VOL. 14, NO. 6

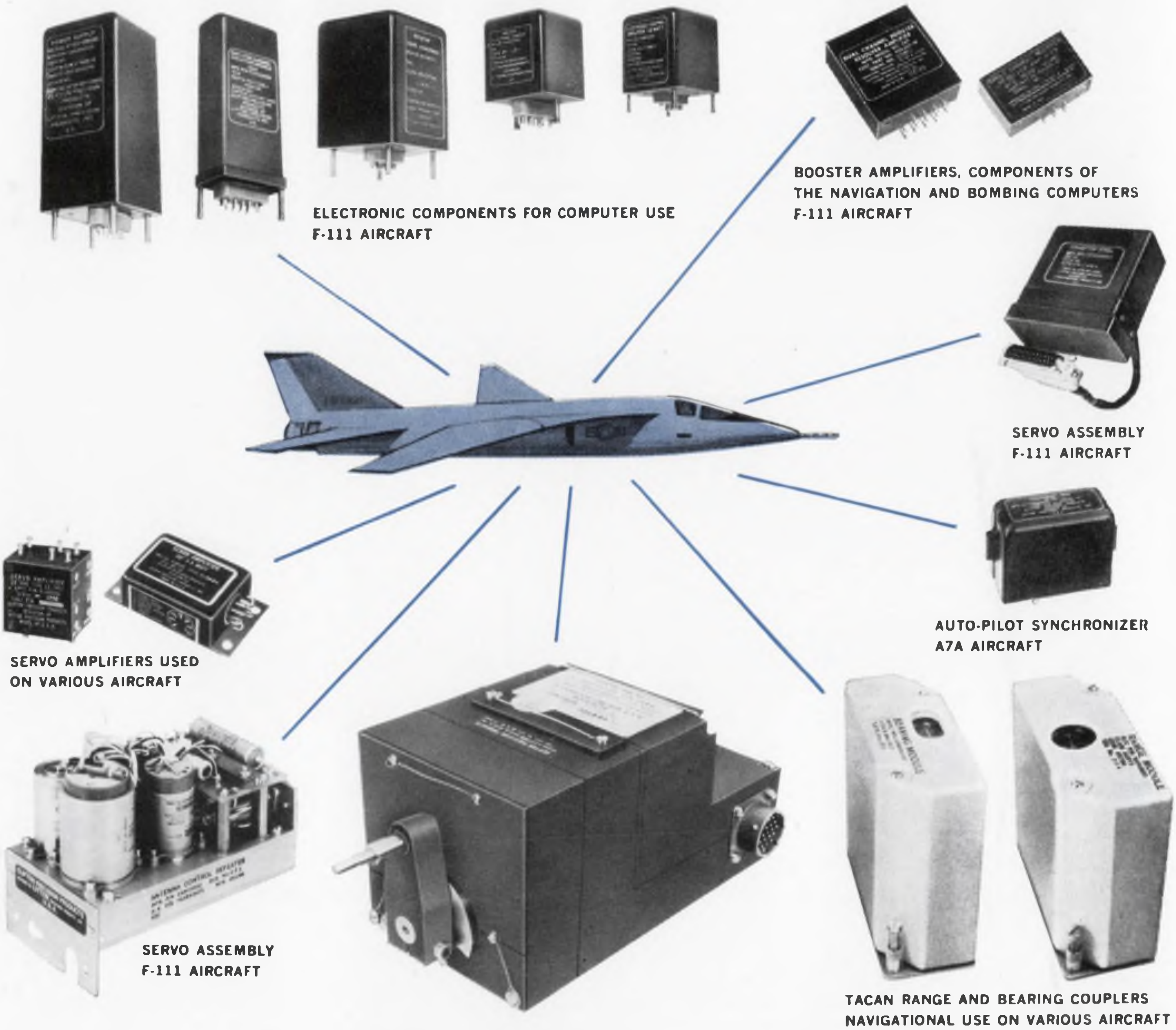
Electronic Design

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

MARCH 15, 1966

IEEE time is here again—this year with more products and more technical sessions than ever. Take a tour through the product exhibits...find out what the speakers will say...analyze the latest trends in technology. Do all of this and more without leaving your desk. How? See the IEEE USA section, **p. U65.**

✓ Check CLIFTON for Servo Packages



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VOL. 14, NO.

Electronic Design 6

THE MAGAZINE OF ESSENTIAL NEWS, PRODUCTS AND TECHNOLOGY

MARCH 15, 1966

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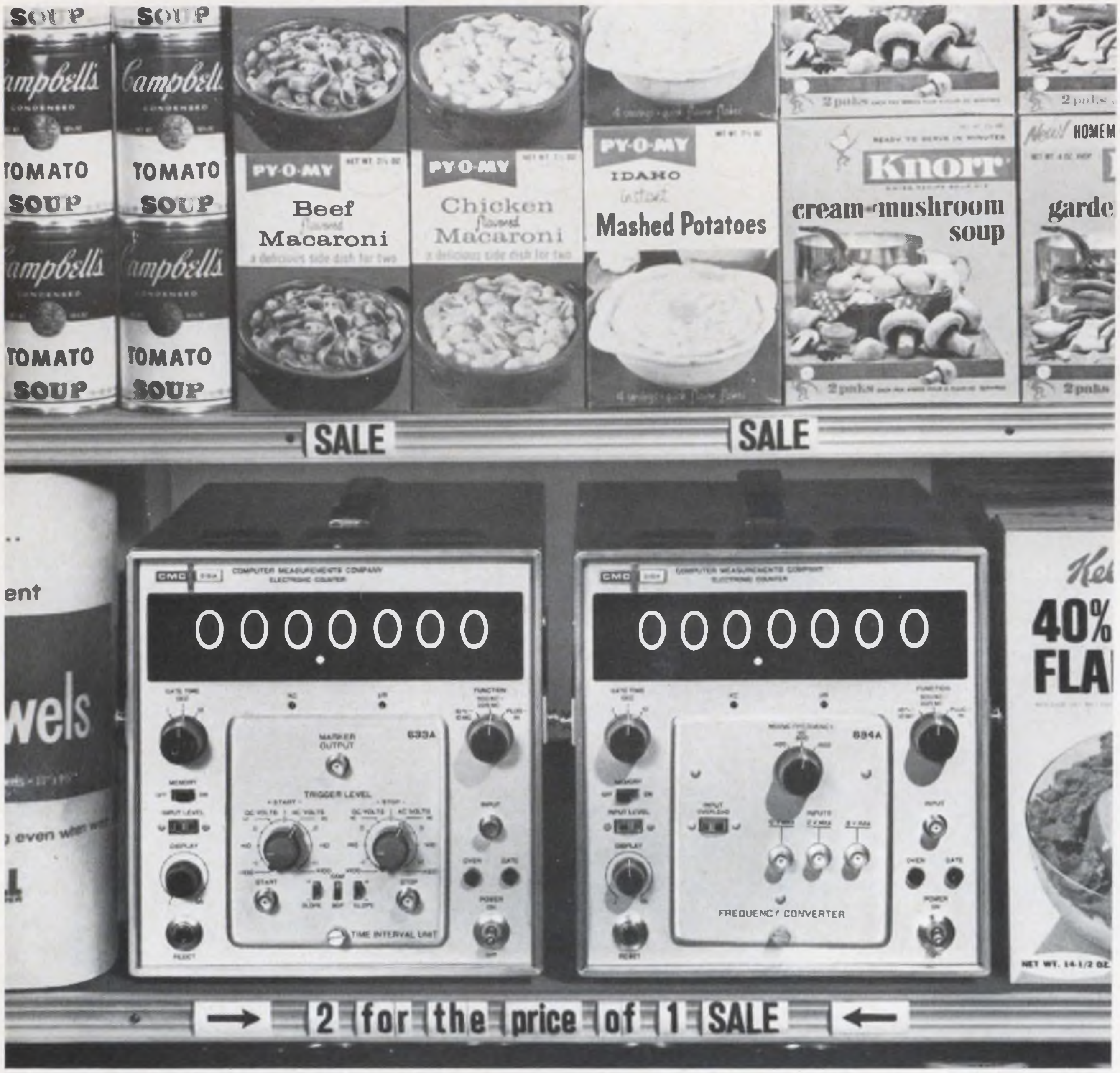

No, it's not the start of a price war. We're simply demonstrating that our new solid-state Model 616A frequency meter costs about half the price of any other comparably performing instrument now available. But, since the 616A is so versatile, who needs two of them anyway? This clever little instrument, with all silicon semiconductor insides, gives you direct frequency measurement through the entire 225 Mc telemetry band, and as high as 12 gigacycles with one plug-in. That's because we cunningly built in the prescaler.

But Hewlett-Packard and Beckman didn't. Theirs is a plug-in to a counter, and the total cost is twice that of our 616A. Then they sell you a second plug-in to measure above 400 Mc. Speaking of plug-ins... the 616A comes well equipped! Slip in a frequency converter or other special CMC frequency extender plug-ins, and your frequency measurements can soar to 1,000 Mc, 3,000 Mc, and even a phenomenal 12 gigacycles! Or, with our time interval plug-ins, measure time from .1 μsec. to 1 sec., or 1 μsec. to 10 sec.

Not only is the Model 616A half the price, but notice, it's half-rack size too! One reason is because, like others in the 600-Series, it features an advanced "mother board" technique. Lost are excess size, weight, and components; gained are new shape, reliability, and ease-of-maintenance. Button it up with its front cover and this rugged 28-pound wizard goes right out in the field.

All this for just $2,185. Interested? Then send now for the complete specs. And, if you're new at comparing our specs to high-powered H-P and big, bad B, you can earn a glorious Crusading Engineers' medal which reveals to everyone that you had the guts to look at somebody else for a change. It's also a great conversation opener for sweet young things you want to dazzle at your next T. G. I. F. party!

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ON READER-SERVICE CARD CIRCLE 3

Excellent stability for 1-watt applications

BW-20 molded wirewound resistors are money savers, too

This IRC molded wirewound resistor offers a low cost solution to tight-tolerance design problems. The average load life change is less than 1%. This excellent stability is the direct result of IRC's unique Hot Clamp termination assembly.

The special cup-lead assembly is heated and flowed around the resistance wire. Wire turns are firmly imbedded in the cup. This eliminates wire shifting or shorting during thermal and mechanical stress.

BW-20 resistors are ideal for low-resistance, low-power circuits in appliances; transistorized auto radios, voltage regulators and ignition systems; and in many commercial and industrial equipments.

The smooth, molded body of this new IRC unit fits all ½-watt automatic inserting equipments. Four forms of packaging are available to cut your assembly costs. The BW-20 can upgrade circuit performance with impressive space and cost savings. Write for data, prices and samples to: IRC, Inc., 401 North Broad Street, Philadelphia, Pa. 19108.

CAPSULE SPECIFICATIONS

Size: .390″ x .140″ diameter.

RESISTANCE:	0.24 ohm to 750 ohms
POWER:	1-watt @ 50°C. Derated to zero @ 150°C.
TOLERANCE—STANDARD:	± 5%, ± 10%
—SPECIAL:	± 2%
INDUCTANCE:	0.22 μh (0.24 ohm) to 2.4 μh (750 ohms)
MIL-R-11 SIZE:	Equivalent to RC20
IRC TYPE:	BW-20

IRC

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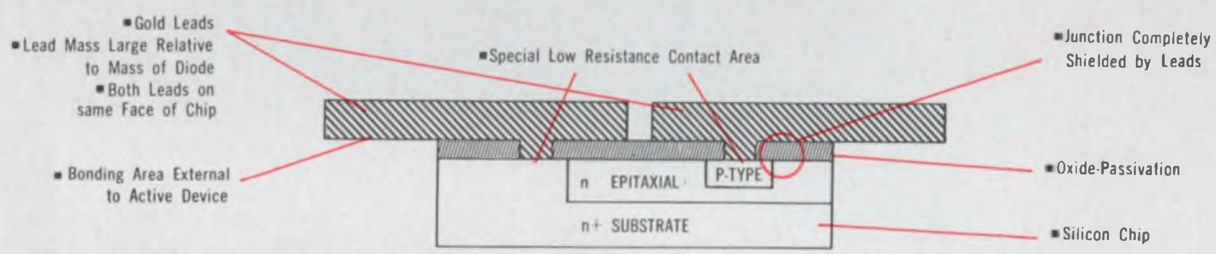
ON READER-SERVICE CARD CIRCLE 4

Now Available from General Instrument...

HERCULEADS™

The ULTIMATE DIODE

actual size



General Instrument's HERCULEADS beam-lead diode is a self-contained diode package with total environmental immunity—the smallest discrete diode available —and it is virtually indestructible.

Ultimate in cost savings

The irreducible minimum in processing achieved via complete batch fabrication and self packaging offers minimum possible cost.

Ultimate in size

The **HERCULEADS** diode is the smallest available. Together with the leads which are uniquely integrated with the diode body, it measures less than 15x30 mils.

Ultimate in reliability

Most potential failure modes commonly associated with diodes, both electrical and mechanical, are eliminated. All bonding leads external to the active device permit simple, economic, high rel connections without the use of eutectics, aluminum or thermal wire bonding. And total surface passivation is assured because of **HERCULEADS'** unique design and metal-over-oxide construction.

Ultimate in versatility

Besides its use as a single, twin lead self-packaged device, the **HERCULEADS** diode is highly adaptable for use in module or stick arrays. Its design and construction make it ideal for automatic handling and positioning, and its pure gold cantilevered leads permit high reliability bonding. Electrical parameters available are comparable to those achieved in the most advanced single-plane devices presently in use.

Electrical Specifications for H100 Series at 25°C

PRV	90 V @ 10 μA
I_F	40 mA @ 1 V
I_R	2 nA @ −40 V
C_D	2.4 pf @ 0 V
t_{rr}	4 ns @ $I_F = 10$ mA to $V_R = -40$ V

HERCULEADS diodes in 10-PAKS are now in stock at your authorized General Instrument Distributor.

Write for full data and specifications.

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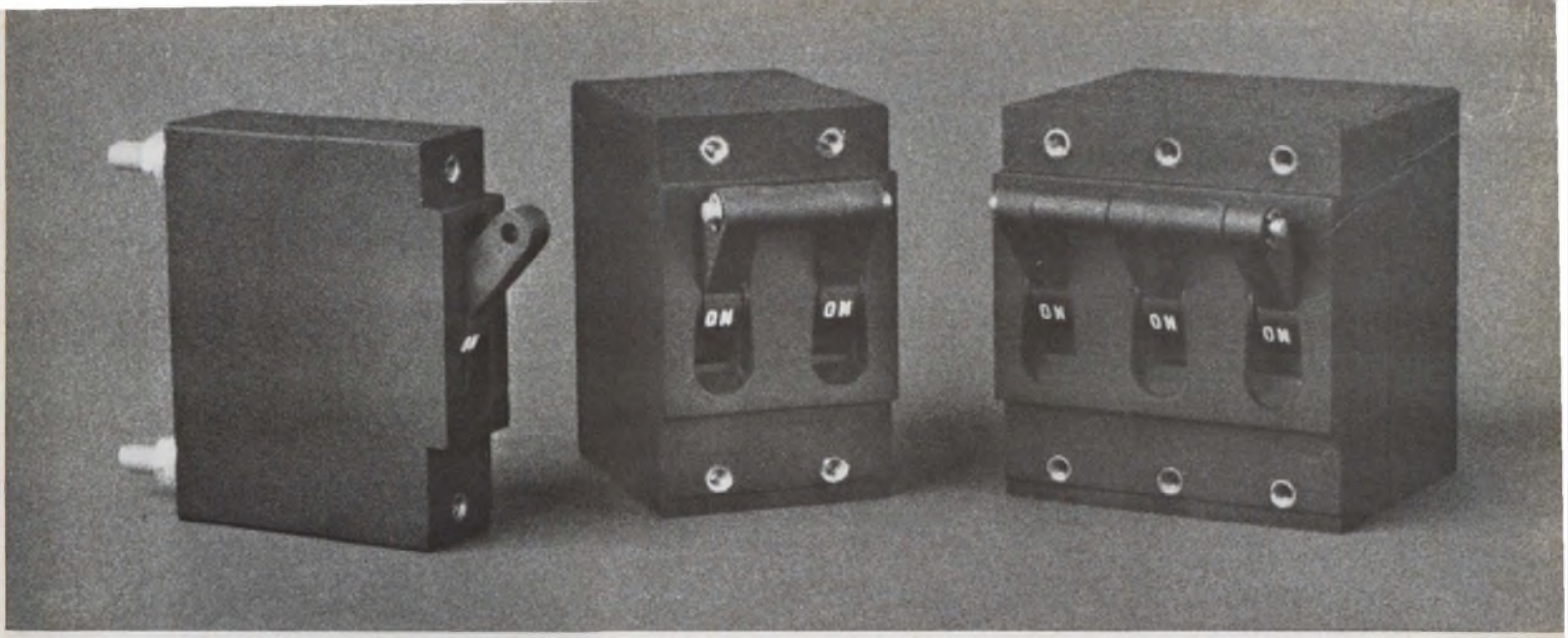
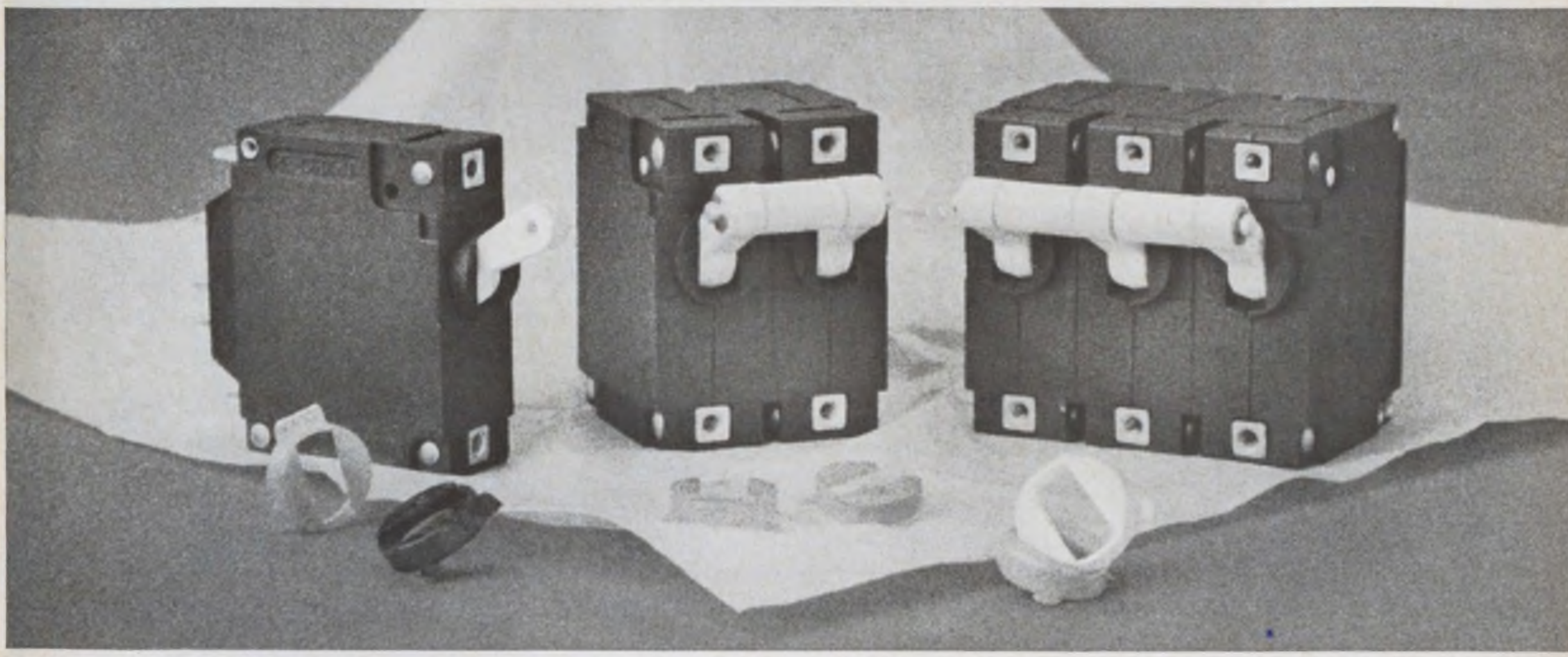


Is it true that the Heinemann Series AM12 is the most popular OEM-type magnetic circuit breaker on the market?



Not anymore.

You're looking at three reasons why. Our new Series JA breaker line.

The new Heinemann JA breaker is one-third smaller and lighter than the AM12.

It is much easier to install (there are no square panel cuts to make).

It is more attractively packaged (note the white handles and the snap-on color caps).

Yet it is available with all the same features and options.

And it carries the same five-year guarantee.

There is one hitch, though. The JA's top current rating is 20 amps, not 50.

But then we're not charging as much for it either.

(For detailed specifications, write for Bulletin 3350. First edition now on press.)

Heinemann Electric Company

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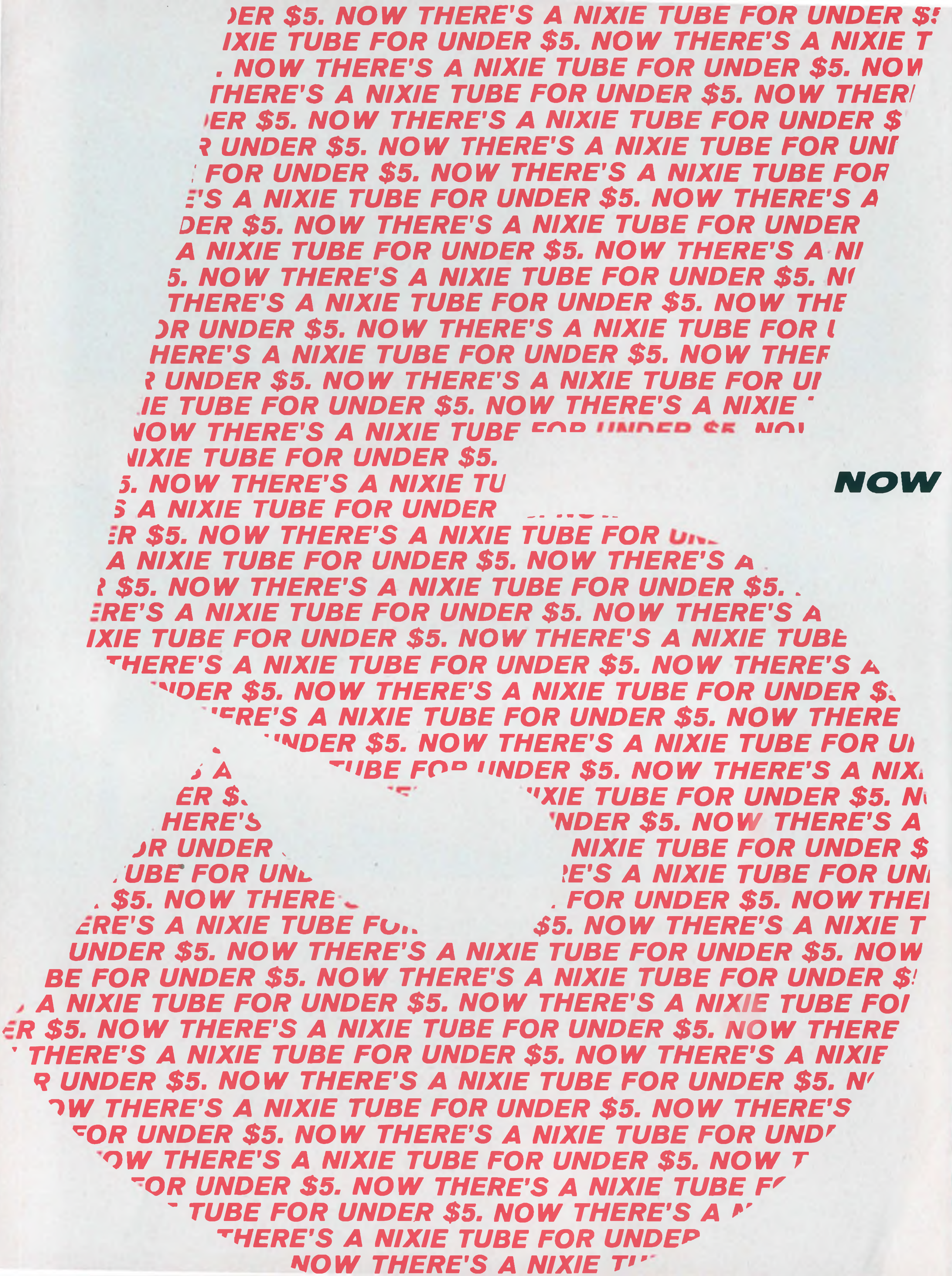
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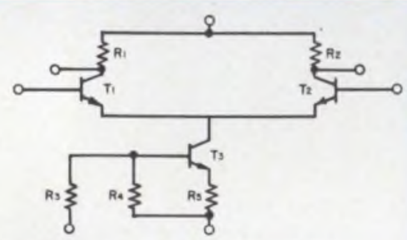
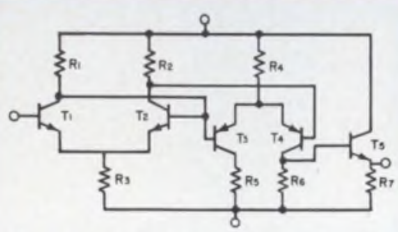
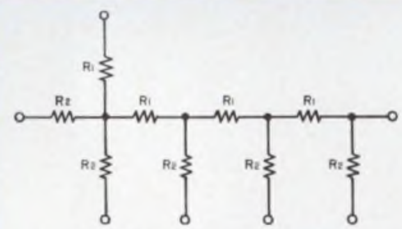


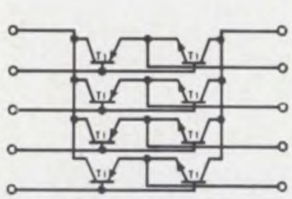
DIFFERENTIAL AMPLIFIER WITH CURREN'



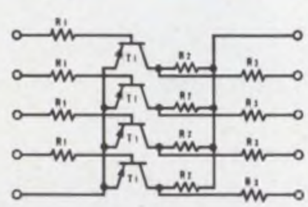
OPERATIONAL AMPLIFIER



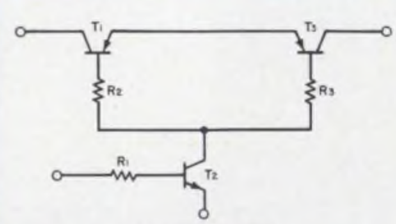
D-A LADDER NETWORK



D-A LADDER SWITCH



D-A BUFFER AMPLIFIER



ANALOG SWITCH

For complete information, write to Technical Literature Service, Sprague Electric Co., 347 Marshall St., North Adams, Mass. 01248

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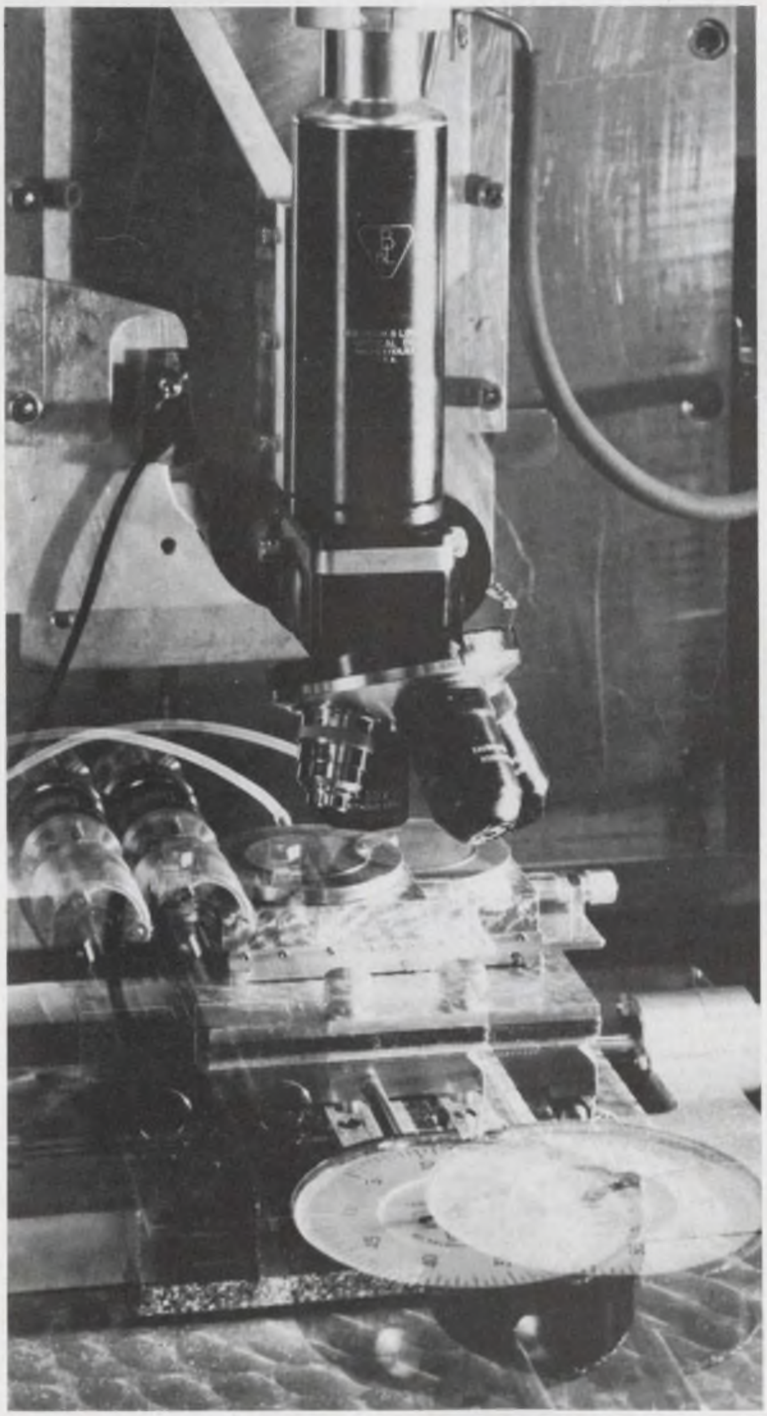
ED News

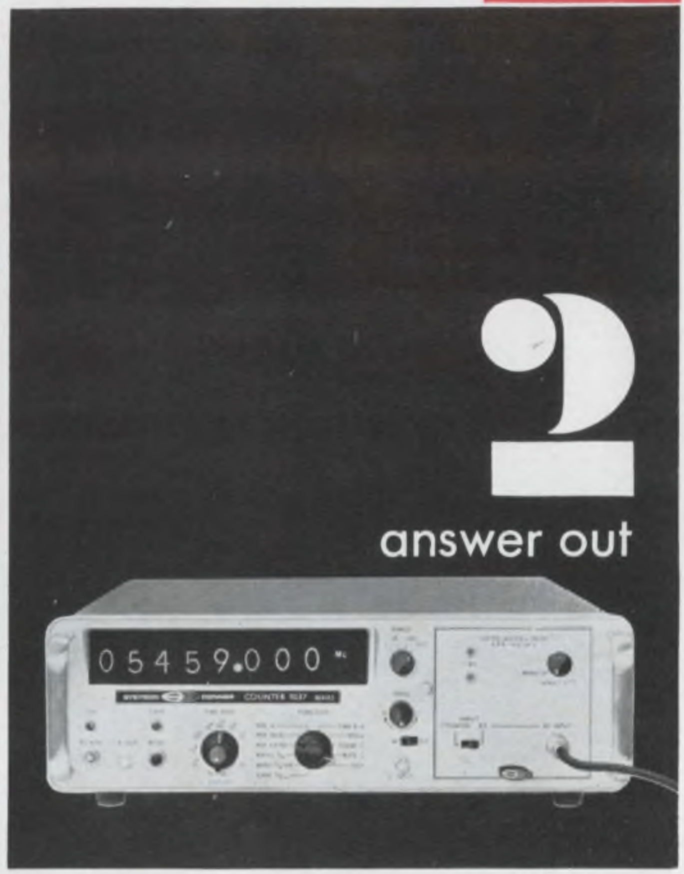
Panel discussions spark solid-state circuits conference PAGE 17
Big role for electronics industry in Federal rail program PAGE 22
Computer wires chip with discretion PAGE 32
ACME to spot flaws in huge radio dishes PAGE 35



If it doesn't work, don't wire it. 32

Voltage readings by "touch." 52

Discussion is the better part of valor. 17



yes, it's that simple to measure microwave frequencies directly

(and with counter accuracy!)

Just connect the input signal and read the answer! Systron-Donner's new frequency measuring system is completely automatic. No calculations, no manipulations of any kind. This great new tool for the lab and production testing will prove to be as necessary as a digital voltmeter.

S-D can deliver this automatic system now for measurements between 3.95 and 8.2 GHz. Soon we'll offer coverage over the rest of the microwave spectrum. The system shown here illustrates the basic concept—a combination of the S-D 50 Mc Model 1037 Counter and the S-D Model 1254 Automatic Computing Transfer Oscillator. Other plug-ins will cover L, S and X bands.

FOR MAXIMUM STABILITY—Systron-Donner exclusively offers a high stability oscillator with an aging rate of *1 part in 10⁹ per 24 hours*. That's a three-fold increase in stability over the best previous oscillators!

Prices: Model 1037 Counter, $2,550. Model 1254 ACTO Plug-in, $1,950. To learn more about automatic GHz counting, please write to us in Concord or contact your nearest S-D sales engineer (listed in EEM).

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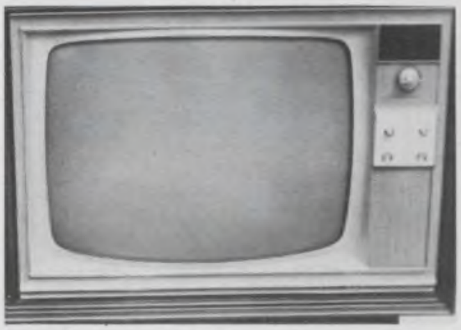
ON READER-SERVICE CARD CIRCLE 8

What size?



News Report

New rule jars TV industry

Much of the television industry is still in a mild state of shock as a result of a ruling by the Federal Trade Commission regarding picture-tube measurements. The new rule, effective July 1, bans the traditional method of specifying tube size—that is, in terms of the over-all diagonal.

After July 1, it will be illegal for a manufacturer "to use any figure or size designation to refer to the size of the picture shown by a television receiving set, or the picture tube contained therein, unless such indicated size is the actual size of the viewable picture area measured on a single-plane basis."

The new rule goes on to say that if the indicated size is other than the horizontal dimension of the actual viewable picture area, the designation must be accompanied by a statement clearly and conspicuously showing the manner of measurement.

In line with its ruling, the FTC provided examples of what will be proper and improper size descriptions for a TV set with a picture measuring 20 inches diagonally, 19 inches horizontally and 15 inches vertically—a picture area of 262 square inches.

PROPER

20-inch picture measured diagonally
19-inch-by-15-inch picture
19-inch picture
262-square-inch picture

IMPROPER

21-inch set
21-inch diagonal set
21-inch over-all diagonal/262 square-inch picture
"brand name" 21

In making the ruling, the FTC said that the practice of unqualifiedly representing picture sizes in terms of the diagonal (in the case of rectangular tubes) or the over-all dimensions of the tubes tends to mislead the public. It also has the effect of diverting business from competitors who do not use unqualified size representations, the FTC noted.

The effects of the new ruling are expected to be far-reaching, especially if the TV industry should adopt the "picture diagonal" method of measurement, as opposed to the other alternatives offered by the FTC. Most TV set designations, would in this case, lose one to two inches, so that what was formerly specified as a 21-inch set would now become a TV set having a 20-inch picture.

A busy period in space

Activity in space has been hectic on both sides of the iron curtain recently, as the next Gemini—number 8—is scheduled to link with an Agena satellite in orbit this week. A two-hour "space walk" is also planned for this mission.

Despite the unfortunate loss in the as-yet-unexplained accident of both Gemini-9 astronauts, that mission's schedule has reportedly not been affected.

And then there were the Russians, embarrassing us again with their Venus crash-landing. U.S. officials are, however, speculating that the hard landing may have been a mistake. But they still did it.

Not too well publicized was the first successful orbit—by the French—of an unmanned satellite recently. Not spectacular by U.S. or U.S.S.R. standards, but *tres bon* in French scientific circles at least.

'Fastest' computer planned

An electronic computer that may be up to 50 times faster than any now contemplated is planned at the University of Illinois. Illiac IV, as the machine will be known, is to pioneer a new concept in special-purpose computer organization. Prof. Daniel L. Slotnick, who developed the concept will head the project.

According to Prof. John R. Pasta of the university, Illiac IV is planned for upwards of one billion computations a second, compared with the eight million of today's fastest machines. To achieve its higher speed, Illiac IV will have one control unit and a very large number of linked arithmetic and storage units. In essence, the organizational concept of Illiac IV can be described as "large-scale, highly parallel."

News Report CONTINUED

Illiac IV is being financed through an $8-million contract with the Department of Defense. Of the total, $6 million is budgeted for construction, to be completed in two and a half years, and $1 million for operation in each of the two following years.

C.B.S. denies video-disc development

Officials of the Columbia Broadcasting System have denied a report that C.B.S. Laboratories has perfected a method of recording video signals on a metal disc.

Although the device has supposedly been demonstrated at the company headquarters in Stamford, Conn., E. K. Meade, vice president of corporate information for C.B.S., states: "We deny we have such a device." But reports persist of C.B.S. activity in the area.

The disc that "doesn't exist" is reportedly seven inches in diameter and three-eighths of an inch thick. It is said to play like a phonograph record on a unit connected to the user's home-TV set, and to record in either black-and-white or color.

RCA reports banner year

Record sales of over $2 billion have been reported by RCA in its 1965 annual report. This represents an increase of 13% over the 1964 sales.

According to the report, color television provided the greatest single stimulus to growth, accounting for one out of every five dollars of current RCA income. Defense business was up over the 1964 figure, with Government business currently accounting for less than 25 per cent of RCA's total volume.

The report predicted further gains for the company in 1966, particularly in the areas of consumer products, data-processing equipment and integrated circuits.

Solid-state light sources being marketed

Visible light from solid semiconductor crystals—hitherto a laboratory curiosity—has become a commercial reality. The Monsanto Co. announces that it has begun to market such devices.

The new light sources are designed for use as instrument signal lights or panel indicators and they have a number of computer uses. The diode-type devices emit a nearly monochromatic red light and have ON-OFF response times of about 8 to 10 nanoseconds.

Typical operating conditions call for the new light sources to be operated at 1.6 volts, with 50 milliamperes of current in the forward direction. When operated this way surface brightness exceeds 50 foot-lamberts. Greater brightness levels occur at higher currents.

Comsat plans global system

The Communications Satellite Corporation has asked the Federal Communications Commission for authority to build six advanced synchronous satellites, to be used in the developing global commercial system.

In filing with the FCC, Comsat expressed the belief that a synchronous altitude of 22,300 miles would be the best orbital configuration for the global satellites. This is the same altitude as Early Bird, the world's first commercial communications satellite, which now links North America and Europe.

The orbital weight of each of the proposed satellites would be approximately 250 pounds, as opposed to 85 pounds for Early Bird. With their increased size, the global satellites would be capable of handling all types of communications—data, television or about 1200 telephone circuits. This compares with 240 voice or phone circuits via Early Bird.

Cost of the six satellites is estimated at $30 million. Comsat is currently engaged in negotiations with TRW/Systems for development and production of the satellites. Launching would begin sometime in 1968. Four of the satellites would be sufficient to provide global coverage. The two others would be reserves.

Recovery operations for the Gemini-8 launch, scheduled for late this month, will be televised "live" from the carrier Boxer. ITT World Communications, Inc., will operate the ground station, the same as it did during the Gemini-6/7 recovery. The pictures will be transmitted from the Boxer to Andover, Me., via the Early Bird satellite.

The formation of an organization for users of computer-circuit analysis programs has been proposed by C. H. Purdue of the Sandia Corp. The primary purpose would be to exchange information, from the user's viewpoint. Those interested can get in touch with Purdue at the Sandia Corp., P. O. Box 5800, Albuquerque, N. M.

Fairchild Semiconductor has undertaken an expansion program that will more than double its research and development facilities by the end of this year. Along with an increase in plant facilities, the company expects to almost double its present R&D manpower level from 450 to 800.

IEEE show exhibit 1F18—1F24

IF IT FLIES...IF IT'S MILITARY...IF IT'S PRECISE IT'S PROBABLY DESIGNED AND BUILT BY

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ALL TYPES OF MILITARY DISPLAYS, COUNTERS AND READOUT ASSEMBLIES

SEND FOR DISPLAY DIGEST

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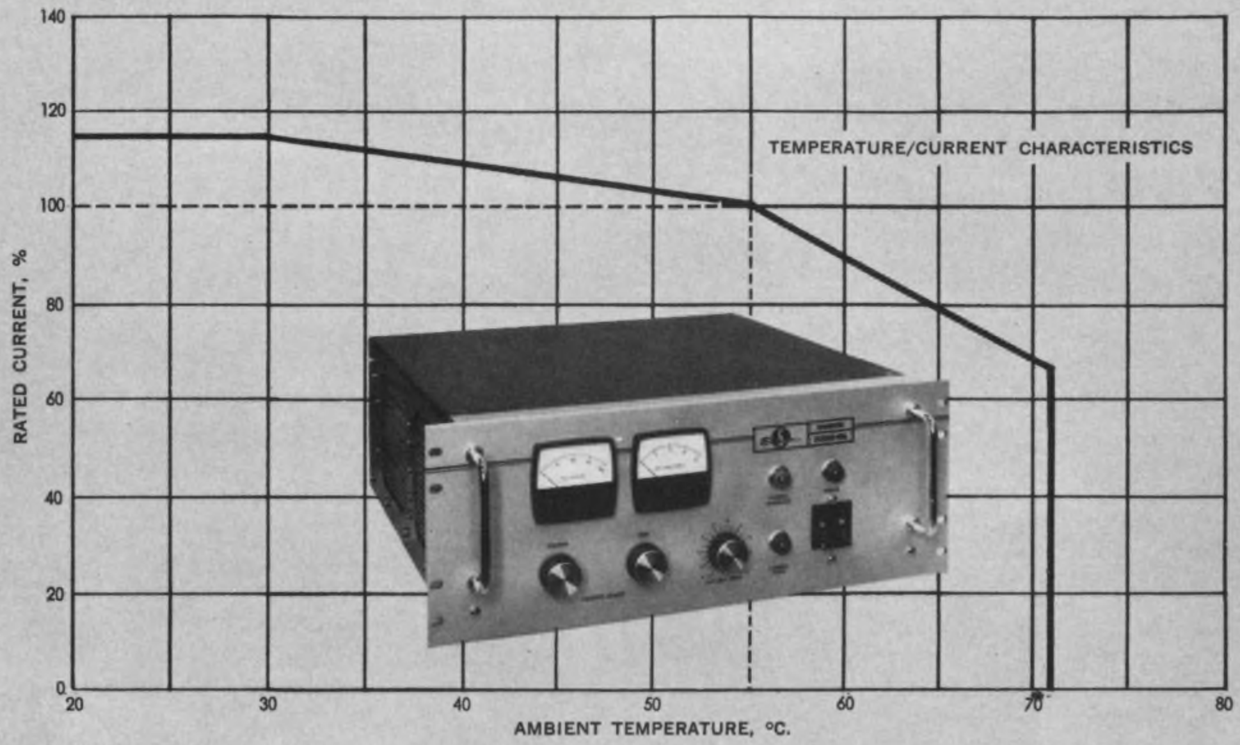

Sorensen DCR Series now with temperature capability to 71°C.

All-Silicon Power Supplies to 20 kW.

Sorensen's wide range DCR Series has been up-dated and improved. What's new about the DCR's? They are now 100% silicon; ambient temperature capability is now to 71°C. • Four 3-phase models have been added extending power capability to 20 kW; 24 models are now available with ranges up to 300 volts. • Multiple mode programming—voltage/current/resistance. • Voltage regulation, line and load combined, is ±.075% for most models • Constant current range 0 to rated current. • DCR's meet MIL-I-26600 and MIL-I-6181 specifications and conform to proposed NEMA standards. • Front panel indicator for voltage/current crossover. These features of the improved DCR (model numbers will have an "A" suffix) are offered at no increase in price.

For DCR details, or for data on other standard/custom power supplies, voltage regulators or frequency changers, call your local Sorensen representative, or write: Sorensen, A Unit of Raytheon Company, South Norwalk, Connecticut 06856.

MODEL SELECTION CHART

Voltage	Amps.	Model	Price	Amps.	Model	Price	Amps.	Model	Price	Amps.	Model	Price
0- 20	125	DCR 20- 125A	$1055	250	DCR 20- 250A	$1495	—	—	—	—	—	—
0- 40	10	DCR 40- 10A	325	20	DCR 40- 20A	525	35	DCR 40- 35A	$ 710	60	DCR 40-60A	$925
0- 40	125	DCR 40- 125A	1350	250	DCR 40 -125A	1995	500	DCR 40-500A	2950	—	—	—
0- 60	13	DCR 60- 13A	525	25	DCR 60- 25A	710	40	DCR 60- 40A	900	—	—	—
0- 80	5	DCR 80- 5A	325	10	DCR 80- 10A	525	18	DCR 80- 18A	710	30	DCR 80-30A	875
0-150	2.5	DCR 150- 2.5A	325	5	DCR 150- 5A	525	10	DCR 150- 10A	710	15	DCR 150-15A	825
0-300	1.25	DCR 300-1.25A	325	2.5	DCR 300- 2.5A	525	5	DCR 300- 5A	710	8	DCR 300- 8A	825

Sorensen

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ON READER-SERVICE CARD CIRCLE 200

LSI highlighted at solid-state conference

Large-scale integration: yea or nay, FET or bipolar, standardization debated. Lively meet also explores micropower, RF, linear, microwave, memory devices.

Editors **Joseph Casazza, Rene Colen, Roger Field, Richard Harnar** and **Mark Leeds** contributed to this article.

The ever-growing complexity of integrated-circuit arrays—becoming known as LSI (large-scale integration) formed the keynote for the 1966 International Solid State Circuits Conference in Philadelphia last month.

- Two LSI sessions were sparked by debates over FET vs bipolar approaches, and various companies discussed techniques.
- A tutorial session on Gunn and Read effects included computer-generated motion pictures of solutions to the basic equations for the effects.
- The MOS technique is invading micropower circuitry.
- RF transistors are being designed for higher powers, to hundreds or thousands of watts.
- Linear ICs are becoming as common as digital types.
- Thin-film memories still hold an edge over semiconductor types.

What and where is LSI?

When does an integrated circuit become an LSI circuit? Joseph C. Logue of IBM sets the borderline at 100 digital logic circuits per chip (a NOR, NAND or equivalent).

Under this definition, the LSI goal has not yet been reached. But Jack Kilby of Texas Instruments, speaking also at the conference keynote session, said that "it is quite realistic to project, by extension of present techniques, 100-gate units of random logic with either the MOS or bipolar technique in the next few years."

Bipolar LSI is better for logic circuits; FET types will end up in smaller, slower machines, agrees the Keynote Panel (l to r, seated) R. B. Seeds, J. Kilby, J. Logue, G. B. Herzog and (standing) J. Raffel and E. A. Sack.

Where are we now? Bipolar 4- and 6-gate packages are readily available, and 15 to 20 functions per chip will be announced this year, Kilby said. In MOS, 15- to 20-gate units and 20- to 100-bit shift registers have been designed.

These figures seem to indicate that the MOS-FET approach to LSI has a good lead. But the 30-ns delay per package achieved by FETs is not fast enough for large systems of 2000 circuits or more, Logue asserts. "As technical problems are solved and LSI penetrates this performance region, we should see FETs losing ground to bipolar devices," he said. At present, however, FETs are still attractive for small, comparatively slow, systems such as memories.

With the possibility of a "runaway technology," a call for LSI standardization is being heard. E. A. Sack of Westinghouse gave the following reasons for establishing standards now: Economies would be possible in the production, packaging and testing of LSI circuits (these items now account for the major part of the costs), and requirements for second sourcing of devices would be facilitated.

The "standard" LSI package is apparently a long way from realization. Should the leads come from the side of the package or the bottom? Will 25- or 10-mil spacing of leads be the standard? What will the next level of external connections be after the 14-lead pack: between 48 and 64 pins? —RH

LSI production problems debated

Three recent production advances in LSI were discussed by another panel.

These are multi-layering of interconnections on a chip, the use of organic insulators in conjunction with molybdenum-gold evaporated connectors, and the use of computer-programed discretionary connection of redundant circuit functions.

Multi-layering techniques have been developed by Motorola of Phoenix to use four layers of connectors. No unusual problems have interfered with the manufacture of these complex structures, and although only small batches have been tested, there is no evidence that these layered connections are unusually fragile. At present, arrays of 4-by-4 memory cells are completely interconnected by the top two additional metalization layers after the first two intraconnect the cells themselves. One distinct advantage to yields is that the cells can be tested after the completion of the second metalization. Then, only chips that have a high number of working, adjacent cells are cut up, so that these good cells can be interconnected.

Texas Instruments, too, has been experimenting with multilayered interconnectors. According to one panelist, J. Lathrop of TI, his company has been using an organic insulator for the upper interconnectors. This insulator is poured into the chip as a liquid, which tends to fill up holes and sharp edges that would be fatal to inorganic insulators. In this manner connector layers can be applied to whole wafers at a time.

The Motorola representative, Raisenen, asked Lathrop: "Why did TI elect to depart from the customary aluminum metalization and silicon-oxide insulation and go to what I would consider a potentially unreliable organic insulation and moly-gold metalization system?"

Lathrop replied: "That's like asking, 'Have you stopped beating your wife?' We departed from the standard aluminum, silicon-dioxide method because, first of all, we don't use aluminum; we use moly-gold. Secondly, we found that silicon dioxide doesn't work. It seems like a simple

(ISSCC, ***continued*****)**

thing to put down an insulating layer, but very few people have interconnected 120 gates. The reason has been that no one has gotten a compatible metal-insulator system that will fit on top of a semiconductor chip. We don't look on this organic material as the ultimate, but at least it has allowed us to get into the computer design of masks."

Lathrop then explained that organic insulation was fine for most commercial and industrial purposes. "You don't heat your computer to 300°C to see how long it'll last," he said. At 125°C the organic insulation will shrink only 5% in weight in 8000 hours, he pointed out. Tests show, he said, that devices can tolerate a 50% shrinkage before they run into difficulties.

There has been a great deal of talk about discretionary connection by computers in large-scale integration. One panelist, R. S. Shahbender of RCA, pointed out that a good portion of the investment in tooling up to make integrated circuits was in making the masks. Also, most of the failures, he said, can be traced to small errors in this operation.

Raisenen insisted that the audience shouldn't put all its hopes on computer-programed, discretionary wiring. He said that the computer is not like "a hole in the wall to which one shouts questions and gets answers." It is costly to rent and program, he pointed out. —**RKF**

Micropower design discussed

Conferees at the informal discussion session on "Elements of Micropower" were treated to the "how to" aspects of micropower design. Linear and switching systems constituted the main subjects, as the panel dwelt on the role of both bipolar and MOS devices.

R. D. Lohman of the Electronic Components and Devices Div. of RCA covered the growing role of MOS transistors in micropower applications. He cited their "negligible standby power, low dynamic power, good noise immunity and high-speed attributes" as meeting the demands of very-low-power digital circuit needs.

Lohman suggested that further power savings accrued when an MOS device, instead of a resistor, was used as the load in logic circuits. Operating as a voltage-variable resistor that is clocked in and out, this extra MOS unit also provides faster switching speeds and lower output impedance.

The all-important aspects of beta (h_{fe}) changes and leakage variations of bipolars in high-radiation environments were considered by A. R. Molozzi of the Defense Research Board, Ottawa, Canada. He pointed out that second-order effects here, especially in near-earth orbits, cannot be neglected. "Aging is as important a factor in micropower design as the circuit itself," he added. The worst-case design must incorporate aging effects and their influence on h_{fe} and I_{cbo}.

"Low-current operation is a must here, and it is in the low-current regions of the transistor where the parameter variations are greatest," Sarles said. The two suggested that annealing be used to minimize the surface effects.

Bulk effects in these environments are marked by decreases in gain, slower transit times and large impedance changes. Leakage currents, however, rise—sometimes by as much as 1000 times.

"For the best performance, small-area devices made up of high-quality oxides should be used. These should typically be heavily doped units with thin bases, to keep h_{fe} high and I_{cbo} low," Molozzi said.

The discussion concluded that bipolar devices were still the trendsetters for linear signal systems and that the MOS might soon be dominating the data-processing (switching) applications in the micropower realm.

More power for RF transistors

A discussion of high power RF circuits indicated that engineers would soon be buying high-frequency transistors capable of accommodating hundreds and even thousands of watts.

Over the last few years the major developmental effort on high-frequency transistors has been aimed at pushing the upper frequency limits up and up. Relatively little has been done to increase the power-handling abilities of these units; tens of watts at 50 MHz or so has been peak. However, recent advances in device technology, improved microelectronic disciplines and a better understanding of high-power, high-frequency circuit design point to the emergence of more powerful transistors for these RF applications.

Complementary MOS pairs are ideal for micropower digital circuits—R. D. Lohman.

Typical of these will be a device capable "of 500 watts output at hundreds of megahertz," said George C. Luettgenau, Research Director of TRW, Inc.

Luettgenau also described the RF transistor of the future as a "super compote of many transistors, interconnected in a one-inch-squared encapsulated circuit."

"This device," he predicted, "will incorporate integrated as well as discrete elements, such as built-in bypass capacitors, and will closely resemble an array in structure."

This opinion was reinforced by another panel member, Donald R. Carley of RCA's Electronic Components and Devices Div. He pointed out that "case developments will be a major factor in these higher-power, high-frequency units of tomorrow." The packages, he said, will feature strip-line and coaxial-line elements, so as to accommodate better the power levels involved in operating at frequencies of 1GHz.

Carley emphasized that individual transistor pellets were now near their ultimate limitations in high-frequency, high-power capabilities: "output impedances can't go much lower, and the packages themselves are as much a part of the input impedance as the devices."

Still another panel member, Neil DiGiacomo of the Wright-Patterson AFB Avionics Laboratory, amplified on the role that IC techniques would enjoy here. He suggested that "a hybrid combination of multi-chips with built-in, etched, discrete inductors on the same sub-

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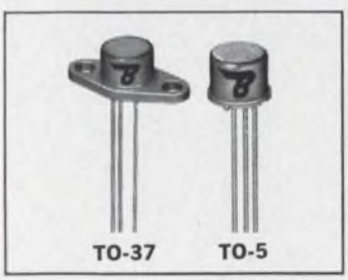
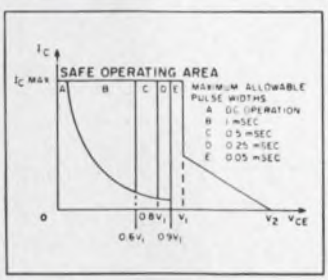
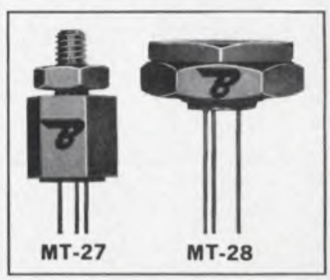




TYPE NUMBER	Ic Amps	V1 Volts	V2 Volts
DAPS 2N2282—2N2284 2N2467—2N2469	3	30 to 70	70 to 110
ALLOYS 2N1038—2N1045 2N2552—2N2567	3 to 3.5	30 to 60	60 to 90



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ON READER-SERVICE CARD CIRCLE 10

(ISSCC, *continued*)

strate as the transistors will be the form of the high-power, high-frequency device."

"These will include," he said, "protection from high VSWRs due to load changes, matching networks and RF Darlington circuits with very-low collector capacities."

The panel cited present device capabilities and a pool of solutions to circuit-design problems as a springboard for predicting what's in the wings. K. H. Fischer of the U.S. Army Electronics Command, R. C. Hejhall of Motorola Semiconductor Products Div. and R. Etherington of General Electric Co. contributed to the discussion here. They and the others on the panel pointed to following achievements:

- For straight CW power at 75% efficiency, 50 W at 150 MHz, 10 W at 500 MHz and 100 W at 5 MHz are now obtainable.
- For ssb operation, 25 W at 30 MHz and 20 W at 75 MHz, with the third harmonic at least 30 dB down, are now commonplace.
- For RF pulse operation, 100 watts per stage at 100 MHz can be achieved; paralleling is used to produce kilowatts of output.
- For a single wafer in a Class C RF amplifier, 5 to 10 watts at 1.0 GHz designs can be built with 8 dB power gains and 60% efficiencies.

The panel also touched on the role of field-effect devices in these high-frequency, high-power applications. Luettgenau said that junction-FETs might soon be capable of handling watts of power at hundreds of

Basic mechanisms of Gunn & Read effects are now well understood, thanks to computers, Alan Chynoweth tells a tutorial session.

megahertz. He outlined a FET power structure with parallel vertical channels that formed a grid-shaped gate and said this configuration would eventually do the job. He added that the square-law properties of FETs made them ideal here, but that the stability problems of FETs were worse today than with their bipolar counterparts. He predicted, however, that these problems would be solved soon. —MBL

More linear ICs foreseen

An evening panel session on "Linear Integrated Circuits" seemed to generate more interest in where and how the devices could be used than in any problems that manufacturers might be encountering.

"The argument that there are problems in manufacturing linear integrated circuits is rubbish," said Robert Widlar of Fairchild Semiconductor.

No one seemed inclined to dispute him.

Widlar pointed out that linear integrated circuits could be made as easily and as well as digital ICs are now being made. He warned, however, that their advantage in circuit design would be realized only by fully employing their unique properties of good device matching and tight temperature coupling. As an example, he said, with the use of ICs, one can use diode bias for transistors, whereas such a bias scheme with the use of discrete components would be expensive and undesirable.

H. C. Lin of Westinghouse supported this view, by pointing out that differential amplifiers built in integrated-circuit form could be much more temperature-stable because of the tight temperature coupling between the differential pairs, more so than with designs that use discrete components.

One recurring question in the audience concerned the establishment of standard amplifiers and standardization of circuit parameters and representation. According to J. Solomon of Motorola, Inc., it seems doubtful that a universal amplifier would be feasible. Circuit demands vary greatly and would not be satisfied by one or two standard amplifiers, he said. In addition, since mask costs are not high and the costs of IC tooling are being quickly reduced, the real determining cost factor becomes the design cost, according to Solomon.

Michael Gay of the Plessey Co. in England described some of the devices his company had recently produced. Within the next six months, he said, his concern will have some 15 linear ICs on the market. Already being marketed are linear wideband amplifiers with typical upper cut-off frequencies of 100 MHz and a log amplifier with a 170-MHz upper cut-off. These devices are primarily intended for IF strips operating in the 10-to-100-MHz region. The intent of the designs is to minimize the number of external components needed. Even the rather large junction type of decoupling capacitors (550 pF) are placed on the chips. One of the IFs built with these devices was a log amplifier that uses four IC packages and two discrete capacitors. This amplifier has a log range of 48 dB ±5 dB from 12 MHz to 120 MHz. Its noise figure is 5 dB.

One problem in the use of ICs was brought out by a member of the audience who asked whether any standardization on required supply voltages would be forthcoming. The answer from a panelist was that "it is a problem." The solution he gave was to design circuits that would tolerate large supply variations. Solomon said such designs might involve larger power dissipations. He also discussed Motorola's program to manufacture a line of integrated power supplies with current-handling capabilities up to 1 amp. This will be accomplished, he said, by diffusing reasonably good zeners onto the chips and by using discrete zener chips mounted inside the power-supply package.

Other panelists were J. G. Linvill of Stanford University; L. Housey, Texas Instruments, Inc., and W. Engl, Institute fur Hochsfrequenztechnik, Braunshweig, West Germany. The moderator was R. S. Pepper of the Sprague Electric Co.—RC

Integrated memories: film vs semiconductors

The consensus of an evening panel session on high-performance memory electronics was that magnetic thin film memories still have the edge over semiconductor types. The costs of both types still remain high, but the appearance of the MOS device and improved manufacturing techniques should result in lower prices, the panelists agreed.

Complementary MOS transistors that draw no standby power will improve the position of semiconductor memories, according to J. D. Schmidt of Fairchild Semiconductor, although bipolar devices are faster and magnetic memories still provide larger system capacity at lower cost. Schmidt described a 150-ns semiconductor memory with a capacity of 2 x 10^4 bits, at a cost of less than $1 per bit; he said it should be available this year.

Magnetic-film memory advantages were discussed by Harley Kukuk of Fabritek, Inc., who described a planar film system with a 10^6-bit capacity and a speed of 0.25 μs; it costs about 15 cents per bit. Fabritek expects to have the memory available this year. According to Kukuk the cost of a film-memory array accounts for less than half the total system cost, with the associated electronics accounting for the larger share. Cost-per-array remains fairly constant and increased array density will reduce cost.

In the opinion of G. A. Fedde of the Sperry Rand Corp., memories using the word-select scheme get rid of the penalty of nondestructive read-out, and he expects a system of this type to be available in two to four years with a capacity of 10^6 bits, a speed of 1 μs and cost of less than 1 cent per bit.

Also on the panel were J. H. Wuorinen, moderator, of Bell Telephone Laboratories, Inc., L. Heusie of Texas Instruments, Inc., and H. Yourke of IBM. —JJC

Integrated-circuit memories are still getting competition from thin films.

Full speed ahead for high-speed trains

150-mph tests planned in Jersey this year, as U.S. presses electronics-oriented transit program with extra R&D millions in the new budget.

S. David Pursglove
Washington Editor

The Government's high-speed rail research program, with stress on electronic controls, is scheduled to move from the planning board to the roadbed this year. By fall, Commerce Dept. officials say, test trains will be whizzing at 150 mph in New Jersey. By year's end, hopefully, faster and more frequent railroad service will begin between Washington and New York.

Unlike most other non-war activities, funds for the High Speed Ground Transportation Research and Development Program were not cut in the 1967 budget. Shortly after the new fiscal year opens July 1, the program expects to let at least $13 million in contracts.

The 1967 budget follows previously announced plans to spend $90 million over three years—two-thirds on R&D and one-third on a demonstration program and a national statistics-gathering project. Most of the money will go into engineering research, with a very large part of it in electronic areas.

For 1967 the Commerce Dept., where the program is centered, is authorized to commit $19,285,000 on engineering R&D, compared with only $1 million in 1966. Officials at the department told ELECTRONIC DESIGN that the three areas requiring greatest effort in the coming year were guideways (tracks, tubes, etc.), vehicle power and control. Two other engineering R&D areas will also receive appreciable attention: materials and aerodynamics.

Many electronics concerns and a large segment of the electronics-oriented aerospace industry have been bombarding the Commerce Dept. with queries on the program's operation, the immediate and long-range plans, and the contract procedures. One Commercial Dept. official said: "Companies have asked us to send everything we have on rail transit that's been printed, mimeographed or even scribbled" (see accompanying list, containing what the program's officials believe are the more useful references).

A key role for electronics

Why is the electronics industry so excited about this new program? Here is how one Commerce official answered the question:

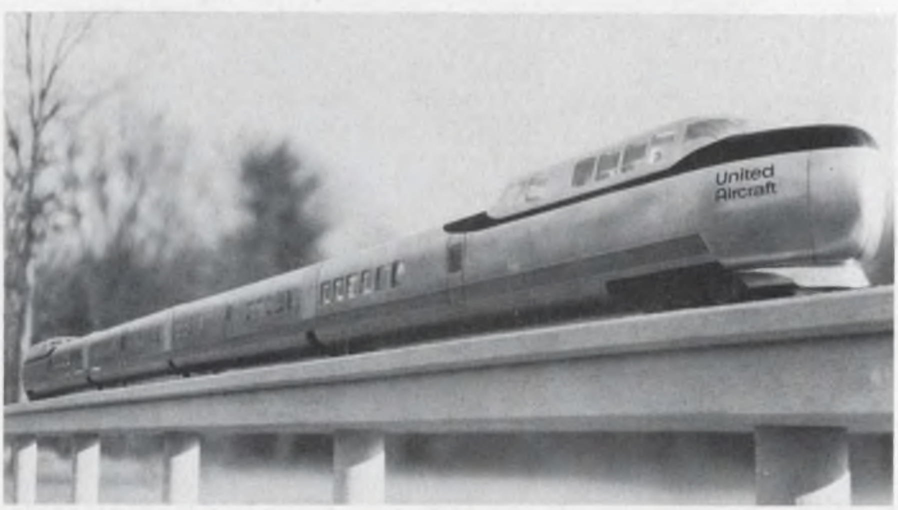
"At the risk of seeming to answer one question with another, the industry is likely excited for the same reason that many of our people in the program are virtually on a hot line to the industry. When you're running 10 trains between Washington and New York just minutes apart, and they're moving up to 160 mph on a single track that they can't veer from, then you darned well want to know where each of your trains is at all times. You want to gauge danger situations and signal those trains to slow or stop, or even to speed up, and you want them to respond immediately.

"You want a reliable, high-speed decision maker to help you out here. And you want those trains to be able to spot other trains—or something else—ahead and slow down automatically. And you've got to price this whole operation low enough to attract riders; so you've got to automate wherever you can—on the operation side and on the business side. That's why we think we have as much call on electronics people as the aviation industry does."

The problems of controlling very-high-speed rail traffic were discussed seriously in debate on the Mass Transportation Act of 1964 and the High Speed Ground Transportation Research and Development Act of 1965. That is when the U. S. public began hearing about the fast, reliable, heavily automated rail service in Europe, and about the extremely high speeds reached on the almost totally automated rail systems in Japan. Some segments of the public began asking: "Why can't we, too?" Congress appropriated funds for studies. Even original skeptics now agree that the U.S. can have high-speed, automated rail passenger service. Few believe that the Federal program will taper off after the planned three years.

Japan leads the way

Right now the fastest train in North America is the Canadian National Railways' "Rapido." It aver-



Gas-turbine engines will power this high-speed train designed by United Aircraft. Two such trains will be used in a demonstration project between Boston and Providence as part of the Commerce Dept.'s Northeast Corridor Demonstration program.

ages 67 mph and hits 93 mph on the 335 miles between Montreal and Toronto. The "Rapido," though, is a slowpoke compared with trains on Japan's 320-mile Tokaido System between Tokyo and Osaka. They make the trip in four hours, frequently hitting 125 mph, and they have done 160 mph in test runs. Engineers respond only to signals sent from a central control station, which collects data by TV and analyzes it by computer. The engineer is really only a monitor; the electronic system can operate the trains without engineers.

It is the Canadian National feat that the U.S. will first seek to emulate, beginning in the Northeast Corridor, which stretches from New England to Washington. By 1980 the American R&D program hopes to top the Tokaido System.

Three projects to start program

To begin measuring public acceptance of New York-to-Washington rail transportation comparable to the Canadian "Rapido," the Commerce Dept. is subsidizing an experiment on the Pennsylvania Railroad. Some 50 cars, each electrically powered but also capable of operating in multiple-car trains, will be built for the Pennsy. The cars are to be capable of sustained speeds of 120 mph and top speeds of 150 mph. They are to be able to accelerate and decelerate rapidly, to take advantage of short stretches of track and thus permit high average speeds. The new cars will be fitted into the railroad's normal Washington-New York and New York-Philadelphia operations.

The most highly publicized test phase of the Commerce Dept.'s R&D program is to be conducted at the same time as the Pennsylvania Railroad experiment. This will involve four specially built, stripped-down cars that will be purchased for about $240,000 each from the railway division of Budd & Co. The cars will be run in New Jersey on a carefully maintained stretch of track between Trenton and New Brunswick. They will be outfitted to measure track profile, riding qualities and other characteristics, and to test such prototype hardware as trucks, suspension systems and catenaries.

At the same time a third project will get underway. The New Haven

(Continued on p 26)

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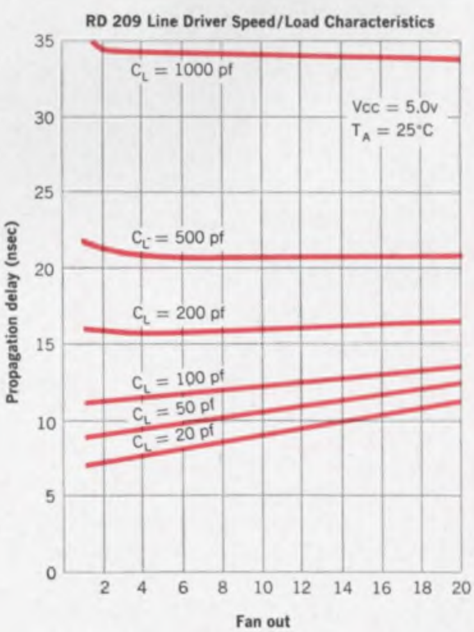

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ON READER-SERVICE CARD CIRCLE 13

(**High-speed trains,** *continued*)

Railroad and the Commerce Dept. will conduct a Boston-to-Providence demonstration, similar to the test on the Pennsylvania. This New England test will use gas-turbine-propelled cars, since the line there is not electrified. United Aircraft and Pullman-Standard will provide two trains of three cars each under a $2.1-million, two-year lease and maintenance contract. The trains will have top speeds of 160 mph.

Projects still being sought

Spearheading the Government's role in all of these programs and in a wide range of smaller research projects soon to be announced is Alan S. Boyd, the Commerce Dept.'s Undersecretary for Transportation. The engineering R&D is being done in the Office of High Speed Ground Transportation, headed by Dr. Robert A. Nelson.

Dr. Nelson says that feasible projects are still being sought for inclusion in the program. Any probable approach will get a personal hearing, without the need for a formal proposal, he said. One area for which R&D funds are slated is investigation of the linear-induction motor and its possible use for high-speed rail transportation.

Although the coming year's R&D contracts are still not set, there is little question that the plans for heavy electronics research will be carried out. These include such areas as communications, high-speed data processing and control.

The direction that some of this research may take is indicated in a study made for the Commerce Dept. by the Massachusetts Institute of Technology. Part II of the study, entitled "High Priority Research Tasks for High Speed Ground Transport," identifies 22 research programs that should be undertaken as soon as possible. Some of the titles alone in the report point to the electronic designer's role in high-speed rail transportation. These include: "Computer Control of the network"; "Communications"; and "Dynamics and control of vehicle groups".

Useful facts on high-speed rail design offered

Want information on high-speed rail transportation?

The following documents are available from the Commerce Clearing House, Springfield, Va. 22151. They should be ordered by number.

- "Report on Research Project on High-Speed Railroad Operations Within the New York Metropolitan Area in Connection with High-Speed Service Between Washington, D. C., and Boston, Mass." (156 pp.), Col. S. H. Bingham; $4. **PB-166887.**
- "Preliminary Engineering Report on Improvements to Railroad Passenger Service Between New York and Washington" (135 pp.), Louis T. Klauder & Assocs.; $4. **PB-1668879.**
- "Supplemental Report on Improvements to Railroad Passenger Service Between New York and Washington" (123 pp), Louis T. Klauder & Assocs.; $4. **PB-166880.**
- "Literature Survey of Passenger Comfort Limitations of High-Speed Ground Transports" (60 pp.), J. P. Castens, United Aircraft; $3. **PB-168171.**
- "Science and Technology in the Railroad Industry" (133 pp.), National Academy of Sciences-National Research Council; $4. **PB-166882.**

The following reports contain sections that are useful to electronic designers interested in rail transportation, even though some of the studies include other transit methods:

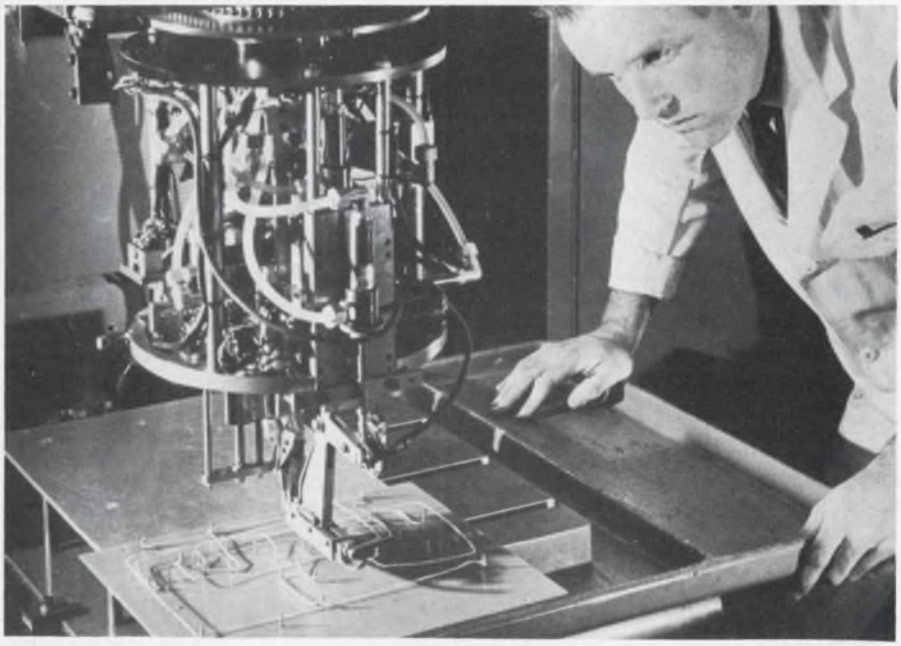
- "Buffeting Tests on the Hudson Tube," a study conducted for the Commerce Dept. by the Stanford Research Institute on the effect on a high-speed train when it passes through a tunnel; $2. **PB-168647.**
- "Washington-Boston Transportation Study: Feasibility and Cost of Improved Railroad Service," by MRD Div. of General American Transportation Corp., with electronic control of the hypothetical study systems; $6. **PB-166886N.**
- "A Projection of the Technology Applicable to the Future Highway System of the Boston-Washington Corridor," Cornell Aeronautical Laboratories; $7. **PB-166878N.**

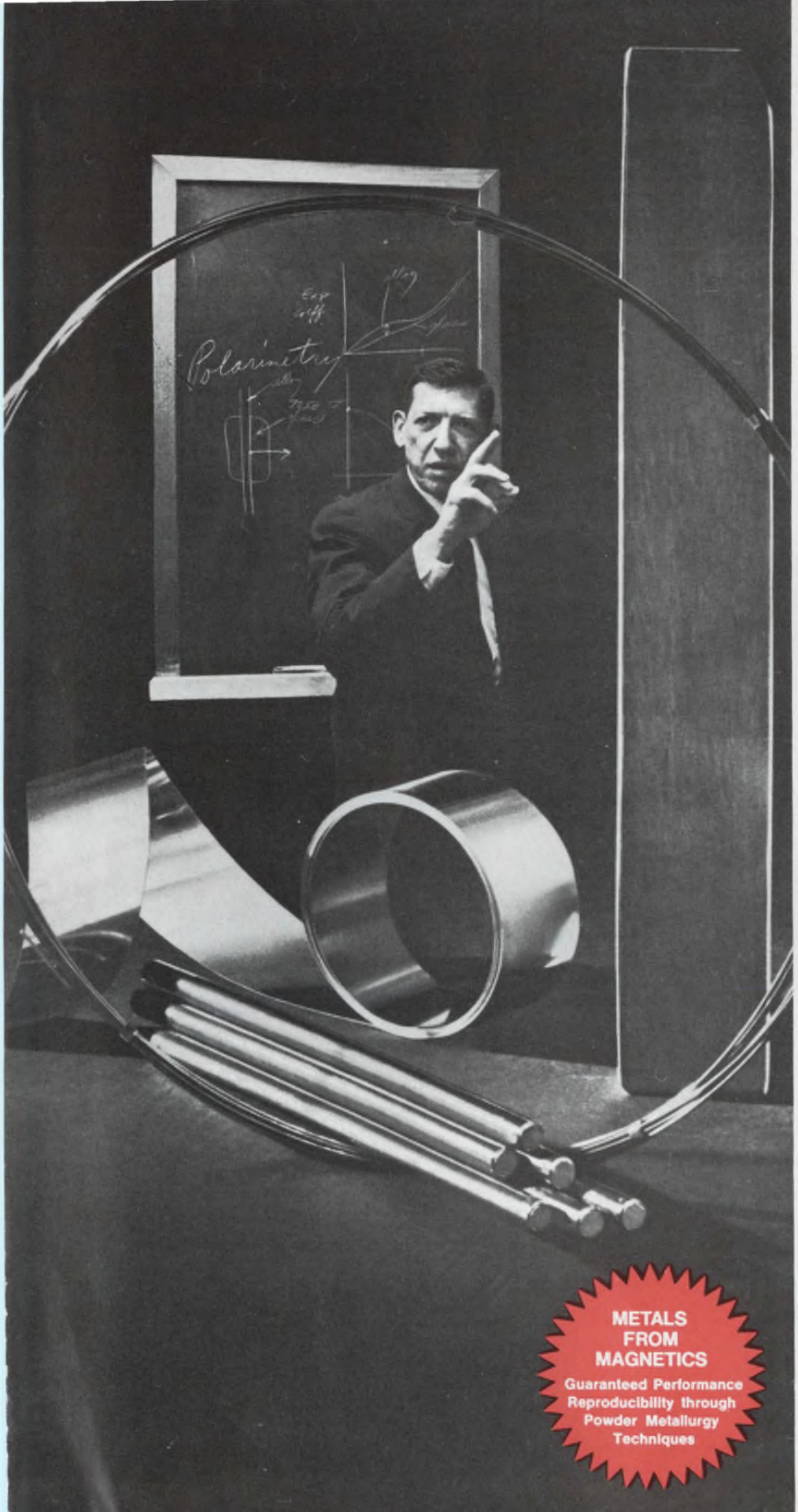
Programed drill press adapted for wiring

A punched-tape controlled drill press, where the head is stationary and the table moves, has been adapted for point-to-point wire-wrap operations.

Standard Telephone & Cable, Ltd., an ITT subsidiary, says that the fixed-head not only allows for less complexity in the machine but also permits wires to be laid on top of each other. This operation, according to the manufacturer, is more difficult to perform with other automated wiring machines.

The machine, now in the advanced prototype stage, will be available on special order, the company says. ■ ■





ALLOYS CUSTOM BLENDED TO YOUR SPECS

through powder metallurgy

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Here at Magnetics Inc. we call such metals Blendalloy®. With more than 10 years' experience in powder metallurgy, we are now prepared to formulate and produce custom blended alloys to your specs—and to guarantee performance under the conditions you name.

Example: Blendalloy 52. We developed this 52% nickel controlled expansion alloy for dry reed switches and mercury wetted relays. Blendalloy 52 is made to match with precision the expansion characteristics of Corning 0120 glass. When used with other types of glass, Blendalloy 52 is modified to match any change in expansion characteristics. Dilatometry and polarimetry tests on both laboratory and production runs assure this match for both standard and modified alloys.

Magnetics Inc. produces Blendalloy metals in bar, rod, strip and wire, in lots from one pound to 50 tons or more. For information, write for our Blendalloy 52 technical data sheet. For general information, ask for our new metals capabilities brochure: *Metals From Magnetics*, Magnetics Inc., Dept. M-98, Butler, Pa. 16001

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NEW MODULES, HARDWARE, ACCESSORIES ADDED TO THE EXTENSIVE I/C μ-PAC DIGITAL LOGIC MODULE LINE

New Model BT-332 TILT DRAWER BLOC houses 240 μ-PACS™ in only 5½" of rack panel height — pulls out, tilts down for PAC access, up to expose wire wrap terminals. Detents hold the BT-332 in any position from . . . horizontal to full vertical for convenient PAC replacement, testing, wiring, or system assembly. To further facilitate system fabrication, new mounting panels are available to adapt standard μ-PAC hardware for 19" . . . rack installation. In addition, 3C offers custom system assembly and wiring capability for the special purpose system builder or volume manufacturer using μ-PACS.

LD-331 HIGH-DRIVE LAMP DRIVER PAC contains 8 independent microelectronic lamp-driver circuits with discrete output transistors. Each driver is capable of switching up to 300 ma at 35 volts from standard μ-PAC signals.

LD-335 NEGATIVE LOGIC LEVEL DRIVER PAC contains 8 two-input AND gates, followed by level shifters. Standard μ-PAC signals (+6 V and 0 V) are converted to negative logic levels (0 V to −25 V at 60 ma per circuit).

PN-335 NON-INVERTING POWER AMPLIFIER PAC contains 6 three-input AND gates. Each gate contains two inverting amplifiers in series which provide the non-inverted output. Electrically common outputs and built in short circuit protection are standard features.

SR-335 SHIFT REGISTER PAC contains 8 prewired integrated circuit shift register stages. Up to 16 custom assembled stages can be supplied to meet customer design requirements.

TP-330 TEST POINT PAC provides convenient system trouble shooting capability without wire side probing for observation of waveform characteristics. Isolated test points for 34 PAC fingers are furnished.

AS-330 COPPER CLAD BLANK PAC kit provides a basic μ-PAC card with 5.5 sq. in of copper plate on each side for custom etching of interconnections. PAC handle and fastener are included.

μ-PACS feature 5 mc operation, high packaging density, low cost per logic function, inherent reliability, low power consumption, and noise protection in excess of one volt utilizing NAND logic with DC coupled circuitry.

Write for complete catalog of μ-PAC monolithic integrated circuit digital logic modules, power supplies, hardware, and system design and fabrication accessories.

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Deep Jeep hunts bomb

Washington Report

S. DAVID PURSGLOVE, WASHINGTON EDITOR

H-bomb search upsets science programs

The search for a U.S. hydrogen-bomb, missing off the southeast coast of Spain following the crash of a jet bomber, has required so much specialized equipment and so many technicians skilled in esoteric tasks that several scientific programs have been damaged. Scientists now fear that not only will their programs be unbalanced but that funds scheduled for scientific projects will be diverted to pay for the search. Many scientists contend that this happened following the search for the sunken submarine Thresher. The Navy contends that the Thresher search was charged to normal operations, and it says the underwater portion of the H-bomb search will be similarly written off. Oceanographers, however, charge that much of the Thresher bill was footed by normal oceanography operations.

Studies planned by the Defense Dept.'s Advanced Research Projects Agency and at least one phase of an Arms Control Agency field exercise, designed to spot illegal nuclear weapons, have been curtailed by the need for equipment and personnel in Spain. The major disruption most clearly linked to the H-bomb search is the postponement of acoustic-positioning and precision ocean-floor photographic experiments that were to have been made at the Tongue of the Ocean underwater range. The Naval Research Laboratory's research vessel Mizar was to have conducted the experiments. However, it has been sent to Spain to join the bomb search.

It was necessary to remove from the Mizar the carefully installed acoustic-positioning system and to change crews. The new crew consists in large part of the same crew that searched for the Thresher. The Mizar was hurriedly re-outfitted with search gear, including pingers and acoustic transponders, side-looking sonar and underwater TV.

Previously the deep-submergence vessels Alvin and Aluminaut had been diverted from other programs to search for the lost bomb.

Automatic air recon near reality

Aerial reconnaissance photo scanners that virtually "teach themselves" what to look for are approaching reality. Pattern-recognition scanners have been used for several years, but they can be programed to recognize only a few clear-cut patterns. Others, called comparison scanners, have been developed to spot differences between today's film strip and yesterday's film of the same area.

Now, however, adaptive pattern-recognition techniques are about to be applied to scanners that will be programed to recognize several general concepts and to proceed from there to spot variations in the taught patterns. The development could mean a major refitting of intelligence and reconnaissance units.

In the meantime one Army laboratory engaged primarily in developments for limited and special warfare is experimenting with novel non-electronic methods in recon work. As a starter, the lab has taught a number of pigeons to recognize the shapes and tones that most often represent trucks on an aerial photo. Pigeons peering at a slowly moving film strip peck at each truck with graphite-rubbed beaks. An officer says: "We haven't completely gone back to nature, though. The graphite dots on the film strips still are read electronically."

Capitol committees prepare to act

A few Congressional committees have completed their hearings on this year's major legislation and soon will begin the behind-the-scenes "marking-up" of bills. Other committees are well on the way toward this, the crucial point in any bill's legislative history. It is at this point—after the public hearings and before the final vote—that the letters and telegrams help most to decide a program's fate.

Here are the Congressional committees, or key subcommittees, of prime importance to the electronics industry, as well as to individual engineers or scientists.

SENATE

Appropriations is the committee that makes or breaks any program. The committee chairman is the "dean" of the Senate, Arizona's Carl Hayden. Leverett Saltonstall of Massachusetts is the ranking minority member. The committee's chief clerk is Thomas J. Scott.

Before a program reaches the Appropriations Committee, it goes first through an "authorizing committee" that determines which programs will be authorized—and which will not—and the maximum funds that can be spent. The Appropriations Committee cannot add programs and cannot exceed set money limits. It very often reduces programs by voting somewhat less than the maximum authorization, and it sometimes kills programs by voting a "zero" appropriation.

The Senate Aeronautical and Space Sciences Committee is under the chairmanship of New Mexico's Clinton P. Anderson. Margaret Chase Smith of Maine is the ranking minority member. James J. Gehrig is the committee's staff director.

The Armed Services Committee chairman is Richard B. Russell of Georgia. Leverett Saltonstall of Massachusetts is the ranking minority member. The committee's chief clerk is Charles B. Kirbow.

Other Senate committees that delve into electronics areas to some degree are Commerce (Warren G. Magnuson of Washington, chairman) Government Operations (John L. McClellan of Arkansas, chairman) and Post Office and Civil Service (A. S. Mike Monroney of Oklahoma, chairman).

HOUSE OF REPRESENTATIVES

The House Appropriations Committee is under the chairmanship of George H. Mahon of Texas. As former chairman of the Subcommittee on Defense, he retains a strong interest in military appropriations. Frank T. Bow of Ohio is the ranking minority member. The committee clerk is Kenneth Sprankle.

The Armed Services Committee is headed by L. Mendel Rivers of South Carolina. William H. Bates of Massachusetts is the ranking minority member. The committee's chief counsel is John R. Blandford. The Science and Astronautics Committee chairman is George P. Miller of California. Joseph W. Martin Jr. of Massachusetts is the ranking minority member. The committee's executive director is Charles F. Ducander.

Other House committees that interest themselves from time to time in electronics include Government Operations (William L. Dawson of Illinois, chairman) Interstate and Foreign Commerce (Harley O. Staggers of West Virginia, chairman) and Post Office and Civil Service (Tom Murray of Tennessee, chairman).

The chairmanship of the Joint Committee on Atomic Energy alternates between the ranking majority Senator and ranking majority Representative. The present chairman is Rep. Chet Holifield of California. The vice chairman (and next chairman) is Sen. John O. Pastore of Rhode Island. The executive director of the committee is John T. Conway.

All Senators and Representatives can be reached by mail. Sample address forms are: Sen. John Doe, United States Senate, Washington, D. C.; or Hon. James Jones, House of Representatives, Washington, D. C. To reach any Congressman by telephone, call CApitol 4-3121 in Washington (Area Code 202). All elected officials urge communications not only from constituents but also from non-constituents whose field of interest is covered by a committee of which the Senator or Representative is a member.

New group pushes industry's interests

A new association, headquartered in the Capital, has been formed to promote the use of private industry resources to support essential Federal Government activities. The National Council of Technical Service Industries, as the association is called, was formed, in part, "to point up that private industry can maintain complex systems and equipments more efficiently and at a cost lower than civil service employees." The membership of the new group already includes large defense contractors.

Airlines adding radar-beacon equipment

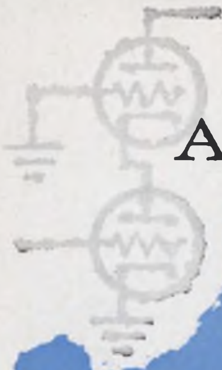
The results of a survey by the Air Transport Association indicate that the scheduled airlines of the U.S. are rapidly fitting their aircraft with add-on elements of the FAA's new semi-automatic air traffic control radar equipment.

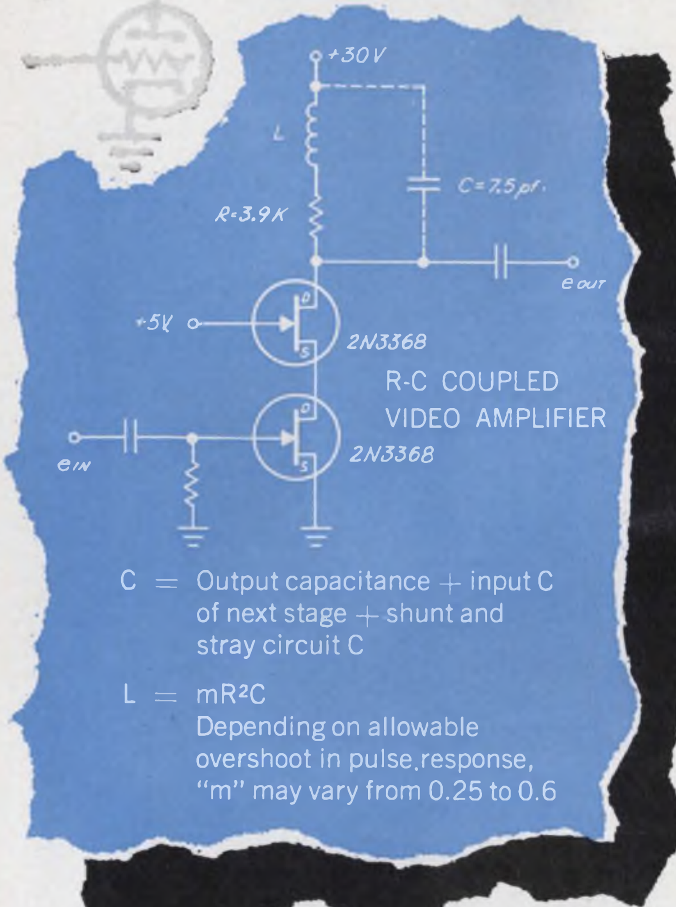
When an aircraft is fully equipped with the system, its transponder will respond with its own discrete code when interrogated by ground equipment installed at the FAA route traffic-control centers. This code will then be displayed on the ground controller's radar scope to identify the aircraft. The same signal will also contain data on the aircraft's altitude.

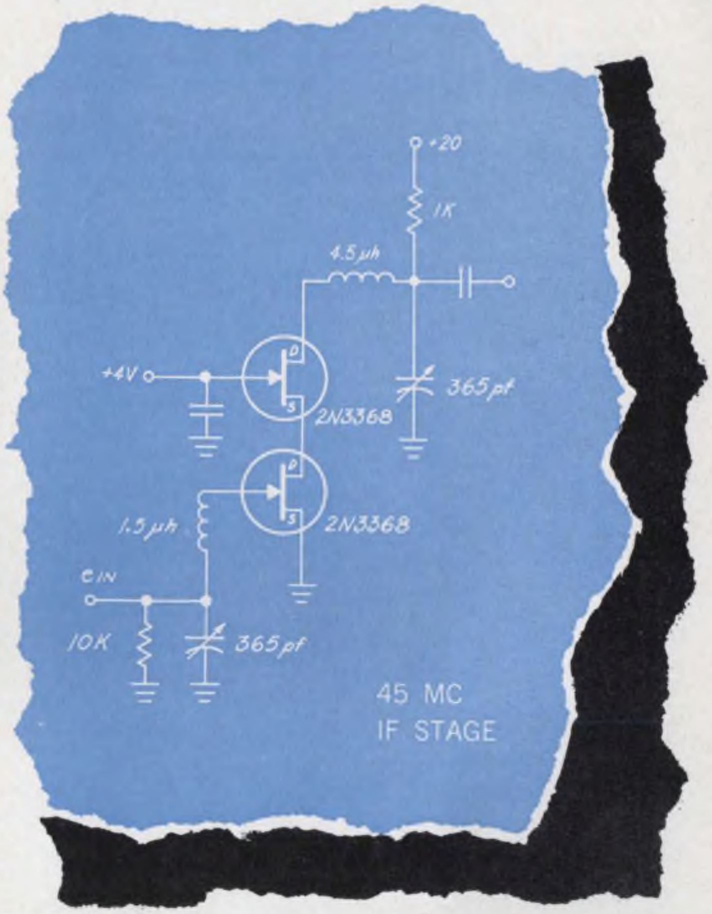
The airlines' response to the ATA survey indicates that by the beginning of 1968 some 60 per cent of the turbine fleet will be equipped to give discrete identity, while 17 per cent will also be able to report altitude automatically to the ground. By 1970 virtually all turbine-powered aircraft will be able to give discrete identity.

Cascode With FETs?

A parody on tubethinking, circa 1943







Siliconix assumes no responsibility for circuits shown, nor does it represent or warrant that they do not infringe any patents.

A single triode tube was usually avoided in wide-band circuits or pulse applications because Miller effect capacitance seriously loaded the input. Then came the cascode scheme, lower noise, practically no more input capacitance than the tube's Cgk. Using FETs in cascode, you have a striking reduction in input C. With shunt peaking, the circuit shown offers a voltage gain of 10 with a 3 db bandwidth over 6 mc.

MONITOR II FET/TRANSISTOR TEST SET • Tests N-channel, P-channel, junction and MOS FETs • Go, no-go, analog readout • Compact, solid state, proven performance on our own production lines • Ideal for incoming QC or production testing • Drives digital voltmeter or printer without modification.

Cascoding again with the 2N3368, we have an IF amplifier operating at 45 mc without neutralization. It has 20 db power gain and a bandwidth greater than 6 mc; for more gain cascade several stages. For more information on cascode-connected FETs, plus the ever-popular FET bibliography (72,000 now in circulation) drop us a line or circle the bingo number.

Yes, the arrow is pointing the right way; *the 2N3368 is one of 27 new N-Channel FETs from Siliconix!*

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ON READER-SERVICE CARD CIRCLE 15

Data system has automatic error detection

A new system for transmitting data between a central computer and remote points features high speed and automatic error detection and correction.

Developed by the Tally Corp., the System 311 incorporates a paper tape perforator, a reader and electronic logic circuits, and can be used to either send or receive over ordinary telephone lines. Operating at 1200 words per minute, the System 311 is reportedly the fastest paper tape data transmission system now on the market.

A major feature of the new system is its ability to recognize transmission errors, such as those caused by phone line static or fading, and to re-transmit them correctly. Equipment with this capability has been available on the market. But according to Tally officials, the combination of error correction, speed and price makes their system unique.

Parity-type error detection is used in the System 311. Either odd or even parity can be selected, depending on the requirements of the user. When a parity error is detected in a transmitted character, that character is deleted. The tape being sent then automatically reverses so that the block of characters containing the one with the error is retransmitted. If an error again appears in the same block, the process is repeated. But should an error occur in the same block a third time, that block will be sent on the fourth pass regardless of whether or not an error again occurs.

Speed of 1200 words per minute is offered by the System 311, which can operate over standard telephone lines.

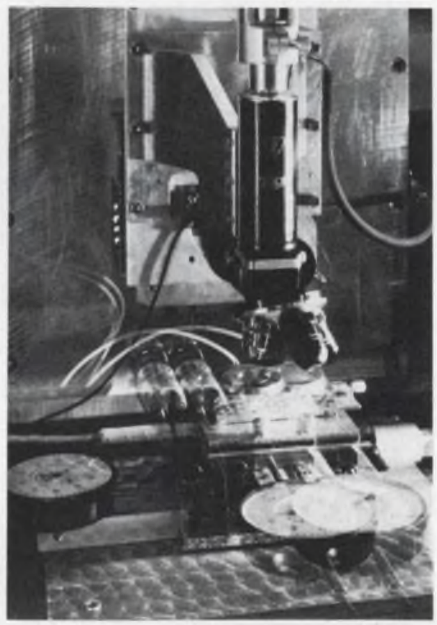
Computer wires chip with discretion

An experimental computer determines how to best interconnect 80 circuits on a silicon wafer and then it connects them.

Faulty circuits are automatically bypassed in this system, designed by Dr. Sol Triebwasser at the research division of IBM. The function to be performed by the finished array, the test results of the individual circuits, the maximum connection length and other data are fed into the computer. It determines an acceptable pattern and records it on a magnetic tape. This tape controls a movable table and a light shutter that regulate a beam of light. The light polymerizes the photoresist on the wafer mounted on the table. This wafer is then developed and the interconnections are made using standard metal etching techniques.

Dr. Triebwasser said that the computer program should be capable of handling many more than 80 circuits on a wafer. This program is then a step toward producing wafers of hundreds of circuits with good yields.

Dr. Triebwasser described his system at the International Solid-State Circuits Conference, where he showed sample arrays of 80 interconnected circuits produced by the process. Each circuit contained five field-effect transistors connected as a four-input NOR gate. According to Triebwasser, the computer interconnection program is also applicable to bipolar transistor circuits.



Light source and movable table that reproduce acceptable wiring on wafer.

Novel ground station records weather pictures

A rolling pin and a rubber band are two of the items used by an RCA engineer in his "do it yourself" ground station for receiving weather pictures from TIROS satellites.

Wendell Anderson built his station in the basement of his home just to prove that it could be done. The basic piece of equipment used was an old (1938 vintage) "ham" receiver. To this, Anderson added about $250 worth of ordinary electronic components. The antenna is a piece of TV-type twin-lead stretched across the roof of Mr. Anderson's home.

A small home-type tape recorder is used to record the signals from the satellite. For processing the signals onto film, Anderson uses a $15 microscope and an argon electric light bulb that together transfer the signal from the tape recorder onto an 8- by 10-inch sheet of Royal X Pan film.

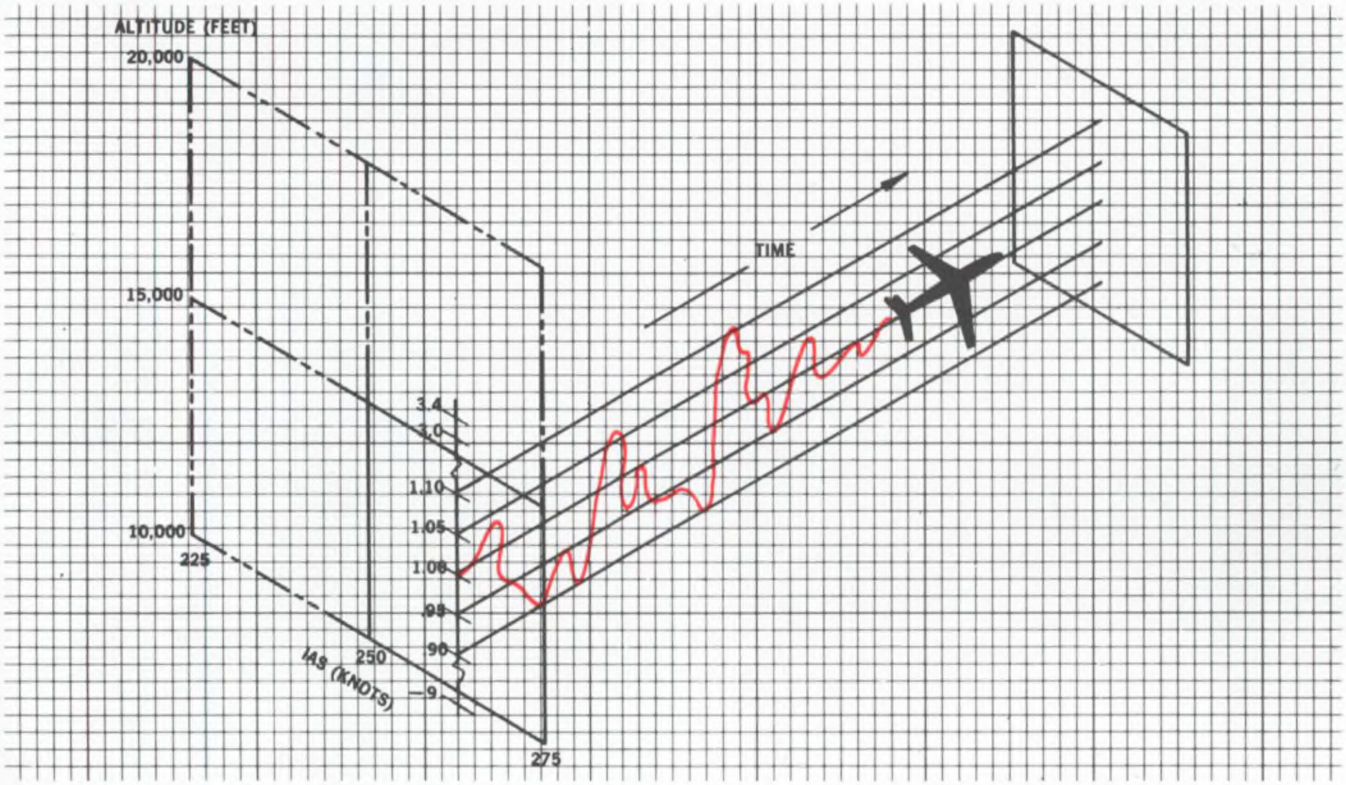
The film is wrapped around a cylinder made from an ordinary rolling pin, and is cushioned for smooth rotation by a rubber band. A small ($10) electric motor rotates the cylinder, while another identical motor drives it horizontally at a very slow pace. As a result, the microscope and argon bulb register on the film the numerous lines that make up the weather picture.

ON READER-SERVICE CARD CIRCLE 250 THRU 255 ➤

SIGNETICS

INTEGRATED CIRCUIT NEWS AND APPLICATIONS

NEW INSTRUMENTATION PACKAGE TO MEASURE FLIGHT STRESS DATA INCLUDES SIGNETICS LOW-POWER IC SERIES



The need for an accurate, reliable statistical recorder was established by USAF's Aircraft Structural Integrity Program which began about seven years ago.

The answer comes in a new instrumentation package developed by Giannini Controls Corporation. Called DASR (Data Acquisition and Statistical Recorder), it defines accurately the G-load history of an aircraft:

1. It counts the number of times an airframe encounters a pre-selected value of G-load.
2. It correlates and records these events only at pre-selected levels of altitude, speed, time and acceleration as shown in the illustration.
3. It produces a tape record that can cover 50 hours of G-history in a 5-minute playback.

The DASR records data in digital form on magnetic tape compatible with IBM data processing equipment.

An important part of the Giannini package is the computer built with Signetics SE400 integrated circuits. These Signetics circuits were selected because they provide high speed at very low power. The feature element in the series is the SE424 five-megacycle dual binary element which operates on less than 9mW per flip flop. The entire SE400 Series operates on 20% to 40% less power than comparable elements while providing equal or better speed and noise immunity. Other elements in the series are:

SE480 — a quadruple 2-input NAND gate, each gate having the fan-out capability of the flip flop, 7 DC or 2 AC loads.

SE416 — a dual 4-input expandable NAND gate with active output pull-up for fast rise times.

SE455 — a dual 4-input driver/buffer for driving high capacitance loads and for high DC fan-out requirements.

Circle No. 250 on Reader Service Card.

Data Acquisition and Statistical Recorder (DASR).

SIGNETICS
INTEGRATED
CIRCUITS

LATEST COMMERCIAL HIGH-SPEED DATA ACQUISITION SYSTEM USES SIGNETICS UTILOGIC

The increasing application of large computers as central processors in industrial operations is making accurate, high-speed data acquisition systems more important than ever before. One of the most recent of these systems to become commercially available is the SOLAR System (Serialized On-Line Automatic Recording), designed and produced by Data Pathing Inc. of Palo Alto, California.

The basic system consists of a programmed receiver incorporating a magnetic recorder and fifteen transmitters which may be located at widely separated points and interconnected by a single pair of wires. Up-to-the-minute reports on material movement, work-in-process, machine and operator utilization, order location, inventory, etc., can be magnetically recorded at the receiver for later processing, or routed from the receiver to a central processor for immediate analysis.

The system logic is implemented with Signetics LU-Series Utilogic elements, selected for their high noise immunity, capacitive drive capability, and the ease with which they interface. The low cost per function and the very high functional density provided by Utilogic have made it economically and physically feasible to incorporate system design features that would otherwise be prohibitive. Among the self-checking features incorporated in DPI's SOLAR system:

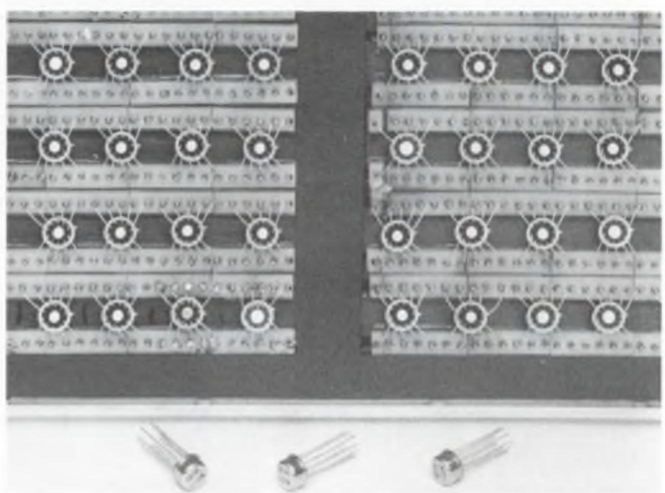
(1) An active visual display at each transmitter which tells the operator exactly what data is wanted and the order in which to enter it via a simple ten-key board.
(2) An immediate check on transmission accuracy.
(3) A continuing check on transmitter condition which automatically removes a defective transmitter from the line and signals for the maintenance man.

To date, no Utilogic element failures have been reported in either the earliest prototypes or the first production models of the SOLAR System. One particular feature of Utilogic elements which has won DPI's unqualified approval has been a number of practical demonstrations that they are, indeed, immune to damage by accidental shorts. The type of "probe accident" or "debugging error" that commonly causes a continual loss of discrete semiconductor devices in new systems development has no effect on Utilogic.

Circle No. 251 on Reader Service Card.

SOLAR System transmitter. (18" high, 22" wide, 16" deep).

SOLAR System receiver.



Signetics LU-Series Utilogic elements in SOLAR System logic boards. Note novel upside-down mounting technique of TO-5 cans.

See the Signetics showcase of new products at the IEEE show

"INNOVATION"

March 21-24, 1966

Signetics booths 2J40 and 2J42 on the second floor of the New York Coliseum

IN PRODUCTION: ADVANCED AUTOMATIC INTEGRATED CIRCUIT TESTER

Signetics Automatic Integrated Circuit Tester.

An advanced Automatic Integrated Circuit Tester, in production by Signetics, now offers for the first time in a standard configuration an internal drum memory of 1.2 million bits program capacity and an access time of approximately 16 milliseconds. This provides a normal internal storage capability of 166 different programs of 25 tests each.

One or more test stations may be used in conjunction with the memory, so that devices of different types may be tested simultaneously and at locations away from the main frame.

The tester is supplied with facilities for testing devices with up to 16 terminals, with provision made for optional expansion of increments of 16 terminals.

The standard Model 850A is equipped to test every known integrated circuit on today's market, including some recently introduced 16-terminal devices.

The 850A is manually programmable from a keyboard supplied as standard equipment. Entry of new programs or program additions can be made at any time, even while testing is in progress. It provides Go/No-Go readout and has facilities for optional addition of DVM readout and data logging equipment.

The system design makes use of the Signetics Utilogic line of commercial/industrial integrated circuits. The drum memory uses the firm's new linear circuit, the SE505 general purpose differential amplifier.

The standard 850A is priced at $44,000, with deliveries approximately 120 days after receipt of order.

Circle No. 252 on Reader Service Card.

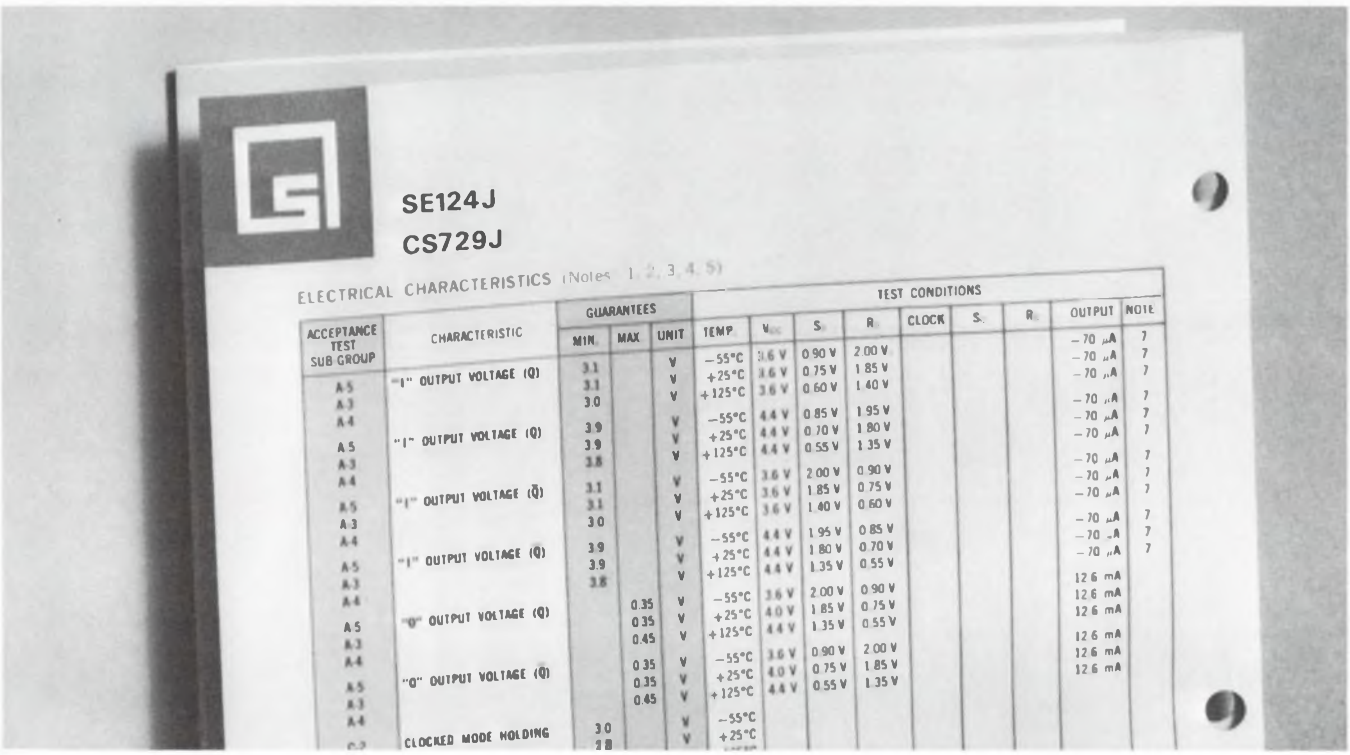
NEW SE100 J-SERIES DATA SHEETS PROVIDE GUARANTEED WORST CASE DESIGN LIMITS

In a move to make integrated circuit data sheets into truly workable tools for design engineers, Signetics has produced a unique set of data sheets for their SE100 J-Series of HI REL DTL circuits. The new data sheets provide clearly defined and guaranteed worst case design limits of immediate use to the systems designer.

