along one edge of the board.

The contacts are designed for staking into 0.052 inch holes. The 0.0625 holes of the board are adapted by eyeletting with tinned tubular eyelets after which the contacts are inserted and then either staked or soldered in place.

Lacking an eyeletting tool, the eyelets are placed in the holes with tweezers. A strip of masking tape is pressed over the eyelet heads. The board is turned over and placed on a hard surface. An automatic hand center punch flares out the protruding ends of the eyelets. Finally the eyelets are peened with a ball peen hammer to flatten the protruding lips.

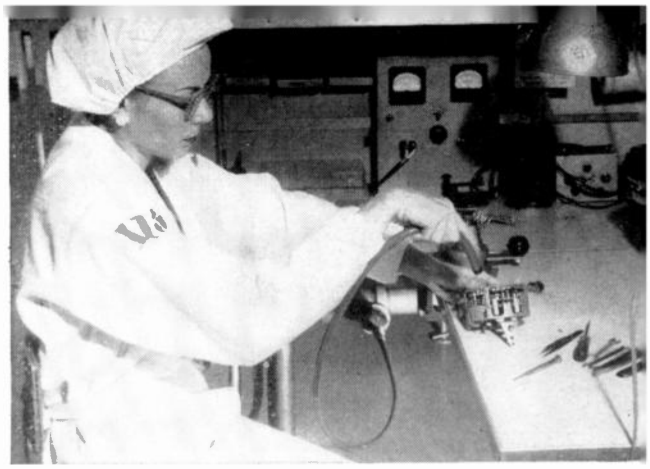
Lugs Take Leads

The contacts are on a thermoplastic supporting strip and can be purchased in exact length or cut from longer strips. The tongues of the contacts are inserted in the eyeletted holes and tapped or pressed in place. The assembly is inverted and the tongues soldered to the eyelets. The thermoplastic is removed after softening with an iron or hot plate.

Miniature hollow turret lugs are set into the board, 1 lug for each component lead. The circuit is wired with bare, tinned copper wire, AWG 22. Component leads are bent and trimmed and placed in the lugs. The board is now ready for soldering. Since component bodies

The unseen enemy

How Summers Gyroscope guards against the invisible anti-missile



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

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

Destroyer Of Standards

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

Dust Moved But Not Removed

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

Double Duty Production Tool

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

Before And After

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

How It Operates

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

Benefits And Advantages

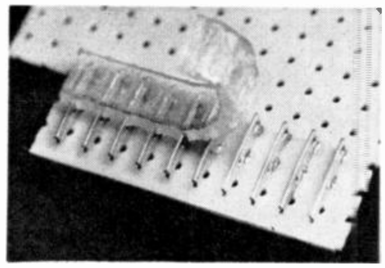
Insuring spotlessly clean work in final assembly and calibration, the Hoffman stationary vacuum system already has paid for itself. It has helped Summers Gyroscope reduce rejects, maintain high reliabilty, increase production and improve employee morale. The Hoffman system enables Summers to meet and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

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

U.S. Hoffman Machinery Corp.
Dept. E-1 Air Appliance Division
103 Fourth Ave., New York 3, N. Y.

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

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



Thermoplastic strip is removed from contacts after soldering to eyelets

and wiring occupy different planes, there is no interference.

The turret lugs can also be set into the holes with the automatic center punch rather than with special swaging tools. Suitable lug types include Precision Metal Products, 2S4-38B; Cambridge Thermionic Corp., X-2100B, and U. S. Engineering Co., 2010B. The board is Vector Electronics Co., 85F24EP; eyelets, Vector T15.0; contact strip and connector, Elco Corp., Varicon Series 5002.

Knurling Joins Small Metal Components

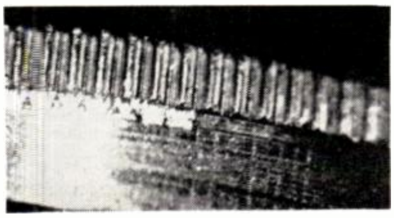
KNURL BROACHING can be used to mount miniature precision gears on hubs without deforming gear concentricity, according to Librascope, Inc., Glendale, Calif. The technique is used when parts are too small to permit normal fastening methods. Joinings made by broaching survive under stresses that loosen or rupture other types of joints.

A recent application is mounting tiny ring gears on hubs of a miniature 2-pinion differential used in analog computers and other equipment where shaft rotation is compared. The differential weights 1.06 ounces, gear input speed is 1,200 rpm and maximum static load is 6 inch ounces. Hubs are stainless steel and the rings gears are brass or aluminum. Temperature range is −65 F to 160 F.

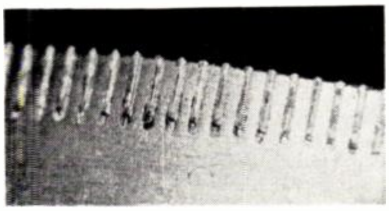
Ring gears vary, but are generally too small for use of pins or set screws. Cutting through for pins causes loss of concentricity during thermal expansion. Screw pressure also causes distortion.

The solution, devised by W. J Opocensky, staff engineer, is to apply a fine pitch knurl, usually 80 pitch, to the hub surface. This increases hub diameter by 0.004 to 0.005 inch in the local area. Knurl pitch depends on load; 80 pitch provides 50 inch pounds minimum torque.

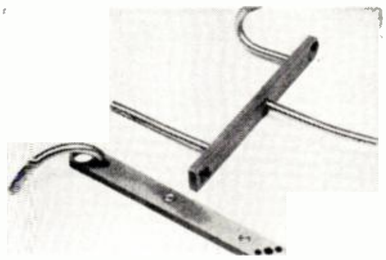
The base of the hub is knurled to slightly less than half the width of the ring gear to be applied. After knurling, a groove is machined around the hub at the leading edge of the knurl. This chip groove cuts across the ends of the knurling and forms sharp edges which act as microscopic broaching teeth as the gear is pressed onto the hub. The groove collects material removed from the gear and prevents galling and spalling of the metal.



Magnified view of knurled area after gear is fitted and removed. Portion of chip groove at right has been cleaned of chips left by broaching action



Mating gear surface after press fit on knurled hub. Some chips are left in the cuts made by the knurling, but there is no chipping or abrasion



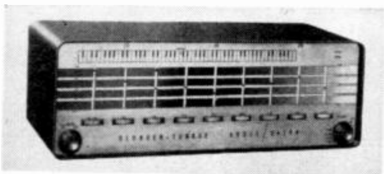
Tests show (foreground) that two shafts have twisted to separation without loosening in mounting hole

Press fit allows gears to be changed. For a permanent fit, a staking groove is made in the hub and the gear is staked in position. About 60 percent of the interior surface of the gear mates with the hub within a tolerance of 0.0004 inches.