Noise margins, speed and fan-out are guaranteed from −55°C to +125°C under worst case power supply and temperature differentials between driving and driven units.

The new SE100 J-Series data sheet frees the engineer from worry about any additional safety factors or guard bands. He gets complete specifics, down to the details of acceptance, quality assurance and environmental test methods and limits in accordance with all applicable MIL specifications.

Circle No. 253 on Reader Service Card.



SIGNETICS
INTEGRATED
CIRCUITS

NEW DUAL IN-LINE PLUG-IN PACKAGE FEATURES DTL IC'S

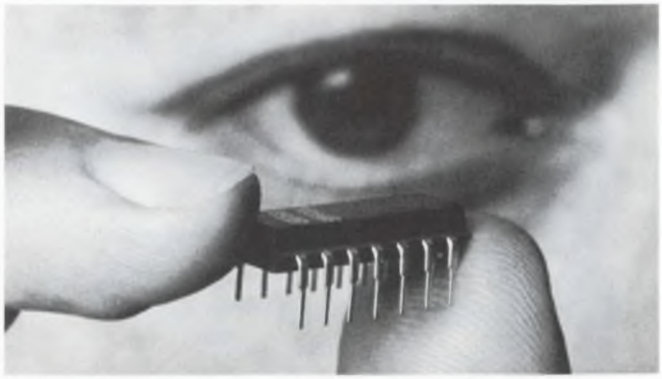
Signetics' new SP600 series comes in a unique monolithic package. A solid epoxy block encapsulates both the circuit chip and the leads connecting it to the external plug-in pins. The new package contains two rows of pins 300 mils apart and spaced on 100 mil centers, conforming to widely accepted circuit board drill patterns.

Although designed for commercial use, the low-cost package has been subjected to mechanical and environmental stresses at levels far in excess of those required by MIL-S-19500D and MIL-STD-750.

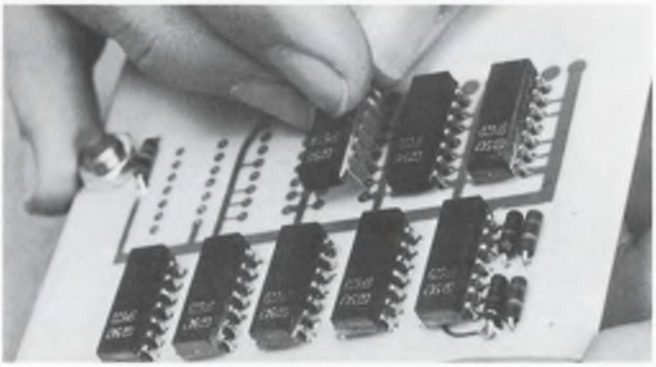
Signetics SP600 series includes a J-K flip-flop, three multiple DTL gate packages (dual, triple and quadruple NAND/NOR), a quadruple gate-input expander, and a dual DTL line driver/buffer element.

The SP600 series circuits are now in stock at Signetics distributors.

Circle No. 254 on Reader Service Card.



SP600 plug-in package.



Manual Insertion of SP600 packages in circuit board.

NEW HIGH-SPEED TTL FAMILY FROM SIGNETICS

In early March Signetics will market a new high-level TTL family of integrated circuits: the SE800 series.

While consuming generally more power than DTL circuits, the most widely used integrated logic form at present, the new family represents a very useful design trade-off in some situations in which the speed performance of DTL may be considered marginal.

The SE800 series consists of six different gate configurations, a gate expander, and a J-K flip flop. They're interchangeable in both function and pin layout with Texas Instrument's Series 54 elements.

All elements are made in Signetics glass-Kovar 14-lead TO-88 flat package.

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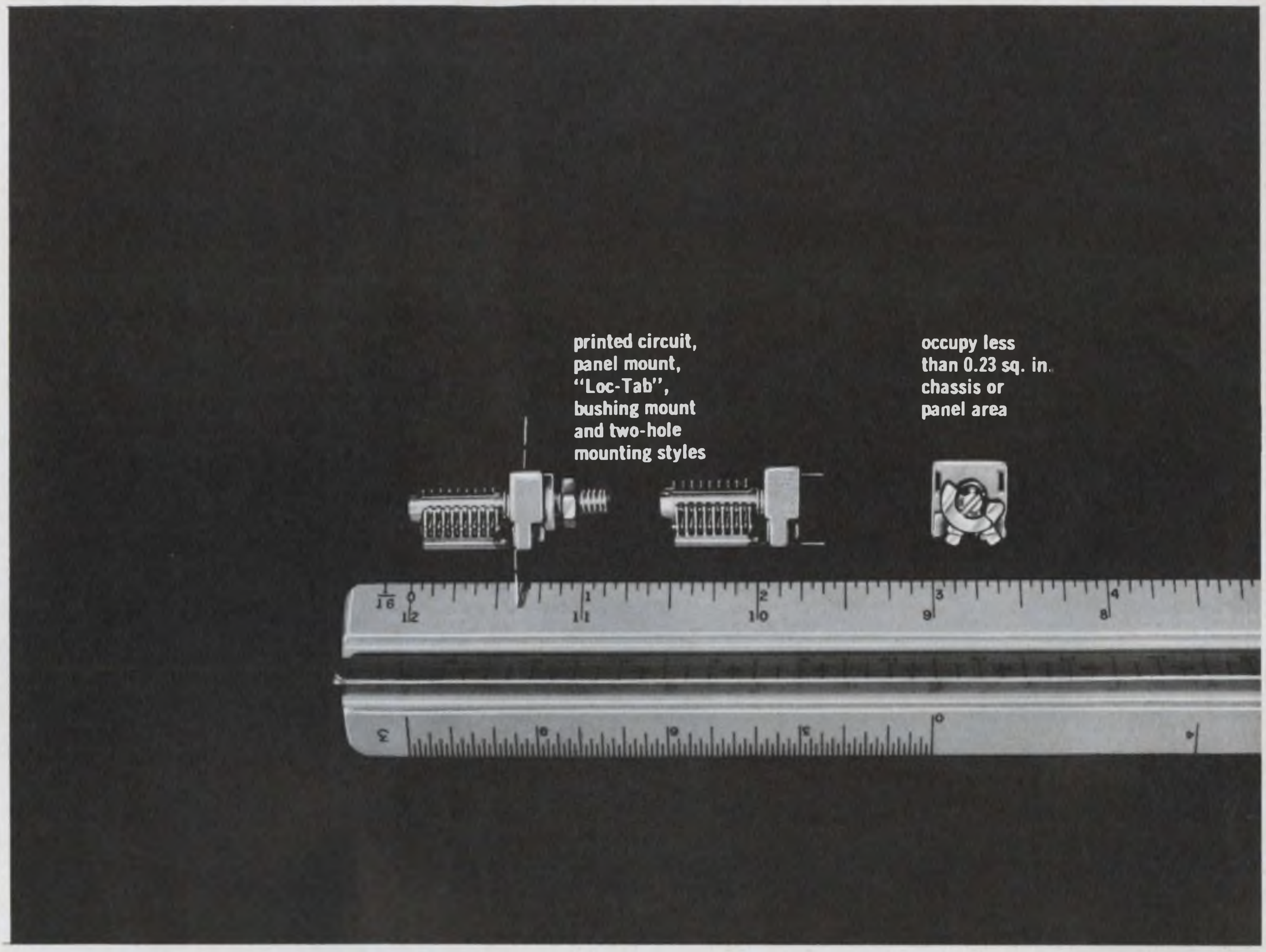

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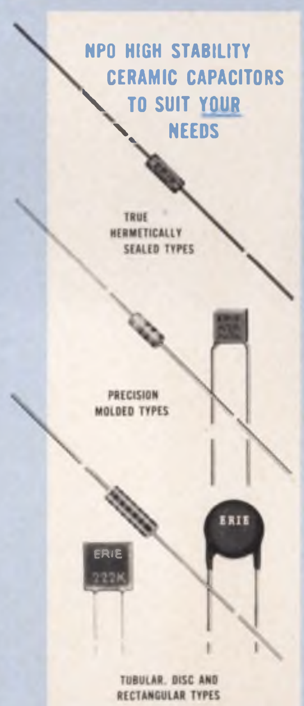
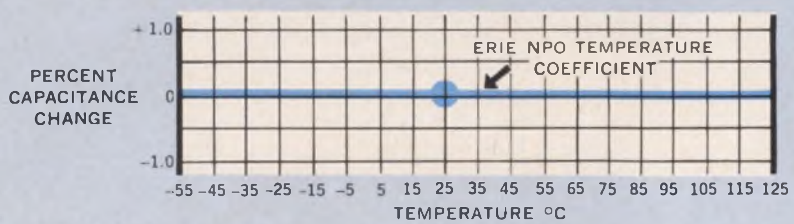


CAPACITANCE CHANGE VS. TEMPERATURE



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ON READER-SERVICE CARD CIRCLE 17

Automatic flaw spotter due for big radio dishes

ACME, to be tested by NASA on 85-foot tracking antenna in North Carolina, detects structural changes with a photosensor and laser.

Ralph Dobriner
West Coast Editor

ACME, an automatic surveying system designed to detect structural defects on the surface of large radio antennas, is scheduled for preliminary field tests within a year.

Under development at ITT Federal Laboratories in San Fernando, Calif., ACME, which stands for Antenna Contour Measuring Equipment, will be delivered to NASA's Goddard Space Flight Center. It will be installed at the 85-foot STADAN (Satellite Tracking and Data Network) antenna at Rosman, N. C.

The idea for ACME was born a number of years ago when NASA engineers became increasingly concerned with manufacturers' and users' ability to hold the surface tolerances of large-dish tracking antennas. These tolerances are especially critical for the fast-scanning microwave antennas used to track space vehicles near the earth. Shocks resulting from sudden surges of the antenna platform's servo motors, as well as natural phenomena—such as earth shocks, wind and temperature variations—can seriously degrade the performance of the antenna system.

Other surveying techniques tried

Previously, standard surveying techniques had been used periodically to check antenna surfaces, but this was generally a time-consuming and relatively inaccurate technique. It was then decided to switch to photogrammetry—photographing the surface of the antenna—a technique that achieved high accuracy and good results. But here, too, it takes about two weeks to get back data. NASA engineers wanted a system with a "quick turn-around time," and ACME seemed to be the answer.

The system is designed to run a check on an antenna in 20 minutes to an hour, depending on the number of points that need checking.

According to a NASA spokesman, the photogrammetric approach will still be used, with ACME as an alternate technique when quick readings are required. The equipment will ride along on the antenna structure and will be used whenever there is reason to believe that structural changes have occurred.

The ACME equipment (Fig. 1) consists of a photoelectric sensor placed at the vertex of the parabolic surface of the antenna. The sensor is mounted on a two-axis (elevation-azimuth) platform and is equipped with precision-angle encoders.

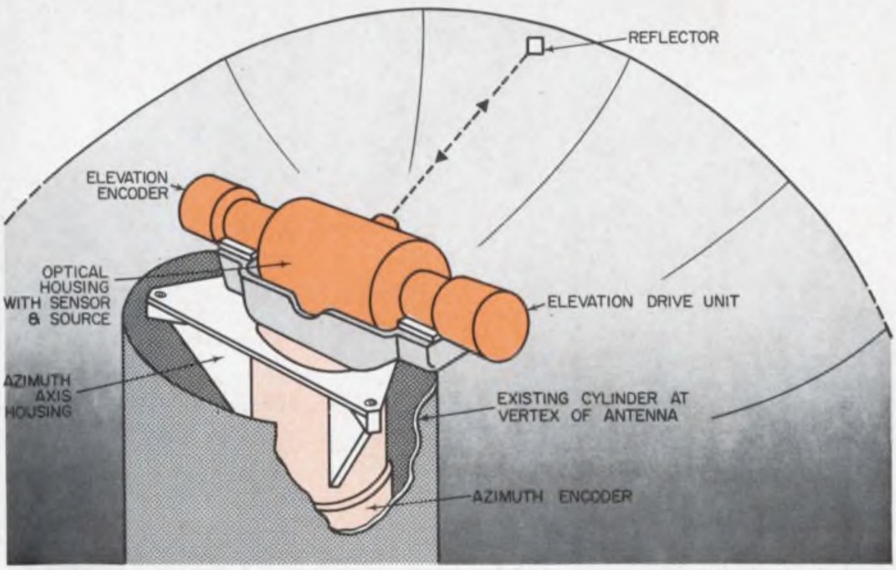
Antenna contour "bench marks," consisting of about 1100 retro-directive corner cube reflectors, will be mounted over the surface of the dish. The beam from a gallium arsenide laser source, located within the sensor housing, is reflected sequentially from the reflector targets.

Accuracy of ±5 arc seconds

A punched-tape input automatically points the platform assembly at the targets and measures the angular coordinates of each target by means of the photoelectric sensor and the angle encoders. The angular coordinates of the targets are measured relative to the vertex, with one axis parallel to the symmetry of the antenna (elevation angles) and the other perpendicular to it (azimuth angles). The system will be designed to make these measurements with an accuracy of ±5 seconds of arc.

As shown in Fig. 2, the punched-tape input, which expresses each target position in ten-thousandths of a degree, is fed into the tape reader and then into the format converter, which changes the information into normal binary code. This positional information is compared in the stepper-drive logic module with the output of a 19-bit, binary-coded, shaft-position encoder. When the difference between the two binary numbers is small enough to indicate that the photoelectric sensor is pointing at the target, and a target presence signal is obtained, the stepper motors stop. The sensor dwells on each target for about 3 seconds.

The output of the photoelectric sensor is converted from analog to digital information, and it is used with the encoder outputs to give the



Photoelectric sensor and source, mounted on a platform at the vertex of the antenna, directs a laser beam at one of 1100 reflectors. The system is designed to detect surface deflections by measuring the angular coordinates of the targets with an accuracy of ±5 seconds of arc.

(ACME, *continued*)

absolute position of the target with respect to the fixed reference. These binary positions are then converted in another format converter to the desired output format, and they are punched out on paper tape.

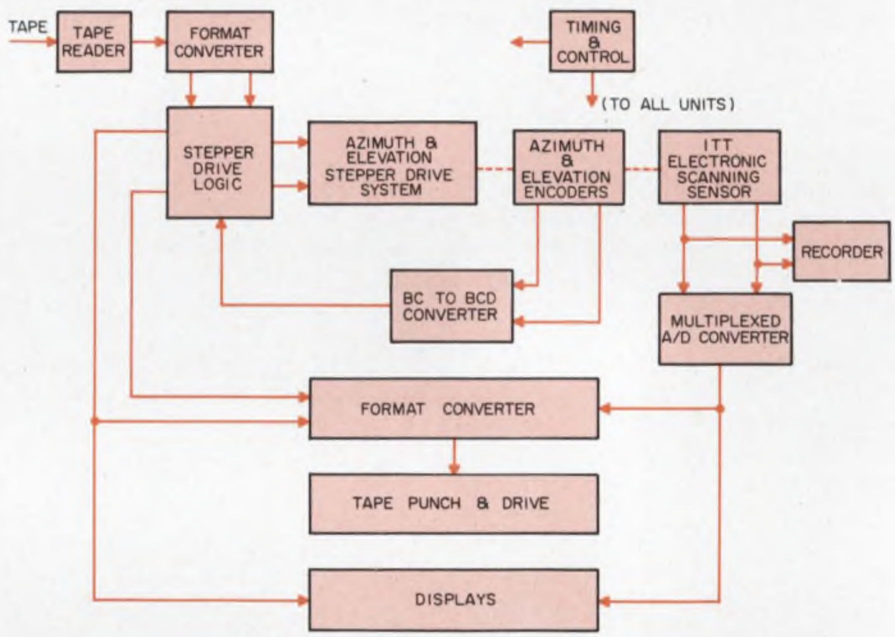
If desired, each target can be held as long as needed and the error signals from the photoelectric sensor can be monitored on a recorder for vibration analysis.

Standard star tracker used

The photoelectric angle sensor is a version of ITT's standard star tracker, consisting of a lens system, multiplier phototube, track-scan generators, signal processors and a power supply. The sensor provides two analog output signals, which are directly proportional to the angular displacement of the target from each of two orthagonal planes, whose intersection is the boresight, or null axis, of the sensor. Thus, when the target lies on this intersection, the output error signals are each zero.

A 20-inch-focal-length lens in the sensor is capable of viewing the reflector targets at a maximum distance of 40 feet (the outside perim eter of the dish) and a minimum of 5 feet from the vertex.

A NASA official said that if the field trials at the Rosman site prove satisfactory, it is planned to install ACME throughout the NASA tracking net, including its 40-foot dishes.



ACME (Antenna Contour Measuring Equipment) system, under development at ITT Federal Laboratories, will be installed at NASA's 85-foot tracking antenna at Rosman, N. C.

Prototype Apollo camera delivered to NASA

Engineers at the Westinghouse Defense and Space Center have delivered a prototype television camera to NASA.

This camera is the forerunner of one to be used by Apollo astronauts to send pictures back to Earth from the moon. According to the project engineers the camera can be easily converted to color operation.

40-dB null depth in Apollo tracker

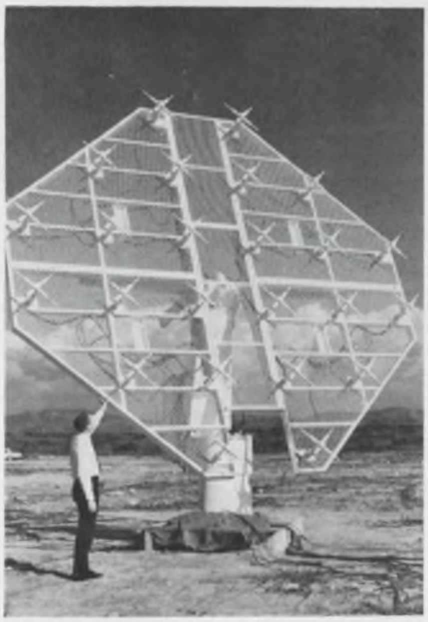
A high-gain telemetry monopulse array antenna, said to have a null depth down to 40 dB, will be used aboard sea-going vessels to track Apollo moonships.

Developed by the Cubic Corp. of San Diego, the antenna is a 24-element cross-dipole array that operates in the 215-MHz-to-265-MHz range. Reportedly, the antenna has a vswr of less than 1.2 to 1 and a gain in excess of 22 dB.

The array is capable of operating the vertical and horizontal linear modes of polarization, as well as circular polarization. The type of polarization used is remotely selectable by the operator.

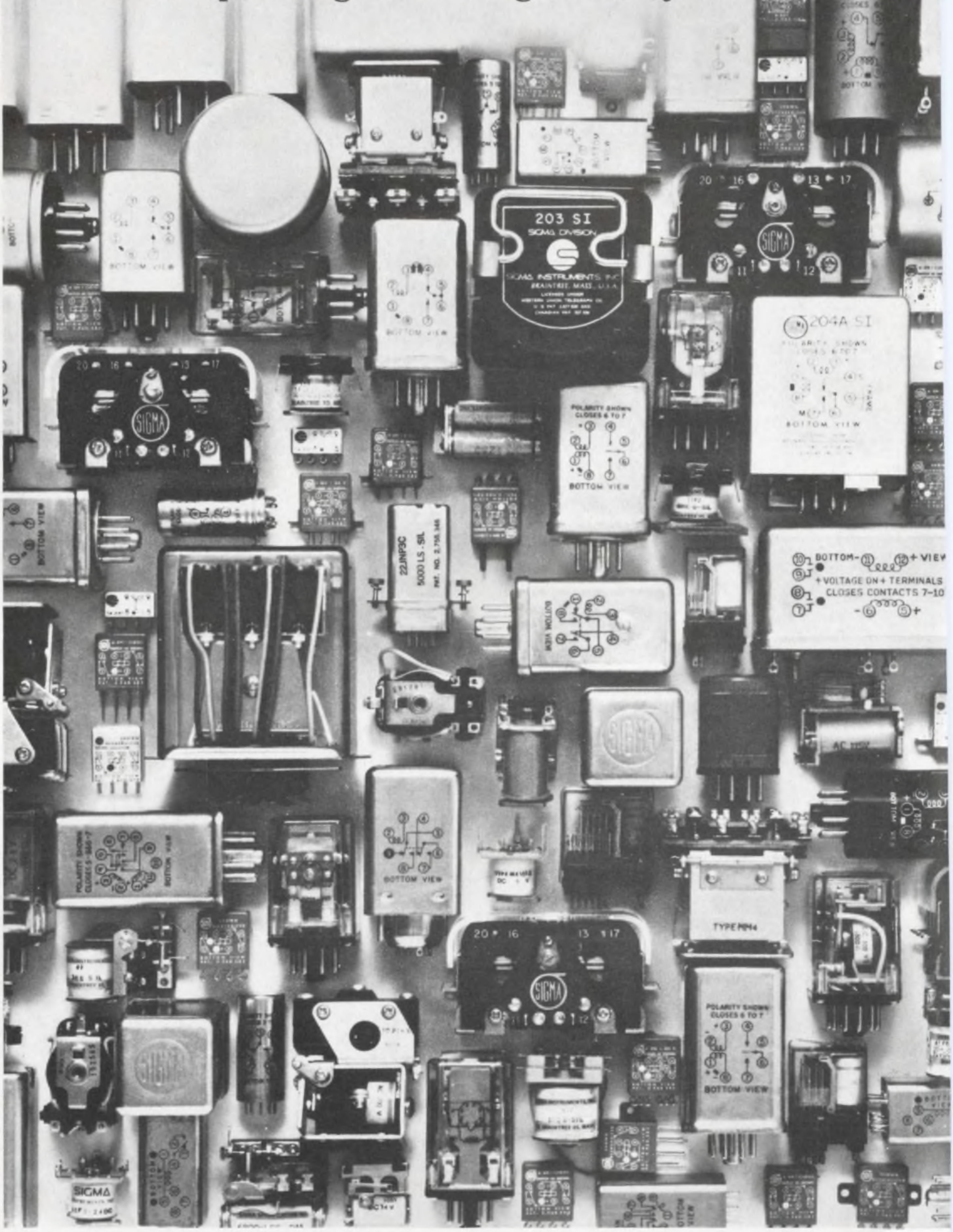
According to a Cubic spokesman, actual measured radiation patterns show side-lobe levels of more than 17 dB down for the sum channel, with the difference channel having only vestigial lobes to well beyond the second side lobe in the sum channel.

The difference-channel nulls, the spokesman noted, are all more than 40 dB below the sum-channel peak. The axial ratio encountered over the frequency range for either righthand or lefthand circular polarization is less than 0.5 dB.



High-gain telemetry monopulse array antenna with 40-db null depths is destined for use in the Apollo tracking program. Built by Cubic Corp., the antenna has a vswr of less than 1.2 to 1 and a gain in excess of 22 db in the 215-MHz-to-265-MHz range.

From the expanding line of Sigma relays . . .



Sky Bus puts electronics in the driver's seat

Westinghouse electric transit system for cities runs on tracks and is controlled automatically by wayside computers at speeds from a crawl to 50 mph.

Roger Kenneth Field
News Editor

"Any community that thinks . . . it can assure mobility on schedule for large masses of people without rapid transit . . . is suffering from that 20th-century opiate of the people—the private automobile. A community may buy buses and lay highways until it is blue in the face, but will not have mobility until substantial numbers of its public-transit vehicles ride on exclusive rights-of-way."—Leland Hazard, chairman of the Rapid Transit Committee of the Port Authority of Allegheny County, Pa., in his key-note address at the recent First International Conference on Urban Transportation in Pittsburgh.

The managers of some cities have reacted to Hazard's statement by pointing out that manually controlled subway systems are far too expensive for all but the biggest cities. "Design a new subway and make it attractive and cheap," they say.

To see how one electronics manufacturer is responding to this critical transit need, and to assess the industry's role in what could become a multi-billion-dollar industry, ELECTRONIC DESIGN visited the experimental track of the Westinghouse Sky Bus in South Park, outside of Pittsburgh (see photo 1).

I went for a ride around the test track with Ray Fields, head of the Sky Bus project; Don Little, designer of the unique control system, and Dixie Howell, lead project engineer. Fields explained that the Sky Bus is for use by cities with populations as small as 300,000. The trains require no motorman or conductor, and, in fact, the whole system can run perfectly with but a single person monitoring the console of a remote central computer.

The Sky Bus is powered by two 60-horsepower dc motors in each car. Small digital computers placed at the wayside control approaching trains and monitor departing trains. Should a computer fail, the computer at an adjacent station on the line controls approaching and departing trains, and service continues uninterrupted.

A smooth, rubber ride

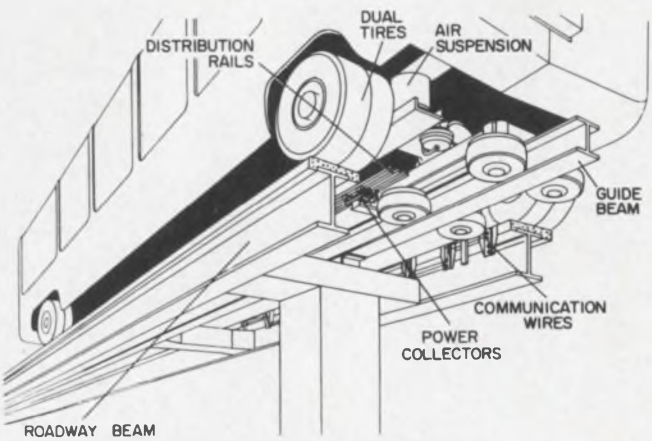
The cars have double sets of rubber tires that roll smoothly on concrete tracks. The designer used large thyristors to control the speed of the motors. Acceleration is smooth, yet brisk, As an experienced city subway rider, accustomed to lurches, I was pleasantly surprised at the absence of them in the Sky Bus.

The computer at the target station controls the effective dc to the motors by triggering the thyristors during a desired part of each cycle of the three-phase supply current (photo 2). This current enters the car through a set of brushes that contact the bottoms of the three-phase power rails (photo 3). The wayside computers can control the train from full speed to a crawl and can bring it to a halt within a few inches of its target alongside the platform.

In addition to accelerating the cars, the dc motors also do most of the braking. Giant open-wound resistors shunt across the armature to brake the train and bring it to very slow speeds. The final braking is done by air brakes because the shunted-motor braking effect decreases as the armature speed decreases. The air brakes, then, are needed to prevent creeping.

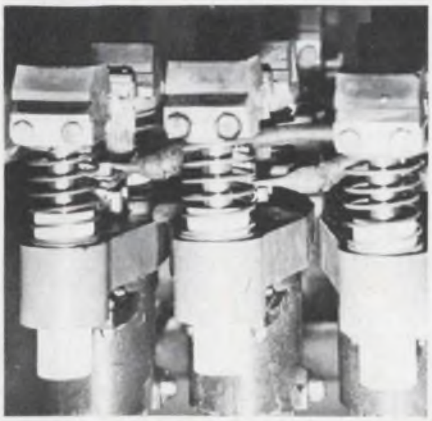
In a typical installation one large Westinghouse Prodac 550 computer oversees the small wayside computers, and one person monitors its main console (photo 4). A loop on the console reproduces in diagram the layout of the track, and lights give the monitor a visual indication of the positions of all trains.

Trains can leave a station every two minutes. The Prodac 550 even decides how many cars each train needs to accommodate passengers waiting on stations up the line. The



1. **The Westinghouse Sky Bus** rolls quietly through South Park controlled completely by computers. Its dual rubber tires run on two concrete tracks that are supported by steel "I" beams. Two dc motors propel each car.

2. **One of the thyristors** that enable the computers to control train speed by regulating the effective dc power.



3. **Articulated pantograph,** or brushes, tap rails for three-phase power. Brushes contact rails from bottom.

4. **Console of Prodac 550** is monitored by man who oversees train operation. Lights show train position.

Westinghouse project team has designed a special set of tracks that enables the computer to direct the coupling of these cars without a single attendant. This is why fine control of the crawl speed is important, Little pointed out.

The cars are coupled both mechanically and electrically. Each couple contains a giant connector. The connector is shielded from the atmospheric elements by a plate, and when one couple presses against another, the shield retracts. Howell pressed the plate to expose the connector (photo 5).

Fields, dressed in a dark, pinstriped suit, held a light while we crawled under the bus to get a picture of the unusual antenna that transmits information via a track wire to the nearest wayside computer. (photo 6). A transmitter aboard the train continuously informs the computers of the status of a number of sensors on the cars. These sensors measure train speed, acceleration, card load, wheel slippage, motor over-load, air-brake drag, air-brake pressure and low line voltage.

Fail-safe action provided

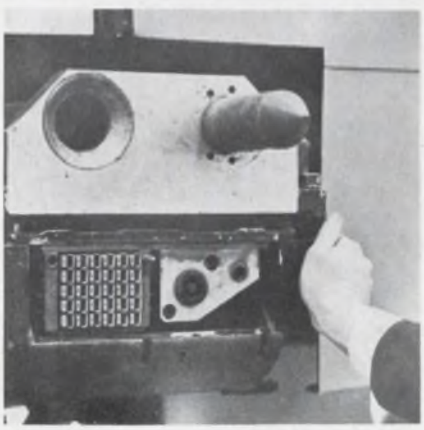
Fields said that the designers of the system has programmed the computer to take appropriate action for any failure. It might simply inform the console attendant of minor irregularities, but it would also pull the main power switch and apply all emergency brakes in case of a serious malfunction. Howell stressed another safety feature inherent in the design of the Sky Bus: four pairs of guide wheels, backed with steel plates, keep the cars on the tracks (photo 7).

I found the Sky Bus system aesthetically attractive. The cars, less than one-fourth the weight of standard subway cars, have clean, modern lines. The tracks and their supports do not mar the landscape, and they are not nearly as expensive as standard railroad supports. The Sky Bus can travel either overhead or on or below the ground at speeds up to 50 mph. It is silent and fume-free.

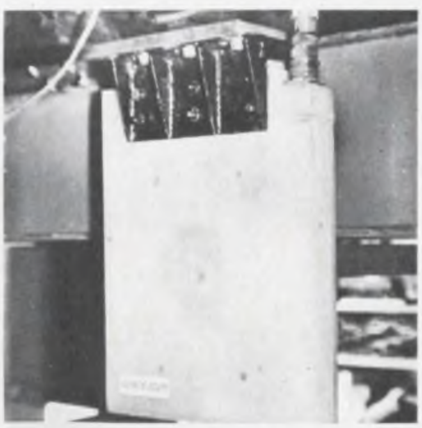
For cities, the cost factor should be important, too. Operation of the transit system requires very few people. And because there are no computers aboard the trains—they just take orders from the wayside computers—cars are not laden with expensive electronic gear.

The train I rode in worked well even with ice on the tracks.

This project demonstrates just one of a number of approaches to the mass-transit problem. Other manufacturers offer approaches that differ considerably from the Sky Bus. Their designs include alternative track material, car size, propulsion systems and track configurations. But all use electronic controls.



5. **Car coupler** contains large electrical connector. Dixie Howell presses plate to remove shield.



6. **Slab antenna** transmits signal via tracklength wire back to computers. Fields held light and I shot photo.

7. **Guide wheels** keep train on tracks. Gear driven odometer sends mileage to transmitter aboard car.

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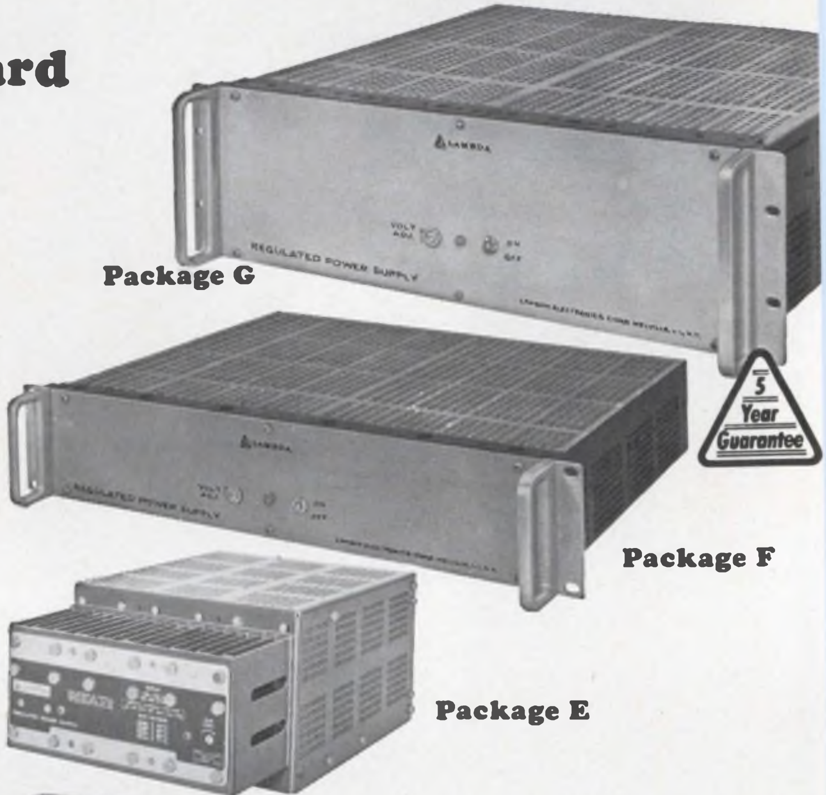

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Package F

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To order these accessory metered panels, specify panel number which MUST BE FOLLOWED BY the MODEL NUMBER of the power supply with which it will be used.

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MP-5	LM-B2	MP-5-LM-B2 $40

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MP-3 MP-5

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Model	ADJ. VOLT. RANGE VDC	I MAX. AMPS[1] 40°C	50°C	60°C	71°C	Price
LM-201	0-7	0.85	0.75	0.70	0.55	$ 79
LM-202	0-7	1.7	1.5	1.4	1.1	99
LM-203	0-14	0.45	0.40	0.38	0.28	79
LM-204	0-14	0.90	0.80	0.75	0.55	99
LM-205	0-32	0.25	0.23	0.20	0.15	79
LM-206	0-32	0.50	0.45	0.40	0.30	99
LM-207	0-60	0.13	0.12	0.11	0.08	89
LM-208	0-60	0.25	0.23	0.21	0.16	109

Package B 3 3/16" x 4 15/16" x 6½"

MP-3 MP-5

Accessory Metered Panels: $40.00

Model	ADJ. VOLT. RANGE VDC	I MAX. AMPS[1] 40°C	50°C	60°C	71°C	Price
LM-217	8.5-14	2.1	1.9	1.7	1.3	$119
LM-218	13-23	1.5	1.3	1.2	1.0	119
LM-219	22-32	1.2	1.1	1.0	0.80	119
LM-220	30-60	0.70	0.65	0.60	0.45	129
LM-B2	2 ±5%	3.4	3.0	2.3	1.4	119
LM-B3	3 ±5%	3.4	3.0	2.3	1.4	119
LM-B4	4 ±5%	3.4	3.0	2.3	1.4	119
LM-B4P5	4.5±5%	3.3	2.9	2.2	1.4	119
LM-B5	5 ±5%	3.3	2.9	2.2	1.4	119
LM-B6	6 ±5%	3.2	2.8	2.2	1.3	119
LM-B8	8 ±5%	3.0	2.7	2.2	1.3	119
LM-B9	9 ±5%	2.7	2.5	2.1	1.3	119
LM-B10	10 ±5%	2.6	2.4	2.1	1.3	119
LM-B12	12 ±5%	2.4	2.3	2.1	1.3	119
LM-B15	15 ±5%	2.1	1.9	1.7	1.2	119
LM-B18	18 ±5%	1.8	1.6	1.5	1.2	119
LM-B20	20 ±5%	1.6	1.4	1.3	1.1	119
LM-B24	24 ±5%	1.3	1.2	1.1	1.0	119
LM-B28	28 ±5%	1.2	1.1	1.0	0.90	119
LM-B36	36 ±5%	1.1	1.0	0.90	0.85	129
LM-B48	48 ±5%	0.90	0.85	0.80	0.75	129

Package C 3 3/16" x 4 15/16" x 9⅜"

MP-3 MP-5

Accessory Metered Panels: $40.00

Model	ADJ. VOLT. RANGE VDC	I MAX. AMPS[1] 40°C	50°C	60°C	71°C	Price
LM-225	0-7	4.0	3.6	3.0	2.4	$139
LM-226	8.5-14	3.3	3.0	2.5	2.0	139
LM-227	13-23	2.3	2.1	1.7	1.4	139
LM-228	22-32	2.0	1.8	1.5	1.2	139
LM-229	30-60	1.1	1.0	0.80	0.60	149
LM-C2	2 ±5%	4.9	4.2	3.5	2.4	139
LM-C3	3 ±5%	4.9	4.2	3.5	2.4	139
LM-C4	4 ±5%	4.9	4.2	3.5	2.4	139
LM-C4P5	4.5±5%	4.9	4.2	3.4	2.4	139
LM-C5	5 ±5%	4.8	4.1	3.3	2.4	139
LM-C6	6 ±5%	4.6	4.0	3.1	2.4	139
LM-C8	8 ±5%	4.4	3.8	3.0	2.0	139
LM-C9	9 ±5%	4.2	3.6	3.0	2.0	139
LM-C10	10 ±5%	4.0	3.5	2.9	2.0	139
LM-C12	12 ±5%	3.8	3.3	2.8	2.0	139
LM-C15	15 ±5%	3.4	3.2	2.7	1.8	139
LM-C18	18 ±5%	3.0	2.8	2.5	1.7	139
LM-C20	20 ±5%	2.9	2.7	2.4	1.7	139
LM-C24	24 ±5%	2.5	2.4	2.2	1.5	139
LM-C28	28 ±5%	2.3	2.1	2.0	1.4	139
LM-C36	36 ±5%	2.0	1.8	1.7	1.3	149
LM-C48	48 ±5%	1.6	1.4	1.3	1.0	149

Package D 4 15/16" x 7¾" x 9⅜"

MP-5

Accessory Metered Panels: $40.00

Model	ADJ. VOLT. RANGE VDC	I MAX. AMPS[1] 40°C	50°C	60°C	71°C	Price
LM-234	0-7	8.3	7.3	6.5	5.5	$199
LM-235	8.5-14	7.7	6.8	6.0	4.8	199
LM-236	13-23	5.8	5.1	4.5	3.6	209
LM-237	22-32	5.0	4.4	3.9	3.1	219
LM-238	30-60	2.6	2.3	2.0	1.6	239
LM-D2	2 ±5%	13.1	11.3	9.2	6.2	199
LM-D3	3 ±5%	13.1	11.3	9.2	6.2	199
LM-D4	4 ±5%	13.1	11.3	9.2	6.2	199
LM-D4P5	4.5±5%	13.1	11.3	9.2	6.2	199
LM-D5	5 ±5%	12.6	10.8	9.2	6.1	199
LM-D6	6 ±5%	12.4	10.6	8.9	6.0	199
LM-D8	8 ±5%	12.2	10.3	8.8	5.9	199
LM-D9	9 ±5%	11.3	10.0	8.6	5.7	199
LM-D10	10 ±5%	10.8	9.7	8.5	5.7	199
LM-D12	12 ±5%	10.0	9.2	8.3	5.7	199
LM-D15	15 ±5%	9.0	8.4	7.9	5.3	209
LM-D18	18 ±5%	7.9	7.4	6.9	5.0	209
LM-D20	20 ±5%	7.4	6.9	6.5	4.9	209
LM-D24	24 ±5%	6.7	6.3	5.8	4.8	219
LM-D28	28 ±5%	6.0	5.6	5.2	4.7	219
LM-D36	36 ±5%	5.4	5.0	4.7	4.3	239
LM-D48	48 ±5%	4.1	3.9	3.6	3.1	239

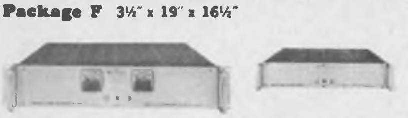
Package E 4 15/16" x 7¾" x 11⅞"

MP-5

Accessory Metered Panels: $40.00

Model	ADJ. VOLT. RANGE VDC	I MAX. AMPS[1] 40°C	50°C	60°C	71°C	Price
LM-E2	2 ±5%	18.0	16.0	15.0	10.0	$269
LM-E3	3 ±5%	18.0	16.0	15.0	10.0	269
LM-E4	4 ±5%	17.0	16.0	15.0	10.0	269
LM-E4P5	4.5±5%	16.0	15.0	14.0	10.0	269
LM-E5	5 ±5%	16.0	15.0	13.0	10.0	269
LM-E6	6 ±5%	15.0	14.0	12.0	10.0	269
LM-E8	8 ±5%	14.0	13.0	12.0	9.5	269
LM-E9	9 ±5%	13.5	12.5	11.0	9.5	269
LM-E10	10 ±5%	13.0	12.0	10.0	9.2	269
LM-E12	12 ±5%	12.0	11.0	9.5	9.0	269
LM-E15	15 ±5%	11.0	10.0	9.0	8.5	269
LM-E18	18 ±5%	10.5	9.5	8.5	8.1	269
LM-E20	20 ±5%	10.0	9.0	8.3	7.7	269
LM-E24	24 ±5%	9.0	8.5	7.7	7.0	269
LM-E28	28 ±5%	8.5	8.0	7.3	6.6	269
LM-E36	36 ±5%	6.8	6.3	5.9	5.2	279
LM-E48	48 ±5%	5.0	4.6	4.3	3.9	299

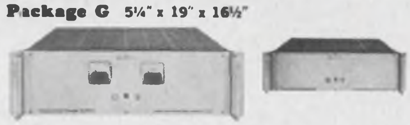
Package F 3½" x 19" x 16½"



For metered models, add suffix (M) to model number and $30.00 to the price below.

Model	ADJ. VOLT. RANGE VDC	I MAX. AMPS[1] 40°C	50°C	60°C	71°C	Price
LM-F2	2 ±5%	44.0	39.0	32.0	24.0	$425
LM-F3	3 ±5%	44.0	39.0	32.0	24.0	425
LM-F4	4 ±5%	44.0	39.0	32.0	24.0	425
LM-F4P5	4.5±5%	44.0	39.0	32.0	24.0	425
LM-F5	5 ±5%	44.0	38.0	31.0	24.0	425
LM-F6	6 ±5%	43.0	37.0	30.0	23.0	425
LM-F8	8 ±5%	40.0	34.0	28.0	22.0	425
LM-F9	9 ±5%	38.0	32.0	26.0	21.0	425
LM-F10	10 ±5%	36.0	31.0	25.0	20.0	425
LM-F12	12 ±5%	30.0	26.0	21.0	16.0	425
LM-F15	15 ±5%	25.0	22.0	18.0	15.0	425
LM-F18	18 ±5%	23.0	20.0	17.0	13.0	395
LM-F20	20 ±5%	21.0	19.0	16.0	12.0	395
LM-F24	24 ±5%	18.0	16.0	13.0	10.0	380
LM-F28	28 ±5%	17.0	15.0	13.0	9.5	380
LM-F36	36 ±5%	13.0	11.0	10.0	7.5	395
LM-F48	48 ±5%	10.0	9.0	7.5	6.0	425

Package G 5¼" x 19" x 16½"



For metered models, add suffix (M) to model number and $30.00 to the price below.

Model	ADJ. VOLT. RANGE VDC	I MAX. AMPS[1] 40°C	50°C	60°C	71°C	Price
LM-G2	2 ±5%	90.0	83.0	62.0	43.0	$575
LM-G3	3 ±5%	85.0	80.0	62.0	43.0	575
LM-G4	4 ±5%	77.0	71.0	61.0	43.0	575
LM-G4P5	4.5±5%	72.0	68.0	60.0	43.0	575
LM-G5	5 ±5%	68.0	64.0	59.0	43.0	575
LM-G6	6 ±5%	60.0	55.0	52.0	43.0	525
LM-G8	8 ±5%	59.0	54.0	48.0	39.0	525
LM-G9	9 ±5%	58.0	53.0	47.0	37.0	525
LM-G10	10 ±5%	56.0	52.0	44.0	35.0	525
LM-G12	12 ±5%	48.0	44.0	37.0	29.0	525
LM-G15	15 ±5%	39.0	37.0	31.0	24.0	525
LM-G18	18 ±5%	32.0	30.0	27.0	21.0	525
LM-G20	20 ±5%	30.0	28.0	25.0	20.0	525
LM-G24	24 ±5%	27.0	25.0	20.0	16.0	480
LM-G28	28 ±5%	25.0	23.0	19.0	15.0	480
LM-G36	36 ±5%	22.0	20.0	16.0	13.0	525
LM-G48	48 ±5%	17.0	14.0	12.0	9.0	575

[1] Current rating is from zero to I max.
Current rating applies over entire output voltage range.
Current rating applies for input voltage 105-132 VAC 55-65 cps.
For operation at 45-55 cps and 360-440 cps derate current rating 10%.

NEWS

Computer checking computer production

An unsalable, prototype Westinghouse Prodac 50 computer has been put to work screening out wiring errors in production models of the computer.

Engineers at the Westinghouse Research and Development Center in Pittsburgh designed the Prodac 50 (Process Digital Automatic Control) to solve traffic and production problems. The prototype is now riddled with the external signs of improvements, in comparison with its trimly packaged production mates.

Each vertical panel on the computer contains 16 cards, with 16 hand-soldered connections on each card. There are 256 chances for error during the wiring procedure, according to Bates Murphy, head of the Westinghouse computer engineer team.

Even though the wirers receive step-by-step intructions, the contact pins play tricks with their eyes after a few hours of work. Formerly another employee spent three days checking to see that every connection was properly made. But the checker had no way of knowing if extra connections had been made by error.

Now the original version of the Prodac 50 checks all connections and reports any that have been overlooked. In addition it reports all extraneous ones. The total time for a complete check has been reduced to under one-half hour, including hook-up time.

Radio opening supply 'chutes in Vietnam

One of the newest Air Force developments for achieving highly accurate parachute supply drops in Vietnam is the 'chute popper—a system that enables a ground observer to open a parachute by pushing a radio button.

The 'chute popper was designed to supply troops in small, remote areas that might be heavily surrounded by Viet Cong guerrillas. If the drop is off target, the parachutes are not opened, and the supplies are destroyed on impact.

A small digital-control unit in the

('chutes, *continued***)**

back pack of a standard Army field telephone is used to activate the 'chute popper or Ground-Controlled Parachute Deployment System, as it is officially called. By pushing a button on the control unit, the ground observer transmits a radio signal to a command receiver on the parachute harness. The receiver, in turn, activates an explosive charge, which blows apart a line that keeps the parachute from inflating.

The same field telephone unit is used to get in touch with the aircraft and guide the drop from the ground.

According to officials of Canoga Electronics of Chatsworth, Calif., developers of the 'chute popper, the device operates on a digitally programmable frequency to insure that it will not be activated by any other electronic signal.

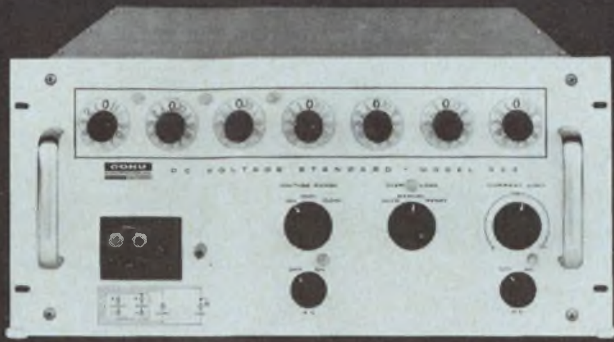
Electronics in medicine still challenges engineers

"You're just going to have to learn new terms" said Dr. S. Fine of Northeastern University to a panel on Biomedical Electronics at the recent international Solid State Circuits Conference. Dr. Fine was talking about the many problems faced by the engineers and doctors engaged in the growing field of biomedical electronics.

L. D. Wechsler of General Electric maintained that many of the bio-medical electronics problems that exist today can be attacked with existing electronic technologies and that there is a definite need for many more electronic specialists to work in this area. Problems involved in pattern recognition, ultrasonic and feedback control of prosthetic devices (artificial arms, legs, etc.) are the domain of the electronic specialist and he already has the tools needed to solve them, according to Weschler.

In addition to the problem of re-educating doctors and engineers, several other problems face workers in this field:

Cheaper devices are needed to encourage wider acceptance and use of electronic instruments, especially in medicine. However, quality and reliability should be considered instead of cost, in the opinion of W.



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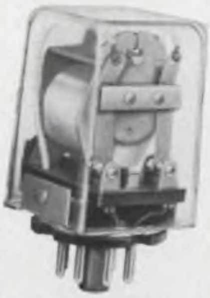

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SPECIFICATIONS

- *Contacts: SPDT, DPDT, 3PDT*
- *Contact Rating: 5 and 10 amps.*
- *Pull-in: 22 milliseconds average*
- *Drop-out Speed: 12 milliseconds average*
- *Size: 1⅜" x 2⅛" x 1⅜"*
- *Weight: 3 ounces*

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. . . toss your toughest medium-power-handling assignments to this workhorse. 25PS types carry loads to 20 amps. on a fast duty cycle in a breeze. UL listed. Features include: rugged ⅜" diameter silver cadmium oxide alloy contact; lower pull-in voltages (DC: 75% of nominal, AC: 76% of nominal); AC operating voltages 4 to 250, DC 1 to 130 in current ranges from .02 to 10 amp. For full technical information on this and other Eagle Signal general purpose and medium power relays, use the Reader Service Card, and circle number 875

SPECIFICATIONS

- *Contacts: SPDT*
- *Contact Rating: 20 amps. 115/230 VAC 60 cycle resistive • 1 HP @ 115/230 VAC motor-inductive*
- *Pull-in: 50 milliseconds max.*
- *Drop-out Speed: 30 milliseconds max.*
- *Size: 2¼" x 1 9/32" x 1 13/16"*
- *Weight: 3 ounces*

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SPECIFICATIONS

- *Contacts: SPDT, DPDT, 3PDT*
- *Contact Rating: 5A and 10A @ 115 VAC•5A-1/10 HP @ 115 VAC, 1/6 HP @ 230 VAC•10A-1/6 HP @ 115 VAC, 1/3 HP @ 230 VAC*
- *Pull-in: 22 milliseconds average*
- *Drop-out Speed: 12 milliseconds average*
- *Size: 1⅞" x 1 9/32" x 1½"*
- *Weight: 2 ounces*

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(Biomed, ***continued*****)**

Greatbatch of the State University of Buffalo. Dr. O. H. Schmitt of the University of Minnesota felt that while neither quality nor reliability should be sacrificed for price advantage, the cost factor should be raised in importance because of its impact on the availability and utilization of needed devices.

Power supplies for prosthetic devices such as "pacemakers" (heart stimulators) present problems in both size and the need for recharging of batteries. To demonstrate this, Greatbatch said that if the size of the electronic portion of a pacemaker were halved, the size of its power supply would only be reduced by 5% and this power supply is many, many times the size of the electronic package. Studies are presently being made to determine the suitability of nuclear power in place of batteries. An aspirin-sized pill of plutonium-238 could keep a pacemaker going for 60 years, according to Greatbatch.

A member of the audience stated that a new probe is needed that will operate reliably without the need for insertion into an organ, which results in tissue destruction. This new transducer must be able to adhere to any body surface.

Braille devices aid blind engineers

Electrical measurements can now be made by blind engineers, according to T. A. Benham, professor of engineering of Haverford College.

Benham has designed a braille meter face with which the sightless can read a variety of instruments. It uses a nulling technique.

Its application to the Wheatstone

1. **T. A. Benham** operates a Heath Impedance Bridge that he fitted with Braille-readout dials.

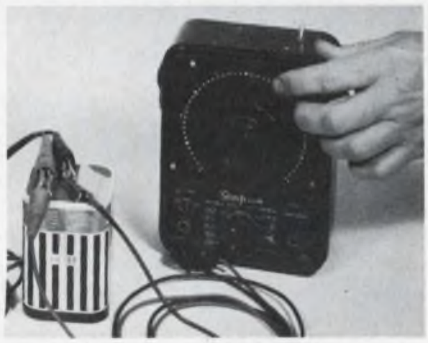
(Braille devices, ***continued*****)**

bridge (see photo 1) uses this technique directly. Instead of nulling a galvanometer until its pointer is undeflected, the blind engineer nulls an audible tone. This is accomplished by turning a dial that points to a set of raised dots. By feeling these dots with his fingers the engineer can determine the value of the "reading."

Benham has also made other Braille-readout devices. A standard Simpson meter is now available with a Braille face (see photo 2). The blind engineer can operate the Simpson on all the scales of the normal meter. Again; he must null the sound that emanates from the top of the meter by moving a pointer. He then feels the value on the Braille face.

The blind engineer can even read punched tape from a computer with a device that converts the hole matrices into a Braille code (see photo 3).

Benham does this work in a program called "Science for the Blind" in Haverford, Pennsylvania.



2. **The face of this special Simpson meter** is read by a blind person.

3. **Punched-tape reader** converts hole matrices to Braille.

A PROBLEM SOLVER RECTIFIER... FOR FREQUENCIES TO 100 KC

INTERESTED?

Read on and learn how fast recovery rectifiers helped one designer

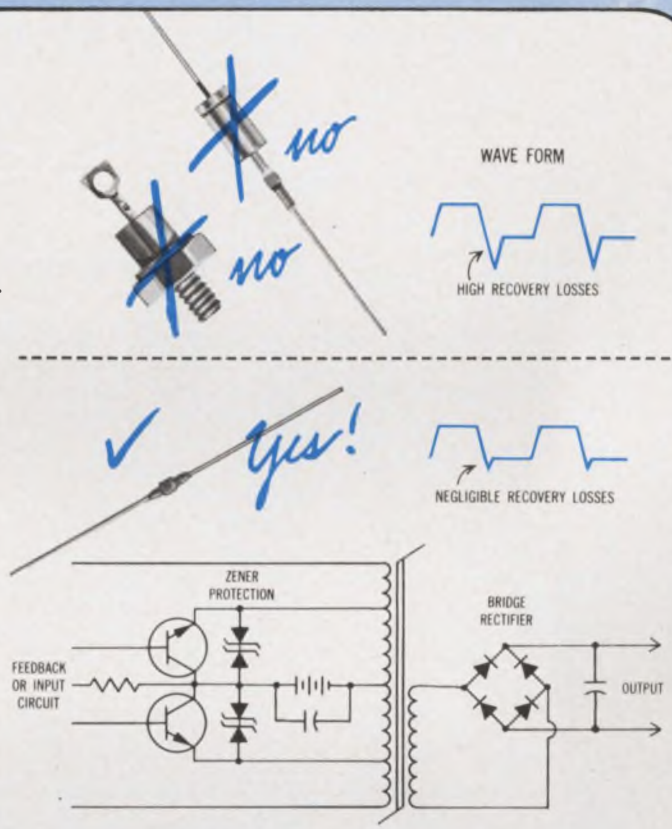
CASE HISTORY

George had a problem--the bridge rectifiers in a 30 KC static inverter power supply were running much too hot. This perplexed him since the bridge output current of 1 Amp was within the rating of these rectifiers, 1N3189s. Although crowded for space, George decided to try larger stud mounted 1N1124As. No help! They also ran hot and in addition reduced output voltage and operating efficiency.

What George needed was a fast recovery rectifier to eliminate the severe reverse recovery losses at this frequency. Such losses cause conventional diodes to overheat and drop their output voltage. The solution ...UNITRODE UTR22s which have recovery times of 100 nanoseconds in the standard 1 Amp to 30 volt test circuit. In contrast the 1N3189 has a typical recovery time of 2 microseconds; a stud mounted 1N1124A is even slower.

In addition, George picked up some other bonuses--much smaller size, lighter weight, higher thermal efficiency and increased reliability because of the unique Unitrode monolithic construction.

P. S. Note the Unitrode 50 watt surge zeners (the same small size as the UTR 22) used to protect the expensive power transistors from burnout due to voltage spikes.



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Letters

MOS FETs are fast enough for RF, semiconductor manufacturer asserts

Sir:

We commend you for an excellent article on MOS FETs in the Jan. 18, 1966 ELECTRONIC DESIGN issue (p 22). This was a most difficult task, because each manufacturer, naturally, would be biased in his approach. However, in all fairness to the industry, we desire to go on record in correcting a few narrow viewpoints reported in the article.

In particular, we respond to the quotation of Mr. Recklinghausen of H. H. Scott [who prefers junction FETs for RF applications]. KMC Semiconductor Corporation was the first company to announce commercially available 200 and 450 MHz operational MOS transistors. These devices have transconductance cutoff frequencies of 1200 and 1500 MHz, respectively. These are *n*-channel, full gate, depletion MOS transistors. We also manufacture *p*-channel enhancement devices. The noise figure and power gain are comparable to the best silicon bipolars on the market. A high transconductance vhf geometry MOS has been used in broadband circuits in the range of 30 to 220 MHz and in narrow-band circuits over the frequency range of 2 to 220 MHz. Other RF applications include single-ended and balanced mixers, oscillators and IF amplifiers. During 1965 prototype sampling totaled 5000 transistors for RF designs. The field returns due to mishandling (the solder iron and electrostatic damages) were approximately one-half of one per cent. MOS transistors in the vhf range will improve CATV performance.

Present reliability data on operating (150 MW) and storage (200°C) life indicate a MTBF of better than 40.000 hours. Techniques on surface stabilization have been responsible for this reliability.

Microwave mixer diodes and germanium mesa transistors are prone to pulse burnout and electrostatic damage. However, present-day equipment incorporates these devices. Tunnel diodes required an education in handling, which is true of any new device.

In summary, the MOS transistor is fast enough for RF performance, and the electrostatic problems are being solved. With regard to its frequency response, McIntosh of Westinghouse Research Labs predicts 10 GHz operation with a MOS design. Eventually the MOS will surpass the bipolar transistor and electron tube in frequency response.

PAUL E. KOLK
Vice President of Engineering
KMC Semiconductor Corp.
Long Valley, N. J.

Recklinghausen replies

Sir:

I fully grant to Mr. Kolk that KMC Semiconductor Corporation was the first company to announce vhf field-effect transistors. I also grant that MOS transistors can have a noise figure and power gain comparable to silicon bipolar transistors. I feel, furthermore, that a prediction of 10 GHz operation for MOS transistors may be possible in the future. However, I feel that more advantageous results, including shf, can be obtained with junction-type FETs.

As a figure of merit, the best measure is the ratio of transconductance to capacitance. The insulating layer between the gate and the active region of a MOS can be thought of as an element that either increases the interelectrode capacitance or decreases the effective field applied to the channel. This reduces the high-frequency figure of merit for an MOS transistor.

Our experience with junction field-effect transistors, totalling over 20,000 units, has shown the noise to be lower than the best silicon bipolar transistor in the FM broadcast band. The junction field-effect transistors used by us have also successfully withstood assembly-line handling without any precautions or additional education. They have even withstood such mishandling as misinsertion in sockets, with applied power.

In our usage of junction-type field-effect transistors we do not have to worry about RF performance or any electrostatic problems.

DANIEL R. VON RECKLINGHAUSEN
Chief Design Engineer
H. H. Scott, Inc.
Maynard, Mass.

A further defense of engineer licensing

Sir:

I read with interest your editorial "The Engineer's License—Is It Worth It?" (Nov. 8, 1965, p. 18).

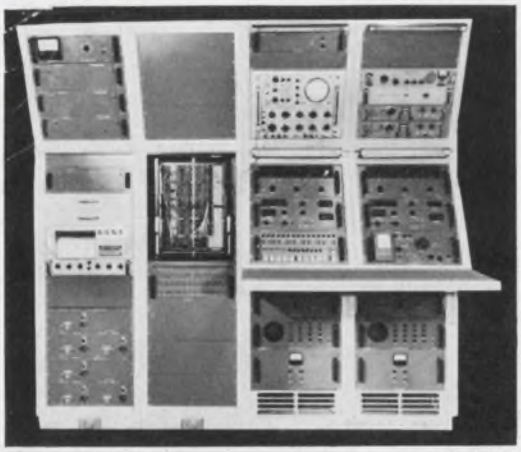
When you use the term "license," I must assume you are speaking of the stationary engineer, who receives a license to perform a prescribed task by paying a fee. The engineer is registered as a professional, capable of exercising judgment based upon a suitable education, both formal and informal, including experience. The purpose of engineering registration is to protect the public and, we hope, nothing else. I feel that in my professional life I have had a greater effect on the health and well-being of more people than a dozen average medical doctors, and I think this is not unusual for a Professional Engineer.

In my opinion, many of the people who consider themselves electronic engineers are primarily technicians who should not be allowed to make engineering decisions, until they have satisfied the broad requirements of a Professional Engineer.

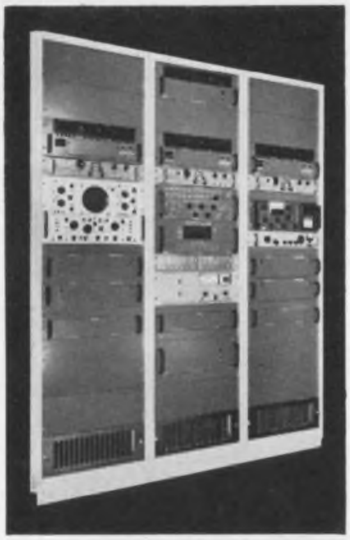
Take, for example, your magazine, which persists in using the symbol for an electrical contact to represent a capacitor. There are many standards in the United States, and all agree upon the proper symbol for a capacitor. Any technician in the field has the right, when examining devices or working on equipment, to assume that the drawings for this equipment have been prepared in accordance with existing national standards. Consider, then, the unfortunate man in the field who assumes that this device shown as a pair of parallel lines is a harmless switch contact, when in reality it is a lethally charged capacitor.

The Professional Engineer has included in his training a knowledge of ethics, economics and regard for public safety, in addition to his theoretical technical knowledge. This training allows him to use the efforts of the technician in preparing devices and systems which, in addition to being technically feasible, are safe an in accordance with generally accepted principles of workmanship, etc.

I cannot speak for the engineering examinations in all states; however, it is my understanding that the Illinois examination is typical of that given in many states and far from being obsolete. It is



U. S. Navy (AUTEC) Master Timing System



NASA Mississippi Test Facility (MTF) Master Timing System

NASA Wallops Island Terminal Time Systems

prepared twice a year, to include a wide variety of subjects, necessary for a knowledge of engineering.

No doubt there will be incompetents who manage to pass this examination. In my years of observing members of this profession, I find these incompetents typically are those who are specialists in a very narrow field.

W. B. Jarzembski, P.E.
Director of Product Engineering
Appleton Electric Co.
Chicago, Ill. 60657

Sir:

Maria Dekany's Nov. 8 editorial espousing liberalism ("The Engineer's License—Is It Worth It?") should be reviewed with a questioning attitude.

The public must be protected, and licensing by law is an accepted method. The purpose of the laws is not as stated in the editorial. High standards and ethical practice are secondary results.

All engineers—although they may be considered specialists by their contemporaries—are not necessarily professionals. It is conceivable, from the standpoint of public responsibility, that many are incompetent.

Very few designs or systems in which the public is involved are so "pure" that they can be evaluated by a specialist in one field only.

A doctor of medicine must be knowledgeable in a great many phases of medical practice. He can, if he chooses, be a specialist.

Professional engineers are likewise obligated.

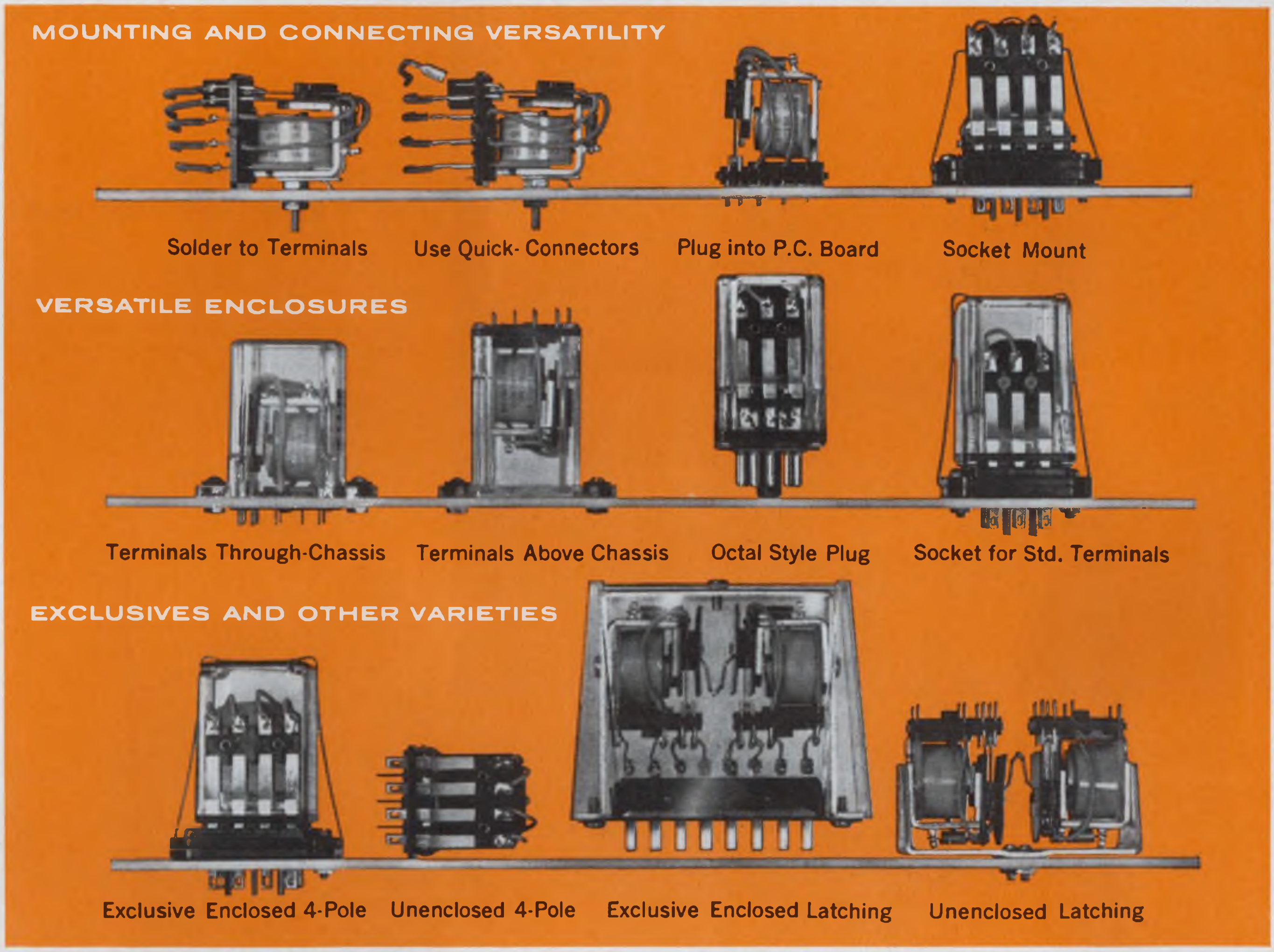
Ray Summerer
Grand Blanc, Mich.

The editorial did not advocate liberalization of the examination required to obtain the license. Rather it urged improvements in the examination. The suggestions were based on a survey of working engineers and consultants, and it reflected the opinion of the majority.

Nor are working engineers alone in calling for improvements. A group of illustrious educators indicated their support of this goal at the annual meeting of the Association of the Engineering Colleges, held in Buffalo, N. Y. Prof. R. C. King, chairman of the State Board of Examiners of Professional Engineers and Surveyors, said: "Part III of the examination should be increased from four to eight hours, since it is considered to be of major importance. A longer time would allow broader coverage, giving op-

down with "specials"!!

who needs 'em with Ohmite's big variety of *stock* GPR relays



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ON READER-SERVICE CARD CIRCLE 35

portunity to examine the candidate on a wide range of specialities and, in general, add flexibility to the examination."

Engineers in New York State who would like to make their opinions known to the board can write to Newell L. Freeman, Secretary, State Board of Engineering Examiners, University of the State of New York, State Educator Dept., Education Building, Albany, N. Y.

In other states, get in touch with State Board of Engineering Examiners.

THE EDITORS

Another advocate of a new transistor code

Sir:

To renew an old controversy about transistor coding, let me suggest a hypothetical situation. Let's imagine ourselves about ten years in the future.

A new transistor, designated the 2N35564, has been recently introduced. This *npn* germanium device has a minimum current gain of 500, a C-E breakdown of 1000 V, a cutoff frequency of 10 GHz, is capable of dissipating 100 watts and is packaged in a stud-mounted TO-43 case.

Now let's consider what useful information is revealed by the type number of this amazing device. All we find is that this high gain, high voltage, high frequency, high power transistor had been registered just after the 2N35563, and just before the 2N35565.

The fact is that we have accepted and are existing with an inferior system of transistor coding, simply because it was an extension of an equally inferior system of diode coding. There is still some confusion about the properties of many popular types.

I believe that a parameter or characteristic coding system for semiconductor devices will benefit the majority of people concerned with these devices.

Let's standardize and implement such a system now. We should be able to distinguish an *npn* from a *pnp*, a silicon from a germanium, a high gain from a low gain, a unijunction from an SCR or from a FET, a signal diode from a rectifier, a tunnel diode from a unitunnel and a 5-V Zener from a 9-V Zener.

GEORGE ROY SKOBLIN
Kearfott Div.
General Precision
San Marcos, Calif.

REEVES-HOFFMAN

"chips" away at the space problem with new

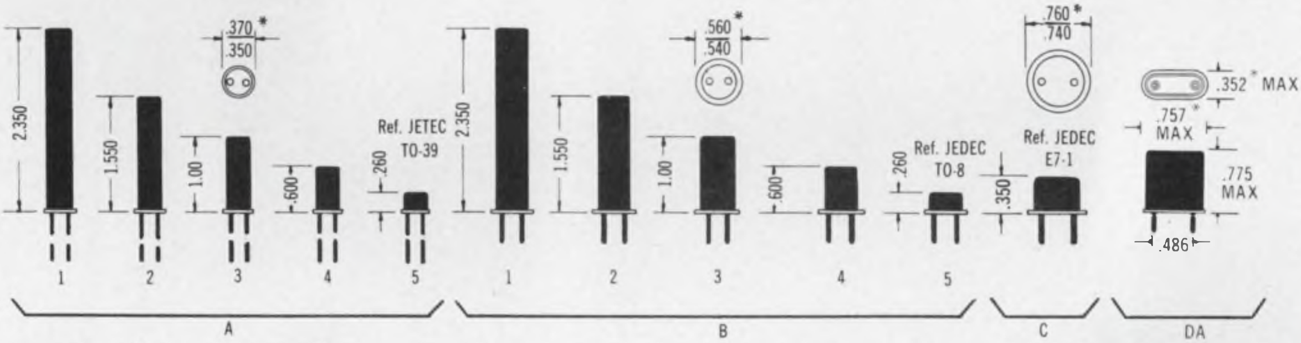
COLD-WELDED CRYSTALS

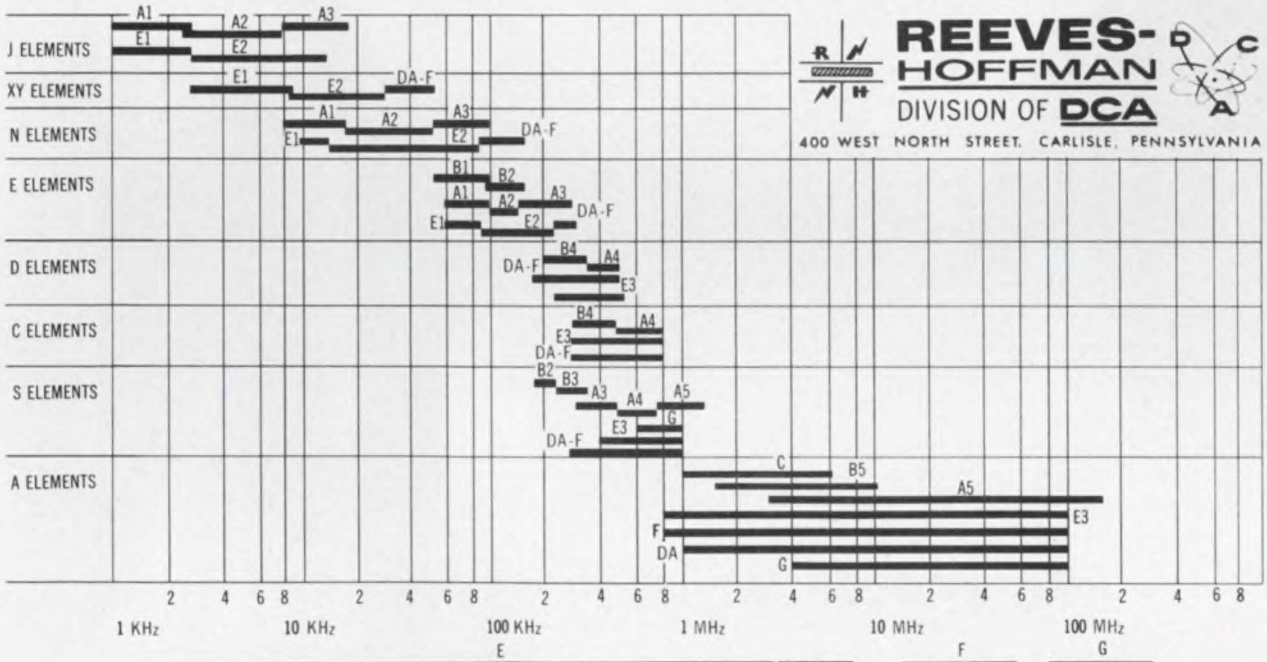
Reeves-Hoffman's newest series of crystals, packaged in cold-welded TO-5 transistor cans, are designed for operation at frequencies from 3 to 125 MHz. Frequency tolerance over the temperature range from —55°C to +105°C is ±0.004%. (Upon special request, ±0.0025% can be provided.) Shock and vibration ratings exceed the requirements of MIL-Spec 3098D. Aging at 65°C is 6 parts in 10^6 per year.

Cold welding eliminates solder and attendant flux and heat, removes undesirable damping and corrosion, solves problems of thermal isolation. Leak rate is better than 10^{-9}cc of helium per second. The results: substantial increases in the reliability and stability of crystal units, oscillators and filters; further opportunity for miniaturization.

For example, by using microminiature circuitry "chips," it is possible to produce a cold-welded crystal oscillator that occupies the space normally used for the crystal alone. The oscillator shown at left, for example, is in the A-4 holder shown below. Can this new micromodule technique solve space problems for you? We invite your inquiry.

IEEE Booth 1B02





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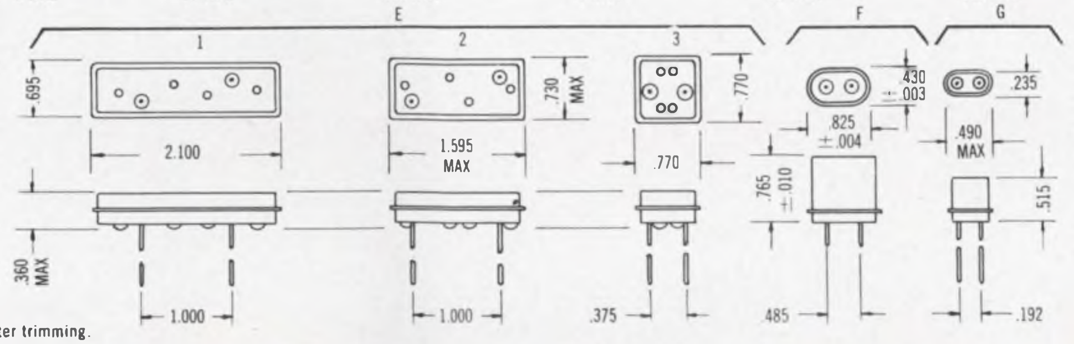
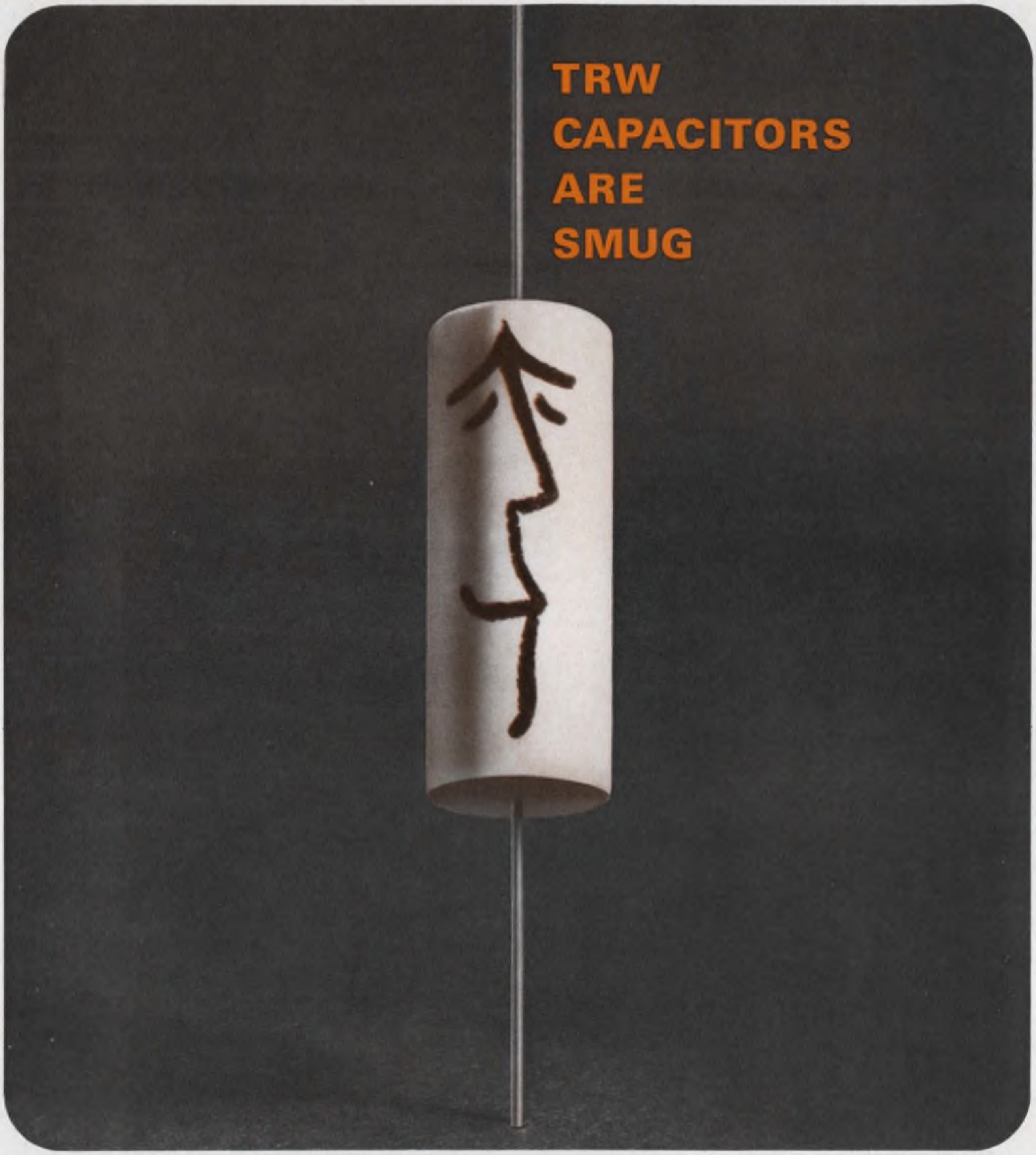


*Dimensions after trimming.

CW-166

ON READER-SERVICE CARD CIRCLE 37



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TRW CAPACITORS

ON READER-SERVICE CARD CIRCLE 38

It's the engineer's job to bring order out of chaos

Why is the electronic design engineer forced to use non-uniform and often incomplete specification sheets for components, instruments and other equipment? Why does he have to operate with a meaningless transistor coding system? Why does he have to look forward to the same type of coding for microcircuits? Why is he forced to make up his own specification sheets or call in competitive salesmen if he wants to obtain all the design data he needs on devices and equipment? These were some of the questions we asked in our survey of engineering societies, trade associations and working engineers (see page 86).

There were good reasons for asking these questions. Problems of uniform test procedures, standard specifications, and meaningful coding systems are not unique to the electronics industry. In the metals field, for example, similar problems existed. As the number of processes and alloying techniques grew, engineers were not fully aware of the variety of metals available, and they found it hard to predict what they would receive when they ordered. Thus, they weren't able to design intelligently. Despite the seemingly impossible task of bringing order out of this chaos, the job was done. Manuals were written to describe the processes in use, their effects on properties, and the effects of different alloying agents.

Our industry's failure to achieve similar results must be blamed, to a great extent, on the engineer himself. Manufacturers can not come up with new specification ideas, uniform test procedures for similar devices, or standardized spec sheets without active participation by engineer-users. And here is where the trouble lies. Most engineers do not communicate effectively with manufacturers, even though several channels exist.

The designer complains to his peers, and to his superiors, but he generally doesn't use the right avenues to his suppliers. Complaints to salesmen may occasionally filter back to the manufacturer, but, if they refer to non-competitive industry-wide practices, little action results.

The answer, we believe, lies in the attitudes we found engineers to have toward technical societies. They are looked upon as "clubs for engineers," where members can get together at least once a year and exchange information. Most engineers have little interest in the policy-making machinery of technical societies. Yet these societies do have subcommittees that work closely with trade associations or other manufacturer groups. Engineers *should* get involved with these groups, attend meetings, voice their complaints. Societies usually welcome worthwhile suggestions from members.

If these attempts are made without success, then it is time to consider opening new channels of communication. Perhaps another organization could be formed to establish requirements for uniform data for design.

In any event, the engineer can not abdicate his responsibility to bring order out of chaos.

MARIA DEKANY

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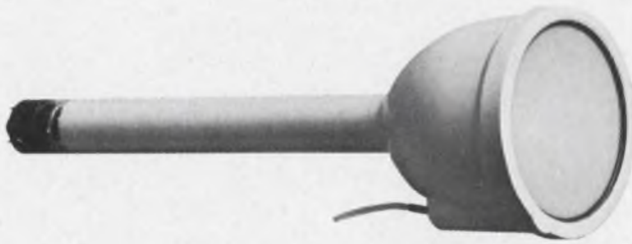

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New York Coliseum . . . home of the electronic industry's biggest event.

What is IEEE USA?

This special section brings the 1966 IEEE International Convention to design engineers all over the United States. Those who will not be attending in person can tour the Show through these pages. Those who will be on hand in New York, March 21-25, will find this section an invaluable aid in planning their activities in advance.

For those who can't attend

If you're not planning on being at the Show, the following sections of IEEE USA will bring the Show to you:

- **Tour of the exhibits.** New products to be shown are arranged by show area (Components, page 110; Systems, page 158; Instruments, page 142; Heavy Machinery, page 129; Production Materials, page 174).

- **Product trends.** New product trends and their significance to the designer are given starting on page 78. Five design areas are covered: Communications, Consumer Electronics, Microwaves, Digital Equipment and Industrial Electronics.

- **Technical program highlights.** A representative cross-section of the technical papers are highlighted starting on page 68.

- **Technical paper order form.** A convenient order form is provided for the proceedings of the technical sessions. You'll find the form in the Planning Guide, which is inserted after page 96. A list of the technical papers, by subject, starts on page 94.

For those who will attend

If you are going to the Show, the following sections of IEEE USA will help you make plans in advance so that your time at the Show can be spent more efficiently:

- **Planning guide.** This booklet, inserted after page 96, provides a "walk-through" of the exhibit areas, pinpointing the booths where new products will be found. Complete descriptions of the new products can be found in the "Touring the Exhibits" section of IEEE USA.

- **Tour of the exhibits.** New products to be shown are arranged by show area (Components, page 110; Systems, page 158; Instruments, page 142; Heavy Machinery, page 129; Production Materials, page 174).

- **Technical sessions by specialty.** A list of technical papers, divided according to specialty, starts on page 94. Highlights of some of the papers are given starting on page 68.

- **Technical paper ordering form.** Save yourself the trouble of carrying technical session proceedings back from the Show. Order the ones you want by using the form contained in the Planning Guide.

For everyone

As an added feature, IEEE USA contains a timely article on engineering societies and their value to practicing engineers.

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Technical paper highlights, as seen through the keyhole. 68

Product trends at this year's Show, and what they mean to the designer. Here's how it looks in five design areas. 78

EE societies—are they doing enough? See what the engineers themselves think about it. 86

When, where and what to hear—Here's the complete scorecard of technical papers by specialty. Time and place is included for each paper. 94

IEEE USA Planning Guide takes you on a walk through the exhibit areas, pinpointing booths where new products will be found. . . . . between 96 and 97

How to use the Planning Guide, including details on the money-saving discount coupons. 96

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Components 110

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Cover: Unified S-band antenna for Apollo moon missions. Built by Collins Radio Co., the antenna will be used with the Apollo tracking/communication system. Space communications is covered in technical sessions 27 and 67.

Here are some technical paper highlights

as seen through the 'keyhole.' A complete index of program papers by specialty starts on p 94.

With over 300 papers and more than a dozen panel discussions, this year's technical program again offers something for everyone and a lot for most. Representatives from industry, Government and the academic world will cover subjects as esoteric as "Ultrasound Analysis of Implanted Cardiac Prosthetic Valves" and as practical as "The Design of High-Performance, Active RC Bandpass Filters."

Even a cursory analysis of such a large and diverse program is impractical. So, instead, here are some of the broadly applicable technical areas and highlights of typical papers within those areas:

Communications

For those interested in communications and related topics, the papers span the range from deep-sea diver communications and their problems to interplanetary spacecraft telecommunications systems. Commercial broadcasting, telephone and

Mariner IV completed its flight to the vicinity of Mars on July 14, 1965 and sent back photographs and other measurements of the "red" planet. Its 10-watt telemetry transmitter spanned the unprecedented distance of 300 million kilometers in telemetering the data back to earth. (paper 67.2) telegraphy are covered, too, along with a host of other topics.

Progress in deep-space probes

A review of the progress in developing interplanetary spacecraft telecommunication systems will be presented by G. A. Reiff of NASA. He will describe the systems and techniques used for the Pioneer and Mariner space vehicles, which have contributed greatly to our knowledge of multimillion-mile radio communication.

The NASA representative feels that if performance in this field continues to increase at the same rate that it has in the last six years, it will soon be possible to transmit large quantities of information from the surface of Mars or to communicate with spacecraft flying in the vicinity of the outer planets. The proposed installation of 100-kw transmitters and 210-foot antennas at ground sites is expected to advance the present capability.

Interplanetary Spacecraft Telecommunication Systems (67.2, Fr. a.m. SN)

Man-made noise analyzed

Unintentionally generated man-made radio noise will be analyzed quantitatively in a paper by E. N. Skomal. The analysis is based on the statistical properties of two electrical noise models, one covering the frequency range of 10 Hz to 20 MHz, and the other from 100 to 500 MHz. A comparison of the theoretical results with available experimental data show the two to be in agreement.

The proposed mechanism of noise generation for the higher frequency interval assumes that the man-made noise arises from randomly occurring narrow pulses. In the model for the higher frequency interval, it is assumed that the noise pulses form a train of independent events having an average frequency of occurrence, v. For both models the attenuation is assumed to be that applicable to radio transmission over irregular terrain from low antenna heights.

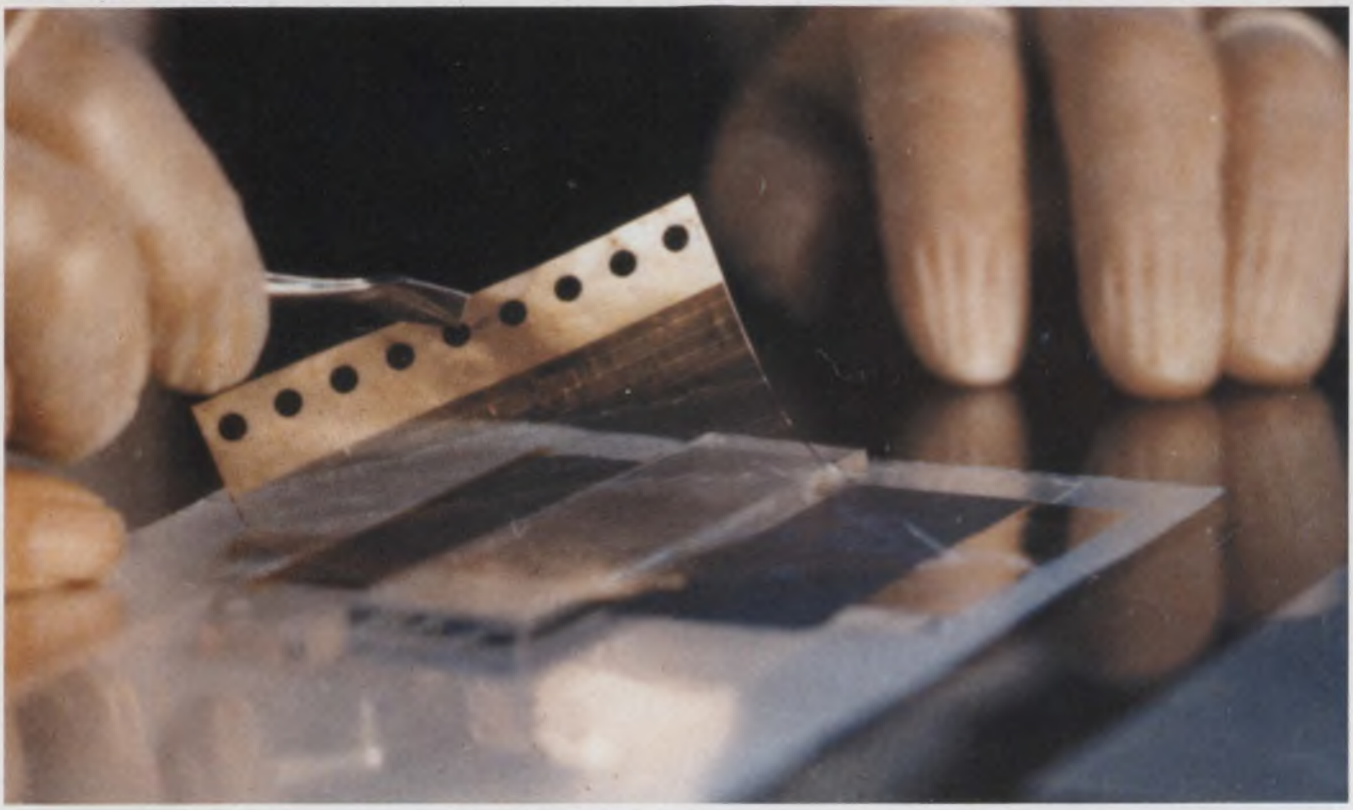
Analysis of the Frequency Dependence of Man-Made Radio Noise (65.5, Fri. a.m. T)

Modular vs. integrated UHF converter

A comparison of the modular and integrated approaches to UHF converter design will be given by H. M. Weil and F. S. Coale. The modular design, using separate components connected by RF connectors and cables, is less expensive in small quantities, and is easier to test and repair. But, the authors point out, various frequency and impedance problems can often occur at the interfaces between components.

An integrated design would use only one assembly, with one component integrated to the next without connectors. Optimum impedance levels and appropriate reference planes could then be chosen. A telemetry converter designed by the authors is described as representing a first step toward complete integration. The converter em-

Pioneer VI space vehicle was launched on Dec. 16, 1965 to provide data on interplanetary environments. Its electronic equipment is powered by 10,368 individual solar cells. (paper 67.2)



Thin-film polycrystalline solar cells are now under development at RCA Laboratories. (paper 77.2)

ploys an integrated microwave frequency translator that converts the 2.2-to-2.3-GHz telemetry band to the 215-to-315-MHz band.
A UHF Telemetry Converter Employing Integrated Microwave Circuits (45.3, Wed. p.m. R)

Control Systems

The papers to be presented on control systems and related subjects strike a balance between theoretical advances and innovations, and practical developments. Optimal control and stability, new motor designs for servo systems, and advances in process-control components are some of the topics that will be covered.

Sleeve induction motor offers advantages

The two-phase servomotor has proved to be a reliable power source in a wide variety of servo systems. However, inertia effects have prevented its use in certain critical applications and have necessitated compromises in others. On Tuesday, D. E. Wiegand of the Argonne National Laboratory will describe how these inertia effects can be reduced by at least an order of magnitude. This can be done by replacing the squirrel-cage, or solid-iron rotor, or the typical two-phase servo motor with a thin sleeve of lightweight metal revolving in the annular gap between the stationary outer and inner core members.

Since the low inertia of such a sleeve motor is obtained at the expense of increased real and reactive power requirements, Wiegand will describe how design trade-offs between these quantities can best be made.
The Sleeve Induction Motor for High-Performance Servomechanisms (22.3, Tues. a.m. N)

Systems methods solve man-machine loops

The single-loop feedback system with a human in the loop is the most commonly occurring configuration in practical manual-control systems. In addition, this configuration is often a component in more complicated systems. The state-of-the art in applying closed-loop-systems engineering principles to human-control systems will be presented by D. T. McRuer, E. S. Krendel and D. Graham.

Based on experimental data collected over the

Unique control system has been in operation for more than a year in this battery-powered mail truck. (paper 14.1)

past 20 years, the three have established a mathematical servo model describing human operation and adaptation for single-loop tracking with a visually presented, random-appearing forcing function. This model characterizes the predominant majority of all the experimental results. The use of the model in predicting the performance and dynamic response of practical man-machine systems will be explained.
The Analysis and Synthesis of Manual Closed-Loop Control Systems (69.2, Fri. a.m. R)

Novel unit controls electric vehicle

A control system for switching two dc motors from a parallel to a series connection and simultaneously switching two batteries from a series to a parallel connection will be described by T. R. Kelley of the I-T-E Circuit Breaker Co. The control has been tested successively for more than a year in a U.S. Post Office delivery truck. Its purpose is to switch the vehicle's two batteries from parallel (for starting) to series (for high speed) and at the same time switch the fields of the vehicle's dual-field dc motor from series (for higher starting torque) to parallel (for high speed).

The I-T-E unit uses two chopper circuits, with their relative conduction angles controlling the switching. The conduction angles, in turn, are controlled by the vehicle's accelerator pedal. Germanium power transistors are used in the choppers, but according to Kelley, SCR or other chopper types could be used.
A New Control Concept for Electric Vehicles (14.1, Mon. p.m. N)

Test Equipment and Techniques

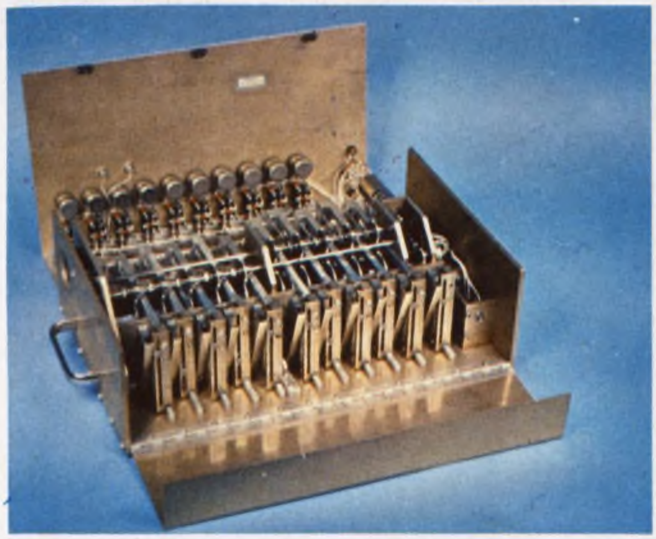
Papers on test equipment and test and measuring techniques are sprinkled throughout the technical program. Anyone with an across-the-board interest in the subject should examine the technical program carefully.

Single-shot transient analyzer aids EMC

Several methods exist for analyzing complex waveforms that are periodic. However, frequency analysis of single-shot transients has for a long time been a relatively tedious task. A new and faster method for performing such an analysis will be described by D. W. Moffat and P. Slysh of General Dynamics/Convair.

The two will describe a Waveform Synthesizer, developed as an aid in electromagnetic compatability measurements. The synthesizer is an electromechanical function generator into which selected points of a waveform can be set. With these points, the instrument then generates sinusoids for the component parts of the spectrum.

Both the imaginary and real parts of the spectrum are generated and then processed to give the absolute magnitude, which is plotted in a continuous envelope. After the settings are made, analysis is completed in 15 seconds.



Single-shot transient analyzer permits easy analysis of complex transient waveforms. The analyzer was developed by General Dynamics/Convair for use in electromagnetic compatability measurements. (paper 65.2)

Other possible approaches to the analysis of single-shot transients will also be described. These include two all-mechanical methods and a computer-aided method.
Single-Shot Transient Analyzer (65.2, Fri. a.m. T)

VAST will test 85% of Navy black boxes

The requirements for shop space, personnel skills and test equipment in the avionic ships aboard U.S. Navy aircraft carriers have been constantly increasing. On Thursday, Capt. A. J. Stanziano of the Bureau of Naval Weapons will describe how the Navy expects to counteract this trend with its Versatile Avionic Shop Test (VAST) System, presently under development.

When completed, VAST will be a computer controlled automatic checkout system, capable of testing 85% of the avionics black boxes in the Navy's inventory. Building blocks that can be programed in various combinations will provide all required test stimuli and measurement capabilities.

According to Captain Stanziano, widespread use of microelectronic equipment will ease the problems in the avionics shops considerably. However, the Navy estimates that microelectronics will not have this impact for quite some time to come. So by early 1968 the first installation of a VAST system on an aircraft carrier is expected.
VAST—A Computerized Test System for Carrier Based Avionics (59.2, Thurs. p.m. T)

Fiber optics speeds transient recording

For the successful recording of ultra-fast transients, CRT voltages as high as 24,000 V and photographic systems with F1 lenses and 10,000-speed film are often necessary. But with a new technique, to be described by F. L. Katzman of the Fairchild Camera and Instrument Corp., the lens optics can be eliminated and the rquirements on the CRT reduced considerably.

The technique uses fiber-optic recording by means of a fiber-optic face plate in contact with the CRT. Improvements in light-gathering power of over 40 to 1 have been achieved. With this high efficiency, compromises can be made in the CRT design. Improved sensitivity and resolution can be built in at the expense of light output.
Improved Ultra Fast Transient Recording by Fiber Optics Cathode-Ray Tube (23.5, Tues. a.m. G)

Microelectronics

There has been considerable activity in microelectronics since last year's IEEE Convention, particularly in integrated-circuit technology. Much of this activity will be brought into focus by this year's technical program. A number of papers deal exclusively with integrated-circuit topics. And a considerable number of others reflect the present impact of ICs, even though a paper may deal primarily with some other topic.

LSI is coming

On Wednesday, Dr. Richard Petritz of Texas Instruments will present an analysis of the logical goals, areas of strength and possible applications of large-scale integration (LSI) techniques. According to him, LSI approaches to complex circuitry will have the most profound effects yet experienced in solid-state electronics.

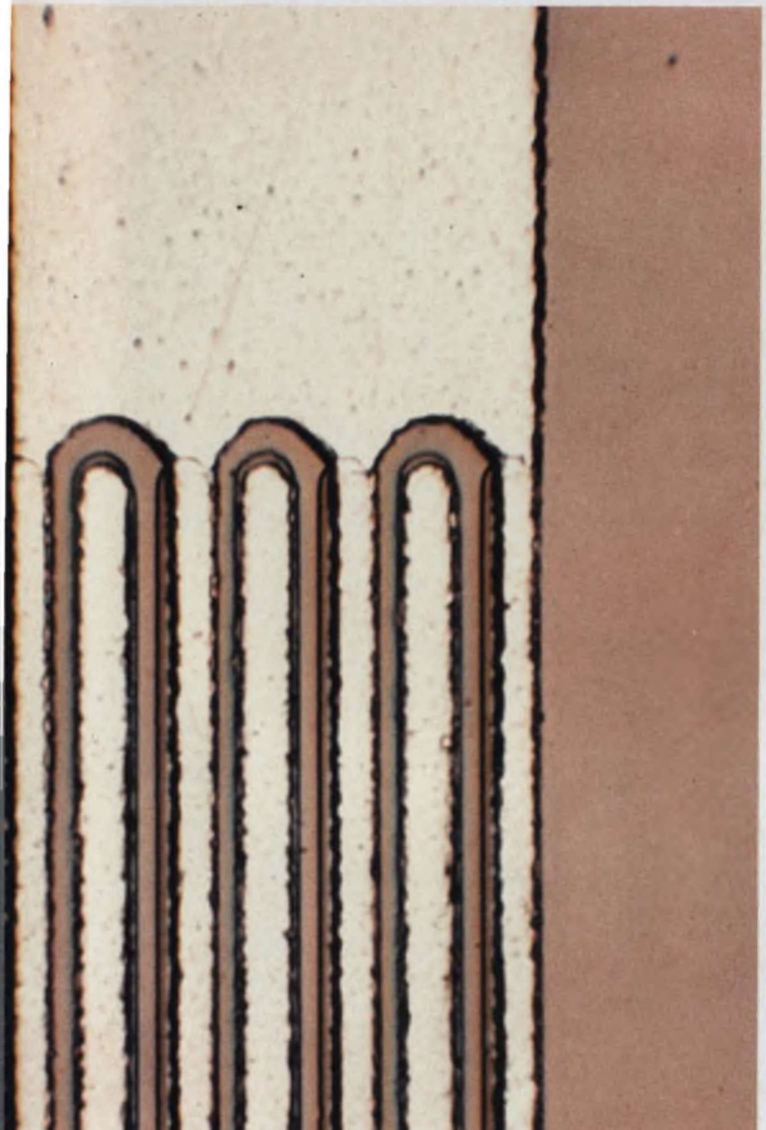
Array technology has reached the point where connections present greater cost and reliability problems than the components themselves. So additional effort must be directed to the connections, to take full advantage of progress over the last five years in component fabrication. Dr. Petritz will also point out that MOS arrays are going to get faster—25 to 50 ns—when the full potentials of complementary switching pairs are employed.
Large Scale Integration—LSI (42.3, Wed. p.m. M)

Computer aids IC design

Because of the high cost of masks in integrated-circuit manufacturing, it is advantageous to forecast circuit performance before the circuit is fabricated. Robert Mammano of ARINC Research Corp. suggests an approach that will greatly improve the chances for obtaining a successful set of fabrication masks on the first try. This method uses a general-purpose computer and should result in substantial savings, particularly in the design of custom circuits.
Integrated Circuit Design Analysis by Digital Computer (52.3, Thurs. a.m. T)

Progress in phased-array radar

One per cent of the components in a radar are responsible for 50 per cent of the failures. The remaining 99 per cent of the components have already been made solid state. Tom Hyltin of Texas Instruments will deliver a report on efforts



PIN switching diode was developed by Texas Instruments for use in IC microwave phased array radar. Over 12,000 such diodes will be required in a system now under development by the company. (paper 45.1)

to substitute solid-state components for those tubes and moving parts that perform microwave generation and reception and antenna scanning. With the use of phased arrays, power requirements can be substantially reduced, thereby bringing the component requirements within the realm of integrated circuitry. This work is being done at Texas Instruments under Air Force contract AF 22(615)-2525.
Microwave Integrated Circuits in Phased Array Radars (45.1, Wed. p.m. T)

Topics at Random

Because the technical program covers such a wide variety of engineering interests, some of the papers cover a miscellany of topics. Here are some that fit the category:

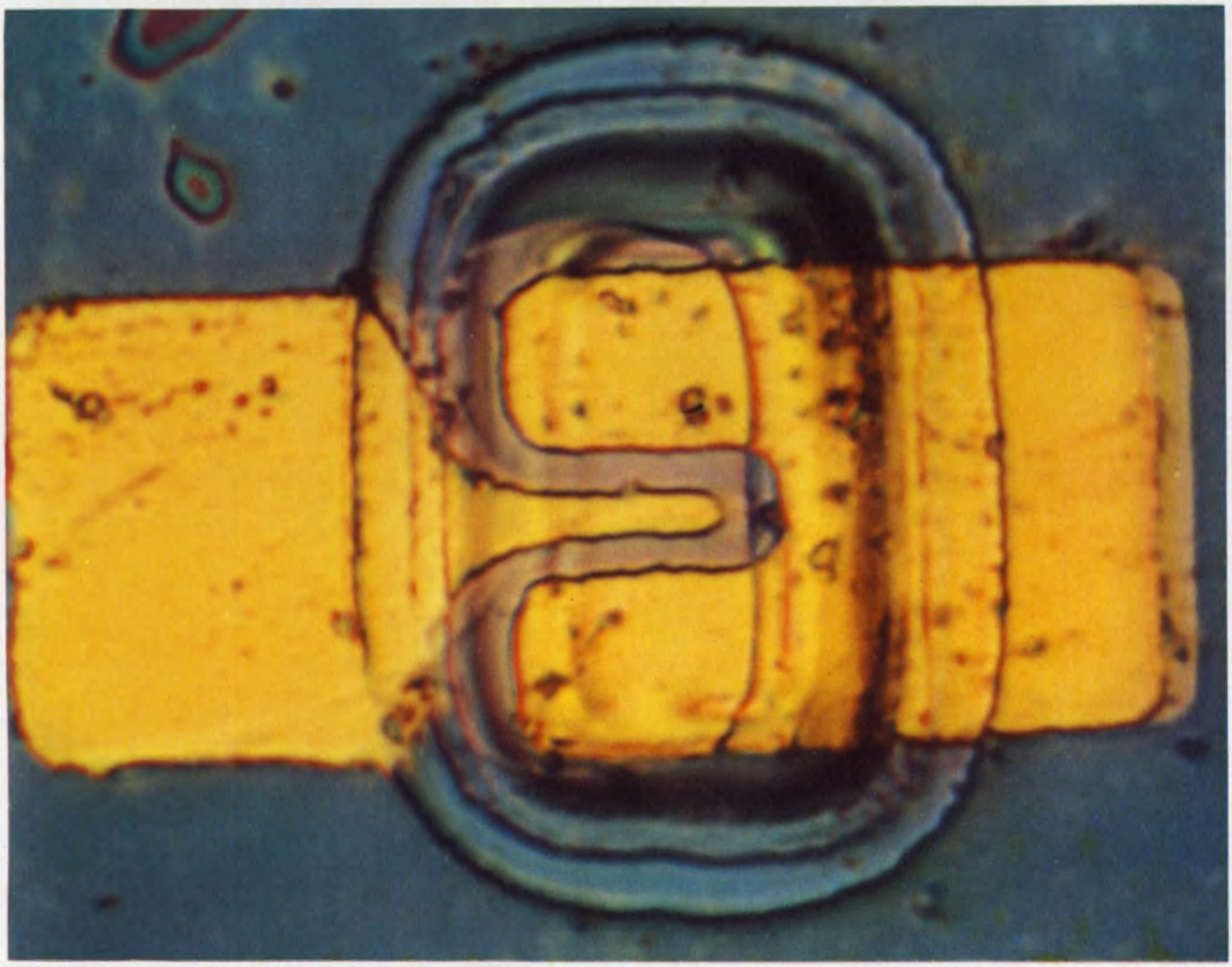
CdS film transducers hold promise

Investigation into the use of cadmium sulfide (CdS) films to high-efficiency, electromagnetic-to-acoustic transducers at microwave frequencies will be described in a paper by D. K. Winslow and H. J. Shaw, both of Stanford University. The two will also cover their investigations into the use of multiple-film assemblies, in which quarter-wave films of various materials are used to transform acoustic impedances for the purpose of increasing conversion efficiency. Experiment using these techniques has produced conversion losses as low as 4.5 dB at 800 MHz and 5 dB at 1600 MHz.

Based on their work, the two Stanford representatives will cover details of the vacuum-deposition techniques for CdS film; formulation of the problem and calculations that yield transducer conversion loss as a function of frequency for multilayer films, and the comparison of calculated and measured conversion loss as a function of frequency from 500 to 4000 MHz.
Multi-Layered Film Microwave Acoustic Transducers (37.1, Wed. a.m. R)

Electronics dives deep

Deep-diving vehicle sensors, displays and controls, and the critical role they play in undersea



Schottky barrier diode will serve as a balanced mixer in the phased array radar being developed by Texas Instruments. The diode is formed in epitaxial packets in high-resistivity silicon substrates. It will be used to convert an incoming 9 GHz signal down to a 500 MHz IF frequency. (paper 45.1) search-and-rescue operations, will be discussed by Joseph A. Cestone of the U.S. Navy's Special Projects Office.