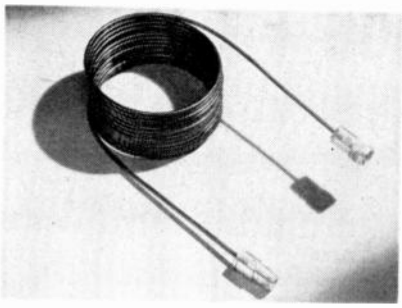
ON THE MARKET

Audio Control
versatile unit

BLONDER-TONGUE LABORATORIES, INC., 9 Alling St., Newark 2, N. J. Model B-9 Audio Baton provides virtually unlimited audio response control on an octave by octave selection basis. Up to 29 db total am-



plitude change for each of the nine octaves is possible. This versatility through unique band-pass type audio circuits leads to many applications: emphasis of the presence frequencies, attenuation of intermodulation distortion, elimination of loudspeaker boom and p-a system feedback, and suppression of noise and other undesirable audio responses. **Circle 200 on Reader Service Card.**

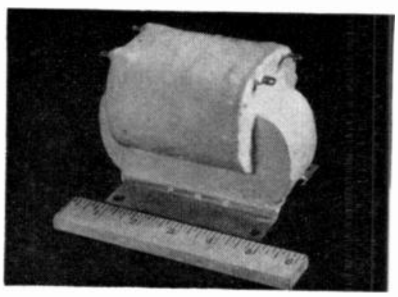


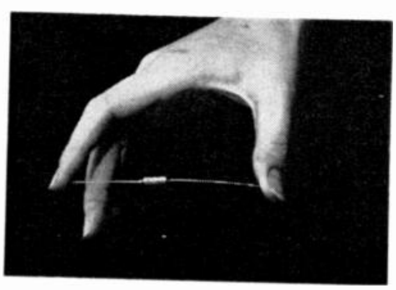
R-F Coax Cable
high temperature

THOMAS A. EDISON INDUSTRIES, McGraw-Edison Co., 61 Alden St., West Orange, N. J., announces a new low-loss r-f coaxial cable which meets the requirements of the high temperature coaxial cable design objective created by Wright ADC within the range of 10 to 1,500 mc. It is a cable of 50 ohm characteristic impedance and 300 C to 500 C environmental capabilities, the outer conductor being solid rather than braided in order to meet the requirements of attenuation, shielding effectiveness and temperature range. **Circle 201 on Reader Service Card.**

Encapsulating Resin
saves weight, space

WESTINGHOUSE ELECTRIC CORP., Manor, Pa., has developed a new silicone modified filled encapsulating resin (Fosterite SFR BT-3199), designed for use in treating electronic components that require high moisture resistance and flame retardance. It provides greater reliability, with savings in weight, space and mold costs, compared with casting techniques. The new resin is recommended for treatment of components such as filament, power and plate transformers for communications, fire control, radar and guided missiles. **Circle 202 on Reader Service Card.**



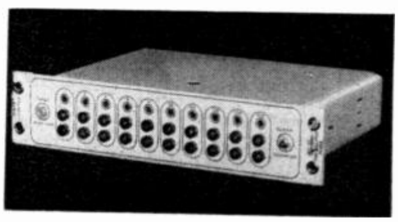


Tantalum Capacitors
solid electrolyte

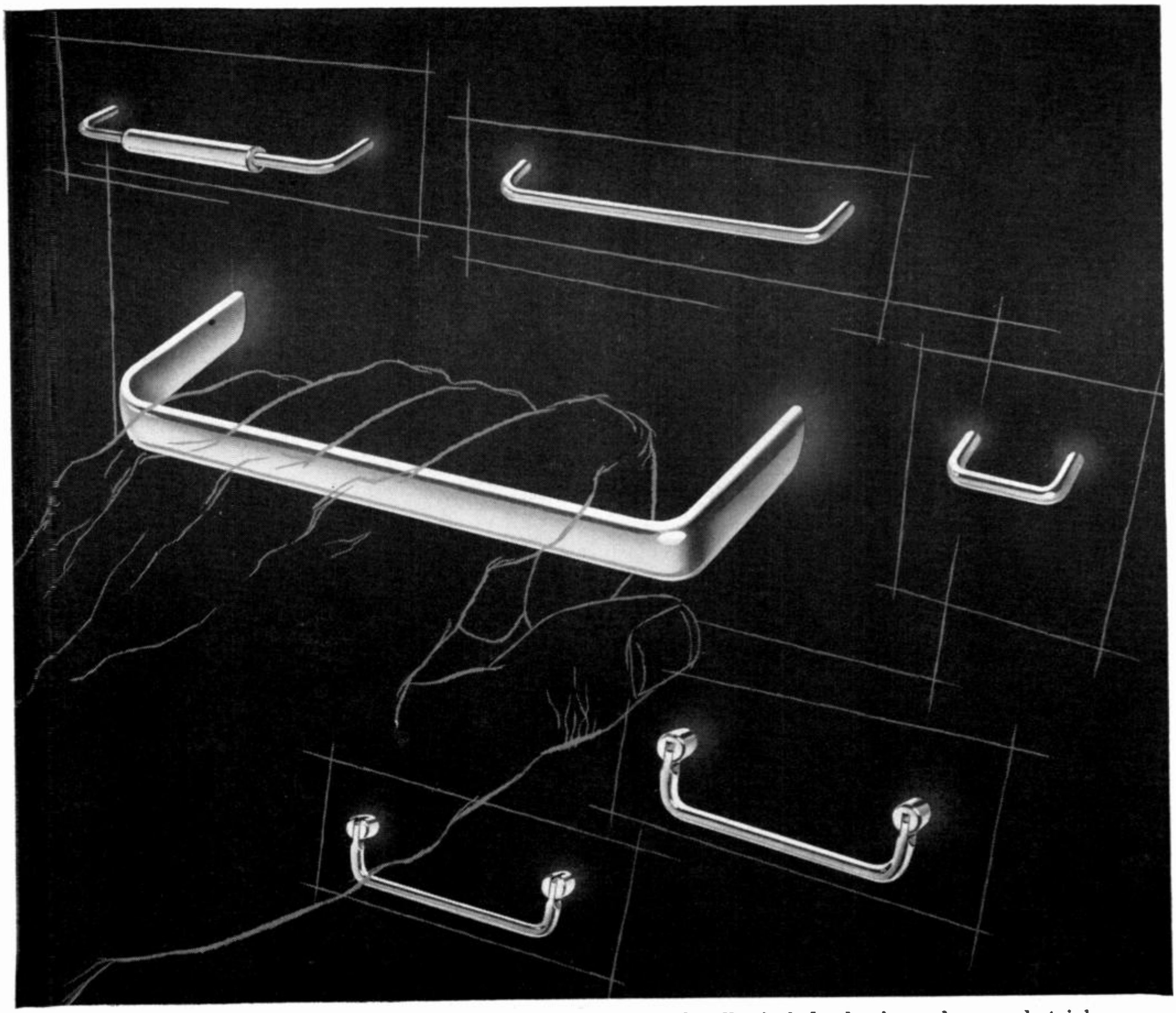
THE MAGNAVOX CO., 2131 Bueter Rd., Ft. Wayne, Ind. Solid electrolyte tantalum capacitors rated at 6, 10, 15, 20 and 35 v are reported. Capacitance range is 2.2 to 47.0 μf and standard tolerance is $\pm$20 percent. Capacitors are hermetically sealed and are constructed to meet applicable military specs. Temperature range is -55 C to $+85$ C. Case size is 0.175 in. by 0.438 in. The low d-c leakage current does not exceed 0.04 μa per μf-v or 2 μa, whichever is greater. **Circle 203 on Reader Service Card.**