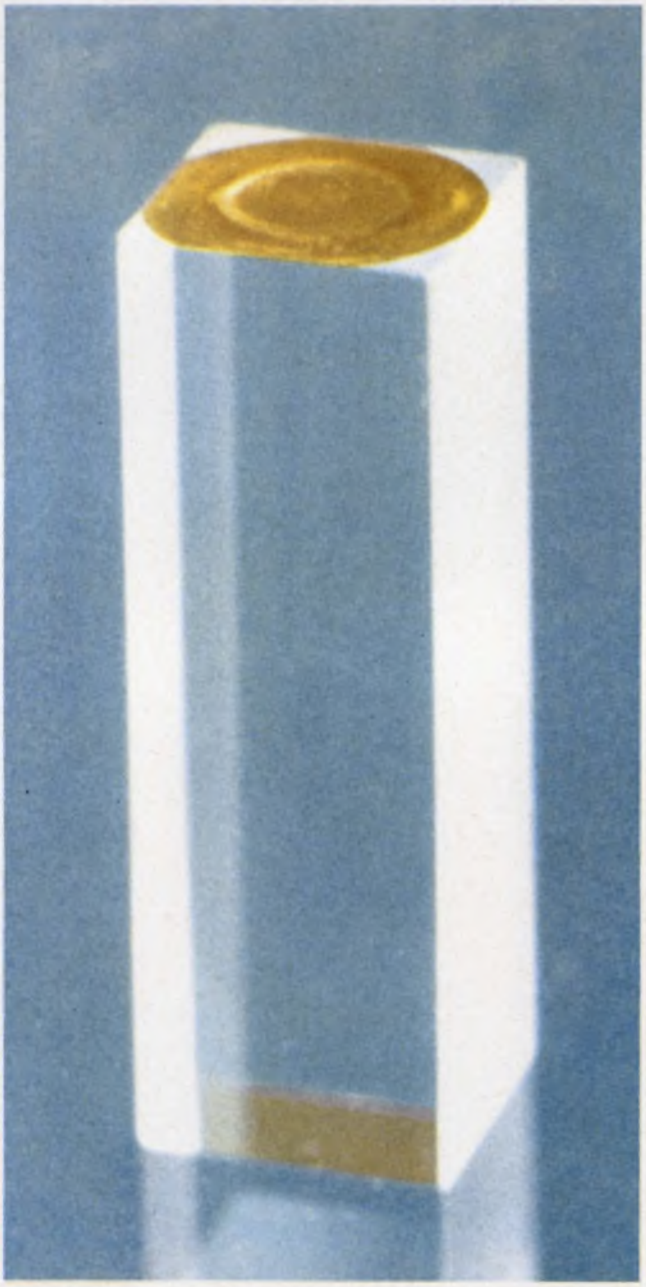
He will describe a typical form of undersea search-and-rescue vehicle and cover its operation in both types of missions. Terrain clearance, hover and attitude control are the most difficult control functions, according to Cestone.

Test programs for the Trieste II, Aluminaut, towed unmanned vehicles and a lowered test capsule will be described, along with the instrumentation systems they use.

Sensor and Navigation System for the Deep Submergence Program (43.3, Wed. p.m. S)

Plasma amplifier advances

Theory of operation and potential advantages of the beam-plasma amplifier (BPA) will be reviewed in paper by P. Chorney of Microwave Associates. Amplification of greater than 50 dB has been obtained at S-band frequencies with the use of beam-plasma amplifiers. Experiments have also shown the BPA to be capable of handling high power levels efficiently: Outputs as high as 22.5 Kw have been obtained at 35% efficiency.



Multiple thin films deposited on single-crystal sapphire rod function as efficient acoustic transducers at microwave frequencies. (paper 37.1)

Beam-plasma amplification is attractive for millimeter waves, since there is no need for metallic interaction with very tight mechanical tolerances. Recent results of experiments in this area will be covered.

Some problems remain before BPAs can become practical and their full potentialities realized. These problems, together with those already solved, will be discussed.

Recent Advances in Beam-Plasma Amplifiers (34.3, Wed. a.m. R)

SCRs used in mobile power systems

Radio-frequency interference and self buildup problems of mobile power systems—and the ways in which silicon-controlled rectifiers can be used to solve these problems—will be discussed in a paper by W. K. Volkmann of the General Electric Company. Several SCR regulator circuits suitable for use with 28-volt dc mobile power generating systems will be described.

According to Volkmann, the regulators permit self-buildup from residual voltage without a battery and also generate negligible radio noise. In addition they are simple, small and economical in cost. Auxiliary circuits for buildup are eliminated, and radio noise suppression circuits are reduced.

SCR Voltage Regulator for Mobile Power Generation (14.4, Mon. p.m. N)

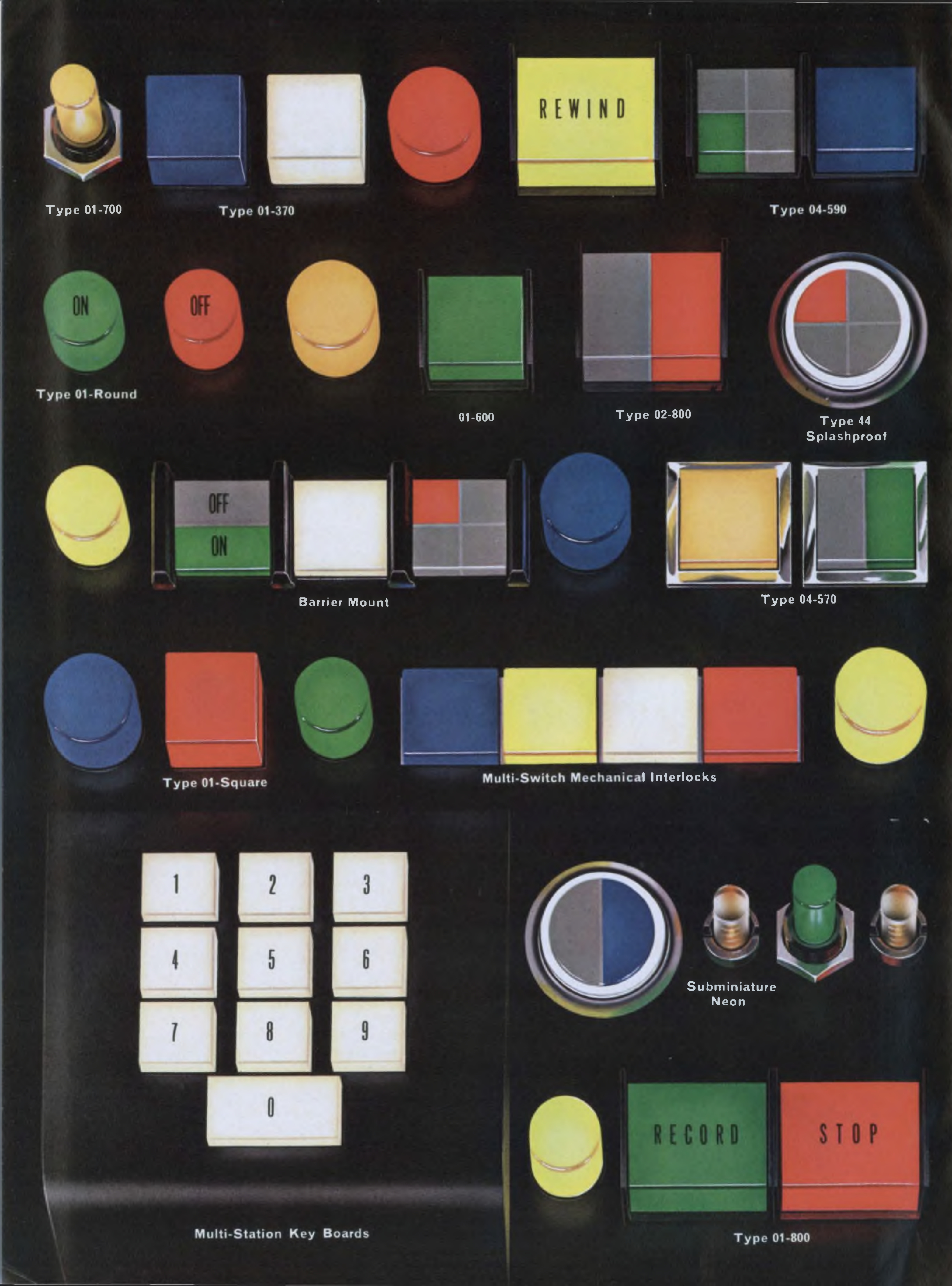
Pulse-compression systems compared

In choosing a pulse-compression system for a particular application, a designer is often faced with the questions:

- How does his system compare with other pulse-compression systems.
- How does his system perform when overlapping signals occcur.
- What will be the effect on the system if it is preceded by a nonlinear device.

A computer technique for answering these questions will be described and evaluated in a paper by R. W. Klassen of the Martin Company. He will discuss how digital-computer simulation of three-pulse compression systems (two-phase-shift-keyed and one frequency-shift-keyed) was used to compare system performance. Logarithmic amplifiers were used at the input of each system to reduce the dynamic-input range, and decreases in peak-signal amplitude and varying amounts of overlap were processed. The performance of two of the systems is evaluated under conditions of CW interference.

Comparison of Frequency Shift Keyed and Phase Shift Keyed Pulse Compression Systems (20.2, Tues. a.m. S)


REWIND
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Type 01-370
Type 04-590
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OFF
Type 01-Round
01-600
Type 02-800
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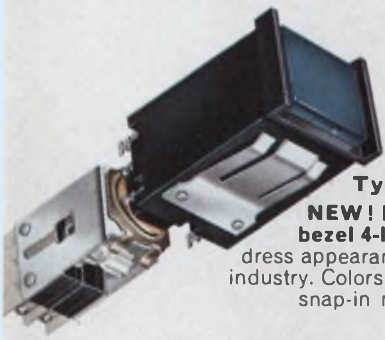

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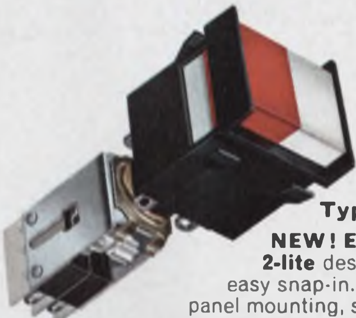

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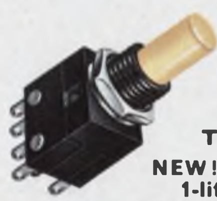

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ON READER-SERVICE CARD CIRCLE 216

What are the product trends at this year's Show—and what do they mean to the designer? Here's how it looks in five major design areas.

Large sampling of digital equipment at IEEE Convention

Digital systems and instruments designed to help automate or otherwise simplify the engineer's tasks are very much in evidence at this year's IEEE show. From a general-purpose digital computer to a high-current switching transistor—and everything in between—the electronic designer has a multitude of new tools to choose from.

Nowhere is the impact of digital technology more apparent than in the field of instrumentation. Digital voltmeters, counters and other measuring instruments abound at the Coliseum. Integrated circuits are seeing wider use in the instruments being exhibited.

Instruments use plug-ins, ICs

Plug-in versatility is featured in the Hickok DMS-3200 Digital Measuring System. All-electronic and fully-transistorized, the DMS-3200 consists of a basic digital-readout unit that can be adapted for use as a DC voltmeter, a 1-MHz counter, an ohmmeter, a capacity meter, or in any of several other measurement functions, by inserting the appropriate plug-in unit.

Two digital counters and a digital voltmeter from Monsanto feature integrated circuitry and compact size.

A portable data-logging system by Electro-Instruments provides automatic measuring and recording in a package that the manufacturer says is suited for small R&D organizations, short-run production lines, etc. The system is built around the Model 620-2 integrating digital voltmeter, and can be expanded to include analog signal scanning, pressure scanning and other functions.

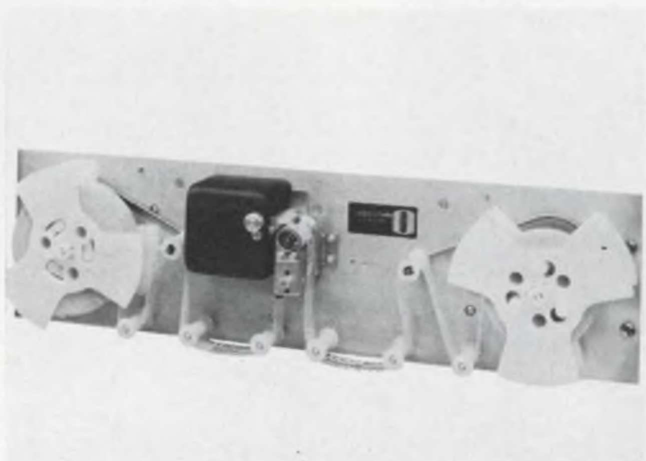
Working computer system displayed

Honeywell's Philadelphia division is exhibiting a working model of its H20 general-purpose digital computer and associated instrumentation. The H20 model represents a system designed for use by electronic-component manufacturers and by research laboratories. With a random-access core memory capacity of from 2,048 to 16,348 20-bit words, the H20 computer has 8,192 directly accessible memory locations with a 6 rms memory cycle time.

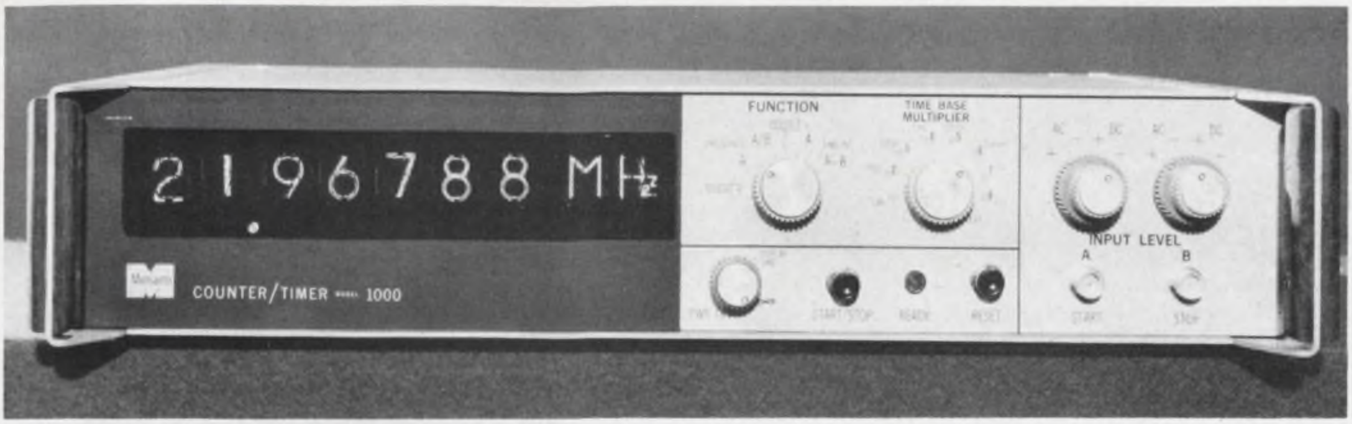
For those who want to retrieve data stored on punched paper tape, Ohr-tronics is offering its Series 119 paper-tape readers. These units can read up to eight channel punched paper tape, bi-directionally, at speeds up to 30 charac/sec.

Some new microelectronic logic packs have been added to the product line of the Computer Control Co., Inc. The four new packs consist of a shift

Measuring and recording are accomplished in a portable package by Electro Instruments.



Ohr-Tronics paper tape readers can handle tapes of up to 8 channels at speeds of 30 charac/sec.



Integrated circuits help shrink the size of Monsanto's new digital counter/timer.

register, negative logic level driver, a non-inverting power amplifier and a lamp driver. In addition 3C has introduced three auxiliary micro-packs that permit tailoring by the user for his individual requirements.

Memories get dynamic test

Also from 3C comes a memory exerciser with 150 ns to 1.5 ms cycle time. The all-solid-state exerciser, Model 3601, has a capacity of 65,536 addresses, word lengths up to 80 bits and a ±6 volt output amplitude.

Fairchild Semiconductor is showing two new PNP high current (up to 300 mA) switches. These two devices, 2N3644 and 2N3645 are said to offer high beta and high breakdown voltage. The manufacturer says that these devices are ideal for use as line drivers in memory applications.

Communications and the design engineer at IEEE

The trend for communication equipment is toward smaller, more reliable and more complex systems. The military remains the prime user of communications equipment with the emphasis being shifted to tactical systems for field use as a result of the Vietnam war.

Military equipment & microelectronics

One example of this type of equipment is the AN/PRC-66, being produced by Collins Radio of Canada, Ltd. under contract to the U.S. Air Force. The PRC-66 is a hand-held transceiver that enables the operator to communicate over any one of 3500 channels in the 225.00 MHz to 399.95 MHz frequency range. An all-solid-state unit making extensive use of hybrid integrated circuits, the PRC-66 is being evaluated by the Air Force and the Marine Corps.

The concept of microminiaturization with hybrid circuits has been widely exploited through military funding. Airborne Instruments Laboratory, a division of Cutler-Hammer, will demonstrate their capabilities at the show with their Microelectronic MTI, a radar receiver subsystem

1. **AIL's experimental microelectronic MTI** being compared to existing operational equipment.

developed for the Rome Air Development Center. This particular unit demonstrates the drastic reductions in size and weight that can be accomplished with microelectronics.

The heavy involvement of the military in integrated circuits has not been duplicated to any large extent in commercial applications, though it is a good indication of things to come. Because it is a still fast-moving technology, most major system houses have been unwilling to make major commitments with their own funds. However, many have or are setting up in-house facilities and will be looking for possible applications in nonmilitary areas. At the show a number of manufacturers will be displaying their capabilities along this line. Microwave Associates, for example, will be showing its MA9E4, which is a 200 MHz linear amplifier with 60 dB gain, a 6 dB noise figure and 30

MHz bandwidth in a hybrid package. Also shown will be their MA963 hybrid pulse amplifier, operating at 100 MHz with 90 dB of gain and a 5 dB noise figure.

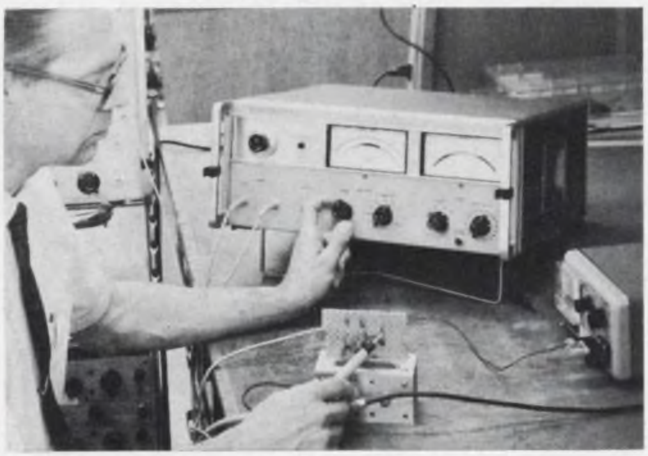
Broadcast systems

Development of telecasting systems with all-solid-state components has long been under way, particularly for remote pick-up and portable-studio-to-transmitter applications. Microwave Associates will also be discussing its improved versions of all-solid-state portable TV transceivers—the MA2A and the MA7A, operating at 2GHz and 7GHz, respectively. The microwave carrier frequency is obtained by varactor multiplication of the 350-to-500 MHz output of a high stability Colpitts oscillator. The obvious advantage of these transceivers is portability, in that one person can carry the entire unit; low power consumption, and increased reliability. Also claimed is a great improvement on color fidelity over existing systems.

Test equipment

A major complaint among communications engineers is a lack of adequate test equipment. This problem can be broken down into two parts: one is the lack of accuracy in existing equipments and a need for even greater accuracy; the other is a lack of simple test equipment in the face of increasingly complex measuring methods.

One of the new products at the show that should help to resolve the problem of simplicity is Hewlett-Packard's new Vector Voltmeter (Model 8405A). This is a dual channel wideband RF millivoltmeter and phasemeter that operates over the 1MHZ to 1GHz frequency range. By means of two pencil probes, voltages at any two points on a circuit can be measured. An integral phase-lock system operates on the signal from the first probe and provides a reference to which the phase angle of the second signal can be compared. A front-panel meter provides direct readout of this phase information, with a resolution of 0.1 degree. With



2. **Hewlett-Packard vector voltmeter** is used to provide voltage and relative phase measurements at a glance.

sensitivities as low as 300 microvolts, the voltmeter will greatly simplify gain, phase, stability and vswr measurements over this frequency range.

As a sidenote, the use of a sampling technique for this instrument should indicate the extent to which digital circuits will be used in analog equipment in the future.

This increased need for test equipment, especially in the 100-to-1000-MHz range, is accentuated by some of the equipment that is being introduced by Anzac Electronics, Inc. A manufacturer of high-frequency and microwave components, Anzac will also be demonstrating a sweep converter to convert the output of a 1-to-2-GHz sweep generator into a 5-MHz-to-1-GHz signal. The maximum power input is 100 mw for an output level of 5 milliwatts. Spurious signals are at least 20dB down. The converter, which uses a vacuum-tube oscillator, also has a detected output that can be used to level the output signal by controlling the sweep generator output. The equipment was originally built to satisfy Anzac's internal needs and was then deemed a worthy product for this growing and unfulfilled market. Anzac will also be showing its RB-3 Standing Wave Ratio Bridge (an improved version of the RB-2), which works over the frequency range of 2MHz to 1GHz with a directivity of 48 dB and 60dB of isolation. With these specifications, VSWR measurements as low as 1.01 may be easily made. If some derating is allowable, the bridge may be used up to 1500 MHz.

Half-price ICs for industrial users!

This year, the IEEE show is likely to appear like one big discount store for industrial electronic equipment designers! Integrated circuit manufacturers are all rolling out the red carpet, arrayed with ID devices selling at half the price of their military/space counterparts.

The catch? There really is no catch. Three factors add up to these low prices:

- Packaging economy—devices in plastic encapsulation, in TO cans or plug-in flat packs, all designed for production-line efficiency.
- Specification economy—devices that exhibit temperature ranges narrower than the military or space requirements call for, but well within industrial needs; some devices exhibit other "sub-mil" specifications.
- Functional economy—recent developments packing more complex circuits in the same 14- or 16-lead packages, allowing 5 to 1 or more circuit complexity, will be available in industrial lines as well as military/space.

As an example, Texas Instruments has available 50 digital type and 5 linear type ICs at prices in the range of 50% lower than Mil types. Indications are that other makers are in a similar push.

Device marketers have noted recently that many designers of industrial electronic products have not been aware of the availability of these sophisticated devices at prices they can afford to pay. As they become more aware of what they can do with the units, they are besieging manufac-

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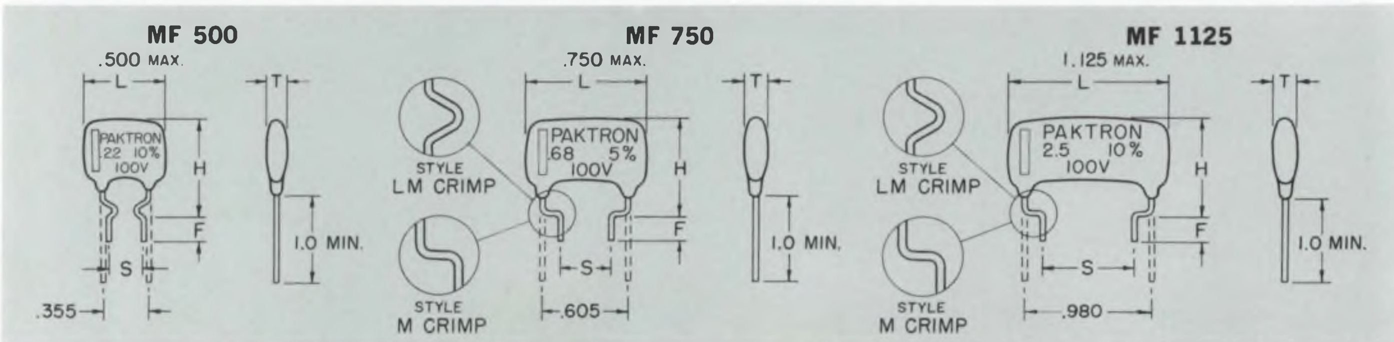

STANDARD VALUES AND SIZES:

MF 500

VALUE MFD.	T DIM. IN. MAX.	H DIM. IN. MAX.
.1	.200	.440
.12	.220	.470
.15	.250	.550
.18	.270	.610
.22	.300	.660

MF 750

VALUE MFD.	T DIM. IN. MAX.	H DIM. IN. MAX.
.22	.250	.550
.33	.300	.660
.47	.350	.690
.50	.360	.700
.68	.400	.740

MF 1125

VALUE MFD.	T DIM. IN. MAX.	H DIM. IN. MAX.
.68	.300	.600
1.0	.350	.660
1.5	.400	.720
2.0	.450	.770
2.5	.500	.820

NOTE: H Dim. shown for M style crimp or long lead, add .075 for H Dim. with LM style crimp.

STANDARD CRIMPS:

MF 500

STYLE	S DIM. ± .032	F DIM. + .01 − .04
M	.250	3/16
LM	.250	or
LM	.312	5/16

MF 750

STYLE	S DIM. ± .032	F DIM. + .01 − .04
M	.312	
M	.375	3/16
M	.400	or
M	.437	5/16
LM	.500	
LM	.562	

MF 1125

STYLE	S DIM. ± .032	F DIM. + .01 − .04
M	.625	3/16
M	.718	or
M	.843	5/16
LM	.937	

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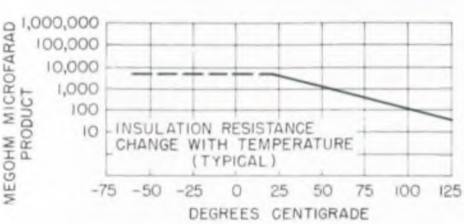

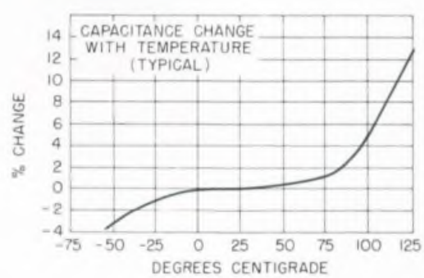

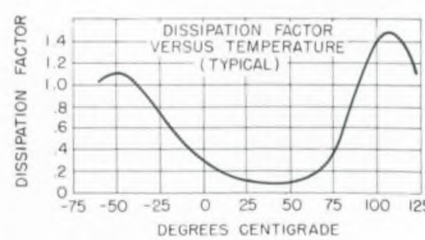

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ELECTRICAL • Tolerance ± 5%, ± 10%, ± 20% standard, others available on request • Dissipation factor less than 1%@+25°C, 1KC • Insulation resistance 3 x 10^4 megohm x microfarad, 2 minutes at W V DC • Temperature stability, from −25°C to +85°C, less than 3% deviation from 25°C value • Dielectric strength, 200 V DC, 1 min.@+25°C.

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turers for more information. So we can expect representatives at the show to be well armed for the onslaught.

Transistors, SCRs in same push

Germanium transistors, thought by many to be passé, are very much alive for the industrial application area. Motorola Semiconductor has recently begun a new push of its germanium lines, accompanied by appreciable price cuts of between 14% and 91% on 29 types. The cuts were said to have been brought about by an improved manufacturing process. Low-cost plastic cases are also a key to several companies' germanium lines, including new types from Texas Instruments.

Higher power and, again, more plastic packages are the headliners in silicon-controlled rectifiers this year. Westinghouse has extended compression bonding to high-power units, to 70 amps and 1200 volts. General Electric will also be increasing power-handling capabilities of its SCRs. Manufacturers are looking for growth in speed control applications in large motors, including traction units for rail transit systems that are receiving more attention from industry and government.

In other areas for the industrial market:

- Many other component manufacturers are continuing their push of low-cost items, some at sub-Mil—but perfectly acceptable industrial—reliability ratings.
- The continuing trend in automation of industrial processes is being aided by ICs, advances in direct digital control and hybrid computer systems. B & F Instruments is showing a system, for example, that receives 100 inputs from remote strain-gage rosettes and computes and prints out in real time the stress, shear and stress angle at a rate of one second per data point.
- Production-line equipment manufacturers will be showing more automation. The Weltek Div. of Wells Electronics is showing an automatic welding unit for production-line integrated-circuit installation.
- Light-activated silicon controlled switches for industrial applications are a relatively new item. General Electric is introducing one as "the lowest cost on the market."

Semiconductors make strides in consumer equipment

One of the spotlights at this year's IEEE show will be on trends in consumer products set by solid-state devices. The applications involved range from large power and control systems down to tiny, light-operated audio units. Common to many of these achievements is the use of inexpensive packages for the semiconductors.

This greater emphasis on the consumer market is evidenced by engineering activity figures and growth rates. In 1960 only 20% of the total developmental effort was devoted to the industrial and consumer markets (with consumer interests getting the lion's share); 80% went to military and defense needs. In 1965, this latter figure dropped to 40%, the consumer effort went to 50% and the industrial rose to 10%.

In 1966, all indications point to further increases in the latter two, with the military programs accordingly dropping off (5 to 10%). In terms of growth rate (volume and dollars of sales), the combined consumer-industrial figure has steadily climbed the past 5 years, while the military portion has been decreasing and leveling off. The two will be just about equal in '66, but this is largely due to the limited war in Vietnam. 1967 should witness the eminence of the industrial-consumer trend for the first time in modern electronics history.

Judge a device by its cover

Every major type of semiconductor is now available in a low-cost (usually plastic) package. These include SCRs, power and other bipolar transistors, diodes, unijunction transistors, FETs and integrated circuits and are a major reason for the thrust into the consumer market.

Representative of this trend are TV sets incorporating 15 ampere-rated rectifiers in a lead-mounted plastic package, automotive electrical assemblies containing epoxy diodes and communications equipment using plastic FETs. In some cases the performance of these units exceeds that of their metal-encased counterparts. What's more, the trend towards line-operated capabilities in semiconductors will also be evident; many devices are replacing traditional components (vacuum tubes, for example) in consumer products on a one-for-one basis. Typical of the applications here are pre-amps, citizen-band transmitter stages, antenna disabling systems and TV deflection circuits.

More power to thyristors

Solid-state achievement in consumer power and control systems will also be apparent at the show. Typical of these will be units employing new thyristor devices (SCRs Triacs, etc.) and power transistors, both with high-power ratings.

These semiconductors are now capable of handling in excess of 1200 amperes at 1800 volts (peak), thanks to technology improvements in heat removal. In effect, a double-heat sink design is employed to both remove heat quickly and store it (for gradual dissipation) where it cannot harm the semiconductor component. This method solves the problems associated with high thermal resistances and heavy inrush currents. It helps point the way to solid-state takeovers in motor applications (blenders, washing machines, machine tools), welders, dimmers, timers and power-control systems and sub-systems, in general.

New gains with FET amplifiers

Field-effect devices are also contributing to the semiconductor role in establishing product trends in consumer equipment. FETs and MOS units (discrete and integrated) are setting the pace by opening up new applications and improving on the functional ability of traditional devices here. Most of the headway in amplifiers has been made by FETs; MOS semiconductors are making their presence felt more so in switching applications.

The relatively new breed of large-signal linear voltage amplifying junction FETs (devices with high BV_{ds} ratings and closely specified bias points) is capable of outstanding performance in audio equipment. These and other FETs are also being employed in high-frequency amplifiers, low-noise systems, mixers, agc networks, FM receivers, IF strips, video amplifiers and modulators.

Discrete MOSs and integrated MOS circuits (arrays) are making strides in RF amplifiers, scratch-pad memories, choppers, calculators, addressable memories and VHF tuners.

Let there be light

Semiconductors are casting still another new light on consumer products. Show attendees may observe a number of displays involving light-emitting diodes (LED) and other optoelectronic devices. These units can be of use in communications, indicating, printing, photographic and tape-recording systems.

LEDs are capable of creating visible light beams of green and red hues. These beams are then modulated at a high-frequency rate ($\geq$1 MHz) to form highly-directional communications links. For example, in one exhibit, integrated circuit amplifiers will be used to process the light signals in establishing an audio system.

Don't be too surprised if you stumble across consumer equipment containing integrated circuit portions. Linear ICs are being used in video and IF stages, synchronization networks and other types of signal-processing systems.

Microwave companies look for greener pastures

Diversification and improvements in devices, rather than breakthrough, characterize the microwave segment of this year's exhibition.

Many companies are venturing into new areas, with the solid-state industry attracting most. This trend is partly explained by the approaching dateline for telemetry systems to convert to the higher L and S bands, and partly by the desire to be able to use in-house components for any systems they build, according to spokesmen of interested companies.

As an example of diversification, Scientific-Atlanta—a company that is better known for its test equipment and telemetry systems—became active in ferrite devices.

The first product from the new laboratory is the 223-1A reciprocal phase-shifter. This latching, digital ferrite device is being shown at the IEEE Show. Its reciprocity permits phased arrays to transmit and receive without switching back and forth between transmitting and receiving elements. In addition the latching design needs low drive power: The 223-1A uses less than 50 μjoules. It covers the range of 5.4 to 6 GHz with a reciprocity of about 1° and a switching time of less than 1 μs. "Our diversification serves a definite purpose," says Howard Crispin, marketing manager of antenna instrumentation; "we want to develop the capability to provide complete systems for our customers."

The YIG-device area also welcomes a newcomer: Microwave Associates, Inc., is showing the first YIG filters of its new production setup.

The MA9A11 YIG filter covers the range from 4 to 8 GHz with four sections. It has an 80-dB off-band rejection and a 4-dB insertion loss in the band, which is 25-30 MHz wide. The tuning linearity is 1% with a sweeping rate of 100 Hz. The voltage is from 0 to 12.

A second filter, type MA9A5, covers the range from 2 to 4 GHz in two sections, with an off-band range rejection of 50 dB and an insertion loss of 2 dB. The band is somewhat wider: It spreads from 30 to 40 MHz. Its tuning linearity and power requirements are the same as those of the MA9-A11.

The filters are available in a package that includes the drive source. The saturation level of both filters is above +10 dBm.

Better instrumentation and components are apparent in the first spin-tuned magnetron on view—the DX 290 of the Amperex Corp.—which operates around 16 GHz with a bandwidth of about 5%. The device has a peak power of 65 kW, a duty cycle of 0.001% and a tuning rate of 2 HMz/μsec.

Eimac, a division of Varian, brings to the show a new 5-cavity, electrostatically focused reflex klystron that is only 6-1/8 inches long, including the tuners, and weighs only 5 pounds. The klystron operates in S-band, around 2100 MHz, with a maximum efficiency of 40%. Electrical and mechanical tuning permit the coverage of either a narrow band or a wide band. In narrow-band operation, the output power is 200 watts, with an efficiency of 40% and a gain of 30 dB. In wide-band operation, the output power is 196 watts, with a gain of 27 dB and an efficiency of 36%.

An overlay transistor, built by the Vector Div. of United Aircraft Corp. and designed to operate as a class-C amplifier, is intended for telemetry systems. The 2N4012 operates at 1.6 GHz, with an output of 2.5 watts and a conversion gain of 4 dB. "The strong interest of telemetry-system people in high-frequency and high-power semiconductors gave us impetus to develop this device," says John Millet, manager of technical publications at Vector.

The precision insertion-loss measurement set (PILMS), which was introduced last year, now has a direct-reading panel and operates with batteries, according to its manufacturer, De Mornay Bonardy. Other improvements on the device include the extension of the dynamic range to 30 dB. Also, in the 0-to-1-dB range, the absolute accuracy is down at 1/7000th of a dB. Last year these figures were 25 dB and 1/5000th of a dB, respectively.

Accuracy ±0.0025%. Maximum meter resolution, 0.1 ppm. Fourteen pounds later you have the new solid-state Fluke 885 DC Differential Voltmeter, the first truly portable laboratory standard. Peak-to-peak reference stability is 15 ppm for 60 days. Use the Fluke 885 as an isolation amplifier. Grounded recorder output is so well isolated that a short-circuit at the output produces no voltmeter reading error. Ground loops are completely eliminated when the battery powered Model 885AB is used.

Other Specifications: Range, 0 to 1100 Volts. Null sensitivity, 100 microvolts full scale. Line regulation better than 2 ppm. No zener oven, less than 30 seconds warm-up time. Cabinets can be half rack or full rack mounted with optional mounting kits. Price of the Model 885A line cord version is $1,195. The battery powered Model 885AB is $1,325.

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EE societies—are they doing enough?

Electronic Design's survey shows engineers feel a need for further standardization of products and for personal recognition and job stability.

Maria Dekany
Technical Editor

Professional EE engineering groups in the country—the many societies and the two trade associations—are of valuable assistance in helping engineers communicate with one another. But many members feel that isn't enough.

An ELECTRONIC DESIGN sampling of engineer opinions across the country shows a need for expanded efforts in two other areas in which professional groups can help the engineer:

-**Communication between engineers and manufacturers.** Needed are uniform testing and specification for similar devices, so engineers can make an intelligent appraisal of what they are buying.

-**Communication between engineers and employers and engineers and the public, to help engineers achieve greater professional recognition.** Needed in some companies are adequate work space for engineers in place of "bullpens"; treatment of engineers as trusted professionals instead of time-clock hirelings, and job security to end the mill-like hiring and firing practices.

Among the comments of engineers in the ELECTRONIC DESIGN survey were these:

"Yes, uniform testing and specification among manufacturers are needed. But you are asking for utopia!"

"The plight of engineers reminds me of the 'Grapes of Wrath'—chasing around the country for jobs. Besides demeaning the profession, it results in waste and inefficiency."

"To put a stop to hiring and firing of engineers in the defense industry, engineers should publish a monthly scoreboard of engineers fired and hired by individual companies. After a while notoriously bad records will make hiring extremely difficult for the offending companies."

"If engineers are treated just as any other employee in the company, they should behave as such and form unions for their protection. But engineers are not joiners, and unions are below their imagined professional status."

Internal communication stressed

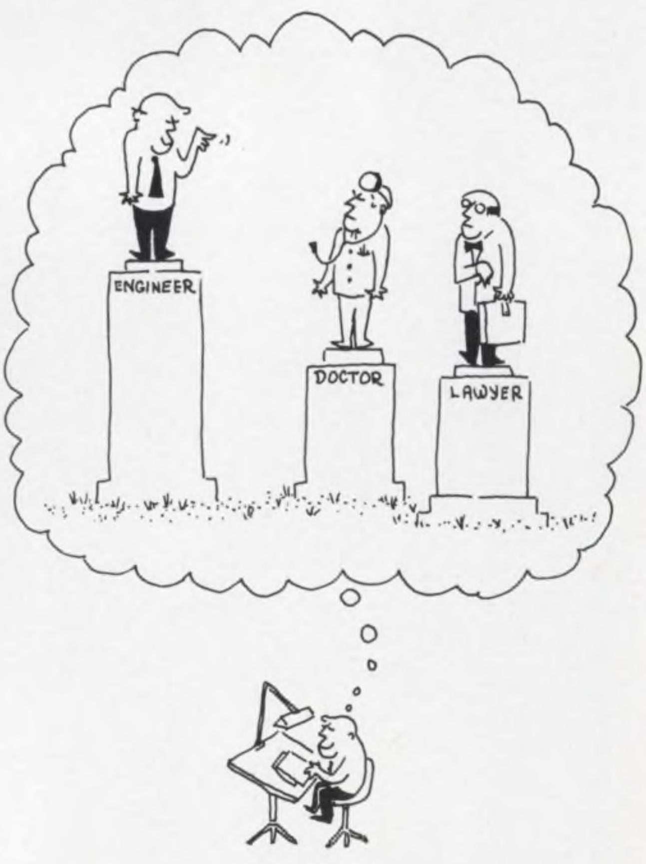
Most professional engineering societies consider themselves purely technical organizations, whose only role is that of communication within the engineering profession. They distribute technical information, establish standard symbols, notations and terminology, and in general serve the scientific community by organizing meetings and discussions and providing a forum for new technical developments.

The accompanying table lists 17 engineering and scientific societies that serve the electronic and electrical industry and have members from these fields. They handle the job of communication among engineers very well.

But what of communication between engineers and manufacturers?

Consider the seemingly easy task of buying a power supply. Since many manufacturers make them, the engineer-buyer wants to compare and find the best supply for his application.

Let's say that the peak ripple is of critical interest. Most manufacturers specify the ripple as an rms voltage at the load, like 15 mV, which cannot be used to find the peak value. In addition, one company may specify the recovery time (maybe without even including the rise time for the load transient), and another may use the



response time. So specification sheets are not much help for the conscientious engineer.

He has two alternatives: He can call up the salesman of each company, or he can make up his own specification sheet and have the companies fill in the needed information. In either case the lack of uniform specifications and test procedures wastes many engineering manhours.

This problem is not confined to power supplies. It exists in antennas, transistors and relays, to name just a few other areas.

A look at the IEEE

But what can the engineer do? Can he call upon an engineering organization that would formulate standards and then convince the manufacturers to adapt the standards? Let's examine the largest engineering society of all, the Institute of Electrical and Electronics Engineers, better known as IEEE.

It is a non-profit organization, like practically all the others. Its announced aims are scientific, literary and educational. The IEEE is presently involved in a court action to obtain an accurate determination of the limitations imposed by the nonprofit operation. Therefore it is not clear whether it operates in this sphere of influence because of the nonprofit nature or because of other considerations. But the fact remains that the IEEE tries not to get involved in controversial engineering problems. For example, on the need for a meaningful transistor registration, the IEEE's comments were as follows (this letter is in reply to ELECTRONIC DESIGN's article on transistor coding, Nov. 9, 1964):

> Sir:
>
> In response to your request for possible participation of the IEEE in attempts to change the present system of transistor registration, I have contacted Jack Hilibrand of our Semiconductor Device Subcommittee and Sorab K. Ghandhi of R.P.I., who has been in charge of most of the symbols-work in IEEE's Solid-State Device Committee in the past few years.
>
> It seemed appropriate to do this since IEEE has collaborated to some extent with JEDEC committees, EIA and other national standards organizations. Professor Ghandhi, in particular, informs me, however, that IEEE has never gone this far in the transistor field and this is primarily a JEDEC matter.
>
> The Solid-State Device Committee deals primarily with basic standards in terms of definition, symbols for basic terms and methods of testing for new devices. Once devices get into industrial use, their handling is almost entirely a matter for the industry-oriented standards organizations. However, thank you again for giving us the opportunity to comment on this matter.
>
> **W. CRAWFORD DUNLAP**
> Chairman
> Solid-State Devices Committee
> IEEE
> Waltham, Mass.

The IEEE also has a Standards Committee. Its function is to define terms, conditions and limits that characterize the behavior of electronic and electrical equipment. When the chairman of the committee was asked about the possibility of extending this function to establish uniform testing and specification, he replied: "Even though there is a definite need for such standards, we feel that it should be the problem of the Electronic Industries Associates (EIA)."

In fact, the EIA does perform some standardization work, but much depends on organizations like the IEEE.

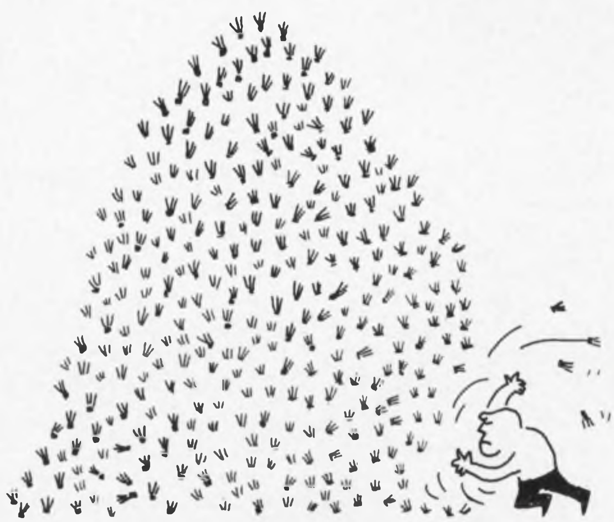
ASA's performance is limited

But how about organizations like the American Standard Association (ASA) and American Society for Testing and Materials (ASTM).

According to the ASA's electrical engineering department, the association's main function is the coordination of work by other societies and the provision of systematic means to avoid duplication. It is a federation of more than 150 societies and trade associations. However, the association does not have the prerogative to suggest or to establish new standards on its own, except in very rare cases. The association accepts standardization proposals from organizations like the IEEE, the EIA and ASTM.

The association has sectional groups, each is sponsored by the leading organization in a particular field. These study a proposed standard before it is submitted to all members. The sponsor of any sectional group finances the operation, takes care of administrative duties and, at the same time, provides guidance and leads the effort of the group. For example, there is an electronic sectional group that studies standards for transistors and other electronic devices. It is sponsored by the EIA, and its members represent users and producers in equal number. According to an ASA official, this group is now inactive:

"There is nothing in the works, but our hands are tied. These groups are independent; their performance is mainly determined by the desire of



List of EE Societies

Organization	Members	Areas of activities	Membership grades	Annual dues	Services
Institute of Electrical and Electronic Engineers (IEEE) Headquarters: 345 East 47th St., New York City, N.Y.	157,000	Information exchange in the disciplines of electrical engineering, electronics and allied fields	Student Associate grade Member Senior member Fellow grade Honorary members	$3 entrance fee (except students) $15	Journals, meetings and special courses
American Association of Engineers (AAE) Headquarters: 8 South Michigan Ave., Chicago, Ill.	1000	Professional aspects of engineering	Member Associate member	$20-25	Publication
Engineers Joint Council (EJC) Headquarters: 345 East 47th St., New York City, N.Y.	Federation of 38 professional eng. societies	National issues versus engineering Technological manpower of the USA, employment situation, salaries			Publications
American Federation of Information Processing (AFIPS) Headquarters: 211 East 43rd St., New York City, N.Y.	Over 25,000 through the federation of IEEE and ACM	Representation of the USA in international affairs Public relations for computer society			Orientation seminars, conferences
American Institute of Aeronautics and Astronautics (AIAA) Headquarters: 1290 Avenue of Americas, New York City, N.Y.	36,000	Aerospace systems	Member Associate fellow Fellow Honorary fellow	$20	Journals, meetings, career information, courses
Society of Automotive Engineers (SAE) Headquarters: 485 Lexington Ave., New York City, N.Y.	26,000	Self propelled mechanisms, including space vehicles, engines	Junior Associate Member	Depends on age, ranges from $10 initiation fee & $12 dues to $25 initiation fee and $30 dues	Journals, handbooks, employment service
Radio Technical Commission for Aeronautics (RTCA) Headquarters: 15th and Constitution Ave., N.W. Washington, D.C.	118 agencies from industry and government	Performance standards for systems in aerospace telecommunication			Annual meetings
Association for Computer Machinery (ACM) Headquarters: 211 East 43rd St., New York City, N.Y.	15,000	Computer design and data processing	Members Student Corporate membership Academic membership	$18 $5 $500 $100	Periodicals, lectures
Society of Packaging and Handling Engineers (SPHE) Headquarters: 14 E. Jackson Blvd., Chicago, Ill.	1500	Industrial and commercial product protection, packaging and materials, transportation	Junior member Associate member Professional member Corporate member	$10 $25 $25 $175	Employment service, meetings and technical publications
Society for Professional Engineers (NSPE) Headquarters: 2029 K St., N.W. Washington, D.C.	Above 54,000	Professional, economical and social aspects of engineering	Professional Engineer-In-Training	$16 plus dues for local and state chapters	
American Institute of Physics (AIP) Headquarters: 335 East 45th St., New York City, N.Y.	Federation of 25 societies in the field of physical sciences	Application and advancement of the science of physics	Only through the member societies		Distributes journals of its member societies
National Association of Power Engineers (NAPE) Headquarters: 176 W. Adams St., Chicago, Ill.	12,000	Power safety, air and water pollution	Member Associate member	Determined by local chapters	Employment service, educational courses, journals
American Association for the Advancement of Science (AAAS) Headquarters: 1515 Massachusetts Ave., N.W. Washington, D.C.	94,000 individual members and 250 scientific societies	Cross-fertilization of all fields of science Public awareness of science	Member Fellow	$25	Awards, seminars
Instrument Society of America (ISA) Headquarters: Penn-Sheraton Hotel, Pittsburg, Pennsylvania	16,000	Telemetry, automatic control, data acquisition processing and display, measurement and precision standards	Senior member Member Associate member Student member	$15 $15 $10 $3	ISA journal, discount on ISA publications, meetings, courses

Organization	Members	Areas of activities	Membership grades	Annual dues	Services
American Standard Association (ASA) Headquarters: 10 East 40th St., New York City, N.Y.	Federation of 150 technical societies and trade associates	Coordination and promulgation of standards			
American Society for Testing and Materials (ASTM) Headquarters: 1916 Race St., Philadelphia, Pa.	13,500	Evaluation of all materials used in the electrical and electronic industries	Member Associate member Student member	\$20 \$10 \$3	ASTM Standards
Society for Nondestructive Testing (SNT) Headquarters: 914 Chicago Ave., Evanston, Ill.	4,700	Establishment of non-destructive test methods	Member Sustaining member Corporate membership	\$15 \$25 \$100	Journals

the sponsor and the members to accomplish something."

According to the same ASA official, the sponsor and the members of the transistor and electronic-devices group appear to be quite satisfied with the standards already established by the EIA. Joseph Werner, the past secretary of the group (who was also the secretary of the JEDEC Semiconductor Device Council till January, 1966) says:

"The semiconductor industry is too volatile; it is moving too fast and changing from day to day. There is no time to go through the ASA, which takes about a year to a year and a half. JEDEC is doing a good job in this area."

The committees of JEDEC, according to Werner, are even doing some of the work that should have been done by the standard committee of the IEEE—establishing symbols and definitions for the semiconductor industry.

"The semiconductor field is in a sorry state as far as definitions go," he says. "Much more work is needed to establish the language of communication between the user and the producer. And this is the responsbility of the IEEE."

The ASA sometimes initiates its own investigation and establishes standards. If there is no outside organization active in an area and the association receives requests for standards, it may form its own committee and do the necessary work. For example, at present two subcommittees are in the process of developing standards for relays and RF connectors—that is, they are involved in defining terminology, specifications, methods of testing, physical dimensions and so on. If any engineer has any constructive comments or suggestions about these two devices, this is the time to tell the ASA.

When a proposal, developed either "in house" or submitted by an outside organization, has been accepted by the responsible ASA committee, it is submitted to the membership for approval.

Testing of materials achieved

The American Society for Testing and Materials, another large organization, investigates the fundamental properties of materials used in the electronic and electrical industries. It establishes basic test procedures for ferrite cores, insulators, insulated and bare wire cables, and semiconductor materials, among others. This society appears to be the closest to meeting the engineer's needs so far as materials are concerned: Anybody can suggest the need for standards at meetings—visitors, nonmembers and members alike.

Examination of the work and functions of the larger technical societies makes it clear that all have very limited activities in areas where the most work is needed: uniform testing and specifications of devices for the design engineer. Most of the societies consider these areas the domain of industry-oriented organizations—the trade association. The nontechnical problems of the engineering profession are clearly outside their areas of interest.

Two major trade associations

There are two significant trade organizations in electrical and electronic engineering: EIA and NEMA (National Electrical Manufacturers Association.

NEMA handles mostly electrical devices—devices that consume 60-cycle power. This includes equipment used to generate, transmit and distribute power; appliances, and materials that go into devices.

EIA deals with passive electronic devices—like resistors, inductors and so on—and with equipment used in the electronic industry.

The Joint Electron Devices Engineering Council (JEDEC) is co-sponsored by both NEMA and EIA. It handles all activities in the areas of semiconductors and other electron devices.

These trade associations do not have individual members. NEMA has only manufacturer members; EIA has, in addition to manufacturers, representatives of users on the management level.

How do these organizations help the engineer-user in his work? Can an engineer submit suggestions as an individual? He can.

Engineer suggestions are welcome

EIA has more than 200 engineering committees, staffed by member and non-member companies and by representatives of the Federal Government. When member companies suggest standardization in a certain area, it is reviewed by the engineering department of EIA, and if it is considered worthwhile, a committee is set up to formulate a proposed standard.

Any engineer can submit suggestions. Proposals on equipment and passive devices can be submitted to Jean Caffiaux, Manager, Engineering Department, Electronic Industries Assoc., 2001 Eye St. N.W., Washington, D. C.

Those who are interested in the development of a transistor coding system, for example, can write to Everett Coon, Type Registration Group Manager, and he will forward it to the responsible committee.

NEMA offers plenty of opportunity, too, to interested individuals. It has joint activities with organizations like the IEEE that involve the investigation of specific groups of devices and equipment. An individual can submit his suggestions through his company, if the company is a member of NEMA. If it isn't, the engineer can work through a subcommittee of the IEEE. Suppose, for example, that a design engineer would like to see the adaptation of uniform specification for switches. He may get in touch with the SF1 subcommittee of the IEEE, which handles switches, fuses and insulators. If the subcommittee considers the suggestion worthwhile, it will propose it to NEMA. The chances are that if the IEEE proposes something, it will be accepted, since it represents the user's opinion to the manufacturers.

Joseph Werner, who is also an official of NEMA, says: "National standards can only be established through the acceptance of all concerned—meaning manufacturers, users and general-interest groups."

Many engineers wary

The apparent willingness of industry-oriented organizations to listen to and accept suggestions from individual engineers is a step toward improving industry-engineer relations. Engineers should use this opportunity. However, many told Electronic Design that they never considered it because:

"I am too busy in my job, to get involved."

"Manufacturers are keeping too much information off their specs sheets, but they are in the business of making money. Uniform testing and specification will never be established through a group supported by manufacturers."

"I would rather spend extra time in finding the best device than have the prices raised. Uniform testing and specification will surely cost money, and manufacturers will pass the cost along to us—the users."

Some engineers even felt that there might be a need for Federal action:

"The Government is the largest buyer, and waste and inefficiency cause the largest losses for the Government. They should force the manufacturers to establish uniform test procedures and specifications."

Most engineers in the survey accepted the existing conditions as "the facts of life," even though they did not like them. Very few had given thought to possible remedies. The most common suggestion was for the establishment of an organization that would serve as a sounding board for engineers. This organization could coordinate engineer-buyer comments and pass them along to manufacturers.

Nontechnical problems persist

What of the nontechnical aspects of the profession—status, job security and working conditions?

The most frequently heard complaints on the professional status of engineering urge the following:

- Increased recognition and respect for engineering as a learned profession.
- Greater voice in management decisions.
- More engineers in management.
- Management encouragement of participation of civic and professional society affairs.
- Release from technician's work.
- Less supervision by non-engineers.
- Better support and service facilities.

Two large organizations serve the general interest of engineers on the job: the Engineers Joint Council (EJC) and the National Society for Professional Engineers (NSPE).

The EJC is a federation of 38 professional engineering societies; it does not have individual membership. Its activities are concentrated on nationwide problems of engineering. For example, it develops and publishes information on engineering demand, salaries, enrollments and degrees; it acts as a liaison between the Government and the EJC member societies on issues that relate to engineering jobs. It is more concerned about the engineer as an employe than as a professional.

The EJC publishes studies on the nationwide employment of engineers, covering such subjects as the demand for engineers now and in the future and the salaries and income of engineering teachers. The list of available reports and their cost may be obtained by writing to the Engineers Joint Council, Dept. P, 345 E. 47 St., New York, N. Y. 10017. In addition to these reports, the council publishes a quarterly newspaper, "Engineer," which covers the professional problems of engineering, including obsolescence, layoff problems in the defense industry and legislative actions that affect the profession.

The membership of the NSPE consist mainly of licensed, or registered, engineers.

The NSPE is conducting a vigorous and extensive public-relations campaign to enlighten the public to the broad spectrum of engineering activities. This society is the only one that is registered as a national and state lobby, and it actively tries to influence legislation for the engineering profession.

The society has been quite successful in its lobbying activities. It supported legislation to improve the economic status of engineers employed by the Federal Government. It obtained full recognition for engineers in the military services and set up minimum compensation standards for engineering consultants. The NSPE publishes newsletters and magazines to keep its members informed of its activities.

However, so far as the majority of the electrical and electronic engineers are concerned, the society hardly exists. Its requirement for licensed members only prevents many engineers from joining; only 18% of its members are from electronic and electrical areas. But there are signs that the NSPE realizes the shortcoming of excluding many able engineers who do not need the license for their work. The society's Long-Range Planning Committee has proposed a broadened membership approach that would make possible the admittance of non-licensed engineers.

The public image of the engineering profession is important, engineers believe. A good image attracts bright young men into engineering, improves the morale of those already in the field and helps raise salaries. Most engineers, the E|D survey showed, feel that the profession lacks luster, that the public is not clearly aware of the importance of an engineer's work. But a Gallup poll, initiated by the NSPE, showed the opposite to be true.

The poll asked the public: "Suppose a young man came to you and asked your opinion about taking up a profession. Assuming that he was qualified to enter any of these professions, which one of them would you first recommend to him?" The replies rated the engineering profession as the second most desirable, ahead of science and law. The medical profession took first place. It would appear that the complaints about the professional status of engineering cannot be written off as the result of public unawareness.

Still, engineers are treated by some companies almost as if they were itinerant workers. They are hired or laid off en masse. If a company receives a fat contract, it may hire hundreds of engineers. When the contracts are terminated or canceled, the engineers are let go. This situation is most apparent in the defense industry, and engineers feel that it strips them of their professional dignity.

The majority of engineers in the defense industry, E|D's survey showed, think that the NSPE is organized to fight for protection against this practice. Suggestions to remedy the situation ranged from contracts that would include some provisions for layoffs to the formation of an engineering organization that would publish a monthly scoreboard of engineers hired and laid off, to discourage employment at companies with bad records. Nearly unanimous opposition to unions was expressed by the engineers. They consider unions to be a last resort.

Engineers outside the defense industry do not feel too strongly about this problem, the survey showed. The most common view was that the higher salaries offered by the defense industry compensate for the risk of steady employment. "If they don't like it, they don't have to take it," one engineer commented.

However, engineers in and out of the defense industry agreed that the lack of a strong organization (like the American Medical Association, some said) contributes to the unprofessional handling of engineering personnel.

The engineer has two good ways to bolster his professional stature:

- Continued study.
- Greater participation in civic and community affairs.

With today's rapid changes in electronics, continued study has become a professional necessity. Engineers believe that employers should help out here, with time off for study and financial assistance.

The educational goal committee of ASPE has recommended that the master's degree—awarded at the completion of a five-year program—become the recognized professional degree of engineering, instead of the bachelor's degree. The resultant curriculum, it is argued, would strengthen the liberal education of engineers, expose them to the social sciences and the problems of society and provide a deeper understanding of the engineering sciences. (See "Engineer," Vol. VI, No. 3).

Engineers can also further their professional status, in the view of some groups, by taking into consideration the needs of people and the community when they design equipment. James K. Carr, former Undersecretary of the Interior and now San Francisco's manager of utilities, put it this way at a recent meeting of the Consulting Engineers Association of California: "To provide leadership in this new era, engineers must remember that engineering works are built to meet man's needs. Too often engineers have been the hirelings of men concentrating on profit alone, who are indifferent to people's needs."

Carr is also an engineer.

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P&B miniature snap-action switches are highly sensitive and especially suited for compact installations where precision is a primary factor. Their small size and high electrical capacity recommend them for applications of multiple installations in limited space. Available with various contact and terminal arrangements.

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Designed for applications requiring exceptionally small size and low operating forces. Especially suited for electronic equipment, business machines, military apparatus and other precision electrical equipment. Available for operation by pushers, cams, or lever actuators with or without rollers. Solder, turret and quick-connect terminals are available.

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Economical, reliable and durable, P&B appliance switches are compact and easy to install. A white nylon enclosure gives protection for most applications. Quick-connect terminals are furnished in side or front-connected configurations. Pin plunger, plain lever, formed lever and panel-mount actuators are available.

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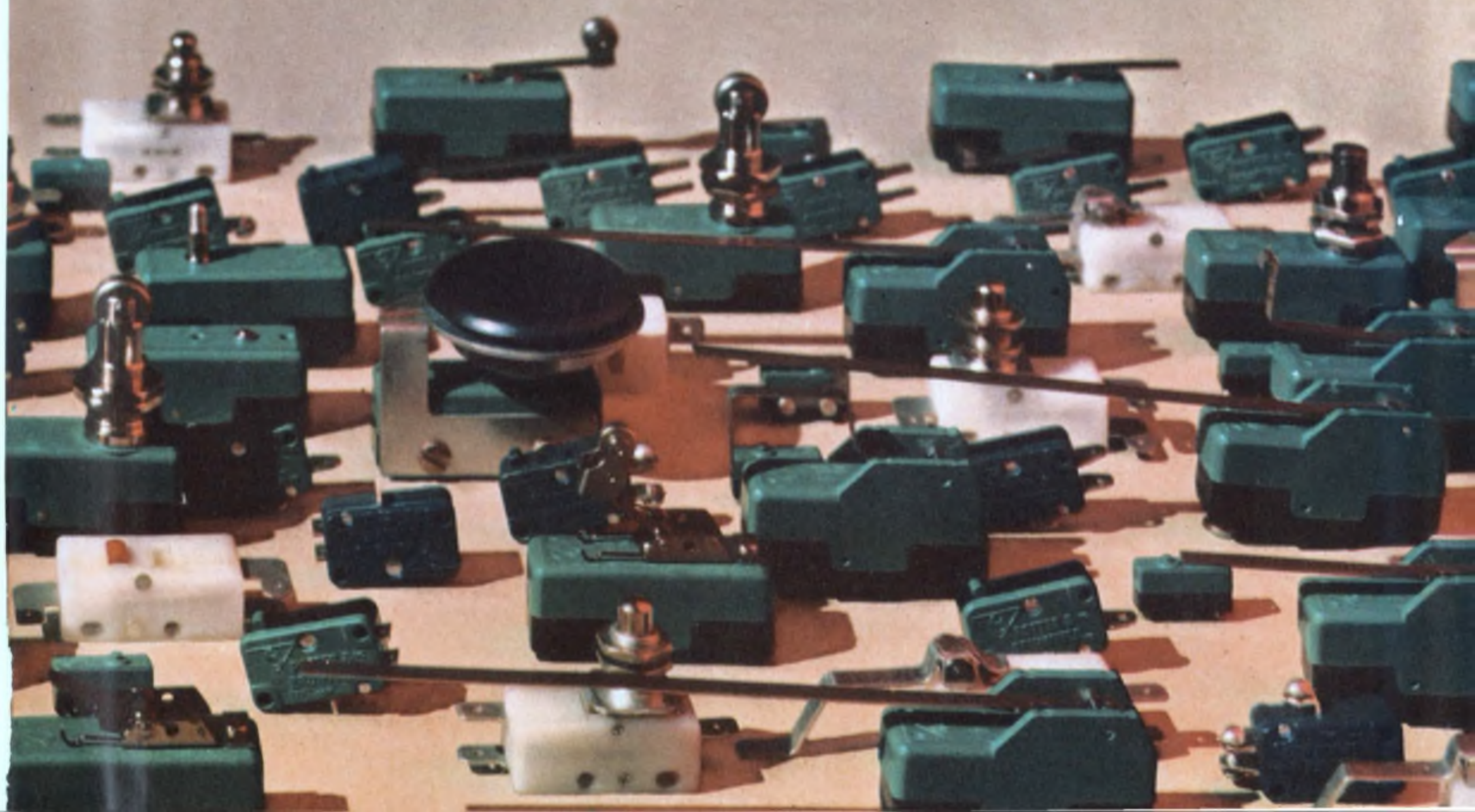

When, where and what to hear—

Here's the complete scorecard of IEEE technical papers by specialty. Time and place is included for each paper.

Categories (papers are grouped as follows:)

Antennas	Lighting	Reliability
Circuits	Management	Sensing and Measuring
Circuit Theory	Medical Electronics	Signal Processing
Communications	Microelectronics	Solid-State Devices and Theory
Components	Microwaves	Space Electronics
Computers	Military Electronics	System Engineering
Consumer Electronics	Municipal Planning	Television
Control Systems	Oceanography and Underwater Systems	Test Equipment and Techniques
Cybernetics	Power Generation and Control	Transportation
Electromagnetic Compatability	Radiation Effects	Writing and Speech
Hardware		
Industrial Electronics		

See Planning Guide for Paper Order Form.

Antennas

Far Field Simulation of Antennas Which Have Complex Aperture Distribution Functions—*D. C. Beste, Hughes Aircraft Co. (55.1, Thurs./a.m./G)*

A Superdirective Array of Higher Mode Helical Dipoles—*A. J. Poggio, F. P. Ziolkowski, P. E. Mayes, Univ. of Illinois (55.2, Thurs./a.m./G)*

A Broadband Interferometer—*W. Waltman, C. D. McGillem, G. R. Cooper, Purdue Univ. (55.3, Thurs./a.m./G)*

An Explicit Relation Between Mutual Coupling and the Pattern of an Antenna Array—*W. Wasylkiwskyj, ITT Federal Labs.; W. K. Kahn, Polytechnic Institute of Brooklyn (55.4, Thurs./a.m./G)*

On a Pattern Synthesis Method for a Linear Array—*Taneaki Chiba, Tokyo Shibaura Electric Co. (55.5, Thurs./a.m./G)*

Array Synthesis Using Lambda Function—*S. L. Shih, General Electric Co.; L. Bergstein, Polytechnic Institute of Brooklyn (55.6, Thurs./a.m./G)*

Lambda Functions for Dipole Applications—*J. F. Ramsey, Airborne Instruments Lab. (63.1, Thurs./p.m./G)*

Traveling Wave Antenna with Nondissipative Loading—*D. P. Nyquist, K. M. Chen, Michigan State Univ. (63.2, Thurs./p.m./G)*

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An Electronically Scanned Antenna Using Fresnel Zone Techniques—*R. W. Ruben, Sylvania Electronic Systems (63.4, Thurs./p.m./G)*

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Automotive AM Broadcast Band Antennas—*J. R. Cherry, Ford Motor Co. (79.4, Fri./p.m./G)*

Circuits

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Design Notes on the DC Chopper—*Eberhart Reimers, Lear Siegler, Inc. (14.2, Mon./p.m./N)*

SCR Voltage Regulator for Mobile Power Generation—*W. K. Volkmann, General Electric Co. (14.4, Mon./p.m./N)*

The Design of a Simple Single-Phase SCR Regulator—*E. S. McVey, R. E. Russell, Univ. of Virginia (14.5, Mon./p.m./N)*

A Simple Noise Eliminator for Television Receiver Synchronizing Circuits—*Kenneth James, Emerson Radio and Phonograph Corp. (15.2, Mon./p.m./G)*

Transistorized Horizontal Output Stage—*Bechara Aboufadel, Warwick Electronics, Inc. (15.3, Mon./p.m./G)*

An Experimental Solid-State Pulse Modulated Wideband Switch—*B. Brightman, Stromberg-Carlson Corp. (19.1, Tues./a.m./M)*

Overload Protection for the New NEMA Rated Motors—*O. A. Herman, General Electric Co. (22.1, Tues./a.m./R)*

The Design of High Performance Active RC Bandpass Filters—*W. J. Kerwin, NASA, L. P. Huelsman, Univ. of Arizona (28.5, Tues./p.m./SS)*

A Precision Television Wave Form Oscilloscope for the Bell System—*J. R. Hefele, Bell Telephone Labs. (61.2, Thurs./p.m./R)*

Optical Parametric Oscillators—*Arthur Ashkin, Bell Telephone Labs. (77.4, Fri./p.m./R)*

Circuit Theory

An Approximate Method for Computing Blocking Probability in Switching Networks—*L. Lee, J. A. Brzozowski, Northern Electric Co. (19.4,*

Code to abbreviations

The abbreviations used within this index are as follows:

a.m.—Morning sessions
p.m.—Afternoon sessions

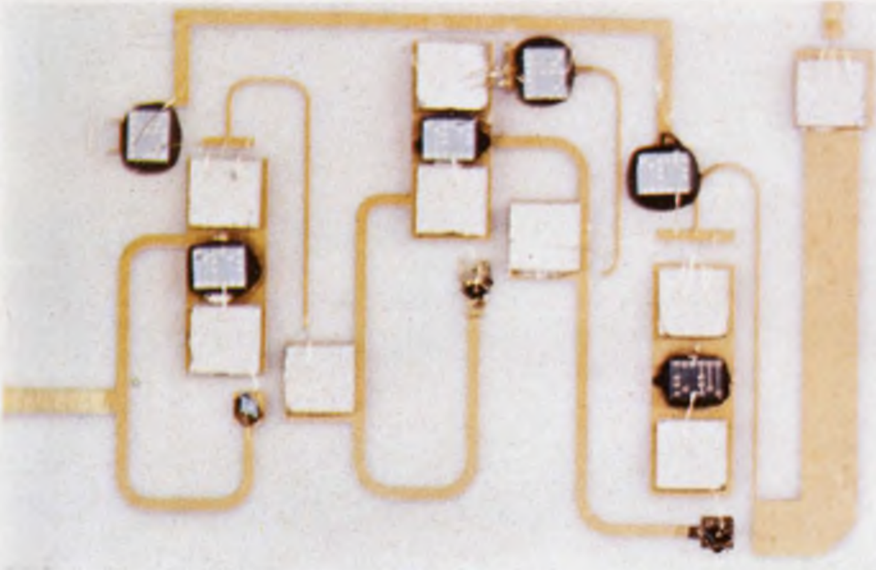
Session locations in the New York Hilton are:

G—Gramercy Suite
M—Mercury Ballroom
MH—Murray Hill Suite
N—Nassau Suite
R—Regent Room
SN—Sutton Ballroom North
SS—Sutton Ballroom South
T—Trianon Ballroom

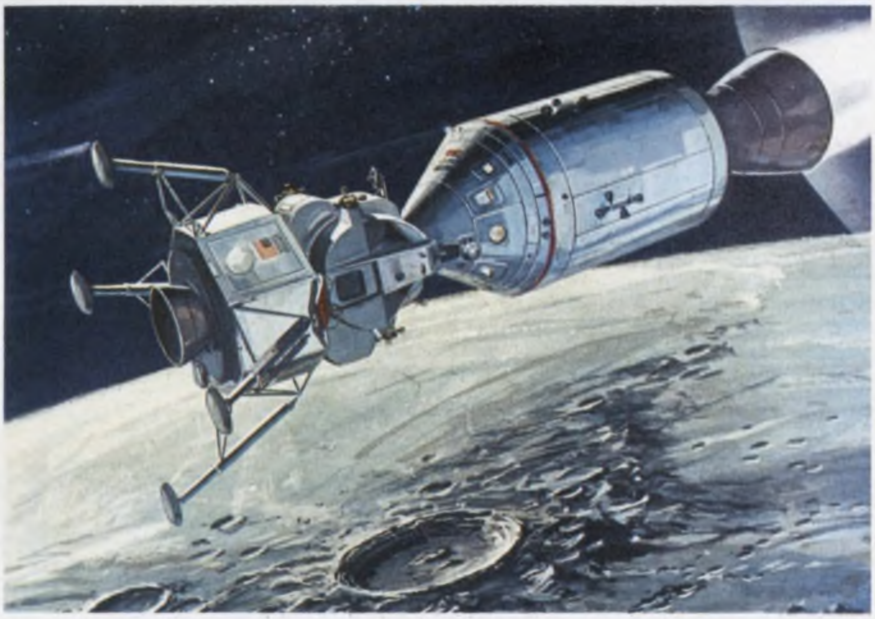
Numerals refer to sessions and to papers within a session—for example, 14.2 is paper 2 in session 14.

The daily schedule for the technical sessions is as follows:

Mon.	9:30 a.m.-12:00 noon 2:00 p.m.- 4:30 p.m.
Tues., Wed. & Thurs.	9:00 a.m.-11:30 a.m. 2:00 p.m.- 4:30 p.m.
Fri.	9:00 a.m.-11:10 a.m. 11:20 a.m.- 1:30 p.m.



Early breadboard of power amplifier for Texas Instruments phased-array radar had as its aim 2 watts of pulse power at 2.25 GHz (paper 45.1).



Lunar Excursion Module prepares to land two astronauts on the moon's surface, as seen in this artist's conception.

Tues./a.m./SN)

On Invariance and Sensitivity—*J. B. Cruz, W. R. Perkins, Univ. of Illinois (57.1, Thurs./p.m./T)*

Optimal Passive Imbedding for Lumped Linear n-Port Networks—*R. A. Rohrer, State Univ. of New York (57.2, Thurs./p.m./T)*

A Note on the Stability of Linear Systems Containing a Time-Varying Element with Restricted Rate of Variation—*I. W. Sandberg, Bell Telephone Labs. (57.3, Thurs./p.m./T)*

Network Synthesis via Reactance Extraction—*D. C. Youla, Plinio Tissi, Polytechnic Institute of Brooklyn (57.4, Thurs./p.m./T)*

Brune's Realization Procedure in a New and Generalized Apsect—*K. H. Hasse, Air Force Cambridge Research Labs. (70.1, Fri./a.m./N)*

A New Method for Steady-State A-C Analysis of RLC Networks—*F. H. Branin, Jr. (70.2, Fri./a.m./N)*

Graphical Aanalysis and Synthesis of Memoryless Nonlinear Networks—*L. O. Chua, Purdue Univ. (70.3, Fri./a.m./N)*

Constant Resistance One-Ports with Nonlinear Time-Varying Elements—*C. A. Desorv, K. K. Wong, Univ. of Calif. (70.4, Fri./a.m./N)*

Maximization Procedure for the Synthesis of Single-Element-Kind Networks—*Guiseppe Biorci, Alessandro Chiabrera, Univ. of Genova (70.5, Fri./a.m./N)*

Distributed Parameter R-C Network Analysis—*E. C. Bertnolli, Univ. of Missouri (78.1, Fri./p.m./N)*

Subarea Determination of the Capacitance of a Torus of Regular Polygonal Cross-Section-Part II—*D. P. Carroll, T. J. Higgins, Univ. of Wisconsin (78.3, Fri./p.m./N)*

Four Abstract Reference Frames of an Electric Network—*Gabriel Kron, General Electric Co. (78.5, Fri./p.m./N)*

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Statistics of Switching-Time Jitter for a Tunnel Diode Threshold-Crossing Detector—*D. E. Nelsen, MIT (80.1, Fri./p.m./MH)*

On the Analysis of Composite Lumped-Distributed Systems—*J. J. Kelly, M. S. Ghausi, J. H. Mulligan Jr., New York Univ. (80.3, Fri./p.m./MH)*

The Reactive Gyrator—A New Concept and Its Application in Active Network Synthesis—*S. K. Mitra, Bell Telephone Labs.; W. G. Howard Jr., Univ. of Calif. (80.4, Fri./p.m./MH)*

An Analysis of Lumped-Parameter Nonlinear Transmission Lines—

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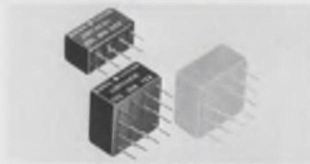

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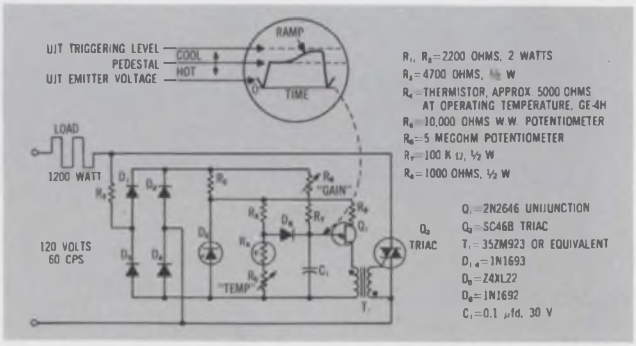

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Panel discussions

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American Electric Power Company's System in Ohio—*Nathan Cohn, Leeds & Northrup Co. (1.3, Mon./a.m./T)*

A New Control Concept for Electric Vehicles—*T. R. Kelley, I-T-E Circuit Breaker Co. (14.1, Mon./p.m./N)*

What Control Theory Gives and Takes from Biology—*(16, Mon./p.m./MH)*

Terminal Control: Minimum Energy Controller for a Linear, Time-Varying, Multiple-Input Discrete System —*J. A. Cadzow, State Univ. of New York (22.2, Tues./a.m./N)*

The Sleeve Induction Motor for High-Performance Servomechanisms—*D. E. Wiegand, Argonne National Lab. (22.3, Tues./a.m./N)*

Solid-State Speed, Acceleration and Load-Control System—*F. T. Thompson, A. Wavre, Westinghouse Electric Corp. (22.5, Tues./a.m./N)*

Spacecraft Command and Control—*J. T. Mengel, NASA (27.2, Tues./p.m./SN)*

Using a Computer for the Design of Analog and Digital Control Systems —*P. J. Wirtz, Reliance Electric and Engineering Co. (38.2, Wed./a.m./N)*

High-Performance Control for Tandem Cold Mill Main Drive Systems—*R. E. Moore, General Electric Co. (38.3, Wed./a.m./N)*

A High-Power Amplifier with Improved Frequency Response in the 0-to-50-c/s Range—*T. H. Barton, McGill Univ., R. S. Birtch, International Business Machines Corp. (47.1, Wed./a.m./G)*

An Electronic System for Continuous Processing of Corn Syrup—*G. G. Taylor, American Maize Products, R. A. Van Schelt, The Foxboro Co. (47.2, Wed./p.m./G)*

Nonlinear Analog Computing Elements for Process Control—*H. H. Koppel, P. J. Wajs, Bailey Meter Co. (47.3, Wed./a.m./G)*

A High-Performance AC Position Servo Using a DC Motor—*P. Will, M. Zeldman, American Machine and Foundry (47.4, Wed./p.m./G)*

A New Current Integrator—*R. J. Bamford, Catalytic Construction Co. (47.5, Wed./p.m./G)*

The Status of Optimal Control Theory and Applications for Deterministic Systems—*Michael Athans, MIT (58.1, Thurs./p.m./M)*

The Status of Stability Theory for Deterministic Systems—*R. W. Brockett, MIT (58.2, Thurs./p.m./M)*

The Status of Optimal Control and Stability for Stochastic Systems—*H. J. Kushner, Brown Univ. (58.3, Thurs./p.m./M)*

The Stability of Pulse-Frequency-Modulated Closed-Loop Control Systems—*J. P. C. Clark, The Boeing Co.; Endrik Noges, Univ. of Washington (66.4, Fri./a.m./M)*

The Analysis and Synthesis of Manual Closed-Loop Control Systems—*E. S. Krendel, The Franklin Institute (69.2, Fri./a.m./R)*

Generalization of the Parameter Plane Method—*D. D. Siljak, Univ. of Santa Clara (74.1, Fri./p.m./M)*

Stability of Linear Systems with Transport Lag—*Lawrence Eisenberg, Newark College of Engineering (74.2, Fri./p.m./M)*

Application of Root Locus Methods for Designing Noninteracting Control Systems—*W. L. Green, Mississippi State Univ. (74.3, Fri./p.m./M)*

A DC Equivalent of an AC Synchronous Motor—*G. S. MacDonald, Photocircuits Corp. (74.4, Fri./p.m./M)*

New Theorems on Absolute Stability of Nonautonomous Nonlinear Control Systems—*Y. H. Ku, H. T. Chieh, Univ. of Pennsylvania (78.4, Fri./p.m./N)*

Cybernetics

Cybernetics in Europe and the U.S.R.R.: Outlooks, Plans and Activities—*R. W. Swanson, Air Force Office of Scientific Research (7.1, Mon./a.m./G)*

A Class of Nonlinear Recognition Procedures—*C. K. Chow, International Business Machines Corp. (7.2, Mon./a.m./G)*

Computer Learning in Theorem-Proving Processes—*D. L. Johnson, A. D. C. Holden, Univ. of Washington (7.3, Mon./a.m./G)*

Towards a Theory of the Reticular Formation—*J. Blum, M.I.T., E. Craighill, W. L. Kilmer, Michigan State Univ., W. S. McCulloch, M.I.T. (7.4, Mon./a.m./G)*

Electromagnetic Compatability

An Operational-Oriented Performance-Control Model —*Frank Pethel, Stanley Cohn, ITT Research Institute (65.1, Fri./a.m./T)*

Single-Shot Transient Analyzer—*D. W. Moffatt, Paul Slysh, General Dynamics/Convair (65.2, Fri./a.m./T)*

The Grounding Concepts for Instrumentation Grounding as They Differ from Lighting and Power, Fault Safety Grounding—*H. M. Hoffart, General Electric Co. (65.3, Fri./a.m./T)*

Oscillator Stability and Electromagnetic Compatability—*F. L. Marek, M. D. Aasen, ITT Research Institute (65.4, Fri./a.m./T)*

Analysis of the Frequency Dependence of Man-Made Radio Noise—*E. N. Skomal, Aerospace Corp. (65.5, Fri./a.m./T)*

Hardware

Recent Studies on the Physics of Electrical Connector Surfaces—*J. P. B. Williamson, Burndy Corp. (10.1, Mon./p.m./M)*

Current Topics in the Surface Chemistry of Electric Contacts—*Morton Antler, Burndy Corp. (10.2, Mon./p.m./M)*

Recent Advances in Sliding Contacts Including Space Applications—*E. I. Shobert 2d, Stackpole Carbon Co. (10.3, Mon./p.m./M)*

Recovery Strength Measurements in Arcs from Atmospheric Pressure to Vacuum—*G. A. Farrall, J. D. Cobine, General Electric Co. (10.4, Mon./p.m./M)*

Current Ideas in the Philosophy of Testing of Electrical Contacts—*H. B. Ulsh, International Business Machines Corp. (10.5, Mon./p.m./M)*

A New Teleprinter for 133 WPM—*W. A. Kaiser, Standard Electrik Lorenz AG, Germany (32.1, Tues./p.m./MH)*

Advance in Printing Telegraphy and Data in 1965—*W. Y. Lang (32.3, Tues./p.m./MH)*

Industrial Electronics

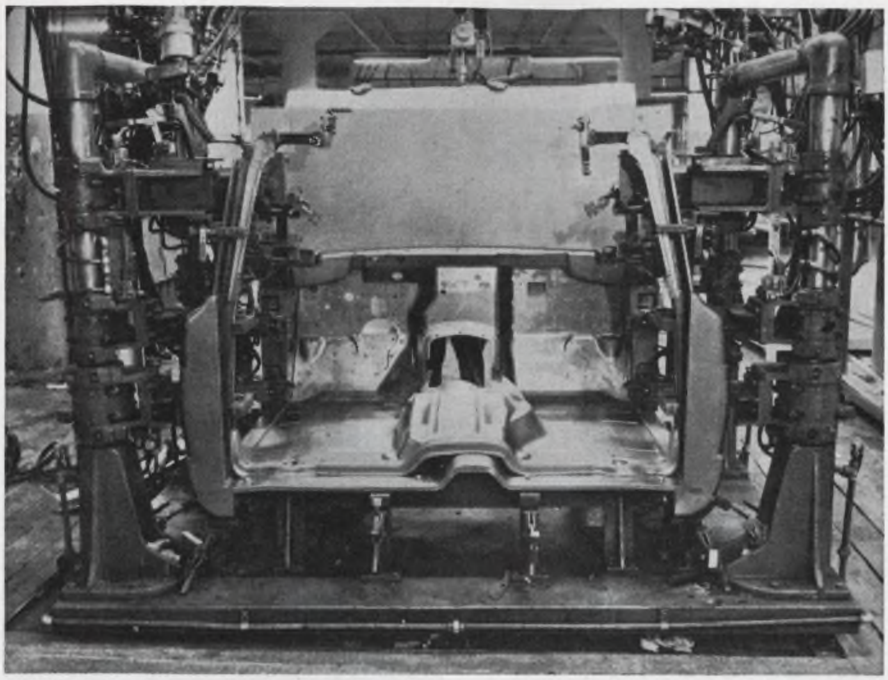
Computer Monitoring Chromatograph —*Ira Lichtenstein, G. R. Marr Jr., Electronic Associates, Inc. (1.2, Mon./a.m./T)*

The PCP-88 System—*Bruce Baldridge, The Foxboro Co. (1.4, Mon./a.m./T)*

Electrical Demulsification, Process and Equipment—*L. C. Waterman, J. D. Winslow, Petrolite Corp. (2.2, Mon./a.m./M)*

Pulse—Width Modulated Inverters for AC Motor Drives—*Boris Mokrytzki, Reliance Electric and Engineering Co. (6.2, Mon./a.m./N)*

An AC Equivalent Circuit for Cyclo-



Resistance-welding fixture at Kaiser Jeep Corp. incorporates simplified tooling plus standardized welding equipment (paper 29.1)

converters—*C. J. Amato, Lear Siegler, Inc. (6.3, Mon./a.m./N)*

Overload Protection for the New NEMA-Rated Motors—*O. A. Herman, General Electric Co. (22.1, Tues./a.m./N)*

The Sleeve Induction Motor for High-Performance Servomechanisms—*D. E. Wiegand, Argonne National Lab. (22.3, Tues./a.m./N)*

A Vernier Type Load Tap Changer for Precision Industrial Voltage Control —*C. C. Haley, Westinghouse Electric Corp. (22.4, Tues./a.m./N)*

Solid-State Speed, Acceleration and Load-Control System—*F. T. Thompson, A. Wavre, Westinghouse Electric Corp. (22.5, Tues./a.m./N)*

Fusing Solid-State Motor Control—*Phillip Jacobs, Chase-Shawmut Co. (26.1, Tues./p.m./M)*

Panel Discussion on Unusual Load Characteristics of New High Energy Metal Tools (26.2, Tues./p.m./M)

European Developments in Resistance Welding—*Walter Masing, Masing and Co. (29.1, Tues./p.m./R)*

Problems and Policies of an International Automotive Welding Operation—*T. F. Ellis, Kaiser Jeep Corp. (29.2, Tues./p.m./R)*

Pulsed Current for Gas-Shielded Arc Welding—*J. C. Needham, British Welding Research Association (29.3, Tues./p.m./R)*

Warehouse Lighting: An Analytic Study—*Norman Falk, Richard Mollin, Holophane Co. (36.2, Wed./a.m./SS)*

Generation and Behavior of X-rays in Thickness Measurement—*W. R. Baarck, Weston Instruments, Inc. (38.1, Wed./a.m./N)*

Using a Computer for the Design of Analog and Digital Control Systems *P. J. Wirtz, Reliance Electric and Engineering Co. (38.2, Wed./a.m./N)*

High-Performance Control for Tandem Cold Mill Main Drive Systems—*R. E. Moore, General Electric Co. (38.3, Wed./a.m./N)*

Induction Heating of Bars and Semifinished Steel—*D. G. Hatchard, Westinghouse Electric Corp. (38.4, Wed./a.m./N)*

SCR-Magnetic Analog Regulator for Single-Phase and Unbalanced Three-Phase Nonlinear Heater Loads—*Baruch Berman, Electric Regulator Corp. (46.2, Thurs./a.m./N)*

A DC Equivalent of an AC Synchronous Motor—*G. S. MacDonald, Photocircuits Corp. (74.4, Fri./p.m./M)*

Lighting

Mechanization of Point-by-Point Calculations—*E. Mahler, Holophane Co. (36.1, Wed./a.m./SS)*

Warehouse Lighting: An Analytic Study—*Norman Falk, Richard Mollin, Holophane Co. (36.2, Wed./a.m./SS)*

Free Heat from Lighting Applied to the All-Electric Building—*George Gilleared, R. S. Wissoker, Day-Brite Lighting (36.3, Wed./a.m./SS)*

Trends in Special Lighting—*H. J. Wald, Wald and Zigas (36.4, Wed./a.m./SS)*

Management

Engineering Management *(31, Tues./p.m./G)*

Synergetic Management of Complex Military Systems—*M. V. Ratynski, U.S. Air Force (49.1, Thurs./a.m./T)*

An Electronic PERT Diagram—*M. G. Kaufman, U. S. Naval Research Labs. (49.2, Thurs./a.m./T)*

Automated Techniques for Problems of Configuration Control —*C. E. Lenz, W. K. Masenten, M. L. Shope, Autonetics (49.3, Thurs./a.m./T)*

Apollo Spacecraft Test Evaluation Management Plan—*R. E. McKann, C. Clark Jr., General Electric Co. (49.4, Thurs./a.m./T)*

Personnel Evaluation: Key to Successful Management—*G. R. Desi, Westinghouse Electric Corp. (49.5, Thurs./a.m./T)*

Medical Electronics

Applications of Computers to Biomedical Work—*O. L. Updike, Univ. of Virginia (1.1, Mon./a.m./T)*

Ultrasound Analysis of Implanted Cardiac Prosthetic Valves—*Benedict Kingsley, G. B. Flint Jr., B. L. Segal, Zdravko Asperger (3.1, Mon./a.m./SN)*

Engineering Aspects of Medical Thermography—*E. E. Brueschke, J. D. Haberman-Brueschke, J. Gershon-Cohen (3.2, Mon./a.m./SN)*

Modal Analysis of the Dicrotic Portion of the Human Blood-Pressure Curve—*R. M. Goldwyn, Rice Univ., T. B. Watt Jr., Baylor Univ. (3.3, Mon./a.m./SN)*

A Permanent Transvenous Standby Pacemaker—*G. H. Myers, New York Univ.; Victor Parsonnet, N. J. College of Medicine; C. W. Keller, Cordis Corp.; I. R. Zucker, L. Gilbert, Newark Beth Israel Hospital (3.4, Mon./a.m./SN)*

A 600,000-Watt Rectangular-Wave Defibrilator—*J. C. Schuder, G. A. Rahmoeller, Harry Stoeckle, Gary Raines, Univ. of Missouri (3.5, Mon./a.m./SN)*

Microelectronics

A Microminiature MTI System for Surveillance Radars—*W. Cappadona, Airborne Instruments Lab., D. Kenneally, Griffiss Air Force Base, Rome Air Development Center (20.5, Tues./a.m./SS)*

Microelectronics Applications in Undersea Instrumentation—*William Liben, Johns Hopkins Univ. (35.3, Wed./a.m./SN)*

Current Developments in Integrated Electronics—*R. L. Petritz, Texas Instruments, Inc. (42.3, Wed./p.m./M)*

Microwave Integrated Circuits in Phased-Array Radars—*T. M. Hyltin, Texas Instruments, Inc. (45.1, Wed./p.m./R)*

Integrated S- and X-Band Mixers—*C. Howell, C. Genzabella, Microwave Associates, Inc. (45.2, Wed./p.m./R)*

A UHF Telemetry Converter Employing Integrated Microwave Circuits—*H. M. Weil, F. S. Coale, Melabs (45.3, Wed./p.m./R)*

Integrated Tunnel Diode Amplifier for Multi-Channel Communication in the Case of f_{ro} Being Higher Than f_{xo}—*H. Yunoki, Y. Ito, T. Kudo, H. Komizo, Fujitsu Ltd. (45.4, Wed./p.m./R)*

Electron Beam Gun in an Exploratory Fabrication System—*D. Zeheb, N. H. Krietzer, D. G. Cullum, International Business Machines Corp. (52.1, Thurs./a.m./SS)*

Birefringent Tape: A New, Easier Technique for Separating Thin-Film and Printed-Circuit Master Drawings with Perfect Registration—*B. J. Askowith, William Middleton, The Martin Co. (52.2, Thurs./a.m./SS)*

Integrated Circuit Design by Digital Computer—*R. A. Mammano, ARINC Research Corp. (52.3, Thurs./a.m./SS)*

Thin Inlays for Electronic Applications—*Ken Comey, Richard Shoemaker, G. L. McDermott, Texas Instruments, Inc. (52.4, Thurs./a.m./SS)*

An Integrated Stabilized Gain Block—*G. W. Haines, Sprague Electric Co. (80.2, Fri./p.m./MH)*

Microwaves

Simultaneous Message and Wide Band Data Loading on a Microwave Baseband—*J. H. Lippard, L. R. Foiles, General Electric Co. (8.2, Mon./a.m./MH)*

Distribution and Microwave Links—*A. D. Fowler, Bell Telephone Labs. (17.3, Tues./a.m./T)*

A Precision DC Potentiometer Microwave Insertion Loss Test Set—*C. T. Stelzried, M. S. Reid, Jet Propulsion Lab. (23.2, Tues./a.m./G)*

Submillimeter Waves—*G. Convert, Centre de Recherches de la CSF, France (34.1, Wed./a.m./M)*

Multi-Layered Film Microwave Acoustic Transducers—*H. J. Shaw, D. K. Winslow (37.1, Wed./a.m./R)*

Computer Analysis of Ferrite Digital Phase Shifters—*E. Stern, W. J. Ince, Lincoln Lab., MIT (37.2, Wed./a.m./R)*

Te-Mode Solutions for Partially Ferrite-Filled Rectangular Waveguide Using ABCD Matrices—*W. P. Clark, K. H. Hering, D. A. Charlton, Hughes Aircraft Co. (37.3, Wed./a.m./R)*

Recent Advances in Digital Latching Ferrite Devices—*L. R. Whicker, Westinghouse Electric Corp. (37.4, Wed./a.m./R)*

A Real Time-Delay Microwave Measuring System—*R. A. Sparks, Litton Systems, Inc. (37.5, Wed./a.m./R)*

Microwave Integrated Circuits in Phased-Array Radars—*T. M. Hyltin, Texas Instruments, Inc. (45.1, Wed./p.m./R)*

Integrated S- and X-Band Mixers—*C. Howell, C. Genzabella, Microwave Associates, Inc. (45.2, Wed./p.m./R)*

A UHF Telemetry Converter Employing Integrated Microwave Circuits—*H. M. Weil, F. S. Coale, Melabs. (45.3, Wed./p.m./R)*

Integrated Tunnel Diode Amplifier for Multi-Channel Communication in the Case of f_{ro} Being Higher than F_{xo}—*H. Yunoki, Y. Ito, T. Kudo, H. Komizo, Fujitsu Ltd. (45.4, Wed./p.m./R)*

Military Electronics

High-Voltage DC Brushless Torpedo Propulsion Motor—*W. R. Cox, Naval Underwater Ordnance Station; V. F. Janonis, Lear Siegler, Inc. (14.3, Mon./p.m./N)*

Land-Clutter Characteristics for Airborne Radar System Design—*J. Cohen, J. Di Stefano, J. T. McManus, Grumman Aircraft Engineering Corp. (20.4, Tues./a.m./SS)*

A Microminiature MTI System for Surveillance Radars—*W. Cappadona, Airborne Instruments Lab.; D. Kenneally, Griffiss Air Force Base, Rome Air Development Center (20.5, Tues./a.m./SS)*

The Elements of Survivability Analysis for Command Control Communications Systems—*E. A. Steeves, The Mitre Corp. (24.4, Tues./a.m./G)*

Synergetic Management of Complex Military Systems—*M. V. Ratynski, U.S. Air Force (49.1, Thurs./a.m./T)*

Role of Automatic Checkout in the Tactical Air Command—*A. E. Smith, Frank Micca, Wright-Paterson Air Force Base (59.4, Thurs./p.m./SS)*

Municipal Planning

Concept for a National Security Information System—*H. R. Johnson, Executive Office of the President (24.3, Tues./a.m./MH)*

The Long Range City Plan—*Joseph Oberman, Office of the Development Coordinator, Philadelphia (30.1, Tues./p.m./N)*

The City as a Physical System—*J. T. Eberhard, Dept. of Commerce (30.2, Tues./p.m./N)*

The City as an Information Network—*T. O. Paine, General Electric Co. (30.3, Tues./p.m./N)*

The City of Tomorrow: Power for Urban Progress—*(30.4, Tues./p.m./N)*

Oceanography & Underwater Systems

The Hostile Sea—*A. J. Finocchi, ITT Federal Labs. (35.1, Wed./a.m./SN)*

Environmental Data for Undersea Technology—*Woodrow Jacobs, National Oceanographic Data Center (35.2, Wed./a.m./SN)*

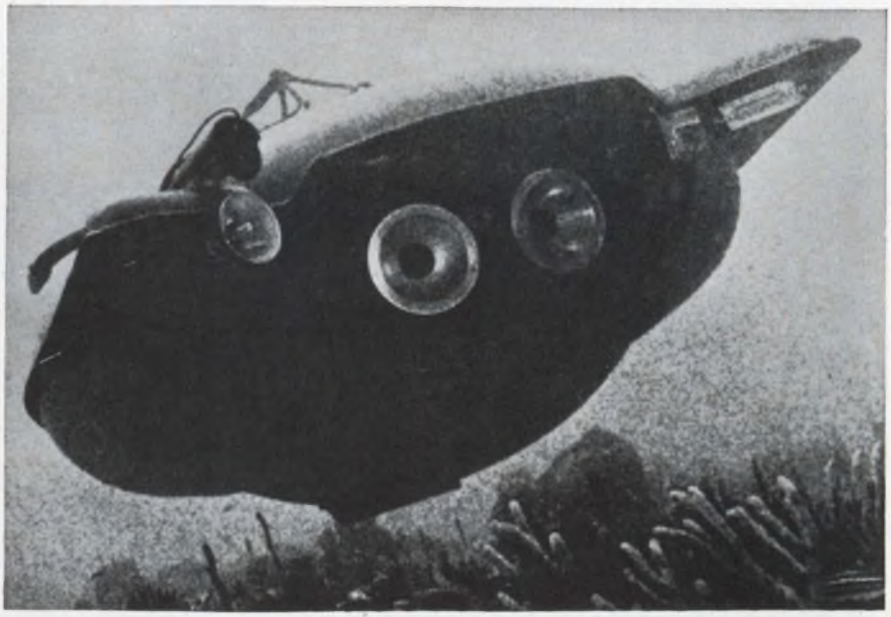
Microelectronics Applications in Undersea Instrumentation—*William Liben, Johns Hopkins Univ. (35.3, Wed./a.m./SN)*

Underseas Instrumentation Reliability! Where Away?—*J. M. Snodgrass, Scripps Institution of Oceanography (35.4, Wed./a.m./SN)*

Panel Discussion on Underseas Technology—*(35.5, Wed. a.m. SN)*

The Role of Electronics in Deep-Submergence Systems—*J. H. Clotworthy, Westinghouse Electric Corp. (43.1, Wed./p.m./SN)*

Command and Control of Deep/Submergence Vehicles—*Victor Ander-*



Deepstar three-man vehicle is designed to dive to a depth of 4000 feet. Developed at the Westinghouse Defense and Space Center, it will be leased for scientific dives.

son, Scripps Institution of Oceanography (43.2, Wed./p.m./SN)

Sensor and Navigation System for the Deep-Submergence Program—*J. A. Cestone, Dept. of the Navy (43.3, Wed./p.m./SN)*

Electronic Aids to Human Physiology Underseas—*C. W. Sem-Jackson, Oslo Univ., Norway (43.4, Wed./p.m./SN)*

Undersea Technology: Industry's Role —*G. W. Miller, Textron Corp. (43.5, Wed./p.m./SN)*

Communication Requirements in Diving Operations—*E. C. Stephan, Ocean Systems, Inc. (68.1, Fri./a.m./SS)*

Underwater Communication Problems from the Navy Swimmer's Standpoint—*B. L. Cannon, U. S. Navy Mine Defense Lab. (68.2, Fri./a.m./SS)*

Wireless Diver Communications, Problems and Performance—*J. E. Kenny, Aquasonics Engineering Co. (68.3, Fri./a.m./SS)*

An Underwater Audio Communicator —*H. J. Webb, J. R. Webb, Hydrotronics Co. (68.4, Fri./a.m./SS)*

Helium Speech Unscrambling—*Michel Copel, U. S. Naval Applied Science Lab. (68.5, Fri./a.m./SS)*

Power Generation and Control

Recent Advances in Electrofluiddynamic Power Generation—*H. E. Brandmaier, Bernard Kahn, Curtiss-Wright Corp. (2.4, Mon./a.m./M)*

Interphase Transformer for Multiple Connected Power Rectifiers—*O. N. Acosta, I-T-E Circuit Breaker Co. (6.1, Mon./a.m./N)*

Pulse-Width-Modulated Inverters for AC Motor Drives—*Boris Mokrytzki, Reliance Electric and Engineering Co. (6.2, Mon./a.m./N)*

An AC Equivalent Circuit for Cycloconverter—*C. J. Amato, Lear Siegler, Inc. (6.3, Mon./a.m./N)*

The Differential Saturable Transformer as the Basic Component of a Controlled High-Efficiency Power Supply —*S. P. Jackson, Solidstate Controls Inc., H. R. Weed, Ohio State Univ. (6.4, Mon./a.m./N)*

Power Measurement Errors in Controlled Rectifier Circuits—*M. S. Erlicki, D. Schieber, J. Ben Uri, Israel Institute of Technology (6.5, Mon./a.m./N)*

Design Notes on the DC Chopper—*Eberhart Reimers, Lear Siegler, Inc. (14.2, Mon./p.m./N)*

High Voltage DC Brushless Torpedo Propulsion Motor—*W. R. Cox, Naval Underwater Ordnance Station; V. F. Janonis, Lear Siegler, Inc. (14.3, Mon./p.m./N)*

SCR Voltage Regulator for Mobile Power Generation—*W. K. Volkmann, General Electric Co. (14.4, Mon./p.m./N)*

The Design of a Simple Single-Phase SCR Regulator—*E. S. McVey, R. E. Russell, Univ. of Virginia (14.5, Mon./p.m./N)*

A Vernier-Type Load Tap Changer for Precision Industrial Voltage Control—*C. C. Haley, Westinghouse Electric Corp. (22.4, Tues./a.m./N)*

Fusing Solid-State Motor Control—*Philip Jacobs, Chase-Shawmut Co. (26.1, Tues./p.m./M)*

Panel Discussion on Unusual Load Characteristics of New High Energy Metal Tools (26.2, Tues./p.m./M)

The City of Tomorrow: Power for Urban Progress—*(30.4, Tues./p.m./N)*

SCR-Magnetic Analog Regulator for Single-Phase and Unbalanced Three-Phase Nonlinear Heater Loads—Baruch Berman, Electric Regulator Corp. (46.2, Wed./p.m./N)

A Synchronous Tap Changer Applied to Step Up Cycloconverters—*W. R. Light Jr., E. S. McVey, Univ. of Virginia (46.3, Wed./p.m./N)*

Anaylsis of an L-C Tuned Static Inverter—*A. G. Potter, Iowa State Univ. (46.4, Wed./p.m./N)*

The Three-Phase Half-Wave Inverter —*Eberhart Reimers, Lear Siegler, Inc. (46.5, Wed./p.m./N)*

A Method for Minimizing the Length of Electric Power Lines Used in Single-Ended Distribution Systems—*L. M. Maxwell, Colorado State Univ. (54.1, Thurs./a.m./N)*

The Cooling of Underground EHV Transmission Cables—*J. A. Hitchcock, M. J. Thelwell, Central Electricity Research Labs. (54.2, Thurs./a.m./N)*

Modal Theory of Skin Effect in Straight Flat Conductors—*P. Silvester, McGill Univ. (54.3, Thurs./a.m./N)*

Network Analogue Solution of Skin and Proximity Effect Problems—*P. Silvester, McGill Univ. (54.4, Thurs./a.m./N)*

Dual Potentials in Silver-Oxide/Zinc Batteries—*R. C. Dawer, Lockheed Missiles and Space Co. (60.2, Thurs./p.m./SS)*

Silicon-Germanium Thermoelectrics for Power Generation—*G. S. Lozier, Radio Corp. of America (77.1, Fri./p.m./R)*

Radiation Effects

Lifetimes of Trapped Charge in Electron Irradiated Dielectrics—*J. Dow, S. V. Nablo, Ion Physics Corp. (2.1, Mon./a.m./M)*

Atomic Origins of Transient Nuclear Radiation Effects in Electronis—*A. W. Snyder, Sandia Corp. (44.1, Wed./p.m./SS)*

Transient Radiation Effects on Passive Electronic Components—*H. W. Wicklein, The Boeing Co. (44.2, Wed./p.m./SS)*

A Review of Diode and Transistor Transient Response to Ionizing Radiation—*S. C. Rogers, Bell Telephone Labs. (44.3, Wed./p.m./SS)*

Computer Usage in Radiation Effects Studies—*W. A. Bohan, H. W. Mathers, F. C. Tietze, International Business Machines Corp. (44.4, Wed./p.m./SS)*

Reliability

Reliability of Plated-Through Holes in Multilayer Boards—*R. H. Gauger, Hazeltine Corp. (73.1, Fri./p.m./T)*

Circuit Failure Asymmetries for Reliability Improvement in Digital Circuits—*H. D. Goldman, Sperry Gyrocope Co. (73.2, Fri./p.m./T)*

Setting Reliability Incentives, Using Linear Programming—*R. T. Maloney, Sperry Gyroscope Co. (73.4, Fri./p.m./T)*

Reliability Testing in a Bayesian Context—*D. M. Brender, System Prediction Analysts (73.5, Fri./p.m./T)*

Achievement and Potential of a New Tool for Quality Assurance: Infrared Techniques—*Riccardo Vanzetti, Stephen Boba, Raytheon Co. (73.6, Fri./p.m./T)*

Sensing and Measuring

Power-Measurement Errors in Controlled Rectifier Circuits—*M. S. Erlicki, D. Schieber, J. Ben Uri, Israel Institute of Technology (6.5, Mon./a.m./N)*

Radar Cross-Polarization Measurements for the Determinatin of Target Surface Properties—*Kumar Krishen, W. W. Koepsel, S. H. Durrani, Kansas State Univ. (20.3, Tues./a.m./SS)*

A Real-Time-Delay Microwave Measuring System—*R. A. Sparks, Litton Systems, Inc. (37.5, Wed./a.m./R)*

Generation and Behavior of X-Rays in Thickness Measurement—*W. R. Baarck, Weston Instruments, Inc. (38.1, Wed./a.m./N)*

Semiconductor Evaluation with the Fast Scanning Infrared Microscope—*Riccardo Vanzetti, Leon Hamiter, Raytheon Co. (39.1, Wed./a.m./G)*

Lock-On Magnetometer Utilizing Superconducting Sensor—*R. L. Forgacs, A. Warnick, Ford Motor Co. (39.2, Wed./a.m./G)*

Force-Field Detection of Objects in Space—*M. G. Kaufman, U. S. Naval Research Labs. (39.3, Wed./a.m./G)*

Lunar Observation Experiment with the Westinghouse Image Dissector—*K. C. Leonard Jr., James Nicholson, Westinghouse Electric Corp. (39.5, Wed./a.m./G)*

A Solar-Burst Radiometer for the Radio Astronomy Explorer Satellite—

R. Donegan, M. Chomet, Airborne Instruments Lab. (39.6, Wed./a.m./G)

The Remote Measurement of Insertion Loss and Echo-Return Loss in Michigan—*D. W. Gilbo, Michigan Bell Telephone Co. (56.2, Thurs./a.m./MH)*

Packset Radio Antenna Measurements—*J. A. Kuecken, General Dynamics/Electronics (63.6, Thurs./p.m./G)*

Additional Results of Actual Measurements Using the Doppler-Shift Technique for Determination of Relative Geodetic Location by the Use of Satellites—*E. S. Keats, Westinghouse Electric Corp. (67.4, Fri./a.m./SN)*

Burst Measurements in Audio and Electroacoustics—*W. W. Lange, International Business Machines Corp. (76.4, Fri./p.m./SS)*

Signal Processing

Analysis of Phase-Locked Loop Acquisition: A Quasi Stationary Approach—*S. A. Meer, ADCOM, Inc. (13.1, Mon./p.m./R)*

Probabilities of Detection and False Alarm for a Coherent Detector With Amplitude Limiting of Arbitrary Hardness—*David Silber, Westinghouse Electric Corp. (13.2, Mon./p.m./R)*

The Problem of Too Many Measurements in Pattern Recognition and Prediction—*D. C. Allais, International Business Machines Corp. (13.3, Mon./p.m./R)*

Adaptive Threshold Detection of M-ary Signals in Statistically Undefined Noise—*J. B. Millard, Ludwik Kurz, New York Univ. (13.4, Mon./p.m./R)*

A Goal: Spurious-Signal Immunity of Solid-State AM/FM Tuners—*R. V. Fournier, C. H. Lee, J. A. Kuklis, Radio Corp. of America (15.1, Mon./p.m./G)*

A Signal Design Philosophy for High-Resolution Radar—*E. L. Titlebaum, Univ. of Rochester (20.1, Tues./a.m./SS)*

Comparison of Frequency-Shift-Keyed and Phase-Shift-Keyed Pulse Compression Systems—*R. W. Klassen, The Martin Co. (20.2, Tues./a.m./SS)*

On-Line Real-Time Data Recording for Analysis—*J. L. Deitz, General Precision, Inc. (28.3, Tues./p.m./SS)*

Graphical to Digital Converter—*G. L. D'Ombrain, L. A. Cox, L. Rozsa, McGill Univ. (28.4, Tues./p.m./SS)*

High-Performance Parallel-Serial Analog-to-Digital Converter with Error Correction—*G. G. Gorbatenko, International Business Machines Corp. (33.2, Wed./a.m./T)*

System Identification in the Presence of Noise by Digital Techniques—*A. I. Liff, New York Univ. (66.1, Fri./a.m./M)*

Statistical Properties of Random-Pulse Trains—*O. A. Z. Leneman, MIT Lincoln Lab. (66.2, Fri./a.m./M)*

Determination of the Output Statistics of a Sampled-Data System with a Nonlinearity—*D. Tabak, B. C. Kuo, Univ. of Illinois (66.3, Fri./a.m./M)*

Limit Cycle Compensation of Switched-Type Nonlinear Systems, Using Pole Zero Techniques—*H. W. Deaner, Sperry Piedmont Co., E. S. McVey, Univ. of Virginia (66.5, Fri./a.m./M)*

Solid-State Devices and Theory

Lifetimes of Trapped Charge in Electron Irradiated Dielectrics—*J. Dow, S. V. Nablo, Ion Physics Corp. (2.1, Mon./a.m./M)*

Solid-State Speed, Acceleration and Load Control System—*F. T. Thompson, A. Wavre, Westinghouse Electric Corp. (22.5, Tues./a.m./N)*

Metal Semiconductor Schottky Barriers and Devices—*M. M. Atalla, Hewlett-Packard Co. (42.1, Wed./p.m./M)*

Unpackaged Devices—*J. M. Early, Bell Telephone Labs. (42.2, Wed./p.m./M)*

Micropower Linear Circuits—*J. D. Meindl, P. H. Hudson, U. S. Army Electronics Command (42.4, Wed./p.m./M)*

A Higher-Power Ultrasonic Switch—*C. F. dePrisco, Aeroprojects, Inc. (46.1, Wed./p.m./N)*

Subminiature Transistors—*F. M. Dukat, Raytheon Co. (76.1, Fri./p.m./SS)*

Statistics of Switching-Time Jitter for a Tunnel-Diode Threshold-Crossing Detector—*D. E. Nelsen, MIT (80.1, Fri./p.m./MH)*

Space Electronics

Recent Advance in Sliding Contacts, Including Space Applications—*E. I. Shobert 2d, Stackpole Carbon (10.3, Mon./p.m./M)*

High-Quality Kinescope-Film Recording of Meteorological Satellite Pictures at Slow-Scan Rates—*S. M. Ravner, Radio Corp. of America (11.1, Mon./p.m./SN)*

Panel Discussion on An Astronaut's Appraisal of His Electrical and Electronics Aids *(27.1, Tues./p.m./SN)*

Spacecraft Command and Control—*J. T. Mengel, NASA (27.2, Tues./p.m./SN)*

Propulsion Systems for Space Operation—*A. Tischler, NASA, (27.3, Tues./p.m./SN)*

Simulators for Manned Space Flight—*F. B. Smith, NASA (27.4, Tues./p.m./SN)*

Space Communication Systems—*N. T. Petrovich, All-Union Electrotechnical Institute of Communications, Moscow (27.5, Tues./p.m./SN)*

Force Field Detection of Objects in Space—*M. G. Kaufman, U. S. Naval Research Labs. (39.3, Wed./a.m./G)*

Lunar Observation Experiment with the Westinghouse Image Dissector—*K. C. Leonard Jr., James Nicholson, Westinghouse Electric Corp. (39.5, Wed./a.m./G)*

A Solar Burst Radiometer for the Radio Astronomy Explorer Satellite—*R. Donegan, M. Chomet, Airborne Instruments Lab. (39.6, Wed./a.m./G)*

Role of ACE-S/C in Spacecraft Checkout—*W. Parsons, NASA (59.3, Thurs./p.m./SN)*

H-F Applications to Re-Entry Capsule Surveillance and Tracking—*M. H. Lowe, Radio Corp. of America (67.1, Fri./a.m./SN)*

Interplanetary Spacecraft Telecommunication Systems—*G. A. Reiff, NASA, (67.2, Fri./a.m./SN)*

Turnstile Antenna for Space Communications—*C. C. Chen, Northrop Space Labs. (67.3, Fri./a.m./SN)*

Additional Results of Actual Measurements Using the Doppler-Shift Technique for Determination of Relative Geodetic Location by the Use of Satellites—*E. S. Keats, Westinghouse Electric Corp. (67.4, Fri./a.m./SN)*

Design Considerations for the Selection of an On-Board Checkout Systems Computer—*L. F. Rowe, General Electric Co. (67.5, Fri./a.m./SN)*

Recent Progress of Thin-Film Solar Cells,—*D. M. Perkins, Radio Corp. of America (77.2, Fri./p.m./R)*

System Engineering

System Engineering Aspects of the RA-I Radio System—*J. Godier, Northern Electric Co., Ltd. (8.3, Mon./a.m./MH)*

A Signal Design Philosophy for High-Resolution Radar—*E. L. Titlebaum, Univ. of Rochester, N. DeClaris, Cornell Univ. (20.1, Tues./a.m./SS)*

Land-Clutter Characteristics for Airborne Radar System Design—*J. Cohen, J. DiStefano, J. T. McManus, Grumman Aircraft Engineering Corp. (20.4 Tues./a.m./SS)*

A Microminiature MTI System for Surveillance Radars—*W. Cappadona, Airborne Instruments Lab., D. Kenneally, Griffis Air Force Base, Rome Air Development Center (20.5, Tues./a.m./SS)*

Panel Discussion on Present Status and Future Utilization of Advanced Technology in High-Frequency Systems Engineering—*(40, Wed./a.m./MH)*

Systems Engineering Aspects of a High-Capacity PCM System—*J. Deregnaucourt, Northern Electric Co.,* *Ltd., Canada (56.4, Thurs./a.m./MH)*

Practical Criteria for Automatic Checkout System Design—*E. Dalca, Grumman Aircraft Engineering Corp. (59.5, Thurs./p.m./SN)*

Television

A Simple Noise Eliminator for Television-Receiver Synchronizing Circuits —*Kenneth James, Emerson Radio and Phonograph Corp. (15.2, Mon./p.m./G)*

Transistorized Horizontal Output Stage—*Bechara Aboufadel, Warwick Electronics, Inc. (15.3, Mon./p.m./G)*

An Analysis of the Necessary Decoder Corrections for Color Receiver Operation with Nonstandard Receiver Primaries—*Norman Parker, Motorola Consumer Products Div (15.4, Mon./p.m./G)*

Hybrid TV Receivers: Color and Black and White—*A. R. Curll, Philco Corp. (15.5, Mon./p.m./G)*

Color TV Standards: Opening Remarks—*D. G. Fink, IEEE (Tues./a.m./T)*

Problems Common to All Systems Cameras, Lighting, Film—*H. Kozanowski, RCA (17.1)*

Tape Recording for Color—*J. Roizen, Ampex (17.2)*

Distribution and Microwave Links—*A. D. Fowler, Bell Telephone Labs. (17.3)*

Systems Under Consideration (NTSC, PAL, SECAM)—*R. Theile, Institut for Rundfunktechnik, Germany (17.4, Tues./a.m./T)*

The European Broadcasting Union (EBU) What is the EBU? Results of Tests by EBU on NTSC, PAL, SECAM—*George Hansen, European Broadcasting Union (17.5, Tues./a.m./T)*

Design and Characteristics of Coaxial Cables for Community Antenna Television (CATV) Systems—*W. T. Smith, W. L. Roberts, Superior Cable Corp. (24.1, Tues./a.m./MH)*

A Figure of Merit for CATV Amplifiers: The Coefficient System—*D. N. Carson, Bell Telephone Labs. (24.2, Tues./a.m./MH)*

Color TV Standards: International Exchange of Programs *(Tues./p.m./T)*

The Conversion of One Standard to Another—*Enzo Castelli, Radio Television Italiana (25.1)*

Special Problems on Program Exchange—*S. N. Watson, British Broadcasting Corp. (25.2)*

Statement by System Proponents NTSC—*G. H. Brown, Radio Corp. of America (25.3)*

PAL, SECAM (Experts in PAL and SECAM are also expected to contribute to the discussion.)