Binary Counter
reversible

NAVIGATION COMPUTER CORP., 1621 Snyder Ave., Philadelphia 45, Pa. Model 111B transistorized 10-stage indicating reversible binary



counter features both serial and parallel read-in and read-out. Eighteen volt d-c levels are available from either side of the counter stages; and they may be directly loaded by other transistor stages. Unit has completely auto-



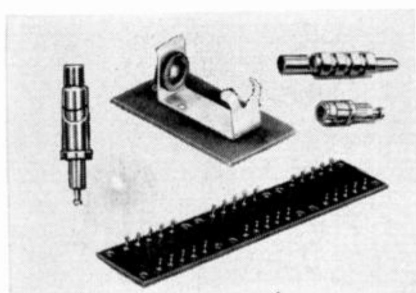
Materials used in the quality-controlled manufacture of CAMBION handles include aluminum, brass and stainless steel. Finishes are of polished nickel, black oxide, and black alumilite. Types available are rigid, adjustable and folding. Folding types are in two different models — designed to fold against the panel in either one or two directions.

How to handle things better — 28 ways

Made in 28 different standard combinations, CAMBION® panel handles are also custom-made to any specifications, in any quantity. All are of quality materials which meet or better government specifications. In addition to a firm grip, all have an attractive appearance. Polishing before plating removes all surface imperfection, and color buffing after plating adds lasting luster.

Expert engineering and manufacturing skill control production of the complete CAMBION line — terminal boards, solder terminals, insulated terminals, coils, coil forms, capacitors, swagers and hardware. In any quantity of CAMBION components you order you get top quality — with every component guaranteed.

Available locally through Authorized CAMBION Distributors. Or write to Cambridge Thermionic Corporation, 437 Concord Avenue, Cambridge 38, Massachusetts. On the West Coast: E. V. Roberts and Associates, Inc., 5068 West Washington Blvd., Los Angeles, California. In Canada: Cambridge Thermionic of Canada, Limited, Montreal, P.Q.

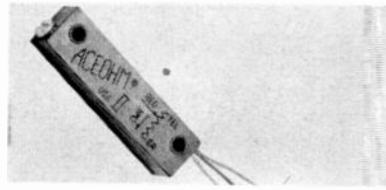


The CAMBION line of panel and chassis hardware is recognized as the best looking, best behaving, most polished family in its field. Besides handles, other popular members are terminal boards, diode clips, battery clips, miniature plugs and jacks. CAMBION custom hardware can be designed and manufactured on request.

CAMBRIDGE THERMIONIC CORPORATION
CAMBION®
The guaranteed electronic components

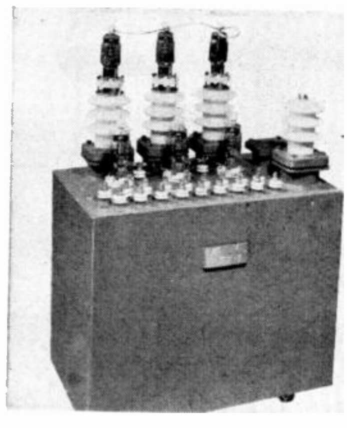
CIRCLE 49 READERS SERVICE CARD

matic internal switching. The counter measures 2¼ in. by 10 in. by 7 in. deep, and weighs less than 2 lb. **Circle 204 on Reader Service Card.**



Trimmer Pot high-temperature

ACE ELECTRONICS ASSOCIATES, INC., 99 Dover St., Somerville 44, Mass. The Aceohm moisture-proof rectilinear trimmer pot has a temperature range of −55 to 225 C. Fully adjustable through 25 turns, it has an anti-jam overtravel-limiting device, straight line, high-temperature dual contacts, and welded construction throughout for higher reliability. **Circle 205 on Reader Service Card.**

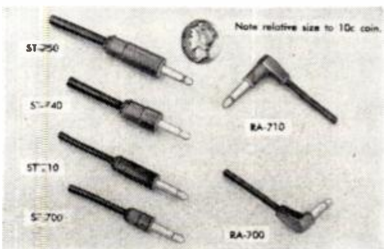


Unitized Rectifier for h-v use

MAGNATRAN INC., P.O. Box 211, Kearny, N. J. Delivering an output of 6 kw at 25,000 v d-c, this compact unitized rectifier employing a 3 phase full wave circuit has been developed to provide an efficient, reliable source of d-c power for use in klystron amplifier equipments and similar applications. With dimensions of only 26 in. by 16 in. by 42 in. high including tubes, and built to military specifications, it operates in an ambient with temperature variations from −50 C to +75 C and altitudes to 10,000 ft. **Circle 206 on Reader Service Card.**

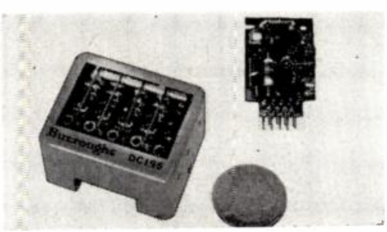
Delay Lines
several new models

DELTIME INC., 608 Fayette Ave., Mamaroneck, N. Y., has developed several new model delay lines. These include the model 129 which is an extra compact magnetostrictive long-delay line, a polarity-sensitive delay line, a compact delay line of one millisec length, an electronically variable delay line and a potentiometer-type delay line. **Circle 207 on Reader Service Card.**



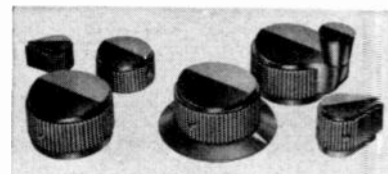
Cable Assemblies
maximum service

SWITCHCRAFT, INC., 5555 N. Elston Ave., Chicago 30, Ill., has available molded cable assemblies with straight and right angle Tini-Plugs. They have a pear-shaped, one piece tip rod that continues from the tip into the assembly directly to the soldered connection of the cable conductor, thus assuring that no tips can drop off inside the equipment. A cable clamp connects the cable shield (or second conductor) to the plug sleeve. **Circle 208 on Reader Service Card.**



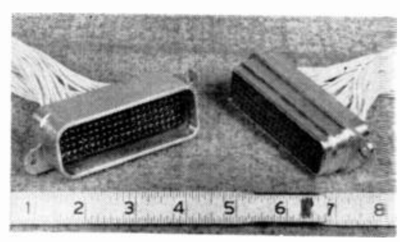
Decade Dividers
solid state

BURROUGHS CORP., Box 1226, Plainfield, N. J. A new line of solid state decade dividers are designed to provide accurate frequency dividing or timing pulses up to 100 kc with a minimum of components, size, and power consumption. Counting is accomplished by the use of two miniature tape wound cores and two transistors. Units are expected to find wide application in computers, frequency measuring instrumentation, electronic timers, and radar and missile timing applications. Circle 209 on **Reader Service Card.**



Control Knobs Mil-Spec

NATIONAL CO., INC., Malden, Mass., has available a line of standard plastic control knobs made to conform with MS-91528. There are four basic knob types: round pointer, spinner (each with or without skirts) and dial skirted round. Each is available in three different shaft sizes. Finishes are either gloss, matte, or to color specifications. All sizes are to Mil-Specs. **Circle 210 on Reader Service Card.**



Connector rack and panel

AMP INC., Harrisburg, Pa. Designed for use in an airborne computer, the 100 position rack and panel connector is compact and lightweight. In application, one-half of the connector mounts on the end of the rack drawer which contains the computer electronic circuitry, while the second half mounts to the fixed panel and

(Continued on p 86)

Promoted by the
Electronics and Communications Section
of The Institution of Electrical Engineers

The **INTERNATIONAL TRANSISTOR EXHIBITION** will be held in the same building and at the same time as the *International Convention on Transistors and Associated Semiconductor Devices.*

●

These two events, both promoted by The Institution of Electrical Engineers, are attracting world-wide interest and an overall attendance of some 60,000 is anticipated.

●

The Exhibition will cover all types of semiconductor devices and their numerous applications, and will include transistor materials, equipment involving transistors and semiconductor techniques, and also various associated and specialized components for use in transistorized equipment.

●

Part of the Exhibition will be devoted solely to transistor research and development, and will include exhibits from government, industrial and university research laboratories.

●

Manufacturers wishing to participate in this unique Scientific Exhibition are invited to contact the organizing company.

●

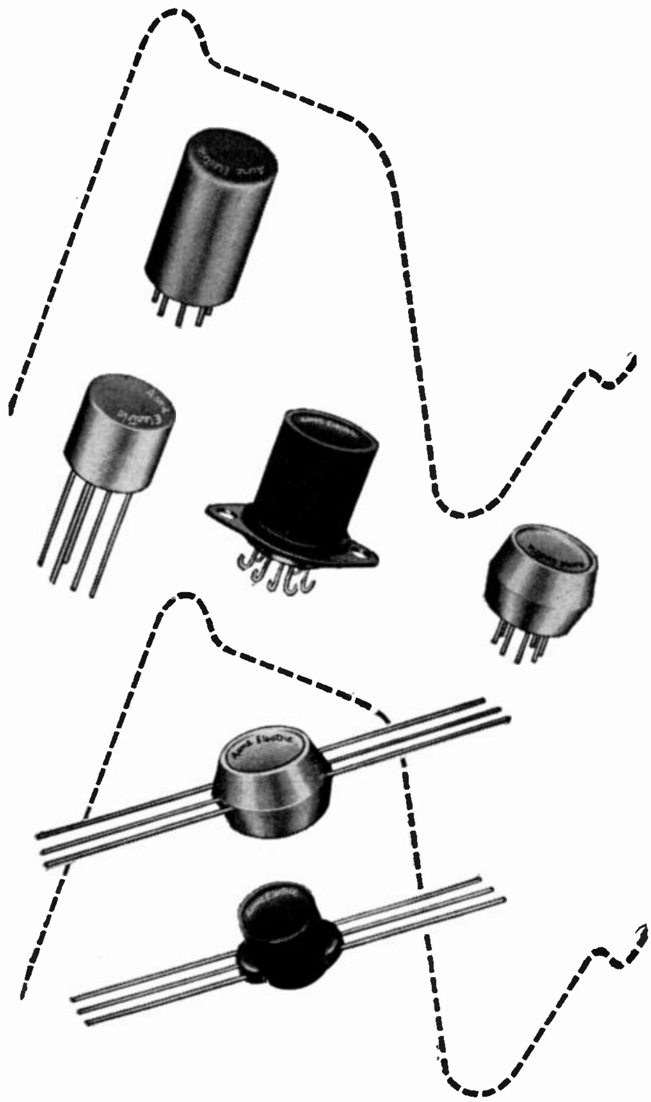
Two thousand scientists and engineers directly concerned with transistors and their application, and coming from all over the world, are expected to attend the International Convention on Transistors, the opening lectures of which will be given by the inventors of the transistor—Dr. W. B. Shockley, Dr. W. H. Brattain, and Professor J. Bardeen.