Discussion Panel on Relative Receiver Complexity *(25.4, Tues./p.m./T)*: NTBC—Harris Wood, Electronic Industries Assoc.
PAL, SECAM (Experts in PAL and SECAM are also expected to contribute to the discussion.)

Television Cathode-Ray Display Tubes —*Fred Townsend, Westinghouse Electric Corp. (34.4, Wed./a.m./M)*

Operational and Control Simplification in TV Studio Video-Switching Systems—*Blair Benson, Columbia Broadcasting System (61.3, Thurs./p.m./R)*

Test Equipment and Techniques

Panel Discussion on Cavitation Measurement *(8.4, Mon./a.m./MH)*

Current Ideas in the Philosophy of Testing of Electrical Contacts—*H. B. Ulsh, International Business-Machines Corp. (10.5, Mon./a.m./M)*

A New Wideband True RMS/DC Converter—*Peter Richman, Weston Instruments, Inc. (23.1, Tues./a.m./G)*

A Precision DC Potentiometer Microwave Insertion Loss Test Set—*C. T. Stelzried, M. S. Reid, Jet Propulsion Lab.; S. M. Petty, Univ. of Southern California (23.2, Tues./a.m./G)*

Status Report on Proposed IEEE Oscilloscope Standards—*C. N. Winningstad, Tektronix, Inc. (23.4, Tues./a.m./G)*

Improved Ultra-Fast Transient Recording by Fibre Optics Cathode-Ray Tubes—*F. L. Katzmann, Fairchild Camera and Instrument Corp. (23.5, Tues./a.m./G)*

A Wide-Range Semiautomatic Filter Test Set—*P. J. Nordquist, Sylvania Electric Products (28.1, Tues./p.m./SS)*

Test by Pulse Reflection of Electro Explosive Devices—*D. E. Landry, J. M. Marshall, General Electric Co. (28.2, Tues./p.m./SS)*

Wide-range filter test set was developed by Sylvania Electronic Systems for use in high-volume filter production (paper 28.1).

Automatic Checkout: The State of the Art—*D. M. Goodman, New York Univ. (59.1, Thurs./p.m./SN)*

VAST—A Computerized Test System for Carrier-Based Avionics—*A. J. Stanziano, Dept. of the Navy (59.2, Thurs./p.m./SN)*

Role of ACE-S/C in Spacecraft Checkout—*W. Parsons, NASA (59.3, Thurs./p.m./SN)*

Role of Automatic Checkout in the Tactical Air Command—*A. E. Smith, Frank Micca, Wright-Paterson Air Force Base (59.4, Thurs./p.m./SN)*

Practical Criteria for Automatic Checkout System Design—*E. Dalca, Grumman Aircraft Engineering Corp. (59.5, Thurs./p.m./SN)*

Automated Test Equipment: An Analysis of the Problem—*J. W. Breehl, Office of Maintenance Policy (59.6, Thurs./p.m./SN)*

Panel Discussion on Automatic Checkout Systems *(59.7, Thurs./p.m./SN)*

Transportation

A New Control Concept for Electric Vehicles—*T. R. Kelley, I-T-E Circuit Breaker Co. (14.1, Mon./p.m./N)*

Policy Decisions in Transportation System Planning—*Alan Boyd, Office of Secretary of Commerce for Transportation (21.1, Tues./a.m./R)*

Models for Railroad Terminals—*C. B. Shields, Battelle Memorial Institute (21.2, Tues./a.m./R)*

Economic Models for Rail Systems—*J. P. Carstens, R. C. Baxter, Julian Reitman, United Aircraft Corp. (21.3, Tues./a.m./R)*

Rail Gauge and Rapid-Transit Train Stability—*E. G. Chilton, Stanford Research Institute (21.4, Tues./a.m./R)*

Stereophonic Tape Cartridge System for Automobile Use—*R. C. Moyer, RCA/Victor Div. (76.6, Fri./p.m./SS)*

Problems of Sound Systems in Passenger Vehicles—*A. B. Cohen, University Sound (79.1, Fri./p.m./N)*

Writing and Speech

An Analysis and Comparison of Defense/Space Marketing Publications —*R. M. Woelfle, Bendix Mishawaka Div. (9.1, Mon./p.m./T)*

Optimum Information Transfer: Engineer to Engineer—*E. T. Clare, Cohu Electronics, Inc. (9.2, Mon./p.m./T)*

The Reading Habits of Engineers in the Avionics Industry—*J. F. Lufkin, Honeywell, Inc., E. H. Miller, The Martin Co. (9.3, Mon./p.m./T)*

The Effect of Thematic Quantization on Expository Coherence—*J. X. Tracey, Hughes Aircraft Co. (9.4, Mon./p.m./T)*

SIEMENS

Siemens MKH
metallized film capacitors

Small size and high reliability are new standards set by Siemens capacitors. Twenty years' experience in making metallized capacitors has resulted in advanced precision techniques which closely control every capacitor property, making them 100% "foolproof" in service. "Self-healing" is an automatic reaction, eliminating the possibility of any voltage breakdown.

Two-way self-healing gives double protection. Internal voltage breakdown very rarely occurs. If it does, the thin metal coatings at the breakthrough point, act as a fuse and immediately vaporize, eliminating the breakthrough point within microseconds.

Electrochemical self-healing is the second protective process. It starts whenever and wherever insulation resistance decreases in the dielectric material. This process operates at any voltage, even as low as 10 mV, changing the metal coating at the point of lowest insulation resistance to a non-conductive oxide—thus eliminating the point electrically.

Less than one breakdown (self-healing) per year and per mF—that is the consistent average shown by tests at nominal voltage. This value, which is for the first year, is even less for succeeding years.

Highly stable capacitance. Overload tests (at 2.2 nominal voltage and at 85°C) show that decrease in capacitance as a result of self-healing is negligible, even after several years.

Small size—low cost. Intricate manufacturing techniques enable MKH (metallized polyester) capacitors to be produced to unvarying standards. They are available with axial or radial leads, in flat compact form. Leads soldered to metallized ends ensure reliable contact. The dielectric is polyester film, widely used for capacitors.

MKH properties. Operating temperatures: −40° to +125°C. Insulation resistance: minimum 20,000 megohms for normal capacitance up to .022mF at +20°C. For higher capacitance values: 10,000 megohms X mF (typical values). Temperature coefficient: approx. .04%/C° between 0° and 70°C. Dissipation factors: 0.5% at 1 kc; 1.5% at 10 kc (typical values).

Immediate shipment. Substantial stocks are held in White Plains, N. Y.

Write now for full information on Metallized Film Capacitors.

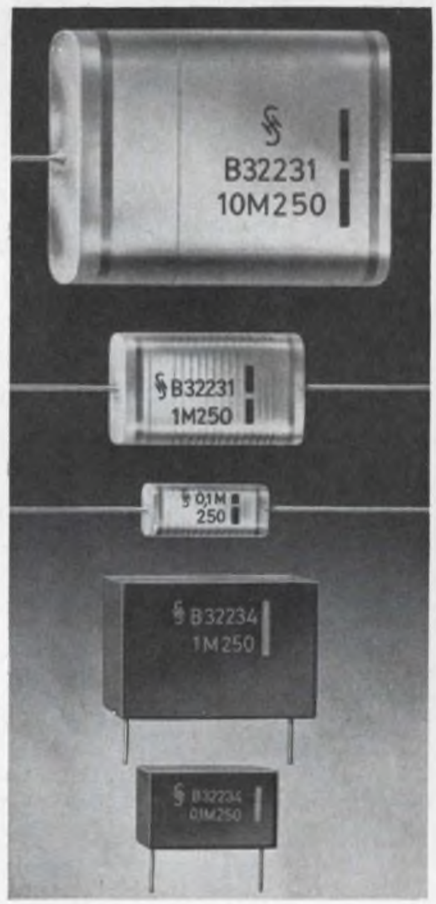


PHOTO: ACTUAL SIZE

SIEMENS AMERICA INCORPORATED
Components Division
230 Ferris Avenue, White Plains, N.Y.

In Canada: SIEMENS CANADA LIMITED
407 McGill Street, Montreal 1, P.Q.

ON READER-SERVICE CARD CIRCLE 42

Touring the Exhibit Areas

The new products at the 1966 IEEE Show have been arranged so that you can take a stroll through the aisles without ever leaving your desk. The show is broken down into main product categories, and products within those categories are located at particular spots on the four floors of the New York Coliseum.

Components—1st floor. Start your tour on page 110, and pay particular attention to TIs' plastic unijunction transistor.

Heavy Machinery—1st floor. Start on page 129 and follow on through the latest developments.

Components—2nd floor. The tour starts on page 132. Curtis has a new time/signal integrator and there's lots more.

Instruments—3rd floor. Starting with page 142 we take you on a tour which includes Weston-ROTEK's rms-to-dc converter.

Systems—3rd floor. Page 158 starts the systems section, but Rowan Controller's plug-in power supply is really on the 2nd floor.

Components—4th floor. Beginning on page 168 a lot of new items are shown, including Zeltex' sine-cosine generator.

Production Materials—4th floor. On page 129 start your tour of this section.

ON READER-SERVICE CARD CIRCLE 226 ➤

Plastic unijunction in planar form has low leakage

A plastic encapsulated silicon unijunction transistor, type SJ-5898, has a fast switching time with 20-200 times lower leakage current than most contemporary devices. Applications include SCR drivers, relaxation oscillators, and V and I sensing.

The SILECT device has a leakage current specified at less than 10 nA. Inter-base resistance is 4 K min, 9.1 K max. Peak emitter current is 1 A, rms emitter current is 50 mA, and base 1 peak voltage is 3 V min. Maximum interbase voltage is 35 V, I_{valley} is a minimum of 2 mA, and I_{peak} per base is 5 μA. I_{B2} is a minimum of 10 mA. Intrinsic standoff ratio is 0.55 min, 0.80 max.

The device operates over the entire military temperature range from −55° to +125°C, while it can be stored at up to 150°C.

Packaging capability is broad in scope; duel flat-packs, dual TO-5s, or any other comparable configuration.

Mechanically the device withstands 60,000 G acceleration.

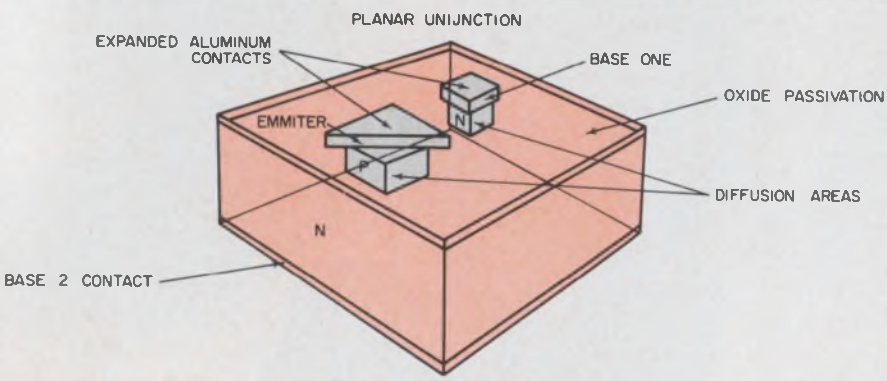
P&A: depends on quantity and configuration; 60 days. Texas Instruments, 13500 N. Central Pkway., Dallas. Phone: (214) 235-3111.

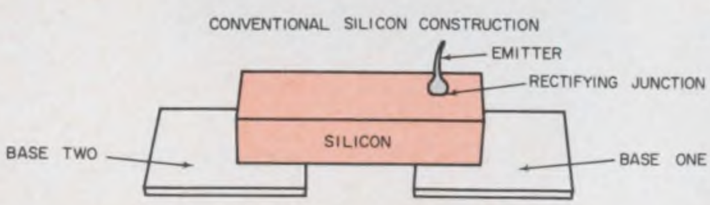
SEE AT BOOTH 1D13-25

Circle No. 504

Planar uni-junction

Specifications for this new planar-unijunction transistor include: 10 nA max leakage; 60,000 G acceleration; emitter rms current, 50 mA max; emitter peak current, 1 A max; base 1 peak pulse, 3 V min; I_V, 2 mA min, I_P, 5 μA max; Ve_{Sat}, 4 V max; R_{BB}, 4 k min—9.1 k max; intrinsic standoff ratio, 0.55 to 0.80; operating temp. range is −55° to +125°C; storage temp. is −55° to +150°C; Max interbase V is 35 V; I_{B2} mod is 10 mA min. No type number has yet been assigned to this unit which is now known only as SJ5898.





Static SCR inverter

A completely solid-state SCR inverter is available in sizes from 10 VA to 10 kVA. Up to 100 kVA is available on order.

The inverter produces regulated, filtered, sine-wave ac power from a dc source. Applications as emergency standby power for critical loads, or as frequency changers (50-60 Hz, 60-120 Hz, 60-4000 Hz, etc.), as dc to dc converters, or as motor speed controls.

Smaller units are mounted in a 19-in. relay-rack cabinet. Larger units are floor-mounted.

Used with a battery charger, battery, and alternate ac, the unit furnishes a fail-safe standby power system. The line voltage is fed through the inverter to the load as is the battery source. Should the line fail or dip, the battery takes over to maintain a constant current out of the inverter. No switching or synchronizing is needed; power is never lost.

P&A: about \$1/VA; 60 days. Fansteel Metallurgical Corp., Rectifier div., 1 Tantalum, North Chicago, Ill. Phone: (312) 336-4900.

SEE AT BOOTH 1E27-29

Circle No. 505

Thrust actuator

A thrust-vector actuator can gimbal velocity control engines.

Stroke is ±0.293-in., load is 3 lb., input V is 19-31 Vdc ±15 Vdc, and it weighs 3.7 lb. Max leakage is 1 cc/year at 1 x 10^{-11} TORR.

Kearfott Div., Gen. Precision, 1500 McBride, Little Falls, N. J. Phone: (201) 256-4000.

SEE AT BOOTH 1C22-24

Circle No. 506

ON READER-SERVICE CARD CIRCLE 43

Time indicators

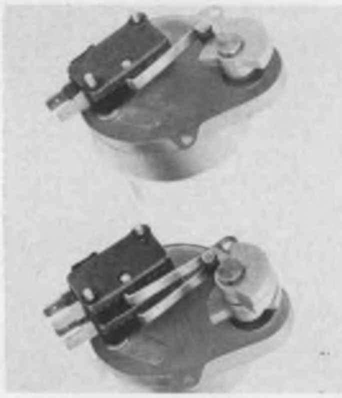
Instantaneous zero reset is a feature of the micro-miniature elapsed time indicators, Models LM19202 and LM19203. Readout is 99.9 and 999 hours respectively. Units are hermetically sealed and meet applicable requirements of MIL-M-7793C. Timing tolerance is ± one digit at 400 Hz. Operating voltage is 115 VAC at 400Hz.

A. W. Haydon, 232 North Elm, Waterbury, Conn., 06720. Phone: (203) 756-4481

SEE AT BOOTHS 1D07-11

Circle No. 631

Repeat cycle timers



A wide range of speeds is available in the K42400 series of low-cost repeat cycle timers.

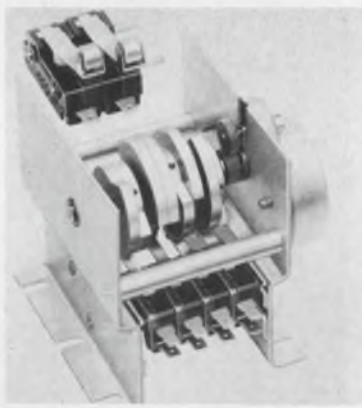
Models are offered with either one of two SPDT switches rated at 15 A resistive or inductive at 115 volts, 60 Hz: Available speeds are up to 8 rpm for the single-switch unit and 4 rpm for the two-switch version.

A. W. Haydon, 232 North Elm, Waterbury, Conn., 06720. Phone: (203) 756-4481

SEE AT BOOTHS 1D07-11

Circle No. 632

Eight-switch timer



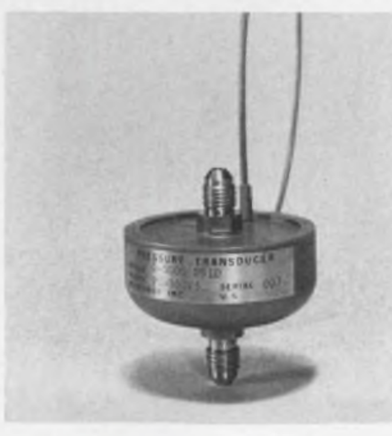
Over-all cycle times from 6 seconds to 25 hours are available with the L42401 and L42402 series of repeat cycle timers. Up to eight SPDT switches are available to control either 15 or 25 A loads at 115 VAC, 60 Hz. Synchronous motor drive is furnished for either 6, 12, 24, 115 or 230 VAC, 50 or 60 Hz operation.

A. W. Haydon, 232 North Elm, Waterbury, Conn., 06720. Phone: (203) 756-4481

SEE AT BOOTHS 1D07-11

Circle No. 633

Pressure transducer



A high-temperature strain gage pressure transducer maintains a thermal-error band of less than ±2%. Because of its extremely low thermal error band, the Microdot PT 100 pressure tranducer needs little or no data correction.

A "C" type Bourdon tube is restrained at creating a strain generating element.

Microdot Inc., 220 Pasadena Ave., South Pasadena, Calif. Phone: (213) 682-3351.

SEE AT BOOTHS 1B08-10

Circle No. 634

Monsanto announces a <u>semiconductor</u> indicator light at prices lower than you'd expect.

New MVE-100 diode offers long life, maximum reliability and fast switching speed!

The new MVE-100 by Monsanto introduces design opportunities and performances never before offered in its price range. The MVE-100's dramatically low price ranges from $14.50 each in lots of one to nine, to $8.00 each in lots of 1,000.

The MVE-100 semiconductor indicator light is suitable for use as an instrument signal light, panel indicator and for many computer uses. In fact, Monsanto is using these lights as trigger and overflow indicators in its new integrated circuit counter/timers.

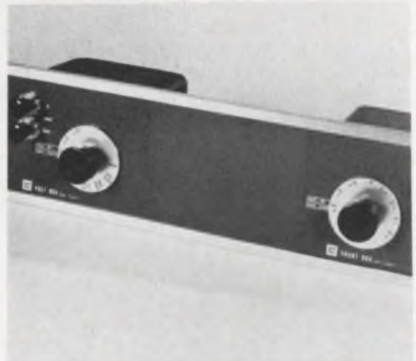
Produced from gallium arsenide-phosphide, the MVE-100 emits monochromatic red light. Under typical use conditions, when the device operates at 1.6 volts, surface brightness exceeds 50 foot-lamberts with a current of 50 ma and is brighter at higher current. Also, it offers the reliability and long life typical of solid state devices where lifetimes of more than 10,000 hours are achieved. On-off response is extremely rapid, on the order of 8-10 nanoseconds.

So if reliability and price are important to you, write us for complete price list and technical data. Monsanto Electronics Dept., 800 N. Lindbergh Blvd., St. Louis, Missouri 63166.

Monsanto

LET THE MEN FROM MONSANTO WORK FOR YOU

ON READER-SERVICE CARD CIRCLE 46



Volt and shunt boxes

These accessories for precise dc measurements have been packaged for ready mounting on 19-in racks. The volt box extends the measurement range of millivolt potentiometers to 500 volts in eight steps. The shunt box provides switch selection of eight settings from 0.05 to 10 A. Error is $\pm 0.02\%$.

Leeds & Northrup, 4907 Stenton Ave., Philadelphia, Pa. Phone: (215) 329-4900.

SEE AT BOOTHS 1B18-20

Circle No. 635

High-voltage transistor

Leading this family of medium power is the 2N3945, a high-voltage, low-saturation general purpose unit. The 2N3945, for industrial non-saturated switching circuits, provides in a 50-volt type a minimum h_{fe} of 40 (at V_{CE} = 10 V, IC = 150 mA), with V_{CE} (sat) less than 0.5 volts at 150 mA.

P&A: $.88-$3.50; stock. Transitron, 168 Albion, Wakefield, Mass. Phone: (617) 245-4500.

SEE AT BOOTH 1B03-11

Circle No. 636

Dual-emitter chopper

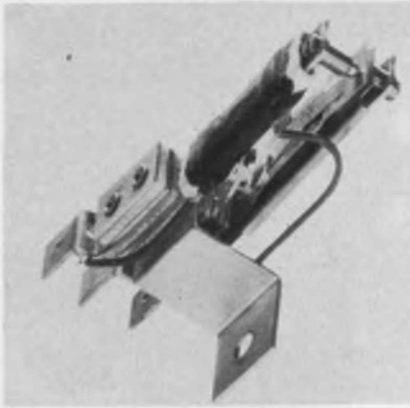
This dual-emitter integrated chopper, is designed to provide an optimum combination of low offset voltage, low thermal drift, very low leakage. The chopper provides a minimum BV_{EFO} of 20 volts and maximum leakage of 0.5 picoamps. The device is suited for multiplex applications. The low offset voltage is 10 microvolts maximum.

Transitron Electronic 168 Albion, Wakefield, Mass. Phone: (617) 245-4500.

SEE AT BOOTHS 1B03-11

Circle No. 637

Thermal switch



A thermal switch, Series 4300 is being offered. The Series 4300 switch is a snap-acting, heavy duty bimetal actuated unit. Contacts are single pole single throw, available either normally open or normally closed. These switch-units are capable of switching up to a 30 A resistive load, or a 1500 watt Tungsten load.

Hart Mfg. Co., 110 Bartholomew Ave., Hartford, Conn. Phone: (203) 525-3491.

SEE AT BOOTH 1B06

Circle No. 640

Magnetic clutches

A magnetic particle clutch, Series T-570, features extremely low output inertia and high power gain for compatability with modern servo systems. Torque-to-inertia ratio is 7.61×10^6 rad/sec^2.

They are mechanically interchangeable with standard Buord size 11 friction clutches. Thus, existing systems can be easily updated.

P&A: $170; 30 days. Designatronics Inc., 76 East Second St., Mineola, N. Y. Phone: (516) 741-7070.

SEE AT BOOTH 1F21

Circle No. 641

Logic cards

A wide range of standard and special purpose logic cards using integrated circuits includes a free running Multivibrator.

Microsystem interconnection of ICs is an advanced technique that allows from 2 to 10 flat packs, of any size, to be interconnected or intermixed with discrete components into a "stick".

Engineered Electronics Co., 1441 E. Chestnut Ave., Santa Ana, Calif. Phone: (714) 547-5651.

SEE AT BOOTH 1B22

Circle No. 642

Rack-mounting pots

Rack-mountable precision potentiometers are now available. These instruments, and the related bridges and accessories, can create test stations with maximum convenience and economy.

In temperature models, there is option of single or double range scales calibrated for any of the common thermocouple types.

Leeds & Northrup, 4907 Stenton Ave., Philadelphia, Pa. Phone: (215) 329-4900.

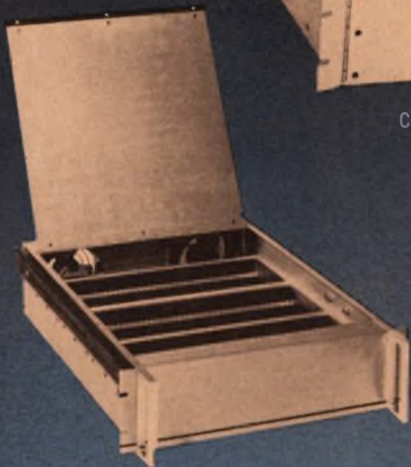
SEE AT BOOTHS 1B18-20

Circle No. 643

CFW-540 CONNECTOR FRAME

CGS-540 40 CARD SYSTEM CAGE

DISTINCTIVE ACCESSORIES FOR SERIES C MICRO LOGIC CARDS



CGD-503 120 CARD DRAWER CAGE

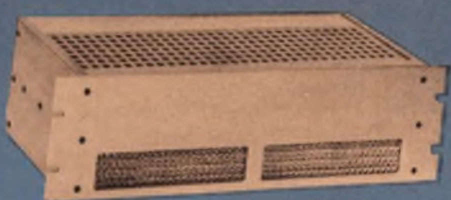
CPS-508 8A POWER SUPPLY

PROGRAM CARD CPC-503 | BLANK CARD CBC-501 | EXTENDER CARD CXC-501

The Series C provides the most advanced 5 MC Logic Cards . . . over 25 in-stock card types include full input/output capability, and offer exceptional features and performance for logical design and trouble-free operation of systems.

A complete, distinctive family of accessories is now available for the application of Series C Micro Logic Cards.

These serve the essential functions of C card mounting, power and test, **but more important** are designed to meet packaging requirements of high frequency wiring, system cabling, adaptation of controls and connectors, and access convenience for assembly and "on line" servicing. In essence, these are designer products — tailored for completeness and flexibility in fabrication and use of equipment.



CCU-502 COOLING UNIT

CTU-502 C CARD TESTER

For complete information on Series C Micro Logic Cards and Accessories, write for Brochure 8b.

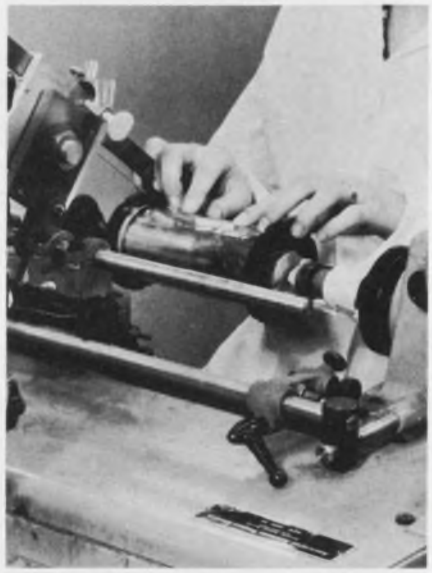
CONTROL LOGIC, INC.

SUBSIDIARY OF SCHAEVITZ ENGINEERING

3 STRATHMORE ROAD, NATICK, MASSACHUSETTS, 617-655-1170 OR 235-1865

See us at the IEEE Show — Booth 3A28

ON READER-SERVICE CARD CIRCLE 49



Superconductive ribbons

Two new commercial superconductive ribbons which offer high-field performance, increased current capability, greatly improved economies of application and superior mechanical strength in high-field magnets are available.

Designated RCA type SR-2100 and SR-2101 they have superior mechanical strength without heat treatment by the user. SR-2100 is recommended for windings that are subject to fields up to 75 k gauss. For use in higher-field regions RCA SR-2101 superconductive ribbon is recommended.

RCA Corp., 30 Rockefeller Plaza, New York, N. Y. Phone: (212) 689-7200.

SEE AT BOOTHS 1F04-10

Circle No. 638

Modified switch

The modified model 910 switch has two more terminals 3 pdt or 4 pst switching, while the overall dimensions remain the same as the predecessor 910 switch. Typical ratings are: 20 A, 1 hp @ 120 Vac; 2 hp @ 240 Vac. Higher ratings are available for special applications.

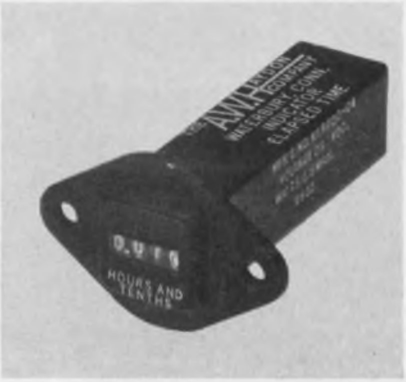
The switch is equipped with standard 1/4-in. spade terminals.

Hart Mfg. Co., 110 Bartholomew Ave., Hartford, Conn. Phone: (203) 525-3491.

SEE AT BOOTH 1B06

Circle No. 639

Time indicator



Two microminiature elapsed time indicators for operation on 28VDC, include model K19703 with a four digit counter providing a maximum of 9999 hours; K19702 has a four digit indicator for hours and tenths. Maximum readout is 999.9.

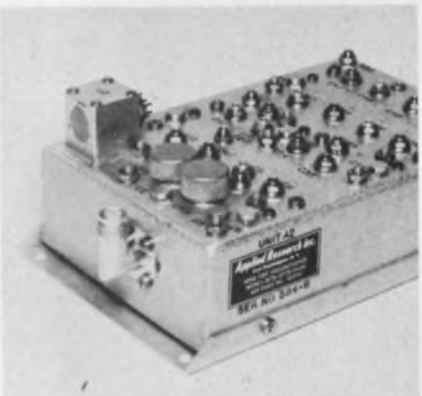
Timing accuracy is ±1 digit between −54°C and +85°C.

A. W. Haydon, 232 N. Elm st., Waterbury, Conn. Phone: (203) 756-4481.

SEE AT BOOTHS 1D07-11

Circle No. 366

50-1000 MHz amplifier



Available in three frequency bands (50 to 300, 250 to 500 to 1000 MHz), this line of high dynamic range transistor amplifiers offers octave bandwidths with low noise.

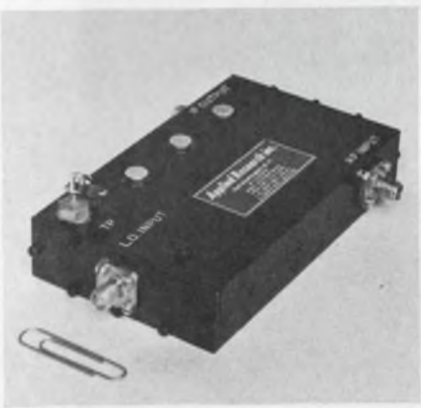
Gain is 18 to 22 dB (50 to 500 MHz), 15 dB (500 to 1000 MHz), (18 dB if the output pad is replaced by a circulator) and the peak-to-valley ratio is less than ±1 dB.

Applied Research Inc., 76 S. Bayles Ave., Port Washington, N. Y. Phone: (516) 767-8707.

SEE AT BOOTHS 1D31-33

Circle No. 367

S-band to vhf converter



Model UHC-2250/100-265 is a down-converter which translates input signals in the 2200 to 2300 MHz telemetry band to the 215 to 315 MHz telemetry band.

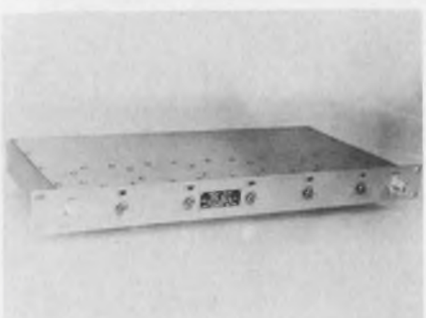
Included within the package are the preselector, mixer, IF matching network and output filter. Minimum conversion loss is achieved by the use of a hot carrier diode.

Applied Research Inc., 76 S. Bayles Ave., Port Washington, N. Y. Phone: (516) 767-8707.

SEE AT BOOTHS 1D31-33

Circle No. 368

Bandreject filter



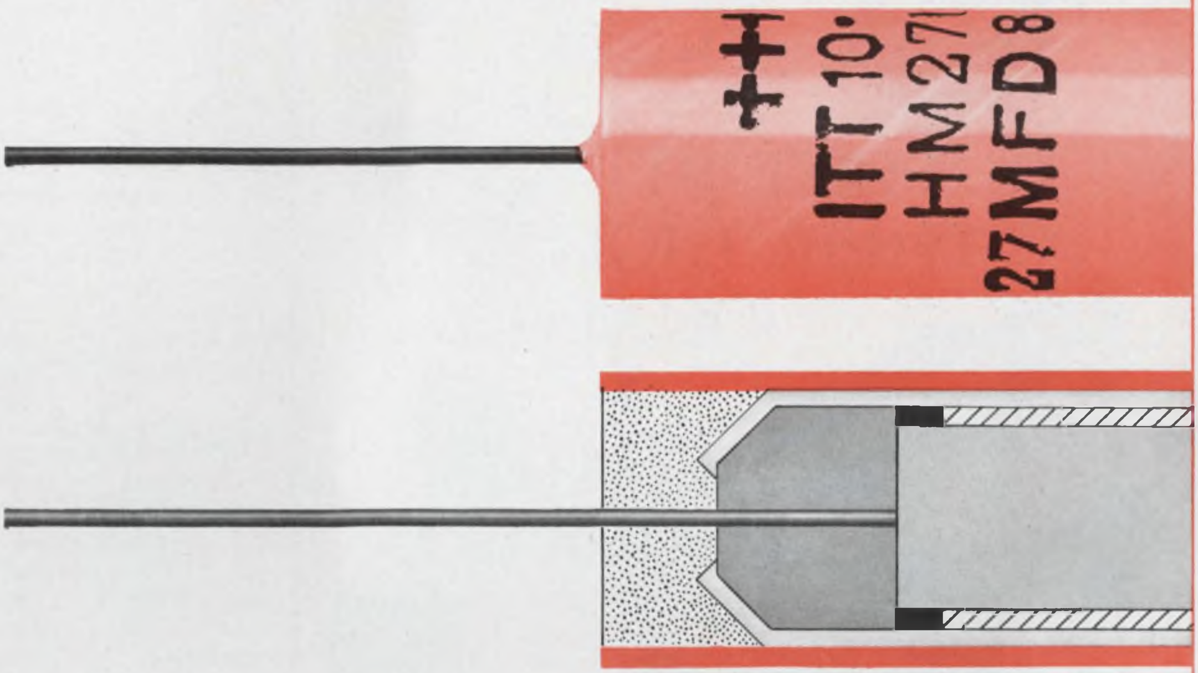
Model MN-69-5 filter is capable of operating over a wide frequency range. It provides high rejection at one frequency between 60 and 90 MHz as well as rejection to as mnay as five separate and independent frequencies within the same operating band.

The unit features single or multiple frequency rejection.

Applied Research Inc., 76 S. Bayle Ave., Port Washington, N. Y. Phone: (516) 767-8707.

SEE AT BOOTHS 1D31-33

Circle No. 369



COMPONENTS—1ST FLOOR

3 ampere rectifier

This 3 A axial lead rectifier offers: high surge current ratings and rugged construction.

The seven device types (1N4719-1N4725) display typical ratings of peak reverse voltage, 50 up to 1000 volts; average forward current 75°C 3 amperes; average forward current 125°C, 1.5 amperes; 1 cycle surge current, 300 amperes.

Transitron, 168 Albion St., Wakefield, Mass. Phone: (617) 245-4500.

SEE AT BOOTH 1B03-11

Circle No. 655

Plastic FET's

Improved sensitivity, reduced cross-modulation, reduced noise, and generally improved performance of much consumer and industrial equipment is claimed for the SILECT FETs. These plastic-encapsulated, silicon junction units are available as n-channel (2N3819) and TIS34) and p-channel 2N3820) devices.

Applications include AM/FM tuners; mixers; low-, and high-frequency amplifiers; and digital applications. Low-cost matched pairs for FET complementary circuits or differential amplifiers can be obtained by clamping matched units together. N = channel g_m is 2000-65000 μmhos at 1 kHz (4000 μmhos min for the TIS23) and 1900 min. at 100 MHz. p-channel g_m is 800-5000 μmhos at 1 kHz, and 700 min at 10 MHz. C_{ss} is 4 pF.

Texas Instr. Inc., 13500 N. Central Expwy., Dallas, Tex. Phone: (214) 235-3111.

SEE AT BOOTH 1D13-25

Circle No. 364

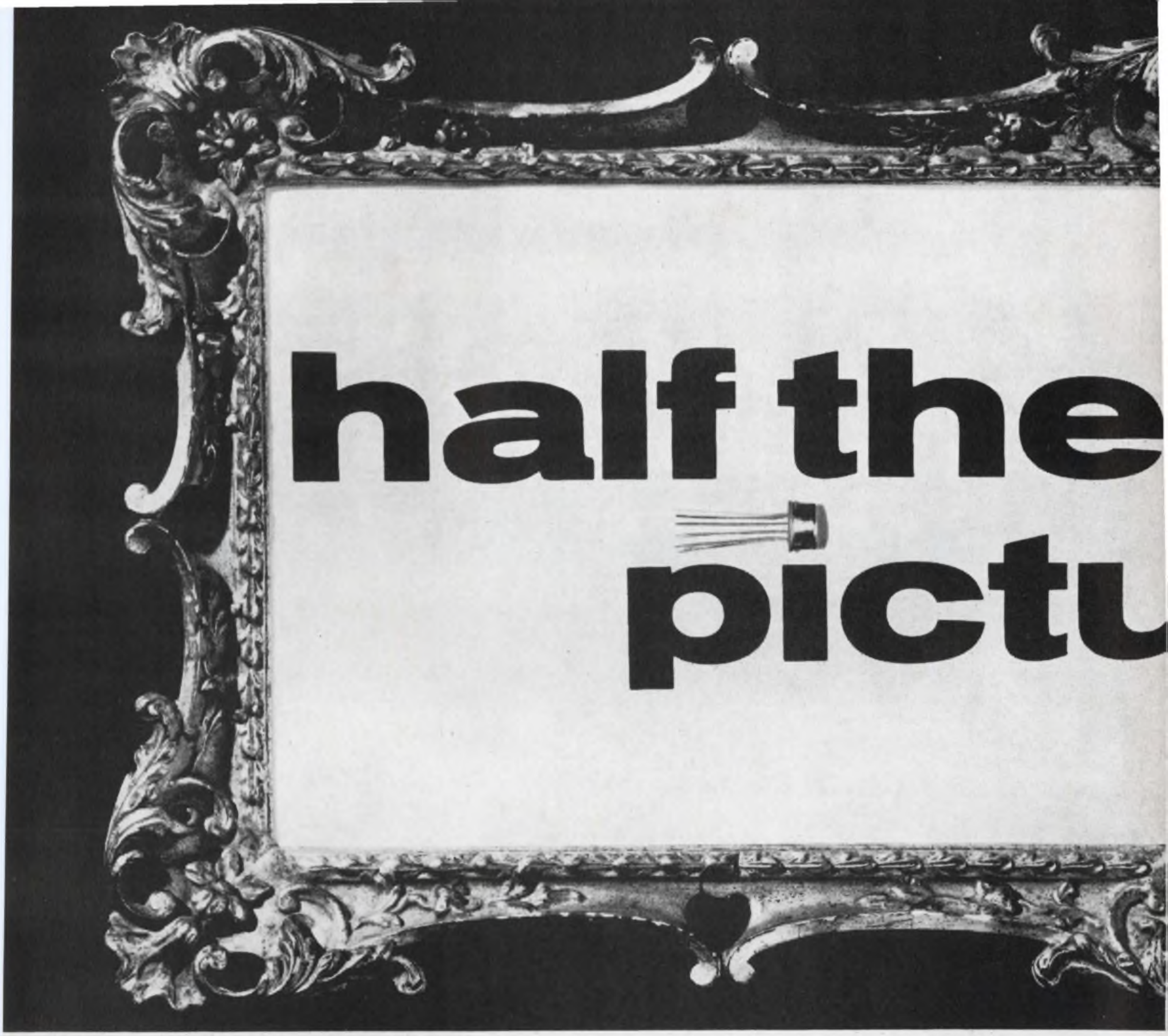
3-dB hybrid couplers

A group of microwave components is being shown. They include: 3-dB hybrid couplers—broadband coaxial devices for applications requiring two signals equal in power but 90° out of phase. Continuous frequency coverage from 0.2 to 8.0 GHz and a hgh frequency instrument load for a 50 ohm coax line up to 18 GHz.

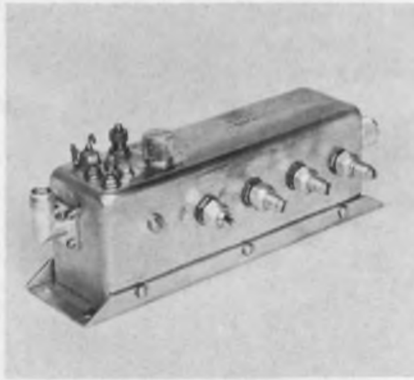
Alford Mfg. Co., 299 Atlantic Ave., Boston, Mass. Phone: (617) 426-2150.

SEE AT BOOTH 1E18

Circle No. 365


half the
pictu

Frequency multiplier



Model VM-2250/100-10, uses the newest snap-action diodes for s-band telemetry multiplying.

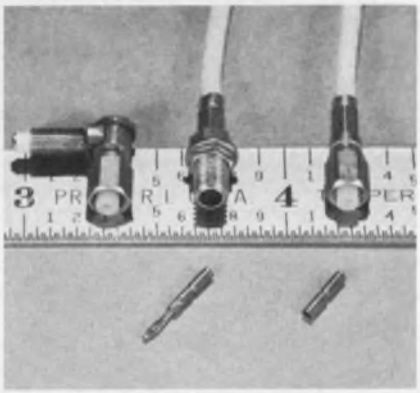
An instantaneous bandpass of the full 2200 to 2300 MHz telemetry band is supplied, thus eliminating the need for any returning input frequency. Power is 100 mW, and multiplication ratio is 10:1. Spurious rejection is 50 dB.

Applied Research Inc., 76 S. Bayles Ave., Port Washington, N. Y. Phone: (516) 767-8707.

SEE AT BOOTHS 1D31-33

Circle No. 396

Coax connector



Half the size of standard microminiature coaxial connectors, this new ultraminiature connector has an outside body diameter of only 1/8-in.

It features the new twist/con pin and socket producing high reliability and continuity. The size enables low level noise equipment to be designed into smaller packages.

Microdot Inc., 220 Pasadena Ave., So. Pasadena, Calif. Phone: (213) 682-3351.

SEE AT BOOTHS 1B08-10

Circle No. 397

Coax attenuators

The models 1 and 2 coax attenuators broaden the range of applications for coaxial systems—including use of the 12.4 to 18.0 GHz, band usually reserved for waveguide. Both models applicable where isolation between RF components is needed. The attenuators can also be used in the calibration of directional couplers, antenna characteristics, and in the simulation of path losses.

Weinschel Engineering, Gaithersburgh, Md. Phone: (301) 948-3434.

SEE AT BOOTH M-14

Circle No. 398

Plastic power transistors

This new npn planar device, types TIP 14, is designed especially for cost critical industrial and consumer application. The low-profile, double-ended plastic package incorporates a mounting tab for simplified assembly. The transistor can be mounted on chassis or heat sink with a single self-tapping screw. CE (sat) = 0.1 typical at 200 mA).

Texas Instr., Inc., 13500 N. Central Expwy., Dallas, Texas. Phone: (214) 235-3111.

SEE AT BOOTHS 1D13-25

Circle No. 399

Elapsed time indicators

The 42200 series of ac elapsed time indicators is for industrial and commercial use. They indicate time for lubrication, overhaul, recalibration, or what-have-you on any electrical equipment.

Standard models in three configurations for 50 or 60 Hz operation between 6 and 230 V have six-place digital readouts in hours, tenths, minutes, tenths, and seconds.

A. W. Haydon, Waterbury, Conn., Phone: (203) 756-4481.

SEE AT BOOTH 1D07

Circle No. 357

RBM CONTROLS IS DOING IT NOW!

(we call them Bi-Reeds®)

We make the complete switch—with automatic equipment in white room facilities for consistent characteristics and reliability. We assemble these unexcelled switches into relay packages. This single source responsibility means total reliability for you. Numerous pole forms are available—miniature or standard switches or relays.

Ask Your Local RBM CONTROLS Sales Engineer for Special Reports Relative to Your Application.

RBM CONTROLS

Serving Major Markets Since 1921

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STANDARD CONTROLS
ARE AVAILABLE FROM YOUR
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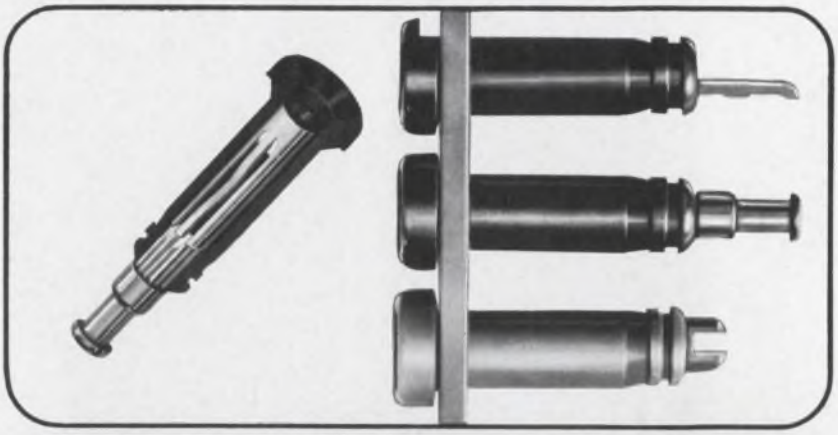
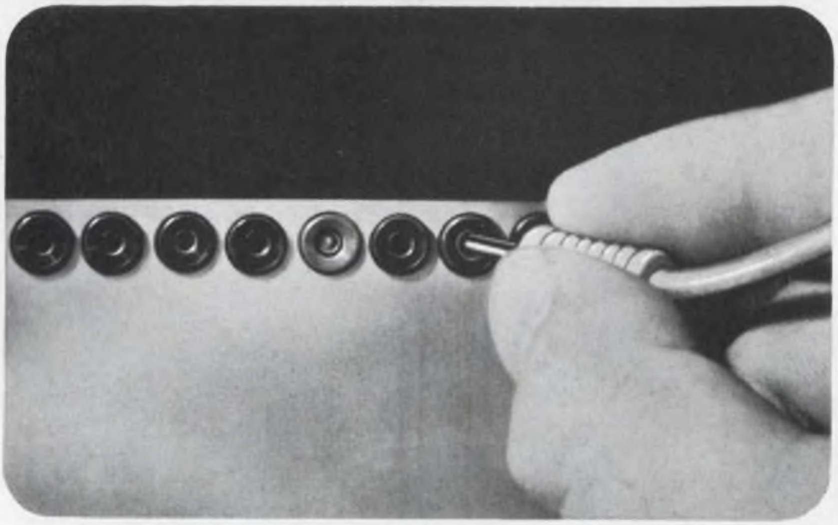
SEE US AT THE IEEE SHOW BOOTH 2H35

ON READER-SERVICE CARD CIRCLE 55





Coax attenuators

Series 210A precision attenuators are made with film resistors which are artificially aged to give maximum stability under, peak pulse power and extreme temperature and humidity cycling to comply with MIL-A-3933A. For maximum life with minimum wear, stainless steel barrels and connectors are featured.

Reliable mating of connectors is assured by holding closer tolerances on critical inside dimensions than NBS or MIL specs. Each attenuator is coded with RETMA color-coding for easy identification of values. As an example, a 3 dB attenuator is banded with an orange nameplate and a 20 dB attenuator is banded with a red and black nameplate. Each attenuator is supplied with a certificate of calibration of stated accuracy giving insertion loss and vswr test data fully guaranteed for the attenuator at four frequencies.

Availability: 60-90 days. Weinschel Engineering, Gaithersburg, Md. Phone: (301) 948-3434.

SEE AT BOOTH M-14

Circle No. 370

Heliax elliptical

A long length flexible elliptical waveguide has attenuation equal to or lower than conventional rigid rectangular waveguide. Small Heliax elliptical waveguide eliminates the numerous bends, twists and other special configurations, the overall cost of an installation is less than half that of a conventional system.

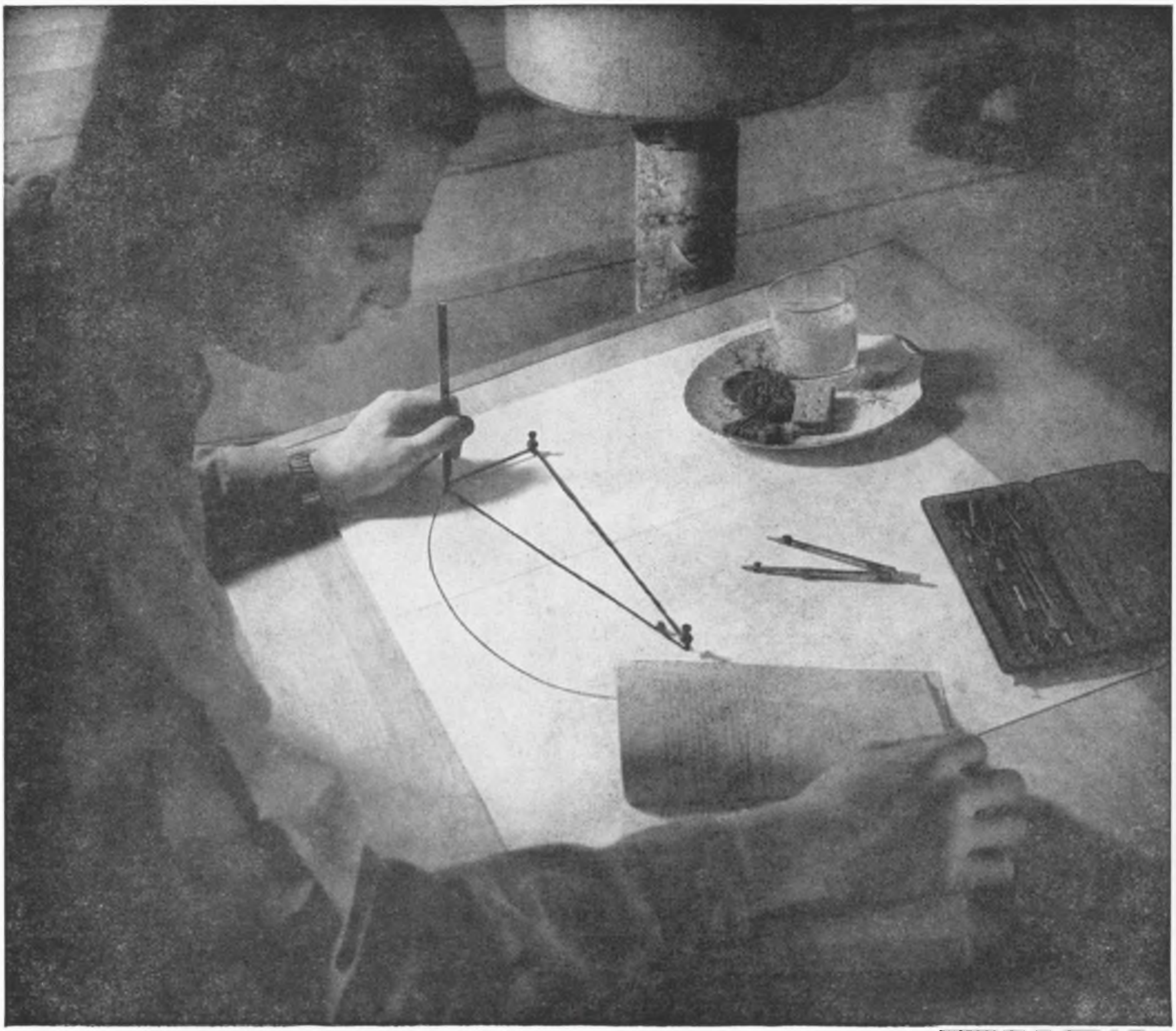
P&A: $2.80-$6.00/ft. $32-$112 for connectors; 2-4 wks. Andrew Corp., Box 807, Chicago, Ill. Phone: (312) 349-3300.

SEE AT BOOTHS 1F12-14

Circle No. 395

ON READER-SERVICE CARD CIRCLE 247 ➤

HUDSON'S ELECTRI-CITY . . . U.S.A.



PHOTOGRAPH BY IRWIN KARNICK


SERIES

How to make sure you are not in the dark on the latest in Lighted Pushbutton Switches

Take a new look into the complete line available from MICRO SWITCH.

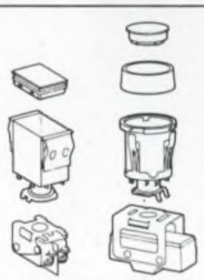
Ever since MICRO SWITCH introduced the first modular pushbutton switch with lighted legends, the line has been expanding. New modules, new assemblies, new ideas now offer you more opportunities to work out custom answers to today's panel requirements.

In addition to the popular Series 2 which started the modular trend, the line now includes Series 2N and Series 2C200. All three offer unequalled freedom of design—in sheer number of possible control and display combinations—in ease of installation—and in panel appearance.

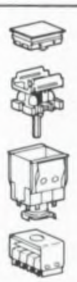
MICRO SWITCH gives you another bonus: application experience. Our specially trained field engineers will be glad to discuss your requirements. They are backed by the industry's most elaborate research and development facilities.

For information, contact a Branch Office or Distributor (see Yellow Pages, under "Switches, Electric") or write for literature.

MICRO SWITCH—the line providing unequalled freedom of design with all this versatility



Series 2 offers both rectangular and round display, permitting shape-coding of stations or group functions. Snap-in mounting. Solenoid pull-in and/or hold-in coil for remote control.



Series 2C200. Snap-in mounting. Relamp without tools. Available with RFI shield, and solenoid pull-in or hold-in coil for remote control.

Series 2N. Shock-resistant spring-lock mounting. Hold-in coil. Relamp without tools. Molded-color housings.

in BUTTONS—Choice of 1, 2, 3, or 4-section buttons.

in COLOR—Wide selection of transmitted and projected (filtered) color schemes, and 1 to 4 lamps for up to 4-color display.

in CIRCUITRY—Up to 4-pole double-throw and 2-circuit double-break contact arrangements.

in RATINGS—Wide selection of modules for handling low energy to heavy duty electrical loads.

in WIRING—Solder, screw or quick connect wiring terminations.

in MOUNTING—Snap-in flange and barrier mountings or spring-lock panel attachment.

in REMOTE CONTROL—Only MICRO SWITCH has both remote actuation and release of switching contacts.

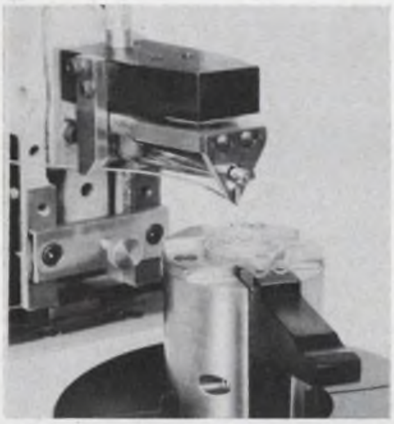
MICRO SWITCH

FREEPORT, ILLINOIS 61032

A DIVISION OF HONEYWELL

HONEYWELL INTERNATIONAL — Sales and service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.

Ultrasonic bonder



Using ultrasonics, this new model WU-100 wire bonder welds a wide range of power transistors such as TO-3's, TO-66's, stud packs and other large devices. It bonds wire from 5 to 40 mils.

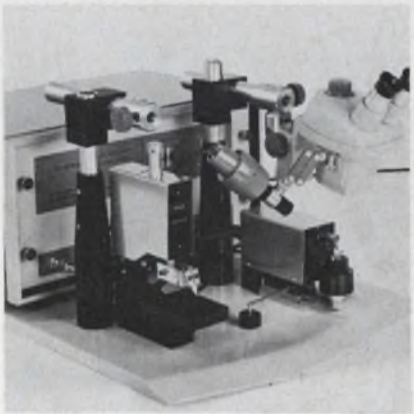
Automatic wire feed and cut-off are featured. Optics are Bausch & Lomb, 7X-30X magnification, a Nicholas illuminator and an ultrasonic generator are included.

Axion, 6 Commerce Park, Danbury, Conn. Phone: (203) 743-9281.

SEE AT BOOTH 4B30

Circle No. 613

Circuit bonder



A multi-purpose microcircuit bonding system welds, brazes, parallel-gap soldering and thin-film diffusion bonding.

The smaller head is designed for ultra-fine materials and can apply bonding pressures as light as 10 g. The large weld head is for soldering of flat packs.

P&A: $4115; 4 weeks. Hughes Aircraft, 2020 Oceanside Blvd., Oceanside, Calif. Phone: (714) 722-2101.

SEE AT BOOTHS 2FO3-9

Circle No. 614

Grid drill

Series 15J tape controlled grid drills operate with infinitely variable spindle speeds of 10,000-50,000 rpm. The positioning table may be moved a maximum of 24-in. in both the X and Y directions. Each individual spindle is programmed to "use" or "not use" for each machine cycle. Control input is through 8-channel 1-in paper tape which can be prepared by flexowriter or equivalent means. Gardner-Denver Co., Grand Haven, Mich. Phone: (217) 222-5400.

Circle No. 615

Sheet Metal Fabricator

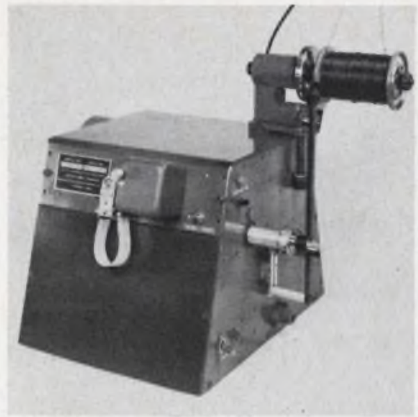
A 30 ton capacity sheet metal fabricator punches 1-in. diameter holes in 1/4-in. material or 3-1/2-in. holes in 10 guage material.

Model Sonic 18/30 has an 18-in. throat when using a pantographic duplicator, and 15-in. when using Microgaging. Right-handed Microgaging eliminates the need for flopping a duplicator template.

Houdaille Industries, Inc., Wales Strippit Co. Division, Akron, N. Y. Phone: (716) 895-8000.

SEE AT BOOTH 1H13-15.

Circle No. 616



Bobbin winding system

The BW-11 tape-controlled, semi-automatic, multi-bay bobbin winder system and turret automatic system wind at high speeds and change from bay to bay accurately, at low speeds.

Specifications are: up to 4-in. O.D., 6-in. long bobbins, up to #16 AWG wire size, 2 speed programable spindle up to 8,000 rpm, with up to 8 channels.

Price: $3,000. Newal, 131 West, Danbury, Conn. Phone: (203) 744-5510.

SEE AT BOOTH A-1H02

Circle No. 619

Data processor

Model HSC 101 solid-state data processor can be used with most dual beam spectrophotometers without major changes. The unit contains a programmable digital magnetic tape memory to compare a standard specimen. It digitizes and punches output on paper tape.

Price: $15,750; Hoffman Electronics, 700 Hoffman, Santa Barbara, Calif. Phone: (805) 966-2273.

SEE AT BOOTHS 1C09-11

Circle No. 618

Encapsulation machine

Among the features of the model 359F are an oversized platen area for low pressure materials, production speed, regulated totally enclosed moving parts, and semi-automatic operation (slow close, manual, jog up and down, etc.)

The unit is a compression and transfer molding press.

Price: $10,700 Hull Corp., 6591A Davisville Rd., Hatboro, Pa. Phone: (215) 675-5000.

SEE AT BOOTH 1J13-15

Circle No. 617


EDISON
HOME
PHONOGRAPH

DOW CORNING

Before you freeze that new design . . .

check with us

If *today's* electronic know-how had been available to designers fifty years ago, would the phonograph have looked like this?

No!

If *tomorrow's* know-how were available to you right now, would it affect your next product design?

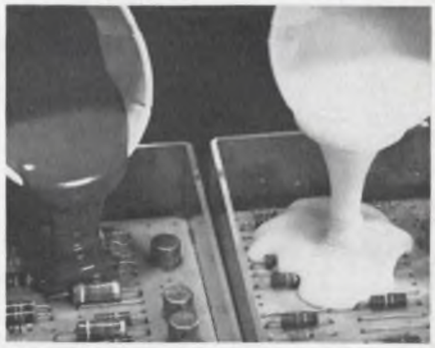
At Dow Corning it is . . . and it can!

Dow Corning, the acknowledged leader in silicone research and development for over twenty years, has a history of producing materials to meet unheard of performance requirements . . . and materials is our *only* business.

More often than not, the suggestions of our Electronic Products Development Laboratory will spark new concepts, new versatility and capabilities for your product . . . *if* you include us in the early stages of your design thinking.

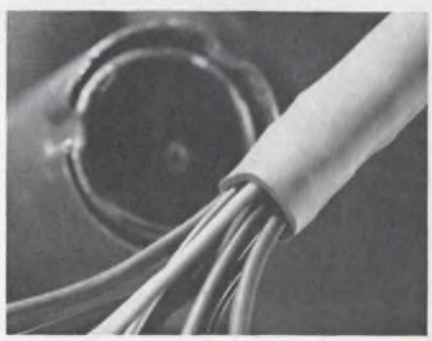
We manufacture high-performance, premium-quality encapsulating rubbers, rigid molding compounds, flexible casting resins and grease-like compounds which meet the most stringent requirements of the electronic industry.

Our Electronic Products Laboratory offers prompt technical assistance in solving *your* specific problem. Write Dept. 3503, Electronic Materials Department, Dow Corning Corporation, Midland, Michigan 48640. Or phone (517) 636-8940 for more information and the name of the Dow Corning representative in your area.



Dow Corning® 3110 RTV encapsulant can be readily color coded by mixing in master batch pigments. It is a low viscosity, deep section curing compound that cures at room temperature and is designed for potting, encapsulating and embedding of electronic circuit and components. It flows readily into place and cures to form a tough, resilient solid. *(Circle No. 851)*

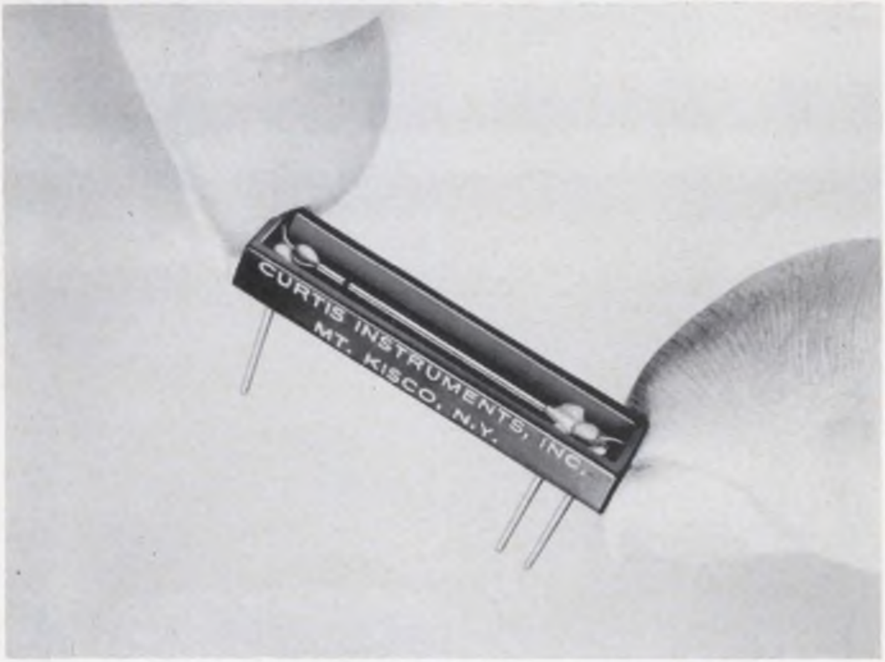
Ready-to-use silicone adhesive encapsulates, seals, bonds. Silastic® 732 RTV rubber is a tough, squeeze-on adhesive/sealant that bonds metal, glass, plastics, rubber and most other materials. It cures at room temperature in 24 hours to a solid rubber . . . stays flexible from −85 to 500 F. Also recommended as adhesive for Silastic® brand heat shrinkable tubing. *(Circle No. 852)*



Shrinkable silicone rubber tubing can be the answer where wiring harness and electronic devices or components must be protected. Silastic® brand heat shrinkable tubing simplifies processing – reduces cost – where quick, easy fabrication of a close-fitting insulating covering for splices, leads, or components is required. Shrinks to 1/2 dia. when heated to 300 F or higher . . . in length less than 5%. *(Circle No. 853)*

We're a materials producer exclusively. Let us tailor a material to your need.

Speed Inquiry to Advertiser via Collect Night Letter



New time-voltage integrator has infinite recall

A new electro-chemical integrator has both visual and electrical readouts with infinite memory capability.

The model 304 utilizes the manufacturer's mercury-electrolytic timer device with differential capacitance readout techniques to provide accurate and symmetrically reversible long and short term integrations. Size, complexity, weight, power consumption, and cost are considerably lower than the electromechanical competition.

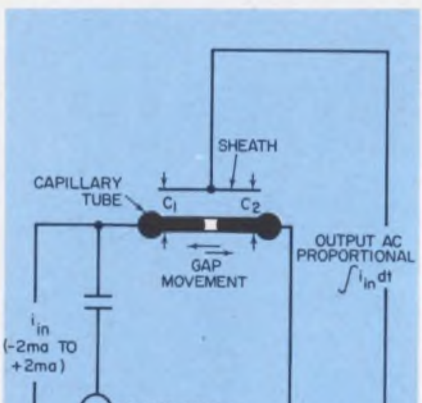
The stored integral is retained indefinitely, regardless of power or other external factors. The unit measures only 1.1-in. long by 0.18-in. wide, and can be used with any input signal between −2 mA and +2 mA. Its input threshold is zero.

A glass capillary tube filled with two columns of mercury has a gap between them, filled with an acqeous electrolytic. The input signal electroplates mercury across the gap at a rate which is a direct function of the amplitude of the input signal. The gap is thereby moved to accommodate the new mercury on its further side. Total capacity is a stored integral of 4 mA-hours. The outside of the capillary tube is coated with a vapor-deposited conductive sheath. Capacitances between this sheath and each mercury eletcrode are differentially proportional to the position of the electrolytic gap, and thereby to the integral of the input signal. This capacity is sensed by superimposing an ac signal on the input signal. Output amplitude is linear and a direct function of the integral of the input. Accuracy is within 0.5%.

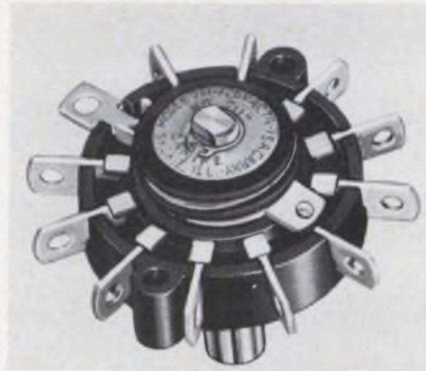
P&A: \$19.50 (\$13.10 in 100 lots); 2-3 wks. Curtis Instruments, 351 Lexington Ave., Mount Kisco, N. Y. Phone: (914) 666-8051.

SEE AT BOOTH 2A08

Circle No. 644



C_1 and C_2 are differentially proportional to the position of the electrolytic gap, thus proportional to the time integral of the input amplitude.



7 A 125 V mini-switch

A miniature selector switch handles 7 A at 125 V, and can carry 15 A ac or dc. The model 711 single-pole non-shorting selector switch has a 1-1/8-in. body diameter.

The contacts are solid-silver alloy. The unit is available with from two to 11 self-wiping contacts, 30° indexing. Action is slow-break, quick-make, thus minimizing sparking and increasing contact life on ac. A melamine-phenolic body has high insulation rating and resistance to arc-tracking.

Normally-unenclosed, the single-unit 711 can be supplied enclosed on request. Tandem assemblies (up to five-in-tandem) are normally supplied enclosed.

P&A: price depends on the unit and quantity ordered; stock. Ohmite Mfg. Co., 3668 Howard St., Skokie, Ill. Phone: (312) 675-2600.

SEE AT BOOTH 2F39

Circle No. 645

5 amp reed switch

A propietary plating technique for rhodium gives a reed switch that handles up to 5 A. Max switched power is 100 VA. The high-or low current device handles a 200 V inductive load.

Operating time is 1 ms, max rate is 350 Hz. Contact resistance is exceptionally constant. Average value of initial contact resistance is below 25 mohms. Insulation resistance is 10^{12} ohms. Two sizes (2.5 or 3.2-in. long) are available.

Ericsson Corp., 100 Park Ave., New York. Phone: (212) 685-4030.

SEE AT BOOTH 2F06

Circle No. 646

These cycle controlled tools give a precise, consistent crimp every time for terminals, lugs, splice fittings, RF fittings, connectors and special devices. They're light and have high-leverage action allowing low-closing hand pressure. Less operator fatigue means higher production . . . lower cost per crimp.

In-line die action and ratchet control provide the most uniform crimping. Tools are corrosion resistant. Available in standard and miniature models.

CT Terminal Tools crimp MS-25036 terminal lugs and MS-25181 thru-splices and other fittings. "Dial-for-Size" selector for quick crimp depth selection. Terminal locator properly positions fittings and wire for crimping. The CT-S standard-size tool crimps fittings 12-10 through 26-24. The miniature CT-M tool crimps fittings 16-14 through 26-24.

CH Tools Crimp Co-axial and Shielded Fittings and Connectors—Dies are interchangeable and positive bottoming. These tools will crimp BNC, TNC, and N series connectors, and many other fittings requiring hex crimps. Miniature models also available.

CD Tools for Special Custom Applications are furnished with blank dies or special dies as required.

Write today for complete information on these high performance crimping tools.

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ELECTRICAL PRODUCTS CORPORATION

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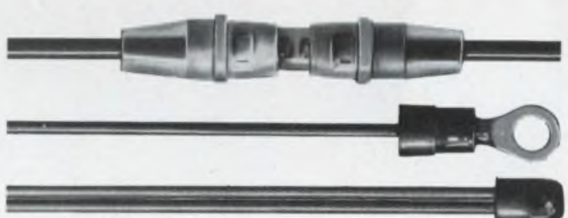
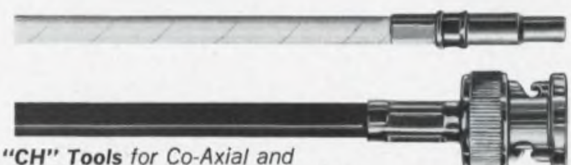
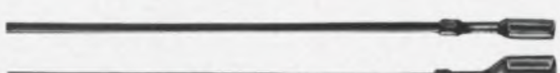
New Die-type tools *Crimp easiest-fastest!*



***"CT" Tools** for Terminals, Splices and End Caps*



***"CH" Tools** for Co-Axial and Shielded Fittings and Connectors*



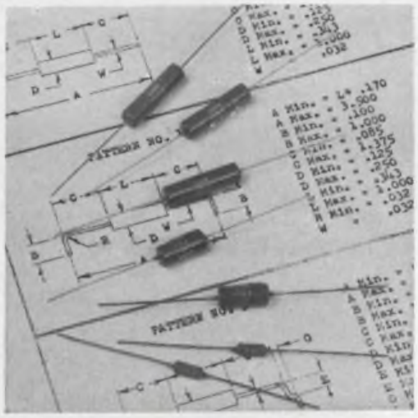
***"CD" Tools** for Special Custom Applications*

264

See us at booth numbers 2F47 and 2F49 at IEEE Show

ON READER-SERVICE CARD CIRCLE 187

Thermistors/varistors



Designed to replace bulky end cap configurations, a new space-saving line of temperature-sensing devices has specifications equivalent to extant units for interchangeability.

Axial or standard formed lead styles are available to fit the fully encapsulated units to various board designs.

The Carborundum Co., Globar Plant, P.O. Box 339, Niagara Falls, N. Y. Phone: (716) 278-2531.

SEE AT BOOTH 2J47-49

Circle No. 329

Crimping tools

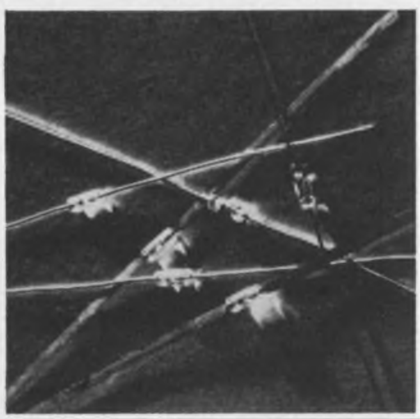
Designed to meet military needs, these "C Series" die-type tools also fill industrial needs. Uses include crimping terminals, lugs, splice fittings, connectors and special devices. Standard and miniature sizes in three categories are available: the CT terminal crimping tools, CH tools for coax and the CD type, with blank dies.

Buchanan Electrical Products Corp., 1065 Floral Ave., Union, N. J. Phone: (201) 289-8200.

SEE AT BOOTH 2F47-49.

Circle No. 330

Point contact diodes



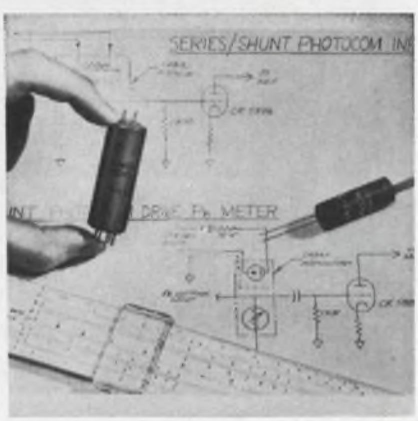
A 2 erg burnout rating is displayed by the Pico-Min family of uhf, S and X-band diodes. They are silicon point-contact mixer and detector units intended for strip transmission line circuits. Cased in hermetically sealed glass, they are available with axial wire or ribbon leads. A typical unit, the MA-4811B S-band mixer, has a 6.5 dB maximum noise figure.

Microwave Assoc., Burlington, Mass. Phone: (617) 272-3000.

SEE AT BOOTH 2D02-4.

Circle No. 331

Choppers/switches



On-resistances exceeding 1 Meg, and off-resistances of more than 10^{11} ohms for use with up to 1000 Meg source impedances are provided by a series of three solid-state choppers/switches. Designed for use in high source impedance, low signal input applications, models C-4812, C-4840 and C-4841 can be used as modulators.

P&A: $39; 5 wks. James Electronics, 4050 N. Rockwell, Chicago. Phone: (312) 463-6500.

SEE AT BOOTH 2A01.

Circle No. 332

Hoffman makes these temperature compensated reference diodes in standard JEDEC packages or to customers' specifications

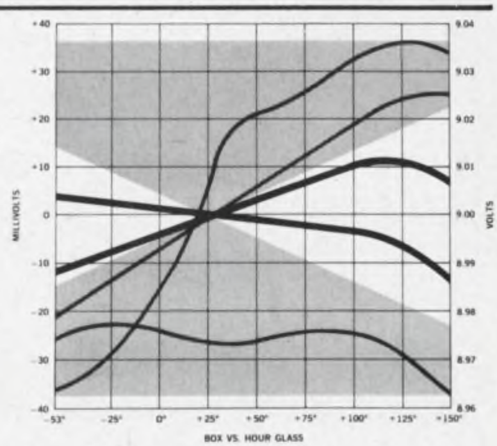
Designed for space and military applications, these high reliability, diffused junction zeners provide an extremely stable reference voltage under severe combinations of temperature and shock. They are adaptable to all types of circuits including welded modules.

For further information regarding these products write: Hoffman Semiconductor Division, Hoffman Electronic Corporation, El Monte, California 91734

Hoffman

Be sure to see these and other new Hoffman Semiconductor products at the I.E.E.E. show in New York, March 21-24, Booths 1C09-1C11

JEDEC Type Number	(1) Temperature Coefficient (%/°C)	JEDEC Type Number	(1) Temperature Coefficient (%/°C)	JEDEC Type Number	(1) Temperature Coefficient (%/°C)	JEDEC Type Number	(1) Temperature Coefficient (%/°C)
1N821	.01	1N3155	.005	1N935A	.01	1N943	.002
1N822	.01	1N3156	.002	1N936A	.005	1N944	.001
1N823	.005	1N3157	.001	1N937A	.002	1N945	.0005
1N824	.005	1N3154A	.01	1N938A	.001	1N941A	.01
1N825	.002	1N3155A	.005	1N939A	.0005	1N942A	.005
1N827	.001	1N3156A	.002	1N935B	.01	1N943A	.002
1N829	.0005	1N3157A	.001	1N936B	.005	1N944A	.001
1N821A	.01	1N935	.01	1N937B	.002	1N945A	.0005
1N823A	.005	1N936	.005	1N938B	.001	1N941B	.01
1N825A	.002	1N937	.002	1N939B	.0005	1N942B	.005
1N827A	.001	1N938	.001	1N941	.01	1N943B	.002
1N829A	.0005	1N939	.0005	1N942	.005	1N944B	.001
1N3154	.01					1N945B	.0005



(1) TEMPERATURE COEFFICIENT INDICATED IS CALCULATED ON THE TOTAL VOLTAGE VARIATION WHEN TESTED AT THE END POINT TEMPERATURE ONLY.

SEMICONDUCTORS

ON READER-SERVICE CARD CIRCLE 60

Transistor lead socket

A 2-3 pF capacitance between two connector receptacles spaced 0.070-in. center-to-center is displayed by this device. Each socket can be soldered or dip-soldered in place on a p/c board. Lead wire sizes can be varied from 0.019-0.016-in. Useable with board thicknesses of 0.032-0.125-in., the socket has a 0.062-in. maximum diameter.

The Milton Ross Co., 511 2nd St. Pike, Southampton, Pa. Phone: (215) 355-0201.

SEE AT BOOTH 2D45.

Circle No. 333

Tunable YIG filters

Highly polished single crystalline spheres of YIG or a similar ferrite material are used as gyromagnetic tuning elements in a new line of electronically tunable filters. Max vswr is 1.5 and all units meet MIL-E-5400, Class II. Frequency range is 0.125 to 12 GHz. Accessory driver-amplifiers and power supply units are available for use with these units.

Microwave Associates Inc., South St., Burlington, Mass. Phone: (617) 272-3000. TWX: (617) 272-1492.

SEE AT 2D02-4

Circle No. 334

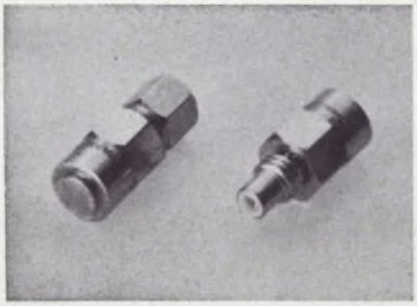
Rotary stepping switch

A 100,000 cycle life, 47-position advance and reset rotary stepping switch, the Series 130-2500, is designed for industrial uses. A variety of multiple circuits can be arranged in the disk. Count can be reset one step at a time or reset to zero from any switch position. Operation is from 12-115 V ac/dc.

P&A: $15 (small lots); 1 week. Chicago Dynamic Industries, Inc., 1725 Diversey Blvd., Chicago, Ill.

SEE AT BOOTH 2A12.

Circle No. 335



Resistive terminations

Maximum vswr of 1.10:1 from dc to 5 GHz, 1.15:1 from 4 to 7.5 GHz and 1.20:1 from 7.5 to 12.4 GHz are reported for a new line of terminations. Precision film resistors are used to provide a well-matched termination over a wide frequency range. Available engagements include SRM, SSRM, Z, BNC, TNC, Conhex and Microhex.

Sealectro Corp., 225 Hoyt St., Mamaroneck, N. Y. Phone: (914) 698-5600.

SEE AT BOOTHS 2G43-45.

Circle No. 336

Cooling fans

Two general purpose blower units are offered. The Sprite, designed for cooling low-profile instrumentation, is 3 1/8-in. square and delivers 35 cfm. It is recommended for uses requiring pressures of 0.05-0.075-in. of water at 25-30 cfm. The Skipper fan delivers 100 cfm. Its 38 dB noise level makes it suitable for computer rooms and test areas.

Roton, Woodstock, N. Y. Phone: (914) 679-2401.

SEE AT BOOTHS 2E39-43.

Circle No. 337

Crystal protector

A crystal protector for operaton in the 16-17 GHz frequency range, the BLT-111 is warranted for 2000 hours, and has a design life of 5000 hours. Maximum input vswr is 1.3:1 and maximum breakdown power is 200 mW. Noise figure is 0.8 dB and insertion loss is 0.4 dB. The 3.25-oz unit operates over the −55° to +125°C temperature range.

Varian, Bomac Div., Salem Rd., Beverly, Mass. Phone: (617) 922-6000.

SEE AT VARIAN, 2nd Fl.

Circle No. 338

Low-power op-amp

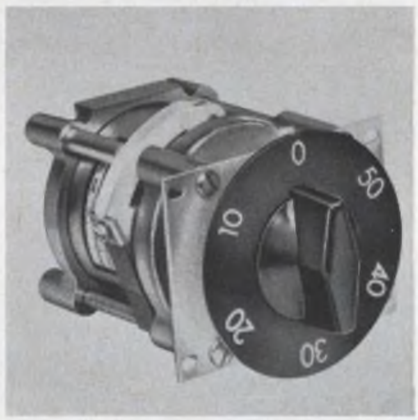
Designed for services requiring low power consumption, Model 2LV-1 operational amplifier features a 4 mW standby power drain at ±2.5 V. The all-silicon unit can be operated from batteries, and offers a dc open loop gain of 10,000 with an output capability of ±1.5 V at ±1.5 mA. The 2.02 x 1.14 x 0.62-in. device operates from −25° to +85°C.

Price: $35 each (1-9). Nexus, 480 Neponset, Canton, Mass. Phone: (617) 828-9000.

SEE AT BOOTH 2H45.

Circle No. 339

Turret attenuators



Each module of the ATV-Series turret attenuators occupies < a 3-in. cube space. Designed for the dc to 1.2GHz frequency range, the units provide from 0-50 dB attenuation. Accuracy is ± 0.5 dB. Maximum feed thru is 0.1 dB at 1.2 GHz. All contacts are coin silver. Carbon disc resistors are used.

Price: $195-$280. Jerrold Electronics Corp., 15th & Lehigh Ave., Philadelphia, Pa. Phone: (215) 226-3456.

SEE AT BOOTH 3J06.

Circle No. 340

Reflex klystron

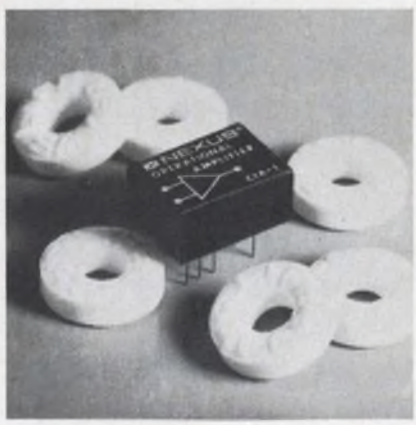
A reflex klystron oscillator designed as a pump tube for parametric amplifiers and masers, the VA-294 delivers a minimum of 100 mW into a matched load over the entire tuning range. Tubes are available to any specified frequency between 26.5 and 40 GHz, and offer a 1 GHz mechanical tuning range. They may be cooled by conduction, forced air or liquid immersion.

Varian, Tube Div., 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

SEE AT VARIAN, 2nd Fl.

Circle No. 341

Operational amplifier

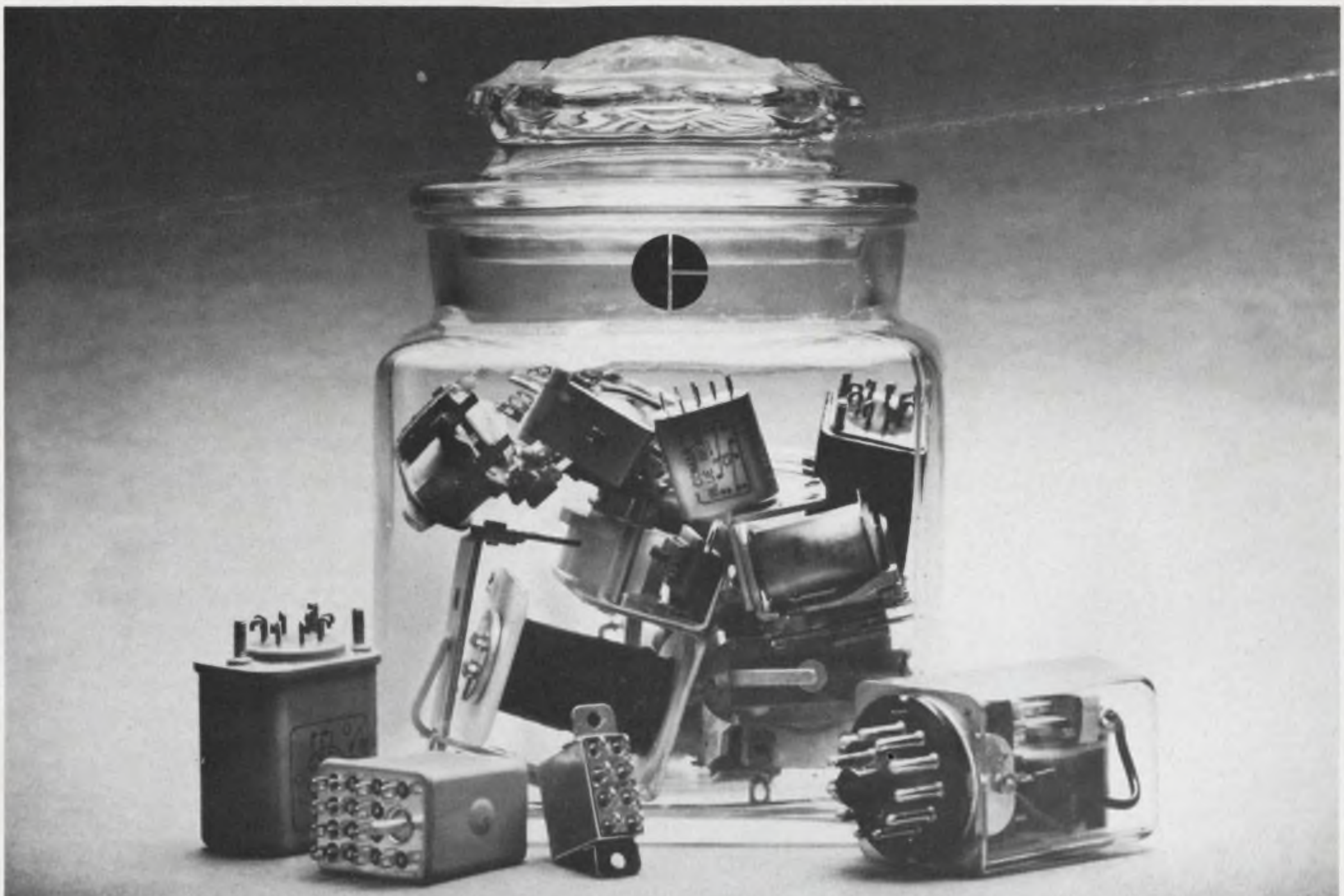


Reported to be more versatile than presently available integrated circuit operational amplifiers, Model CIA-1 is designed for use in OEM equipment where cost and size are important factors. The 0.85 x 0.6 x 0.375-in. device provides a 50,000 open-loop gain at dc. Completely self-containing, it needs no external damping.

Price: $30 each (1-9). Nexus, 480 Neponset, Canton, Mass. Phone: (617) 828-9000.

SEE AT BOOTH 2H45.

Circle No. 342



ENGINEER

Just what the ~~doctor~~ ordered . . .

Into all **COMAR** relays are built a versatility that anticipates engineering needs and requirements. There is, in the **COMAR** line, a relay designed to solve your problem. And for the rare occasion when you can't find a standard relay to do a specific job, **COMAR** stands ready, willing and exceptionally able to design and build one that will! Just give us your prescription.

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VISIT US IN BOOTH 1D27 IEEE SHOW

ON READER-SERVICE CARD CIRCLE 64

Local oscillator

Short-term stability of $\pm5 \times 10^{-9}$ 100 ms and -30 dB spurious response are featured in the MA-8730. The solid-state, crystal controlled local oscillator operates in the 14-16 GHz frequency range. Minimum power output is 4 mW with low input power drain on a single 28-V supply. The 1.5 lb unit has data link applications.

Microwave Associates, Inc., Burlington, Mass. Phone: (617) 272-3000.

SEE AT BOOTH 2DO-24.

Circle No. 343

Duplex spiral blower

Up to 94 cfm air-flow and 2 psig pressure are featured in the Spiral blower. Three versions are available, including model SL6. This unit, in computer applications, uses two independent air paths to serve separate functions. One, for magnetic tape slack control; the other, for capstan motor cooling. Other models are for document and card handling.

Rotron, Hasbrouck Lane, Woodstock, N. Y. Phone: (914) 679-2401.

SEE AT BOOTHS 2E39-43.

Circle No. 344

Coaxial diode switch

Capable of operating at any 500 MHz band in the 7-12 GHz frequency range, the MA-8304 S is a low power spdt switch. It weighs 2.5 oz and has a switching time under 10 ns. Power handling capabilities are 25 W peak and 2 W average. Insertion loss is 1 dB and isolation is 20 dB. Uses include antenna lobing, system calibration and pulse shaping.

Microwave Assoc., Inc., Burlington, Mass. Phone: (617) 272-3000.

SEE AT BOOTH 2D02-4.

Circle No. 345

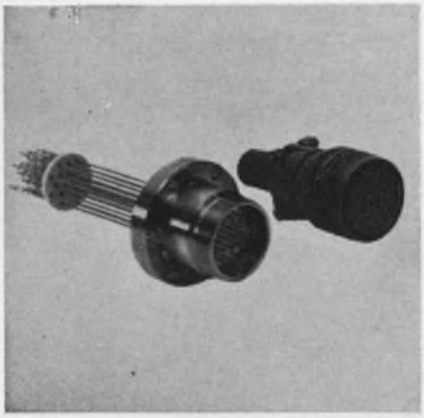
CRTs

Three new CRTs are offered. The KC237P (pictured) is a line-scan type featuring a flat fiber optic faceplate; it is used to display separate line-scan for film readout. The KC2287P is a fiber optic tube with 3-in. diameter, designed for radar application to convert circle to line scan. The K2619P is a 5-1/4-in. faceplate, single beam type unit for computer readout.

Fairchild Dumont Div., Clifton, N. J. Phone: (201) 733-2000.

SEE AT BOOTH 2G03-13.

Circle No. 346



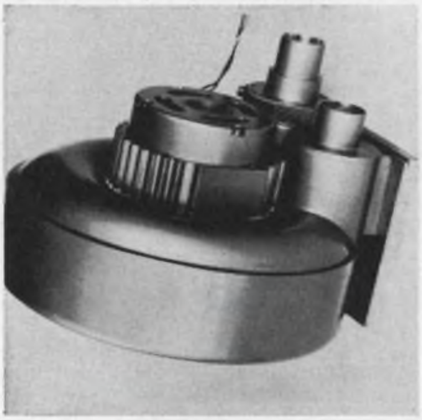
Electrical feedthroughs

A series of 20-pin and 8-pin units is designed for passing multiple electrical connections into a vacuum system. The 954 is available unmounted or flange-mounted. Standard MS connectors and internal connectors that can be crimped or soldered to internal wiring are provided. The devices are rated 7 amps/wire, 700 Vdc or 500 Vac.

Varian, 611 Hansen, Palo Alto, Calif. Phone: (415) 326-4000.

SEE AT VARIAN, 2nd Fl.

Circle No. 652



Single-stage blower

Driven by an integral induction motor at 3350 rpm, the Series 925 is reported to give the same performance as a high-speed, brush type and/or multi-stage blower. The unit delivers 61 cfm in free air. Blower diameter is 9.6-in., including mounting pads; depth is 6.8-in., including motor. Typical uses are in fluid computers and as a tape transport vacuum.

Diehl Div., Singer, Sommerville, N. J. Phone: (201) 725-2200.

SEE AT BOOTH 2B39-43.

Circle No. 653

Wideband true rms/dc converter covers 20 Hz-100 kHz.

A wideband true rms-to-dc converter for use with dc digital voltmeters covers the range of 20 Hz to 100 KHz and 30 mV to 1 kV full scale. Crest factor is in excess of 7:1.

Operation is based on the use of two precision dual-heater thermistors in an automatic double-bridge circuit. By means of this bridge circuit the temperatures of both thermoelements are maintained constant to within 0.002°C.

This unit, model PR840 true rms to dc converter, fills the need for accurate, fast, and automatic measurement of sinusoidal and non-sinusoidal waveforms through the audio range and well beyond. It has a meaningful accuracy of 0.1% of full-scale, or 0.33% of reading. Linearity is 0.02% over a 4:1 input range. Response time takes typically 2.5 seconds to settle to within 0.1% of final value.

The new converter features input Z of 1 Meg, 25 pF max on the 1 V to 1 kV ranges; and 1 Meg, 100 pF max on the 30 to 300 mV ranges. Temperature range is 20-30°C. The unit's output fullscale and impedance is 10 V: driving a 10 to 11 Meg or infinite load. The converter can be supplied to drive loads down to 1 Meg on special order.

Other features of the unit include common-mode rejection of 110 dB at 60 Hz for 1 k impedance in input-low lead; output ripple less than 1 mV, and stability of 0.02%/8 hours. An auxiliary probe supplies a 10-Meg input impedance, with less than 7 pF input capacitance.

Applications for this converter range from ac signal-conditioning for digital voltmeters, to 0.01% ac-ac transfer work—with non-sinusoidal waveforms as well as quasi-sinusoidals, typical in field measurement situations. The model PR-840 is guarded and shielded for compatability with guarded digital voltmeters now on the market.

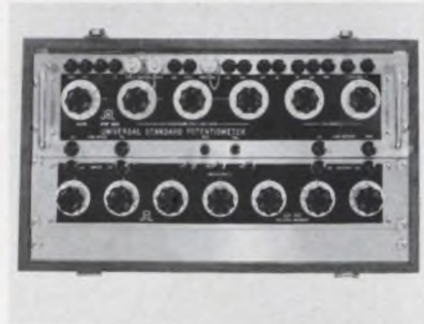
P&A: under $2,000; 90-120 days. Weston Instr., Weston-Rotek Div., 11 Galen St., Watertown, Mass. Phone: (617) 926-1750. TWX: (617) 924-1886.

SEE AT BOOTH 3K07

Circle No. 647

Rms-to-dc conversion

This audio range converter operates from double-bridged thermistors with error-correcting feedback holding their temperatures within 0.002°C. Linearity is 0.02%, accuracy is 0.01% full-scale, and common-mode rejection is 110 dB at 60 Hz. Stability is 0.02%/8 hrs.



Wide-range resistance thermometer bridge

A versatile wide-range resistance thermometer bridge was designed in response to the chemical and electronics industries' usage of higher resistance probes.

The model 2550 Universal instrument can be used with all base and precious metal probes and solid-state resistance probes which employ two, three, or four terminal configuration. It can also be operated as a Mueller or Callander-Griffiths bridge.

The over-all resistance range is 0 to 1111.11 ohms. 6-place digital readout reads 0.001 ohm resolution direct, and 0.0001 ohm resolution with interpolation. Direct accuracy is ±0.008% + 0.0015 ohms, corrected to ±0.0025% + 0.001 ohm.

Self-calibration of this unit is possible with a precision resistor and a decade box. Calibration is traceable to the NBS.

P&A: $1150; 30-45 days. Radio Frequency Labs, Powerville, Boonton, N. J. Phone: (201) 334-3100.

SEE AT BOOTH 3B00

Circle No. 648

Standards potentiometer has 0.0003% accuracy

The model PVP-1001 Universal Standard Potentiometer is an extremely accurate device. All standards used are traceable to the National Bureau of Standards.

Accuracy in the 0-10 V, 0.1-1.1 V, and 0-1 V ranges is 0.0003% $\pm 1 \mu V$. In the 0-0.1 V range it is 0.0005% $\pm 0.1 \mu V$; in the 0-0.01 V range it is 0.0008% $\pm 0.01 \mu V$; and in the 0-0.001 range it is 0.0013% $\pm 0.001 \mu V$.

The unit consists of a standard cell ratio set, an ultra-stable, thermally lagged mercury working cell reference, battery adjust and calibration rheostats, an accurate calibrated resistance chain, and an integral precision ratio range selector.

Primary standard accuracy is achieved by close control of error sources, and by designing around the JRL NB-1 primary standard resistor and the JRL standard oven (SCO-106).

P&A: $1925; 30 days (NBS certification at slight extra cost and delay). Julie Research Labs, 211 W. 61 St., New York, N. Y. Phone: (212) 245-2727.

SEE AT BOOTH 3G11

Circle No. 649

Vector impedance meter

Vector magnitude, R, C, and L can be read with the model 320. No bridge balance is required.

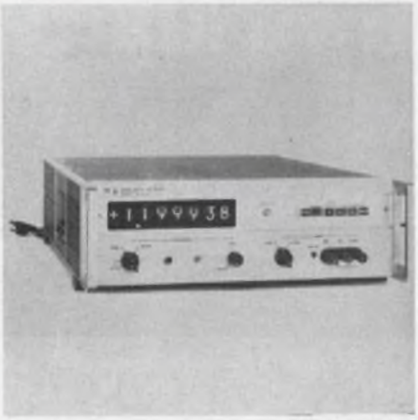
Ac outputs give Z angle with a phasemeter. Dc out indicates Z amplitude and osc. frequency. 5 Hz to 500 kHz, 1Ω to 7 Megs, 1 μH to 100 kH, 0.1 pF to 10,000 μF are the unit's ranges. A 5 Hz to 5 kHz signal is available. The units may be portable or rack-mounted.

P&A: $795; July. Dranetz, 1233 North Ave., Plainfield, N. J. Phone: (201) 755-7080.

SEE AT BOOTH M-4

Circle No. 650

7-digit DVM



A 1 ppm resolution is featured in the Model H04-3460A Digital Voltmeter. An integrating-potentiometric unit, it measures 100 mV within 0.005% of reading. Accuracy is retained for at least 90 days. Designed for automatic operation in digital data acquisition systems, the unit's four ranges, up to ±1000 V, can be selected.

P&A: $4250; 30 days. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000.

SEE AT BOOTH 3E01.

Circle No. 347

DVM plug-in

Designed for use with HP's Model 3440A digital voltmeter, model 3446A ac/dc remote plug-in unit makes it possible to remote-control the instrument's voltage range and/or function. The remote unit adds usefulness to the DVM in programed automatic data acquisition or manual test service. DVM remains accurate.

P&A: $575; stock. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000.

SEE AT BOOTH 3E01.

Circle No. 348

VLF function generator

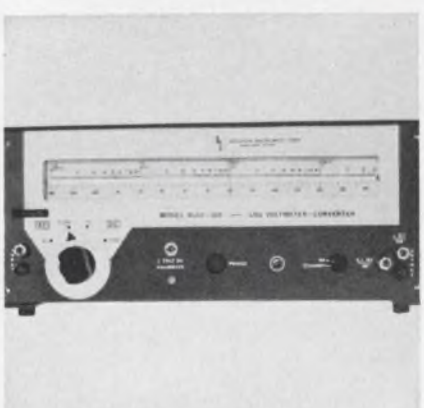
Model SG-88 function generator creates any single-valued waveform. A rotating transparent disc with an opaque representation of the desired waveform is scanned by a narrow light beam. Lenses, mirrors, and a phototransistor convert the light to a signal producing a waveform (0.005-50 Hz at levels from + 25 to − 25 Vdc).

P&A: $2300; 30 days. Houston Omnigraphic, 4950 Terminal, Bellaire, Tex. Phone: (713) 667-7403.

SEE AT BOOTH 3K34-35

Circle No. 349

Log frequency converter



The model HLFC-120 frequency converter provides a dc output voltage directly proportional to the logarithm of the input frequency. Input can vary from 0.5 V to 100 V with high harmonics and not affect accuracy. Output is 100 mV at 350 ohms. Plug-in frequency discriminators cover 3 decades, 5 Hz to 20 kHz.

Houston Omnigraphic, 4950 Terminal, Bellaire, Tex. Phone: (713) 667-7403.

SEE AT BOOTH 3K34-3K35

Circle No. 350

FM/AM meter

Model 2300 covers a 4-1000 MHz frequency range, and measures deviation in five ranges: ±5, 15, 50, 150 and 500 KHz at modulating frequencies up to 150 KHz. The solid-state unit is unaffected by spurious AM to 80%. Deviation due from FM noise is under 15 Hz-15 KHz bandwidth.

P&A: $1735; Mid-1966. Marconi Div., English Electric, 111 Cedar, Englewood, N. J. Phone: (201) 567-0607.

SEE AT BOOTH 3G01-05

Circle No. 351

Automatic analyzer

Model 310B is a phase, amplitude and impedance analyzer provided swept frequency over the 20 MHz to 18 GHz range. When used with its companion resolver, it replaces slotted lines, reflectometers, insertion loss meters, Z plotters and bridges. It is suited to FM systems requiring phase and impedance control.

P&A: $8000; 8 weeks. Wiltron Co., 930 E. Meadow Dr., Palo Alto, Calif. Phone: (415) 321-7228.

SEE AT BOOTH 3B33.

Circle No. 352

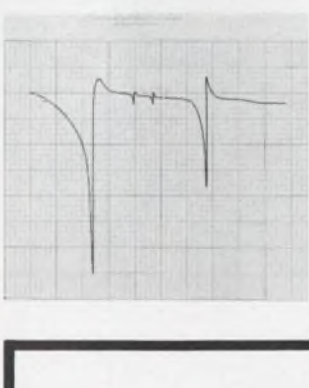
ADD
new capabilities to your
SM-2000
SWEEP GENERATOR

These two new plug-in oscillators permit fast or slow scanning rates with built-in frequency indication and they're both solid-state.

VR-2M Plug-in Oscillator

200 Hz to 12 MHz
- ***Variable Sweeping Rate***
- ***Ultra-stable Oscillator***
- ***Built-in Variable Marker***
- ***1 V RMS Output***

Here's the quickest route to direct determination of frequency response from audio through AM, FM, IF and video frequencies all in a single oscillator. The VR-2M gives the SM-2000 control unit a whole new degree of versatility in checking amplifiers, tuners, oscillators and other wide and narrow band devices. Sweeping rate of the unit may be varied from 0.01 to 100 Hz, and its integral marker system provides precise frequency location over the entire range. Output may be scope displayed or X-Y recording in slow mode, providing db vs. frequency, precisely and directly.

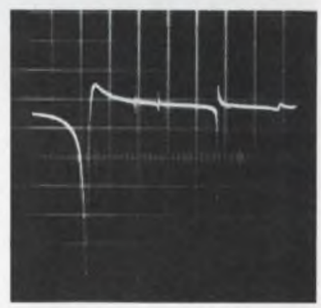


CRYSTAL FILTERS?
A primary application of the VR-2M is check-out of crystal filters. Exceptional stability and slow-sweep rates permit precise recordings of frequency response, as shown in the chart reproduction at left.

VR-50M Plug-in Oscillator

500 to 1000 MHz
- ***Sweeps 5 MHz to Full Octave***
- ***Variable Sweeping Rate***
- ***Solid State Dependability***

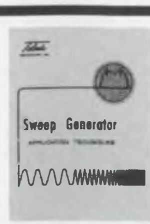
The combination of an SM-2000 Controller with the new VR-50M oscillator can deliver a display of frequency vs db over its entire range of 500 to 1000 MHz in a single trace. It can also sweep any portion of that range from 5% up, and at a rate variable from .01 to 100 Hz. It provides fast answers for check-out, alignment and testing of frequency response in IF, RF, and broad-band video devices.



Combine all that performance with the VR-50's solid-state reliability, a .3v RMS level output, an integral, continuously variable frequency marker, and you have another reason why the SM-2000 is the most useful, inexpensive investment in swept instrumentation today.

Detailed specification on these two new oscillators, the SM-2000 control unit and 18 other plug-in heads will be sent on request, or contact your nearest Telonic representative.

SWEPT FREQUENCY APPLICATIONS
An invaluable collection of data sheets covering swept frequency applications is also available—send for your set now.