Full details from the organizers:

INDUSTRIAL & TRADE FAIRS LIMITED
Drury House, Russell Street, London, W.C.2
TEMple Bar 3422

CIRCLE 53 READERS SERVICE CARD

MINIATURE AND SUB-MINIATURE PULSE TRANSFORMERS



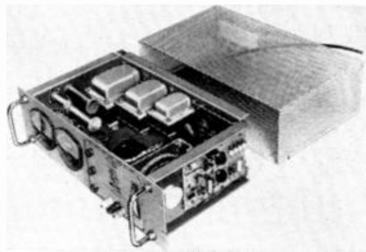
These transformers are designed to become an inherent part of the circuitry in which they are used. Designs developed feature good, low-frequency response with minimum droop of the output pulse amplitude during pulse period as well as having good high-frequency response to minimize rise and decay times. Write for Bulletin PT 315 outlining mounting types, general specifications and outstanding features. Our facilities assure exceptional deliveries.

ACME ELECTRIC CORPORATION
313 WATER STREET • CUBA, NEW YORK
West Coast Plant: 12822 YUKON AVE., HAWTHORNE, CALIF.
PO 3254

Acme ACME Electric
TRANSFORMERS

CIRCLE 54 READERS SERVICE CARD

thereby connects the electronic circuits to feeder cables attached to the rear of the panel. **Circle 211 on Reader Service Card.**

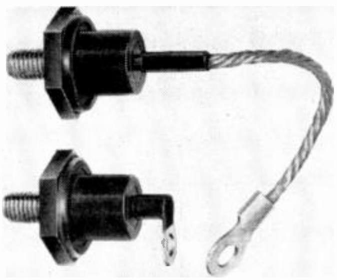


Power Supplies high current

ELECTRONIC RESEARCH ASSOCIATES, INC., 67 Factory Place, Cedar Grove, N. J. The Magitran line of transistor-magnetic regulated power supplies provide full automatic voltage and current protection against all types of short-circuits and transients and recover instantaneously without the necessity of resetting relays or fuse changing. High voltage units provide regulated outputs up to 300 v d-c at 0-1 ampere. Low voltage models provide outputs of 0-36 v d-c in ratings of 0-4, 8, 12, 20 amperes. **Circle 212 on Reader Service Card.**

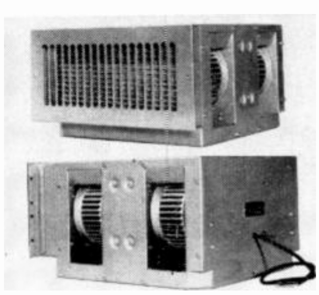
Transistor Tester time-saving unit

SIERRA ELECTRONIC CORP., 3885 Bohannon Drive, Menlo Park, Calif. Model 219A enables measurement of the transistor beta parameter while the transistor remains in the circuit. It thus provides considerable savings in trouble shooting and service time. Beta and collector leakage current parameters may be measured with the transistor removed from the circuit. Packaged in a sturdy, compact carrying case, the unit operates from either a self-contained battery supply or 110 v, 50/60 cycles power line. **Circle 213 on Reader Service Card.**



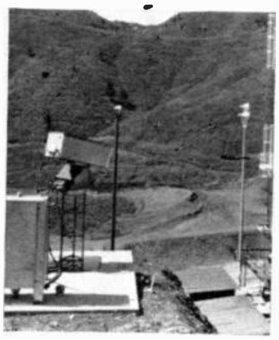
Silicon Rectifiers
two new types

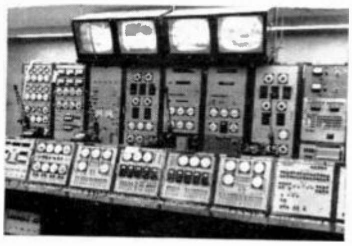
FANSTEEL METALLURGICAL CORP., North Chicago, Ill., announces two new silicon power rectifiers for heavy-duty high temperature (165 C) service. Type 4A—35 amperes in half-wave service, 100 amperes in bridge circuits; type 6A—20 amperes in half-wave service, 60 amperes in bridge circuits. Both are unaffected by storage temperature from −65 C to 200 C. They are furnished with and without flexible lead. **Circle 214 on Reader Service Card.**

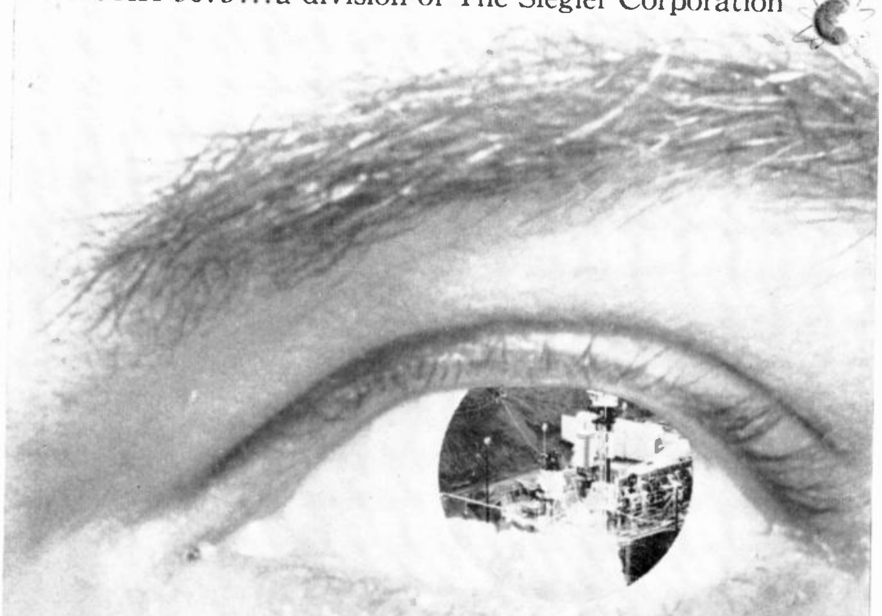


Recessed Blower
side exhaust

MCLEAN ENGINEERING LABORATORIES, Princeton, N. J., introduces a new, recessed, 2-speed packaged blower for use where side exhaust is required or where air is to be diverted into a duct system. Blower has a panel size 8¾ in. deep and fits standard 19 in. racks. It has an extra-quiet air delivery of 800 cfm at high speed and 600 cfm at low. The long-life unit meets the intent of MIL-E-4158A. **Circle 215 on Reader Service Card.**







Literature of

MATERIALS

Sintered Nylon Parts. Halex Corp., 26302 W. 7 Mile Rd., Detroit 40, Mich., has available a 4-page brochure on Nylasint nylon parts, nylon components formed by cold pressing and oil sintering nylon powders in a process somewhat similar to that used in forming powdered metal parts. **Circle 250 on Reader Service Card.**

COMPONENTS

Rectifier Catalog. International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif. A 16-page catalog gives ratings, characteristics and descriptive data on 405 types of silicon and selenium rectifiers and diodes. For a free copy, write on your letterhead requesting "Short Form Catalog".

Snap-Action Switches. Micro Switch, Freeport, Ill. Vol. 1 No. 26 of *Micro Tips* contains ideas submitted by plant engineers and others showing how they've used snap-action switches to increase production efficiency. **Circle 251 on Reader Service Card.**

Temperature Controller. Hagan Chemicals & Controls, Inc., Route 60 at Campbell Run Road, Pittsburgh 30, Pa. An illustrated bulletin describes the new electronic temperature controller for electric heat treating furnaces and other applications. **Circle 252 on Reader Service Card.**

Electronic Cable. Robertshaw-Fulton Controls Co., Aeronautical & Instrument Division, Santa Ana Freeway at Euclid Ave., Anaheim, Calif. A 4-page booklet describes the division's capabilities and facilities in the field of custom electronic cabling for the aircraft and missile industries, from design and development through fabrication and installation. **Circle 253 on Reader Service Card.**

Rotating Servo Components. Ketay Department, Norden Division,

the Week

United Aircraft Corp., Commack, L. I., N. Y. An important tool for engineers working on servo systems is the new "Nomenclature For Rotating Servo Components" now available. **Circle 254 on Reader Service Card.**

Precision Pot. Helipot Division of Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, Calif. Data sheet 1357, telling the story of the $1\frac{3}{4}$ in. series 5500 single-turn precision potentiometer, is now available. **Circle 255 on Reader Service Card.**

Toroid Coils. Kelvin Electric Co., 5907 Noble Ave., Van Nuys, Calif., has available 4-page bulletin KT-1 describing a complete line of uncased, hermetically sealed and plastic encapsulated toroid coils. **Circle 256 on Reader Service Card.**

EQUIPMENT

Milliohmmeter. Keithley Instruments, Inc., 12415 Euclid Ave., Cleveland 6, Ohio. Two-page *Engineering Notes* Vol. 6 No. 3 contains complete data and specifications for the model 502 milliohmmeter. It gives detailed description and circuit diagram. **Circle 257 on Reader Service Card.**

Strip Chart Recorder. Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Philadelphia 44, Pa. Specification 153-20 gives full details on the company's ElectroniK strip chart recorder with continuous integration. **Circle 258 on Reader Service Card.**

FACILITIES

Dry Electrolytic Capacitors. Syncro Corp., Hicksville, Ohio. Catalog No. ME-58 discusses the company's facilities for the manufacture of Quad-Nine electrolytic capacitors which are made of 99.99 percent purity etched aluminum foil. **Circle 259 on Reader Service Card.**

Infant Itek Mushrooms

ITEK CORP., a Waltham, Mass., research company, is rounding out its first 18 months by acquiring a Rochester, N. Y., firm, investing in a new West Coast subsidiary, and splitting five-for-one Itek stock which had zoomed from $2 to well over $200.

The Massachusetts firm specializes in aero-space reconnaissance and information retrieval systems, electronic and photo-optical equipment. Shareholders recently approved plan to acquire Photostat Corp. of Rochester and to invest in Vidya Corp. of California, which studies problems to be encountered in upper atmosphere and space.

Commercial descendant of Boston University Physical Resarch Lab, Itek last year acquired Vectron, Inc., Waltham electronics firm.

Starting in Sept. 1957 with four men and a secretary, Itek now employs more than 500, with nearly 50 percent holding either master's or doctor's degrees. It has a financial interest in Geophysics Corp. of America, Boston company formed in 1958 by five government scientists who left Air Force Cambridge Research Center to start their own firm.

Original financing of Itek was done by Laurance Rockefeller and Associates.

Heading company's founders is Richard S. Leghorn, president, who was manager of Eastman Kodak's European operations when he left to organize Itek. Other founders: Duncan E. Macdonald, former dean of BU Graduate School; Arthur W. Tyler and Jesse X. Cousins. Norman H. Taylor, formerly of MIT Lincoln Lab, now heads Itek's electronics lab.

Sales now exceed $600,000 per month, according to company. For fiscal year ended last Sept. 30, $3.5 million sales and $169,000 earnings were reported.

In addition to authorizing stock split, resulting in 659,555 shares outstanding, stockholders increased authorized capital to 1.5 million shares, approving plan to raise at least $4 million.

New general headquarters and labs will be built on 43-acre tract of land in Lexington, Mass., which company purchased last year.

Classified government projects comprise bulk of Itek's work. Firm has National Science Foundation contract for study of information storage and retrieval problems. Principal commercial product to date is microwave spectrum analyzer, developed by Vectron.

Chaffee To Get Medal of Honor

EMORY LEON CHAFFEE, Harvard professor emeritus of physics, will receive the IRE Medal of Honor "for his outstanding research contributions and his dedication to training for leadership in radio engineering."

The 73-year-old educator and electronics researcher held both the Gordon McKay and Rumford chairs in physics at Harvard and was director of the Laboratories of Engineering Sciences and Applied Physics. He received his bachelor's degree in electrical engineering from MIT in 1907 and was awarded master's and doctor's degrees by Harvard.

From 1940 to 1948, he was director of Harvard's Cruft Laboratory and supervised fundamental research in electronics and communications under Navy and Office of Scientific Research and Development contracts.

He also directed war training courses at Harvard from '41 to '45.

Although he retired from academic and administrative duties at Harvard in 1953, Chaffee continues his scientific work as consultant for industrial firms in electronic and optical projects, particularly in the fields of precision measuring equipment and measurements of pressures at high temperatures.

"I should be writing, but I'm not," says Chaffee. He is author of "Thermionic Vacuum Tubes," published by McGraw-Hill in 1940, and co-author of "Electronic Circuits and Tubes," McGraw-Hill, 1947.

A fellow of IRE, the American Physical Society and the American Academy of Arts and Sciences, he is a former vice president of IRE.