Telonic® **INDUSTRIES, INC.**
60 North First Avenue, Beech Grove, Indiana
Tel: (317) 787-3231 TWX: 810-341-3202

See Telonic at IEEE, booths 3K24-3K26
ON READER-SERVICE CARD CIRCLE 68

Volt/ratio meter

Model DAN 60 differential volt/ratio meter combines 3 instruments: differential voltmeter, differential ratiometer, and null detector—into one package. The unit has two primary components—a complete differential voltmeter and a differential ratiometer. In addition, independent use of the transistorized voltmeter as a sensitive null detector is provided.

General Resistance, Inc., 430 Southern Blvd., Bronx, N. Y. Phone: (212) 487-0242.

SEE AT BOOTH 3D08

Circle No. 507

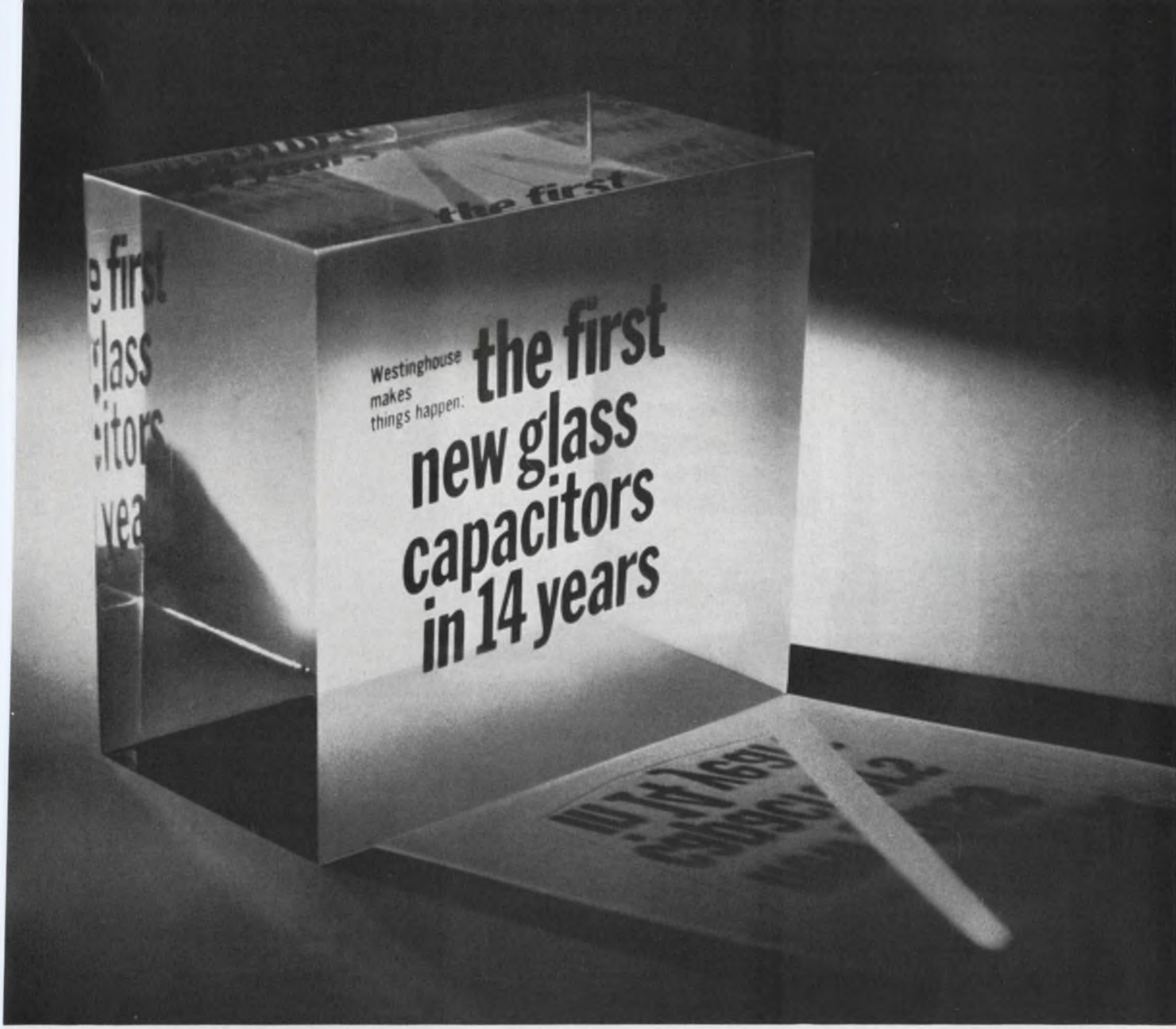
Dc oscilloscope

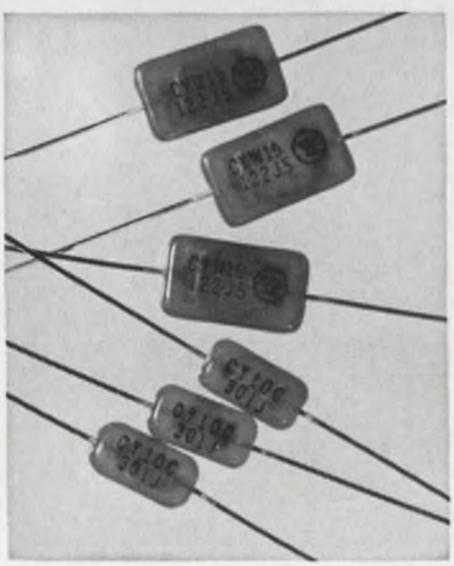
Designed for use in industrial, academic, and medical laboratories, the 10-14 dc oscilloscope is available in either kit or wired form. The vertical channel of the scope has a dc to 8 mc bandwidth and a sensitivity of 0.05 V/cm ac or dc. The horizontal channel of the 10-14 has 18 triggered sweep rates in 1, 2, 4 sequence from 0.5 sec/cm to 1 usec/cm with an accuracy of $\pm 3\%$.

P&A: Kit $299, wired $399; April. Heath Co., Benton Harbor, Mich. Phone: (616) 983-3961.

SEE AT BOOTH 3K13

Circle No. 508





Now Westinghouse introduces two lines of capacitors with monolithic glass construction . . . a true glass-to-metal seal. At last you can do some comparison shopping in glass capacitors.

Type CY exceeds MIL-C-11272. Every capacitor is individually "wrung out" in a battery of punishing tests.

Type CYW is the same capacitor, but at a fraction of the cost. The only difference is that it doesn't get this exhaustive individual testing. It gives you the stable performance of glass, the ideal dielectric, at a price competitive with ordinary capacitors.

What do we mean by stable performance? Plenty. Compare these specs to the capacitors you're now using.

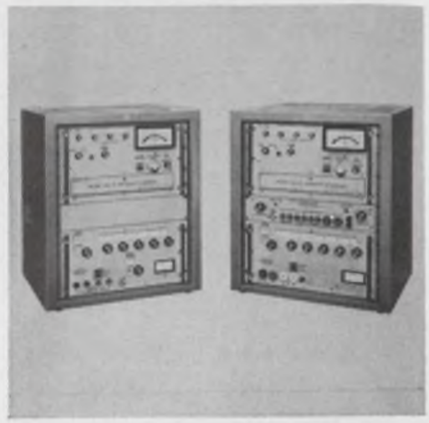
1) Capacitance drift less than 0.1% per decade of frequency. 2) Dissipation factor less than .001 at 25°C and 1 Kc. 3) Monolithic construction—glass to metal seal. 4) 50% greater high-voltage breakdown capability than conventional glass capacitors. 5) Insulation resistance: minimum of 100,000 megohms at 25°C and 10,000 megohms at 125°C.

When a whole circuit's performance can depend on one capacitor, why take chances? Be sure. Specify Westinghouse glass capacitors.

Call your Westinghouse distributor for immediate delivery. Or, for detailed technical data, write G. Blackmon, Marketing Manager, Westinghouse Capacitor Department, P.O. Box 868, Pittsburgh, Pa.

You can be sure if it's Westinghouse

ON READER-SERVICE CARD CIRCLE 70



Voltage/current source

Designed for calibrating voltmeters, ammeters and wattmeters, the model 100 system is an ac voltage and current standard for separate or combined operation. The solid-state sine wave source offers ac emf from 1 mV to 1000 V at frequencies from 50 Hz to 10 kHz.

P&A: $7250-$14,500. Radio Frequency Laboratories, Inc., Powerville Rd., Boontoon, N. J. Phone: (201) 334-3100.

SEE AT BOOTH 3B00.

Circle No. 353

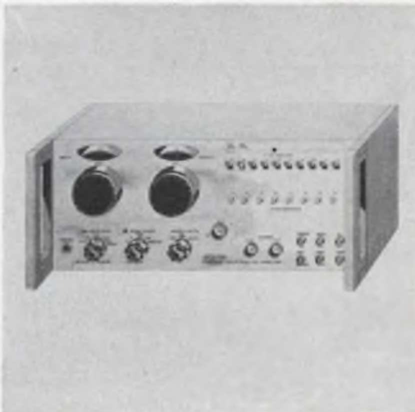
Insertion loss tester

Direct insertion loss in dB, eliminating calibration charts is featured in Model DB-3000-3. The battery-operated unit measures loss with ±0.007 dB absolute accuracy and ±0.002 dB relative accuracy, up to 1.0 dB. Measurements of ±0.01 dB are obtainable over one-third of its 29 dB dynamic range.

P&A: $2495; 4 weeks. Datapulse Inc., DeMornay-Bonardi Div., 780 S. Arroyo Pkwy., Pasadena, Calif. Phone: (213) 792-4142.

SEE AT BOOTH 3K27-29.

Circle No. 354



Sweep generator

A 10 kHz wide harmonic marker, said to be better by a factor of 40 over existing systems, is featured in model 1001 sweep generator. The solid-state unit operates over the 100 kHz to 20 MHz range. The marker can be selected to be 10 kHz, 1 kHz or 100 Hz wide. Operation of the generator can be in the swept or cw mode.

Telonic Industries, Inc., 60 N. First Ave., Beech Grove, Ind.
SEE AT BOOTHS 3K24-26.

Circle No. 355

DC voltmeter

A 0.002% dc voltage accuracy is featured in Model 740B Standard/Differential Voltmeter. It has 6 digital places, offered in discrete steps to 1 ppm resolution. As a dc source, the unit produces outputs from 0 to 1000 V. Accuracy remains for 30 days without recalibration, with temperature variations from 15-35°C.

P&A: $2350; 60 days. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000.
SEE AT BOOTH 3E01-18.

Circle No. 356

INSTRUMENTS—3RD FLOOR

Semiconductor tester

Diodes, rectifiers, transistors, and FETs are checked by model 259 in- or out-of-circuit. It measures both transistors and diodes, in-circuit, for reverse leakage down to 500 ohms of loading. It also measures FETs for leakage and transconductance, and both low and high power transistors for Beta (h_{fe}) within a 1 to 100 range.

American Electronic Laboratories, Inc., P.O. Box 552, Lansdale, Pa. Phone: (215) 822-2929.

SEE AT BOOTH 1A11.

Circle No. 359

Waveform oscilloscope

For testing TV waveforms, Model 191A oscilloscope features a 1% vertical accuracy for most measurements, 1% stability for all operations. A new CRT shows low-duty-cycle signals full screen. T/2, T and 2T sine-squared test pulses, used to test transmission facilities, are 62.5 to 250 ns.

P&A: $1295; Summer 1966. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000.

SEE AT BOOTH 3E.

Circle No. 360

Delay distortion analyzer

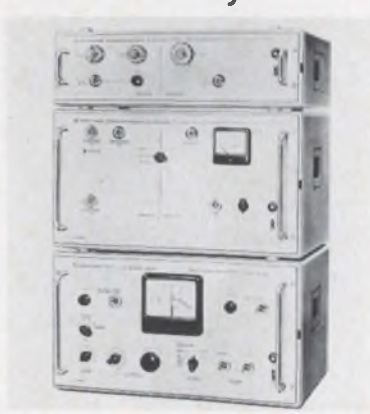
An FM receiver is used in this analyzer designed for use in testing FM circuits. The receiver covers 50-90 MHz, and converters allow RF measurements over 3.7-11.7 GHz. Resolution is 0.5 ns. The model 336 receiver has a companion FM transmitter, model 335.

P&A: Receiver, $5800; Transmitter, $1950. Converters range from $3600 to $3900. 11 wks. Wiltron Co., 930 East Meadow Dr., Palo Alto, Calif. Phone: (415) 321-7428.

SEE AT BOOTH 3B33

Circle No. 361

Test assembly



Test assembly type LFM determines group delay and phase distortion of transmission systems. The group-delay measuring section has ±1000 ns, ±300 ns, ±100 ns, ±30 ns, ±10 ns ranges, all ±2%. The group-delay test set video modulator covers a range of 100 kHz to 10 MHz. The RF modulator covers 25 to 250 MHz.

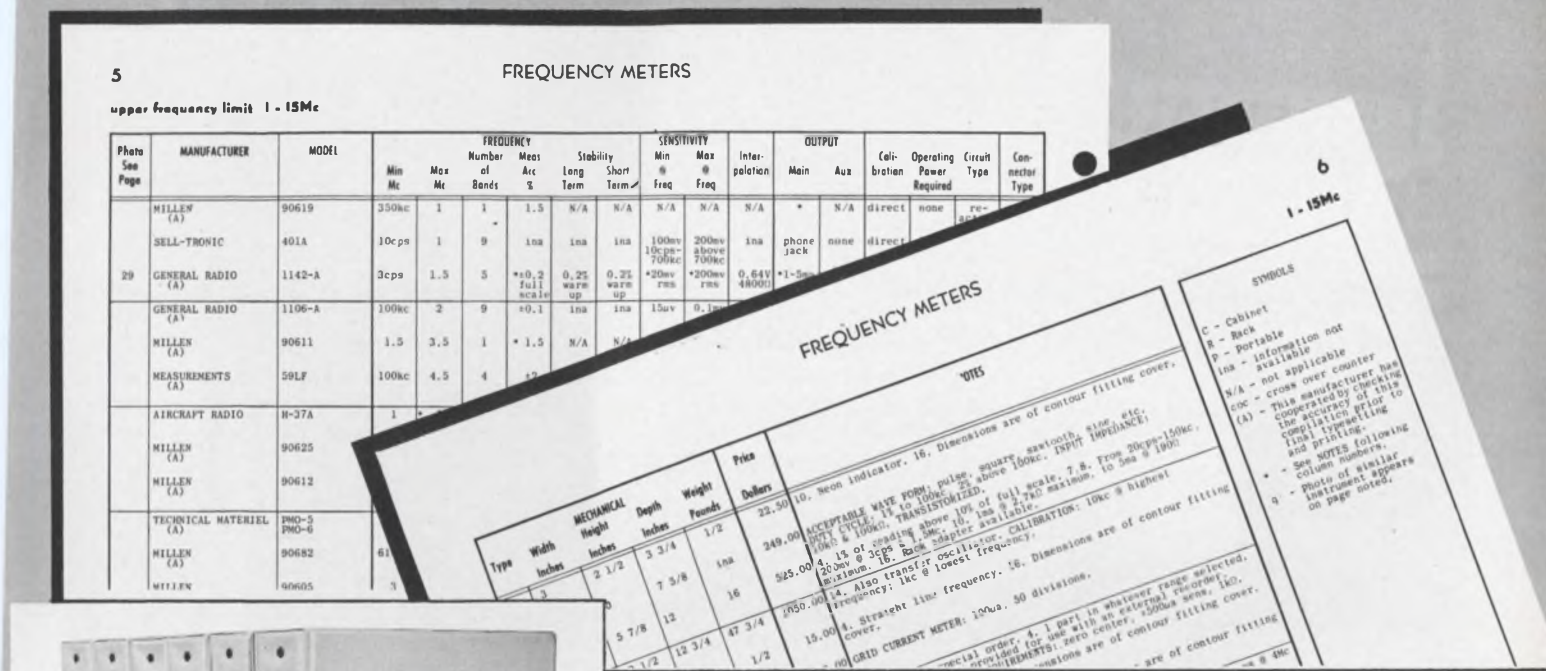
P&A: $8,400; 6 mos. Rhode & Schwarz, 111 Lexington, Passaic, N. J. Phone: (201) 773-8010.

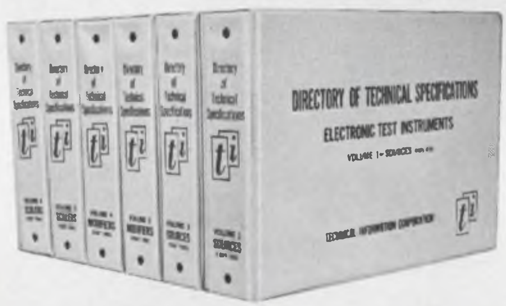
SEE AT BOOTH 300A

Circle No. 362

The Standard Reference For Electronic Test Instruments

DIRECTORY OF TECHNICAL SPECIFICATIONS





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SAVE HOURS OF ENGINEERING TIME

The Directory eliminates once and for all the necessity of searching catalogs, sales literature and periodicals to find suppliers, specifications, performance characteristics and prices. It provides in one comprehensive source, arranged and indexed for convenient use, all the information you need to keep completely up-to-date on available instruments, to evaluate competitive products and to select the best instrument at the best price.

NO NEED FOR CATALOG FILES

Keeping and maintaining your own files of manufacturers catalogues, brochures and loose data sheets is completely unnecessary. The DIRECTORY OF TECHNICAL SPECIFICATIONS gives you all the required data to select and specify electronic test instruments—all in one compact and easy to use reference. No other reference source is as complete or efficiently organized. The six-volume Directory lists approximately 14,000 instruments of more than 500 manufacturers and comprises 46 sections, each covering a different type of instrument.

ALWAYS COMPLETE AND UP-TO-DATE

The constant changes in specifications and performance of electronic test instruments is making it increasingly difficult to keep abreast of the latest developments. The Directory is kept continuously up-to-date by the mailing of section revisions to subscribers at the rate of approximately one each week. The information in the entire Directory is completely revised in less than a year.

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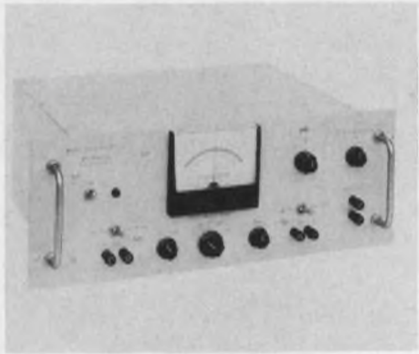
ON READER-SERVICE CARD CIRCLE 75



LF phase meter

The range from 10 Hz to 500 kHz is covered in this unit with 0.1° full phase resolution at any phase angle. Any part of the phase range can be expanded. Fixed accuracy is 0.5°. It measures over a 60 dB range without an attenuator (1 mV to 50 V). Swept frequency phase plotting can be done with the unit because of the large dynamic range. In this case, phase measurements have to be made accurately in the presence of amplitude fluctuations. This type of measurement is gaining importance at audio frequencies.

Added sensitivity eliminates the need for external or plug-in preamplifiers which may introduce phase errors of their own into the measurement.

Phase output is provided on a meter as well as in a voltage form with linear calibration from 0 to 180°. The voltage output for 180° is +1.8 V. This sort of voltage-to-angle equivalence makes the unit particularly suited to use with a digital voltmeter of recorder.

The meter also includes a +180° switch so that the operator can easily switch to a more convenient range. This feature is useful where measurements directly around 180° are involved. It is convenient to have these relationships occur around zero degrees, so that the meter doesn't tend to swing back and forth between plus and minus 180°.

Input impedance is 1 Meg shunted by 20 pF.

P&A: $935 FOB Palo Alto. 8 weeks. Wiltron, 930 East Meadow Drive, Palo Alto, Calif. Phone (415) 321-7428.

SEE AT BOOTH 3B33

Circle No. 363

Precision phase standard

Accuracy of 0.018 deg is offered in this wide-band primary precision phase standard, type 209. Coverage is from 50 Hz to 10 kHz continuous, with self-calibration and self-checking by bridge balance. Phase shift can be set to 7-digit resolution from 0 to 360 deg. Unit is suitable for production line or for calibrating phase meters.

Ad-Yu Electronics, 249 Terhune Ave., Passaic, N. J. Phone: (201) GR2-5622.

SEE AT BOOTH 3D05

Circle No. 536

Electronic counter

When used with a voltage to frequency converter, the model EC 715 high speed counter/timer can function as an integrating digital voltmeter in addition to its counting and timing capabilities. The EC 715 unit is said to have all the operating modes usually found in much larger instruments which are normally used for similar digital applications. The count of the EC 715 is visually displayed on the front panel.

Specifications of the counter/timer include: accuracy, ±1 count plus 1 MHz crystal stability of ± 0.1 ppm per week; temperature coefficient of the EC 715 is ±0.002 ppm per degree centigrade warmup. With an overall weight of 7 pounds the EC 715 counter/timer is described by the manufacturer as being a fully portable instrument.

P&A: $1450; 45 days. Aerojet-General, P. O. Box 216, San Ramon, Calif. Phone: (415) 837-5311.

SEE AT BOOTH M16-17

Circle No. 538

There's a big new addition to the DIEHL line of servo components, motors and packages . . .

SERVO AMPLIFIERS

ALL NEW

VORTEX BLOWER

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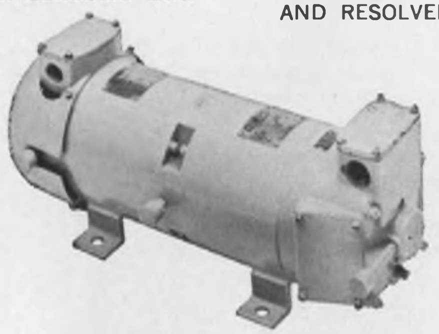

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D-C MOTORS

INSTRUMENT SERVOMOTORS

See these products at Booths 2B39-43 at IEEE, or Send for Detailed spec sheets.

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ON READER-SERVICE CARD CIRCLE 77

See us at the I.E.E.E. Show, Booth 4H13

INSTRUMENTS—3RD FLOOR

Wide-band phase meter

Designed for simplified operation, the wide-band digital phase meter, type 524A3, provides a direct readout of relative phase with an accuracy of $\pm 0.03°$. Frequency range is 20 Hz to 500 kHz and amplitude range is 0.3 volts to 50 volts. Phase angles from 0° to 360° can be measured without making any instrument adjustments.

An analog output provides direct connection to recorders or programmable systems. This output has a characteristic impedance of approximately 200 kΩ and provides a voltage of 1 mv per 0.1° of phase angle. The digitized output may be read out to four places with the digital indicator, type 524R1.

Instrument accuracy is not affected by the presence of either even or odd harmonics which have either 0° or 180° of phase difference with the fundamental. There is no ambiguity or instability in making measurements in the vicinity of 0° or 180°.

The instrument may be used to plot phase characteristic curves from 20 Hz to 500 kHz and delay distortion curves for telephone lines and communication systems. Phase characteristics of heavily distorted signals may also be plotted if the unit is used in conjunction with the Dual Channel Synchronous Filter, Type 1034, also manufactured by Ad-Yu Electronics, Inc.

Ad-Yu Electronics, Inc., 249 Terhume Ave., Passaic, N. J., Phone: (201) GR2-5622.

SEE AT BOOTH 3D05

Circle No. 539

Why specify Mallory MTP wet slug tantalum capacitors?

☐ they're much smaller than solid tantalum types <u>and</u>

☐ they don't need voltage de-rating!

Suppose you need a high-reliability capacitor for a miniaturized circuit. You know working DC voltage, required capacitance, ambient temperature. What capacitor will meet these parameters in minimum size?

Our answer—the Mallory MTP wet slug tantalum capacitor. C x V "density" of the MTP goes up to 172,000 mfd-volts per cubic inch—about 5 times as much rating per unit size as solid electrolyte tantalum types.

Next step—pick the exact rating you need. The circuit says 30 volts. So you decide to specify a 50 volt unit. Right?

Wrong. You *don't* need to de-rate the MTP. Contrary to long-standing belief, operating at reduced voltage neither improves nor impairs performance. Not for this capacitor. We've made tests to prove it. Here is typical data:

	% change in Capacitance after 1000 hours								
	at 26°C			at 65°C			at 85°C		
Rating	0% RV*	50% RV	100% RV	0% RV	50% RV	100% RV	0% RV	50% RV	100% RV
6.8 mfd, 50V	−1	−1	−1	−0.1	−0.1	0	−1.3	−0.7	−0.9
30 mfd, 50V	0	0	0	0	0	0	−1.0	−2.5	−5.2
78 mfd, 50V	0	0	0	−0.1	−0.2	−0.3	−1.2	−1.2	−1.2
450 mfd, 6V	0	0	0	−0.2	−0.7	−3.0	−1.0	−2.2	−8.0

*RV: Rated DC Voltage

Running the MTP at rated voltage can often help you make further savings in size. 33 mfd at 60 volts, for instance, goes in a "C" case, .225″ in diameter and .775″ long. But a 33 mfd *50* volt rating fits in the "B" case, which is only .145″ in diameter and .590″ long. And the cost is about 13% lower.

And that's not all. The MTP is made in the same facility as similar capacitors for Minuteman II. And like all Mallory wet slug tantalum capacitors, it has lower DC leakage and greater freedom from catastrophic failure than solid tantalum types.

Write today for our latest engineering report on voltage rating tests on MTP capacitors, for bulletin giving complete specifications. Mallory Capacitor Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

50th ANNIVERSARY

MALLORY

Speed Inquiry to Advertiser via Collect Night Letter
ON READER SERVICE-CARD CIRCLE 83

Portable phasemeter

The model PM 720 phasemeter is a fully portable, all-solid state instrument designed for measuring the phase angle between two alternating voltages. Half mega cycle frequency response is combined in the PM 720, with a high degree of accuracy. The phasemeter is capable of accepting two inputs with amplitude differences of as much as 1000 to 1 without having any effect on the phase reading of the instrument.

Phase angles ranging from 0 to 180 degrees can be read directly on the meter located on the phasemeter's front panel. The phasemeter's output signal can be used to trigger external equipment for control of phase shift. The unit is capable of handling signals ranging in frequency from 5Hz to 500 kHz with a reading accuracy of ± 1 degree. Weight of the portable phasemeter is 5 lbs.

P&A: $950; 45 days. Aerojet-General Corp., P.O. Box 216, San Ramon, Calif. Phone: (415) 837-5311.

SEE AT BOOTH M16-17

Circle No. 560

Signal generator

Studying high-quality communications equipment is the function of the SMAR signal generator. It combines the features of low frequency, high frequency, high power, and microvolt generators. It can determine the quality of signal detection equipment, or be a low power transmitter (2-watt output) for lab checking of antennas, receivers, front ends, etc.

P&A: $5,950; stock. Rohde & Schwarz, 111 Lexington, Passaic, N. J. Phone: (201) 773-8010.

SEE AT BOOTH 300A

Circle No. 537

Dual trace oscilloscope

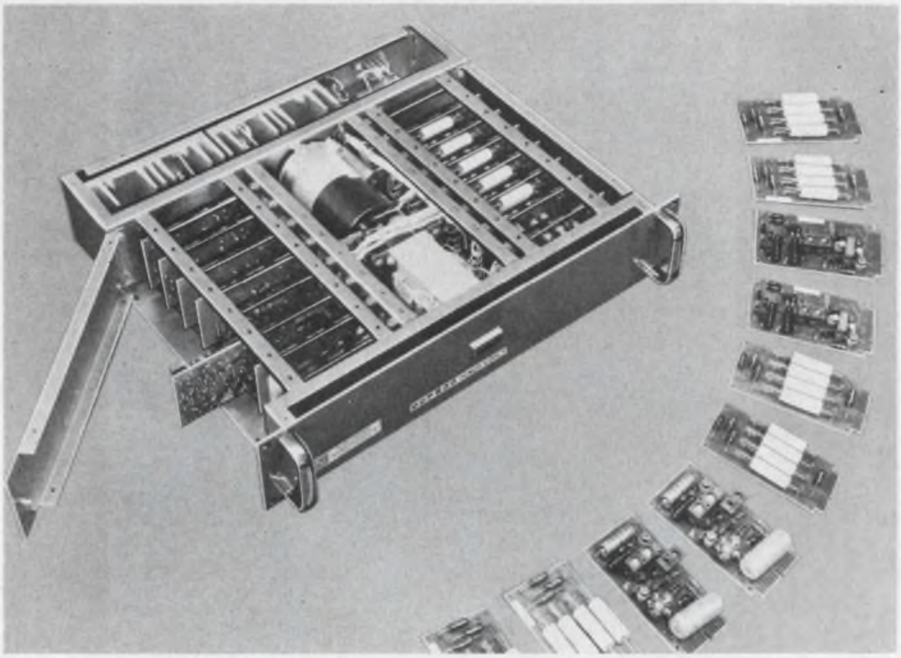
A dc to 200 kHz frequency response is featured in the OCA-12A dual trace scope. Sensitivity is 20 mV p-p/ division. Linear time base is triggered or repetitive. Sampling display is from 3 to 300 cps. The 9-lb unit accepts either 115 or 230 V input voltage, and can be converted for rack mounting.

The OCA-12A is intended for use in industrial servicing and educational field, where it is desirable to observe phase and magnitude relations between input and output. Other features of the OCA-12A are: Dual or single trace at will; sensitivity, 20 mV peak to peak per division; low frequency response, to dc; frequency compensated attenuators "gain" and calibrated output, 20 mV to 50 V; p to p/div in 11 steps using 1-2-5 sequence; trigger and repetitive linear time base, using a single time constant; sampling or alternate operation, automatically selected by sweep range switch; rectangular display, 13/4 x 23/8 inches divided in 0.2 division; signal display, only during "go" time of sweep; automatic sync, without use of level and magnitude controls; dual voltage input, either 115 or 230 volts and 50 to 400 Hz. The scope controls are all on the front panel with six operating controls and five static controls. Signal voltage readings are direct, similar to a voltmeter.

P&A: $295; stock. Waterman Instrument Corp., 1919 E. Boston Ave., Philadelphia, Pa. Phone: (215) 423-5161.

SEE AT BOOTH 3B30

Circle No. 561



Current and voltage are fully programable with easily interchanged modular circuits.

Programable power supply regulates one microampere

The DCP800 power system is a versatile solid-state dc unit. It is a digitally programed unit for use with automatic test equipment, and provides automatic changeover from regulated current to regulated voltage.

The unit makes this possible through the use of two independent regulator channels which provide sharp automatic crossover for extremely close control or limiting in either mode. Remote sensing or operation under a remote load are within the regulator systems capabilities.

Plug-in cards for reference supplies, amplifiers, and voltage and current decades are included. All control functions are directly driven from relay drivers of a computer into a connector at the rear of the DCP800. A 1-2-4-8 binary code is the standard input for both current and voltage.

Current programing can be 4-digit from 1 μA to 1 A with the use of 3 current ranges (0.001 mA-9.999 mA, 00.00 mA-99.99 mA, and 000.0 mA-1000.0 mA. One μA steps up to 1 A can be programed by means of the current decades and current range selectors

Voltage programing can be either 4 or 5 digit, covering a range of 00.001 V to 100 Vdc in 1 mV increments.

Both voltage and current decades use precision control resistors and reed relays.

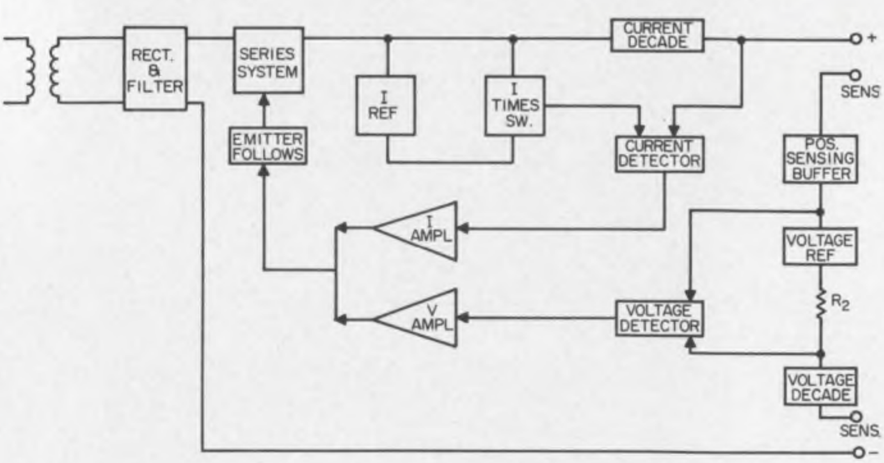
This unit fits 19-in. relay racks and features modular programability with easy access to test points. A standard constant voltage, constant current unit can be converted to a constant voltage unit with current limiting, or to a constant current supply with voltage limiting. This is done by replacing programing boards. If a unit with better stability and temperature coefficient is needed, either or both voltage or current reference and amplifier boards can be changed.

Any code can be substituted for the 1-2-4-8 binary, by replacing voltage or current decade boards with those coded for the desired input. Other relay coil voltages are also available.

P&A: $1500-$1750; 12 weeks. Electronic Measurements Co. Div. of Rowan Controller, 30 Bridge, Red Bank, N. J. Phone: (201) 747-5094. TWX: (201) 741-0771.

SEE AT BOOTH 2G14

Circle No. 651



Current and voltage limiting are accomplished through independent regulator channels which provide automatic crossover to either mode for limiting or control. Remote sensing and load are related by these systems.

Programable supply

The DCP800 is a multi-function power source within its voltage current limits. It can be programed to any current-voltage combination, with limiting of either or both, by simple replacement of modular circuit boards. It features a current control system with accurate shunt paralleling for constant-current control down to 1 μA, and crossover circuitry for voltage control to buffer normal 1 mA current so as not to interfere with range or control of constant current. Sinking currents up to 30 mA are also featured.

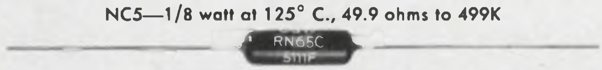
Precision you can trust, because it's built in.

±50 ppm TC.
1/2% and 1% tolerances.
<0.5% load-life ΔR guaranteed.
Mil-R-10509E, Char. C.

New CORNING® NC-style Resistors.

NC4—1/10 watt at 125° C., 49.9 ohms to 150K

NC5—1/8 watt at 125° C., 49.9 ohms to 499K



NC6—1/4 watt at 125° C., 49.9 ohms to 1 Meg.

True precision resistors with all the long-term reliability you've come to expect from CORNING glass-tin oxide film. And not just tested into some. Nor sorted out of many.

But precision that's built in . . . in a continuous manufacturing process that provides the highest inherent reliability of any resistor made today. Here's how:

The tin oxide film is bonded *molecularly* to a glass cane substrate at red heat . . . it isn't plastered on, or sputtered on.

Temperature coefficient of film and substrate match perfectly. The substrate is chemically inert to the film.

Once cooled, the film compares in hardness to high-carbon tool steel . . . you can't scrape it off.

We make CORNING NC-styles with these materials and this technique to guarantee you constant resistivity, constant quality . . . precision that's built in.

Call your CORNING distributor for technical data and samples or send the coupon today. Evaluate the new NC-styles, and see how their built-in precision gives you new design confidence.

CORNING GLASS WORKS, 3909 Electronics Dr., Raleigh, N.C.

Please send me new NC-style Resistors data and samples.

Name.. Title..

Company..

Address..

City.. State.............................. Zip..............................

CORNING
ELECTRONICS

ON READER-SERVICE CARD CIRCLE 86

RESOLVE THIS YEAR TO DEMAND BETTER RESOLVERS AND SYNCHROS

RESOLVERS

(400 cycle except as noted)

SIZE	PART NUMBER	TYPE	INPUT VOLTAGE (volts)	INPUT CURRENT (ma)	INPUT POWER (watts)	INPUT Z (ohms) (secondary open circuit)	OUTPUT Z (ohms) (primary open circuit)	SENSITIVITY (mv/°)	PHASE SHIFT (°)	RESIDUAL NULL VOLTAGE (mv) (total)	MAX. ERROR FROM E.Z. (min.)	TRANSFORMATION RATIO
5	CJ0 0585 100	Lo-Z	26	47	.640	935∠69°	1325∠73°	455	16	40	10	1
	CJ0 0585 900	Hi-Z	26	23	.3	1660∠69°	2210∠72°	455	19	40	10	1
8	CM0 1034 107	Conventional	26	44	.39	270+j630	39+j142	189	20	20	7	.415
	CM4 1033 008	RX	26	45	.28	137+j558	30.2+j137	206	11	20	3	.454
	CM4 1033 009	RDX	11.8	42	.112	66+j279	83+j327	206	9.75	20	3	1
	CM4 1033 010	RC	11.8	13	.031	210+j956	887+j3912	393	8.8	20	3	1.9
	CM4 1033 011	RDX	11.8	30	.062	71.7+j397	107+j445	206	8.4	20	3	1
	CM4 1033 012	RDX	11.8	5	.010	446+j2464	634+j2756	206	8.4	20	3	1
	CM4 1084 007	Wndg. Comp. Hi-Z	15	9	.051	624+j1960	590+j2100	256	16.2 (a)	12	±.1% (b)	.980
	CM4 1084 003	Wndg. Comp. Lo-Z	13	9.6	.022	246+j812	310+j940	213	15 (a)	12	±.1% (b)	.985
11	RS931-2	Conventional	26	52	.34	550∠78.1°	150∠80.3°	220	8	30	3	.484
	RS931-3	Conventional	26	20	.08	1680∠78.5°	1400∠78°	384	7	18	3	.846
	3R982-004	RX Data Trans.	26	176	.9	170∠77°	42∠80.5°	206	8	20	3	.454
	3R982-002	RDX Data Trans.	11.8	143	.25	95∠80.2°	110∠75°	206	5	20	3	1
	3R982-009	RDX Data Trans.	11.8	41	.084	330∠80°	380∠76°	206	5	20	3	1
	3R982-011	RDX Data Trans.	11.8	15.9	.03	855∠80°	1000∠79°	206	5	20	3	1
	3R982-003	RC Data Trans.	11.8	6.8	.012	2000∠80°	8000∠79°	390	5.5	40	3	1.9
	3R982-012	RC Data Trans.	11.8	6.8	.012	2000∠80°	8000∠76°	390	5.5	40	3	1.9
	CR4 0948 006	Computer Chain	20	12	.036	2060∠79.5°	2380∠83.5°	356	8.5	40	3	1.02
	CR4 0918 003	Computer Chain	26	395	.9	38.2+j166	16.5+j93.5	314	8	40	3	.692
	CR4 0948 003	Computer Chain	15	.19	.004	90,000 tuned	54,000+j7250	157	±6′	15	.05% (b)	.6
	CR4 0980 030	Hi-Z Wndg. Comp.	26	4	.01	380+j2200	400+j2325	445	7.5 (a)	10	±.1% (b)	.980
	R980-41	Hi-Z Wndg. Comp.	60	5.1	.015	500+j2200	550+j2300	1026	7.5 (a)	25	3 (g)	.980
	CR4 0980 016	Lo-Z Wndg. Comp.	20	11	.014	120+j900	198+j934	342	5.6 (a)	20	±.1% (b)	.980
15	CT9 0918 003	RX Data Trans.	26	150	.47	20+j170	8+j38.2	215	3.1	12	±40 sec. (e)	.437
	CT9 0948 003	RDX Data Trans.	11.8	43.8	.048	24+j265	59+j285	206	3.5	6	±40 sec. (e)	1
	CT9 0908 001	RC Data Trans.	11.8	12.3	.012	80+j960	650+j5125	455	3.15	13	±40 sec. (e)	2.228
	CT9 0987 001	Lo-Z Computing	20	75.5	.181	24+j265	59+j285	349	3.5	10	±.02% (e)	1
	CT9 0987 002	Med.-Z Computing	20	14.6	.035	100+j1365	230+j1580	363	2.6	10	±.02% (e)	1.04
	CT9 0987 003	Hi-Z Computing	20	4.5	.011	400+j4400	750+j4800	349	3.5	10	±.02% (e)	1
	CT9 0980 008	Hi Acc. Wndg. Comp.	26	4.5	.014	220+j2200	330+j2300	445	4 (d)	7	±.02% (e)	.980
	T980-003	Wndg. Comp.	26	5.9	.004	480+j2500	440+j2650	445	8.5 (a)	15	±.1% (b)	.980
25	Z5161-001	RX	115	321	4.6	450∠84°	300∠83°	1571	2	47	.3	.783
	Z5191-001	RDX	90	129	1.1	850∠84°	900∠85°	1571	2	47	.3	1
	Z5191-002	RDX	90	39	.52	2700∠80°	2580∠80°	1571	1	47	.3	1
	Z5151-001	RC	90	40	.52	2700∠80°	4600∠80°	2000	2	60	.3	1.278
	Z5151-003	RC	90	12	1.6	8500∠82°	14,000∠82°	2000	2	60	.3	1.278
	Z5151-004	RC	90	12	.180	8500∠83°	3800∠84°	1000	2.5	30	.3	.639
	CZ0 5180 202	Wndg. Comp.	115	.5	.05	225+j1730	166+j1700	1967	2.5 (a)	25	.3	.980
	CZ9 5082 001	Wndg. Comp.	15	6.6	.2	480+j2200	270+j2200	250	8.7 (a)	45	±1.5 (e)	.957
28	Z5153-004	Hi Acc. 4-wire	90	12	.18	8500∠83°	3800∠84°	1000	2.5	30	.33	.639
	Z5163-001	Hi Acc. 4-wire	115	321	4.6	400∠85°	260∠85°	1571	2	47	.33	.783
	Z5193-001	Hi Acc. 4-wire	90	129	1.6	850∠83.6°	900∠84.6°	1571	2	47	.33	1

NOTES:

a. Rotor to stator phase shift. Rotor to compensator Ø shift ranges from 0° to 6 minutes
b. Functional accuracy
c. Available with either 10′, 7′, 5′, or 3′ accuracies as R980-41, 7R980-41, 5R980-41, or 3R980-41 respectively
d. Interaxis error
e. Angular accuracy

Operating temperature range for all units except CZ9 5082 001 is −55°C to +125°C. Max. temperature for CZ9 5082 001 is +85°C. Higher temperature models available.

Components having higher accuracies than those shown are also available.

Bu/Weps, Transolvers & Size 25 Pancakes, in Hi & Lo-Z.

Sizes 5, 8 and 11 transolvers in addition to certain Size 11 Bu/Weps resolvers are available. "Pancake" resolvers for operation at 800 cps and 1600 cps in Size 25 diameter also available.

Reader/spooler

A high-speed photocell punched tape reader/spooler combination is designed for high-speed systems.

The RRS-302D unit includes on-off servo operated reels, and electronic noise suppression. Speeds of up to 300 characters per second with push-button control rewind of 40 inches per second are specified. Reels of 5-1/4-in. diameter store 500 feet of punched tape.

REMEX/Rheem Electronics, Div. Ex-Cell-O Corp., 1200 Oakman, Detroit, Mich. Phone: (313) 868-3900.

SEE AT 3J07-09 *Circle No. 371*

Oscilloscope cameras

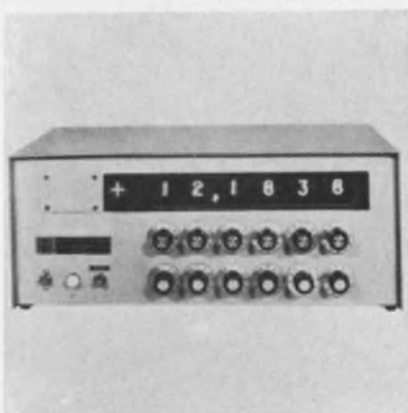
Interchangeable Polaroid or 4 x 5 backs are features in three oscilloscope cameras. Beattie-Coleman Model MIIA offers a 1:1 to 1:0.5 object-to-image recording ratio without special lens. Model 565A records nanosecond traces with an f/1.2 86 mm lens. Model K5R is compact, designed for limited-space areas.

Coleman Engineering Co., Inc., Box 1974, Santa Ana, Calif. Phone: (714) 546-1600.

SEE AT BOOTH 3G12.

Circle No. 372

Electronic counters



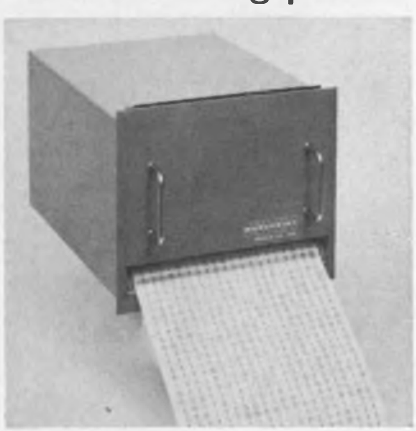
The Digi-Master is a line of high-speed, bi-directional solid-state counters. Two standard models are available: the Series 1844 has up to 6-digit capacity, with Nixie tune readout, and adds or subtracts through zero. The Series 1845 has an additional Nixie tube for plus or minus indication. Reset is to zero or to a variable number.

P&A: $495-$1500; 6 wks. Veeder-Root, 29 Andover, Danvers, Mass. Phone: (617) 774-6110.

SEE AT BOOTH 3G07.

Circle No. 373

Panel mounting printers

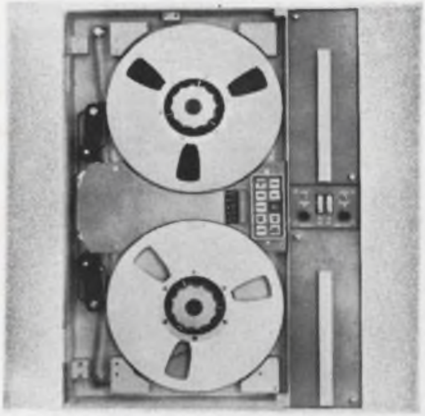


Tape printed data in binary form is presented by the Moduprinter series. According to size, they have capacities for 9, 14, or 20 bits. Each bit needs 6 ms minimum to reach 1 or 0. The installed modules may be moved to either position without decoding from binary sources. Maximum line printing rate is six per second.

P&A: $215; 4-6 wks.. Presin Inc., 226 Cherry St.. Bridgeport, Conn. Phone: (203) 333-9491.

SEE AT BOOTH 3A47.

Circle No. 374



Portable recorder

Model P-5000 recorder/reproducer, in 7- or 14-track configurations, operates at 2.0 MHz, with up to 120 ips tape speed. The units servo system has low-time-displacement error (4μs at 60 ips, 6μs at 30 ips, and 10 μs at 15 ips).

The unit weighs 140 pounds, and has airborne, ship, and mobile applications as a predetection, telemetry, or instrumentation recorder.

Winston Research, Fairchild, 6711 S. Sepulveda Blvd., Los Angeles, Calif. Phone: (213) 670-3305.

SEE AT BOOTH 3D10-18

Circle No. 375

Serial entry printer

Designed for data monitoring and logging systems, the Digit-Matic Series is compatible with systems requiring up to 8 columns printing capacity. This includes communications systems, digital counters, flow-meters and production scales. Solenoids and print command are activated by 24 V.

P&A: \$335-\$385; 45 days. Victor Comptometer Corp., Business Machines Group, 3900 N. Rockwell, Chicago. Phone: (312) 539-8210.

SEE AT BOOTH 3G10

Circle No. 376

SYSTEMS—3RD FLOOR

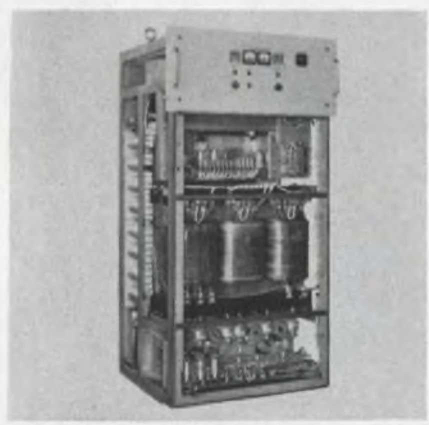
Laser system

An 800 μs pulse length and 3-5 J output are provided by the 104A. The basic system consists of a power source, Laser head, Q-switch and interconnecting assemblies. Operating mode is determined by the mode selector on the Q-switch. A 15 V, 50-μs synchronization pulse is delivered by the power source. The system beyond is maintenance-free 25,000 cycles.

TRG, Route 110, Melville, N. Y. Phone: (516) 531-0600.

SEE AT BOOTH 2D43.

Circle No. 377



GSE power supply

Features designed to exclude transistor series regulator circuitry are reported for a 0-500 A, 28 Vdc power supply. One of a series of units built to NASA specs, others are rated at 50, 100 and 250 A, with output voltages of 24-40 Vdc. Line and load regulation are ±0.1%. Calculated MTBF ranges up to 198 K hours. All rated units fit 19- and 24-in. racks.

Perkin, 345 Kansas St., El Segundo, Calif. Phone: (213) 772-2171. Phone: (213) 2171.

SEE AT BOOTH 1D01.

Circle No. 378

Digital program clock

A digital clock reads out 24 hours in hours and minutes. It features integral time base, BCD control contact closure at five intervals from 1 minute to 1 hour, and an inhibit circuit to prevent ambiguous readings. Used with voltmeters or thermometers and a printer, it provides a "time/voltage" or "time/temperature" system.

Price: $390. United Systems Corp., 918 Woodley, Dayton, Ohio. Phone: (513) 254-3567.

SEE AT BOOTH 3A34-35

Circle No. 379

Scientific calculator

The model 320, desk top calculator provides sum, difference, product, quotient, square, square root, natural log, and exponent.

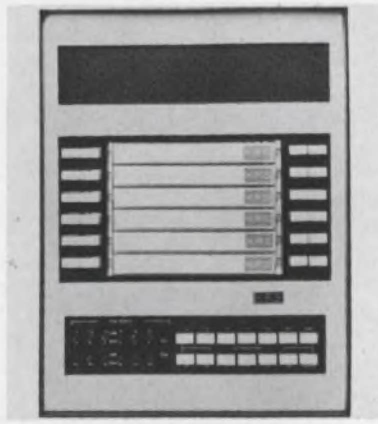
All data are converted to nat logs, operated, and reconverted for decimal readout. Two summing sections store sums and remainders. A third multiplies. Keyboards may be 200 ft. away.

Price: $2095. Wang Labs, 836 North, Tewksbury, Mass. Phone: (617) 851-7311.

SEE AT BOOTH 3B17-18

Circle No. 380

Portable data recorder



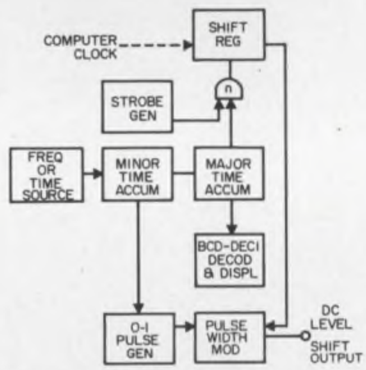
Twelve data channels are provided by the KRS Data-Stact DR-2 recorder. Different versions offer front panel/remote control, or remote control alone, of: random access, cartridge serial/parallel control, cartridge group sequencing, and cue tones. This basic system building block records dc to 100 kHz.

P&A: $4500-$9700; 30-60 days. KRS Instruments, Div. Data-Pulse, Inc., 780 Arroyo Parkway, Pasadena, Calif. Phone: (213) 681-7416.

SEE AT BOOTH 3K27

Circle No. 381

IC-type digital clock



Here's a digital clock-time code generator using integrated circuit logic. It can provide BCD outputs of time and date in either parallel or serial form, or in any combination.

Output pulse train is width-modulated to distinguish between 0 and 1. For tape recording or com links dc level shift can be used to modulate a carrier. It uses a Nixie display.

Parabam, Inc., Hawthorne, Calif.

SEE AT BOOTH 3A42

Circle No. 382

High-precision pot

A guarded high-precision potentiometer, known as the K-5 model contains improvements over the earlier K-3. Range and balancing controls are aligned from left to right in order of usage.

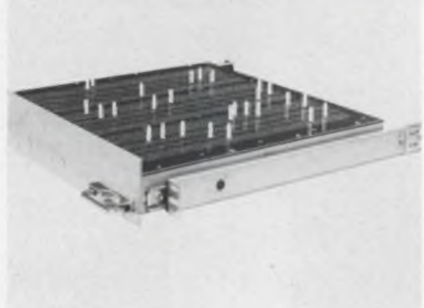
Volts to 5 (or 6) digits are read with three switch decades and a detente slidewire of 115 divisions. Error is $\pm 0.003\%$ of reading + 2 uV max.

Leeds & Northrup, 4901 Stenton, Phila., Pa. Phone: (215) 329-4900.

SEE AT BOOTHS 1B18-20

Circle No. 383

Chassis-mounted boards

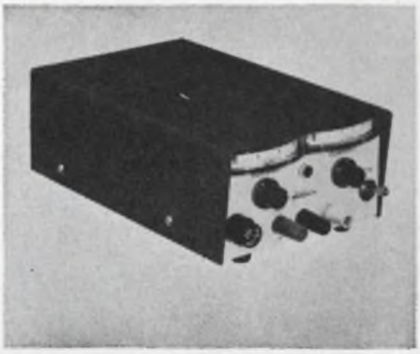


Chassis-mounted multi-switch and program boards with mechanical pull-out and lock-in features are equipped with lever handles that are designed for positive latching of the drawer in the rack. It can make or break multiple pin connectors mounted at the rear of the chassis. Pin friction of up to 400 pounds is easily overcome.

Sealectro Corp., 225 Hoyt St., Mamaroneck, N. Y. Phone: (914) 698-5600. TWX: (710) 566-1110.

SEE AT BOOTH 2G43-45

Circle No. 384



Power supplies

Three new lines of power supplies are offered. The 24 compact models in the ED/EA line (shown) feature the "Duet" twin amplifier for controlling voltage and current with automatic crossover to either mode. The L Series offers 720 models with up to 1.8 Kw output. Model 2909 features advanced circuitry.

Delton Inc., 4th and Cambria, North Wales, Pa. Phone: (215) 739-1101.

SEE AT BOOTH 2H50.

Circle No. 557

Universal recorder

Model 6521 Recorder provides a wide-speed range strip chart recorder, an XY recorder that can control its own test, and a sequential chart mode where the paper advances after a given time or XY test. Chart movement can be controlled directly from external encoders or analog transducers. Paper can reverse for curve families.

P&A: $2700; 4-6 weeks. Houston Omnigraphic, 4950 Terminal, Bellaire, Tex. Phone: (713) 667-7403.

SEE AT BOOTHS 3K34-35.

Circle No. 558

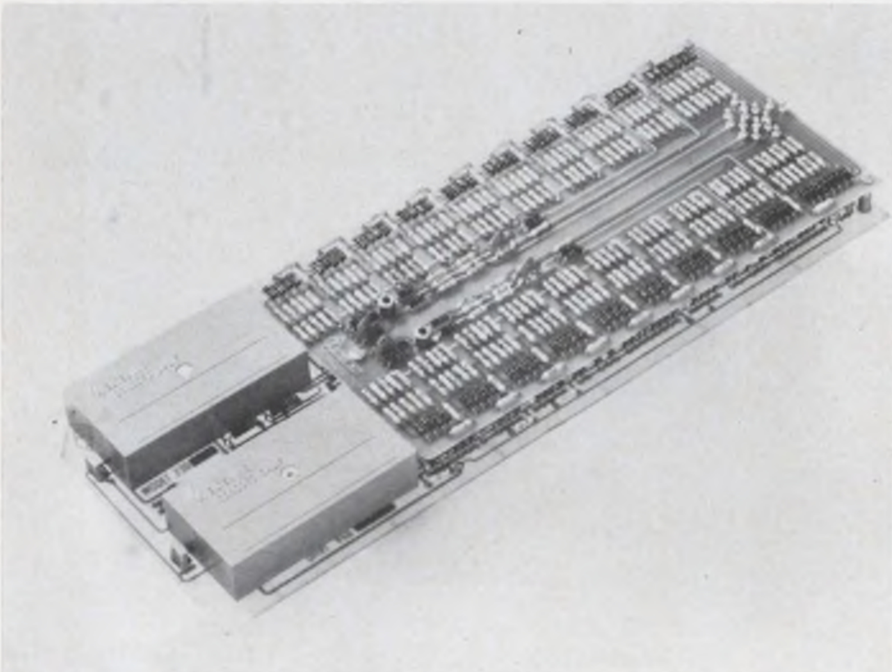
Pulse generator

A 40 MHz pulse generator, model 111 features an independently variable linear rise and fall to 2 ns. Outputs are single or double pulse to ±5 V, with full baseline offset. Variable pulse delay from 10 nsec advance to 50 msec delay and leading edge to leading edge double pulse separation to 20 nsec are offered.

P&A: $1480; June, 1966. Datapulse, 509 Hindry, Inglewood, Calif. Phone: (213) 671-4334.

SEE AT BOOTHS 3K27-29.

Circle No. 559



Two-channel function generator gives sines and cosines

A new two-channel function generator is intended for analog computations involving sines and cosines. It has been designated model 530 by the manufacturer, and is a printed-circuit card module, fully compatible with the rest of the manufacturer's 500 series elements operating at ±100 V output. This unit rounds out the analog capabilities of the line.

The 530 may be mounted in the 560 cabinet with power supply, multipliers, amplifiers, and fixed function generators.

The generator features a maximum static error of less than 25 millivolts, a sine capability of ±270°, and a cosine capability of +180° to −270°. The operational amplifier output generates −sin X and −cos X in the range of ±100 V.

An active error suppression method is used for an accuracy of better than 0.025%. Built-in amplifiers provide very stable and accurate line-segments in the critical portions of the non-linear curves, and resistor-diode network drift becomes negligible.

P&A: $700; 30 days. Zeltex, Inc., 2350 Willow Pass Rd., Concord, Calif. Phone: (415) 686-6660.

SEE AT BOOTH 4M12

Circle No. 385

Printed circuit guides

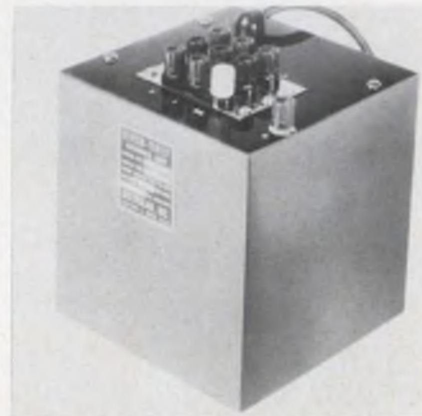
Series 30 one-piece non-magnetic card holders of polycarbonate resin offer quick assembly.

An integral cantilever spring, preventing lateral motion, holds boards from 0.05-0.125-in. thick. Integral lugs permit snap-in placement. The units withstand up to 250°F. Air flow cooling through open areas is featured.

P&A: $.15 (at 5,000). Taurus, Academy Hill, Lambertville, N. J. Phone: (609) 397-2390.

SEE AT BOOTH 4A13

Circle No. 386



Dc transfer standard

The portable 221G-NW-19 guarded dc transfer standard gives 1, 2, 3, 4, and 5 Vdc outputs ±0.02% at 0.0 mA. Ripple is less than 0.001% Vrms, on an input of 117 Vac, 50-60 Hz ±17 volts, 6 watts.

Line regulation is 0.001% max output change per 10 V line change for both long and short term.

The unit is encased in a 6- x 6- x 6-in. case with shielded line cord, output, ground and guard terminals.

P&A: $300; 4 wks. Instrulab Inc., 1205 Lamar, Dayton, Ohio.

SEE AT BOOTH 4A14

Circle No. 387

Instrument cases

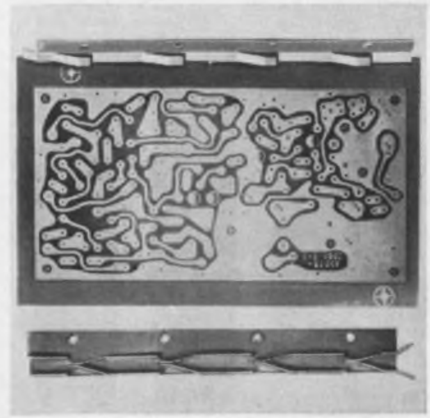
Formica cases for precision instruments are available in woodgrain or solid color patterns. Mahogony cored, the formica is epoxy bonded under heat and pressure, resulting in considerable strength.

Any size and shape, all manner of partitions, cutouts, seatings, and hardware are offered. These cases have passed US Navy shipboard requirements.

W. A. Miller, Oquossoc, Me. Phone: (207) 864-3344.

SEE AT BOOTH 4C28

Circle No. 388



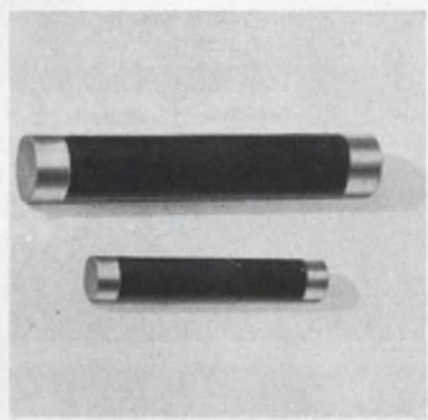
Circuit board holders

Board thicknesses from 0.030 to 0.125-in. are accepted by the Series 70 printed-circuit board holders. Available in 2, 3, 4, 5, and 6-in. tracks, these units are reported to be ideal for airborne applications and other uses requiring light weight. Heat-treated beryllium copper spring clip guides (per QQC-553) are stock.

Taurus Corp., Academy Hill, Lambertville, N. J. Phone: (609) 397-2390.

SEE AT BOOTH 4A13.

Circle No. 389



Film rod resistors

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Circle No. 390

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For technical data and additional information, write to Chemicals Division, EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, Kingsport, Tennessee. EASTMAN 910 Adhesive is distributed by Armstrong Cork Company, Industry Products Division, Lancaster, Pa., and Loctite Corp., 705 N. Mountain Road., Newington, Conn.

Here are some of the bonds that can be made with EASTMAN 910 Adhesive

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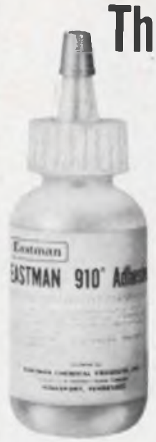

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The use of EASTMAN 910 Adhesive is not suggested at temperatures continuously above 175°F., or in the presence of extreme moisture for prolonged periods.

See Sweet's 1966 Product Design File 8a/Ea.

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ON READER-SERVICE CARD CIRCLE 107

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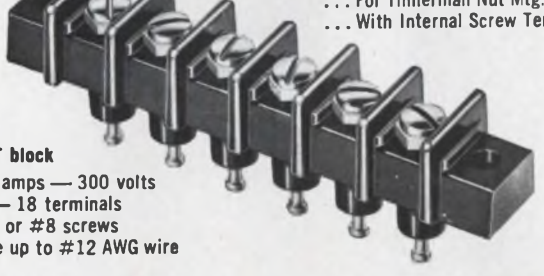

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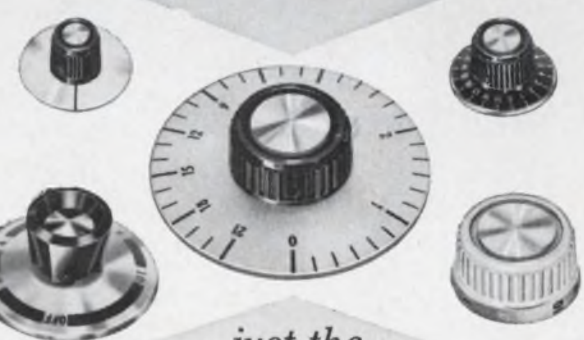

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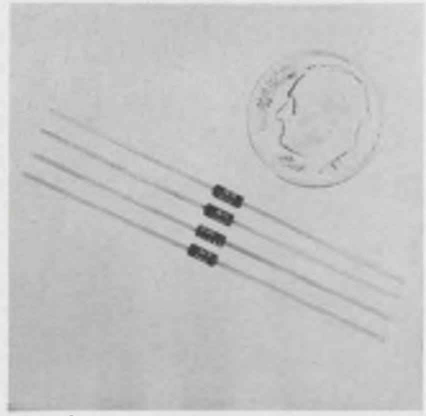


Mini precision resistor

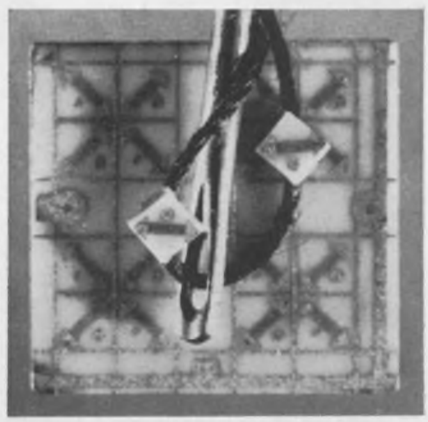
The EE-1/20 conforms to all requirements of MIL-R-10509F and MIL-R-55182B, styles RN50 and RNR50.

It measures 0.068 x 0.156-in. long. Leads are 0.016 x 1-in. and are available in tinned copper, gold-plated dumet, or bare nickel. Rating is 200 V, 1/20 W at 25°C. Resistance range is 10 ohms to 110 k. Tolerance is 1% down to 0.05%, temperature coefficient is ±50 ppm/°C, down to ±10 ppm/°C.

P&A: $0.54-$2.06; samples, stock, production quantities; 2-5 weeks. American Components, 8 Ave. at Harry, Conshocken, Pa. Phone: (215) 828-6240.

SEE AT BOOTH 4A06

Circle No. 391



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Microminiature metal-film resistors, for T-O cans or flat packs, measure 0.04-in. 0.01-in. As many as 36 resistors can be made on a single substrate and sliced for production use.

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BOOTH NO. 4A26 *Circle No. 392*

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SEE AT BOOTH 4A14

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Hoffman Eng., Anoka, Minn. Phone: (612) 421-2240.

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Circle No. 394

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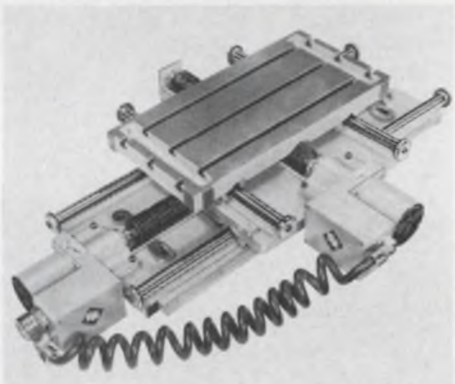
SEE AT BOOTH 4A36

Circle No. 573

X-Y positioning tables



Digitally driven Slo-Syn X-Y positioning tables are complete two-axis positioning systems which can be installed on a macine or can be easily moved from machine to machine.

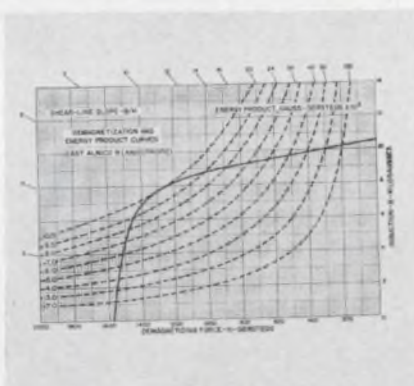
They are designed for use with machine tools or for automated assembly equipment. Ball nut lead screws give low friction and backlash, plus high accuracy.

Superior Electric Co., Bristol, Conn. Phone: (203) 582-9561.

SEE AT BOOTH 2G26

Circle No. 574

Permanent magnet



Alnico 9, a new permanent magnet material, has an energy product of typically 10.0 M.G.O. and a coercive force of 158O H Oersteds, as shown on graph. Its straight line magnetic axis and high coercive force permits use in short sections such as flat squares, rectangles, discs and rings as well as cylinders, solid or cored, and blocks.

Thomas & Skinner, 1120 E. 23rd St., Indianapolis, Ind. Phone: (317) 923-2501.

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An air-cooled combination temperature/humidity cabinet is capable of meeting MIL-202C, method 106B and other stringent single steady state test requirements.

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SEE AT BOOTHS 3A07-8

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500 KHz to 1700 MHz

This solid-state instrument is an electronically swept VHF-UHF wide-sweep and marker generator which accepts a variety of UHF plug-ins to provide extended frequency ranges and sweep widths. With its plug-ins, the 121-C covers a range of 500 KHz to 1700 MHz, offers octave-wide sweeps at low UHF frequencies where most generators in this range are limited to narrow widths. Narrow sweep and wide sweep plug-ins cover special applications such as UHF-TV — full 440 to 920 MHz in a single wide sweep. A digital frequency dial provides smooth center frequency control and remarkable vernier adjustment for narrow sweep operation.

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0.5 volt rms into 50 ohms
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± .5 db to 1700 MHz

FREQUENCY . . . *Set*

digital frequency dial;
vernier control at all frequencies

SWEEP WIDTH . . . *Set*

5 KHz to 500 MHz
VHF: 50 KHz to 300 MHz
UHF: *P-121 — 124 Plug-ins

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single-freq. type birdie markers

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***P-122:** 900 to 1300 MHz
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***P-123:** 100 to 1000 MHz
Sweep: 5 KHz to any octave

***P-124:** 1300 to 1700 MHz
Sweep: 500 KHz to 400 MHz

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ON READER SERVICE-CARD CIRCLE 881

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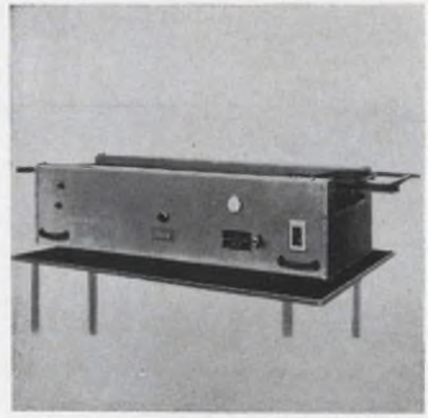
United Shoe Machinery Corp., 140 Federal St., Boston, Mass. Phone: (617) 542-9100.

SEE AT BOOTH 1J17.

Circle No. 501



Soldering Machine

Adjustable speeds of 5-25 ft./min. are featured in the SSM. An automatic unit geared for printed-circuit board makers, it handles boards up to 8 x 9-in. The solder bath is accurately controlled to ±5 F. Solder level is not critical because the boards float on the solder surface preceeded by a skimmer.

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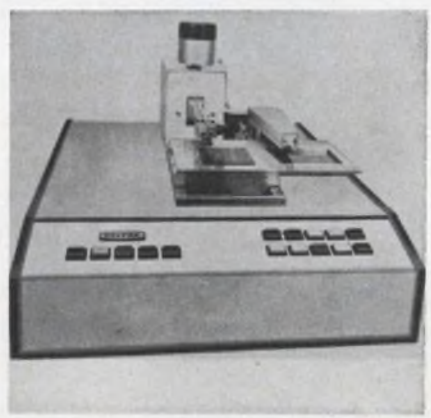
SEE AT BOOTH 4K15.

Circle No. 502



Flatpack welder

High-speed programed welding of flat packs to printed circuits at up to 300 welds per minute is the Autobond II programed welder's job. Featured are: weld programs up to 5 x 7-in., pulse amplitude of 0.2-2.0 volts, pulse durations of 1-10 ms, 2-20 ms, and 4-40 ms, and X-Y travel up to 6-in. either way.

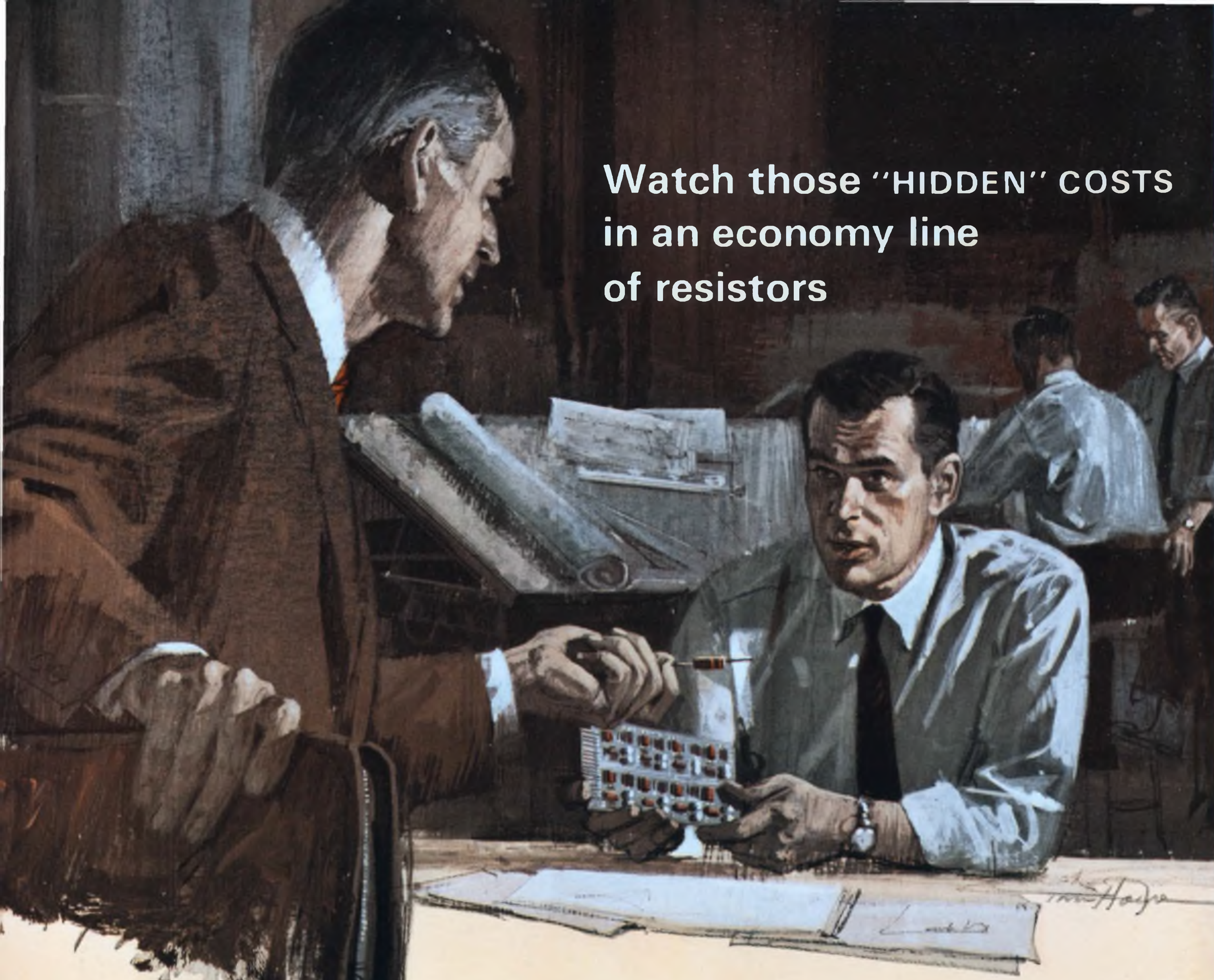
A pulse transformer is an integral part of the weld head. Operating voltage is 100-130 Vac.

Unitek, 950 Royal Dr., Monrovia, Calif. Phone: (213) 359-8361.

SEE AT BOOTH 4M37.

Circle No. 503

ON READER-SERVICE CARD CIRCLE 242 ➤



Watch those "HIDDEN" COSTS in an economy line of resistors

The "saving" is not pure "money in the bank" when you buy low cost, inferior grade resistors. Actually, the few pennies that you believe yourself to be "ahead" through purchasing resistors of uncertain performance can cost dollars in test line rejections, or worse, in customer disappointments with the product—a situation that is beyond repair.

How can you protect yourself against such accidents? Easy—standardize on Allen-Bradley resistors!

Allen-Bradley makes *only* one quality of resistors—a premium quality. The many manufacturers who have standardized on Allen-Bradley resistors find these resistors function also as an endorsement of the quality of the instrument in which they are used. Being produced by a unique hot molding process on highly specialized automatic equipment—designed and used only by Allen-Bradley—the resultant uniformity of characteristics from resistor to resistor—from one billion to the next—is not even approached by other resistor manufacturers. In fact, long term resistor performance is accurately predictable. And no user of Allen-Bradley resistors has ever encountered a catastrophic failure in service.

You'll be more fair with your customers when you permit your resistor dollar to buy for you the ultimate in dependability, performance, and uniformity of Allen-Bradley hot molded resistors. Allen-Bradley Co., 222 W. Greenfield Ave., Milwaukee, Wisconsin 53204. Export Office: 630 Third Ave., New York, N.Y., U.S.A. 10017.

HOT MOLDED FIXED RESISTORS are available in all standard EIA and MIL-R-11 resistance values and tolerances, plus values above and below standard limits. Shown actual size.

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ED Technology

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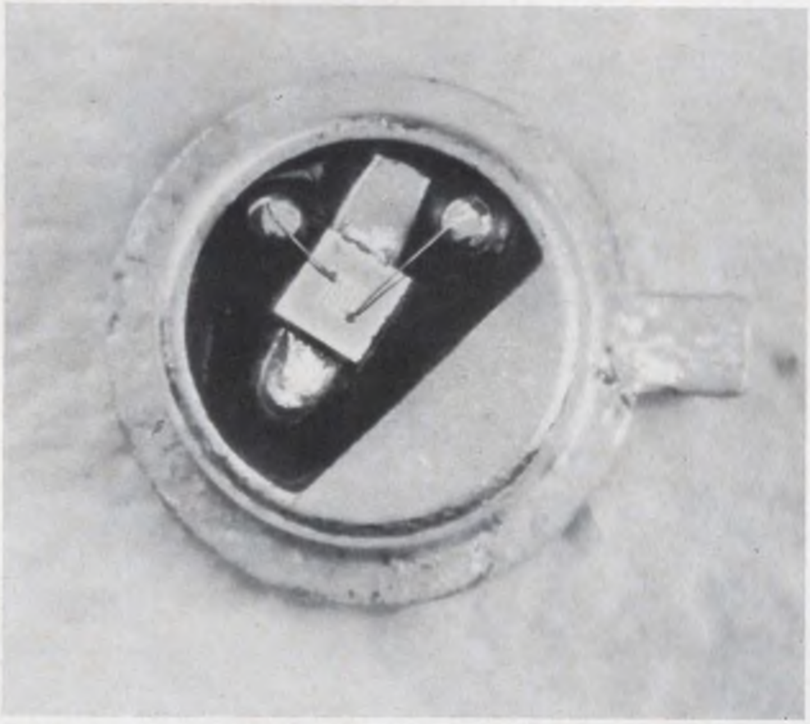
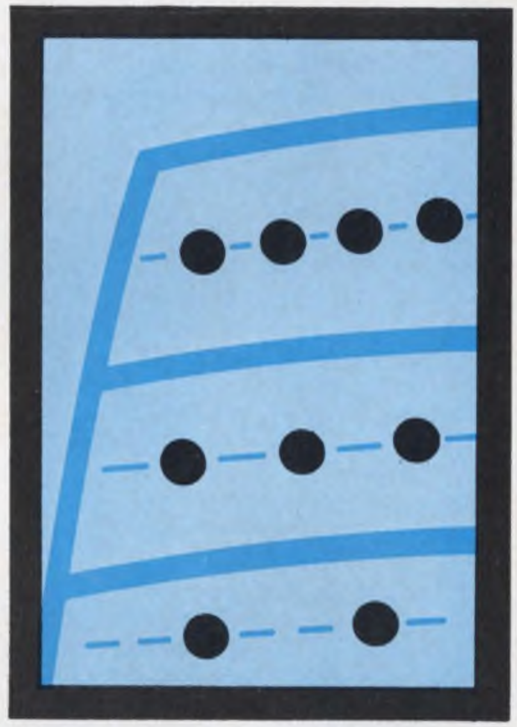
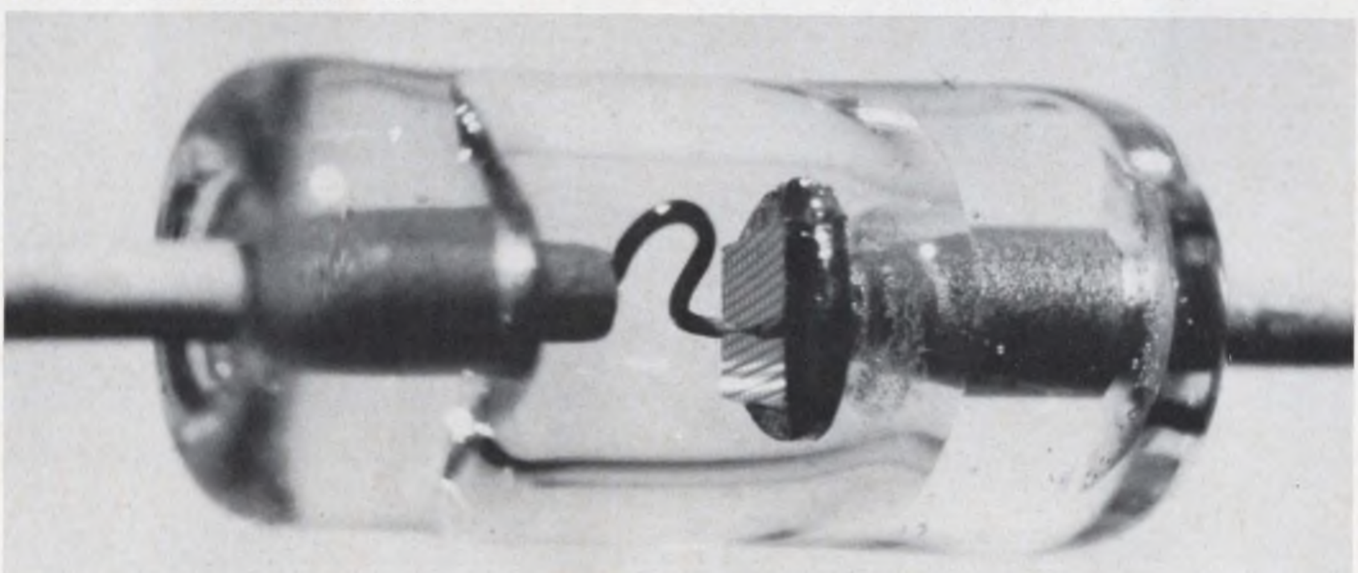
How to design magnetic deflection amplifiers—part II. PAGE 210
Try carpet plotting for fast, accurate interpolation PAGE 226



FETs are a hit in the home. 196



Carpet plotting is easy. 196



Schottky-barrier diode bridges the gap. 178

Hot-carrier diode opens new vistas for designers of high-frequency and microwave devices. Fast, quiet and well-behaved, it combines best of 2 'worlds.'

The hot-carrier, or Schottky-barrier, diode bridges the gap between the *pn* junction diode and the point-contact diode, and, in so doing, it makes possible new design approaches to many high-frequency and microwave devices.

A newcomer that combines the favorable properties of both *pn* and point-contact diodes, the hot-carrier already is finding widespread use in the design of microwave mixers and detectors.

What are its main properties and how does it work?

The hot-carrier diode has these desirable characteristics:

- Fast turn-on and turn-off.
- Low noise.
- Very uniform forward and reverse behavior.
- Lack of charge storage.

In pulse operations, for example, the new diodes are useful for fast gating, clamping, sampling, waveform generating and logarithmic conversion in the fractional nanosecond region.

In the microwave area, they are useful as mixers, detectors, power monitors and rectifiers, limiters, discriminators, harmonic generators, and ultra-fast switches and modulators at nanosecond rates.

The uniformity of forward characteristics between diodes permits a relatively easy and economic selection of matched pairs or quads for use in balanced circuit configurations, or where accurate tracking between circuits is required.

Essentially the hot-carrier diode is a rectifying metal-semiconductor junction. The metal-semiconductor interface can consist of a variety of metals in conjunction with either *n*-type or *p*-type silicon. In general, *n*-type silicon is preferred, because its higher electron mobility results in better high-frequency performance.

The diode is a more efficient rectifier[1] at high frequencies than a *pn* junction type is, because it does not store minority carriers during normal operation (Fig. 1). It is similar in concept and in operation to the ideal point-contact diode, inasmuch as both employ a Schottky barrier and both are based on majority-carrier conduction. In practice, however, their characteristics are quite different (Fig. 2). In the practical point-contact diode, a sharp metal whisker makes contact with the semiconductor element. The hot-carrier diode has a true Schottky-barrier, which is a planar-area contact between the metal and the semiconductor. The planar contact results in uniform contact potential and uniform current distribution throughout the junction. This, in turn, results in:

- Lower series resistance.
- Lower noise.
- Higher power capability.
- Greater resistance to transient pulse burnout.

George N. Kaposhilin, Applications Engineering Mgr., hp associates, Palo Alto, Calif.

Equivalent circuit shows current dependence

The hot-carrier diode's performance conforms closely with theory. Its low-level V-I characteristics can be accurately described by the following equation:

$$i = I_s\left[\exp\left(\frac{qv}{nkT}\right) - 1\right] \tag{1}$$

where

I_s = saturation current (8×10^{-9} A for -hpa-2300 series).
q = electron charge (1.6×10^{-9} coulomb).
T = temperature (°K).
k = Boltzmann's constant (1.38×10^{-23} joule/°K).
n = diode ideality factor (1.05 for -hpa-2300 series).
v = the voltage across the diode junction (volts).

Since n is close to unity, at room temperature (T = 300°K) Eq. 1 can be simplified to:

$$i = I_s\left(\exp\frac{v}{26}\right) - 1, \tag{2}$$

where v is now in millivolts.

The voltage v in Eqs. 1 and 2 is the portion of the applied external bias voltage that appears at the diode junction. At dc and low frequencies this voltage is equal to the total bias voltage, V_a. At microwave frequencies V_a is reduced by the presence of a series inductance and a junction capacitance. This is clear from the equivalent circuit of the diode (Fig. 1). The values of the parameters depend on the specific diode.

The junction resistance R_j and the junction capacitance C_j are both functions of the current through the diode.

The junction resistance can be obtained from Eq. 2 by differentiation:

$$R_j = \frac{dv}{di} = \left(\frac{26}{I_s}\right)\exp\left(\frac{-v}{26}\right) \tag{3}$$

If v is much greater than 26, or if i is much greater than I_s, further simplification is possible:

$$R_j = \frac{26}{i}, \tag{4}$$

where i is in milliamperes.

The junction capacitance C_j can be obtained accurately from the depletion-layer capacitance expression for a step junction:

$$C_j = C_j(0) / \left(1 - \frac{v}{V_b}\right)^{1/2} \tag{5}$$

where

$C_j(0)$ = the zero bias junction capacitance (typically 0.8 pF).
V_b = the built-in potential ($\approx$ 0.45 electron volts).

Typically the series resistance R_s is about 11 ohms, the package capacitance C_p is 0.15 pF and the package inductance L_p is 3 nH, if we assume zero lead length outside the glass envelope.

Mixing and detecting are main functions

Among the many applications of the hot-carrier diode, the most interesting are those of mixing and detecting. The high-frequency attributes of the diode and its characteristic behavior become most evident then. Each application imposes different requirements.

In mixers the diode's noise figure, conversion losses and IF and RF impedances are the critical factors.

In detectors we must distinguish between small-signal and large signal types. In small-signal detectors the most significant factor is sensitivity, which is affected by the diode's rectification efficiency, output impedance and noise properties. In large-signal types the emphasis shifts to the linear range of the V-I characteristic, its reverse resistance and breakdown voltage, and its series resistance.

Noise figure depends on mixer circuit

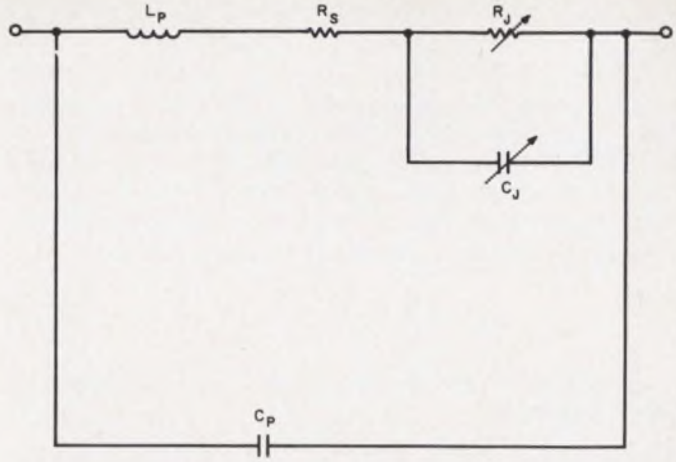
The noise figure of a receiving system, consisting of a mixer followed by a high-gain IF amplifier, is:

$$NF_o = 10 \log [L_m t_m + (F_{IF} - 1)L_m] = 10 \log L_m(F_{IF} + t_m - 1), \tag{6}$$

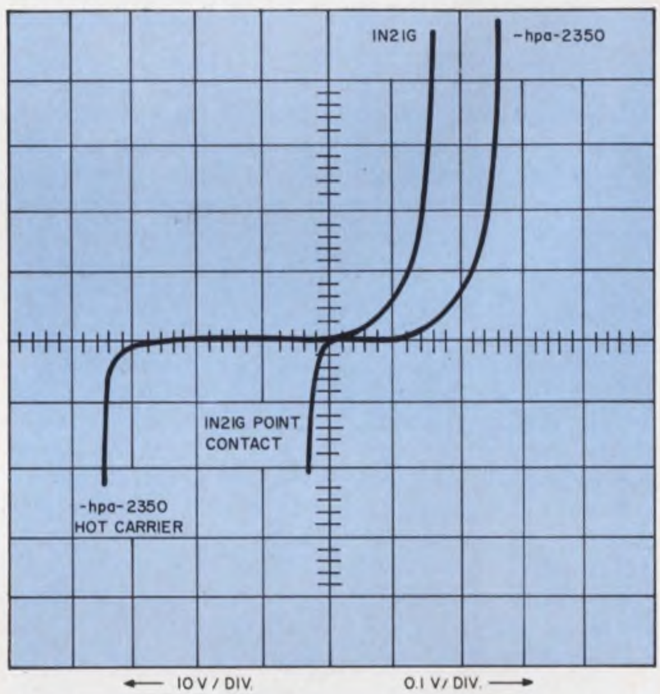
where:

L_m = the effective mixer conversion loss.
t_m = the effective mixer noise temperature.
F_{IF} = the noise factor of the IF amplifier.

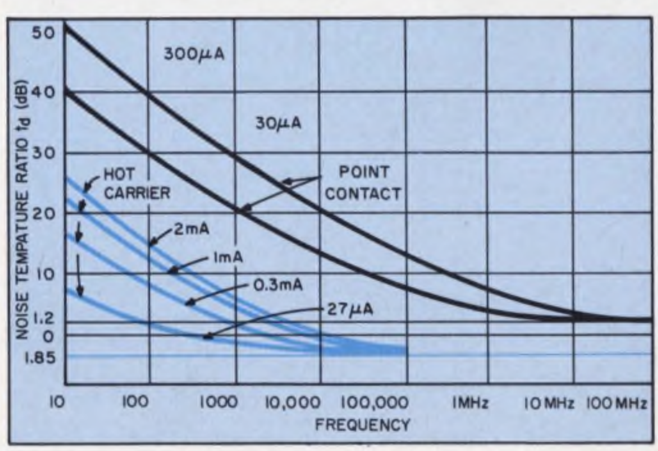
The terms L_m and t_m are characteristics of the mixer and are not the inherent conversion loss, L_d, and the noise temperature ratio, t_d, of the diode. However, it is common practice to state the diode's attributes in terms of its performance in a specific mixer circuit and, hence, to use the terms



1. **Equivalent circuit** of hot-carrier diode shows important parameters. Typical values are: 11 ohms series resistance, 0.15 pF package capacitance, and 3 nH package inductance.



2. **Voltage vs current profiles** of a hot-carrier diode and a point-contact diode show the higher reverse breakdown voltage of the hot-carrier type.



3. **The intristic noise temperature,** t_d, of hot carrier diodes is less than that of point-contact types. The asymptotic value of t_w is shot and thermal noises.

L_m and t_m as characteristics of the diode.

Although both factors can be measured, it is more useful to examine the relationship between these and the inherent properties of the diode.

The effective noise temperature, t_m, is related[3] to the intrinsic noise temperature of the diode, t_d. The expression depends on the image band. If the image frequency is terminated, this relation is:

$$t_m = \frac{2}{L_m}\left[t_d\left(\frac{L_m}{2} - 1\right) + 1\right] \qquad (7a)$$

For the image-open or shorted case, the expression becomes:

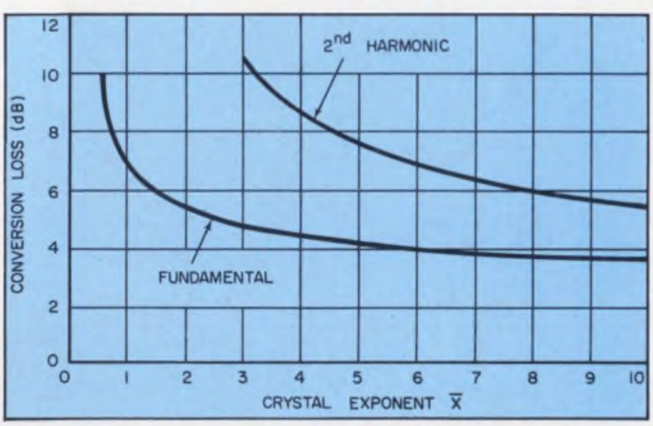
$$t_m = \frac{1}{L_m}\left[t_d(L_m - 1) + 1\right] \qquad (7b)$$

The noise temperature, t_d, is independent of the mixer's frequency. It depends on the quiescent bias current through the diode and on the IF. The variation of t_d (in dB) with the IF for several values of current is shown in Fig. 3 for both a hot-carrier and a 1N21G low-noise, point-contact diode. These curves show that t_d varies inversely with frequency at low frequencies and has a finite, and constant, minimum value at high frequencies. For the hot-carrier diode, t_d can be described accurately:[4]

$$t_d = t_w + \frac{K_n I_d}{f} \qquad (8)$$

The first term in this equation is a constant that stands for the shot and thermal noises. The second term represents the flicker, or 1/f, noise. I_d is the diode current. For an average hot-carrier diode, t_w is typically 0.8, which is lower than for the point-contact types. This is the result of the planar junction, which assures uniform contact potential. K_n is usually around 1.8 Hz/μA. By integrating over the band, we find that the noise temperature in a given band is:

$$t_d = t_w + \frac{K_n I_d}{B}\ln\frac{f_2}{f_1}, \qquad (9)$$



4. **The actual conversion loss** at the diode's junction may be expressed in terms of $\overline{x}$, which is d log i/d log v (a logarithmic relation of the diode's V-I characteristics). The loss decreases rapidly as $\overline{x}$ increases. These curves were plotted while the image frequency in the mixer was matched. As a result, the diode has wide dynamic range.

where:

B = the bandwidth $(f_2 - f_1)$.

f_2 = the upper frequency.

f_1 = the lower frequency.

The noise characteristic in Fig. 3 and the conversion loss determine the noise figure of a mixer for any given IF and bandwidth. The conversion loss, L_m in Eq. 6, is the effective loss realized in a specific mixer. It is really a sum of three types of losses.

The first type of loss depends on the degree of match obtained at the RF and IF ports. It can be expressed as:

$$L_1 = 10\log\frac{(S_1+1)^2}{4S_1} + 10\log\frac{(S_2+1)^2}{4S_2}, \qquad (10)$$

where S_1 is the RF vswr and S_2 is the IF vswr.

The second loss represents a loss of signal power due to the series resistance, R_s, and the junction capacitance, C_j, in the diode. The amount of this loss can be evaluated from the diode's equivalent circuit. This loss is the ratio of the input RF signal power and the power delivered to the junction resistance:

$$L_2 = 10\log\frac{P_{in}}{P_j} = 10\log\left[1 + \frac{R_s}{R_j} + \omega^2 C_j^2 R_s R_j\right]. \qquad (11)$$

R_j is the time average value, established by the local oscillator (L.O.) drive. The loss becomes a minimum when R_j is equal to $1/\omega C_j$:

$$L_{2(min)} = 10\log(1 + 2\omega C_j R_s). \qquad (12)$$

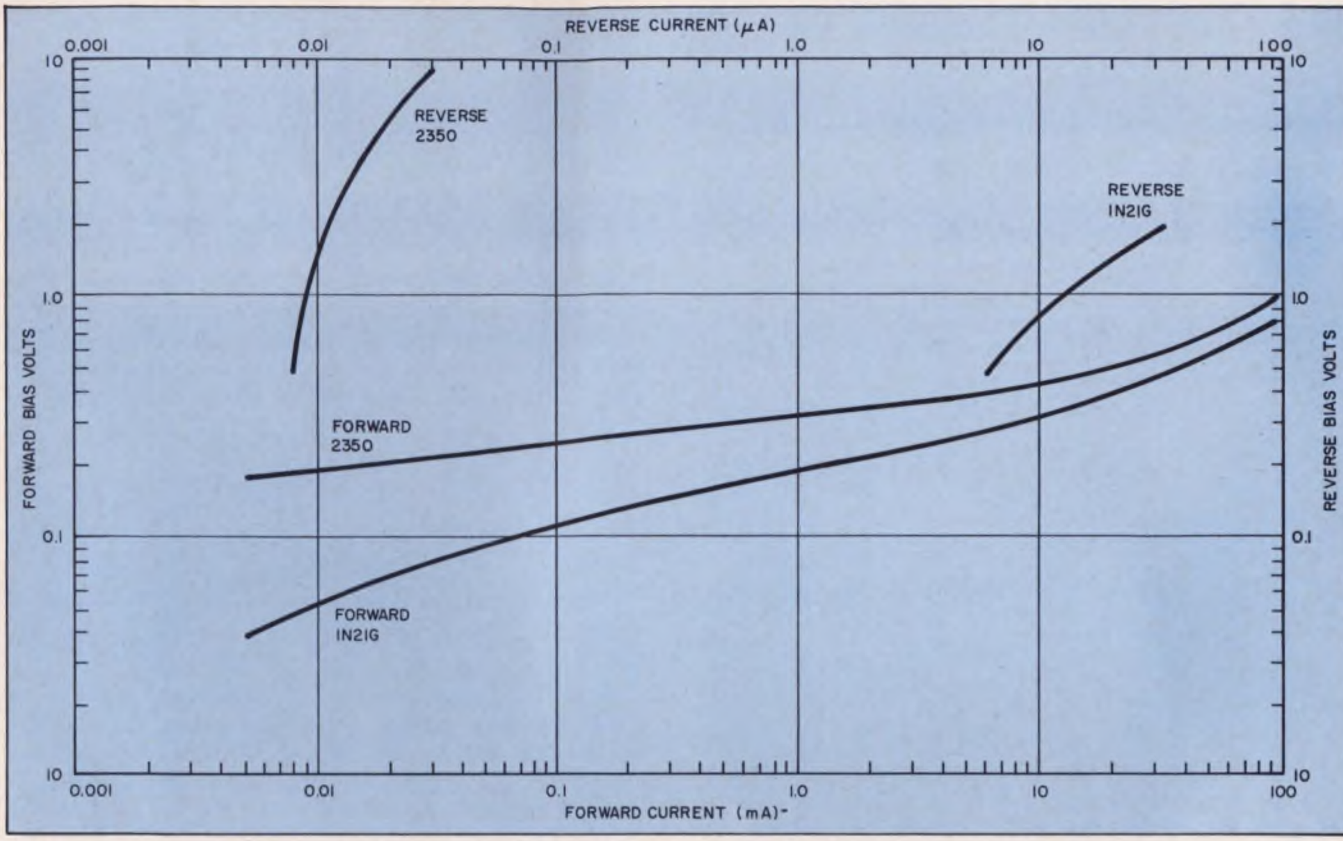
To achieve this value at a specific operating frequency, the L.O. drive level must be increased until the required R_j is reached. This level of drive is the optimum required at that frequency. For example, at 2 GHz it is approximately 1 mW for the -hpa- 2350 diode. The loss described by Eq. 11 is more pronounced at lower drive-signal levels than at high ones. This can be compensated for by introducing a constant dc bias on the diode in the forward direction. The increase in the drive signal brings along a decrease in the noise. However, care must be exercised in this trade-off to avoid introducing excessive noise with the dc bias current.

The third factor affecting the over-all conversion loss is the actual conversion loss at the diode junction. This depends mainly on the forward V-I characteristic. If the V-I characteristic is expressed as:

$$i = K v^{\overline{x}} \quad \text{for } v > 0,$$
$$i = g_b v \quad \text{for } v < 0, \qquad (13)$$

where $\overline{x} = d(\log i)/d(\log v)$, the reverse conductance is g_b and K is a constant factor, then the minimum available conversion loss is a function of $\overline{x}$ only.[5,6] For the image-terminated case, this function becomes.

$$L_{3(min)} = \left(1 + \frac{\sqrt{1+\gamma_2 - 2\gamma_1^2}}{1+\gamma_2}\right)\left(\frac{1+\gamma_2}{\gamma_1^2}\right), \qquad (14)$$



5. **The value of $\bar{x}$** is the slope of the log-log plot of the V-I characteristics, shown here. For hot-carrier diodes $\bar{x}$ is much larger and remains constant over a larger range of diode current than for point-contact types. This results in low conversion losses over a very broad range of local oscillator drive in mixers.

$$\text{where } \gamma_1 = \frac{\left(\frac{\bar{x}-1}{2}!\right)^2}{\frac{\bar{x}}{2}!\,\frac{\bar{x}-2}{2}!},$$

$$\gamma_2 = \frac{\left(\frac{\bar{x}-1}{2}!\right)^2}{\frac{\bar{x}+1}{2}!\,\frac{\bar{x}-3}{2}!}.$$

From the plot of Eq. 14 (Fig. 4), we can conclude that the conversion loss decreases rapidly for increasing $\bar{x}$. The value of $\bar{x}$ is the slope of the log-log plot of the V-I characteristics, and it can be determined from:

$$\bar{x} = \frac{\log \frac{i_2}{i_1}}{\log \frac{v_2}{v_1}}, \qquad (15)$$

where $i_2 > i_1$ and $v_2 > v_1$. From the plot of this equation (Fig. 5), it can be seen that $\bar{x}$ is about 8.8 for the hot-carrier diode and it remains high and constant over a large range of diode current (0.01 to 10mA). For the point-contact diode $\bar{x}$ is about 4.3, and its range is from 0.2 to 5mA. This means that the hot-carrier diode can have a low junction conversion loss over a very broad range of L.O. drive.

The curves in Fig. 5 imply two addition facts:

- High L.O.s level will yield a very large dynamic range, up to the point where the decrease in x will affect the conversion loss.
- Low L.O. drive levels will yield good sensitivity.

Besides these two conflicting restrictions, the drive signal is mainly limited by the need to minmize L_2.

The over-all conversion low is the sum of these three factors: $L_m = L_1 + L_2 + L_3$ dB.

Impedance depends on drive signal

In addition to the diode's noise properties, two more characteristics have bearing on the practical design of hot-carrier diode mixers. These are the RF and IF impedances of the diode.

At typical IF (30 to 60 MHz), the reactances due to L_p, C_p and C_j are negligible. Therefore the IF impedance is a pure resistance. The typical value of this resistance (given in Fig. 6) indicates that for the optimum L.O. drive of 1 mW, it is around 180 omhs. This is about one-half the value obtained for point-contact diodes, and it is in the range of the normal impedance levels of low-noise, transistorized IF amplifiers. This considerably reduces matching problems. For example, in the case of balanced mixers, the combined impedance of the two diodes is about 90 ohms, and practically no matching is needed.

At higher RF the impedance is influenced by C_p, C_j and L_p. Therefore the impedance becomes complex and depends on the frequency, the drive signal and on the output RF load.

How to design small-signal detectors

As mentioned, the diode affects the detector's sensitivity by its rectification efficiency, output impedance and noise properties.

The rectification efficiency of the diode is usually stated as either its current sensitivity, β—meaning the ratio of incremental output current to the RF input power—or its voltage sensitivity, γ—meaning the ratio of incremental output voltage to the RF input power. The two are interrelated, as follows:

$$\beta = \frac{\Delta i}{P_{in}}, \qquad (16)$$

and

$$\gamma = \frac{\Delta v}{P_{in}} = \beta R_v, \qquad (17)$$

where R_v is the dynamic resistance of the diode, called video impedance or video resistance.

By a Taylor expansion of the diode's characteristic, represented by $i = I_s\,(e^{uv})$, where $u = q/nKT$ (Eq. 1), it can be shown that the current sensitivity is:

$$\beta = \frac{u}{2}\left[\frac{1 + \left(\frac{Au}{4}\right)^2}{1 + 2\left(\frac{Au}{4}\right)^2}\right], \qquad (18)$$

where A is the peak amplitude of the voltage at the diode junction.

At low signal levels the bracketed factor is approximately unity, and detection is in the square-law region. The upper limits of square-law operation are shown in Fig. 7, as the bracketed term deviates from unity by 0.5, 1 and 1.5 dB.

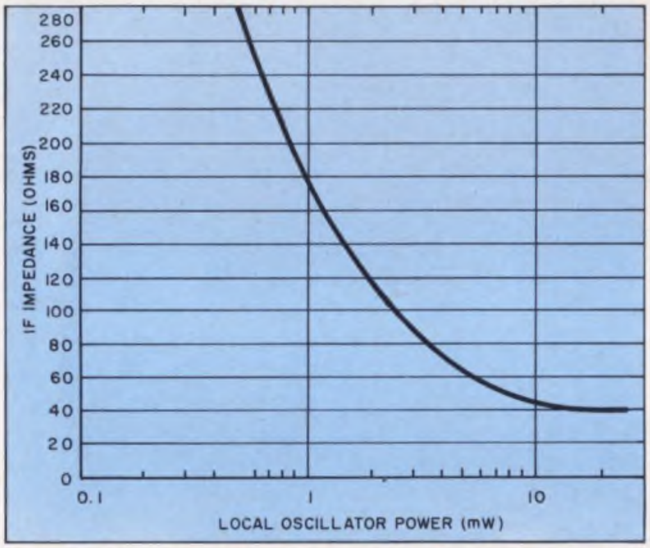
The low-level current sensitivity for these diodes is typically 18.4 μA/μW for an n of 1.05. For higher values of n, β will be correspondingly smaller. For the point-contact diode, the value of n at low signals is typically 1.7-1.9, and the corresponding current sensitivity is 11-10 μA/μW.

The current sensitivity, as defined above, is based on the junction characteristics of the diode and does not include the effects of the series resistance and the junction capacitance of the diode. These effects can be included by defining a conversion efficiency of the diode as follows:

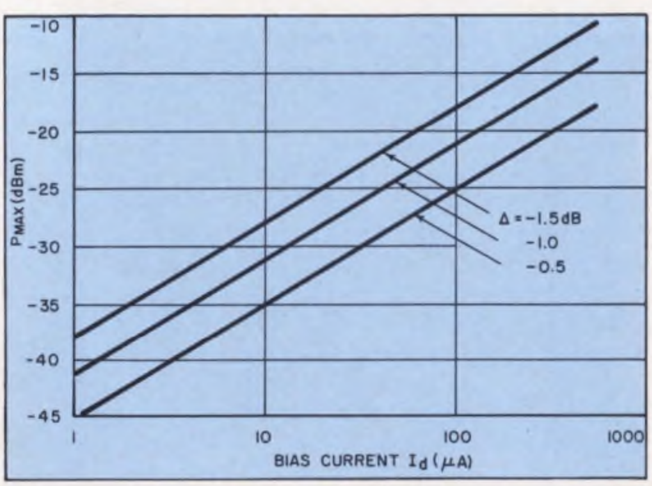
$$\beta_c = \beta\left(\frac{P_j}{P_{in}}\right) \qquad (19)$$

The factor P_j/P_{in} represents the ratio of the power delivered to the junction to the input power. This factor depends on the frequency and the bias, and it increases rapidly with the latter at low bias levels (Eq. 11).