Elin Appoints Chief Engineer

NEW chief engineer at Electronics International Co., Burbank, Calif., is Otto G. Leichliter. He will co-

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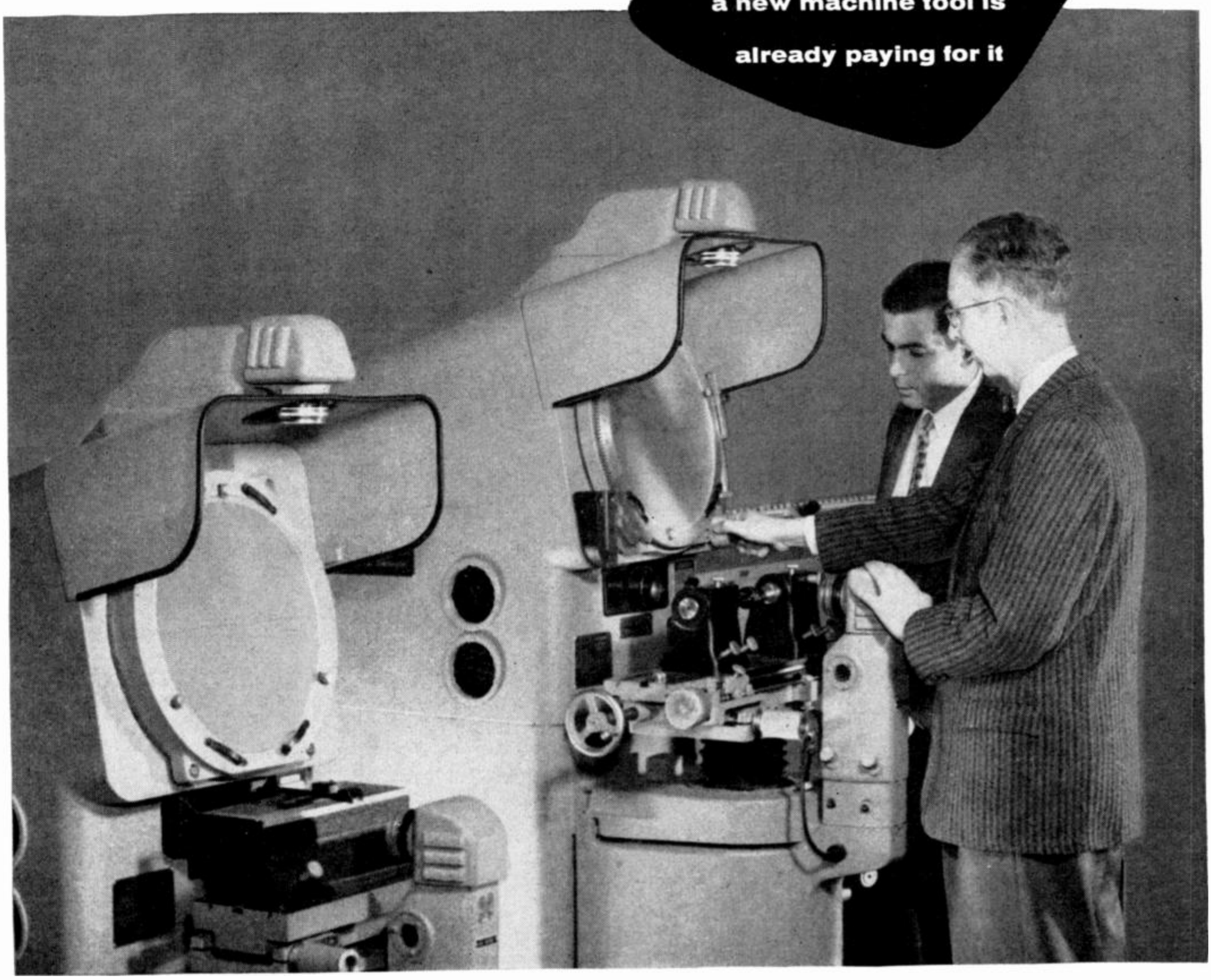

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ordinate project design, development and manufacture of the firm's instrument line and also engage in experimental projects for the company.

Leichliter was formerly project engineer for Packard Bell Electronics, Home Products Division.

Appoint Hobbs To New Post

FORMER director of marketing for the Stewart-Warner electronics division, Marvin Hobbs is named to the newly created post of director of defense marketing for General Instrument Corp., manufacturer of industrial, military equipment and tv/radio components.

With General Instrument supplying electronic systems and components for defense on both prime and subcontract bases, Hobbs, in addition to his marketing duties, will act as the firm's representative during government "team" programs involving other major producers of military equipment.

He will make his headquarters at GIC's defense products division in Brooklyn, N. Y.

Syntron Opens Another Plant

A COMPLETELY new and modern silicon recifier plant was recently put into operation by Syntron Co., Homer City, Pa.

With temperature, humidity and

atmospheric pollution held within rigid limits by an elaborate system of electronic controls, company says this plant is designed to produce the highest possible quality silicon rectifiers with higher yield rates than are possible in conventional manufacturing operations.

Completion of this silicon rectifier plant follows by just one year the opening of a new selenium rectifier plant by Syntron Co.

News of Reps

Appointment of the **B. B. Taylor Corp.** of Long Island, N. Y., to represent Telemeter Magnetics, Inc., Los Angeles manufacturer of ferrite core products and data handling systems, is announced. Rep firm will cover the metropolitan New York area and northern New Jersey.

Freed Transformer Co., Inc., Brooklyn, N. Y., appoints **Martin P. Andrews, Inc.,** of Fayetteville, N. Y., as its rep for New York state. The Andrews organization will handle the entire Freed line of power and communication components as well as precision laboratory test instruments and counters.

The **O. F. Masin Co.** of Pelham, N. Y., is named New York area sales rep for Columbus Electronics Corp., Yonkers, N. Y., manufacturer of double diffused silicon rectifiers and other semiconductor devices. Territory to be covered includes: metropolitan New York. Nassau, Suffolk, Westchester, Dutchess, Putnam, Orange, Rockland, Sullivan and Ulster counties in New York state; Fairfield County, Conn.; Monmouth and Mercer plus counties north in New Jersey.

The Andruss-Peskin Co. was recently formed as exclusive reps in the New England states for the following manufacturers of measuring and testing equipment: Statham Instruments, Inc., Los Angeles, Calif.; Bytrex Corp., Newton, Mass.; and Alpha-Molykote Corp., Stamford, Conn.

COMMENT

Anesthesia Control

I would like to comment on the article by Dr. Bellville and Mr. Attura, "How Electronics Controls Depth of Anesthesia" (p 43, Jan. 30).

This is not a new idea; it has been worked on by many, Bickford and Faulconer of the Mayor Clinic, and Frumin of Columbia Presbyterian, as examples. The problem with the techniques in practice is based on the reliability of the data being fed into them.

The assumption is made that only anesthesia affects the electroencephalograph pattern in this particular application. In fact, there are many things that affect the eeg, a most important one being cerebral circulation. For one example, if the cerebral circulation changes (and this may not be related to changes in blood pressure, pulse or respiration) the eeg may change. Our experience has been that the changes as reflected in the eeg would generally indicate deepening anesthesia, as the direction of circulatory changes is usually in the direction of reduced flow. In the application described in this article, this would signal reduction in the amount of anesthesia being administered, which might not be desirable for many reasons.

I am an advocate of electroencephalography during anesthesia, but I believe the technique should be used as another monitor, not to control anesthesia. In other words, I believe that if the eeg changes, the anesthesiologist should find out why it changed, not let it control the administration of an anesthetic. He may be very much surprised. There is yet no substitute for the human mind to test the reliability of data.

JOHN B. DILLON, M.D.
UNIVERSITY OF CALIFORNIA
MEDICAL CENTER
LOS ANGELES

Co-author Bellville sends the following reply to Dr. Dillon's letter:

In this and earlier scientific publications we have given credit to the contributions of Bickford and Verzeano.

The novelty that the servo we

described possesses over Bickford's (ELECTRONICS, Sept. '50) is that ours is a continuous servo that can be set up to control inhalation or intravenous agents, whereas Bickford's device is an on-off type servo.

I still believe more complex devices that sense several variables and have memories and failsafe features are possible. Equipment complexity will probably limit their immediate application to the laboratory.

J. WELDON BELLVILLE, M.D.
MEMORIAL CENTER
NEW YORK

Weather

This advanced weather-research program—of which last month's Vanguard II was a big first step—seems to omit or overlook a very important matter: data-processing.

The Weather Bureau already has warehouses full of records in its center in Asheville, N. C., which could be reduced to meaningful intelligence if someone took the time. But with all the Bureau's computer power, it doesn't seem as if anyone's taking the time—because information is being gathered by observers far more rapidly than it can be processed.

There are correlations and cross-correlations in weather data: synods of major and minor planets, solar storms on the central disk and the annular disk, and so forth. If these correlations could be made, some reasonable and firm basis for understanding the forces that move air masses and cause weather could be adduced.

CLINTON R. TRUXALL
ST. LOUIS, MO.

Two things. Firstly, observations of cloud cover and air-mass behavior are important in short-range weather forecasting, and so will be of immediate interest. The more remote astronomical phenomena are of primary concern to long-range forecasting—which is why they have not properly been cross-correlated with weather data.

Secondly, Weather Bureau chief Reichelderfer assured us the other day that computers and data-processing are indeed a primary matter of concern in laying out the research program.

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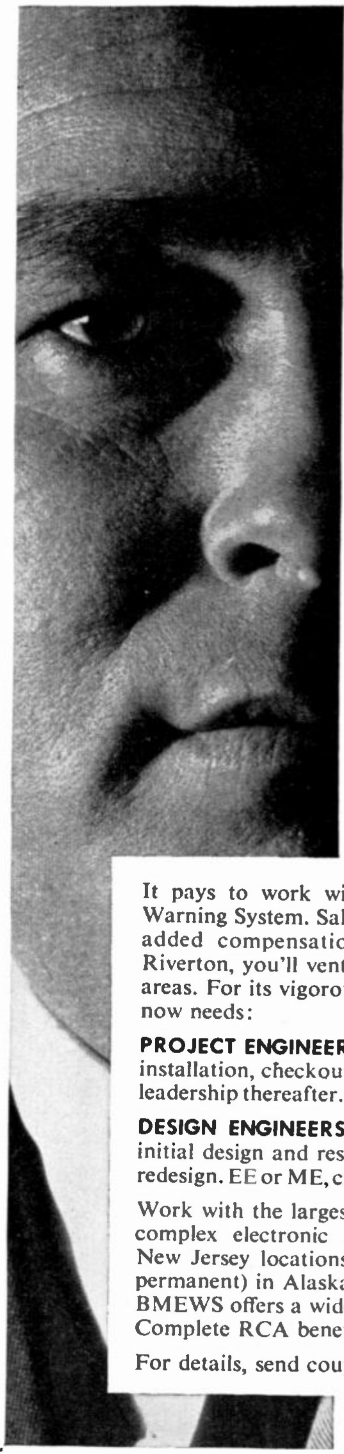

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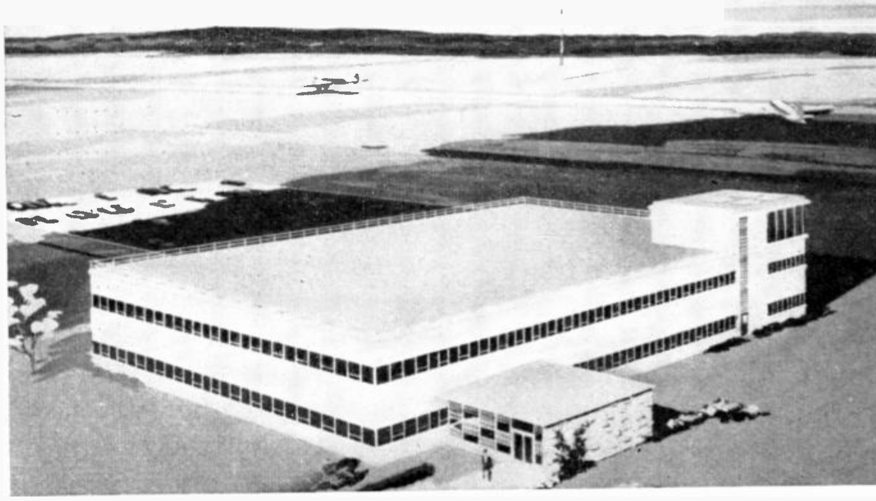

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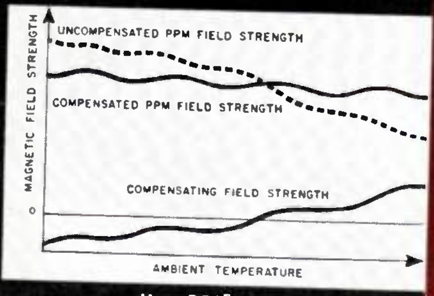

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