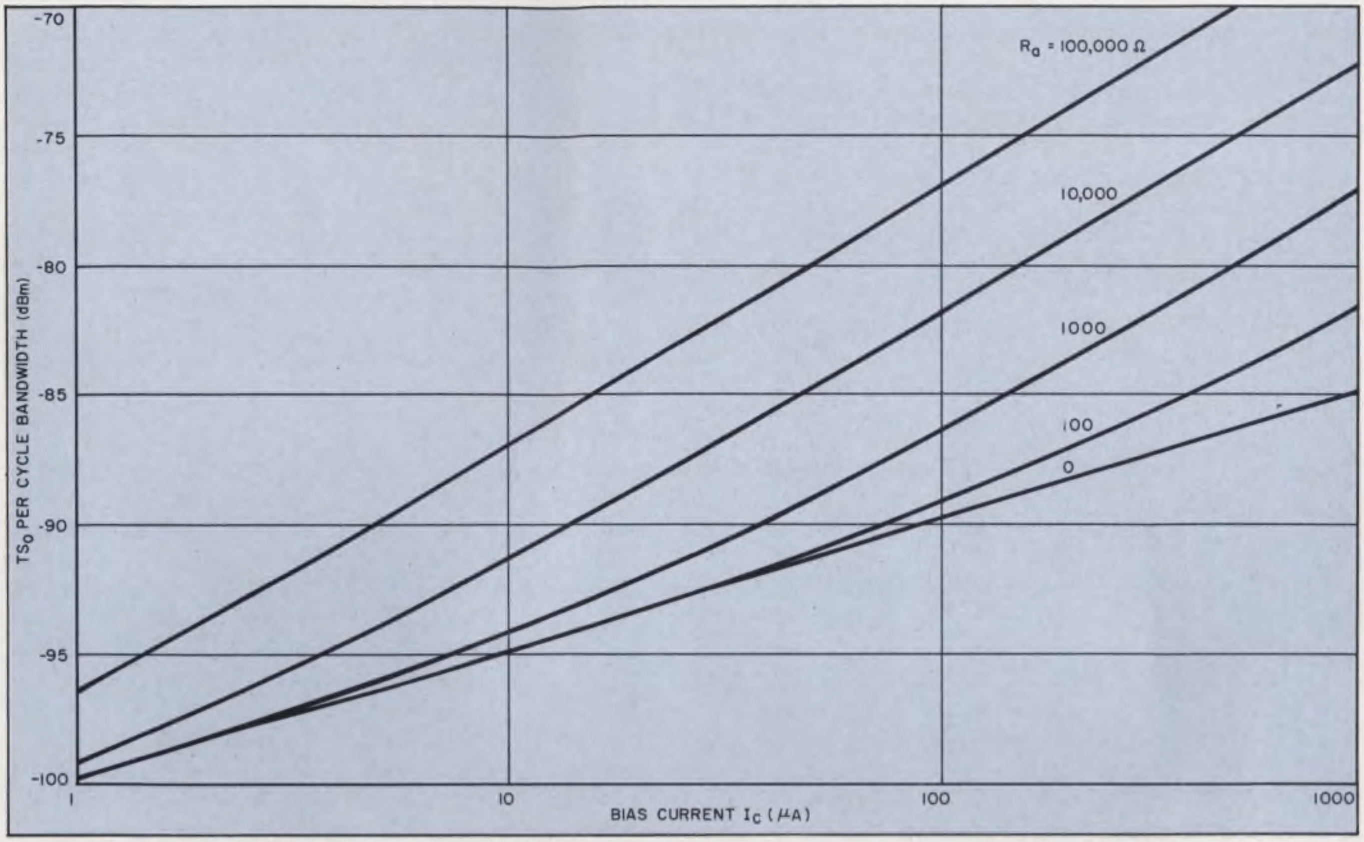
In normal detector operation the self-bias-current is extremely small, resulting in low β_c. This situation can be improved by a forward external bias on the diode. It also lowers the RF and the output, or video, impedance of the diode. The lower RF impedance makes it easier to match the input impedance of the diode to the usually low impedance of the RF source (typically 50 ohms). The lower output impedance permits the use of a lower imput impedance in the amplifier and results in increased bandwidth for the output circuit. This is particularly beneficial when transistorized amplifiers, with low input impedances, are used. However, there is also a limit as to how much bias can be tolerated. This limit is set by the 1/f noise characteristics of the diode, shown in Fig. 3, and by the amplifier's noise properties.



6. **At typical IF** (30 to 60 MHz) the impedance of hot-carrier diodes is a pure impedance and depends only on the level of the local oscillator drive signal. For hpa-2350 diodes the impedance is around 180 ohms at the optimum local-oscillator level of 1 mW. In the case of balanced mixers the combined impedance is about 90 ohms, eliminating the need for extra matching circuits for IF amplifiers.



7. **Upper limit of square-law operation** in small-signal detectors depends on the amount of deviation from square-law detection, denoted by Δ. This deviation appears in Eq. 18, where the bracketed factor will become larger than unity.



8. **The dc tangential sensitivity,** TS_o, decreases with increasing bias current and with increasing R_a. R_a is the noise resistance of the amplifier used in the detector. The flicker noise has been neglected.

Consequently a trade-off possibility is indicated. The optimum amount of bias depends on the effect of the conversion efficiency and the noise on the sensitivity of the detector.

Trade-offs to optimize sensitivity

The most common definition of sensitivity in industry, the tangential sensitivity (TS), will be used here, even though it is a highly subjective measurement and depends upon the operator. It corresponds to a signal-to-noise ratio of approximately 2.5. With Eqs. 16 and 18, the TS can be stated as:

$$TS = \frac{5i_n}{u\left(\frac{P_j}{P_{in}}\right)}, \qquad (20)$$

where i_n is the total noise current at the input to the amplifier. It includes the contributions of the diode junction (given by Eq. 9); of the diode's dynamic resistance, $R_v = R_j + R_s$; of the load resistance, R_L, and of the equivalent noise resistance of the amplifier referred to the input, R_a. With the simplifying assumptions that $R_a/R_L << 1$ and $R_L > 5\ R_v$, the following expression for i_n can be obtained:

$$i_n = \sqrt{\frac{4kT\beta}{R_v}\left(1 + \frac{R_A}{R_j}\right)} \qquad (21)$$

where β is the bandwidth of the output circuit. Substituting this into Eq. 20 and rearranging terms, we can express the TS as follows:

$$TS_{(dBm)} = 10\log\left[\frac{5\sqrt{4kT}}{u}\frac{\sqrt{R_v + R_j}}{R_j}\sqrt{\frac{R_j + R_a}{R_j}}\right] + 10\log\left[1 + \left(\frac{f}{f_c}\right)^2\right] + 5\log B \qquad (22)$$

$$= TS_o + TS_f + 5\log B,$$

$$\text{where } f_c = \sqrt{1 + R_s/R_j}\Big/\left(2\pi C_j\sqrt{R_s R_j}\right) \qquad (23)$$

($R_A = R_a$ + flicker noise, which starts to become important below 100 KHz).

The first bracketed term in this expression can be considered as the "zero frequency" tangential sensitivity, TS_o. This term depends on R_a and R_j. The latter is a function of bias current, and R_a is a constant for a given amplifier. The variation of TS_o with the bias for several values of R_a is shown in Fig. 8. TS_o decreases with increasing bias. (Fig. 9 shows the diode.)

The second bracketed term, here defined as TS_f, accounts for the variation in sensitivity with the RF frequency and the cut-off frequency. The latter term changes with the bias current. The effect of this dependence is an increase in sensitivity with increasing bias (Fig.10).

The last term in the expression accounts for the usual variation of sensitivity with bandwidth.

The optimum bias current for any given RF frequency and noise characteristic can be obtained by considering the variation of the slopes of TS_o and TS_f with bias. A plot of these slopes is shown in Fig. 11. The optimum bias current is found at the intersection of the specified R_a curve with the required frequency curve. The values of TS_o and TS_f, corresponding to this bias point, are then obtained from Figs. 8 and 10, respectively. The final tangential sensitivity for a specified bandwidth is obtained from Eq. 22. A comparison of the predicted and measured TSs of the -hpa- 2350 diodes, at a 27-μA bias, is shown in Fig. 12.

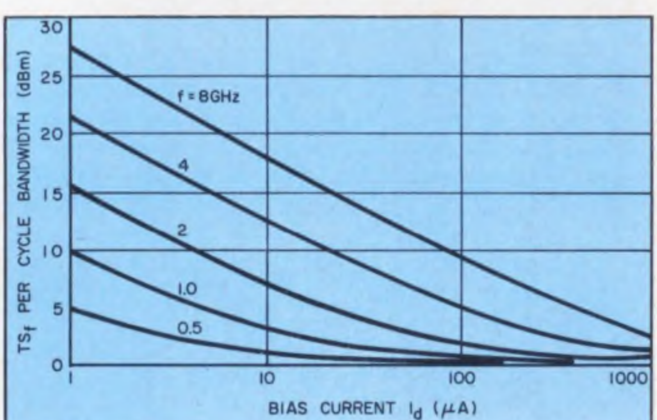
The output resistance of the diode, R_r, is also established by the choice of bias current, since it is equal to $R_s + R_j$. For the best sensitivity and the highest square-law range, the load resistance should be as high as possible relative to the diode output resistance. Therefore the lower output resistance, made possible by the bias, results in a lower load impedance. Since the load is usually the input resistance of an amplifier, this places less stringent requirements on the input resistance of the amplifier.

The output resistance of the diode, in conjunction with the capacitance of the output circuit, also determines the bandwidth of the output circuit. The lower output resistance of the diode permits the use of higher output capacitances, which are needed to maximize the RF power delivered to the diode.

How to design large-signal detectors

In large-signal or linear detection the most important characteristics of the diode are its low series resistance, large linear range of the V-I characteristic, high reverse resistance, and high reverse breakdown voltage.

9. **Schottky-barrier diode** has a multiple pad surface which allows whisker contact to any one of the metal pads.



10. **The frequency-dependent sensitivity factor, TS** increases with increasing bias current. It also depends on the cut-off frequency, f.

The requirements for the RF input circuit for large-signal detectors are the same as for low-level detectors: The circuit must be designed for a good match or low vswr.

The RF bypass capacitance at the output of the diode must be high enough to provide a good short at the RF frequency, consistent with the RC requirements of the output circuit.

The RC time constant of the output circuit must be sufficiently small to assure that the output voltage follows closely the peaks of the modulated RF signal. The RC time constant is therefore a function of both the maximum modulation frequency and the index of modulation. Because of the high reverse leakage characteristics of point-contact diodes, the RC time constant is highly influenced by the reverse resistance of this diode, and it is dependent on the drive level. The extremely high and constant reverse resistance of the hot-carrier diodes relieves this restriction, and therefore the design of the output circuit depends only on the modulation requirements.

The linear range of the diode must be sufficiently large to assure linear detection at the crest and valley points of the modulated RF waveform, as determined by the modulation index. Because of the high levels of drive used in linear detection, the diode is usually substantially back-biased. Under these conditions, the ability to operate in the linear region at both the crest and valley points of the modulated waveform is determined by the reverse breakdown voltage. Higher reverse breakdown voltage of the hot-carrier diode allows operation at higher peak signal voltages, thereby assuring linear detection for larger modulation indexes or higher available power levels. For hot-carrier diodes, the minimum RF signal level at which peak detection begins is approximately 0.1 volt rms. The upper limit is that at which the peak-to-peak RF voltage equals the reverse breakdown voltage, or $BV_r/2\sqrt{2}$ volts rms. ■ ■

Acknowledgement:

The author wishes to acknowledge the very helpful assistance and technical advice of several members of the -hpa- technical staff. Particular thanks are owed to Mike Cowley for assistance in theoretical aspects of hot-carrier operation and to Hans Sorensen for the analytical analysis of detector operation.

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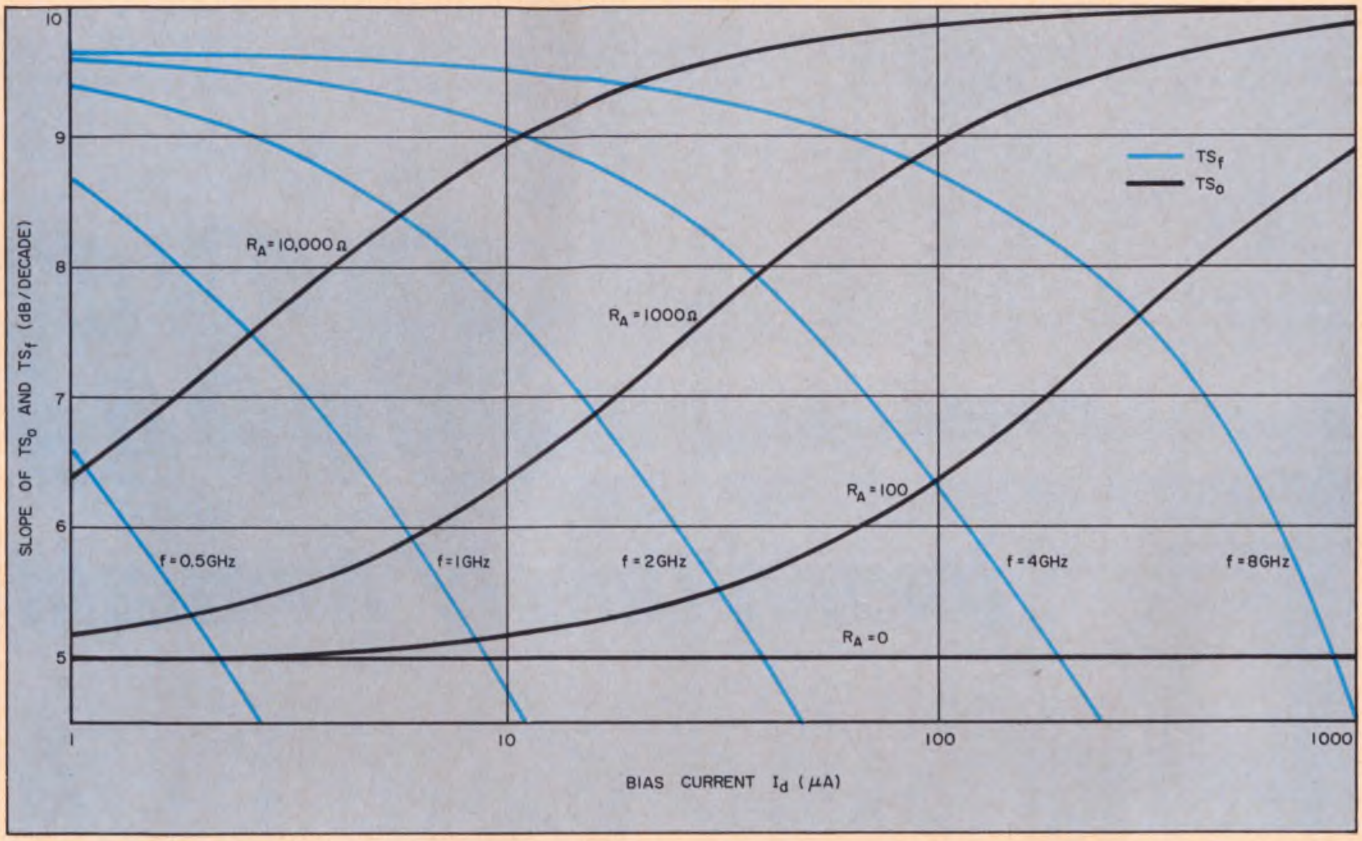
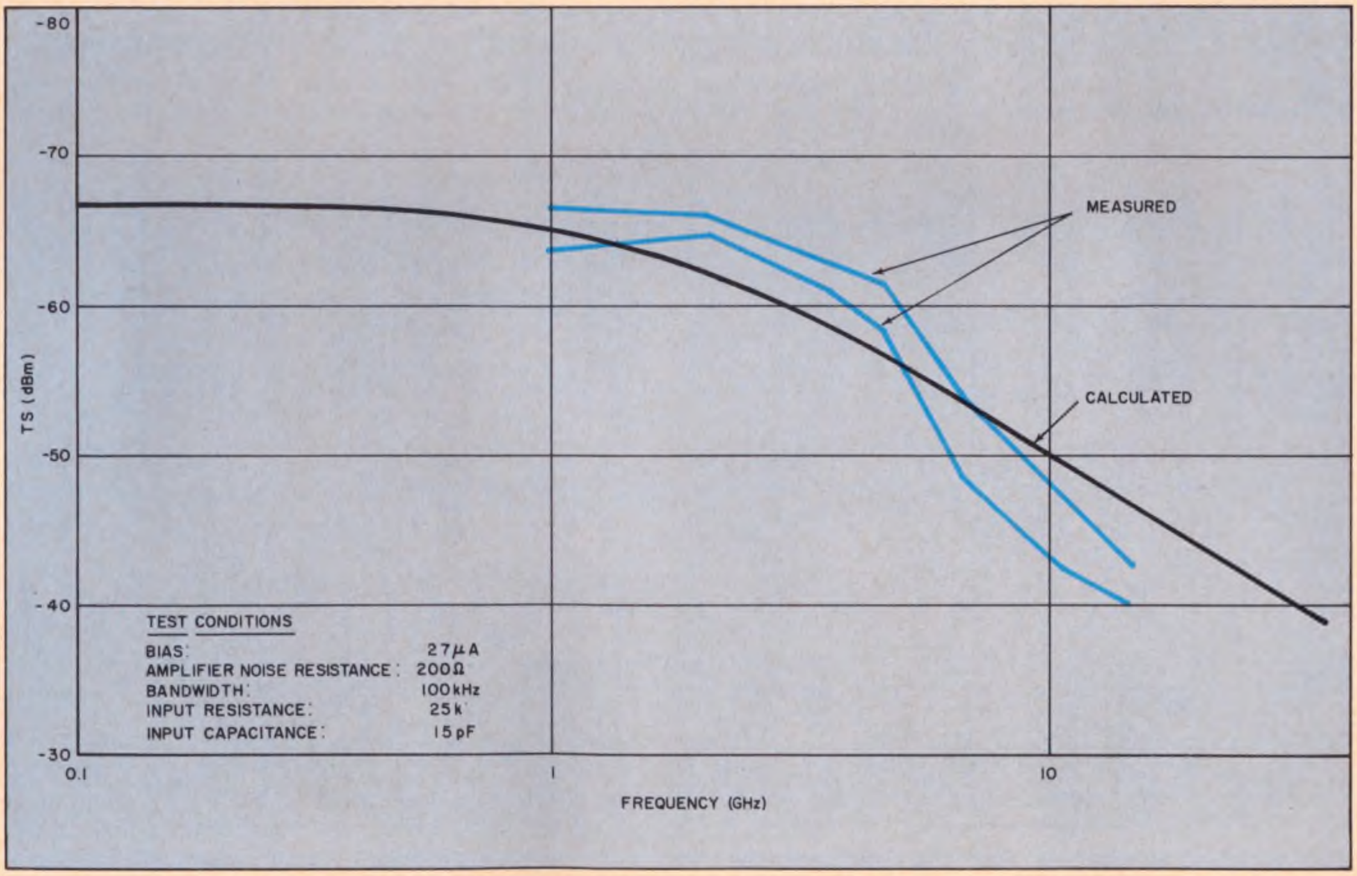


11. **Optimum bias current** for a specified frequency, **f**, and noise resistance, R_a, may be found from the intersection of these two sets of curves. The curves indicate the variation of the slopes of TS_o (solid lines) and TS_f (color), with the bias current. We can find TS_o and TS_f with the aid of Figs. 9 and 10.



12. **A comparison of measured and calculated sensitivity values** for hot-carrier diodes indicates a close correlation. The test conditions were determined for an -hpa- 2350 diode.

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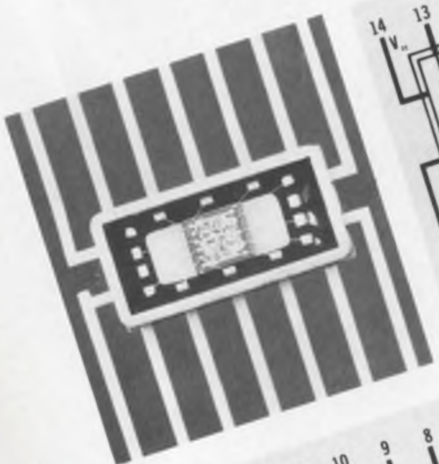

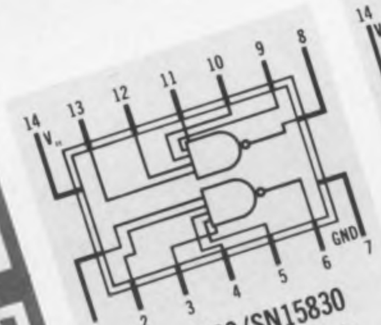

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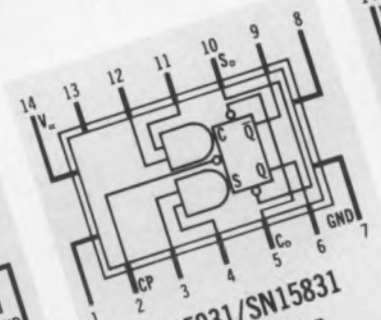

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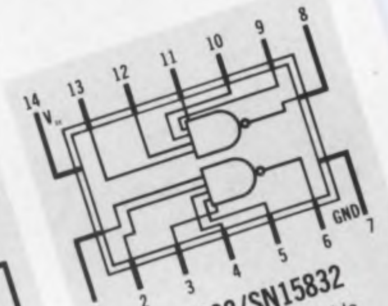

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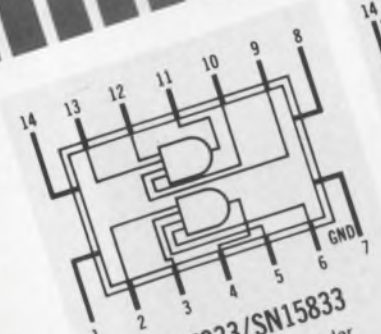

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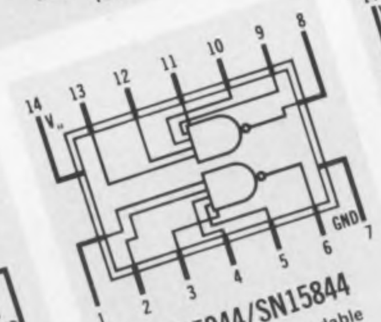

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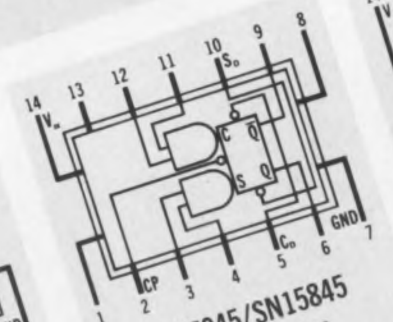

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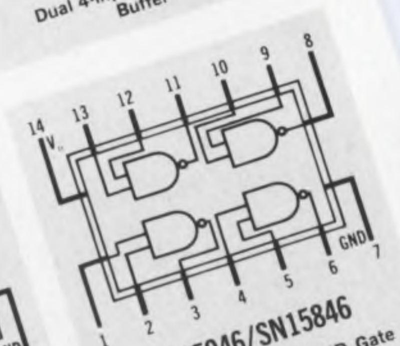
High-performance J-K/R-S Flip-flop



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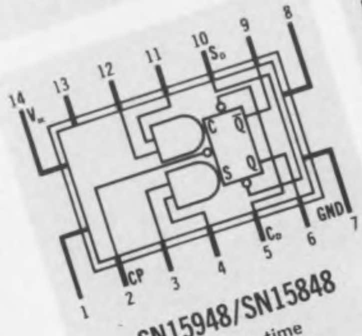
Quadruple 2-input NAND Gate



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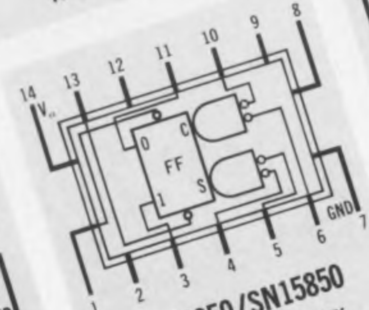
Fast-rise-time J-K/R-S Flip-flop



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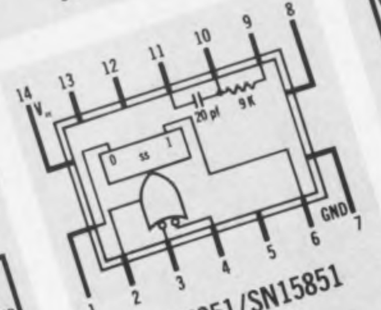

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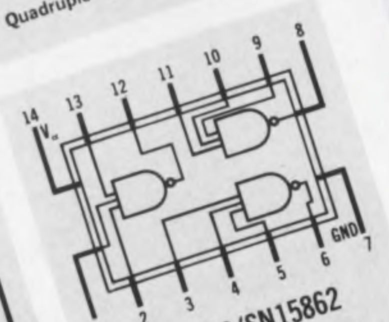

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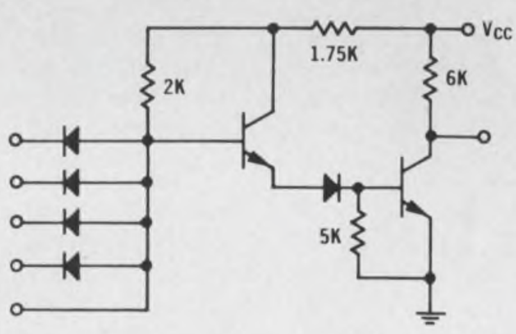
TYPICAL CHARACTERISTICS

Parameter	Basic Gate	Flip-flop
Propagation delay	25 nsec	50 nsec
Power dissipation	5 mw	20 mw
Fan-out	8	7
D-c noise margin	750 mv	750 mv
Supply voltage	4.5 to 5.5 v	4.5 to 5.5 v
Temperature range		
Series 15930	–55° to +125°C	–55° to +125°C
Series 15830	0° to 70°C	0° to 70°C

Typical circuit diagram for Series 15930/15830 NAND gate



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Try capacitance transducers. You just might be surprised at the advantages. Here are equations and useful circuits for applying this versatile sensor.

If capacitance transducers had feelings, they might feel neglected. They have been available for decades, and they have certain inherent advantages; yet engineers have not exploited them nearly as much as other transducer types—such as, linear variable voltage transformers, potentiometers or strain gages. Why?

In large part the neglect has been due to difficulties encountered with associated circuitry and to misapplication. But, with care, these pitfalls can be avoided. The advantages of the capacitance transducer can then be used in a diversity of applications.

The principle of the capacitance transducer is simple. All that is required is that the physical parameter being measured or controlled be made to produce a capacitance change. This change is then sensed by one of many different types of electrical circuits. As shown in the accompanying table, many physical parameters can be sensed in this way.

Capacitance transducer applications

Application	Remarks
Aircraft fuel gauges	Capacitance-type gauges were first developed for military aircraft in the early 1940's. Today they are virtually the only type of fuel and liquid-oxygen gauges used in aircraft.
Level detectors	These are either in the form of coaxial units—such as one tube inside the other, arranged so that the liquid rises between the plates—or as a metal tube with an insulating material, such as Teflon, coating the outside.
Interface detectors	These are used to detect the interface between two liquids having a large difference in dielectric constant, or between two liquids, one of which is conductive and the other nonconductive.
Pressure sensors	Capacitance method permits use of extremely small sections. This makes possible devices with very high frequency response characteristics and capable of being placed in very hot or corrosive environments.
Proximity sensors	Unlike magnetic proximity sensors, capacitance devices will sense the change in a given electric field of any material—magnetic or nonmagnetic, metallic or nonmetallic.
Moisture detectors	In these applications the capacitance transducer is arranged so that it senses a very small change in dielectric. Such devices have been used widely in detecting moisture in thin paper sheets, cloth and certain granulated materials, as well as in the oil industry, where they have detected small amounts of water in the oil being pumped out of the ground.

Dielectric constant is frequency dependent

Basic capacitance theory is well enough known to forego repetition of it. However, there is one theoretical consideration of special significance for transducer purposes. That is the relaxation time associated with the dielectric constant of a material.

Normally the dielectric constant is considered in either a static electric field or in one where the frequency is low enough to permit the dielectric dipoles to achieve a steady-state condition during each cycle. The formation of the dipoles, however, consists of moving masses (the electrons and nuclei), which have inertia. It is thus apparent that as the electric field frequency is raised, a condition will be reached where the inertia of the dipole will be too great to respond to the change in the electric field. Consequently the apparent dipole moment will be reduced to its intrinsic value, or the one it would have without the presence of the

R. J. Levine, Technical Director, Penn Meter Div., Badger Meter Co., Philadelphia.

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electric field.

This phenomenon is shown in Fig. 1 for a material of low density. Although the relaxation frequency (ω) varies with different materials, it generally lies at or above a frequency of about 10^9 cps. As a result, the apparent dielectric constant decreases from its original, or so called static, value (ϵ_s) toward its so called optical value (ϵ_∞), with the latter being equal to the square of the index of refraction. It can be shown that for low-density materials the relaxation frequency occurs at the value

$$\frac{\epsilon_s + \epsilon_\infty}{2}$$

This phenomenon can be recognized as one commonly associated with reactive circuits, where the quantities are vector rather than scalar. The dielectric constant can thus be considered to be made up of both a real and imaginary component, such that the real component (ϵ') is

$$(\epsilon_s + \epsilon_\infty)/2$$

and the imaginary component (ϵ'') is

$$(\epsilon_s - \epsilon_\infty)/2$$

The tangent of the angle of the ratio of these two components, tan δ, is the dissipation factor. An interesting plot showing this parameter in a pure dielectric, with the theoretical values indicated, is presented in Fig. 2.[1] This phenomenon at the sub-optical frequency is one that may be very useful in instrumentation, both as an analytical tool and as a means for sensing mass or flow.

Application dictates transducer configuration

To use capacitance techniques to sense the presence or amount of materials, or as pressure or displacement sensors, it is necessary to put the sensing elements into one of many different forms, so that they become transducers. The number of possibilities is limited only by the imagination and ability of the application engineer and designer. The most common forms—as well as some that are not so well known—are shown in Fig. 3a through 3k, where dimensions are given in inches, angles in degrees and capacitance in picofarads (pF). In the equations shown on these illustrations, all logarithms are to the base 10.

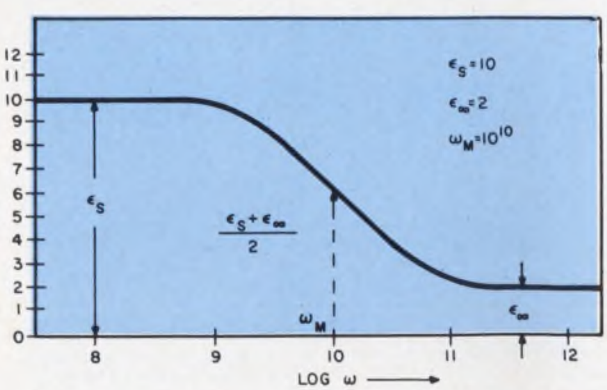
Fig. 3a shows the most common capacitor, which consists of two or more flat plates with or without a dielectric between them.

Since it is frequently necessary to protect the plates or electrodes of a capacitive transducer with a nonconductive coating, the expression for the capacitance of a device like this, with more than one dielectric, is given for both the flat plate (Fig. 3b) and the cylindrical form (Fig. 3d). It should be noted that, in general, the contribution of each dielectric is always the sum of 1 over each thickness divided by its dielectric constant. The maximum value of the capacitance is always equal to the capacitance that will be obtained if one of the dielectrics becomes a conductor, with the other dielectric being of the value and thickness chosen. The resulting function of capacitance vs changing dielectric constant is a curve that is asymptotic to the capacitance of the single dielectric device.

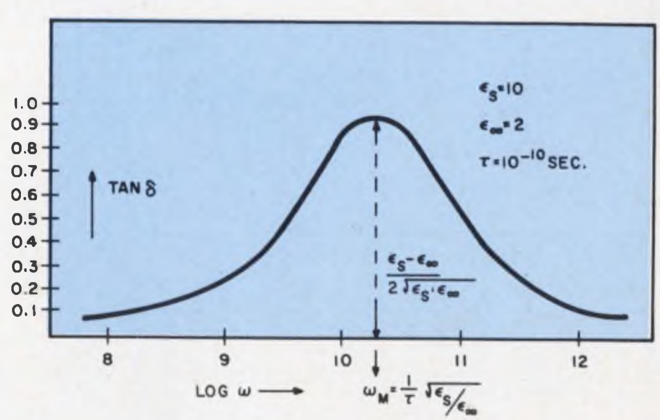
In the measurement of liquid level, a very common form of capacitance transducer is the one shown in Fig. 3c and 3d. Fig. 3c depicts one cylinder inside of another in the form of a coaxial capacitor. A linear capacitance versus liquid-level function is obtained as an insulating liquid rises between the two electrodes. However, if the liquid being measured is conductive, the inner electrode must be insulated to prevent it from being short-circuited, and the arrangement becomes that shown in Fig. 3d.

The curve in Fig. 4 shows the capacitance of such a device, with a 3/8-inch metal rod covered with a 1/16-inch-thick Teflon sleeve, sealed at the bottom. This is the sort of curve that is used by application engineers who specify capacitance probes for electrically nonconductive materials whose dielectric constants range between 1 and 50.

From a practical point of view, there are not many cases when the dielectric constant of the material suitable for capacitance gauging is over approximately 30, although some long-chained molecules with higher values are found in the chemical and pharmaceutical industries. Fig. 4 shows the variation in probe capacity, both as a function of different dielectric constants and as a function of the diameter of the outer electrode.

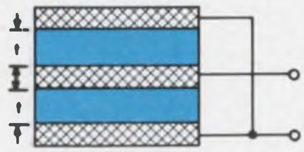
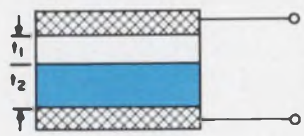
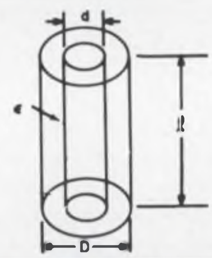
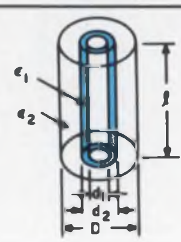
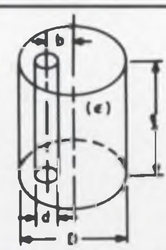
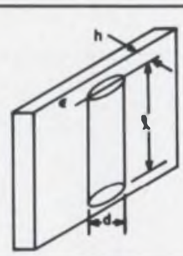
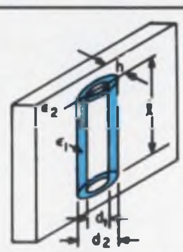


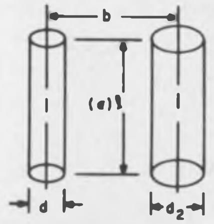
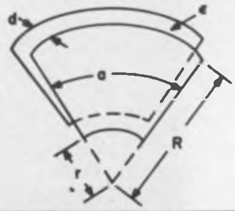
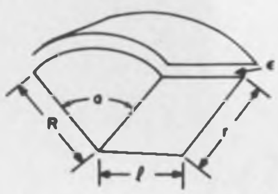
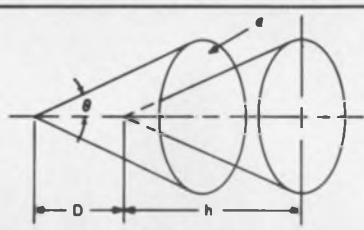
1. **Dielectric constant decreases** with increasing electric-field frequencies of about 10^9 Hz and higher. This is shown for a low-density material.



2. **Resonant-like characteristic** is exhibited by the dielectric constant when it is considered to be made up of a real and an imaginary component.

3. Transducer arrangements and capacitance formulas.

TRANSDUCER ARRANGEMENT		CAPACITANCE FORMULA	NOTES
a. PARALLEL PLATES		$C = \frac{0.225\,\epsilon A(N-1)}{t}$ pF	$A = in^2$ N = NUMBER OF PLATES ϵ = DIELECTRIC CONSTANT
b. PARALLEL PLATES (MULTIPLE DIELECTRICS)		$C = \frac{0.225A}{\frac{t_1}{\epsilon_1} + \frac{t_2}{\epsilon_2} + \cdots}$ pF	
c. COAXIAL CONCENTRIC		$C = \frac{0.614\,\epsilon \ell}{\text{LOG } D/d}$ pF	
d. COAXIAL CONCENTRIC TWO DIFFERENT DIELECTRICS BETWEEN PLATES		$C = 0.614\ell \left[\frac{\epsilon_1 \epsilon_2}{\epsilon_1 \text{ LOG } \frac{D}{d_2} + \epsilon_2 \text{ LOG } \frac{d_2}{d_1}}\right]$ pF	
e. ECCENTRIC CYLINDERS		$C = \frac{0.614\,\epsilon \ell}{\text{LOG } \frac{\left(\frac{D}{2}\right)^2 - b^2}{D/2 \times d/2}}$ pF	
f. ROD NEXT TO INFINITE FLAT WALL		$C = \frac{0.614\,\epsilon \ell}{\text{LOG } \frac{4h}{d}}$ pF	ϵ SURROUNDS ROD. h MUCH GREATER THEN d
g. INSULATED ROD NEXT TO INFINITE FLAT WALL		$C = 0.614\ell \left[\epsilon_1 \text{ LOG } \frac{4h}{d_2} + \epsilon_2 \text{ LOG } \frac{d_2}{d_1}\right]$ pF	ϵ_1 COMPLETELY ENCLOSES ROD ϵ_2 BETWEEN ROD AND WALL. h MUCH GREATER THEN d_2.

TRANSDUCER ARRANGEMENT		CAPACITANCE FORMULA	NOTES
h. TWO PARALLEL CYLINDERS		$C = \frac{0.614\epsilon l}{\log \frac{2A}{d_2}}$ pF $A = \frac{2b^2}{d_1}$	$b \gg d_2 > d_1$
i. ROTARY PARALLEL PLATES		$C = 0.00196\,\epsilon\left[\frac{(R^2 - r^2)a}{d}\right]$ pF	
j. SEGMENT OF ROTARY CYLINDER		$C = 0.00196\,\epsilon l\left[\frac{(R+r)a}{R-r}\right]$ pF $R - r \gg r$	
k. COAXIAL CONES		$C = \frac{1.41h}{\log\left[1 + 2\frac{D}{h}\cos^2\theta\right]}$ pF	ϵ BETWEEN THE CONES

(All logarithms are to base 10.)

This outer electrode, in practice, is generally the wall of the tank, which is at ground potential. It is interesting to note how quickly the effect of the outer wall falls away as the ratio of the probe-to-tank diameter increases.

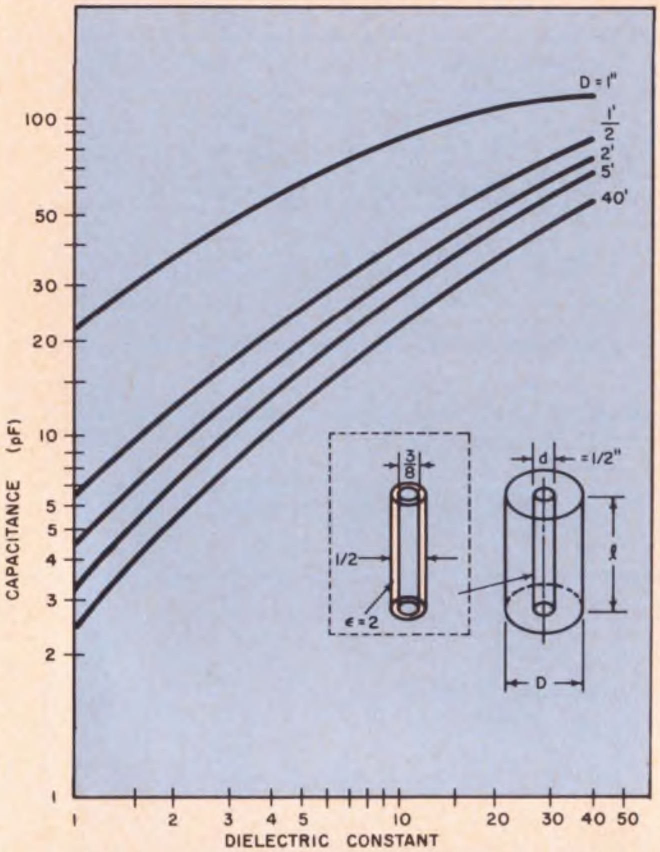
In using the curve of Fig. 4, the application engineer determines the capacitance of a given dielectric constant and tank diameter, and he substracts from it the capacitance of a dielectric constant of 1, representing the case with the tank empty. The usable capacitance function then is the change in capacitance as the material is introduced into the tank.

From the expression given in Fig. 3d, one can see that there is a linear function between the level of the material and the output capacitance. It is, however, not a linear expression for increasing dielectric constant. This, however, is not of serious consequence once a given material is chosen, so long as either the dielectric does not change or the device is used in such a manner as to discriminate between the presence or absence of the material—as in discrete level sensing. If the dielectric constant does change, there are a number of methods that can be used to compensate for it and provide true level sensing.

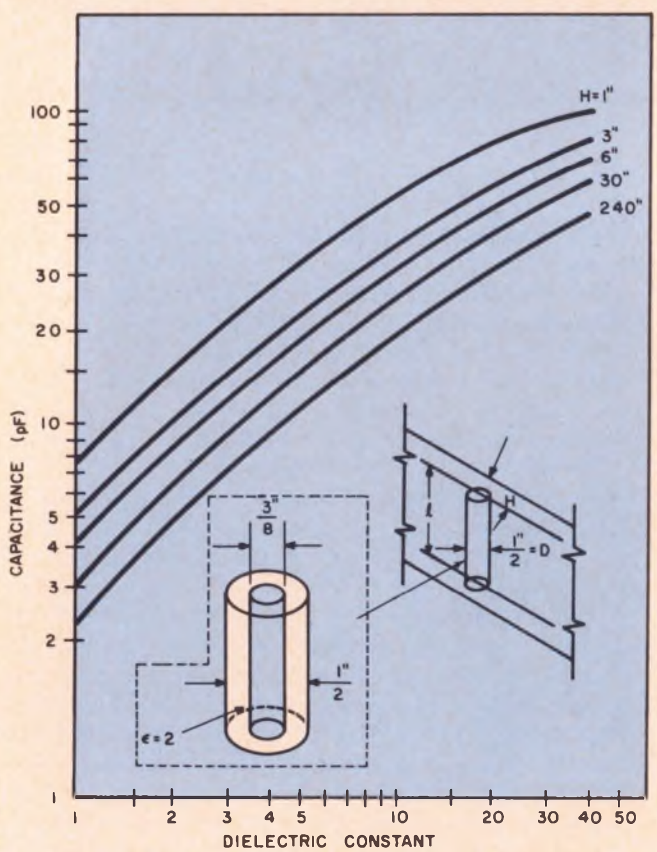
The formula in Fig. 3e for an eccentric cylinder is presented not so much as a practical formula for a capacitance transducer but rather to enable the designer to determine the effect of eccentricity of the center electrode when employing coaxial capacitors. A plot of capacitance vs. the distance from the center axis will show that this type of capacitor is extremely stable as the center electrode is moved over short distances, and also as the diameters change as a result of the expansion of the electrodes with temperature.

The arrangements of Figs. 3f and 3g are for a cylinder next to a flat wall. The equations for these are similar to those for the coaxial arrangements (Figs. 3c and 3d). The curves in Fig. 5 are for the arrangement of Fig. 3g. As would be expected, they are similar to those of Fig. 4, except that their absolute values are lower. This type of curve can be used when the sensor is near a flat wall, when the eccentricity in a tank is great, or when an attempt is being made to determine the capacitance of a small cylinder or rod next to an irregularly shaped wall.

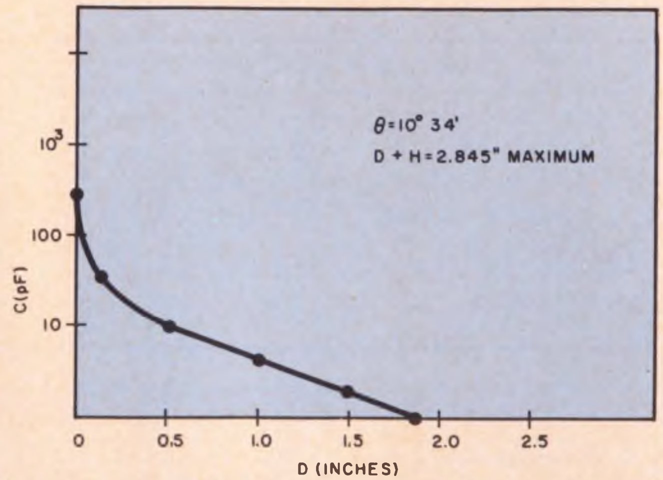
The arrangements in Figs. 3i and 3j are useful for determining the effect of rotary displacement of plates or sections of cylinders. These types of



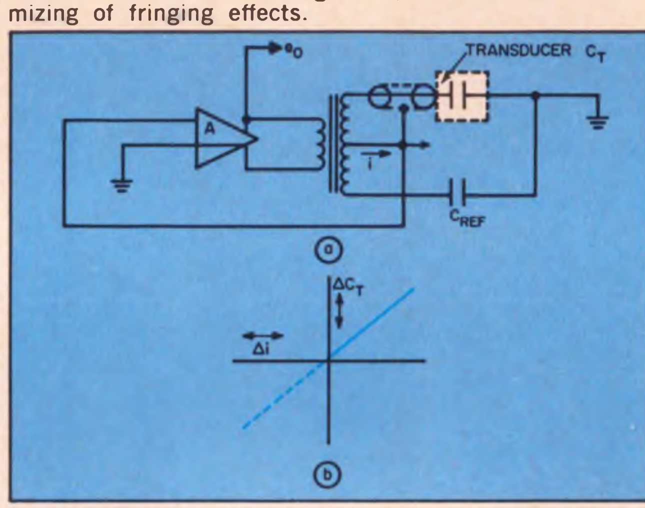
4. **Probe capacitance** varies as a function of dielectric constant as well as the diameter of the outer electrode.



5. **For a cylinder next to an infinite wall,** the capacitance variations are similar to those for the coaxial-cylinder case, although the absolute values are lower.



6. **Large displacements** of the transducer are possible with the coaxial-cone arrangement, because of the minimizing of fringing effects.



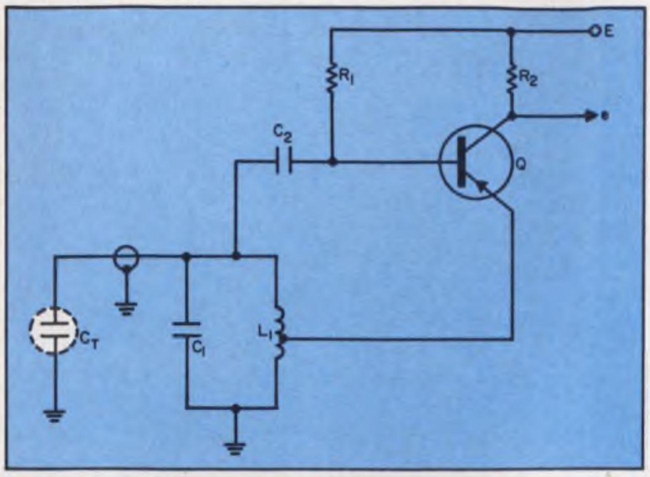
7. **Basic RF oscillator circuit** has a disadvantage in that it responds to the capacitance of the lead connecting the transducer to the measuring circuit.

sensors are most frequently used in transducers with a mechanical input that is rotary rather than linear, as is the case with pressure transducers or tuning capacitors.

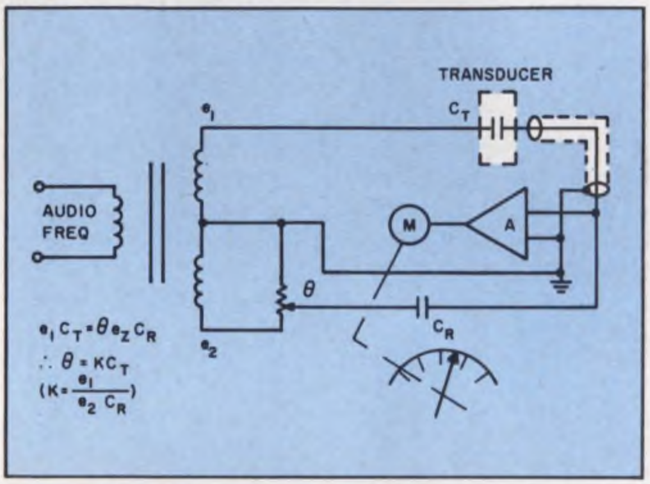
An interesting capacitance transducer form[2] is shown in Fig. 3k. There are two coaxial cones, one fixed and the other moving along the central axis common to both. In previously discussed transducer arrangements, the function of capacitance vs. displacement of the electrodes was generally a linear one. However, it is only linear so long as fringing effects are discounted. When a capacitance transducer is to be used over a very wide dynamic range, the fringing effects cannot be discounted, with the result that the amount of useful displacement of the transducer is limited. With coaxial cones this is very much less the case, since the electric field between the two cones is designed to be self-containing rather than spreading, as in the other devices. With this configuration a variation in capacitance of over 100-to-1 can be produced by a mechanical change of slightly over 10-to-1 (Fig. 6).[2]

Many measuring circuits possible

The measuring circuits associated with all



8. **Bridge circuit** can be placed hundreds of feet from the transducer. This is because the transducer lead is not in parallel with the capacitance of the transducer.



9. **Self-balancing servo type of bridge circuit** provides a continuous measurement of capacitance. The capacitance value is indicated by a motor-driven potentiometer.

capacitance transducers are devised to measure a change in capacitance, since no transducer of this type starts with a zero value. Consequently all of the circuitry must be set up to provide a zero offset, or otherwise take into account the starting, or zero, capacitance.

RF oscillator circuits are oldest

The oldest type of capacitance transducer circuit employs a radio-frequency oscillator. The circuit can take any of a number of different forms, but always it includes a parallel capacitance and inductance leg. In this circuit the capacitance transducer is either the complete capacitance of the oscillator circuit, or it is in parallel with the primary capacitance, so that when the capacitance changes, the oscillator frequency changes. By proper selection of the values of L and C, the oscillator may be made to start and stop oscillating as the capacitance of the transducer changes through some predetermined value.

One form of this circuit is shown in Fig. 7. The circuit is very simple, frequently requiring only one transistor or vacuum tube. In the most commonly used forms, however, it suffers from one serious drawback. This is caused by the fact that both the capacitance transducer and the capacitance of the lead going to the transducer are in parallel with the oscillating circuit. So the circuit will respond not only to the capacitance changes of the transducer but also to the capacitance changes in the shielded wire or coaxial cable. With such circuits calibration must be done with the wire in place and then the effect of the wire balanced out.

In the event it is necessary to place the transducer any distance from the electronic circuitry, the value of the capacitance of the wire becomes much larger than the value of the capacitance change being produced. Under these conditions the system has a tendency to become unstable. Nevertheless circuits of this general type are widely used, and they are completely practical for many applications where the transducer is a simple Teflon-coated probe and where the process is being controlled in an ON-OFF manner.

Bridge circuits can measure continuous changes

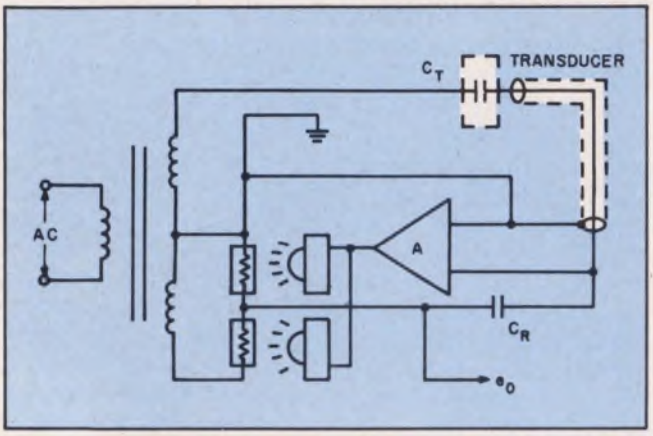
Bridge circuits are capable of measuring both discrete and continuous capacitance changes. Such circuits were pioneered by a number of companies that manufacture military fuel-quantity gages.

One form currently in wide use for ON-OFF control in a number of different variations is shown in Fig. 8. The circuit consists of an oscillating bridge-detector, generally operating in the audio-frequency range. The transfer function of the circuit is shown in Fig. 8b. The circuit is arranged so that oscillation occurs when the differential capacitance exceeds a certain value. The oscillation is then used to operate subsequent drive circuits or relays.

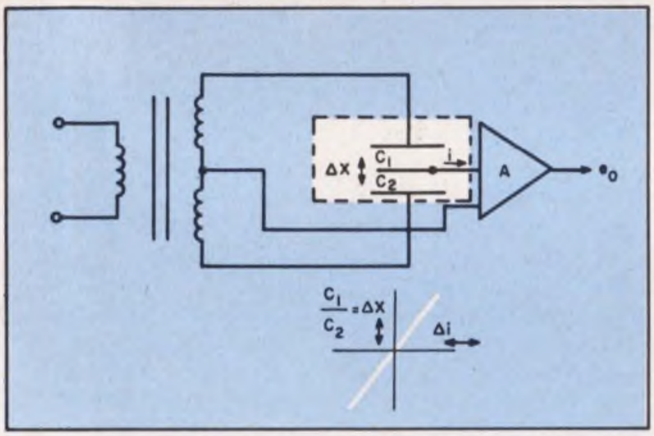
This circuit has two features not found in that of Fig. 7. The transducer-lead shield is not in parallel with the capacitance of the transducer, and therefore has only minor effects on the operation of the circuit. Since the operating frequency is low, long sections of shielded wire can be used, making it practical to place the transducer hundreds of feet from the circuit. The other advantage is that the operating point can be readily changed, or even switched to produce a differential effect, by simply changing the value of the reference capacitor.

Another type of bridge circuit for continuous measurement of capacitance is shown in Fig. 9. This is essentially a self-balancing servo, where the position of the motor-driven potentiometer is directly proportional to the value of the transducer capacitance (C_t). Note again that the lead going to the high-impedence electrode of the transducer is not in parallel with the transducer, so that the electronics may be placed at a considerable distance. Practical values here range into the thousands of feet, when the operating frequency is under 1 kHz and the probe capacitances are on the order of the 100 pF.

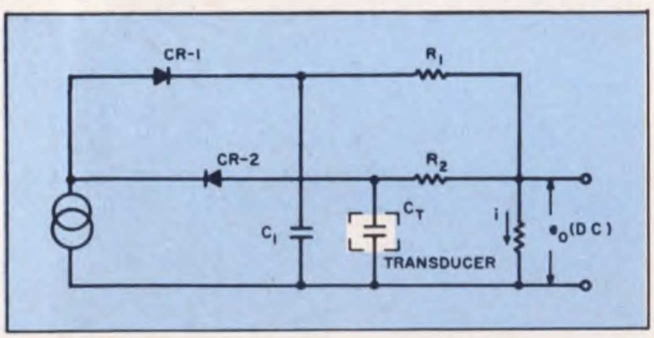
Modifications of Fig. 9 substitute an all-electronic, self-balancing network for the electro-



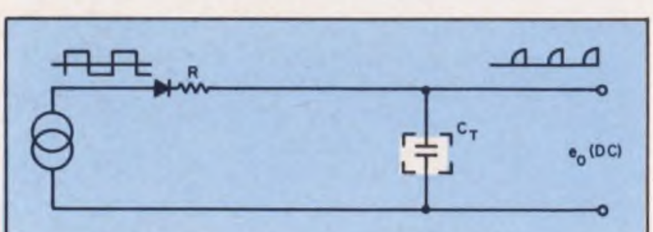
10. **Light-sensitive resistors** and light sources can be used as the balancing elements in an electronic self-balancing bridge network.



11. **Output current** in this ratio-type arrangement is proportional to the displacement of the common electrode of the transducer.



12. **Dc output voltage** that is a linear function of transducer capacitance is produced by this rectifier-type circuit. Either one or both of the capacitors may be a transducer.



13. **Integrator network** is formed by resistor R and the transducer in this circuit.

mechanical self-balancing servo. A variety of methods can be used to generate a rebalance voltage proportional to the transducer capacitance.

In Fig. 10 one such method is shown, where the rebalance is a potentiometer made up of light-sensitive resistors. The output is the junction between the resistors. For practical use, some means of either stabilizing the input bridge voltage, or using a stabilized output voltage or a ratio, is required different. Several means are possible.

A bridge circuit for transducers used for pressure measurement is shown in Fig. 11, where the capacitor output is a ratio rather than a differential signal. If the current is taken as the output, then the displacement of the common electrode of the capacitor (x) is a linear function of the output current.

An interesting and extremely simple circuit[3] is that in Fig. 12. It uses a low-frequency ac or rf exitation, but it produces a dc current or voltage directly. The output is a linear function of either of the capacitors, each of which may be transducers, or of both of the capacitors connected as a differential transducer. With a drive signal of 46 volts rms at 1.3 MHz, a variation of -7 to $+7$ pF will cause a change in the output voltage of from -5 to $+5$ volts dc into a 1-megohm load. This sensitivity is at least 10 times greater than that of most of the other circuits described.

A somewhat simplified form of the network of Fig. 12 is shown in Fig. 13. In this case the transducer is used merely as one element of an integrator. This circuit requires carefully regulated sine- or square-wave inputs, followed by a high-impedance voltage amplifier. If the frequency is high enough and the conditions specified above are met, this can be a very simple method of measuring a multitude of capacitance transducers, since they may all use a common supply source.

One final class of circuits has been used for capacitance transducers. These, like the one in Fig. 7, use an oscillator. However, rather than operating as ON-OFF devices, they use the capacitor to modulate the carrier frequency. Since the modulation is FM, the advantages of low noise and good fidelity may be obtained. This type of circuit is especially useful for rf telemetry.

These, then, are examples of some of the more practical measuring circuits for capacitance transducers. There are, of course, endless variations. ■ ■

References

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2. M. C. Selby, "Analysis of Coaxial Two-Terminal Conical Capacitor," *Monograph 46*, April 1962, U.S. Dept. of Commerce, NBS, Washington, D. C.

3. K. S. Lion, *U.S. Patent No 3,012,192.*

NEW wideband DC data amplifier for $495

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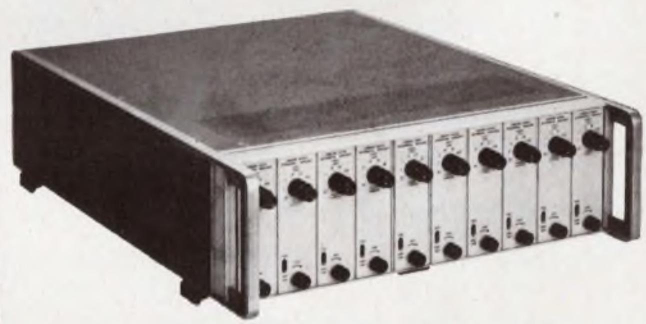

SPECIFICATIONS

Bandwidth:	dc to 75 kc within 3 db.
Gain:	from 1 to 1000 in seven fixed steps
Gain Accuracy:	±0.1%.
Gain Stability:	±0.01%.
Vernier Gain:	continuously adjustable between fixed steps.
Gain Trim:	±3% with sufficient resolution for setting any one gain to ±0.01%.
Common Mode Rejection:	120 db from dc to 60 cps, 40v p-p tolerance.
Output Circuit:	±10 volts across 100 ohms and 0.2 ohms max. output impedance at dc.
Drift:	±3 μv referred to input, ±0.2 mv referred to output.
Non-Linearity:	Less than 0.01% full scale value, 10 volts.
Overload Recovery Time:	recovers to within 10 μv R.T.I. +10 mv R.T.O. in 10 msec. for 10 v overload.
Power:	115/230 volts ±10%, 50-400 cps, 6 watts.
Available options:	Switch-selected filtering, dual output (±10v, ±10ma; ±10v, ±100ma; a short on one output has negligible effect on the other output).

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New FETs replace tubes in audio equipment on a one-for-one basis. The advantages include higher gain and reduced distortion, with little parameter drift.

A new breed of junction field-effect transistors —FETs with high breakdown-voltage ratings—is putting the squeeze on vacuum tubes heretofore used in line-operated audio equipment. Unlike most bipolar transistors (which typically show a 2:1 substitution ratio), the FETs can replace the tubes on a one-for-one basis.

Among the audio-circuit applications for this FET type are source-followers for pre-amplifying and buffering, phase-splitters, high-fidelity drive stages and phase inverters. A close look at the design, characteristics and ensuing performance of each demonstrates the advantage of FET usage here.

The FET approach yields high gain, lower noise, less distortion and little parameter drift. Moreover the temperature stability of the FET obviates the need for a compensating circuit adjustment for wide-range, ambient temperature environments.

Source-follower leads the way

The FET source-follower circuit is incorporated directly or in essence in each of the audio stages in the accompanying diagrams. In the basic follower configuration (Fig. 1a) the output, or source, follows the input, or gate, because of the negative series voltage feedback arrangement. This type of feedback* decreases output impedance and increases input impedance. The feedback factor of the circuit is, by definition, equal to unity, since all of the output signal is applied in series with the input signal.

If A is the gain before feedback of a standard common-source amplifier, the gain with feedback of the source-follower or common-drain circuit is denoted by A' and is given by

$$A' = A/\ (1 + A). \tag{1}$$

The input impedance R_{in}' with feedback is readily derived[1] as

$$R_{in}' = R_{in}/\ (1 - A'), \tag{2}$$

where R_{in} is the input impedance without feedback and A' is the voltage gain of the source-follower. Similarly the output impedance is given by (approximately)

$$R_o = 1/g_m, \tag{3}$$

where g_m is the effective circuit transconductance.

*One of four possible feedback configurations. The others are series-current, shunt-voltage and shunt-current feedback.

William A. Rheinfelder, Applications Consultant, Dickson Electronics Corp., Scottsdale, Ariz.

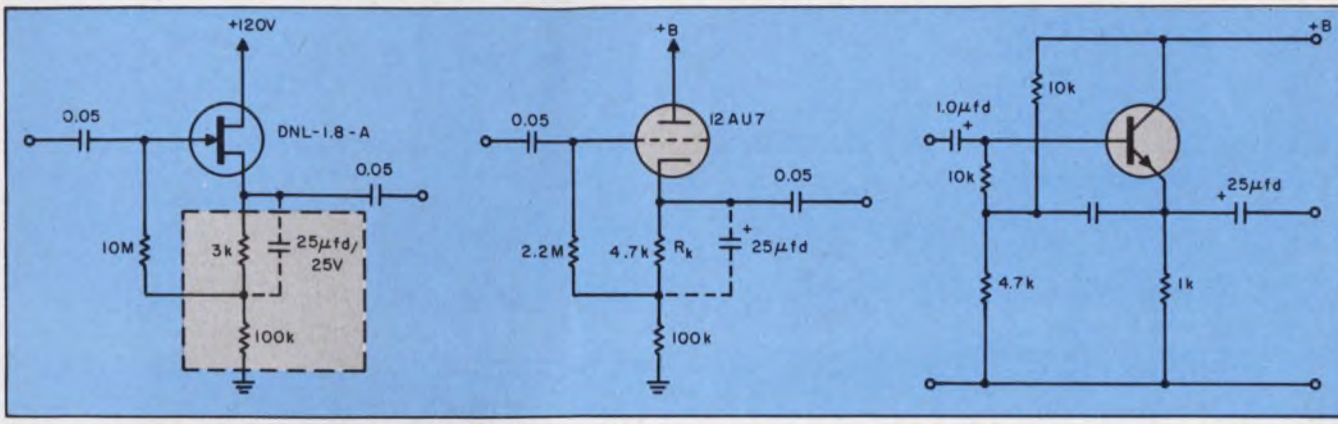
The factor $1/(1 - A')$ may be used as a figure of merit for source followers. When A' is closest to unity, this factor is a maximum, and therefore the feedback is highest. This is achieved when the gain without feedback (the gain from gate-to-source to source-to-ground) is largest. This mode of operation entails use of the same design procedures as are used for FET voltage amplifiers,[2] with respect to bias and load resistance and supply voltage.

The influence on performance of this gain-without-feedback factor (A) is plainly seen; measurements on the circuit of Fig. 1a agree with Eqs. 1 to 3. For example, a value of $A = 70$ leads to a gain with feedback of 0.985 and an impedance multiplication factor of 666. The latter figure represents more than 6000 MΩ with a gate impedance of 10 MΩ (neglecting shunted gate-to-drain resistence). The output impedance is of the order of 500 Ω, for a transcondance of 2000 μ-mhos.

An undistorted view of loading

The output capability for the source-follower is identical to that of a common-source stage; however, the distortion below overload is considerably better in the former because of the feedback. The

A FET with filaments? That's an inaccurate definition of a vacuum tube. "Besides," says author Rheinfelder, "this FET audio stage provides more gain, less distortion, lower noise, and less drift than its tube and bipolar counterparts."



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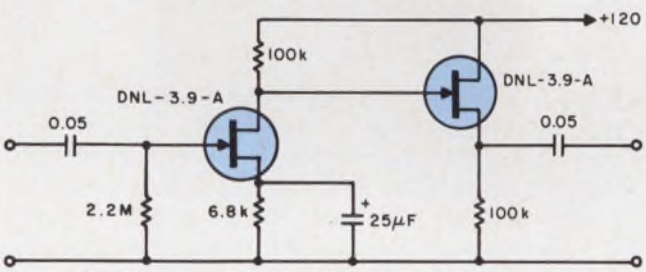
1. **The FET source-follower stage** is a basic audio circuit (a). It exhibits high input impedance and low output impedance because of the negative feedback employed in the source. Use of the FET yields higher gain and lower distortion and drift than in vacuum tube (b) and bipolar (c) counterparts. Input impedance of the tube cathode-follower approximates that of the FET, but the single-stage bipolar circuit features only 200 kohms input impedance.



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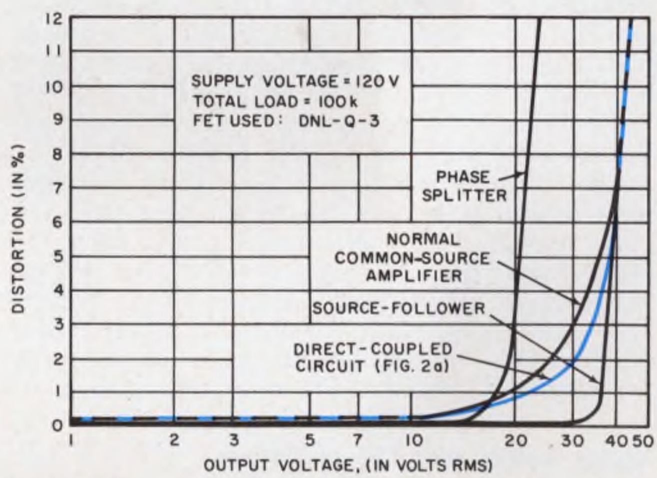

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2. **Direct-coupled source-follower circuit** employs a FET to obtain a high gain-bandwidth product (a). This stage makes for an excellent audio preamplifier output stage. A comparison of its overload characteristics with those of other basic audio circuits (b) shows its low-distortion and high-output capability.

source-follower is especially useful whenever an extremely high input impedance or a low output impedance is desired. It should not, however, be applied in all cases. To cite a few, it should never work into a load smaller than 100 kΩ, or be used with a generator resistance higher than the input resistance before feedback (10 MΩ in Fig. 1a).

Tests indicate that optimum performance is obtained with the source set at 65% of the supply voltage. This condition is obtained by a 3-kΩ bias resistor for the Dickson DNL-1.8A FET. This bias resistor may be bypassed to avoid local (current) feedback. However, the improvement rendered by the bypass is hardly noticeable and rarely needed. The frequency response of the source-follower in Fig. 1a is down 3 dB at 290 kHz with a source resistance of 100 kΩ. This corresponds to a total input capacitance (including socket) of 5.3 pF.

The performance with tube (Fig. 1b) and bipolar (Fig. 1c) counterparts of the FET source-follower is below that obtained with the FET. For example, gain is lower, distortion higher and the tendency to drift (with temperature and time) is considerably greater.

Moreover the input impedance of the tube circuit is slightly less than that of the FET, and filament power is needed. With a single-stage bipolar transistor, the input impedance is of the order of 200 kΩ—far below the FET figure. However, the bipolar's output impedance is much lower.

TABLE 1. Source-follower performance (fig. 2a)

Drain Resistance	Source Resistance*	Gain	3dB Bandwidth
(k)	(k)	(dB)	(kHz)
100	6.8	35.6	30
220	15.0	39.0	23
470	39.0	41.2	15
100	7.5**	20.5	—

*For Dickson FET type DNL-3.9-A

**Unbypassed

Pre-amp uses direct-coupled follower

The optimum gate voltage of a source-follower is usually very near one-half the supply voltage, as is the case with a common-source amplifier. Consequently a direct-coupled circuit (Fig. 2a) is attractive for applications requiring low-output impedance or a high gain-bandwidth product. Typical of these would be an audio preamp's output stage, and as a basic building block in dc amplifiers. The representative bandwidths and gains of this circuit are given in Table 1. Its overload characteristic is plotted in Fig. 2b alongside those of other basic audio stages.

Phase-splitter halves load

A typical FET phase-splitter is diagrammed in Fig. 3. This is an adaptation of the source-follower, with the load split equally between drain and source. Resistors of 47 kΩ were found to be best for performance, independent of the FET used or the supply-voltage level. This is analogous to the 100 kΩ load which is best for conventional FET source-followers.

Because the output signal is split, only half of it is now available; however, the feedback is nearly as effective. Figure 2b also shows how distortion is rapidly reduced below the overload level with this circuit. Note that the application of a higher supply voltage would result in an increased output level, until breakdown in the FET is reached. With available devices, as much as 30 volts' output can be obtained from a FET phase-splitter.

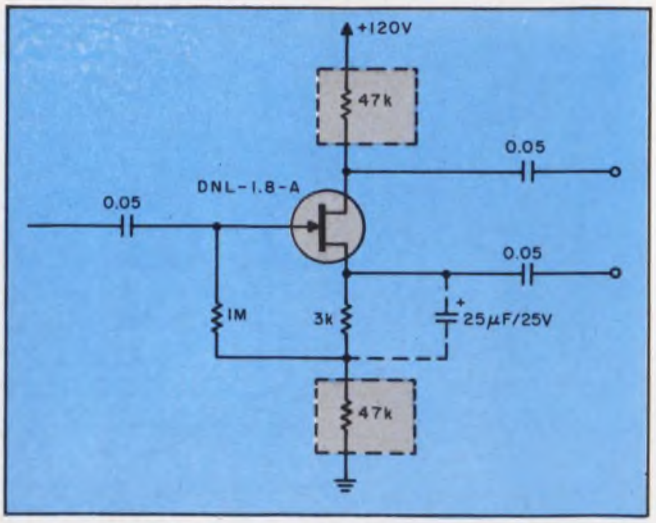
The results are comparable to those available with vacuum tubes. For example, a pair of EL 84 tubes used in a 15-watt amplifier need drives of about 5 volts each, while a pair of EL 34s deliver 100 watts in a push-pull circuit for a drive level of 23.4 volts each. Such a drive is available from a FET with a 160-volt breakdown, with less than 1% distortion when a 160-volt supply is used.

Higher quality with FET hi-fi-driver

In high-fidelity power amplifiers, a standard high-quality tube system used to consist of a voltage amplifier, a phase-splitter or inverter, driver stages and a push-pull output stage. Recently an improved circuit version dropped the need for driver stages: Phase splitters were used to drive the output stages directly. This concept, which used a pentode in the first stage, led to better balance and extra gain. However, the pentodes often show excessive drift in the screen characteristics. In turn, this results in increased distortion levels, even with over-all feedback. Bipolar transistor designs also fail to combine superior performance with circuit simplicity.

Present solid-state high-fidelity amplifiers, using bipolar transistors, exhibit amplifier performance that is close to that obtained with vacuum tubes. However, this is accomplished with a great many more stages and more complex circuitry, including multiple-feedback loops and special temperature compensation. Even with this bipolar armada, production spreads in the devices produce distortion at levels of 20 to 30 dB below rated output (normal listening levels). In some cases this figure exceeds 10%.

FETs, with their high gain and low distortion characteristics, fill the bill nicely.



3. **Phase-splitting can also be achieved** with a FET. The circuit basically is a source-follower, with the load shared by both the drain and source. Lower distortion levels (in comparison with higher-driven tube counterparts) are achieved.

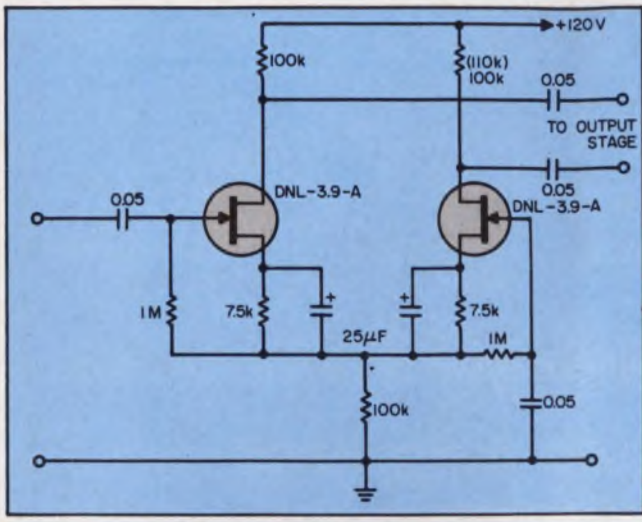
Figure 4 is the schematic of a direct-coupled FET input stage for a high-fidelity power amplifier. Since the phase-splitter's output capability is below that of the common-source stage (see Fig. 2b), the biasing here must be adjusted to favor the phase-splitter. Because optimum performance is normally achieved in FET circuits with the drain-to-source voltage at 45% of the supply level, the gate voltage should run at about + 33 volts dc. Note that this is not the optimum drain voltage of the first stage, which is + 55 volts.

Somewhat improved performance in the first stage can be achieved by lowering the supply voltage (for the first stage) with the components shown in Fig. 4 in dashed form. These are not extra components, because they are usually needed for decoupling and line-filtering purposes. Because of the compromise taken in decoupling, the performance here is not quite as good as with either stage alone or with both capacitively coupled. However, the phase shift at low frequencies is better in this circuit than in the two others. In any event the FET circuits (Figs. 2a and 3a) offer better performance than the best tube counterparts (Table 2).

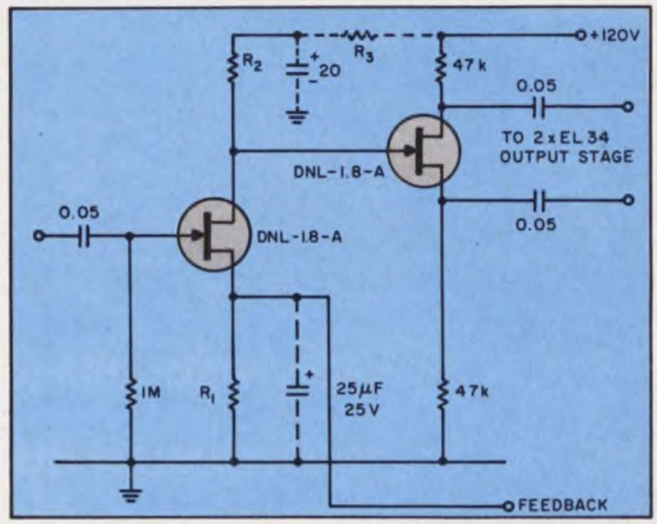
Look to the source for inversion

The FET source-coupled-phase-inverter circuit (Fig. 5) may be used to obtain a higher output level. However, balance of better than 10% is realized only with a large source impedance, typically of the order of 100 kΩ. It is possible to use the output characteristic of a transistor for this purpose, but then one more bipolar is needed. The use of a resistor leads to a large voltage drop, which reduces the output capability. Separate bias resistors are sometimes used for better dc-balance, but this entails extra components.

Note that this FET circuit has no better output capability than the FET direct-coupled phase-



4. **Hi-fi power amplifiers may be driven** by this direct-coupled FET phase-splitter. High gain and low distortion are provided by the phase-splitter and source-follower FET combination. The dashed components are used for filtering.



5. **To obtain higher output levels** in audio stages, a FET source-coupled phase inverter may be put to work. However, the balance here is not sharp, unless the generator source impedance is 100 kohms or more.

splitter, and it has less gain and requires well-matched FETs. It therefore appears that the best over-all circuit is the one given in Fig. 4. Should more output capability be required, a higher supply voltage and a higher breakdown-rated device would be the logical means of obtaining it.

Bias key to amplifier design

The techniques used in FET audio-circuit design closely resemble those used with vacuum tubes.[3] The key elements of design are the bias, the load and the supply. In essence, the FET common-source amplifier is a major part of each of the five audio stages under consideration.

Here is the step-by-step procedure for designing a FET common-source amplifier:

1. Use a device with a closely specified bias point.
2. Load resistance is a compromise between distortion and gain. A value of 100 kΩ is the best all-around figure; it results in the lowest distortion. A 47-kΩ value produces wider bandwidths, but less gain and more distortion, than the 100 kΩ. A 220-kΩ resistor yields more gain, but there is more distortion and less bandwidth than with 100 kΩ. For audio work, 100 kΩ appears best, regardless of the particular FET or the supply voltage.
3. Supply voltage should be picked for maximum output voltage and gain. The gain increases 3 dB every time the supply voltage is doubled. Output voltage increases directly with supply voltage. Therefore use the highest supply voltage possible.

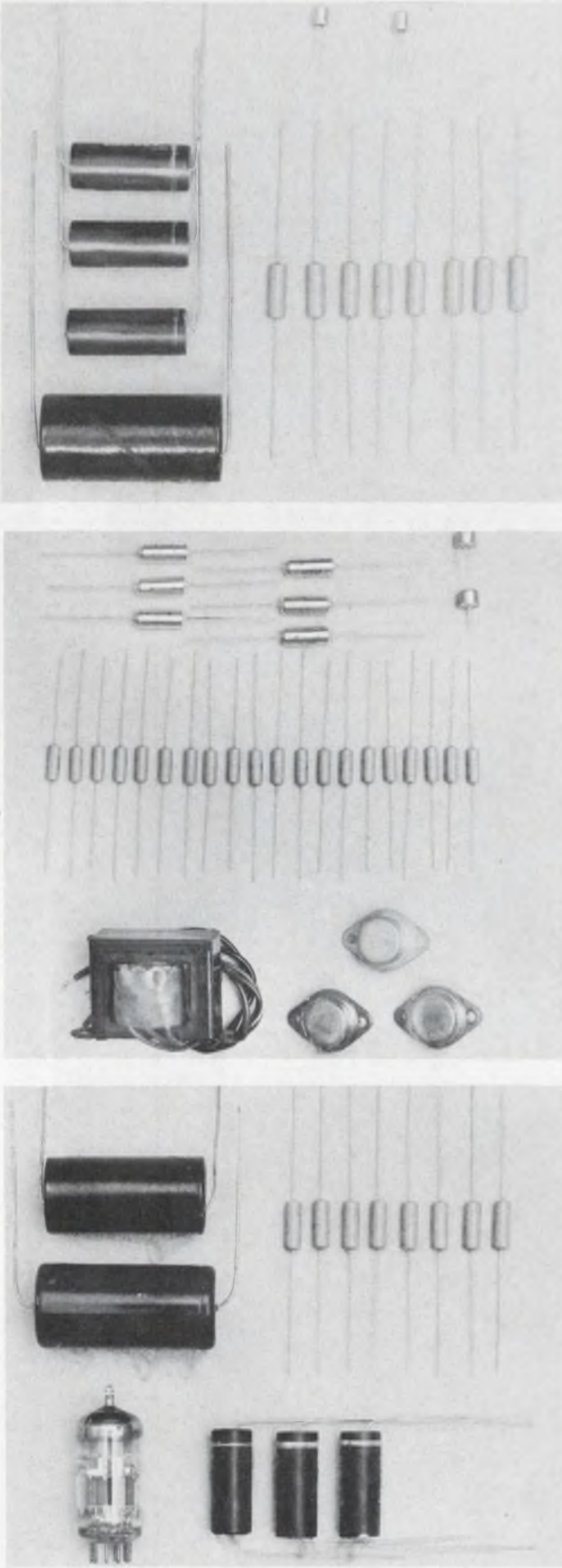
Note that maximum supply voltage is determined by breakdown, because the audio-output voltage shows no further increase with supply voltage once breakdown is reached. Observe that damage to the device is of no consideration with load resistances on the order of 100 kΩ. The maximum supply voltage is then about 2.2 times the breakdown voltage, because the drain voltage under optimum conditions is very close to 45% of the supply.

For standardization, supply voltages at 30, 60, 120 and 240 volts have been chosen, with 120 volts as the first choice. This implies a breakdown of 55 volts for small-signal and 110

TABLE 2. Phase-splitter performance (fig. 4)

Supply Voltage (volts)	R_1 (K)	R_2 (K)	R_3 (K)	Coupling	Output (volts)	Distortion (%)	Gain (dB)
200	7.5	220	0	ac	30	3.4	43.0
120	5.6	220	0	ac	15	1.9	40.7
120	2.1	100	0	ac	15	2.1	37.9
120	2.1*	100	0	ac	15	0.97	29.3
120/200**	7.5	220	—	dc	30	3.5	40.4
120	12.0	220	220	dc	20	5.5	—
120	5.0	100	100	dc	20	6.0	—

*unbypassed
**first and second stage, respectively



Reap another beneFET! In addition to the superior performance FETs offer in audio equipment, they require (top) less in the way of associated components and size than bipolar (middle) and tube (bottom) counterparts.

TABLE 3. Phase-inverter performance (fig. 5)

Supply Voltage	R_D	R_S	Output Voltage	Distortion	Gain
(volts)	(k)		(volts)	(%)	(dB)
240	100	(k) 100	25	2.0	27.8
120	100	22*	25	4.0	25.0

*Unbalance-1.5 dB

volts for large-signal applications.

Gate circuit closes design

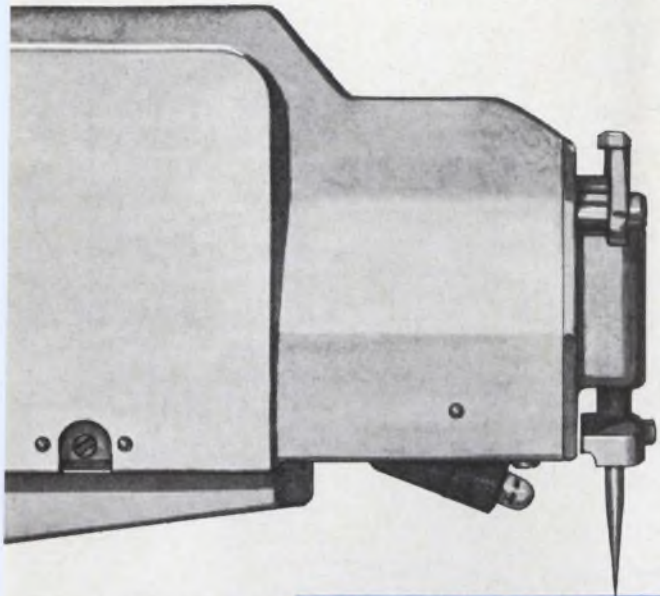
4. Gate bias is the last remaining parameter. It is best set by a resistance in series with the source terminal of a FET (analogous to the cathode resistor with tubes). To obtain correct biasing, a bias-point with a narrow tolerance must be specified. The source resistor is then determined by dividing the optimum gate bias by the drain current. Drain current is given by supply voltage minus drain voltage divided by load resistance. For example, with a 120-volt supply, the drain voltage is 55 volts. Dividing the 65-volt difference by 100 kΩ, we get a drain current of 0.65 mA. If the optimum gate bias is -2.7 volts, this requires a self-bias resistor of $2.7/0.65 = 4.15$ kΩ. Choose either 3.9 or 4.3 kΩ if standard values are desired.

   As an alternative, the manufacturer's data sheet may be used. Take the resistance values from the sheet, which lists optimum load and bias resistances, supply voltages, distortion, gain and other data for a practical circuit. However, only a few FET manufacturers provide this information at present.
5. Note that a source-follower is designed in exactly the same way as a common-source amplifier, with respect to bias, load resistor and supply voltages. In a phase-splitter the load resistor is split into two equal values. Because of the 100% feedback factor ($\beta = 1$) of a source-follower, the exact bias point is less critical. This permits a direct-coupled design, as in Fig. 4, where the signal and bias voltage levels are close. The elimination of distortion caused in interstage networks (diagonal loading) helps to offset the distortion caused by operation not quite at the optimum bias point.

Observe that common to each of the circuits covered is the element of design simplicity. In comparison, to its tube and (especially) bipolar counterparts, the FET requires little in the way of auxiliary components. With power-FETs waiting in the wings (devices capable of handling a few amperes under line voltage operation), this simplicity feature will become even more eminent. • •

References:

1. Radiotron Designer's Handbook, 4th ed., RCA, p. 322.
2. "Design of FET Voltage Amplifiers," Engineering Report No's. 3 & 8, Dickson Electronics Corp., Scottsdale, Ariz.
3. Op. Cit. (Reference 1), Chapters 7.2, 12.2 and 12.3.



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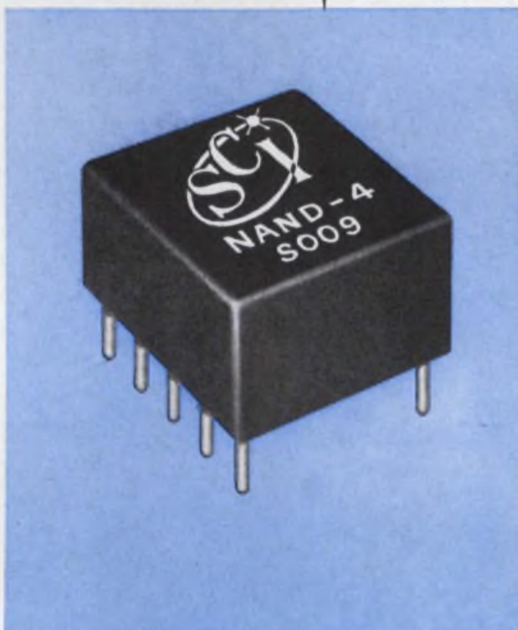

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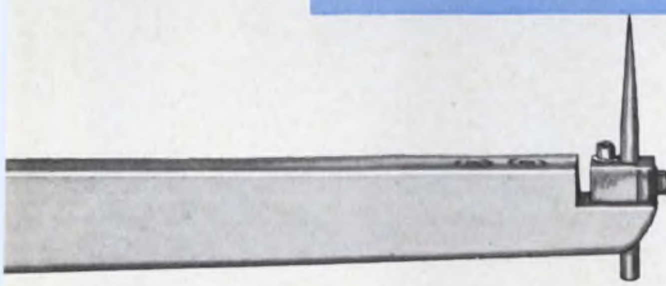

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Simplify NAND-circuit synthesis in your next logic design. Here are various methods for implementing a logic function entirely with NAND gates.

With NAND gates enjoying widespread popularity as basic logic elements, designers are often faced with a problem: How to synthesize minimized logic circuits consisting entirely of NAND-gate circuitry. A variety of solutions are available.

The simplest method of implementing a logic function with NAND blocks is to plot the function on a Karnough map, obtain the minimized form and convert this to a NAND form, using De Morgan's theorem ($\overline{AB} = \overline{A} + \overline{B}, \overline{A + B} = \overline{A}\,\overline{B}$). An example of this is shown in Fig. 1. Although the minimal form of the function is easily converted to a form that can be directly implemented by NAND circuits, the result contains both the complemented and uncomplemented forms of the input variables. Additional inverters are needed if only the uncomplemented input functions are available.

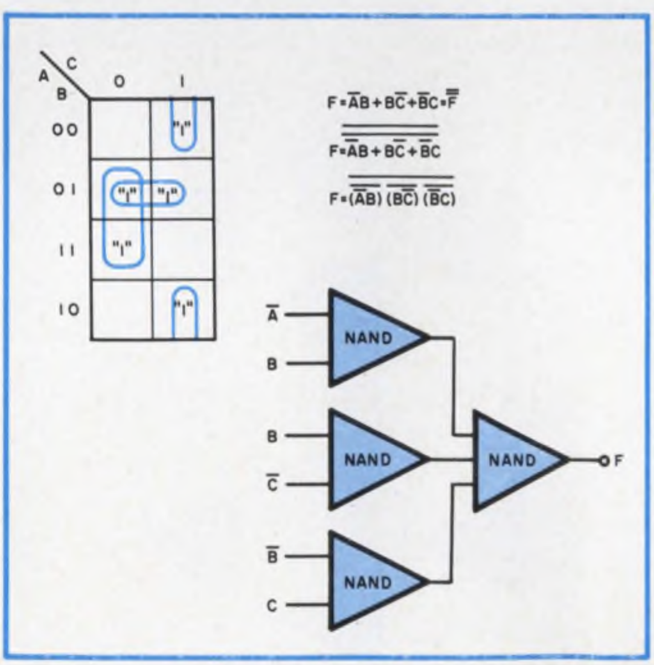
Another technique, which provides greater flexibility, is to alter the output function equation directly. This method of synthesis is shown in Fig. 2—for transforming an AND/OR circuit to a NAND circuit.

James A. Walker, Engineer, Westinghouse Defense and Space Center,* Baltimore, Md.

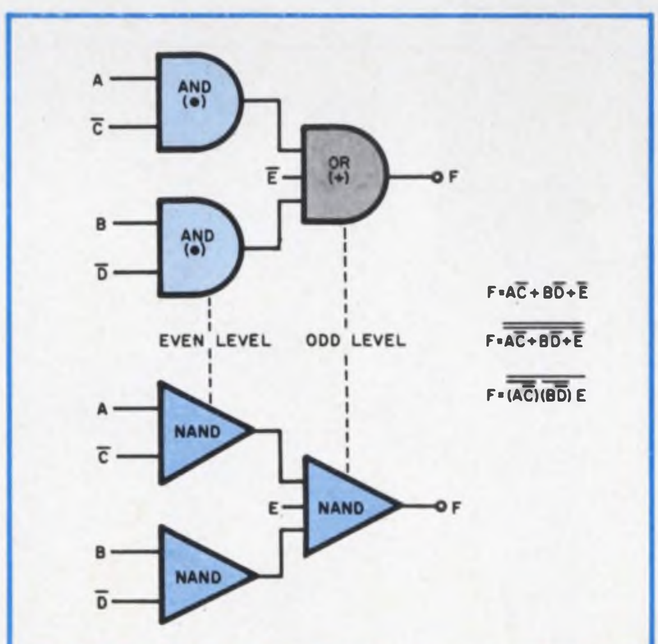
*The author is now with Fairchild Hiller Corp., Bladensburg, Md.

Fig. 2 demonstrates that in the transformation from AND/OR to NAND circuitry, any variables present at odd levels are complemented. This is based on an output function whose last level is an OR. Fig. 3 shows another transformation. This type of AND/OR to NAND transformation holds true for more complex functions, where the output level is defined as the first, or odd, level of logic, the second level is even, the third odd, and so on.

Figs. 2 and 3 illustrate the ease of transforming from AND/OR to NAND logic, but again with the disadvantage of requiring both the functions and their complement. This requirement may be eliminated if the equation can be rearranged so that all complemented functions are at odd levels of logic. Then the complements can be dropped in the transformation, as was previously shown. Fig. 4 demonstrates how the equation for Fig. 3 might be rearranged, so that complemented functions or inverters would not be needed. Certain theorems



1. **DeMorgan's theorem** can be used for quick conversion of a function to a NAND form. But the results contain complemented and uncomplemented variables.



2. **AND/OR TO NAND transformation** results in the complementing of all variables that are present at odd levels. Variables at even levels are not.

are very useful for separating the complemented variables to odd logic levels (see box).

It should be realized that the foregoing methods do not always insure complete elimination of the need for inverters. More important, the logic designer cannot easily see whether or not his circuit is a minimized one.

Map factoring may be best

Probably the best method to date for design of NAND logic is one developed by Gerald Maley and John Earle.[1] It utilizes map factoring to obtain a minimum form that contains only uncomplemented variables. This is done by using only those map loops that contain uncomplemented variables. Fig. 5 shows these allowable loops for three- and four-variable maps.

The example in Fig. 6 demonstrates the principle of the mapping method. If a loop function *A* (allowable loop) is the input to a NAND gate (1) and the output of this gate is fed into a second NAND gate (2) along with another loop function (*B*), the output of gate *2* will be loop *B* inhibited by loop *A*, with a complement over the resultant loop (*C*). This complement over the resultant loop gives the loop the power of inhibition, if it in turn is fed into a third NAND gate along with some other loop function. When this method is used, either all of the "1" blocks or all of the "0" blocks of the map are generated. It must be remembered that when these resultant loops are generated, they are complemented.

Figs. 7 and 8 show how the "1" blocks of a simple function are generated and then combined to form the output function. When the loops representing the "1" blocks are fed into the output NAND gate, we are essentially inhibiting unity (a "1" or an open circuit input to the output NAND gate) with these loops. The output of the NAND represents the "0" blocks complemented ("$\overline{0}$"), or the "1" blocks.

In Fig. 7 the *BC* loop is generated (loop *1*) and

Useful theorems for separating complemented variables

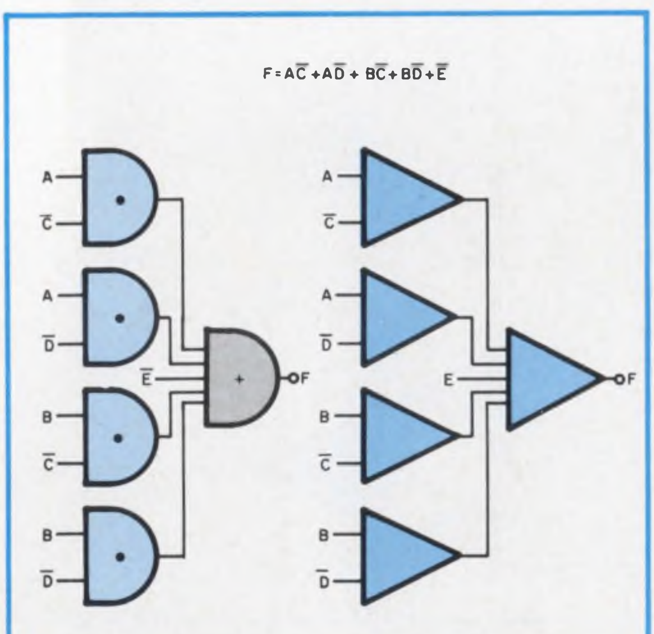
1. **Distributive law:**
   $\overline{A}\overline{B}+CD=(\overline{A}+CD)(\overline{B}+CD)$
   This form now requires the addition of a constant (0) to change the output level to an OR function.

2. **Addition of a constant:**
   $(\overline{A}+CD)(\overline{B}+CD)=(\overline{A}+CD)(\overline{B}+CD)+0$
   This 0 at the output level (an odd level) changes to a 1, or an open circuit input, in the transformation to NAND.

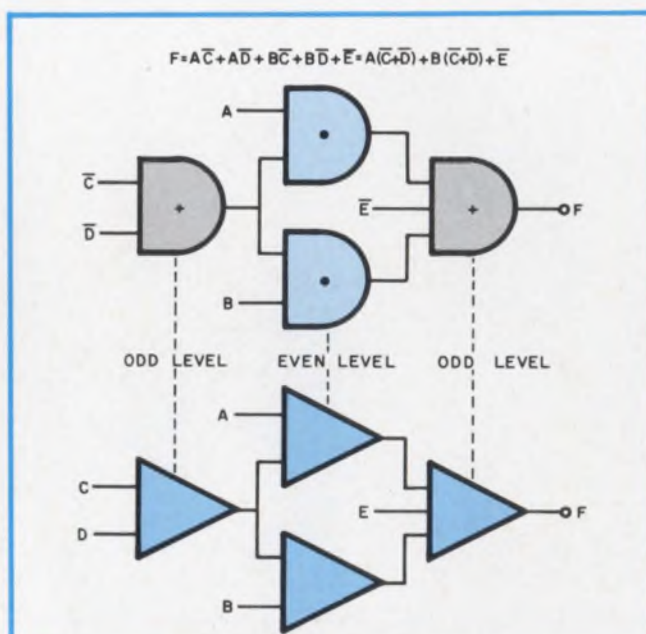
3. **Association:**
   $A(B+\overline{C}+\overline{D})=A[B+(\overline{C}+\overline{D})]$
   Isolating the complemented variables allows the use of partial multiplication to separate them to an odd logic level.

4. **Partial multiplication:**
   $A[B+(\overline{C}+\overline{D})]=AB+A(\overline{C}+\overline{D})$
   The use of this theorem puts complemented variables at an odd logic level and uncomplemented ones at an even logic level.

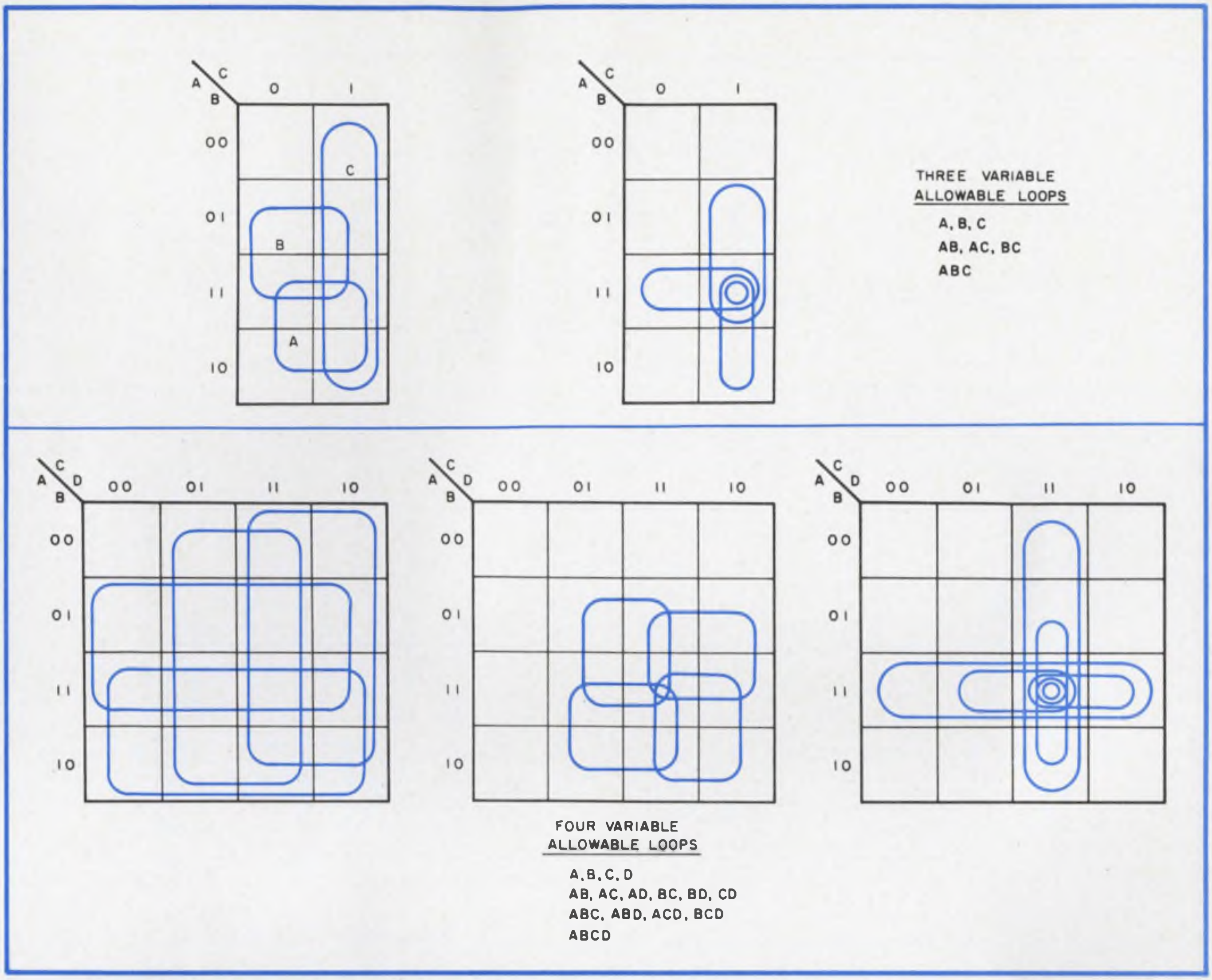
5. **Addition of redundant terms:**
   By adding redundants to two or more terms, we can make them identical and create the need for only 1 gate.
   $A(\overline{B}+\overline{C})+B(\overline{A}+\overline{C})+C(\overline{A}+\overline{B})$
   $=A(\overline{A}+\overline{B}+\overline{C})+B(\overline{A}+\overline{B}+\overline{C})+C(\overline{A}+\overline{B}+\overline{C})$



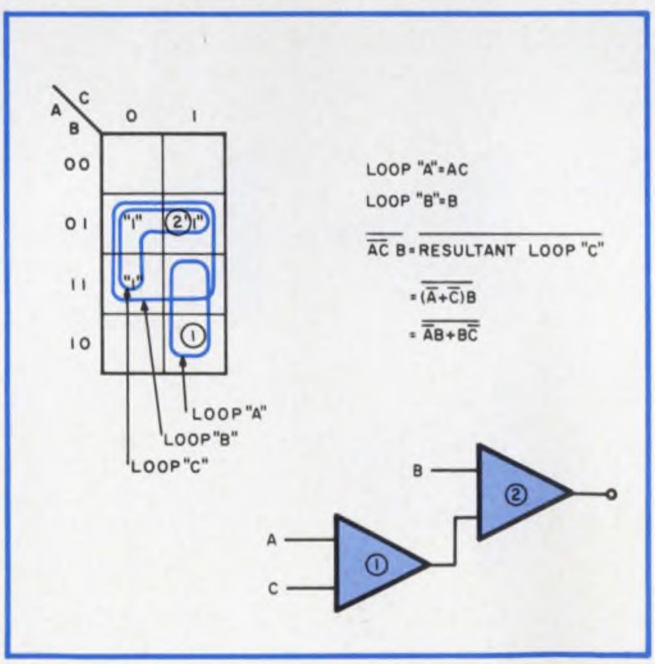
3. **Complemented variables** appearing at even levels remain complemented.



4. **By rearranging the function equation,** complemented variables can often be located at odd logic levels.



5. **Map-factoring method** makes use only of map loops that contain uncomplemented variables. For functions containing three variables there are seven allowable loops; and for those with four variables there are 15 loops.



6. **Either all "0" or all "1" blocks** of the map must be generated when using the map-factoring method.

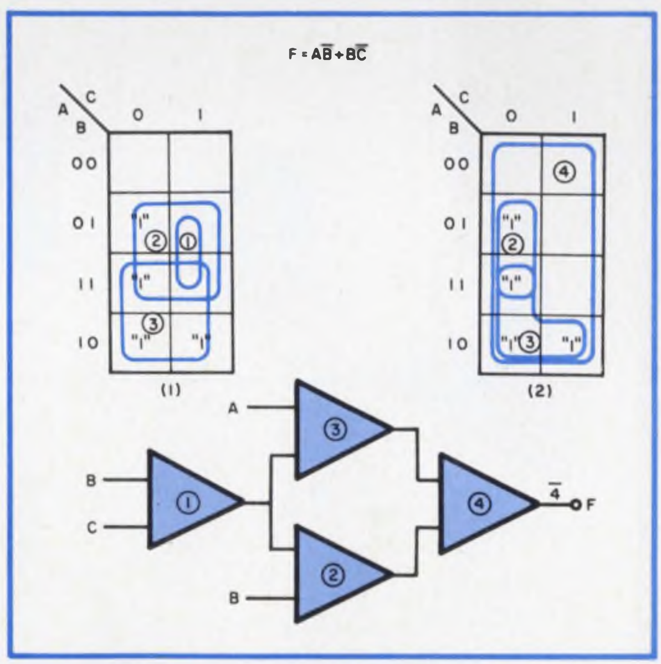
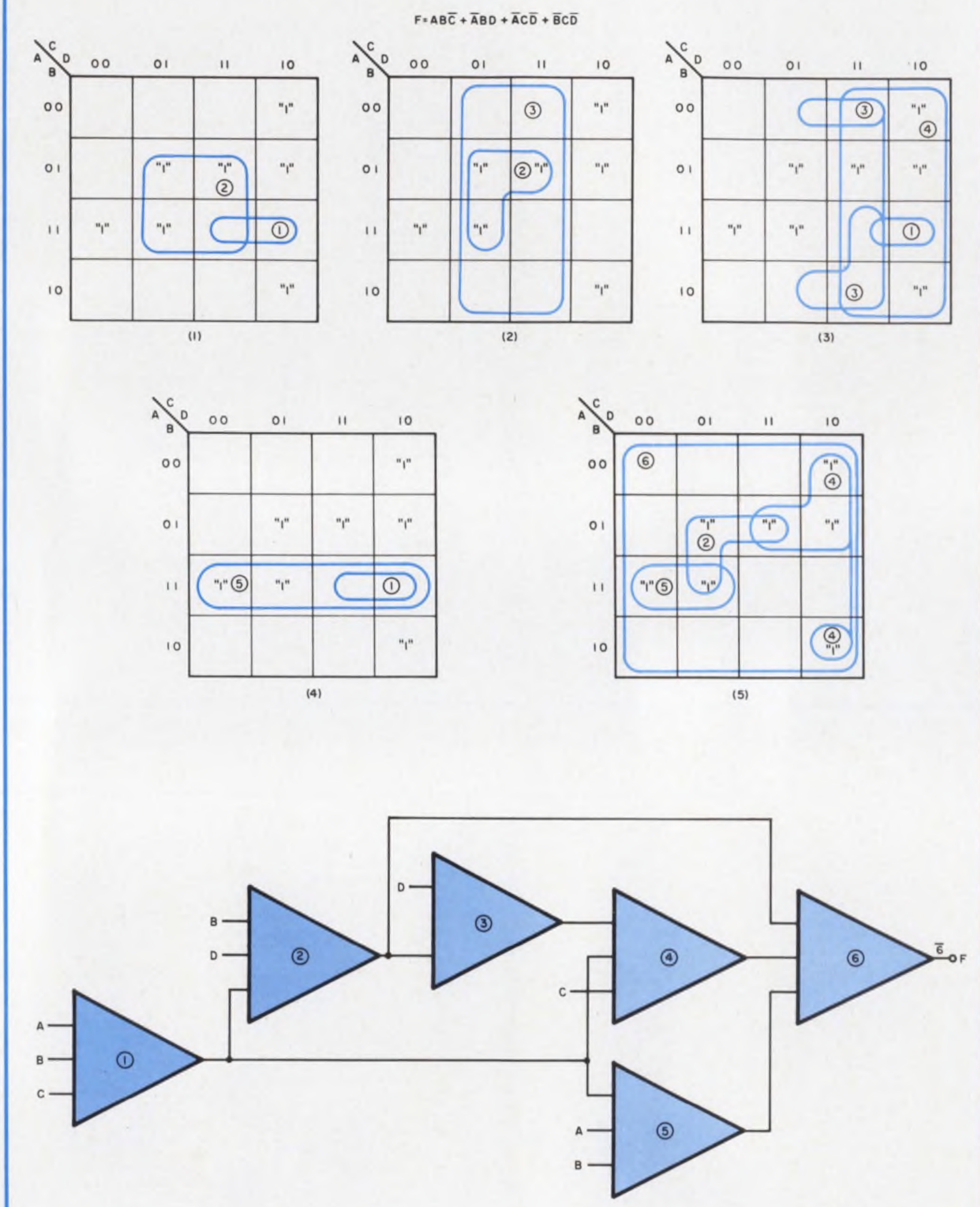
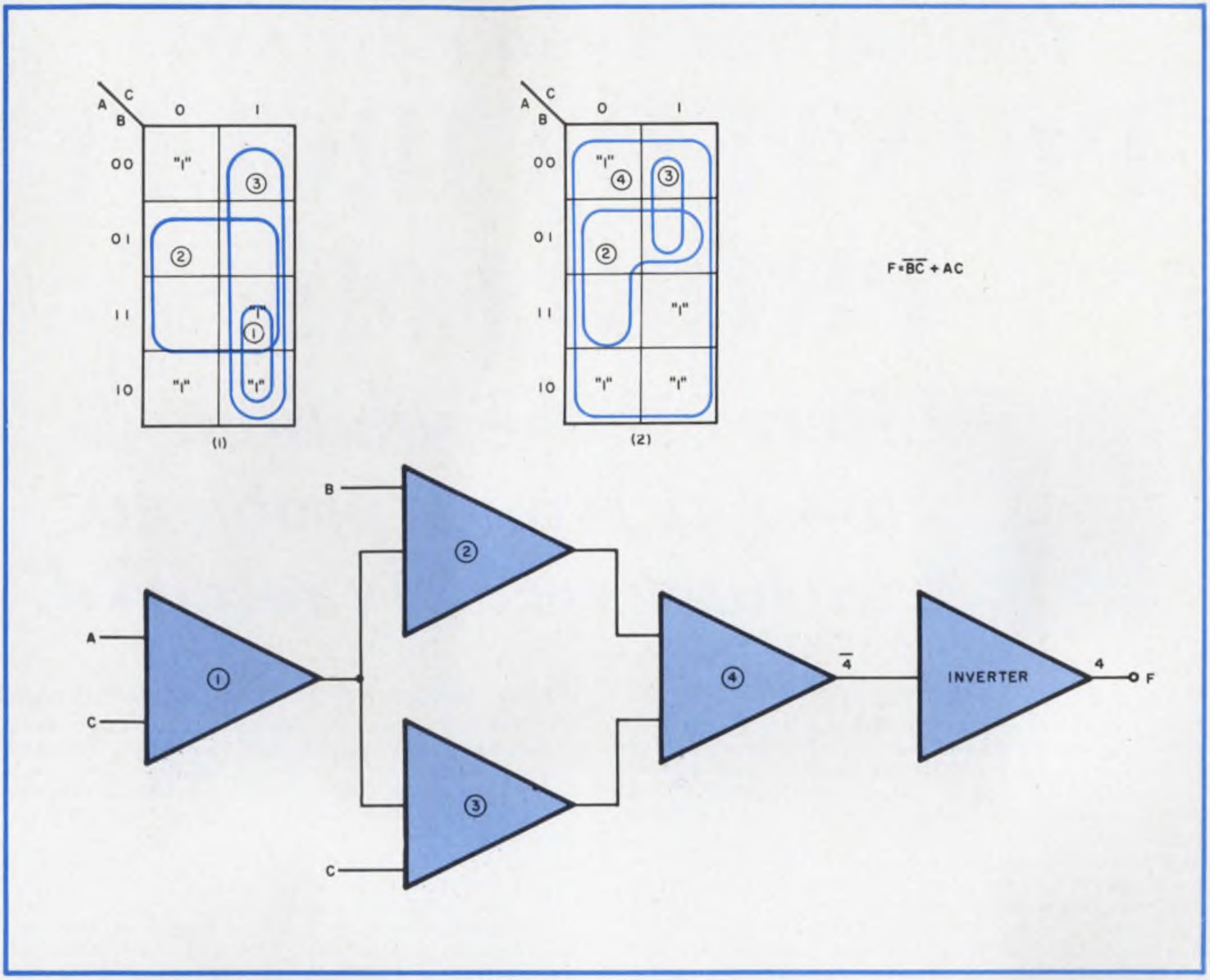


Fig. 7. **Each NAND block** corresponds to one of the loops generated on the map by the inhibiting process.



8. **Complexity of the map-factoring method** increases with the number of variables. Here, five loops are required in order to generate all of the "1" blocks of the map and produce the desired NAND function.



9. **Inverter is needed** at the output when 'O" blocks are generated by the map-factoring method. This is because the output produced by the map factoring results in the "1" blocks complemented, or "$\bar{1}$."

used to inhibit loop *B*, resulting in the *BC* loop (loop *2*). The *BC* loop is also used to inhibit the *A* loop, resulting in the A$\bar{\text{C}}$ + A$\bar{\text{B}}$ loop (loop *3*). The use of redundancy (the AB$\bar{\text{C}}$ term is contained in both loops *2* and *3*) helps to simplify the circuitry here. Finally unity is inhibited by the "1" loops in the output NAND, resulting in the "0" blocks, or the "1" blocks, as the output function.

Fig. 8 shows a more complex example. Loop *ABC* (loop *1*) is first generated and used to inhibit loop *BD*, resulting in loop *2*. Loop *2* is then used to inhibit loop *D*, resulting in loop *3*. Loops *1* and *3* are both used to inhibit loop *C*, resulting in loop *4*. Finally loop *1* is again used to inhibit loop *AB*, resulting in loop *5*. All of the "1" blocks have been looped, and these loops are now used to inhibit unity in the output gate, resulting in the generation of the desired function.

In some cases it may be simpler to generate the "0" blocks. In this case the "0" blocks in the output NAND are used to inhibit unity, and the output represents the "1" blocks complemented ("1"). For this case an inverter stage is needed at the output to complement "$\bar{1}$" and generate the "$\bar{\bar{1}}$," or "1," blocks. Fig. 9 demonstrates this approach.

Although the mapping method becomes inherently cumbersome as the number of variables increases, it can be very useful in solving problems with a small number of variables. In addition it often can guide the designer to a good solution that may not have been achieved with another method.

The mapping method described here also has several advantages when used in the design of sequential circuits, in addition to the expected aid in circuit synthesis. First, when the output function is derived from the output matrix, any resulting feedback loops may form an R-S flip-flop that can be implemented with a standard integrated circuit block. Second, static hazards, which can be more easily seen on a map, can be eliminated by the use of redundant loops. ■ ■

Reference:

1. G. A. Maley and J. Earle, *The Logic Design of Transistor Digital Computers* (Englewood Cliffs, N. J.: Prentice-Hall, 1963).

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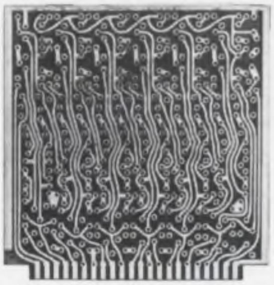

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CONCERN OVER MULTILAYER CAPACITY

PROBLEM: A system we are designing requires over 40 multilayer boards. We anticipate a production schedule of five systems per month. Our initial vendor surveys indicate this quantity is too large for the multilayer capacity of local suppliers. Is ours an unusually large multilayer requirement?

SOLUTION: Not for the larger printed circuit manufacturers who have been supplying multilayers for a number of years and have noted the increasing demand for this versatile product. As an example, five years ago Photocircuits was able to fill all customer multilayer requirements with a capability of 50 average size parts per month. Two years ago we had to increase our capacity to 500 parts per month. The newest multilayer facility at our Glen Cove plant is capable of producing over 5000 parts per month. If your boards are typical of those we have made for other systems use, only 5% of our total multilayer capacity would be needed to meet your requirements.

BOARD BREAKAGE

PROBLEM: We are presently using XXXP base material for the printed circuits in our equipment. Production line handling and power driven assembly tools result in cracked and broken boards which have to be scrapped. We can't afford G-10 or epoxy paper. Are there any available low cost materials with high impact strength?

SOLUTION: Photocircuits' new CC-4 additive printed circuit process allows the use of new and unique base materials which are not available as foil-clad laminates. One which seems particularly well suited for your application is a low cost, polyester glass mat material, GL-52R, which was specially developed for use with the CC-4 process. This new material has electrical and mechanical properties superior to XXXP and epoxy paper. Although GL-52R is no more expensive than XXXP, it has an impact strength almost ten times greater. Commercial users have found that breaking, cracking and crazing during assembly and manufacturing are greatly reduced with this material.

SLOW PRICE AND DELIVERY QUOTATIONS

PROBLEM: We often need a quick price and delivery quotation on a number of types of circuit boards for a new application. The time cycle involved in sending out prints to manufacturers and waiting for their reply is often too long for our schedule. How can we get price and delivery information faster?

SOLUTION: Our Standard Circuit Division was set up to help medium quantity users of printed circuits eliminate red tape and delays in quoting and procurement. By only manufacturing boards to a limited number of choices in such areas as base materials, platings and tolerances, the paperwork and communication problems of buying a custom-made component are drastically reduced. The Standard Circuit concept simplifies design and procurement to the point where boards can be ordered from a catalog. The published prices and fixed delivery schedules included in the Standard Circuits catalog should solve your problem. Write us for a copy.

ARTWORK FOR MULTILAYER CIRCUITS

PROBLEM: We've always prepared the master patterns for our printed circuit boards. We have our first application for multilayers and wonder if there are special or unusual requirements for the artwork?

SOLUTION: It would be wise to talk to an Applications Engineer from a reliable printed circuit manufacturer with multilayer experience before beginning the artwork. In addition to requiring much more stringent tolerances and tooling symbols, multilayer artwork almost always requires special attention because of the particular manufacturing process used. Since the artwork for one board may require individual patterns for as many as 15 layers, cost-cutting opportunities should be carefully investigated. Photocircuits' Master Circuit System, for example, uses automatic equipment to produce photographic glasswork for each layer with perfect registration and can save as much as 50% over regular drafting techniques.

(If you have a problem in printed circuitry, let us hear from you.)

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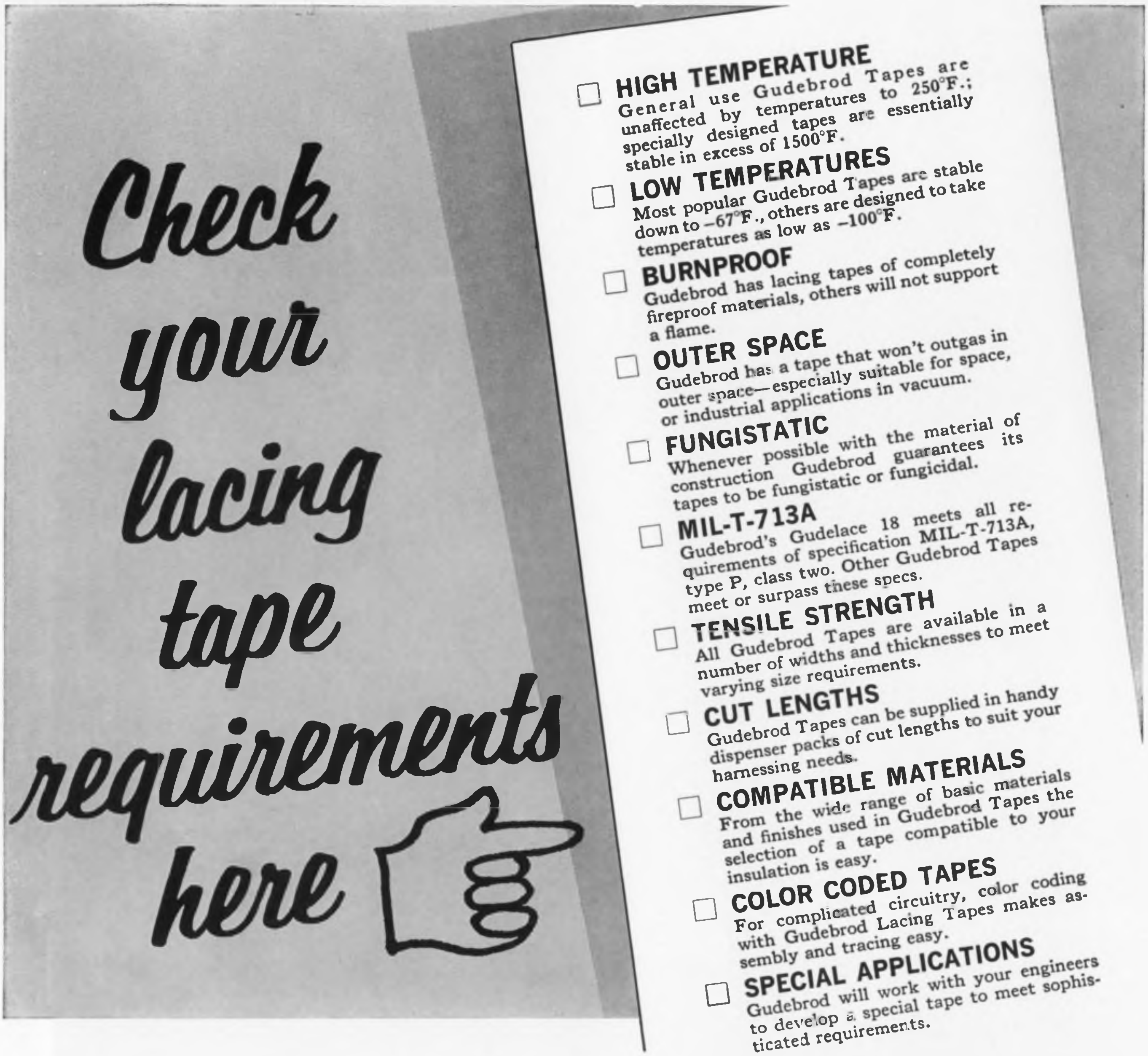

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Use magnetic deflection to iron out problems in display systems. It offers wider design freedom and as good a frequency response as electrostatic methods.

Part 2 of a two-part article

It is no longer difficult to obtain moderately high bandwidth and fast speed from a magnetic-deflection display system. For large display tubes, these key performance criteria can be made to equal those obtained with electrostatic deflection when the amplifier-yoke complex is connected in a feedback loop.

Magnetic-deflection methods top electrostatic approaches when it comes to design freedom, reliability, size of the system, power-supply requirements and quality of the display itself. Having examined these characteristics and the general design considerations, (ED, March 1, p 46), we turn to the analysis and actual design of a number of practical stages.

Emitter-follower circuits are often used to obtain single-ended deflection. These are characterized by a feedback arrangement and a preamplifier, wherein the yoke is part of the output amplifier stage (Fig. 1). Analysis shows the preamp, not the yoke, to be the bandwidth-limiting factor. Note that negative feedback is obtained by placing a small current sampling resistor (R_L) in one coil lead. Its voltage drop is therefore proportional to the coil current.

To ease the analytical treatment, the gain-frequency curve of the amplifier is assumed to have a single breakpoint at the angular frequency $\omega_o = 2\pi f_o$ (or an equivalent time constant $T_c = RC = 1/\omega_o$) and a constant slope of 6 dB per octave. This approximation will result in slightly shorter settling times than are usually experienced in multistage amplifiers. Since R_L is small with respect to R_2 (a practical ratio is 1:1000), its loading effect and that of the coil capacitance on the coil circuit are neglected. The coil resistance (R_c) is assumed to be zero, which is a valid assumption for low-inductance yokes. If R_c is relatively large (as with high inductances), simple scaling methods can be applied to include its effect. Finally the amplifier input impedance is assumed to be infinite.

Step inputs require damping

To derive the input-to-output relationship of the amplifier-yoke complex, $G(s)$ is used as the forward transfer function. It comprises both the amplifier with its time constant $T_c = RC$ and the coil circuit, described by the coil time constant $T_L = L/R_L$ (Fig. 2a). $C(s)$ is the system output voltage measured at the series resistor R_L, and it therefore represents the coil current. $R_o(s)$ is the reference input, or the effect of input voltage $E_1(s)$ at the summing point.

The transfer function for the circuit is

$$\frac{C(s)}{R_o(s)} = \frac{G(s)}{1 + G(s)H}, \tag{1}$$

where $G(s) = A/(1+sT_c)(1+sT_L)$, $H = R_1/(R_1+R_2)$ and $R_o(s) = E_1(s)\,R_2/(R_1+R_2)$. In these relationships, A is the preamplifier open-loop gain, T_c is the amplifier time constant with $T_c = RC = 1/\omega_o$, $T_L = L/R_L$ is the coil time constant, and ω_o is the 3 dB point of the gain-frequency curve.

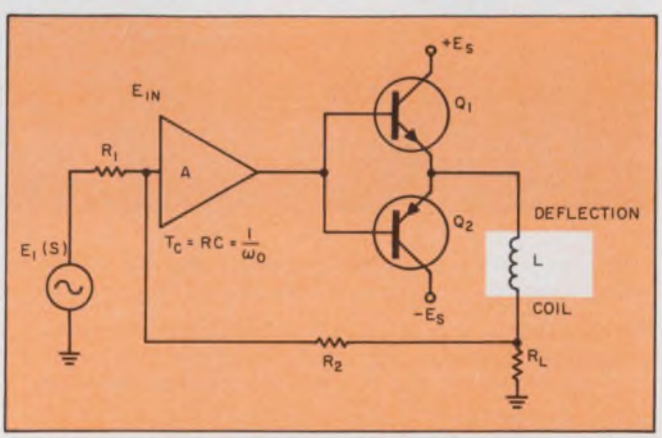
The input-to-output transfer function is therefore

$$C(s) = \frac{E_1(s)\,n\,A}{A + (1+n)\,(1+sT_c)\,(1+sT_L)}, \tag{2}$$

where $n = R_2/R_1$.

If the system input is a step function defined as $E_1(s) = E_1/s$, the transfer function becomes

$$C(s) = \left(\frac{E_1 An}{1+n+A}\right) \frac{1}{s\left[s^2\dfrac{(1+n)T_cT_L}{1+n+A} + s\dfrac{(1+n)\,(T_c+T_L)}{1+n+A} + 1\right]} \tag{3}$$



1. **In a single-ended deflection system** the yoke is connected to the output of an emitter-follower stage. A voltage-drop sample of coil current is then fed back to the preamplifier. Observe that the preamp is the limiting factor on over-all bandwidth.

A. E. Popodi and **R. M. Williams**, Design Engineers, Westinghouse Electric Corp., Defense and Space Center, Baltimore. (Mr. Williams is now with Saunders Associates, Nashua, N. H.)

The solution (to Eq. 3)* for the unit step becomes

$$C(t) = \frac{E_1 An}{1 + n + A}$$

$$\left[1 + \frac{1}{\sqrt{1 - \xi^2}} e^{-\xi\omega_1 t} \sin(\omega_1 \sqrt{1 - \xi^2} \cdot t - \Psi)\right] \quad (4)$$

where

$$\xi = \frac{1 + m}{2\sqrt{m}} \sqrt{\frac{1 + n}{1 + n + A}},\ \omega_1 = \sqrt{\frac{1 + n + A}{(1 + n)T_C T_L}},$$

$$n = \frac{R_2}{R_1},\ m - \frac{T_L}{T_C},\ \text{and}\ \Psi = \tan^{-1}\frac{(1 - \xi^2)^{\frac{1}{2}}}{-\xi}$$

Note that ξ is the damping ratio, which determines whether the system is overdamped, critically damped or underdamped. This depends on whether ξ is larger, equal to or smaller than unity.

Equation 4 shows that for $\xi < 1$ the final output level of $nAE_1/(1 + n + A)$ is reached within a given accuracy after a number of exponentially decaying sinusoidal oscillations (Fig. 2b). Typically the gain A is usually large with respect to n but may not be large with respect to m. Thus, the value for ξ is usually smaller than unity (for example, $\xi = 0.4$ corresponds to a 25% overshoot).

The exponential term $e^{-\xi\omega_1 t}$ describes the maximum deviations from the steady-state output or the worst-case error. The actual error will then always be equal or less than $e^{-\xi\omega_1 t}$. The peak error is therefore $\varepsilon\% = e^{-\xi\omega_1 t} \times 100$ and since $\xi\omega_1 =$

$$\frac{1 + m}{2} \frac{t}{T_L},$$

the peak error is

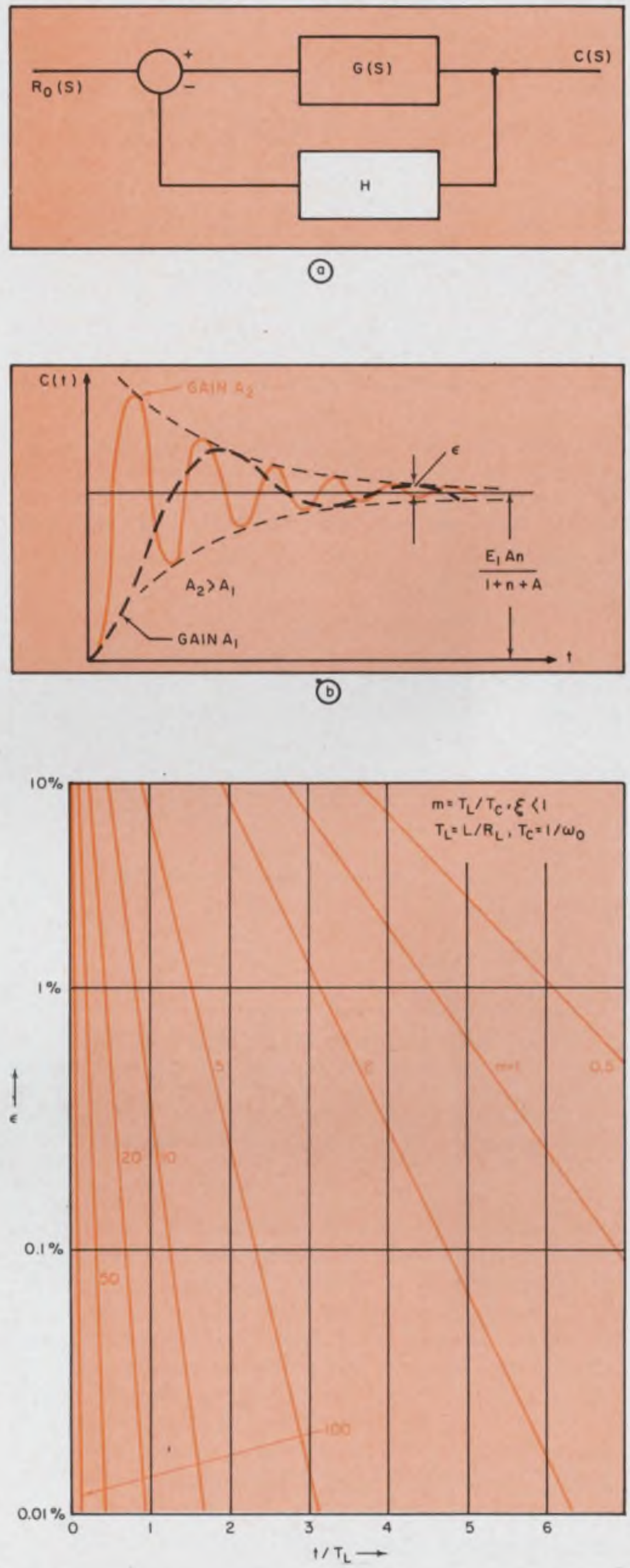
$$\epsilon\% = e^{-\frac{1 + m}{2}\frac{t}{T_L}} \times 100 \quad (5)$$

Figure 2c shows a normalized plot of the error vs time curve for various time-constant ratios. It can be used to determine the settling time of an underdamped system. If, for instance, $T_L = T_c$ or $m = 1$, the coil current is within 1% of its final value after an elapsed time of 4.5 T_L. It is interesting to note that in a second order system the settling time is independent of amplifier gain A and feedback ratio n, as illustrated. These two parameters, in conjunction with m, influence only the frequency of the oscillations. This frequency is given by f_o equal to

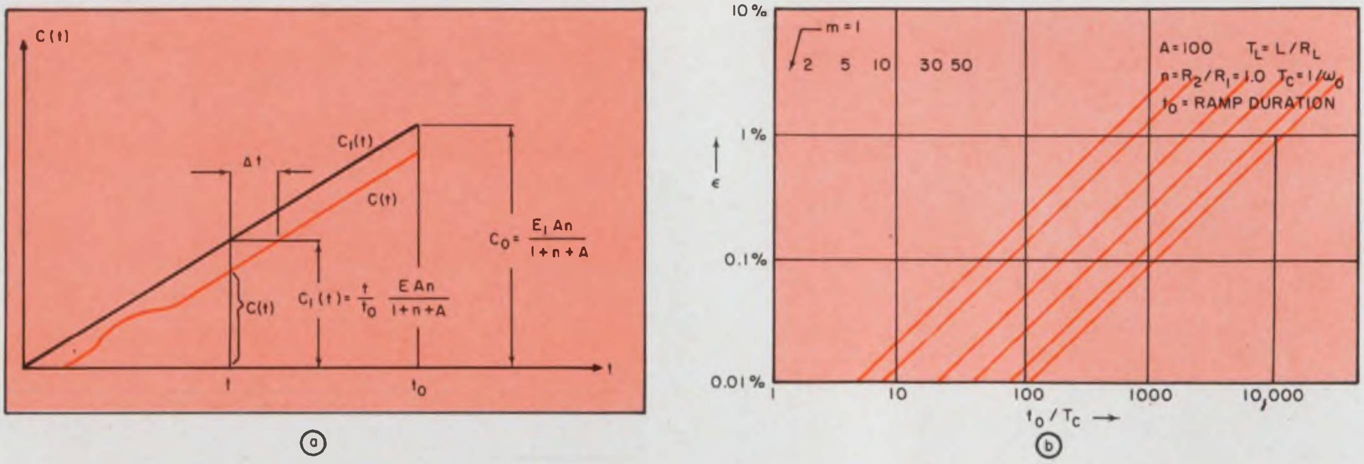
$$\frac{\omega_1\sqrt{1 - \xi^2}}{2\pi} = \frac{1}{4\pi T_L} \sqrt{\frac{4Am - (1 + n)(m - 1)^2}{1 + n}} \quad (6)$$

Rewriting the exponent of Eq. 5 as $(1 + m)/2T_L = 0.5\ (T_L + T_c)/T_c T_L$, we note that if $T_L = T_c$, both time constants have an equal effect on settling time. To increase the display bandwidth, either the amplifier time constant T_c or the coil

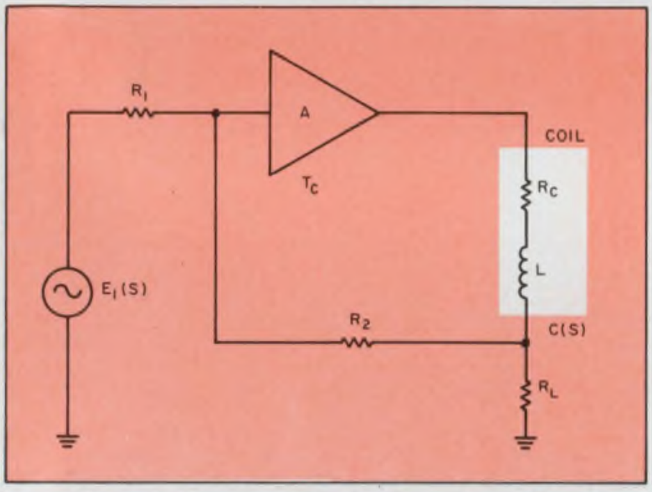
*The time function for the normalized quadratic equation (which resembles Eq. 3) $1/[s\ (s^2/\omega_1^2 + 2\xi s/\omega_1 + 1)]$ is found in Nixon, "Handbook of Laplace Transformation," p 71.



2. **The forward transfer function** of the amplifier-yoke complex is determined by using the block diagram of the feedback system (a). As the gain is varied, the coil current goes through a number of different decay cycles before leveling off at its steady-state value (b). Maximum deviation from steady state, defined as the error ϵ, is a function of the system time constants (c). Here the plot of error vs time is based on m, the ratio of coil time constant (T_L) to amplifier time constant (T_c), and the damping ratio, ξ.



3. **Longer time lags are the result** of a ramp (instead of a step) function being applied to the input of Fig. 2a. A plot of the resulting output waveform (a) is used to determine the transient and error portions. Here $C_1(t)$ represents the ideal case and C(t) the actual signal. The amount of ramp delay is a function of both amplifier gain and bandwidth, and (of course) the system time constants (T_L and T_o) (b).



4. **Greater coil inductances exhibit large resistances.** For larger yokes, the resistor's influence on the transfer function must now be considered. Here R_c denotes the coil resistance, which modifies the gain and feedback values, according to its comparison with the load.

time constant T_L may be decreased. The latter can be achieved by either lowering the coil inductance or increasing the current sampling resistor R_L. Both measures, however, will affect the amplifier response. In the first case the amplifier must exhibit the same bandwidth at higher current levels. In the second case the same phenomenon is observed at higher voltage levels. In general, it is more economical to lower the amplifier time constant T_c to achieve higher bandwidths.

Ramp produces time delay

Because of the limited bandwidth and gain of the deflection system, a time lag exists between a linearily rising input signal and the coil current. This may be improved if a ramp voltage is used as the input. If the input is given by $e_1(t) = E_1 t/t_o$, where t_o is the ramp duration and E_1 is the input voltage at the end of ramp, its Laplace function is $E_1(s) = E_1/s^2\, t_o$. With the use of this term, the input-to-output transfer function becomes

$$C(s) = \frac{E_1 An}{t_o(1+n+A)} \left\{ \frac{1}{s^2\left[s^2 \frac{(1+n)T_c}{1+n+A} T_2 + s\frac{(1+n)\,(T_c T_L)}{1+n+A} + 1\right]} \right\} \quad (7)$$

The solution in the time domain is*

$$C(t) = \frac{E_1 An}{t_o(1+n+A)} \left[t - \frac{2\xi}{\omega_1} + \frac{1}{\omega_1\sqrt{1-\xi^2}} e^{-\xi\omega_1 t} \sin(\omega_1\sqrt{1-\xi^2}\, t - \Psi) \right] \quad (8)$$

where

$$\Psi = 2\tan^{-1}\frac{\sqrt{1-\xi^2}}{-\xi},\ \xi = \frac{1+m}{2\sqrt{m}}\sqrt{\frac{1+n}{1+n+A}},$$

$$\omega_1 = \sqrt{\frac{1+n+A}{(1+n)T_c T_L}},\ n = \frac{R_2}{R_1},\ m = \frac{T_L}{T_c},\ T_L = \frac{L}{R_L},$$

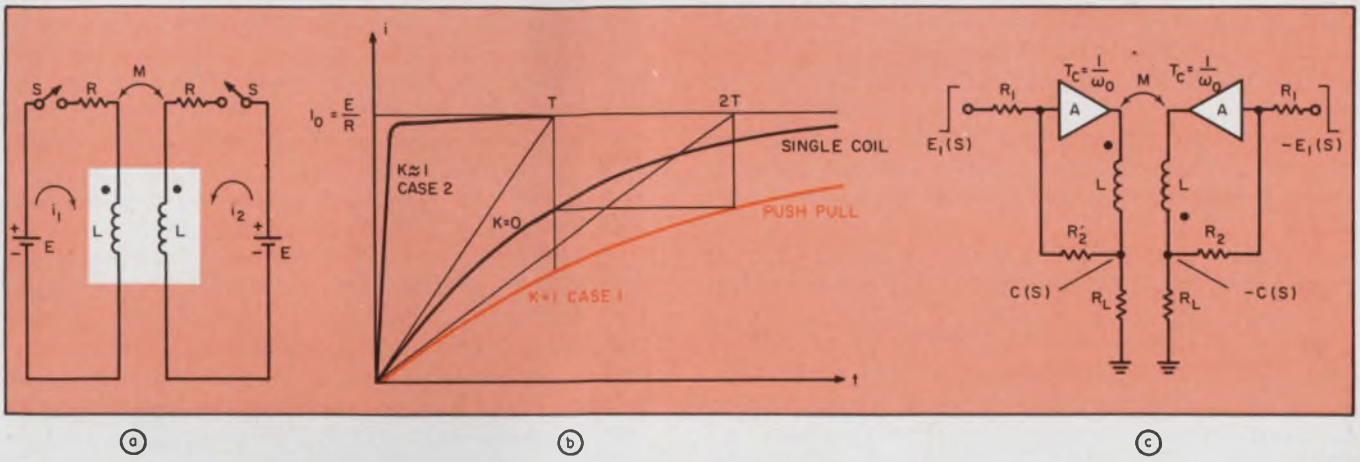
$$T_c = \frac{1}{\omega_0} \text{and } e_1(t) = E_1\frac{t}{t_0}.$$

The first term in the equation represents the ideal amplifier output without any time delay. The second term is the current, or time lag, and the last part describes the exponentially decaying transient portion. Fig. 3a shows the actual output signal, denoted by $C(t)$, versus the ideal output $C_1(t)$. At the end of ramp the ideal output signal is given by C_o. This value is calculated from Eq. 8 for $t = t_o$ and by neglecting the second and third term. The relative error at a given time t can be defined as the difference between the ideal and actual output signal divided by the ideal end-value. This is expressed as:

$$\epsilon\% = \frac{C_1(t) - C(t)}{C_o} \times 100, \quad (9)$$

where $C_1(t)$ is the ideal ramp output without time delay, $C(t)$ is the actual output at time t and C_o is the ideal ramp output at the end of sweep. The relative error ϵ actually denotes an output volt-

*op. cit., Nixon, p. 76.



5. **Push-pull circuits are sometimes preferred** to single-ended deflection stages (a) because they offer constant load, less stringent power supply needs and ease of display referencing. Bandwidth and current rise time with the push-pull circuit configuration are essentially the same as with single-ended deflection (b). Actual amplifier circuit (c) shows the input-output transfer connections used in this mode.

age ratio, but because of the linear input-output relationship, it also represents the relative time lag Δt, referenced to the ramp duration t_o. If $t >> t_c$, the transient in the expanded Eq. 9 can be neglected, and the relative delay becomes

$$\epsilon\% = \frac{T_L + T_c}{t_o}\left(\frac{1 + n}{1 + n + A} \times 100\right) \qquad (10)$$

Equation 10 shows that the ramp delay is proportional to the ratio of the sum of amplifier and coil time constants to the ramp duration. Since amplifier gain A is generally large compared with n, the ramp delay is inversely proportional to A. Figure 3b is a plot of the ramp delay for different amplifier bandwidths and coil time constants, with as assumed gain of 100. If A were 1000, the delay would be 10 times smaller than indicated, assuming a constant-bandwidth situation.

As stated before, the coil resistance has been neglected in the preceding calculations. This is a valid assumption for low-inductance yokes. For large inductances, the coil resistance must be considered. Figure 4 shows the equivalent circuit for this case, where R_c denotes the dc coil resistance. The input-to-output transfer function is:

$$C(s) = \frac{E_1(s)\ (\alpha An)}{\alpha A + (1 + n)(1 + sT_c)(1 + \alpha sT_L)}, \qquad (11)$$

where $\alpha = R_L/R_L + R_c$, and $n = R_2/R_1$.

A comparison between Eqs. 2 and 11 shows that all formulas and curves previously derived for the case $R_c = 0$ can be used if the amplifier gain A and coil time constant T_L are replaced by αA and αT_L, respectively.

Push-pull offers design freedom

Push-pull operation of the deflection coil offers several advantages over single-ended deflection. Among these are a constant load on power supplies, less stringent ripple and regulation requirements, and ease of display referencing. From a bandwidth point of view, however, push-pull is virtually identical to the single-ended method.

To calculate the rise time of each half-axis current of a push-pull yoke and to demonstrate the interaction between the half axis coils, the equivalent circuit of Fig. 5a will be analyzed. For convenience, perfect circuit symmetry is assumed. Each half-axis deflection coil has an inductance L and a mutual inductance M defined by $M = kL$, where k is the coupling coefficient. For deflection yokes, k is approximately unity (practical values range from 0.92 to 0.96). When the switches (S) are closed simultaneously, the following applies:

$$i_1R + L\frac{di_1}{dt} + M\frac{di_2}{dt} = E \qquad (12a)$$

$$i_2R + L\frac{di_2}{dt} + M\frac{di_1}{dt} = E \qquad (12b)$$

Solving for i_1, the half axis coil current, produces

$$i_1 = I_o\left(1 - e^{-\frac{t}{T(1+k)}}\right), \qquad (13)$$

where $I_o = E/R$, $k = M/L$ and $T = L/R$. If the polarity of one coil is reversed without changing the source polarities, the terms containing M reverse sign, and the half-axis current becomes

$$i_1 = I_o\left(1 - e^{-\frac{t}{T(1-k)}}\right). \qquad (14)$$

A comparison of Eqs. 13 and 14 shows that in the former, the apparent coil inductance, as seen from the driving source, is approximately $2L$ because of the mutual coupling. In Eq. 14 it is very small, and the coil current rises very fast. But typical push-pull operation is accurately given by Eq. 13 because the driving voltages are out of phase and one coil polarity is also reversed simultaneously. Fig. 5b shows the current rise times for both cases, with the coupling coefficient k close to unity, as opposed to single-ended deflection, where k is zero.

Note that a 2:1 increase in rise time is evident if a single-ended coil is replaced by two push-pull coils of equal inductance. To maintain the response time, each half-axis inductance should be reduced by 50%. The number of turns per half axis is then 0.707 times smaller, and each half-axis deflection current is 70.7% of its previous value. In this case the push-pull connection is less economical than the single-ended. Note also that if rise-time specification tolerate the larger inductance, it is then desirable to double the series resistor R_L. This effectively halves the coil current, thereby keeping the total power dissipation constant.

A better evaluation of what push-pull entails comes with the presentation of a more complete schematic. Figure 5c illustrates a true push-pull deflection amplifier with opposite coil and voltage polarities; it is functionally equivalent to Fig. 5a. Rise time and ramp delay for this circuit can be obtained from the previously derived formulas for single-ended deflection, provided the coil inductance value L is replaced by $L(1 + k) \approx 2L$.

Overdrive affects settling time

The exact determination of current settling-time presents great difficulties for several reasons. Because of the large number of poles in the actual feedback loop, high-order equations must be solved. These render the purely analytical method impractical. A graphical approach, such as the root-locus, can be adopted to predict the stability of a multi-pole system under steady-state conditions. It can also be used to reduce a more complex system to an equivalent, second-order system which can then be treated analytically.

However, the root-locus method is valid only for small-signal analysis. For step inputs (for example, maximum center-to-edge deflection), both of the above methods are inadequate, because the deflection amplifier does not operate in its linear region. It is therefore necessary to consider separately the overdriven state of the amplifier and its contribution to settling time.

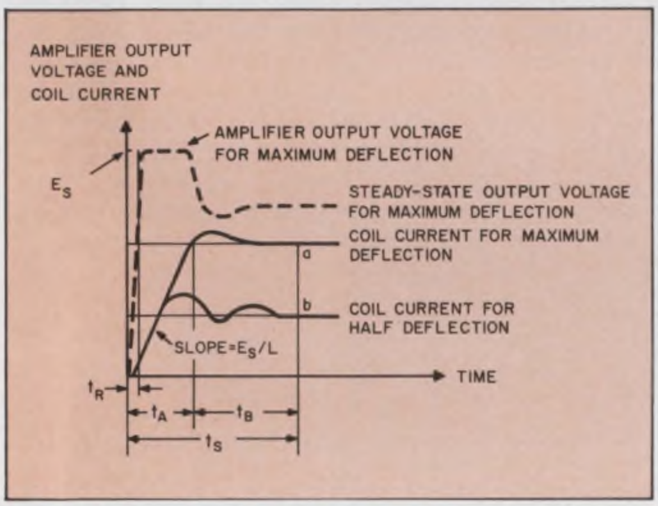
From Fig. 1 it can be seen that amplifier input voltage $E_{in}(s)$ is a function of the difference between signal input $E_1(s)$ and feedback voltage $C(s)$. Since $E_1(s)$ is instantaneously applied and $C(s)$ can only rise linearily toward its theoretical peak value E_s, the amplifier is initially heavily overdriven. Its output is equal to the supply voltage E_s. This condition will last until the feedback voltage is large enough to reduce $E_{in}(s)$ below the saturating level. Up to this point the coil current rises linearily with a rise time t_A of curve a in Fig. 6. This is due to the constant voltage E_s applied to the coil circuit consisting of L and R_L.

After a time t_A has elapsed, negative feedback assumes control, and it takes another time period (t_B) for the current to settle to within a given percentage of its final value. Time t_B can be obtained from the curves derived for the simplified, single-pole amplifier. The total settling time is then the sum of t_A and t_B.

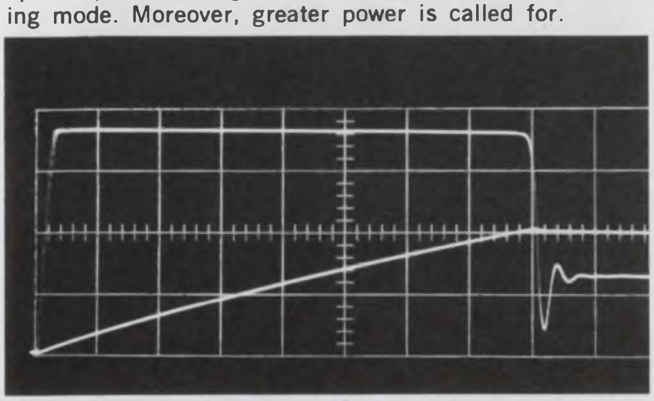
Although the above calculations were made for the full deflection case, the total settling time $t_s = t_A + t_B$ remains relatively constant for lower input drives. In this case, t_A decreases but t_B increases because of the lower system damping constant the less-overdriven amplifier.

Figure 6 also shows the amplifier output voltage for full deflection. Because of the heavy initial overdrive, the amplifier output voltage rises fast to its maximum potential, which is approximately equal to E_s. As the feedback regains control of the output current, the amplifier output drops in an oscillatory manner to its steady-state level. Because of the overdrive and its associated phase delay, both output voltage and current are out of phase. In addition the slightly underdamped system returns to its settling level faster, and the oscillations are cancelled more rapidly (than with less overdrive).

If a single-deflection coil is connected in the collector circuit of the output stage, two different conditions exist. For a fast current increase, the output transistor is in saturation and the full supply voltage is applied to the coil. For a fast current decrease, however, the base of the output transistor is driven to cutoff, and the coil voltage at the collector terminal rises above the supply voltage because of the stored energy in the coil. This action continues until clamping at the protec-



6. **Overdriven stages aren't faster!** The plot of output vs time for various overdrive conditions shows that settling time t_s remains fairly constant. Since overdriving does not speed up the settling time, it is not a recommend operating mode. Moreover, greater power is called for.



7. **Step-up display performance:** Coil voltage and coil current data taken from a single-ended deflection amplifier show good agreement with calculated values. For E_s=18 volts, L=25 μh, R_L=0.5 ohms and T_c=50 ns, the system exhibited a settling time of 17.0 μs. One vertical centimeter represents 5 units (volts and amps) and each horizontal centimeter 2 μs. Voltage is displayed as a step function and current as a ramp.

tive diode occurs. Therefore the rise and fall times may not be equal.

In push-pull applications, however, this dissymmetry does not exist. Because of the tight coupling between the two half-axis coils, the voltage at the turn-off side is controlled by the turn-on voltage, which naturally cannot exceed E_s.

Practical example gives time data

An actual design problem in which the settling time is to be calculated will now be presented. This will demonstrate the design techniques and show how the various parameters operate.

Given is a single-ended deflection amplifier with an open loop gain (A) of 310 and whose first breakpoint of the gain-frequency curve (3dB point) is at $f_o = 3.1$ MHz. The supply voltage of the output stage is 18 volts. E_1, the peak input signal for full deflection (edge-to-edge) is 10 volts. Coil inductance $L = 25$ microhenries, sampling resistor $R_L = 0.5$ ohms, $R_1 = 2k$ and $R_2 = 1k$ (see Fig. 1). Let us now determine the 0.1% settling time of the deflection current.

Step 1. Find time t_A. Since the open loop gain of the amplifier is generally high, $E_{in}(s)$ can be neglected, and the peak feedback voltage $C(s)$ for full deflection can be found from $C(s) = E_1(s)R_2/R_1$. Thus $C(s) = 10\ (1/2) = 5$ volts. The peak coil current is $\Delta i = C(s)/R_L = 5/0.5 = 10$ amps. During time t_A, the full supply voltage of 18 volts is applied to the coil circuit. The time required to reach the final current level (10 amps) is given by $\Delta t = \Delta i L/E_s$. Thus t_A becomes $t_A = (10)25/18 = 14\ \mu s$.

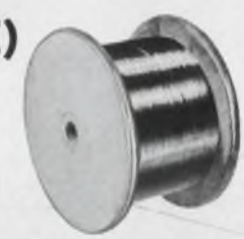
Step 2.

Find time t_B. To obtain an approximate value for the settling time, it is assumed that the current overshoot for full input drive is less than 5% and that the amplifier has a single breakpoint at the frequency f_o. The latter assumption means that the calculated settling time t_B will be smaller than the actual value, because the addition of amplifier poles increases the settling time. During its linear operating mode the amplifier has to settle from the initial overshoot level of 5% to within 0.1% (which corresponds to the signal settling from 100% to 2%).

The settling time t_B can be found from Fig. 2c, or, since m is large, more accurately from Eq. 5. Thus $\epsilon = e^{-(1+m)t_R/2tL} \times 100\%$ is used. Since an exponential function e^{-x} decays from 100% to 2% for $x = 3.91$, time t_B can be found from $t_B(1+m)/2T_L = 3.91$, or $t_B = 0.39\ \mu s$. The total settling time of the system is $t_s = t_A + t_B = 14 + 0.39 = 14.39\ \mu s$.

Actual test results (see photograph in Fig. 7) show good agreement between measured and calculated rise time. The measured values for t_A and t_B are 16.0 and 1.0 μs, respectively. Time t_A is longer than calculated, because the loss in the load resistor R_L and the initial voltage rise time t_R were not considered. Time t_B is longer, because the amplifier time constant is actually larger if the higher-order poles are not neglected. ■ ■

(any way you want it)



For example. Let's take a spool of wire. We can straighten it and cut it. (Diameters from .004 to .125, in lengths from .020″ to 12 feet). And form it into shapes of all kinds. Or coil it. Head it in sizes as fine as .008″. Upset it even in multiples as fine as .009″. Or flatten it wherever you want. Pierce it to specs. Swage it in many ways. Or chamfer one end or both ends–make a full radius on .025″. And even give you any combination you may want.

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ON READER-SERVICE CARD CIRCLE 139

Buying a spectrum analyzer? Both conventional and plug-in units are available; so make sure you choose the type best suited to your needs.

Which superheterodyne spectrum analyzer is best? Conventional, with self-contained CRT and associated circuits? Or plug-in analyzer, which converts a standard oscilloscope into a spectrum analyzer?

From the standpoint of cost alone, the plug-in is usually cheaper in practice. It also has a decided size and weight advantage over a conventional analyzer. But that doesn't mean it would be the best choice for you.

Only when considered in the light of a particular application can the two types be properly compared. Both have advantages and disadvantages, and neither is inherently better than the other.

Sampling principle used

The superheterodyne spectrum analyzer, whether conventional or plug-in, is based on a sampling process. The incoming signal is heterodyned with the output of a swept-frequency local oscillator, and the difference frequency is sampled by a stationary narrowband IF amplifier. In this way the frequency-domain signal is converted to a time-domain signal, which can readily be displayed on an ordinary time-domain oscilloscope.

Plug-ins have advantages

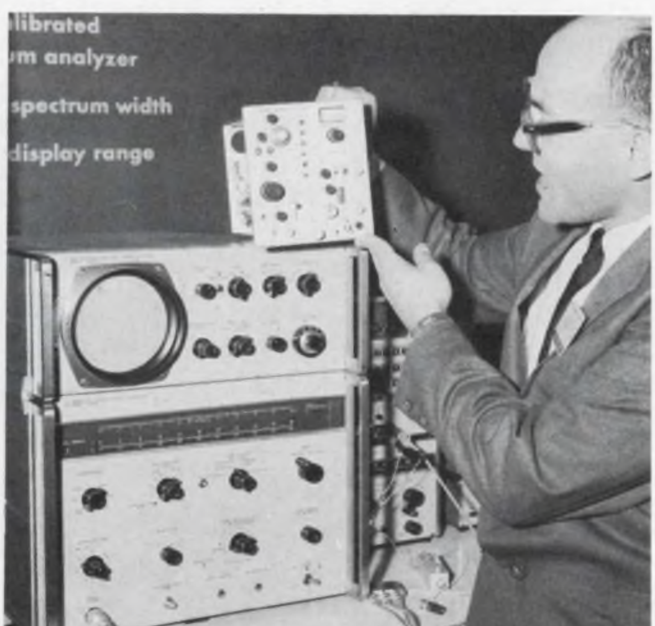
By its very nature, a plug-in spectrum analyzer is smaller and lighter than a conventional analyzer, since it must fit into the available space of some standard oscilloscope. The conventional spectrum analyzer has its own separate scope.

The matter of cost is somewhat more subtle. The plug-in analyzer uses the power supplies, CRT, saw-tooth generator, trigger circuits, etc. that are in the main frame of a standard oscilloscope. So the cost of these elements must be added to that of the plug-in itself, if a true cost comparison is to be made. Nevertheless, because the volume of standard scope sales is at least 20 times that of spectrum analyzer sales, the cost of an oscilloscope is usually considerably less than that of the scope portion of a conventional spectrum analyzer. Thus a plug-in analyzer/scope combination can usually be obtained at a saving in cost over a conventional unit.

Plug-ins provide flexibility

One of the greatest advantages of plug-in analyzers is their increased flexibility. Most can be used with a variety of scopes. Instead of requiring a separate analyzer for every different application, a single plug-in can be used for widely divergent applications by merely mating it with a suitable type of scope.

One example of this flexibility is in the aligning of radar sets. The point of interest is the adjustment of pulse width and pulse shape to obtain a desired output spectrum. With a conventional spectrum analyzer, it is not possible to observe the modulating pulse and the output spectrum concurrently; however, with the use of a dual-beam scope and a spectrum analyzer plug-in, this becomes a simple matter.



Significant size difference between a plug-in and a conventional spectrum analyzer is demonstrated by the author.

Morris Engelson, Project Engineer, Tektronix, Inc., Beaverton, Ore.

Another example occurs in oscillator stability measurements, where it is highly desirable to observe the spectrum over a long period of time (minutes and sometimes hours). The only way to do this with a conventional spectrum analyzer is to take photographs at periodic intervals and then compare the photographs to determine total drift. An easier method is to use a storage scope and spectrum analyzer plug-in, thus permitting the simultaneous display of all the desired information on the CRT.

Plug-in analyzers can also take advantage of many other features that are standard on most scopes but are not available on the scope portion of a conventional spectrum analyzer. These include wide-range calibrated time base, versatile triggering, Z-axis modulation capability and sweep expansion.

Such additional features permit many novel measurements for the spectrum analyzer plug-in that are difficult or impossible to make with a conventional spectrum analyzer. For example, one of the parameters of interest in pulsed RF investigations is the modulating pulse repetition rate. Only a spectrum analyzer with a calibrated time base is capable of supplying this information.

Another example involves the troublesome problem of radio frequency interference from equipment operating in the vicinity of the measurement site. Versatile triggering of the scope can be very helpful in such cases, if a trigger from the signal under observation is available. Once the sweep is triggered to run in synchronism with the desired signal, most other signals will tend to drift across the CRT, making identification of the desired spectrum much easier.

Plug-ins have disadvantages, too

But let's not forget that the plug-in spectrum analyzer also has certain disadvantages. These stem from the small volume available in the plug-in, and they include:

- No RF attenuator.
- Restricted frequency range.
- More crowded front panel.

The state of the art in attenuators and local oscillators is such that sufficient space is simply not available to incorporate all the hardware that certain applications require.

What about conventional analyzers?

The conventional, or self-contained, spectrum analyzer has all of the advantages offered by unrestricted size, weight and power consumption. Front panels are larger, accessories, such as attenuators, are incorporated as part of the package, and the number of local oscillators is limited only by economic factors. For many applications these features are important, and the conventional rather than the plug-in spectrum analyzer is the logical choice. An example of this is spectral measurements of high-power radar sets, where many kilowatts of peak power are involved. This power usually has to be attenuated if the spectrum analyzer is not to be damaged. Disregarding economics, the conventional analyzer is the logical choice because of its built-in attenuator.

In other applications the frequency range to be investigated may be quite large. Here, the conventional spectrum analyzer again has the advantage, since it can contain several RF oscillators and cover the required frequency range. The plug-in, on the other hand, is limited.

As for the performance of a spectrum analyzer, whether conventional or plug-in, it is determined by a series of parameters. But various manufacturers define these in different ways. When comparing specifications, therefore, you may encounter anomalies. They can best be resolved by getting in touch with the respective manufacturers.

Analyzer performance parameters

1. **Frequency range:** The total frequency coverage of the instrument. To analyze the frequency range thus defined, it is usually necessary to tune or band-switch by hand the frequency determining elements of the spectrum analyzer.

2. **Dispersion (sweep width):** The frequency difference that can be analyzed in one sweep. The dispersion can be considered as that frequency width over which sampling can be performed. The dispersion is always equal to or less than the frequency range.

3. **Resolution:** The minimum frequency difference between signals that can be discerned on the analyzer display. The resolution can be considered as the bandwidth of the window that is performing the sampling. Different makers and users tend to define the resolution bandwidth in a different way. Some consider that the resolving capability is defined by the IF amplifier 3-dB bandwidth, while others consider that the 6-dB bandwidth is more realistic.

4. **Sensitivity:** The minimum, or smallest, signal that can be observed, in view of the masking effect of the noise generated by the spectrum analyzer itself.

5. **Maximum signal input:** The maximum, or largest, signal that the system can handle without saturation or other degradation.

6. **Total dynamic range:** The ratio of maximum signal input to sensitivity.

7. **Display dynamic range:** The maximum signal difference that can be displayed simultaneously on the CRT screen. The display dynamic range can never be greater than the total dynamic range.

8. **Sweep speed, or rate:** The rate at which the sampling is performed.

Bibliography:

1. Engelson, M., et al. "Separate Frequencies with a Spectrum Analyzer." ELECTRONIC DESIGN, May 3, 1965, p 64.
2. Feigenbaum, M. "Introduction to Spectrum Analyzers." MICROWAVES, April, 1963, pp 56-60.
3. Frisch and Engelson. "How to Get More Out of Your Spectrum Analyzer." MICROWAVES, May, 1963, p 28.
4. "Microwave Spectrum Analysis." EDN, September, 1965, pp 162-170.

Plug-in analyzer specifications

Here is a list of specifications for available plug-in spectrum analyzers. The instruments are grouped according to manufacturer. Within these groups, they are listed in ascending order of maximum frequency capability. The specifications listed are as given by the manufacturers.

Specifications for conventional spectrum analyzers are given in ELECTRONIC DESIGN's 1965 Test Equipment Reference Issue, copies of which are available for $5.

Mfr	Model No	Frequency Range	Dispersion Range	Resolution Bandwidth	Max Signal Input (volts)	Price approx $	Compatible Oscilloscopes
ANALAB	SA101-1	dc - 20 kHz	100 Hz - 6 kHz	10 - 100 Hz	500	875	Analab: 1100, 100R, 1120, 1120R, 1220, 1220R
	SA101-2	dc - 100 kHz	500 Hz - 30 kHz	35 - 250 Hz	500		
	SA101-3	dc - 500 kHz	2.5 - 150 kHz	150 Hz - 2 kHz	500		
FAIRCHILD	74-91A	10 Hz - 23 kHz	100 Hz - 6 kHz variable; 20 kHz fixed	10 - 100 Hz	240	820	Fairchild: 765, 765H, 766, 766H, 767, 767H, 765MH, 777
	74-92A	35 Hz - 115 kHz	500 Hz - 30 kHz variable; 100 kHz fixed	35 - 250 Hz	240		
	74-93A	150 Hz - 575 kHz	2.5 - 150 kHz variable; 500 kHz fixed	150 Hz - 2 kHz	240		
	74-94A	1 kHz - 2.3 MHz	10 - 600 kHz variable; 2 MHz fixed	1 - 8 kHz	240	950	
	74-96A	600 kHz - 36 MHz	100 Hz - 100 kHz	10, 35 and 100 Hz, and 2 kHz	0 dBm without RF attenuation; +25 dBm with	1250	
	74-97A	10 MHz - 4 GHz	10 kHz - 50 MHz	1 - 100 kHz	–30 dBm	ina	
MICROWAVE PHYSICS	MPR-U/TB	0.5 - 5 GHz	500 - 4500 MHz	5 - 10 MHz	0 dBm	1795	Tektronix: 530, 540, 550 series
	MPR-U/TA						Tektronix: 560 series
	MPR-X/TB	2 - 12 GHz	500 - 10,000 MHz	15 MHz	0 dBm	1795	Tektronix: 530, 540, 550 series
	MPR-X/TA						Tektronix: 560 series

Notes

1. For single sideband applications.
2. At specified sensitivity. Up to 108 MHz with harmonics, at reduced sensitivity.
3. Internal local oscillator.
4. Automatically programed when dispersion range is selected.
5. External local oscillator.

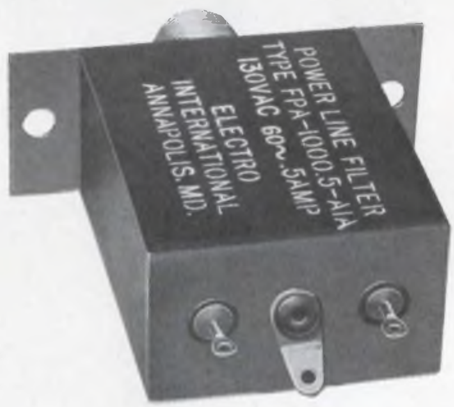
Abbreviations

ina Information not available

Mfr	Model No	Frequency Range	Dispersion Range	Resolution Bandwidth	Max Signal Input (volts)	Price approx $	Compatible Oscilloscopes
NELSON-ROSS	PSA-016	0.5 Hz - 2 kHz	10-600 Hz variable; 2 kHz fixed	0.5 and 50 Hz	500	945	Tektronix: all that use letter series plug-ins
	PSA-026	↓	↓	↓	↓	1150	Tektronix: 560 series
	PSA-036	↓	↓	↓	↓		Hewlett-Packard: 140A
	PSA-011	10 Hz - 20 kHz	100 Hz - 6 kHz variable; 20 kHz fixed	10 - 100 Hz	500	555	Tektronix: all that use letter series plug-ins
	PSA-021	↓	↓	↓	↓	760	Tektronix: 560 series
	PSA-031	↓	100 Hz - 6 kHz	↓	↓	↓	Hewlett-Packard: 140A
	PSA-012	35 Hz - 100 kHz	500 Hz - 30 kHz variable; 100 kHz fixed	35 - 250 Hz	500	625	Tektronix: all that use letter series plug-ins
	PSA-022	↓	500 Hz - 30 kHz	↓	↓	830	Tektronix: 560 series
	PSA-032	↓	↓	↓	↓	↓	Hewlett-Packard: 140A
	PSA-013	150 Hz - 500 kHz	2.5 - 150 kHz variable; 500 kHz fixed	150 Hz - 2 kHz	500	645	Tektronix: all that use letter series plug-ins
	PSA-023	↓	2.5 - 150 kHz	↓	↓	850	Tektronix: 560 series
	PSA-033	↓	↓	↓	↓	↓	Hewlett-Packard: 140A
	PSA-014	1 kHz - 2 MHz	10 - 600 kHz variable; 2 MHz fixed	1 - 8 kHz	500	845	Tektronix: all that use letter series plug-ins
	PSA-024	↓	10 - 600 kHz	↓	↓	1050	Tektronix: 560 series
	PSA-034	↓	↓	↓	↓	↓	Hewlett-Packard: 140A

Mfr	Model No	Frequency Range	Dispersion Range	Resolution Bandwidth	Max Signal Input (volts)	Price approx $	Compatible Oscilloscopes
NELSON-ROSS (con't)	PSA-201[1]	600 kHz - 36 MHz[2,3]	5 ranges selectable from 10 Hz/cm to 1 kHz/cm; variable from 1 to 10 kHz/cm	note (4)	−100 dBm (threshold) to −46 dBm (full scale in log); +2 dBm with attenuator	1600	Tektronix: all that use letter series plug-ins
	PSA-231[1]	↓	7 ranges selectable from 10 Hz/cm to 10 kHz/cm	↓	↓	1700	Hewlett-Packard: 140A
	PSA-200[1]	500 kHz - 100 MHz[2,5]	5 ranges selectable from 10 Hz/cm to 1 kHz/cm; variable from 1 to 10 kHz/cm	note (4)	−100 dBm (threshold) to −46 dBm (full scale in log); +2 dBm with attenuator	800	Tektronix: all that use letter series plug-ins
	PSA-230[1]	↓	7 ranges selectable from 10 Hz/cm to 2 kHz/cm	↓	↓	900	Hewlett-Packard: 140A
	PSA-311	1 - 300 MHz	10 kHz/cm to 10 MHz/cm	5, 10, 50 and 100 kHz	−30 dBm	1200	Tektronix: all that use letter series plug-ins
	PSA-331	↓	↓	↓	↓	1300	Hewlett-Packard: 140A
	PSA-510	10 MHz - 15 GHz[5]	0 - 1 GHz	5, 10, 50 and 100 kHz	−30 dBm	1250	Tektronix: all that use letter series plug-ins
	PSA-530	↓	↓	↓	↓	1350	Hewlett-Packard: 140A
TEKTRONIX	1L10	1 - 36 MHz	Calibrated: 10 Hz/cm to 2 kHz/cm; Search: 20 kHz +1 kHz/MHz dial freq.	10 Hz - 1 kHz; Search: 10 kHz	¼ watt (+24 dBm)	1200	Tektronix: all that use letter series plug-ins
	3L10	↓	↓	↓	↓	1300	Tektronix: 561 561A 564
	1L20	10 - 4200 MHz	1 kHz/cm to 10 MHz/cm; 10 kHz - 100 MHz full screen	1 - 100 kHz	−30 dBm	1995	Tektronix: all that use letter series plug-ins
	1L30	925 MHz - 10.5 GHz	↓	↓	↓	↓	↓

Philter or FILTER?



Some RFI filters are a little like good luck charms. Install them, cross your fingers, and hope they work.

But that was before Electro International offered their Power Line Filter series—tested and warranted to eliminate interference as specified by applicable military and commercial specifications. These current carrying filters were developed as a result of Electro International's basic work in controlling RFI. Because they could not find a supply of filters which would reliably reject broadband RFI, they built their own, to meet their own critical standards. Now, these same high attenuation filters are available to you, with inherent quality that means you can be confident that each will perform as a reliable component of your system.

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		DB	FROM	TO	WIDTH	LENGTH	DEPTH	
	(Amperes)					(Inches)		
FPA-1000.5-A1 (*)	½	40	0.150 MC	1 KMC	1¾	2¼	1	
FPA-1000.5-B1 ( )	½	60	0.150 MC	1 KMC	1¾	2½	1	
FPA-1000.5-C1 ( )	½	80	0.150 MC	1 KMC	1¾	3½	1	Mounting (A)
FPA-1000.5-D1 ( )	½	60	0.100 MC	1 KMC	1¾	2¼	1½	
FPA-1000.5-E1 ( )	½	70	0.100 MC	1 KMC	1¾	2½	1½	
FPA-1000.5-F1 ( )	½	100	0.100 MC	1 KMC	1¾	3½	1½	
FPA-1001-F1 ( )	1	60	0.300 MC	1 KMC	1¾	3½	1½	Mounting (B)
FPA-1003-G1 ( )	3	60	0.300 MC	1 KMC	2¼	2¾	1½	
FPA-1005-K1 ( )	5	60	0.300 MC	1 KMC	3	3½	1½	
FPA-201 ( )	1	70	0.150 MC	1 KMC	2 5/16	2 11/32	1⅝	Mounting (C)
FPA-203 (C)	3	60†	0.150 MC	1 KMC	3 1/16	3 9/16	1 9/16	(C) MTG. ONLY
FPA-205 (C)	5	60†	0.150 MC	1 KMC	3 1/16	3 9/16	1 9/16	(C) MTG. ONLY

**Not including mounting brackets, terminals and connectors † 80 db at 0.400 kc to 1 kmc

* ( ) Letter assigned according to method of mounting desired by customer.

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ON READER-SERVICE CARD CIRCLE 142

Carpet plotting is easy, and it increases interpolation accuracy. Simple to construct, the plots allow visual pinpointing between families of curves.

Are carpet plots "foreign" to you? Or maybe you shy away from them because the graphs seem hard to set up? A simple, mechanical retracing process should prove helpful to you in constructing and using these plots.

Basically carpet plotting is just another way of presenting a three-variable function that is usually plotted as a family of curves. Carpet plotting adjusts the family of curves to provide accurate visual interpolation within each curve.

Carpet plots are easy to construct. Leave the first curve of the family intact. Then merely step each successive curve the equivalent of 10 minor units on the graph paper. This forces the family of curves into a carpet format.

Typical applications include the use of such plots to determine the operational characteristics of vacuum tubes and semiconductors.

Since carpet plotting is based on linear stepping, the process can be used for all rectangular coordinate format graphs, semi-logarithmic format graphs and even polar coordinate format graphs. However, because of the linear stepping process, the method is not applicable to double logarithmic function plots.

To see how easy the method works, construct a sample carpet plot, with a large grid presentation for simplicity. (It is recommended that 8-1/2 x 11 inch graph paper be used, with a scale of 10 x 10 to the half-inch or 10 x 10 to the centimeter.)

The plotting consists of six steps:

1. **Draw a family of straight lines** from the x-y origin, as shown in Fig. 1. Four random straight lines are used in this sample, to keep the plotting simple. Since the family plot will be expanded in later steps, the x axis is limited to cover only one-half of the graph paper.

2. **Place another sheet of graph paper** of the same grid on top of the first. Trace the y axis (independent variable in this case) and copy the scale. Next add line $b = 4$, and highlight $x = 1$, 2 and 3, as shown in Fig. 2.

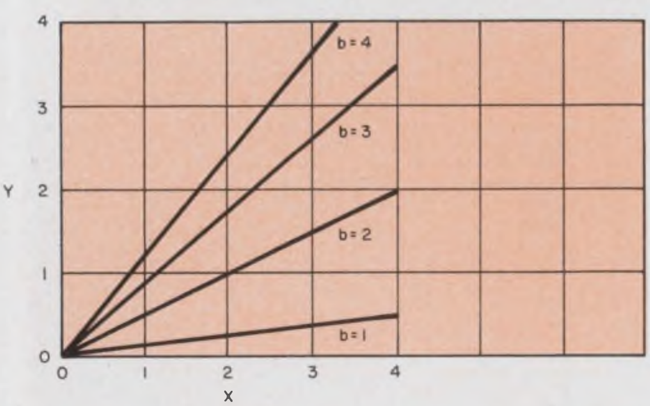
3. **Slide the top graph 10 small units** (one major division) to the left, maintaining the coordinate scale digits in correct position, and line up the vertical and horizontal grids accurately. Trace line $b = 3$, and highlight $x = 1$, 2, 3 and 4, as shown in Fig. 3.

4. **Repeat step** 3 for $b = 2$ and $b = 1$ to produce a graph similar to that in Fig. 4. Note that the original grid line, $x = 1$, is no longer a single vertical line but a series of points on $b = 4$, 3, 2 and 1, as a result of the stepping process.

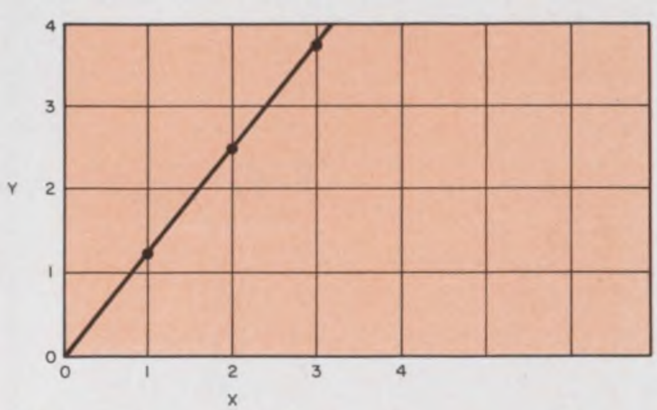
5. **Join the highlighted marks** for $x = 1$ with a smooth curve or straight line, as the case may be (Fig. 5). Whether a line or curve is required depends upon the family of lines or curves selected. In the example shown here the points fall in a straight line.

6. **Repeat step** 5 for $x = 2$, 3 and 4 and $x = 0$. Note that $x = 0$ is now a horizontal line running between $b = 4$ and $b = 1$ and not the x-y origin shown in Fig. 1. Also observe that the graph paper's minor vertical grid lines separate the x and b variable curves into 10 divisions, as indicated in the upper portion of Fig. 6. Only the vertical grid lines are used to construct the intermediate values of x and b, since the selected family division steps were based *only* on the vertical grid scale.

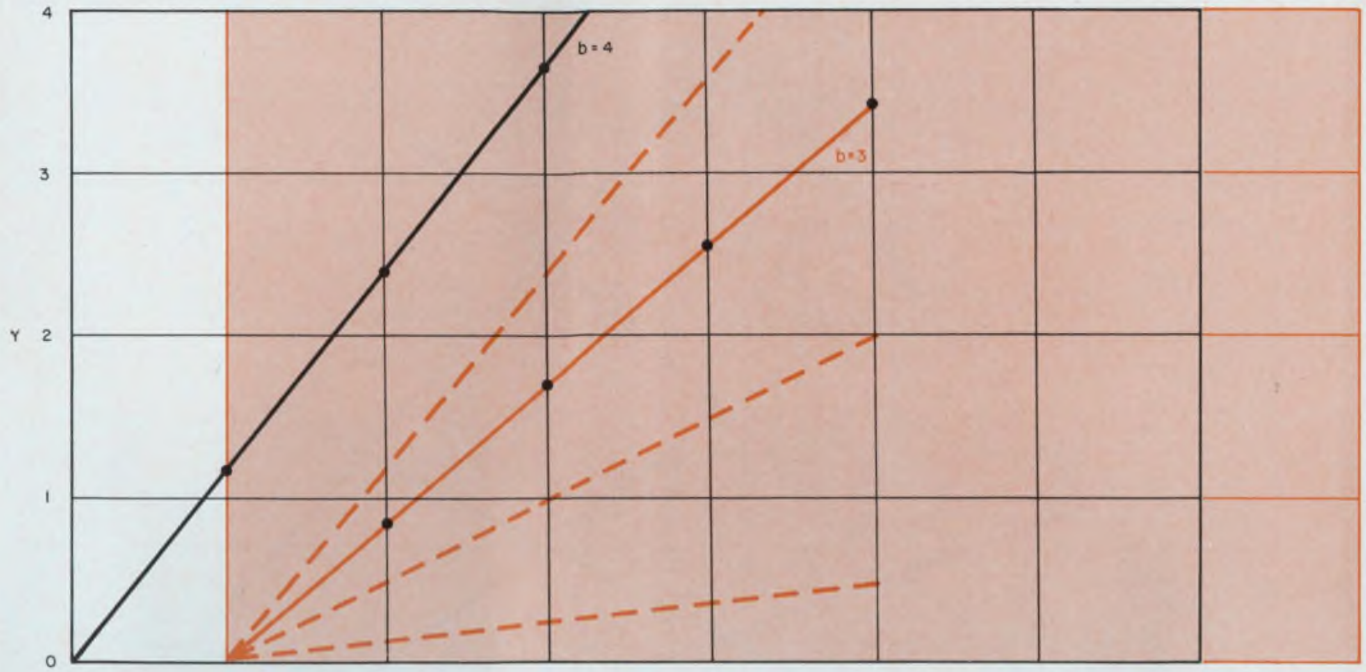
Edgar R. Bourke 2d, Raytheon Company,
Space & Information Systems Div., Lexington, Mass.



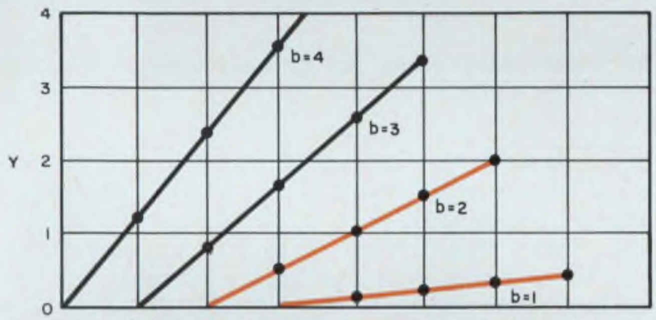
1. **Sample plot to be used** in demonstration of carpet plotting.



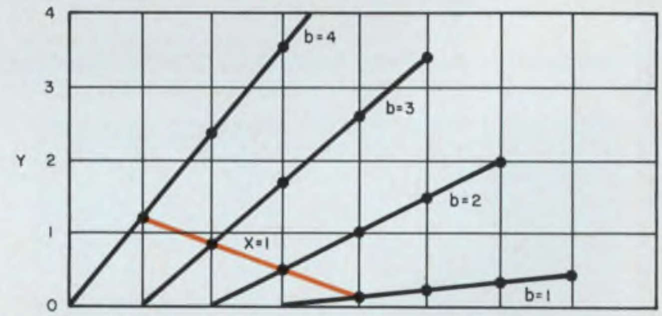
2. **Overlay made by tracing** scale and b = 4 curve from Fig. 1.



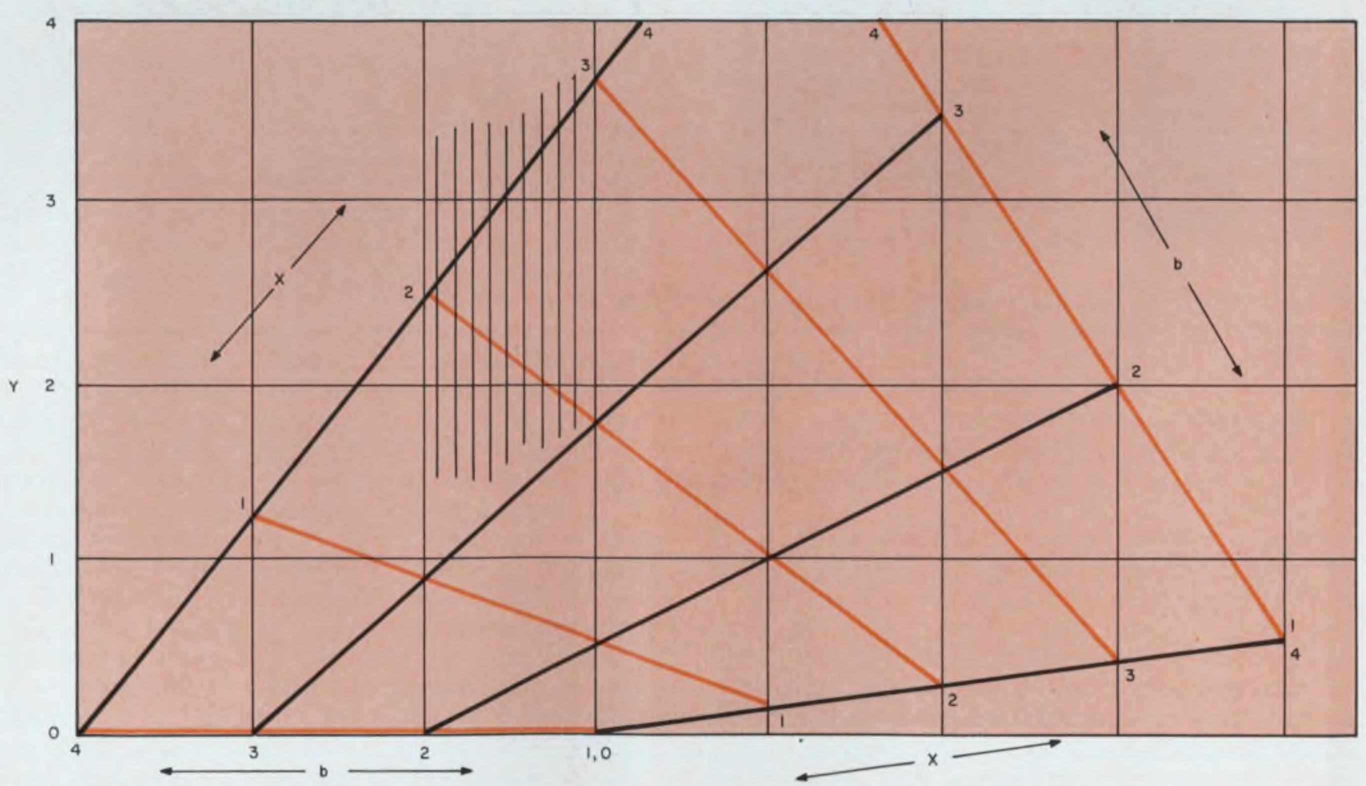
3. **Superimposition of Figs. 1 and 2.** The line b = 3 is traced on the overlay and the points X = 1, 2, 3 and 4 are highlighted. The top graph has been slid 10 small units (one major division) to the left.



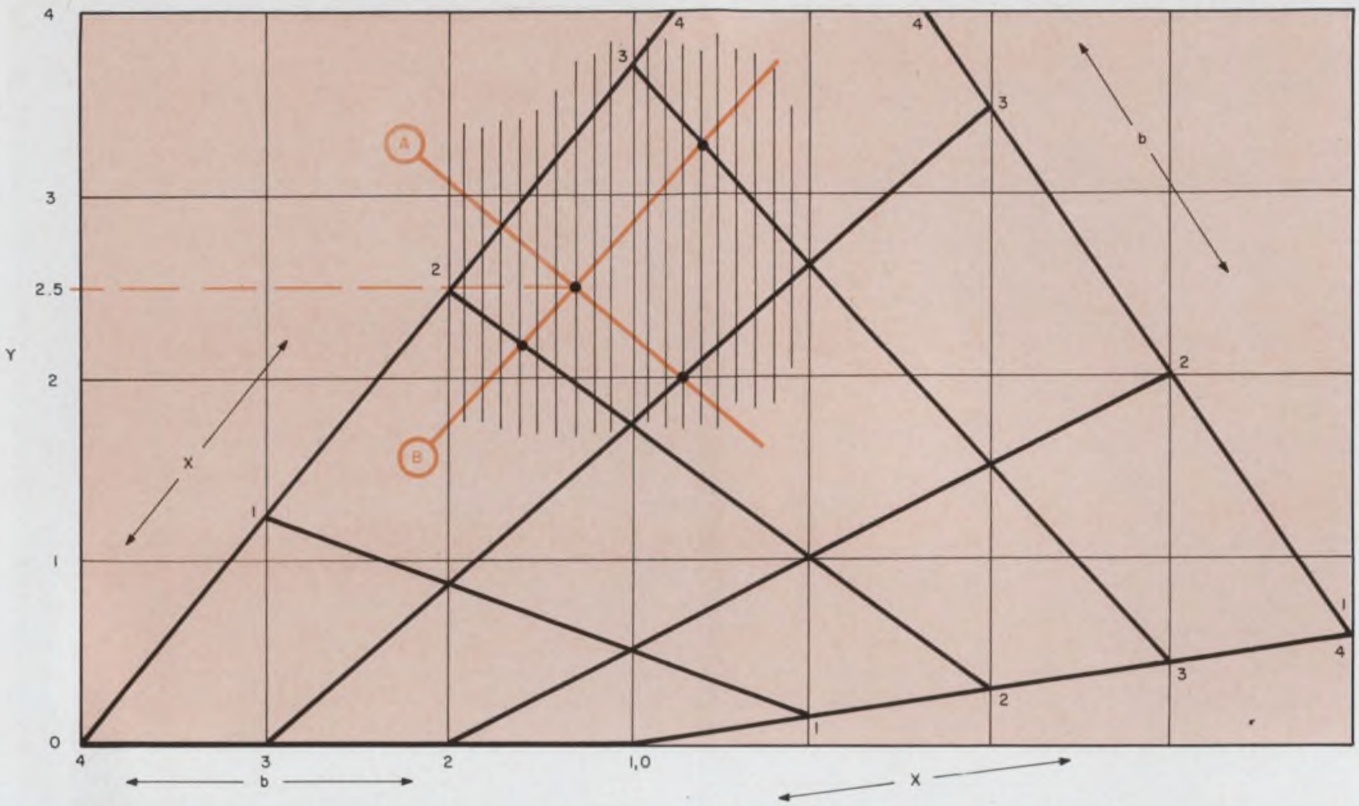
4. **Third step** shows tracing of lines for b = 2 and b = 1.



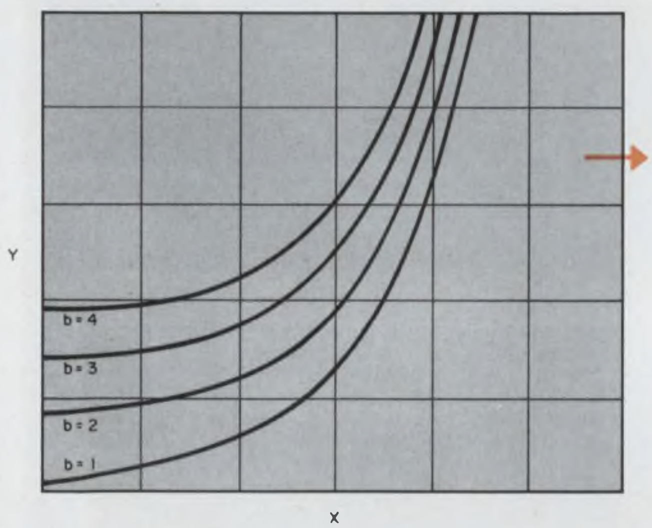
5. **Joining of X = 1** yields a straight line.



6. **Joining of X = 0,** X = 2, X = 3, and X = 4 points on overlay. Interpolation is the next step.



7. **Interpolation for** points where X = 2.3. By observing the intersection of the lines A and B relative to the graph's horizontal grid lines, we can fix the y value of b = 3.6 and X = 2.3 at 2.5.



8. Either horizontal or vertical stepping can be used for carpet plotting. The choice depends on the particular set of curves.

The plot is now ready for interpolation, and let us assume that it is desired to establish the y value for $b = 3.6$ and $x = 2.3$. Only two steps are involved.

First, establish the curve (or line) for $x = 2.3$ by counting three minor divisions in the vertical grid up along the $b = 3$ and $b = 4$ lines (Fig. 7, line A).

Next establish the curve (or line) for $b = 3.6$ by counting six minor divisions up along the $x = 2$ and $x = 3$ line. (Fig. 7, line B). By observing the intersection of the lines A and B relative to the graph horizontal grid lines, we fix the y value of $b = 3.6$ and $x = 2.3$ at 2.5.

To expand the functional scope of the carpet plot, let us assume that the $b = 2$ line was missing. The step between $b = 3$ and $b = 1$ should then be increased from 10 to 20 minor units, to maintain the proper interpolative scale of the carpet. After the $x = 1$, 2, 3 and 4 curves (or lines) are added to the plot, the intersection of the x variable curves with the 10-unit scale permits the inclusion of line $b = 2$.

Extending this concept enables the plotter to add any additional intermediate curves. It may, for instance, be useful to add $x = 0.5$, 1.5 and 2.5, and $b = 1.5$, 2.5 and 3.5. To do this, simply join the locus of points formed by the intersection of the x and b variable curves with the vertical grid. The appropriate points on the grid are found in the same way as y was when the values for b and x were given.

Determination of the stepping direction for a family of curves is a matter of judgment; it is always desirable to spread the family as much as possible. In Fig. 8 it is obvious that the uppermost black curve should be traced first and that the rectangular coordinate graph paper should be stepped to the right for each succeeding curve of the family. On the other hand, for the colored curves in Fig. 8 the x axis should be made the independent variable, the lowest colored curve should be traced first, and the graph should be stepped vertically.

Finally the procedure for the use of a semi-log coordinate format is essentially the same as for a rectangular coordinate format. The main difference, however, is that in this case the logarithmic scale must *always* remain the independent variable scale. ■ ■

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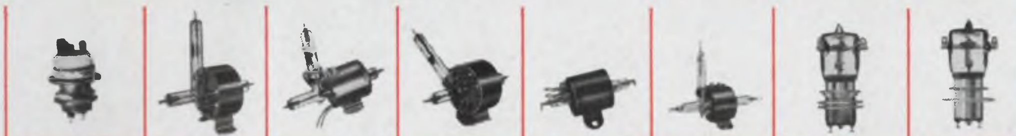
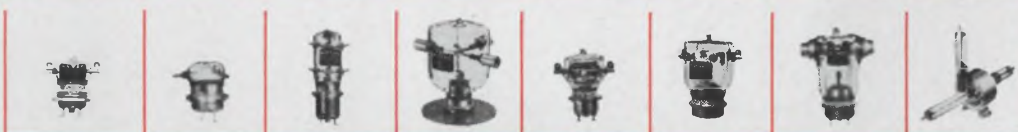


HYVAC TYPE	HC-1†	HVS-1	HVS-4	HVS-10	H-5	H-7	H-8	H-9
Contact arrangement	SPDT	SPDT	SPDT	SPDT	SPST N.O.	SPDT	SPDT	SPST N.C.
Rated Operating Voltage (KV)	2.5	17	17	17	5	5	15	15
Test Voltage (KV)	5	22	22	25	7.5	7.5	20	20
Continuous Current, max. (amps RMS)	18	7	8	8	4	4	15	15
Contact resistance, max. (ohms)	0.010	0.015	0.020	0.015	0.015	0.020	0.015	0.015
Operating time, max. (ms)	6	20	15	20	10	10	15	15
Coil resistance (ohms ± 10% @ 25°C)	335	128	40	65	250	200	250	250
Coil voltage (vdc, nominal)	26.5	28	24	40	24	24	26.5	26.5
Nominal Dimensions (inches — L × H)	.925D x 1¼	4¾ x 5	4¾ x 4½	4¾ x 3¼	¾ x 2	2⅞ x 2½	1⅛D x 2¾	1⅜D x 2¾
Mounting Style*	threaded base	foot bracket	foot bracket	foot bracket	foot bracket	foot bracket	threaded base	solder flange
Approximate unit price (1-9 pcs)	$59	$55	$48	$55	$62	$62	$98	$98

*Other styles available †Ceramic envelope



HYVAC TYPE	H-11/S2	H-12	H-16	H-17	H-18	H-19	H-20**	H-35
Contact arrangement	SPST NO.	SPDT	DPDT	SPDT	DPDT	DPDT	SPST, N.C.	SPDT
Rated Operating Voltage (KV)	12-air 18-oil	8-air 12-oil	12-air 18-oil	25-air	10	20	28	35
Test Voltage (KV)	15-air 20-oil	12-air 15-oil	15-air 20-oil	30-air	12	30	30	40
Continuous Current, max. (amps RMS)	15	15	15	25	10	20	75	10
Contact resistance, max. (ohms)	0.015	0.015	0.030	0.015	.020	.010	.003	0.015
Operating time, max. (ms)	18	18	20	25	15	40	25	30
Coil resistance (ohms ± 10% @ 25°C)	250	250	120	120	265	265	118	50
Coil voltage (vdc, nominal)	26.5	26.5	26.5	26.5	24-28	24-28	26.5	28
Nominal Dimensions (inches — L × H)	1D x 1 13/16	1 1/16 x 1 13/16	1⅜ x 3	2D x 3½	1½D x 2	2½D x 3½	2½D x 3 11/16	8 x 5
Mounting Style*	threaded base	threaded base	threaded base	flange base	threaded base	threaded base	threaded base	mounting bracket
Approximate unit price (1-9 pcs)	$105	$110	$128	$128	$135	$135	$150	$110

*Other styles available **H-21, same spec as H-20, except H-21 is SPST, N.O.

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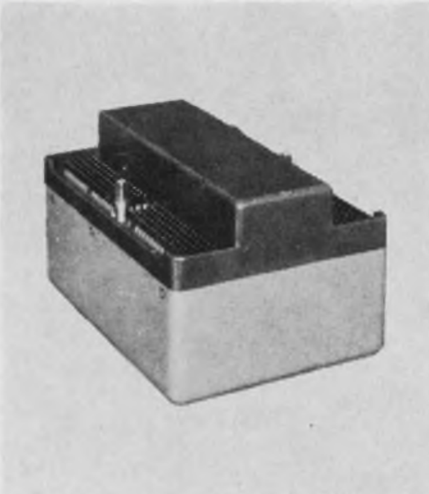
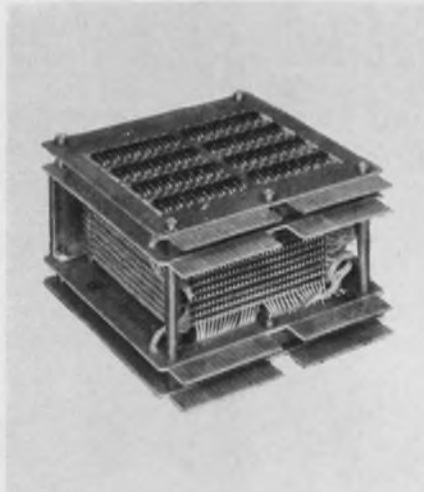
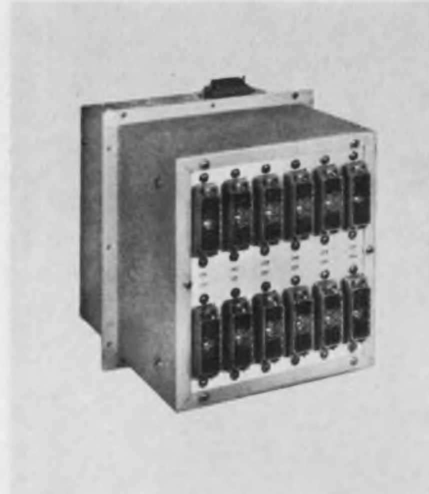


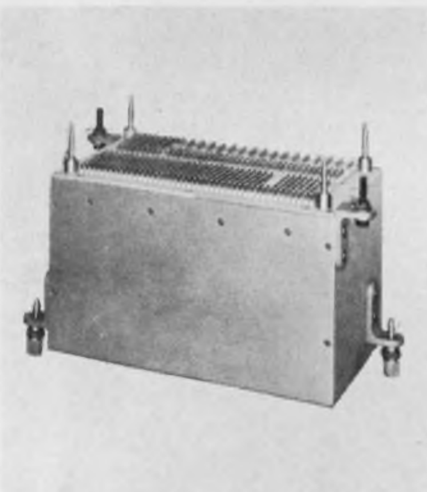
Customer: Control Data Corporation
128 x 64 x 12 capacity, temperature controlled stack for Polaris program



Customer: Honeywell
64 x 64 x 9 stack for H-200 computer

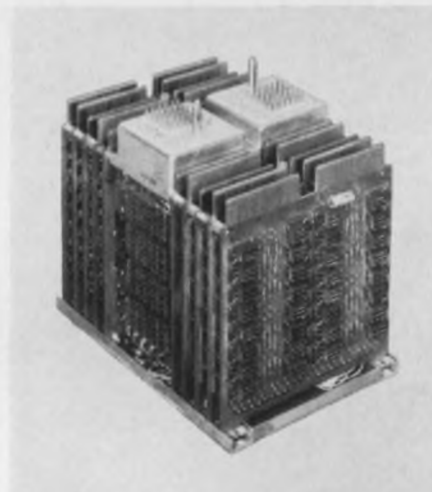


Customer: Scientific Data Systems
16,384 x 25 stack for 930 computer



Customer: Bunker-Ramo Corporation
16,384 x 16 stack for BR 133 computer

Customer: Dynatronics
2048 x 19 stack for simulator system



Customer: Honeywell
128 x 128 x 9 stack for H-2200 computer

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EIMAC

25 kW magnetron is now at work putting the crackle in potato chips for Cryodry Corporation

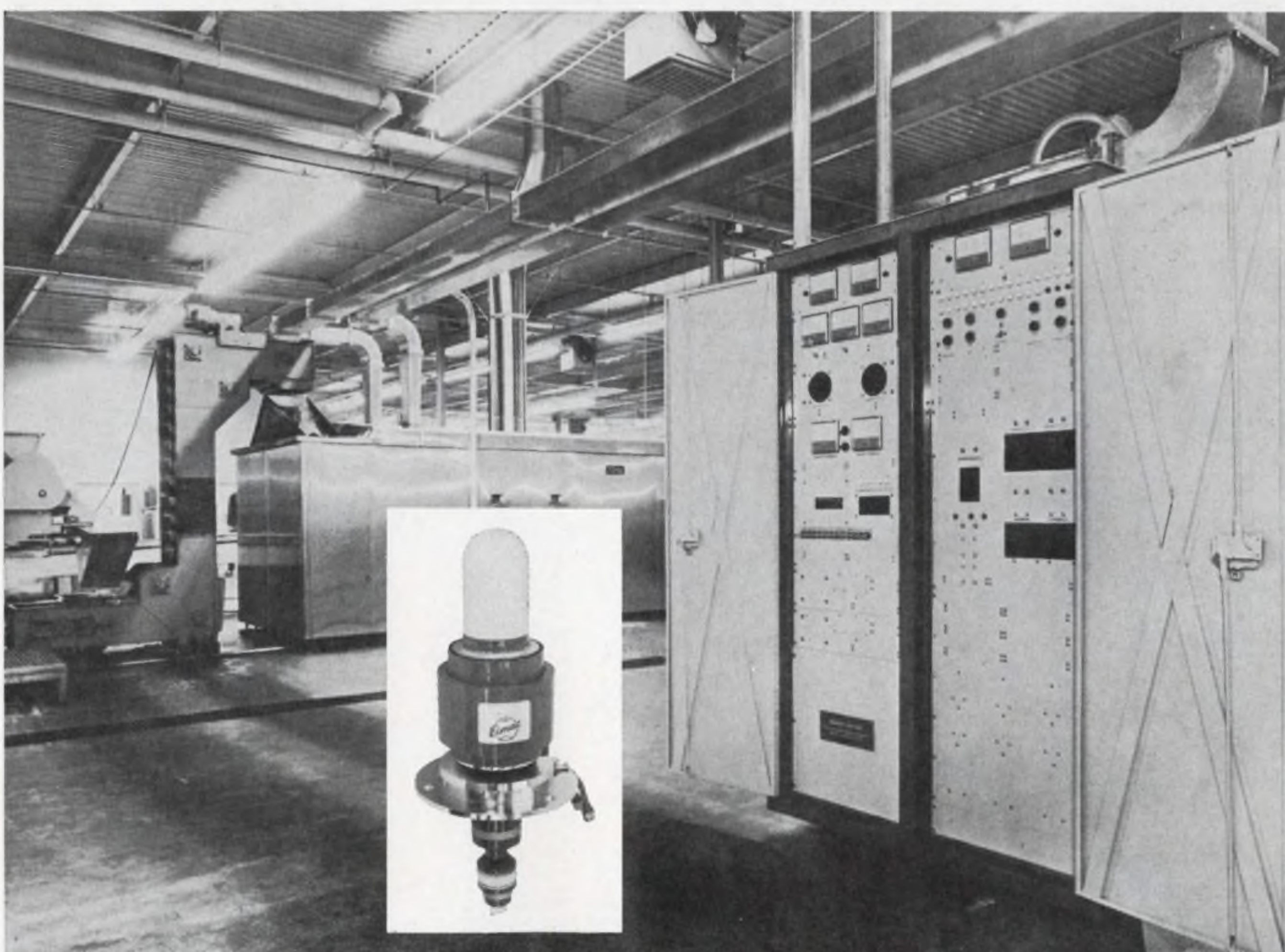
Microwave heating has recently emerged from the laboratory and is now finding its place in the food processing and other industries. Because it is fast, efficient, and highly controllable, microwave heating is particularly suitable for on-stream operations.

For example: Revolutionary new potato chip processing machinery manufactured by the Cryodry Corporation, a subsidiary of the Armour Company, uses the EIMAC EM15LS magnetron in a conveyorized microwave oven to finish-dry to optimum color potato chips which have been pre-cooked in oil.

M. R. Jeppson, President of Cryodry, says: "We chose Eimac's new magnetron to power our machinery because the tube has an unusually high dc-to-rf conversion ratio—80%—and promises a very competitive life cost per kilowatt hour of only 2¢."

Moisture removal is only one of the tasks which industry can assign to microwave heating. Others include chemical catalysis, distillation, puffing, fermentation, and sterilization. Eimac has built pioneering tubes to supply microwave power for this new technique. As fast as new applications for microwave heating arise, Eimac is developing appropriate power supplies. If you'd like to find out more about what *you* might do with microwave heating, write on your letterhead to *Microwave Marketing, Eimac.*

EIMAC
San Carlos, California 94070
A Division of Varian Associates



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ON READER-SERVICE CARD CIRCLE 146

What do they mean by "an engineer's company"?

Some very successful companies are "sales oriented"—others, equally successful, receive their primary impetus from accounting, legal or business-management directions. Probably because of the highly technical nature of its product, Motorola has always been a company wherein engineering has been the moving force. At any management conference at Motorola, you'll find men think like engineers, and talk like engineers, because so many in the management echelon *are* engineers.

At Motorola the engineer achieves full professional status—because he is working in an environment where the state of the art has progressed to the point where only an "engineering oriented" management can direct the flow of achievement.

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- The "circle number" portion of the form is detached before the application is sent to an employer, so that no company will know how many numbers you circled.
- All original applications are placed in confidential files at ELECTRONIC DESIGN and after a reasonable lapse of time they are destroyed.

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March 1, 1966

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Position Desired ____

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Low power and very high power monolithic and hybrid circuits.

Silicon Transistors—from very high frequency 10 milliampere through 25 ampere, 1000 volts.

Thyristors—from 50 milliampere through 500 ampere, 2000 volts.

Zener Diodes.

Silicon Rectifiers—from milliampere through 250 ampere, 3000 volts.

Continuing R&D efforts already have led to Delco's leadership in high power, high voltage silicon transistors. Delco rectifiers—rated at 250 amps, 2000 volts—are going into alternators designed to handle the full power generated by the latest Diesel-electric locomotives.

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If you'd like more information immediately, pick up the phone and call us collect, Area Code 317/459-2808. Ask for C. D. Longshore. Or, send your resume to Mr. Longshore, Salaried Employment, Dept. 101, Delco Radio Division, General Motors, Kokomo, Indiana.

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The Apollo Support Department is working on the frontiers of reliability, integration and checkout for the NASA Apollo mission. Reliability and quality engineers use mission models to pinpoint critical equipments and sequences in the lunar mission, and simulate entire equipments before they're built to make sure they'll work. Extensions in the reliability art are the order of the day.

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Engineers—Reliability End-Item	BSEE/ME	Houston, Texas
Systems Instructors, Training Planners, or Programming Analyst Instructors	BSEE/Physics/Math	Daytona Beach, Fla.
Engineering Programmers	BS Math/Physics/Engr'g.	Daytona Beach, Fla.
Programmers/Programming Analysts	BS Math/EE	Kennedy Space Center, Fla.
Engineers—Telemetry Systems	BSEE/MSEE	Kennedy Space Center, Fla.
Mechanical Engineers—Systems Analysis	BSME	Kennedy Space Center, Fla.
Computer Programmers	BS Math/Statistics/EE/ ME/Bus. Admin.	Kennedy Space Center, Fla.
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Please write, in full confidence, including salary requirements to: Mr. D. M. Hill, Professional Placement, General Electric Co., Apollo Support Dept., Room 1142-L, Box 2500, Daytona Beach, Florida 32015.

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ON READER-SERVICE CARD CIRCLE 909 ➤

NASA Tech Briefs

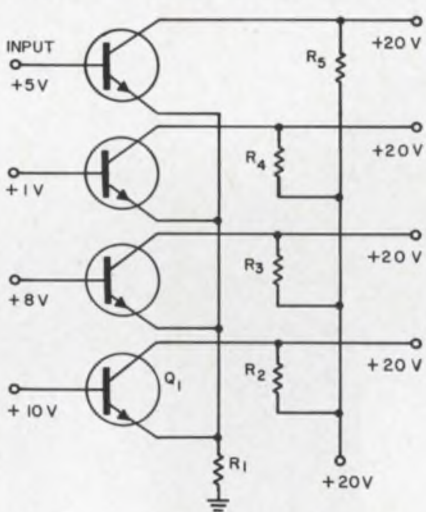
Voltage comparator is also sensor

Problem: Detect the highest voltage input among a group of varying voltage inputs without the aid of external circuits.

Solution: A transistorized circuit that can be directly coupled to a binary encoder for readout.

The voltage comparison circuit uses one transistor for each input line. The base-emitter junctions of the transistors are connected as in a standard diode comparator circuit. The collector circuits of the transistors perform the sensing function.

The emitters of all the transistors are tied to one common resistor R_1. Each transistor has a load resistor in its collector



circuit. With the maximum input voltage on the base of Q_1, the base-emitter junction of Q_1 will be the only one forward biased. Voltages on the emitters of all transistors, except Q_1, will be more positive than the voltages on their respective bases and they will be cut off. The output voltages of these transistors will be very high compared to that of Q_1.

For further information, contact: Technology Utilization Officer, Goddard Space Flight Center, Greenbelt, Maryland 20771 (B65-10028).

FET audio signal mixer exhibits linearity, isolation

Two FETs forming a mixer circuit will produce an output envelope corresponding to the difference between two closely spaced audio transducer signal inputs. The high Z_{in} and large g_m of the FET give the circuit excellent isolation and linearity and also enable it to function as a complex signal simulator.

The mixing action in this circuit (Fig. 1a) is one of pure combination of two differing frequency signals. The basic circuit operation is as follows:

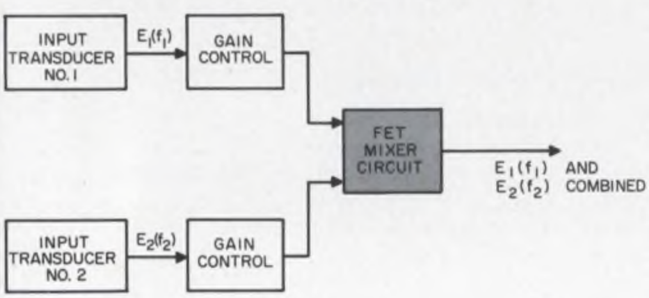
Each input transducer has its respective gain control, represented by potentiometers, for providing numerous amplitude ratios between the input signals. A single drain-load resistor is used to facilitate output coupling to succeeding stages. Degenerative feedback in the common-source lead is provided by an unbypassed resistor.

A 3:1 feedback ratio between source resistors has been found to provide adequate stability and to ensure predictable circuit performance with device interchangeability. The output signal is shifted 180° with respect to the gate input. If "in-phase" operation is desired, a bipolar stage may be added, as shown in the circuit diagram (Fig. 1b). The performance is typified by a frequency response of 10 Hz-5 kHz (flat), with the upper 3 dB cutoff at 25 kHz. The input impedance is 10 MΩ, and the input dynamic range is 0-400 mV before any output distortion is noted. The voltage gain is 3.0 at 1.0 kHz.

The circuit will combine any two frequencies in the audio range. Either of the input frequencies may be recovered at the output, by passing the total output spectrum through an appropriate narrow-band filter network. The circuit functions very well as a complex signal simulator, since a phase shifter may be placed in either or both signal inputs to provide simulated transducer operation over a broad range of amplitude, frequency and phasing ratios.

C. R. Seashore, Senior Research Engineer, Honeywell, Inc., St. Paul, Minn.

VOTE FOR 110



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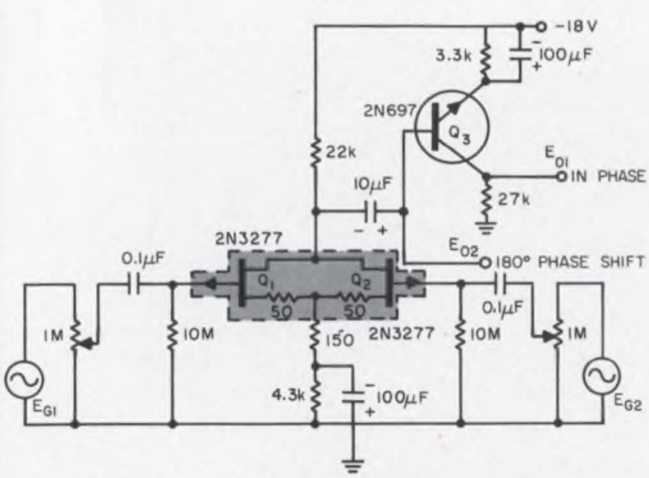


ⓑ

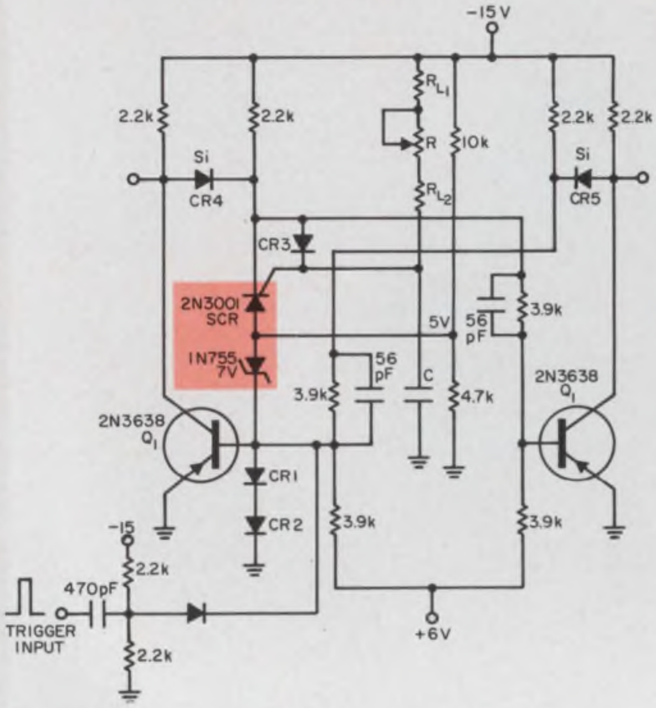
Two closely spaced transducer audio input signals are combined in a FET mixer (a). Complete circuit (b) shows high isolation (Z_{in} = 10 MΩ), good linearity (400 mV dynamic input range) and dual outputs (0° and 180° phase shifts).

SCR plus zener extend one-shot's time delay

Adding an SCR and a zener diode to a one-shot multivibrator results in longer time delays and prevents the rounding of output waveforms caused by long capacitor-charging times. Designed for use in an optical character reader, this circuit will lend itself readily to other pulse applications.

The SCR-zener combination shown in the accompanying figure completely isolates the *RC* timing network from the switching circuit and permits the use of high *R* and low *C* components for long time delays. Operation of the modified multivibrator closely resembles that of conventional types. It is as follows:

Transistor Q_1 is normally ON, holding *C* discharged through CR_1. A positive input pulse turns Q_1 OFF, thereby switching Q_2 ON. This circuit state persists until *C* charges through *R*, R_{L1} and R_{L2} to a voltage sufficient to forward-bias the SCR gate. The SCR then fires, switching the circuit back to the normal state. Capacitor *C* is



This modified one-shot multivibrator uses an SCR-zener combination for longer time delays and squarer outputs. In effect, these components isolate the timing elements from the switching network.

discharged through CR_3, and the circuit remains "ready" by virtue of the feedback from Q_2, until another trigger appears.

Diodes CR_1 and CR_2 prevent zener firing and SCR triggering on large-input trigger amplitudes. CR_4 and CR_5 isolate the output from the switching circuit, allowing full logic output swings.
D. R. Hobaugh, Project Manager, Recognition Equipment, Inc., Dallas, Tex.

VOTE FOR 111

Dc-coupled flip-flop acts as Schmitt Trigger

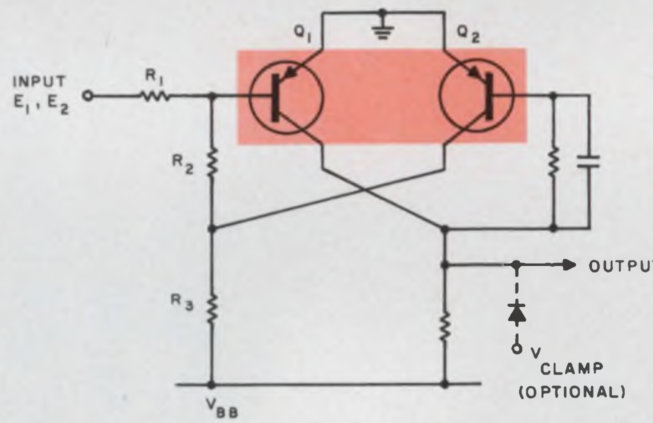
By substituting a saturating flip-flop for the conventional Schmitt trigger, a ground-level output capability is achieved. This feature is especially useful in digital applications.

The traditional Schmitt trigger is a bistable multivibrator employing a common-emitter resistor in its feedback loop. The resistor is essential in developing the switching threshold voltages. Because current flows through the resistor at all times, it is difficult for the Schmitt circuit to produce a ground-level output. Since the circuit has many applications in digital circuits, and many of these often use ground as one of the two stable logic levels, several methods have been devised to produce a ground-level output. Typically, these techniques make the circuit more costly and complex.

A less costly, far-less complex alternative appears in the illustration. The circuit is a collector-coupled bistable multivibrator revised to act much like the Schmitt circuit. The change is minor and consists of direct-coupling by means of resistor R_1, instead of the usual capacitive coupling at the input. When Q_2 is cut off, current is supplied by R_1 and by the base of Q_1 to R_2 and R_3. When E_1 becomes large enough to cause all the current to be supplied by R_1, (that is, when the voltage at the base reverse-biases the base-emitter junction of Q_1), the multivibrator will regenerate. This first threshold is of opposite polarity to V_{BB} and is defined by the ratio of R_1 to $R_2 + R_3$ as:

$$E_1 - V_{BE} = \frac{(V_{BB} - V_{BEQ_1})\, R_1}{R_2 + R_3} \qquad (1)$$

Note that all values of voltage must be of the same sign as their polarity with respect to ground. R_2 is now brought to ground through the saturated Q_2. The circuit will remain in this state until the base voltage is sufficient to forward-bias the base-emitter junction and until sufficient current to



Dc-coupled flip-flop acts like a Schmitt trigger, but provides a ground-level output capability. Q_1 and Q_2 are saturating transistors with small V_{CE} and large V_{BE} ratings.

cause regeneration is supplied to the base. This second threshold is of the same polarity as V_{BB} and is defined by the ratio of R_1 to R_2 as:

$$\frac{-E_2 + V_{BEQ_1}}{R_1} = \frac{V_{CEQ_2} - V_{BEQ_1}}{R_2} - \frac{V_{BB}}{\beta R_L} \qquad (2)$$

If we assume that $I_{BQ1} << I_{R1}, I_{2R}$, this formula can be simplified to:

$$\frac{(V_{CESAT} - V_{BE})\, R_1}{R_2} = V_{BE} - E_2 \qquad (3)$$

Since the difference between V_{BE} and V_{CESAT} is of considerable importance to proper circuit function, transistors with a small V_{CESAT} and a large V_{BE} should be chosen.

Note that this circuit is unusual, in that it may be unconditionally set to respond to the E_1 threshold by pulsing the base of Q_2 with a positive pulse. This positive pulse can be applied at any time. In other words, while normal Schmitt action requires that the input pass both thresholds before the circuit will regenerate, this configuration can regenerate at any time and may be set to a specific threshold. Thus, to set to respond to E_1, we may

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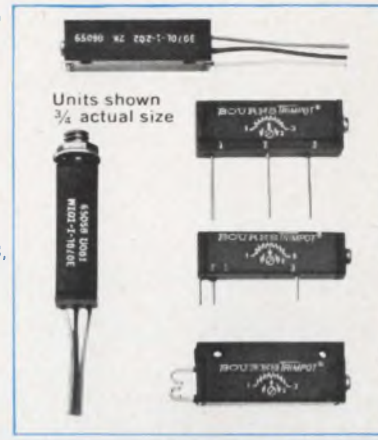

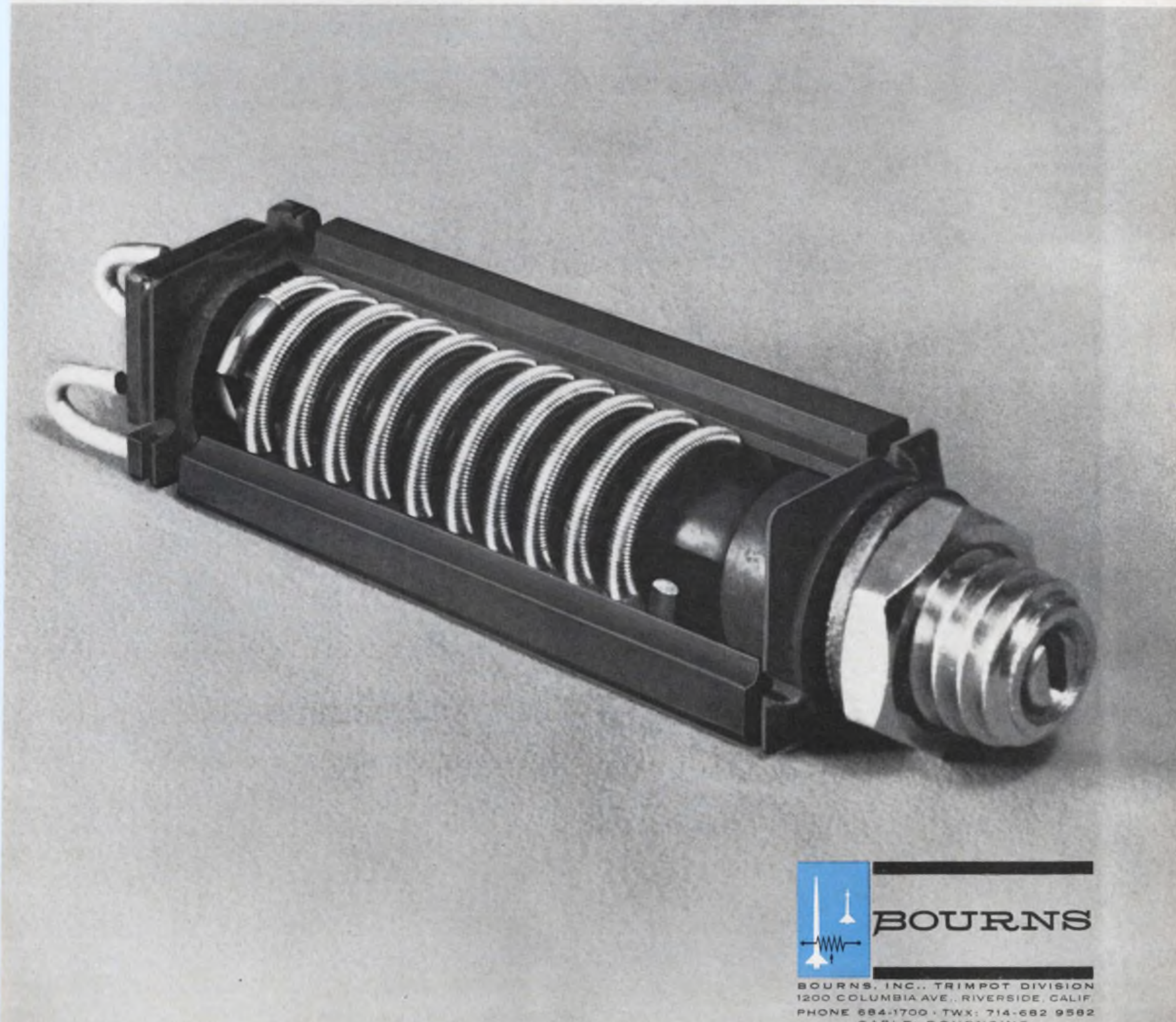

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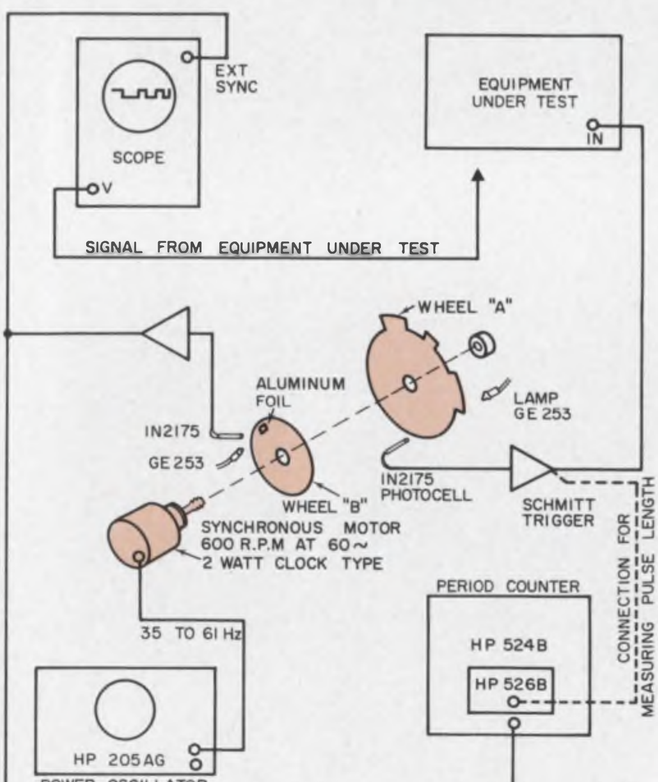
Ray Schwegler, Staff Member, Digital Equipment Corp., Maynard, Mass.

VOTE FOR 112

Variable-speed photochopper generates teletype signals

In testing teletype equipment, such as distortion analyzers, it is desirable to have available any letter of the teletype code with any degree of distortion (misplaced pulses). It is also desirable to provide for a variable-speed range, so as to simulate overspeed and underspeed conditions. These requirements are neatly filled by a photochopping system.

The circuit and equipment for generating and viewing teletype signals appear in the accompanying illustration. Wheel A, composed of one or more discs of stiff opaque paper, chops the light beam into a teletype letter. Six discs (one for the stop pulse and five for character pulses) suffice for all perfect teletype characters. Additional discs can be cut for any type or degree of distortion. Accurate measurements of the pulse lengths may be made with an electronic time-interval meter by installing one disc at a time.



Teletype signals are generated by this variable-speed photochopping system. Wheels A and B produce the various facsimile and timing pulses. The system is also capable of viewing teletype signals.

Wheel B is a smaller-diameter black paper disc with a dot of aluminum foil glued near the rim. This provides a pulse to synchronize a scope positively, regardless of the character being transmitted or the condition of the equipment under test. This same pulse can be put into an electronic period-counter to monitor the speed with a high degree of accuracy.

By setting the HP 205AG oscillator to any frequency between 35 and 61 Hz, we get a speed range capability of 60 to 100 words a minute.

Marriott Dickey, Design Engineer, Orinda, Calif.

VOTE FOR 113

UJT pulse generator makes bistable multi more versatile

The simple addition of a unijunction transistor trigger, a potentiometer and four diodes turns the standard bistable multivibrator into a versatile circuit capable of pulse generation, encoding, or decoding. Moreover variations in symmetry, pulse width and repetition rate are made independent of one another.

For example, output symmetry can be varied while repetition rate is kept constant, or vice versa. In another variation, pulse width can be changed while constant repetition rate is maintained. Finally repetition rate can be varied with no interaction between pulse rate and pulse width.

Referring to the circuit schematic, we see that Q_1 and Q_2 make up the basic multivibrator and that Q_3 is a UJT used to generate positive trigger pulses. Gating diodes D_3 and D_4 steer the trigger pulses to the proper side of the multivibrator. D_1 and D_2 are diode switches used for both isolation and to select the proper side of resistor R_T for timing the pulse generator.

With Q_1 conducting, D_1 conducts and places the left side of R_T in as the timing resistor for C_T. Note that D_2 is reverse-biased, thereby isolating the right side of R_T. D_3 is also reverse-biased, isolating any triggers from the left side of the multivibrator. D_4 conducts coupling triggers to the right side of the multivibrator.

When the UJT fires, the positive-going trigger pulse is coupled to the right side of the multivibrator, placing it in its other state (Q_2 conducting, Q_1 OFF). This action also switches the diodes. Since D_2 is now conducting, the right side of R_T is timing the charge of C_T. D_3 also conducts, coupling the next trigger to the left side of the multivibrator.

The next trigger from the pulse generator switches the multivibrator back to its original state. Therefore the conduction time is controlled by the wiper position on R_T. This potentiometer

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DC MILLIAMPERES: 0-1; 0-10; 0-100; 0-500

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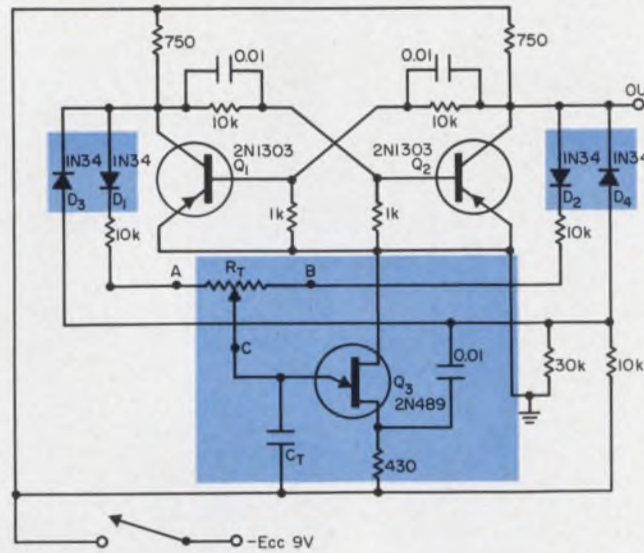

UJT, steering diodes and potentiometer add to versatility of bistable multivibrator. Q_3, $D_1 - D_4$ and R_T enable symmetry, pulse width and repetition rate to be independently controlled.

(the over-all resistance) also controls the symmetry of the square wave while maintaining a constant frequency.

For the component values shown, the turn-off time of Q_1 and Q_2 is 30 ns, and the frequency changes less than 1% with symmetry variations. The output pulse level varies between zero and $-E_{cc}$. The circuit was used as a digital encoder for a closed-loop servo system, and it offers promise in a number of other encoding and decoding applications.

Cyril B. Smith 2d, Research Technician, Federal Aviation Agency, Oklahoma City, Okla.

VOTE FOR 114

Analog-to-frequency converter has improved linearity, range

The simple addition of a one-shot and a feedback resistor improves the linearity and increases the frequency range of the basic analog-to-frequency converter. This modification overcomes the error introduced by the converter's integrator reset time.

Many requirements exist for precision voltage-to-frequency conversion in such applications as analog to digital converters, digital integrators and precision servo systems. The conventional analog-to-frequency converter (Fig. 1a) can be used for converting analog voltages to a pulse rate when low pulse rates are desired. However, at high pulse rates the linearity error becomes significant because of the integrator reset time.

We can use the circuit in Fig. 1a to demonstrate the deviation from linearity. If we assume that the gain of the amplifier is infinite (that is, that the

New EI-85 Digital Multimeter* in one encoding makes ± .005% measurements in 10 ms!

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Accurate, full 5 digit measurements are now possible in 10 msec with the EI-85's successive approximation logic.

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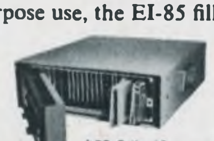
Whether your need is for accurate high speed measurements of dynamic fast changing signals, high speed system operation (100 readings/second) or a versatile accurate multimeter for general purpose use, the EI-85 fills the bill!



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ON READER-SERVICE CARD CIRCLE 149

output of the integrator has a perfect slope), the operational time interval is:

$$t = \frac{E_c}{e_i} R_i C_F + T_R, \qquad (1)$$

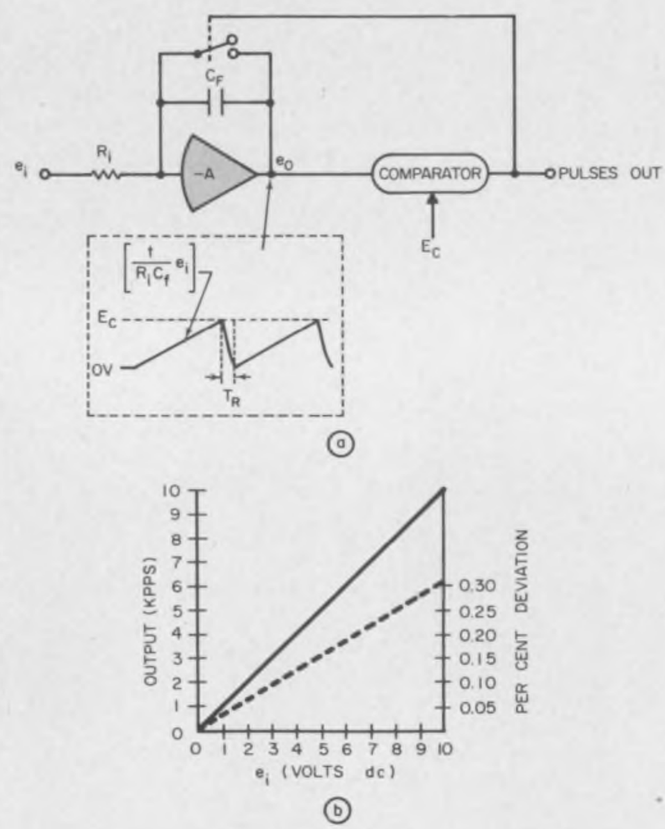
where $1/t$ = pulse rate; E_c = comparator reference voltage and T_R = time required to reset integrator.

A plot of e_i vs pulse rate and e_i vs percentage deviation from linearity is shown in Fig. 1b. The circuit parameters are such that E_c is 10 V, e_i is 0 to 10 V, T_R is 3.0 μs and the output pulse rate is 0 to 10 Kpps. We conclude from these graphical data that by adding a voltage, Ke_i, to the output of the integrator, the error introduced by T_R can be corrected.

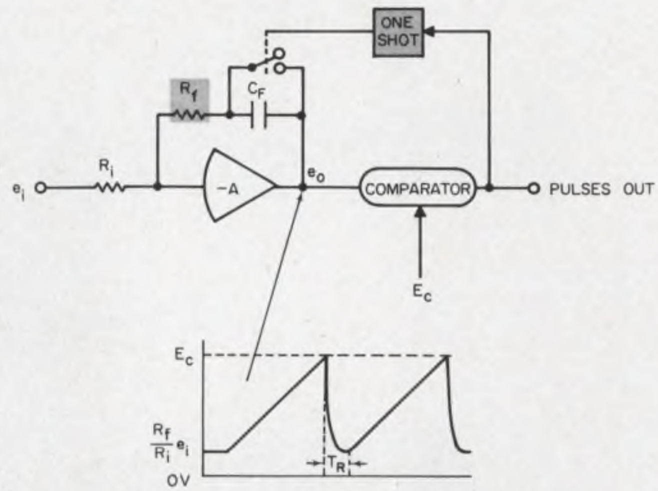
The circuit configuration in Fig. 2 performs this correction. The output of the integrator then becomes:

$$e_o = Ke_i + \frac{t'}{t_c} e_i, \qquad (2)$$

where $K = R_f/R_i$ and $t_c = R_i C_F$. The integrator will reset when e_o is equal to the reference voltage



1. **Conventional analog-to-frequency converter** (a) operates with an output of 0-10 Kpps and has linearity of 0.5%. Integrator's reset time (T_R) limits linearity of the response, especially at high pulse rates. Curve shows the relationship between input voltage, output pulse rate and deviation from linear response (b). Note error due to T_R.



2. **The simple addition of a feedback resistor** and a one-shot to the circuit of Fig. 1a produces an A-to-F converter that operates up to 250 Kpps with a 0.01% linearity figure.

E_c on the comparator. Then

$$E_c = Ke_i + \frac{t'}{t_c} e_i. \tag{3}$$

Solving Eq. 3 for t' (the operational time of the circuit), we get:

$$t' = \left[\frac{E_c}{e_i} - K\right] t_c. \tag{4}$$

The one-shot is used to insure a constant reset time, T_R. Note that T_R can be regarded as system deadtime. Thus the operational time of the system is

$$t = \left[\frac{E_c}{e_i} - K\right] t_c + T_R. \tag{5}$$

To select the proper value for the constants in Eq. 5, let E_c = maximum e_i, $t_c = R_i C_F$ = minimum t (t_m) or maximum pulse rate and $K = R_f/R_i = T_R/t_m$.

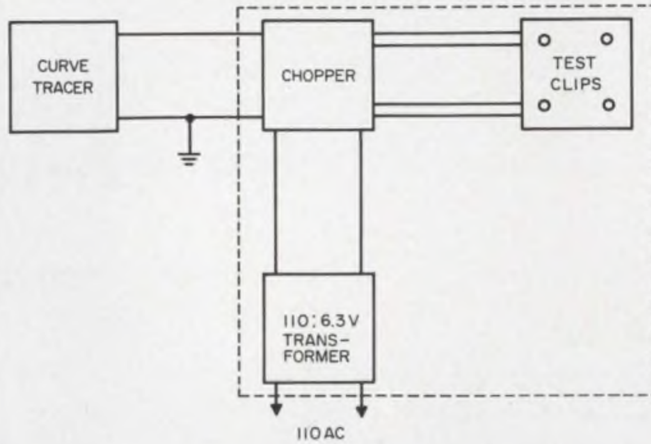
The advantage of the modified circuit becomes obvious when plotting e_i vs t (as given by Eq. 5). We see that the K term cancels the effect of T_R and that there is no error due to reset time.

This circuit has been used as an analog-to-frequency converter with the following specifications: $e_i = 0$ to $\pm$ 10 V, output = 0 to 25 Kpps, $T_R = 2$ μsec and linearity = 0.01% over full range. *Robert B. Jones, Project Engineer, Continental Device Corp., Hawthorne, Calif.*

VOTE FOR 115

Curve-tracer test jig matches diodes quickly

A small test device, easily built, can be used in conjunction with a Tektronix 575 Transistor



Diodes are quickly and simply matched when this test jig is used in conjunction with a curve-tracer. The chopper is employed for viewing the low-voltage portions of the E/I curves. For higher level portions, a reed relay should be substituted for the chopper.

Curve Tracer to match diodes rapidly.

The test jig consists of a chopper, a 6.3-volt step-down transformer and four standard test clips. All elements are mounted on a small chassis. The circuit permits two diodes to be matched by displaying both E/I curves simultaneously.

When interested in the low-voltage portion of the E/I curve, the user employs a chopper (as shown). If high-voltage or high-current portions are required for display, a mercury-wetted contact or reed relay may be substituted for the chopper.

This system may be used for matching transistors, but provision must be made to intensify one of the displays, so they can be easily separated and thus distinguished. Note here that the transistor may oscillate if the leads from the device to the curve-tracer are too long.

Ancil S. Zeitak, Senior Technician, Radio Astronomy Observatory of the University of Michigan, Ann Arbor.

VOTE FOR 116

IFD Winner for Nov. 22, 1965

Harold T. McAleer, Engineer, General Radio Corp., West Concord, Mass.

His idea, "Diode improves voltmeter's linearity and stability", has been voted the $50.00 Most Valuable of Issue Award.

IFD Winner for Dec. 6, 1965

Roy Foerster, staff engineer, The Bunker-Ramo Corp., Canoga Park, Calif.

His idea, "Locking monostable circuit immune to false triggering", has been voted the $50.00 Most Valuable of Issue Award.

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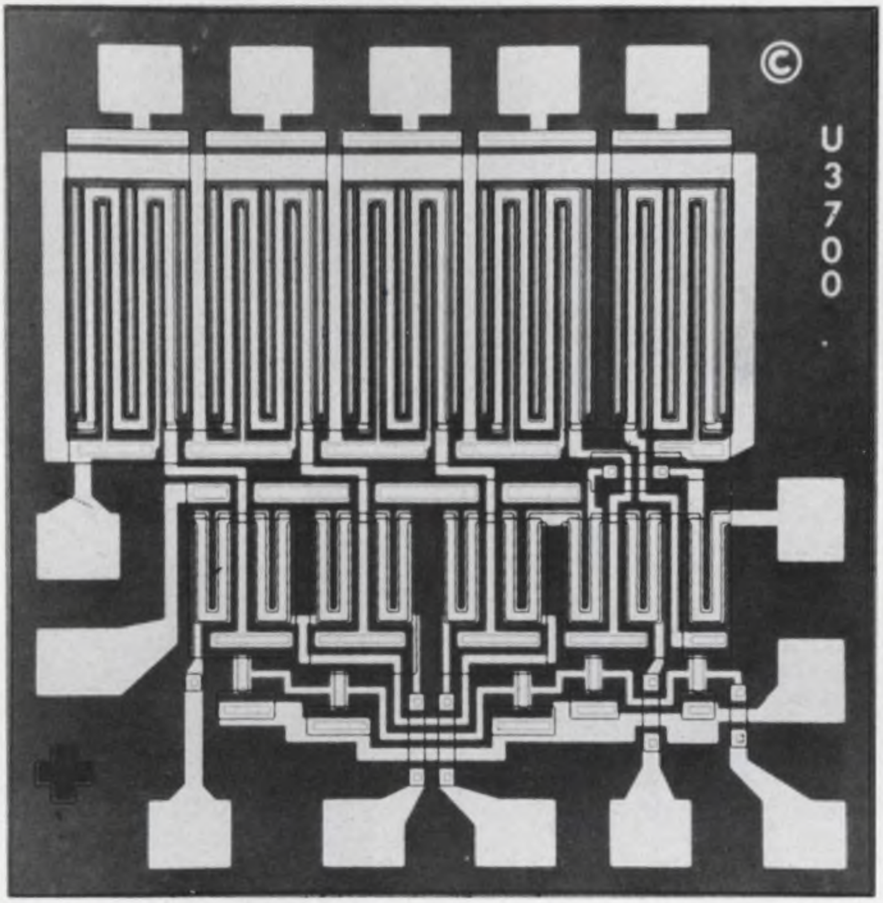
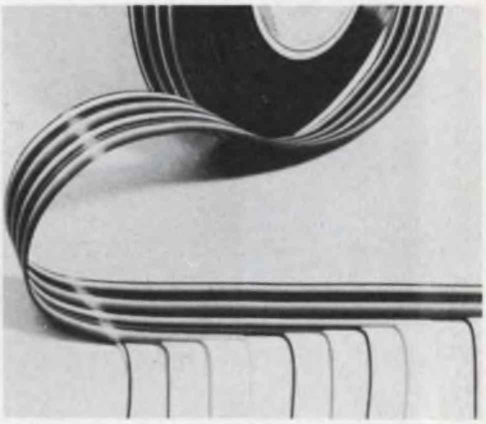
ED Products

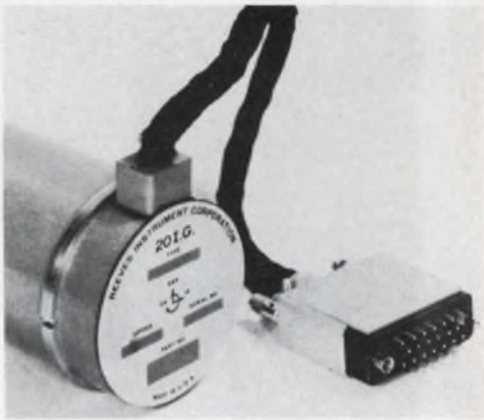
Integrating gyro eliminates hysteresis PAGE 264
Schottky–barrier diode for RF mixers PAGE 266
Flat-bonded ribbon cable PAGE 271
IC Commutator uses MOSFETS PAGE 272



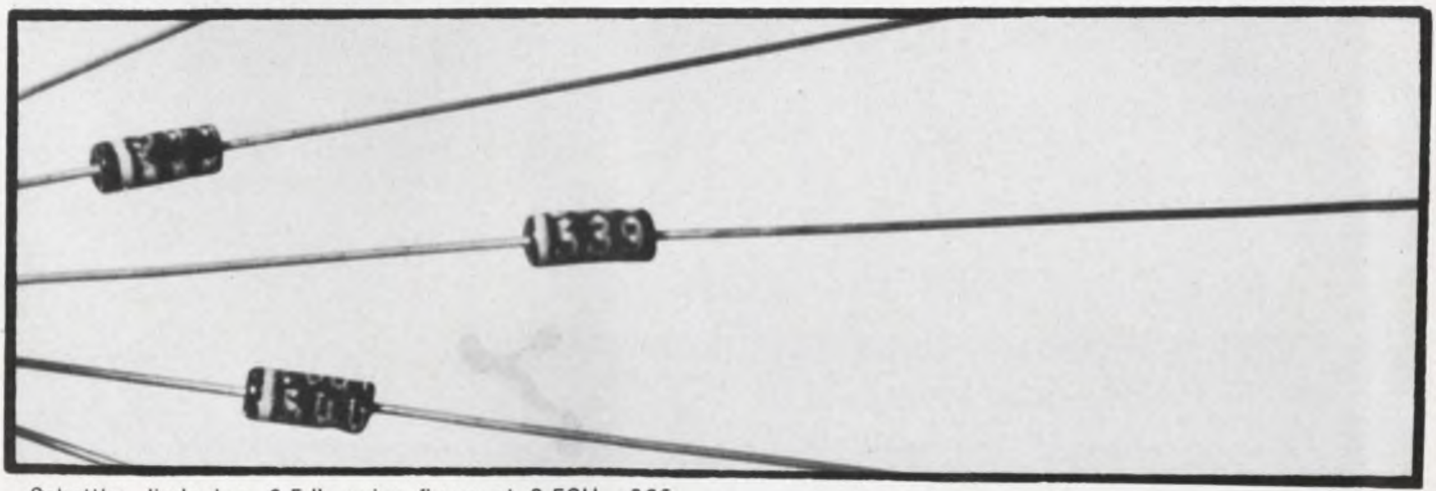
Multi-channel IC commutator has low on-resistance.



Ribbon cable has many uses. 271



Integrating gyro has 0.1% linearity. 264



Schottky diode has 6.5db noise figure at 2.5GH$_z$. 266

Stepping motor controls

A line of modular controls for stepping motor positioning systems includes logic and pulse circuits.

Motor driver logic, pulse generators, decade counters, general-purpose logic, power supplies and hardware are compatible with most digital systems. Applications include automatic printers, tape transports, X-Y plotters and other multi-axis purposes.

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Traid Corp., P. O. Box 1839, Glendale, Calif. (213) 245-9393.

Circle No. 511

Guidance FM decoders

Three new FM command guidance receiver decoders operate in the 406 to 550 MHz band in one, five and ten-channel configurations. The units are designated 34-23-00860, -00770, and -00800 respectively.

Applications are primarily in the area of command guidance and destruct. Selectivity is determined by a passive, 6-pole LC filter followed by a five-stage IF amp.

Electronic Specialty Co., 4561 Colorado Blvd., Los Angeles, Calif. Phone: (213) 246-6767.

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SYSTEMS

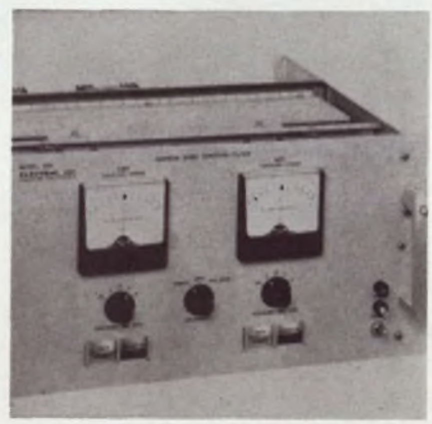
Spectrum analyzer

The Diramic Ubiquitous spectrum analyzer covers all frequencies simultaneously in real time within an analysis band up to 10 kHz. The standard model has a 48-dB dynamic range and 60 dB and 72 dB options are available. An internal memory can be used to capture transients and replace tape loops and storage scopes.

Federal Scientific Corp., 615 W. 131st St., New York, N. Y. Phone: (212) 286-4400.

Circle No. 523

Filter/comparator



The Model 219A phase-lock tracking filter and phase comparator provides two identical 100 ±3 Hz channels and selectable noise bandwidth from 0.03 to 3 Hz. Phase slope is only 0.7 degrees/Hz. The system is entirely solid-state. Pulse outputs are furnished for use with an external digital phase meter. Applications are in the area of radio interferometry and other angle measuring systems.

Electrac Inc., 1614 Orangethorpe Way, Anaheim, Calif. Phone: (714) 879-6021.

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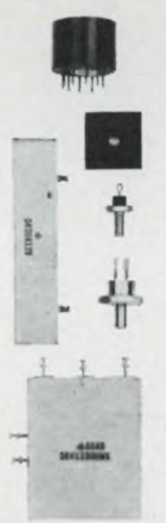

All Dickson products are produced with the same care and engineering excellence demanded by critical military and space projects. For example, each standard Dickson high-voltage rectifier is engineered to *exceed maximum specified characteristics*, so it will operate reliably under those maximum conditions.

When producing custom high-voltage rectifiers, Dickson's unique cell construction not only assures exceptional reliability but provides unlimited flexibility in package configuration. Each cell contains carefully selected P-N junctions soldered in series and terminated with pure silver leads. To insure long-term stability under extreme environmental and electrical stresses, all junction surfaces are treated before encapsulation.

Dickson is currently supplying high-voltage rectifiers up to 135 KV for a wide variety of applications including: aerospace boosters, space vehicles, medical equipment, and military weapons systems.

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1N1136	1N1731	1N1757	1N2384	1N3883
1N1137	1N1732	1N1758	1N2385	1N3889
1N1138	1N1733	1N1759	1N3052	1N3890
1N1139	1N1734	1N1760	1N3053	1N3891
1N1140	1N1745	1N1761	1N3054	1N3892
1N1141	1N1746	1N1762	1N3055	1N3893
1N1142	1N1747	1N2374	1N3056	1N4933
1N1143	1N1748	1N2375	1N3057	1N4934
1N1143A	1N1749	1N2376	1N3058	1N4935
1N1144	1N1750	1N2377	1N3059	1N4936
1N1145	1N1751	1N2378	1N3060	1N4937
1N1146	1N1752	1N2379	1N3061	
1N1147	1N1753	1N2380	1N3879	

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DICKSON
ELECTRONICS CORPORATION

PHONE (602) 947-5751 TWX (602) • 949•0146 TELEX 66706
P.O. BOX 1387, SCOTTSDALE, ARIZONA 85252

Manufacturers of quality zener diodes, rectifiers, tantalum capacitors, solid state circuit breakers, field effect transistors.

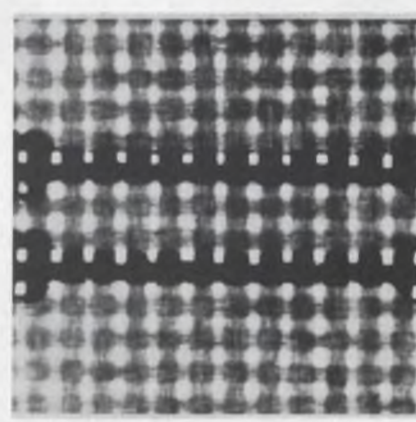
ON READER-SERVICE CARD CIRCLE 159

Flux remover

A solder flux remover in aerosol form is said to provide a convenient means of completely removing flux residues from electronic circuitry. The solvent used is DuPont's Freon TMC. Offered in 16-oz. aerosol cans, the solvent can be applied to soldered joints as a heavy, flushing spray. A heavy-duty formulation, MS-190Hd is also available in this form. Extension nozzels are available with both types.

Miller-Stephenson Chemical Co., Rte. 7, Danbury, Conn. Phone: (203) 743-4447.

Circle No. 521



Multilayer PC boards

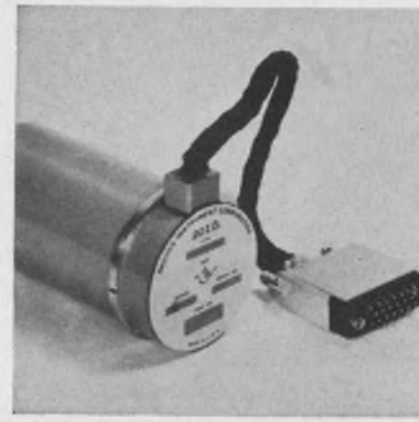
Materials for a new process for making multilayer printed-circuit boards are available for a wide variety of applications. Called the Friedman Process, the result is discrete layers of circuitry that are easily joined by several methods. The copper lines are handled without disturbing spatial inter-relationships and such layers are easily joined to insulation where required.

The Leal Co., 1716 S. 6th St., Camden, N. J Phone: (609) 365-0098.

Circle No. 522

SYSTEMS

Integrating gyro

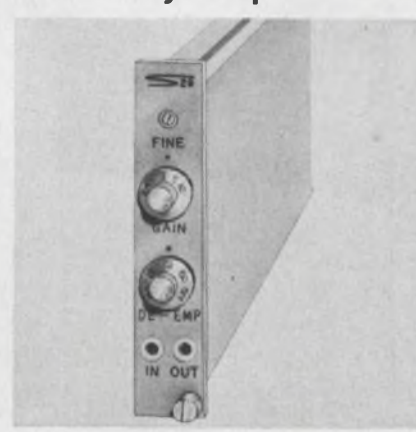


Containing a D'arsonaval torquer, the 20IG type C40D permanent magnet torquer rate integrating gyro is said to eliminate magnetic restraints, hysteresis, saturation non-linearities and power drain from a reference field. The 0.1% torquer linearity holds for 300,000 degree/hours torquer rate and the company guarantees 5000 hours as the dynamic wearout wheel bearing life.

Reeves Instrument Co., Garden City, N. Y. Phone: (516) 746-8100.

Circle No. 513

Telemetry amplifier



Features of the Model S-29 telemetry amplifier include a switchable de-emphasis circuit and a frequency response of 300 Hz to 2 MHz at a gain of 5 or less. In addition, dual inputs provide a low impedance for summing the outputs of the manufacturer's line of VCOs containing built-in mixing resistors. Output voltage is 20 V and current is 100 mA.

Sonex, 20 E. Herman St., Philadelphia, Pa. Phone: (215) 843-6400.

Circle No. 514

ENGINEERS . . . DESIGNERS . . . RESEARCHERS

WIN A COLOR TV

other outstanding prizes . . . in the

FENWAL ELECTRONICS "MR. THERMISTOR" CONTEST

ATTENTION . . . THERMISTOR USERS

If you have ever employed *thermistors* for temperature measurement, temperature compensation, industrial control, or any one of the dozens of other applications for which they are ideally suited, here is a chance to cash in on your experience. All you have to do is describe the applications briefly, in accordance with the contest rules below, and send it to Fenwal Electronics, Inc. before April 30, 1966. Just for entering, you will receive an F. E. I. Experimenters Thermistor Kit (valued at $9.95). And you will be eligible to win one of the three valuable grand prizes described below.

1ST PRIZE

23" COLOR TV . . . A handsome 23" Motorola table-model color set (valued at $500) goes to "Mr. Thermistor". This prize, guaranteed to please the whole family, will be delivered to the winner's home, installed, with a full ninety-day warranty.

2ND PRIZE

ACCUTRON® TIMEPIECE . . .

The winner of the second "Mr. Thermistor" prize will receive this striking timepiece . . . said to be the world's most accurate. Electronically-driven by pulses from a tuned oscillator, it is a real engineer's watch, guaranteed to make you the envy of the whole department. Retail value $125.

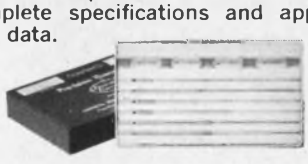
3RD PRIZE

SPANISH TREASURE PEN

This unique Parker 75 pen (which lists for $75) is a conversation piece you will treasure for years. The beautifully-wrought barrel is genuine antique silver, recently salvaged from the remains of a Spanish plate fleet which foundered in a hurricane off the East coast of Florida in 1715. With the pen you get documentary proof of its authentic origin. It is also a fine writing instrument.

EVERYBODY WINS

Everyone who submits an entry in the April Fenwal Electronics "Mr. Thermistor" Contest will receive one of F.E.I.'s large G-701 Experimenter's Thermistor Kits (which sell for $9.95) containing 10 assorted precision thermistors with complete specifications and application data.



Fenwal Electronics
63 Fountain Street
Framingham, Mass.

"MISTER THERMISTOR" CONTEST RULES

1. F.E.I.'s "Mr. Thermistor" Contest is open to all qualified engineers and researchers residing within the United States, with the exception of employees of Fenwal Electronics, Inc., Fenwal, Inc., and their advertising agencies.

2. Each entry should describe in as many words as necessary:

a. The product, system or application in which the thermistor was used.

b. The specific function of the thermistor, (or thermistors), operating parameters, and the type used.

c. Why a thermistor was used, instead of some alternative approach, and how well the application achieved objectives.

A sketch or schematic (pencil is OK) must be included to illustrate the application.

3. More than one entry may be submitted by a contestant.

4. Entries should be typed, or written clearly, on 8½ x 11 paper. Sender's name, title, company affiliation, and home or company address should be clearly indicated. Each entry must be signed in ink. More than one individual may sign, but only one prize will be awarded per entry.

5. Entries will be judged on: ingenuity of thermistor utilization, sophistication of probe design or thermistor circuitry, and/or effectiveness of the thermistor approach in solving a specific design problem.

6. Decision of the judges will be final. All entries become the property of Fenwal Electronics, Inc.

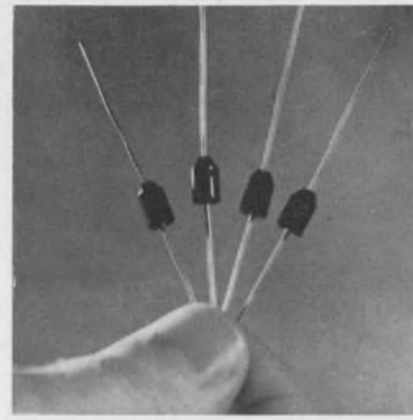
7. Entries for this "Mr. Thermistor" Contest must be postmarked no later than midnight, April 30. Winners will be advised directly.

8. **First Prize** winner (1) will receive a 23" Motorola Color Television Set. **Second Prize** winner will receive an ACCUTRON® Timepiece. **Third Prize** winner will receive a Parker 75 Treasure Pen.
Every contestant will receive a G-701 Thermistor Kit.

9. Entries should be addressed to:
Thermistor Contest
Fenwal Electronics, Inc.
63 Fountain Street
Framingham, Massachusetts

GET YOUR ENTRY IN *NOW* BEFORE THE APRIL 30, DEADLINE

ON READER-SERVICE CARD CIRCLE 163



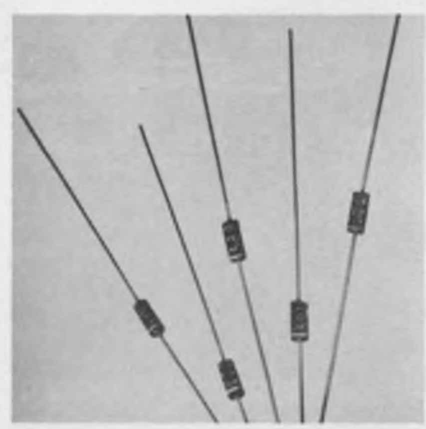
Silicon rectifiers

A group of moisture-proof epoxied silicon rectifiers has 1.5 A rating at 40°C case temperature. Surge rating is 50 A (peak half-cycle current at 60 Hz under full-load).

Designated 1N4816-4822 and 359 P, S, and Z, these units have peak reverse voltage ratings from 50-1000 V. JEDEC registered devices (1N numbers) carry lifetime guarantees.

Price: $.28 each 50-V to $1.15-1000-V. Westinghouse Semiconductor, Youngwood, Pa. Phone: (412) 925-7272.

Circle No. 515



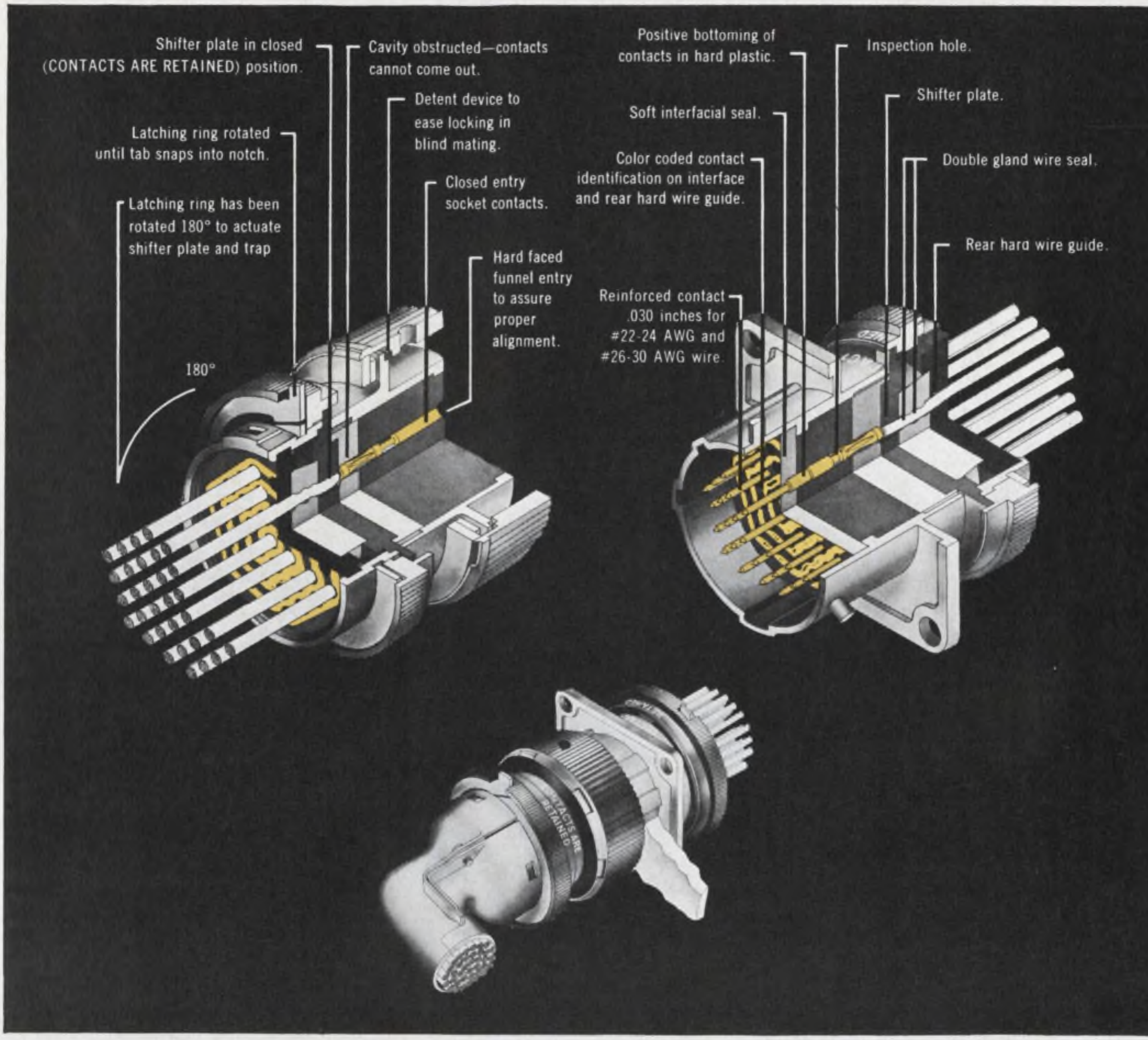
MW hot-carrier diode

An improved hot-carrier microwave mixer diode is called the hpa-2350. This metal-silicon Schottky-barrier diode has applications as an RF mixer through 2.5 GHz.

Noise figure at 2 GHz is typically 6.5 dB, IF impedance is 175 ohms typical, vswr is 1.3 typical, total capacitance is 1 pF max, power dissipation is 125 mW at 25°C, and peak pulse power rating is 5 ergs.

P&A: $22; stock. hp associates, 620 Page Mill Rd., Palo Alto, Calif. Phone: (415) 321-8510.

Circle No. 516



This connector begins where others leave off

Take the best subminiature pin and socket connector on the market. Eliminate its inherent failure modes. Give it twice the contact density of other connectors. Then add the very latest innovations in design and materials. This was our objective in developing the new CH-AMP★ Subminiature Circular Connector.

The result shown here is in many ways even more spectacular than the objective. Here is a bayonet-coupled connector with a unique twist-to-lock contact retention mechanism that eliminates the need for retention clips and *extraction tools*—an environmentally sealed connector designed in a stainless steel housing that provides continous grounding from mounting flange to cable clamp.

The contacts are a special reinforced spring design with closed entry for probe protection and a four-indent crimp for maximum electrical conductivity. A resilient wafer grips them in the proper position prior to locking. Color-coded interfaces and positive visual checks top off the many precision engineered features that give the CH-AMP Connector a positive GO for all high grade military and industrial applications.

- Meets or exceeds the requirements of MIL-C-26500 and MIL-C-26482
- Available in 85, 58, 37, 26, and 14 contact configurations
- Contact retention force: 2 lbs. unlocked, 10 lbs. locked
- Positive depth-controlled contact insertion
- Moisture-proof, double gland wire seal
- 90° or 180° cable clamp can be applied *after* connector is wired

Available in five shell configurations for wire sizes AWG 22-30. For full details, write today for the new A-MP★ Subminiature Circular Connector brochure.

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AMP INCORPORATED
Harrisburg, Pennsylvania

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A-MP★ products and engineering assistance are available through subsidiary companies in: Australia · Canada · England · France · Holland · Italy · Japan · Mexico · Spain · West Germany

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ON READER-SERVICE CARD CIRCLE 164

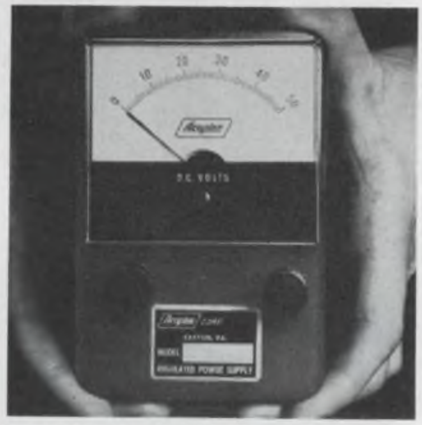
IC power source

The regulated supplies SPS-2055 and 2062 are designed especially to provide dc power to integrated circuits. The model shown, SPS-2055, has a voltage adjustment range from 1 to 6.5 V and can continuously deliver 0 to 300 mA. Line and load regulation is better than 3 mV dc and ripple is typically 1 mV. Both use silicon transistors and include overload protection.

Plug-In Instruments, Inc., 1416 Lebanon Rd., Nashville, Tenn. Phone: (615) 244-1330.

Circle No. 517

Plug-in supply

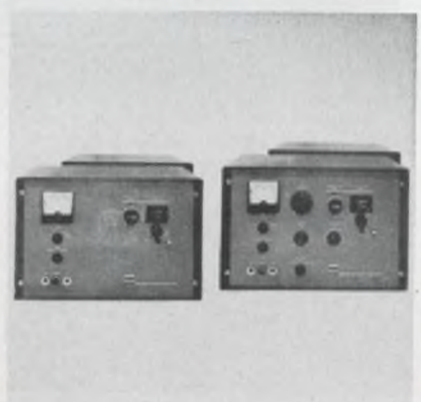


The Pow-A-Meter is an adjustable power supply with an integral voltmeter. The supply can be plugged into a breadboard, instrument or other equipment, eliminating the need for external power supplies, voltmeters and leads. Four models are available with nominal output voltages from 6 to 50 V and current out from 200 to 500 mA.

Price: \$95-\$115. Acopian Corp., 927 Spruce St., Easton, Pa. Phone: (215) 258-6149.

Circle No. 518

Magnet power supply



A dial on the V-FR2000 series 2-kW dc power supplies permits resetting the field intensity of a laboratory electromagnet to any desired value within the magnet's range, independent of hysteresis effects.

Accuracy of 0.2% up to 10 kilogauss is specified, field repeatability is of an even higher order. The field-sweep instrumented V-FR2903 is otherwise similar to the basic V-FR2902.

Varian Assoc., 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

Circle No. 519

Variable-slope supply

A new rectifier type power supply features continuously adjustable voltage and slope. With a 100% duty-cycle rating of 600 amps (750 at 60% duty-cycle), it has an 85% or better efficiency rating, and a 0.9 or better power factor. Rectifiers are surge-rated at 8000 amps.

The unit is called CW600CS, measures 27- x 32- x 32-in., and weighs 700 pounds.

Glenn-Pacific Div. of Teledyne, Inc., 703-37th Ave., Oakland, Calif. Phone: (415) 532-7404.

Circle No. 520

Low Cost Test Signals

10 MHz to 1000 MHz

—*with the* **3200B VHF OSCILLATOR**

Using the new Frequency Doubler Probe 13515A

The VHF Oscillator Model 3200B is designed for general purpose laboratory use including receiver and amplifier testing, driving bridges, slotted lines, antenna and filter networks, and as a local oscillator for heterodyne detector systems in the frequency range from 10 to 500 mc.

The push-pull oscillator is housed in a rugged aluminum casting for maximum stability and extremely low leakage; six frequency ranges are provided for adequate bandspread on the slide-rule dial. Internal CW operation is provided; AM and pulse modulation may be obtained through the use of a suitable external source. The RF output is coupled through a waveguide-below-cutoff variable attenuator; in addition, an electrical RF level vernier is included as a front panel control.

An optional accessory Frequency Doubler Probe, Model 13515A incorporates a solid-state doubler circuit and provides additional frequency coverage from 500 to 1000 mc.

Features:

- ±0.002% Frequency Stability
- External AM and Pulse Modulation
- Waveguide-Below-Cutoff Output Attenuator
- Solid-State Power Supply

Data subject to change without notice.

SPECIFICATIONS 3200B

Frequency range: 10 to 500 Mc (MHz) in six bands: 10 to 18.8 Mc; 18.5 to 35 Mc; 35 to 68 Mc; 68 to 130 Mc; 130 to 260 Mc; 260 to 500 Mc.

Frequency accuracy: within ±2% after ½ hour warmup (under 0.2 mw load).

Frequency calibration: increments of less than 4%.

Frequency stability (after 4-hour warmup under 0.2 mw load): short term (5 minutes) ±0.002%; long term (1 hour) ±0.02%; line voltage (5-volt change) ±0.001%.

RF output:
Maximum power (across 50-ohm external load): >200 mw (10 to 130 Mc); >150 mw (130 to 260 Mc); >25 mw (260 to 500 Mc).
Range: 0 to >120 db attenuation from maximum output.
Load impedance: 50 ohms nominal.

RF leakage: sufficiently low to permit measurements at 1μv.

Amplitude modulation: externally modulated.
Range: 0 to 30%.
Distortion: <1% at 30% AM.
External requirements: approximately 15 volts rms into 600 ohms for 30% AM, 200 cps to 100 Kc.

Pulse modulation: externally modulated.
External requirements: 1 volt peak pulse into 2000 ohms. 5-volt rms sine wave will provide useable square-wave modulation.

Power: 105 to 125 v or 210 to 250 v, 50 or 60 cps, 30 w.

Dimensions: 7 25/32'' wide, 6½'' high, 12 17/32'' deep (198 x 165 x 318 mm.)

Weight: net 15 lbs. (6, 8 kg), shipping 19 lbs. (8, 6 kg).

Accessories available: 13515A Frequency Doubler Probe; 501B, 514B, 517B Output Cables; 502B, 506B Patching Cables.

Price: Model 3200B, $475. F.o.b. factory.

13515A FREQUENCY DOUBLER PROBE

Frequency range: 500 to 1000 Mc (MHz) with the 3200A/B operating at 250 to 500 Mc.

Harmonic suppression: (at 4 mw output): fundamental: >16 db down; higher order: >16 db down (500 to 800 Mc); >14 db down (800 to 1000 Mc).

RF output: more than 4 mw across external 50-ohm load, controlled by probe depth.

Weight: net 4 oz. (110 gms), shipping 8 oz. (220 gms).

Price: Model 13515A, $95. F.o.b. factory.

For more information contact your local Hewlett-Packard field engineer or write Hewlett-Packard, Green Pond Road, Rockaway, N. J. 07866; Europe: 54 Route des Acacias, Geneva.

See us at the I.E.E.E. Show
BOOTHS 3E01 - 3E18

HEWLETT hp PACKARD
An extra measure of quality

ON READER-SERVICE CARD CIRCLE 168

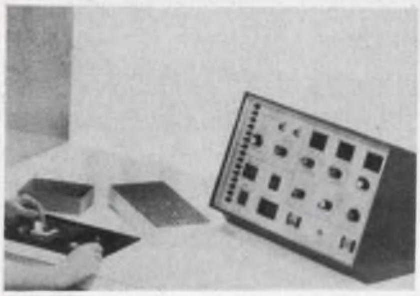
Automatic synchronizer

Model 8708A signal-generator synchronizer uses phase-lock techniques to give test signals stable within 2 parts in 10^7 over 10 minutes. Automatic synchronization is achieved within the range of the 606B (50 kHz to 65 MHz) or 608F (10 MHz to 455 MHz sig gens.

P&A: $1800; stock. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000.

Circle No. 525

Transistor tester



A high-speed go/no-go diode and transistor tester has 10-second program changing.

Both dc and pulse testing are provided by the model 665, as are 15 device-sorting outputs and built-in failsafe circuitry.

P&A: about $25,000; 60 days. Test Eqpt. Dept., Industrial Prod. Group, Texas Instruments Inc., 3609 Buffalo Speedway, Houston, Tex. Phone: (713) 526-1411.

SEE AT BOOTH 1D13-25

Circle No. 526

Speed and torque meter

The TM9 measures speed, torque and horsepower, presenting all three measurements as direct dial readouts, or signals for remote application. Used with a strain-gauge torque transducer, several ranges are possible within the full-scale range of 3 lb-ft. to 40,000 lb-ft., 250 to 6,000 rpm, and 0.5 to 5,000 hp. Accuracy of ±1% is attained on full-scale readouts, and greater accuracy is possible using the calibration charts provided. The unit is suitable for direct plotting of torque/speed and horsepower/speed curves of short rated motors in conjunction with an X-Y plotter.

Price: meter, $1,048; transducers, $532 to $1420. Westland Aircraft Ltd., Saunders Rowe Div., East Cowes, Isle of Wight, England.

Circle No. 527

Machinable ceramic

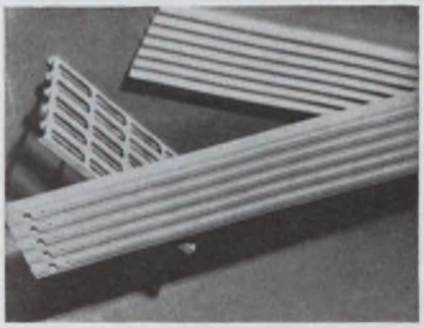
Machining of this material, CERAMSOFT, can be done with conventional tools such as Lathe, drill press and milling machine. Firing produces a hard, dense, high-temperature (1177°C) ceramic.

The material can be used for induction heating devices, and precision components of all types.

Availability: Stock. Metal CERAM 17 N. West St., Mt. Vernon, N. Y. Phone: (914) 664-2800.

Circle No. 528

Flat ribbon cable



Spectra-Strip is a flat-bonded ribbon cable that is available in a wide variety of configurations for virtually any application.

Options in the line include your choice of conductor size, color coding and length of the conductors. Many types are offered.

Spectra-Strip Wire and Cable Corp., P. O. Box 415, Garden Grove, Calif. Phone: (714) 537-4530. TWX: (714) 530-0313

Circle No. 529

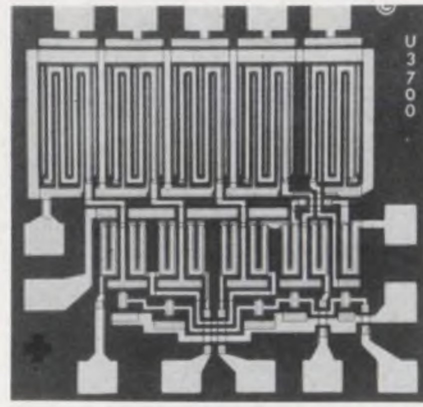
Powdered epoxy resins

Two new powdered epoxy resins are designed for insulation and protection of electronic parts. Called Scotchcast types XR-5106 and 5115, both are one-part systems that can be spray-coated or dipped. XR-5106 is semi-flexible and unfilled for applications requiring high impact resistance, such as coating capacitors and resistors. Type XR-5115 is a filled system with particularly high impact resistance recommended for insulation and protection.

Cure times for both systems range from 3 minutes at 400°F to 30 seconds at 400°F. Impact resistance of the system by the Gardner tester is rated 160 inch pounds for XR-5106 and 140 for XR-5115. Both are self-extinguishing and highly resistant to moisture.

3M company, 2501 Hudson Rd., St. Paul, Minn. Phone: (612) 733-4033.

Circle No. 530



Commutator

A monolithic multi-channel commutator is intended for use in multiplexing and telemetry systems where low on-resistance and low channel leakage is required. The uM 3700 offers on resistance less than 200 ohms and leakage less than 1nA per channel. Using MOS-FETs as active resistors, the device has all channel blanking for four channel operation. Each gate diode: protected.

Availability: April. Fairchild Semi., 333 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-2530.

SEE AT BOOTH 2G03-2G13

Circle No. 580

90° deflection yoke

Type C4179 encapsulated 90° deflection yoke has 1″ ID, permitting proper fit on CRTs with neck sizes from 7/8-1 in. Neck shadow is eliminated by the flare which allows the yoke to nestle against the CRT.

Resonant operation is achieved by a high Q ferrite core. A variety of impedances are available.

P&A: $100; 6 wks. Syntronic Instruments, 100 Industrial, Addison, Ill. Phone: (312) 543-6444.

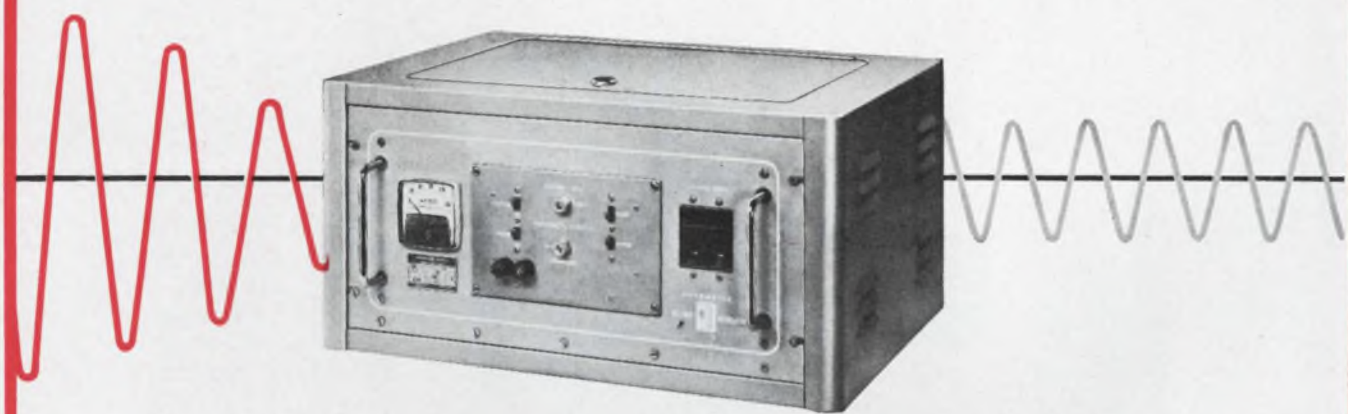
SEE AT BOOTH 2G15

Circle No. 581

volt-pac®

AUTOMATIC VOLTAGE REGULATOR

VOLTAGE PROBLEM SOLVERS



Automatically smooths input fluctuations

G-E Automatic Volt-Pacs maintain pre-selected output voltage levels within ±1 percent despite variations in both line and load conditions. Use automatic Volt-Pacs as an integral component or for separate indoor mounting to supply a constant voltage to circuits which are sensitive to voltage variations. Typical specifications for G-E Automatic Volt-Pacs:

Regulation accuracy	±1%
Speed of correction	10.4 v/sec
Output voltage	Adjustable from 110-120v
Input voltage	95v-135v, single-phase
Frequency	60 cycles
Load range	0 to full load
Efficiency	Up to 99%
Power factor range	0 to 100%
Wave form distortion	None
Ambient temperature operating range	—20 to +40C

In addition to its full line of automatic Volt-Pac voltage regulators, G.E. offers conventional static-magnetic and Stabiltron a-c voltage stabilizers, and manual and motor-operated Volt-Pac variable transformers.

Contact your G-E Sales Engineer for application assistance. Or, for free Volt-Pac literature, write for publications GEA-8068 (automatic) or GEA-8110 (manual and motor-operated) to General Electric, Section 413-31, Schenectady, N. Y. 12305.

Specify General Electric for all your voltage regulation and control needs

Stabiltron

A-C VOLTAGE STABILIZERS

Maintain precise voltage output despite wide fluctuations of line voltage, frequency, load, load power factor and ambient temperature. Stabiltron is available in 0.5, 1, 2, 5, and 10 KVA ratings. Write for publication GEA-7358.

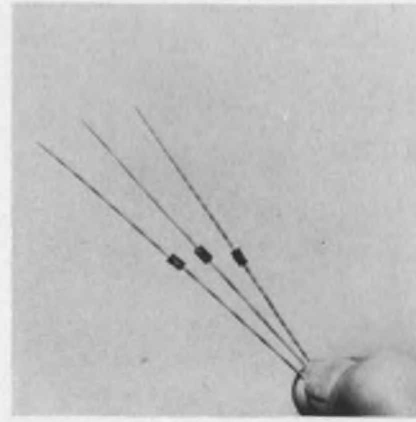
POWER SUPPLIES

Keep d-c output voltage constant for computers, process control, electronic measuring devices despite fluctuating line voltage with G.E.'s d-c power supply. Get output up to 2 KVA, 50- or 60-cycles. Write for publication GEA-7353.

Progress Is Our Most Important Product

GENERAL ELECTRIC

ON READER-SERVICE CARD CIRCLE 182

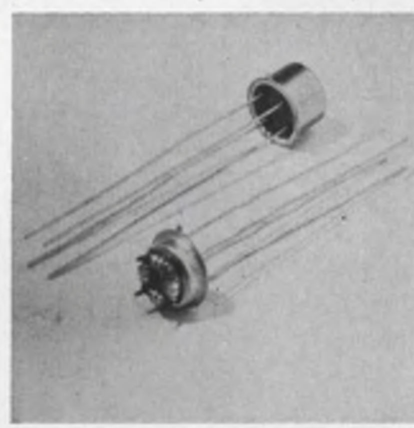


Micromin capacitors

A line of microminiature tubular capacitors is a 0.17 x 0.10-in. ceralam monolithic ceramic element in an epoxy jacket. The units, designated ML-10, have normal temperature coefficients of ±15%, with −1-1/2 ±5%, and ±5% optionally available. Ratings are 25 Vdc with up to 12,000 pF, 50 Vdc with up to 6,000 pF, and 100 Vdc with up to 2,000 pF.

Hi-Q Div., Aerovox, Olean, N. Y. Phone: (716) 372-6611.
SEE AT BOOTH NO. 2A36

Circle No. 582

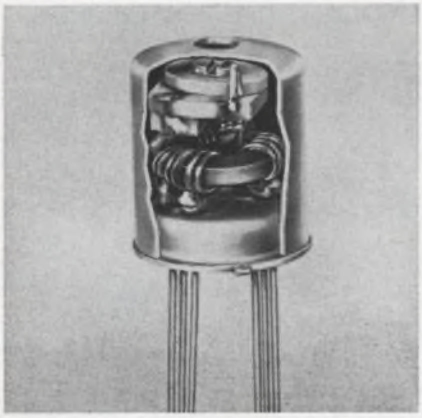


Rectifiers/drivers

Packaged in a modified TO-5 package, the HBR-5/40 rectifiers operate from 50-400 v. Average output current is 500 uA at 25°C, with diodes matched to within 25 mV at 0-75°C. The HCD-3 and HCD-4 Core Driver Diodes are hermetically sealed glass, axial-leaded types. Switching time is as low as 6 nsec, with 2 pf capacity.

P&A: $1.60-$5.20 (1-99); stock. Hoffman, 4323 N. Arden, El Monte, Calif. Phone: (213) 686-0123.
SEE AT BOOTHS 1C09-1C11.

Circle No. 583

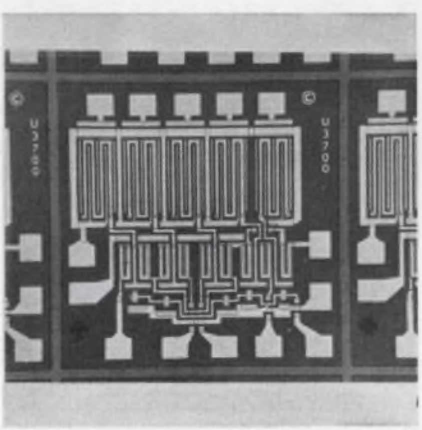


Tunable LC Networks

Series MTLC units are housed in a TO-5 enclosure. Center frequencies range from 3-250 MHz, tuning ranges from 2-8-325 MHz. Bandwidths (3 dB down) range from 0.04-4 MHz, and minimum unloaded Q (3 dB down) from 60-95. Operating temperature range is from −55° to 90°C.

Availability: 2 weeks. JFD Electronics Corp., Components Div., 1462 62 St., Brooklyn, N. Y. Phone: (212) 331-1000.
SEE AT BOOTH 1E12.

Circle No. 584



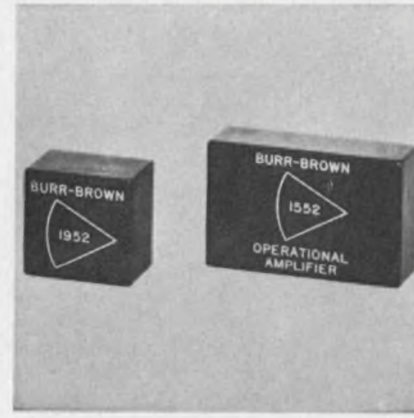
Multi-channel commutator

A monolithic multi-channel commutator has low on-resistance and low channel leakage. The μM3700 offers on-resistance below 200 ohms and leakage under 1 nA per channel. Using MOSFETs as active resistors, the device has blanking for four channel operation. Each gate is diode protected.

Available: April. Fairchild Semiconductor, 313 Fairchild, Mountain View, Calif. Phone: (415) 962-2530.
SEE AT BOOTHS 2G03-2G13

Circle No. 585

ON READER-SERVICE CARD CIRCLE 185



FET op-amps

Models 1552 and 1952 are all-silicon, epoxy encapsulated operational amplifiers with very high impedance.

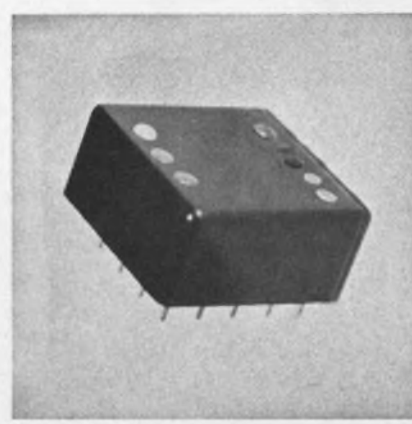
They feature 10^{10} ohms input impedance and 100 kHz bandwidth at their rated ±10 V, 20 mA output. Gain of both is 106 dB, and small-signal bandwidth is 1.5 MHz.

Measurements are 1 x 1 x 0.7-in., 1952; 1.2 x 1.8 x 0.6-in., 1552.

Prices: 1552-$145, 1952-$165. Burr-Brown, Box 11400, Tuscon, Ariz. Phone: (602) 294-1431. TWX: (910) 952-1111.

SEE AT BOOTH 3A26-27

Circle No. 571



High frequency op amp

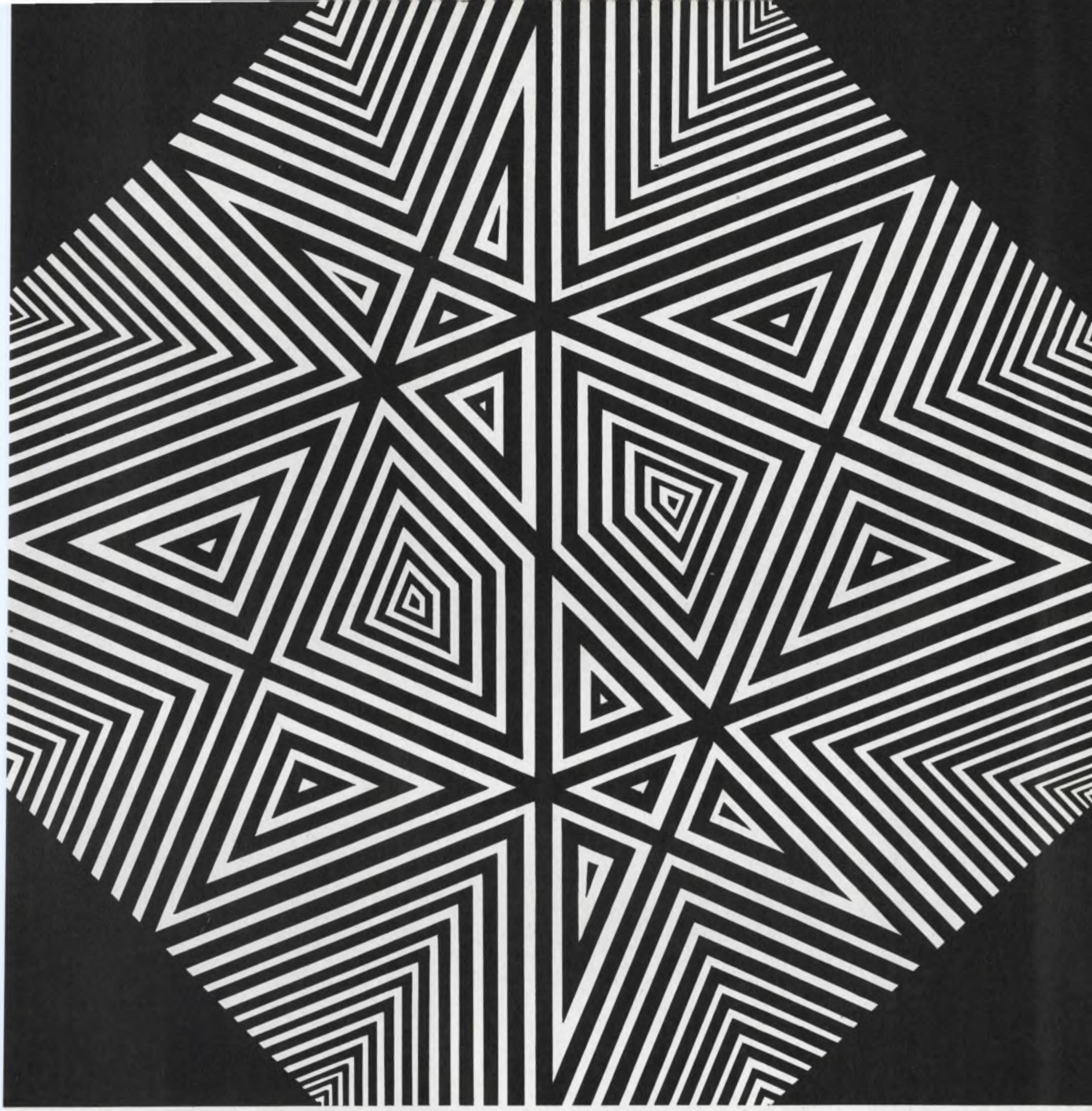
The model 976, high frequency operational amplifier has a unity gain frequency of 300 MHz. Slewing rate is 250 V/μs, output voltage is ±10 V max, and open-loop output Z is 1,000 ohms.

Open-loop gain is 300 min with a differential input Z of 3,000 ohms min. Operating temperature is 0-50°C, and the equivalent input-voltage drift is 50 μV/°C. Measurements are 1.0 x 1.0 x 0.5-in.

Price: $47.00; stock. Optical Electronics, Box 11140, Tucson.

Circle No. 572

ON READER-SERVICE CARD CIRCLE 234 ➤



Reset counter

The Series 1983 is a reset version of the company's non-reset Econocounter. The 5-digit 1983 is furnished with either base or rack mounting. Both ac and dc operating units are offered. Nominal power consumption is 6 W ac and 5 W dc. Designed for UL listing, the manual reset mechanism uses a bouncing pinion.

Veeder-Root Inc., 70 Sargeant, Hartford, Conn. Phone: (203) 527-7201.

SEE AT BOOTH 3G07.

Circle No. 569

Electric counters

The Series 1981 is a line of 6-figure general purpose counters. Reset or non-reset, base or panel mount models for either ac or dc operation are available. Nominal power consumption is 8 W. Typical uses are on communications and production equipment, business machines, fuel meters and other counting operations.

Veeder-Root Inc., 70 Sargeant, Hartford, Conn. Phone: (203) 527-7201.

SEE AT BOOTH 3G07.

Circle No. 570

Low-level choppers

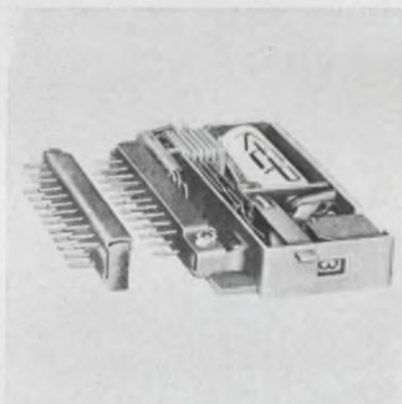
These solidly encapsulated units can alternately connect and disconnect a load from a signal source.

An adjustable frequency vibrator drives a chopper. Models 80 and 90 are spdt make-before-break devices, 81 and 90 are dpdt versions for synchronous modulator-demodulator applications. Frequency ranges are 1.5-6.5 kHz for the 80 and 81, 1.8-4.4 kHz for the 90 and 91.

P&A: $155; stock. Solid State Electronics, 15321 Rayen, Sepulveda, Calif. Phone: (213) 894-2271.

Circle No. 565

Modular counter



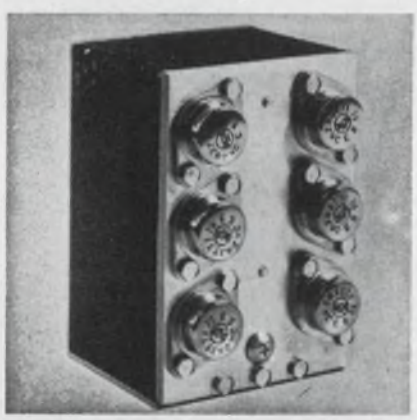
A single-digit count module displays its count visually as it indicates it electrically. These units may be mounted side-by-side to form a multi-digit counter for electrical control functions.

Each module is equipped with separate reset and transfer switches. Adding and substracting models operate from 24 Vdc, or can be specially ordered with other voltages.

Available from stock. Kessler-Ellis, 46 Center Ave., Atlantic Highlands, N. J. Phone: (201) 291-0500.

Circle No. 566

Protector/relay



The Voltrac is an over-or-under voltage protector capable of protecting circuitry by shutting down a power source delivering up to 100 Amperes. It may be specified to operate at any differential voltage from supply nominal, and can be wired to track the output of an adjustable supply while still providing protection. An integral contactor is included.

Price: From $25. Chalco Engineering, 15126 S. Broadway, Gardena, Calif. Phone: (213) 321-0121.

Circle No. 567

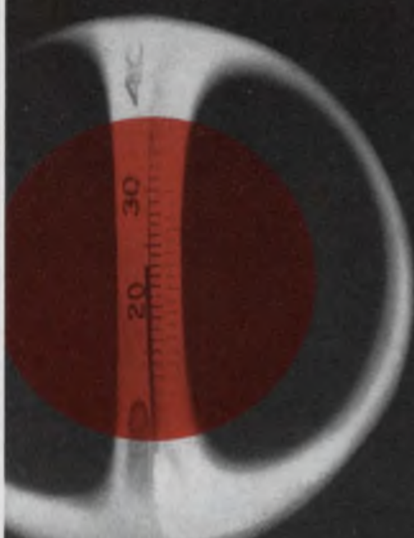
High voltage converter

Model SFU High Voltage Converter outputs are from 6 to 20 kVdc tapped in 2 kV steps, up to four common-ground taps.

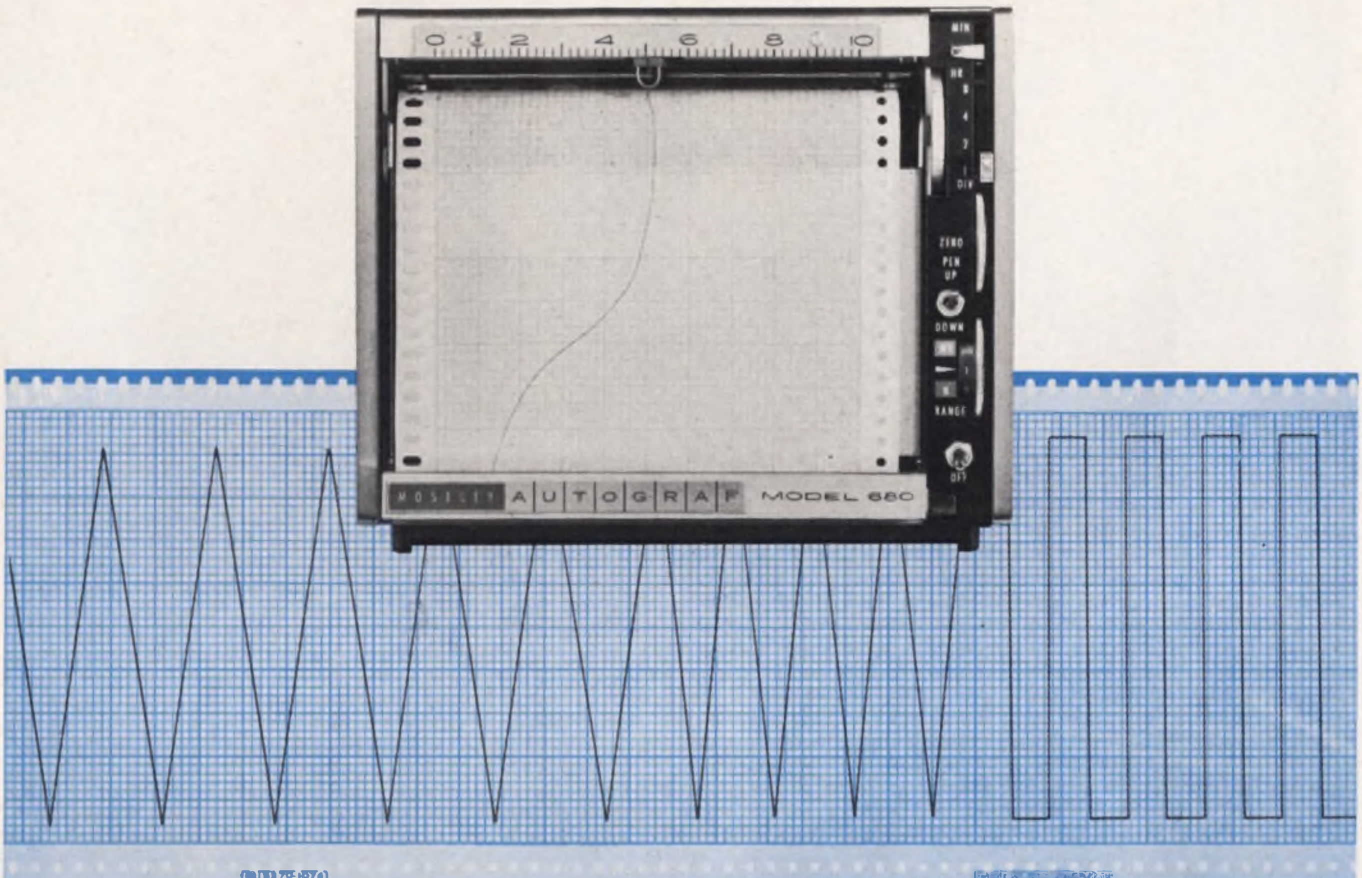
Input is 26-30 Vdc with line regulation of 0.4% and load regulation of 5.0%. Temperature range is −10° to +65°C. The 59 ounce unit measures 4-3/4 x 3-1/2 x 2-3/4-ins.

P&A: $259 plus $35/tap; 10-12 weeks. Arnold Magnetics Corp., 6050 W. Jefferson Blvd., Los Angeles, Calif. Phone: (213) 870-7014. TWX: (213) 836-0430.

Circle No. 568



INKLESS



NEW STRIP-CHART WRITING TECHNIQUE:

Ends pen clogging, ink drying
Gives clear, clean traces
Provides new economy

New Hewlett-Packard electrosensitive paper, available as a standard option on Moseley 680 and 7100 Series Strip-Chart Recorders, ends the problems associated with pen-and-ink writing techniques . . . at an economical price and without the disadvantages inherent in other available electric writing methods.

The Hewlett-Packard electrosensitive paper is a special electro-chemical coated chart paper. The coating is current sensitive, changing to a dark brown trace with application of voltage from the recorder stylus. The new technique eliminates the familiar arc method of electric writing on carbon-backed paper.

With Hewlett-Packard electric writing, you can use your strip-chart recorders for long-term, unattended monitoring, with increased performance at slow writing speeds, as well as at high writing speed. It is non-pressure sensitive, so that you can't damage or obscure your recordings.

Here's another advance in recording capability from Hewlett-Packard. Call your Hewlett-Packard field engineer for information on converting your strip-chart recorder to maintenance-free electric writing. Or write for information: Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

Data subject to change without notice.

HEWLETT PACKARD hp MOSELEY DIVISION

1189

Visit the Moseley Division of Hewlett-Packard at IEEE
3rd floor New York Coliseum, March 21-24

ON READER-SERVICE CARD CIRCLE 190

28V T-1 lamp

A micro-miniature 28 V lamp features an extended life expectancy. Size T-1 (1/8-in. by 1/4-in. long) lamps, with 99.9% tungsten filaments and nickel-iron alloy wires with a life expectancy of 5,000 hours, are hand-made, aged at rated voltage for 16 hours, and final-tested. They are available either based or unbased, #128 and #129, respectively.

Precision Lamp Engineers, 809 San Antonio Rd., Palo Alto, Calif. Phone: (415) 321-0905.

Circle No. 562

Class "K" connector

This class "K" series 238 connector is capable of withstanding MIL-C-26500 environments, in addition to meeting flame requirements of MIL-C-5015.

They provide complete interchangeability with existing MIL-C-5015D connectors and servicable crimp poke-home contacts in accordance with MIL-T-22520.

Amphenol, 1830 S. 54th Ave., Chicago, Ill. Phone: (312) 242-1000.
SEE AT BOOTH 1E13-25

Circle No. 563

Ultra-pure zinc crystals

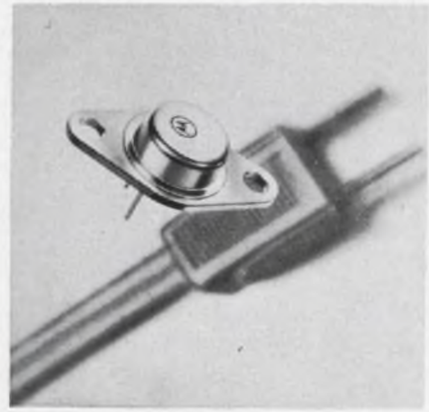
Zinc single crystals of 99.9999% purity are available in rods from 1/4 to 2-1/2-in. diameter at lengths of 1, 2, 4 and 6 inches.

These crucible-grown crystals are normally supplied with random orientation; however, specific orientations within 3° of major axes 100, 110, and 111 are available at higher cost.

Price: 1-in. x 1/4-in. diameter, \$146.25; 2-1/2-in. diameter x 6-in length, \$1014.25. Aremco Products, Inc., P. O. Box 145, Briarcliff Manor, N. Y. Phone: (914) 762-0685.

Circle No. 564


VARIAN
CENTER
electron tube and device group
IEEE
2nd Floor
BOMAC division
EIMAC division
LEL division
Palo Alto Tube division
S·F·D Laboratories, Inc.
Varian of Canada, Ltd.
over 100 NEW
microwave products



HV power transistors

Two high-voltage npn silicon power transistors, designed to operate directly from ac line voltages, are available. The 2N3738 and 2N3739 are intended audio amplifiers in line-operated sets. Power outputs of these units are one to three watts in class A, and between five and twenty watts in class B operation.

Packaged in the TO-66 case, they feature a maximum collector-emitter voltage rating of 225 V for the 2N-3738 and 300 V for the 2N3739. The min-max current-gain limits are 40 and 200 when operating at a collector current of 100 mA and a collector-emitter voltage of 10 V. The devices can be used over a broad collector-current range of 10 to 250 mA, and have a minimum current-gain-bandwidth product of 15 MHz.

Price: 2N3738-$2.25, 2N3739-$2.45. Motorola Semiconductor Products Inc., P. O. Box 955, Phoenix, Ariz. Phone: (602) 273-6900.
SEE AT BOOTH 1A18-1A24

Circle No. 586

Voltage regulators

A 50 μs response time and a 1% load and line regulation are featured in the R-3200 series voltage regulators. The units operate over a 47-63 Hz frequency range, and accommodate a wide range of load power factors. The miniature all silicon, units in the line include 15, 30, 60, 120 and 250 VA capacities.

Wanlass Electric, 2189 South Grand, Santa Ana, Calif. Phone:
SEE AT BOOTH 4M09

Circle No. 587

RF detector

The model CD-75 detectors are designed for video, vhf, and uhf operation at 75 ohms impedance.

Detection is provided between 100 kHz and 1 GHz with a vswr of better than 1:2:1 at 1 GHz. Frequency response is flat within ±0.15 dB over any 100 MHz segment and ±0.8 dB over the full 1 GHz. Either positive or negative dc can be supplied with any combination of male and female BNC or TNC connectors.

Texscan, 51 S. Koweba Lane, Indianapolis, Indiana. Phone: (317) 632-7351.

SEE AT BOOTHS M-8, 9

Circle No. 588

TTL digital ICs

Six different gate configurations are included in the SE800 series, including a gate expander and a J-K flip-flop. The circuit elements are packaged in a glass-Kovar 14-lead flat-pack EIA designated TO-88. They are said to be interchangeable in both function and pin layout with the Texas Instruments series 54 elements.

Price: $17.60 (gate), $22.80 J-K (flip-flop). Signetics Corp., 811 E. Arques Ave., Sunnyvale, Calif. Phone: (408) 739-7700. TWX: (408) 737-9965.

SEE AT BOOTHS 2J40-42

Circle No. 589

Integrated circuits

Two groups of TTL integrated circuits (SUNL I and II) are for high speed and ultra-high speed applications. Each group includes four series. They include 28 circuits categorized by temperature and fan-out or two military and two industrial ranges.

Fan-out capability is 6-30, average power dissipation per stage is 15 milliwatts. Noise immunity is 1 V (25°C).

Availability: stock. Sylvania Electric Products, Johnson St., Seneca Falls, N. Y. Phone: (315) 568-5881.

SEE AT BOOTHS 2C25-36

Circle No. 590

Flat wirewound resistors

The HLM series of flat, wirewound resistors can be used as direct replacement for vitreous enamel types. They combine a precision wirewound element with a multi-layer silicone coating for greater stability and long-term performance than most vitreous types. Tolerance of 5% on values above 1 ohm, and a temperature coefficient of ± 30 ppm/°C are features.

Three models are available: HLM-10 (10 watts, over-all length 1.312-in.), HLM-15 (15 watts, over-all length 1.562-in.), and HLM-20 (20 watts, over-all length 2.625-in.) All are self-stacking, and can be mounted horizontally or vertically. Special brackets offer vibration resistance and heat dissipation.

P&A: about $.30 for HLM-10 (depending on value and quantity); 3-4 weeks. Dale Electronics, P. O. Box 488, Columbus, Nebr. Phone: (402) 564-3131.

Circle No. 591

Reflex klystrons

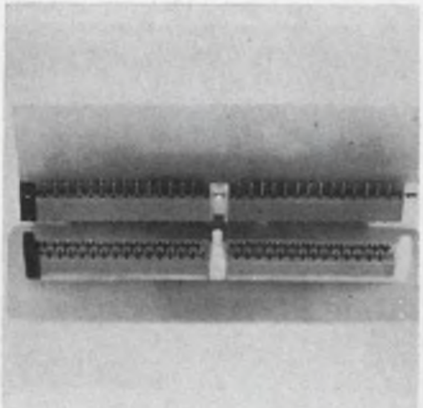
Suited for use as pump tubes for masers and parametric amplifiers, the VA-254 series reflex Klystron delivers 150 mW into a matched load over its entire 1 GHz tuning range. Tubes are available for any specified center frequency plifiers, the VA-254 series reflex between 18 and 26.5 GHz. Tuning is mechanical. The sealed unit is suited for airborne use.

Varian Associates, Tube Div., 611 Hansen Way, Palo Alto, Calif. Phone: (415) 326-4000.

SEE AT VARIAN, 2nd Floor.

Circle No. 592


Honeywell's
NEW
Auto-Torque
METERS
Now available in many styles!
This revolutionary new meter comes in conventional Bakelite models in 2½, 3½, and 4½-inch sizes — a modern, dull black model "45" with a picture frame window — brand new clear plastic 4½-inch square meter priced for the volume user — the distinctive Medalist series and the contemporary "MS" series, each in 3 standard sizes. Auto-Torque meters give you the widest selection of band-type meters available today.
More Reliable!
Auto-Torque's simplified design has 50% fewer parts. And since Auto-Torque meters are machine made, they give you uniform quality and precision never before possible in conventional meters. You can just about say good-bye to service problems!
Revolutionary and fast selling
D.C. MILLIAMPERES
MILLIVOLTS
D.C. MILLIAMPERES
milliamperes
DIRECT CURRENT
VOLTS
D.C. MICROAMPERES
You save money!
Quantity-order prices for volume buyers are below comparable pivot and jewel meters!
Outlasts conventional meters! Auto-Torque's moving system is suspended on metal bands under tension. As a result, there's no friction and wear.
Self-shielded mechanism
Auto-Torque meters can be mounted on any panel without special calibration; accuracy is unaffected by external fields!
For more information on the revolutionary Auto-Torque meters, write Honeywell Precision Meter Division, Manchester, N.H. 03105.



Printed-circuit connector

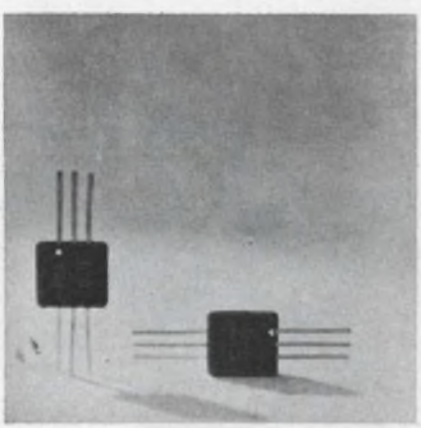
Series 8218 has up to 76 contacts in a diallyl phthalate insulator. The terminations are in two offset rows on 0.10-in. spacing giving a 0.05-in. grid—or in one row on 0.05-in. spacing.

Multiple units may be coupled by nylon sections. Ratings are 5 A, .006 ohm max contact R.

P&A: $.06 per pos. ELCO, Maryland and Computer, Willow Grove, Pa. Phone: (215) 659-7000.

SEE AT BOOTHS 1D22-23

Circle No. 593



Diode arrays

A family of eight ultra-fast silicon Planar epitaxial diode arrays is for high speed core driver applications. The arrays are sealed for operation to 400 mW.

They include 16-diode and 8-diode TO-5 and ceramic packages, with common-anode and common-cathode models. Forward V is 1.50 V max with forward current of 500 mA.

Price: $15-45. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. Phone: (415) 962-2530.

SEE AT BOOTH 2G03-2G13

Circle No. 594

Power wirewounds

Adjustable and tapped power wirewound resistors are designated HLA (adjustable) and HLT (tapped) series. Made to MIL-R-19365C, the 12 model HLA is 12 to 225 W, 1 to 100 k ohms ±5%.

The HLT has 13 models from 11 to 225 W, 1 ohm to 1.1 Meg. ±10%. They can be tapped into sections, resistance and power to order.

P&A: HLA-$.39, HLT-$.27; 3-4 wks. Dale Electronics, P. O. Box 488, Columbus, Neb. Phone: (402) 564-3131.

SEE AT BOOTH 2H33-35

Circle No. 595

High-resolution CRT

A high resolution 1-in. screen CAT is available with or without fiber optic face-plate. The fiber optics version offers full screen fiber area for contact recording of phenomena.

The M-1236 features 1000 lines/in. resolution. It is μ-metal shielded against external magnetic fields. The unit is suited for fine detailed phenomena.

Price: $850; 12-14 wks. General Atronics, 1200 E. Mermaid, Phila., Pa. Phone: (215) 248-3700.

SEE AT BOOTH 2G25

Circle No. 596

ON READER-SERVICE CARD CIRCLE 236 ➤

Low-priced nixie

A new entry in the cold-cathode readout line of Nixie tubes is the B-5440. The side-view unit measures 1.8-in. high with a 0.6-in. digit. Sockets, configuration and dimensions are designed to make the device compatible with printed circuitry. Decimal points and plus and minus signs are built in.

P&A: $4.95 in 1000 lots; stock. Burroughs, Electronic Components Div., Plainfield, N. J. Phone: (201) 757-5000. *Circle No. 597*
BOOTH NO. 1B13-1B19.

Feedback elements

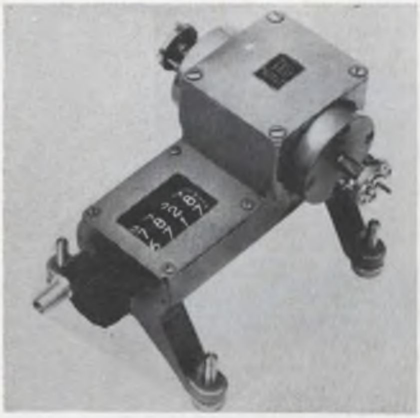
Logarithmic modules, LGP-4 and LGN-4 are designed to obtain, when used with Nexus' amplifiers, an output voltage proportional to the log of an independently variable input signal current. The 1.55 x 0.78 x 0.75-in. units are temperature compensated to provide log conformity of better than ±0.5 dB over the +5° to +55°C range.

P&A: $65 each; 6 weeks. Nexus, 480 Neponset, Canton, Mass. Phone: (617) 828-9000.
SEE AT BOOTH 2H45.
Circle No. 598

PIN diodes

A complete line of silicon PIN diodes is offered, designed for series mounting in strip transmission line circuits. A typical model, the MA-4732C, has a 75 v minimum breakdown voltage, and maximum total capacity of 0.3 pf, 2 ohms series resistance and 10 nsec switching speed. The devices are available with axial wire or ribbon leads.

Microwave Assoc., Inc., South St., Burlington, Mass. Phone: (617) 272-3000. *Circle No. 599*
SEE AT BOOTH 2D02-2D04.

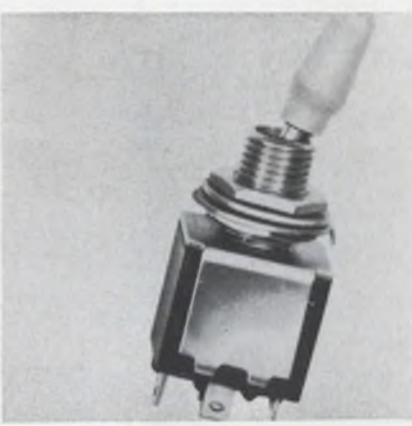


Phase shifter

A direct-reading unit, Series 528 is designed for use in millimeter RF bridge networks. Available in the standard waveguide bands from 12.4-110 GHz, the instrument consists of two quarter-wave plates separated by a rotary half-wave plate in circular waveguide. Rotation at the center section produces a phase shift equal to twice the angle of rotation.

TRG, 400 Border St., East Boston, Mass. Phone: (617) 569-2110.
SEE AT BOOTH 2D43.

Circle No. 600



Toggle switches

Called Series 7203, a line of on-off-on dpdt switches is offered. Contact rating is 5 amps resistive load at 115 Vac. Contact resistance is 20 milliohms at 2-4 Vdc, 1 amp. Dielectric strength is 1000 Vrms at sea level. Electrical life for the 5.5 gm units is 100,000 make-and-break cycles min. Uses include test equipment, computers, and communications switchboards.

C&K, 103 Morse, Newton, Mass. Phone: (617) 926-0800.
SEE AT BOOTH 1F33.

Circle No. 601

Photon-coupled isolator

A 2 pf and 10^{11} ohms non-photon coupling between input and output is featured in the hpa-4310 isolator. The solid-state device is housed in a 4-lead TO-18 case, permitting its use on p/c boards. Intended for use in circuits needing moderate-level input/output common mode isolation, the unit's 10 MHz bandwidth permits isolation of video bandwidth signals.

P&A: $55 (1-9); stock to 5 weeks. HP Associates, 620 Page Mill Rd., Phone: (415) 326-7000. Palo Alto, Calif.

SEE AT BOOTH 3E01.

Circle No. 577

Small power rheostat

Smaller than most 1/2-watt composition potentiometers, the model C rheostat is rated 7-1/2 watts at 40°C ambient (104°F). It measures 1/2-in in diameter and 15/32-in depth behind panel and is available in values ranging from 10 ohms to 5k ohms in standard and lock-bushing types. A high torque version will hold its setting under vibration and shock.

Ohmite, 3670 Howard, Skokie, Ill. Phone: (312) 675-2600.

SEE AT BOOTHS 2F39-43

Circle No. 578

Connector

A contact resistance under 0.002 ohms is featured in the Quadricon connector. Said to provide MIL performance at commercial prices, it offers one-piece insulator, crimp-on-snap-on contacts, and a one-piece insulator which requires no shells, brackets, or other mounting hardware.

Cinch Manufacturing, 1026 South Hoffman, Chicago. Phone: (312) 632-2000.

SEE AT BOOTHS 2W05-06.

Circle No. 579

How Beldfoil* reduces hum—noise

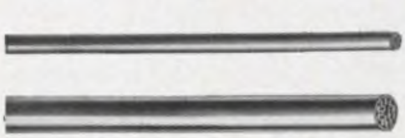
By Frank Timmons, Chief Engineer, Electronics Division, Belden Manufacturing Company

Today's sensitive electronic equipment, in most instances, cannot tolerate hum and noise resulting from pickup and interaction between conductors in cable and wire. In an effort to assist electronic engineers to meet these requirements, Belden Manufacturing Company, in 1957, introduced Beldfoil, a cable with total shielding. Frank Timmons, Chief Engineer of the Electronics Division at Belden's Richmond, Indiana plant answers a number of frequently asked questions on Beldfoil.

Q *How does a Beldfoil shielded cable differ from other types of cable?*

A Beldfoil cable is shielded with a laminated material . . . a sheet that is a combination of Mylar† and aluminum foil. The result is a high dielectric insulation that gives *total* shielding . . . 100% isolation between adjacent pairs.

Q *Are Beldfoil shield cables smaller than other types of cables?*

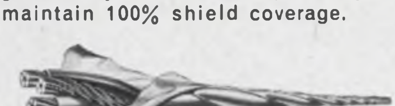


A Yes. Beldfoil shielding reduces the diameter of some multiconductor cables by as much as 66⅔%.

The two cables shown above have the same number of twisted pairs with identical AWG. The smaller of the two is the Beldfoil shielded cable. Beldfoil helps electronic engineers design for miniaturization. It provides extra conduit, raceway, console, and rack space.

Q *What about flexing?*

A Because Beldfoil shielding is applied spirally (as shown below) instead of longitudinally, it will flex repeatedly and maintain 100% shield coverage.



Q *What is meant by "pressure points" in a cable with braid-shields?*

A Braid-shields present a very irregular surface to the insulations under, or beside the shield. Pressures, within the cable, and as a result of crushing forces upon the cable, cause the braid to be forced into insulation at these pressure points. These conditions may be a cause of early cable failure. Beldfoil shields are smooth and do not contain these pressure points.

Q *What about terminating Beldfoil shielded cables?*

A Every Beldfoil shield features a drainwire that contacts the aluminum portion of the shield along the full length of the cable, draining any accumulated static charges from the shield. This drainwire is a convenient ground wire with sufficient circular-mil-area so that it may be used as a conductor for relay and annunciator circuits.

Q *What are some of the applications of Beldfoil?*

A Beldfoil is effective over the entire audio and RF range (even to 1000 Mc). Typical applications include instrumentation, data processing, and telemetering equipment, as well as any information measurement circuits. Recent specific applications have been for TV audio circuits, Air Force communications systems, TV receivers, radios, phonographs, aircraft communications equipment, and mobile communications equipment.

Q *How would you summarize some of the important benefits and properties of Beldfoil?*

A Beldfoil eliminates dirty (wide-band) noise, and the problems of crosstalk. It saves space, it's easy to install, it is easy to terminate, and it has long life. And users report that it reduces end costs because of minimum maintenance or repair required of installations after they are in the field.

Q *I assume descriptive literature is available on request.*

A Yes. Requests should be directed to Belden Manufacturing Company, P.O. Box 5070-A, Chicago, Illinois 60680.

Belden 8-10-4

*Belden Trademark Reg. U.S. Pat. Off. † duPont Trademark

SEE US IN BOOTHS 4C-27, 4C-29 IEEE SHOW

ON READER-SERVICE CARD CIRCLE 787

Coaxial attenuators

Flat from dc to 12.4 GHz, Model 8491A fixed units have either a 10 or 20 dB nominal value.

Calibration accuracy is ± 0.5 dB to 7 GHz, ± 1 dB from 7-12.4 GHz. SWR specification is < 1.2 to 7 GHz, < 1.3 from 7-12.4 GHz.

The 2-7/16-in. long units are 13/16-in. in diameter. One male and one female Type N connector is provided.

P&A: $50 each; 2 weeks. Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, Calif. Phone: (415) 326-7000.

SEE AT BOOTH 3E01

Circle No. 602

Circuit sockets

A contact design reported to assure minimum contact resistance with repeated device insertions is reported for the Press-Fit Series 60.

Sockets units for 8-, 10- and 12-lead TO-5 integrated circuit packages as well as 3- and 4-lead TO-18 and TO-5 packages are available. Bushings designed to serve as spacers between circuit boards and chassis and other uses are also offered.

Sealectro Corp., 225 Hoyt St., Mamaroneck, N. Y. Phone: (914) 698-5600.

SEE AT BOOTHS 2G43-45.

Circle No. 603

Time-delay relay

A low cost electronic time-delay relay features interchangeability with motor-driven types.

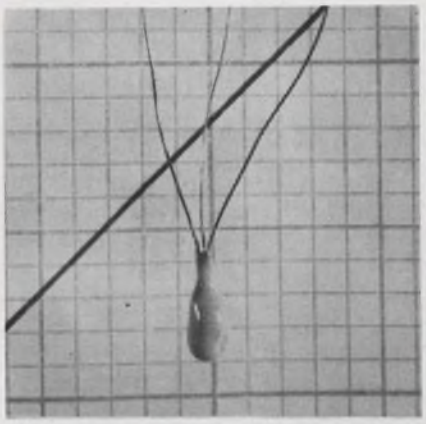
One to 90 second timing ranges in either fixed or adjustable delay types are offered.

Other specifications include dpdt output, 105-125 Vac input, solder terminals, and $\pm 5\%$ repeat accuracy at nominal voltage and room temperature.

P&A: $15.50; stock. Aemco div. Midtex, 10 State, Mankato, Minn.

SEE AT BOOTH 4A03

Circle No. 604



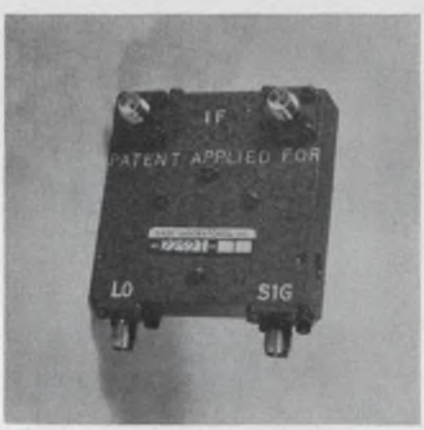
Composite thermistors

Linear resistance changes of up to 127 ohms/°C with deviations of 2 parts in 1000 from 0° to 100°C are featured in the thermilinear of composite thermistors. Smaller deviations are reported over smaller ranges. The units are interchangeable for easy replacement or for multiple readings.

P&A: $11.60; stock. Yellow Springs Instruments, P.O. Box 279, Yellow Springs, Ohio. Phone: (513) 767-7242.

SEE AT BOOTH 1A23

Circle No. 621



Coaxial attenuators

The dc to 8 GHz frequency range is covered by models 9317-3, -6, -10 and -20 coaxial attenuators. Attenuation is 3 dB ±1 dB. Vswr is under 1.30. The 3/4 oz. devices have a 1 W power handling capacity. Any combinations of miniature connectors are available.

P&A: $30; 60 days. Sage Labs. 3 Huron, Natick, Mass. Phone: (617) 653-0844.

SEE AT BOOTH 1B27.

Circle No. 622

Hybrid couplers

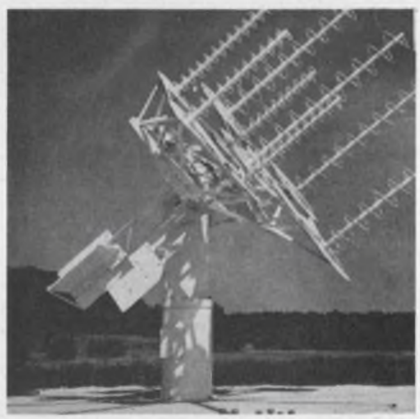
A 25 dB directivity over a full octave frequency range, with a ±1 dB coupling deviation are featured in Series CA hybrid couplers. Mainline vswr is 1.15. Six units cover the 200 to 4000 MHz range in overlapping octave bandwidths, with either N or TNC connectors. The 4-port devices offer both ends of the auxiliary line.

P&A: $90; stock. Microlab/FXR, Livingston, N. J. Phone: (201) 992-7700.

SEE AT BOOTHS IG27-29.

Circle No. 623

Telemetry antennas



Designed for use aboard instrumentation ships, a line of telemetry antennas is mounted on a heavy duty positioner and is reported to withstand 120 mph winds with icing conditions. The elevation-over-azimuth positioner will operate at a maximum speed of 40°s under a windload of 75 mph.

P&A: about $45,000; 6-9 months. Andrew Corp., Post Office Box 807. Chicago, Ill. Phone: (312) 349-3300

SEE AT BOOTHS IF12-14.

Circle No. 624

Video detectors

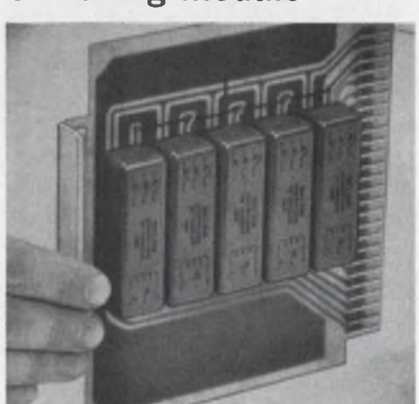
A series of three video detectors measures under 0.75 cu in., meet Class 4 environmental requirements of MIL-E-5400 and MIL-T-5422. All three units can be operated with self- or external-bias. A typical unit, model TV 11 has a −53 dB sensitivity over the full RF bandwidth from 2-4 GHz with video bandwidth exceeding 17 MHz.

Sanders, 95 Canal, Nashua, N. H. Phone: (603) 883-3321.

SEE AT BOOTHS 2W02-04

Circle No. 625

Switching module



Signals from microvolts to 200 V are switched in under 750 μs by a low-to-medium level signal switching sub-system module, the Microscanner. Available in six models (three dpst and three 3pst, two or three circuits/channel), the units accept drives of 6, 12 or 20 Vdc. Uses include data multiplexing and analog data switching.

P&A: $59-$97; 3-8 wks. James Electronics, 4050 N. Rockwell, Chicago. Phone: (312) 222-0745.

SEE AT BOOTH 2A01.

Circle No. 626

Because *one* data sheet — representing Motorola's new MR1120-30 series 12-ampere, 7/16" stud rectifiers — now gives you the chance to replace any of more than 65 older EIA 3 to 12-ampere devices . . . *all* priced considerably higher than this new series (the lowest-cost counterpart to a \$1.00,* 400-volt MR1124 unit is \$3.05*)! And Motorola 12-ampere capability in lower-current sockets gives you an extra cost-saving bonus in lessened heat sinking needs.

But don't let the low price tags obscure the topnotch performance and efficiency advantages of these rectifiers:

- highest obtainable current/temperature capability — handles a 12-ampere load up to 150°C . . . superior to more than 4 out of 5 other 7/16" stud devices
- greatest surge-current handling ability — 300-amperes (½-cycle) @ 150°C . . . at least 20% more protection than other 12-ampere units
- low forward voltage drop — 0.55 $V_{F(AV)}$ @ $T_C = 150°C$ . . . less power loss in your circuit — minimizes thermal excursions and early device failure

*100-up

Contact your franchised Motorola semiconductor distributor now for evaluation units. For the latest word in comprehensive, low-to-medium-current-rectifier data sheets, write Dept. TIC, Box 955, Phoenix, Arizona 85008.

TYPE	$V_{RM(rep)}$ Volts
MR1120	50
MR1121	100
MR1122	200
MR1123	300
MR1124	400
MR1125	500
MR1126	600
MR1128	800
MR1130	1000
Reverse polarities available	

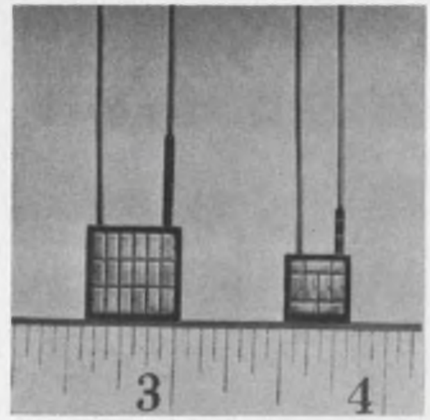
MOTOROLA
Semiconductors

See total 1 to 1,000-amp Rectification Capability at IEEE Booths 1A18-1A24

Design in DC for ⅔ Less

(and throw out 27 data sheets)

Speed Inquiry to Advertiser via Collect Night Letter
ON READER-SERVICE CARD CRCLE 792



Thermoelectric modules

Two thermoelectric modules are designed for heat and power applications where size and construction are critical. The TL0606 measures 0.445 x 0.445 x 0.167-in. and weighs only 3 grams. Operating at hotface temperatures of up to 180°C, it offers a minimum capacity of 3 W at zero δT. The TL0404 is similar, measuring 0.315 x 0.315 x 0.167-in.

Asarco Intermetallics, 120 Bway., New York. Phone: (212) 732-9500.
SEE AT BOOTH 4E15.

Circle No. 627

Annunciator lamp

High brightness and a 10,000-hour environmental life are featured in a new annunciator lamp. Available in three voltages and two base types, it is produced in 12 V, 0.170 amp; 60 v, 0.050 amp and 120 v, 0.025 amp versions. The 120 V lamp is a range voltage unit up to 130 V. All are produced in bayonet or candelabra screw bases.

Sylvania, Lighting Products Div., 60 Boston, Salem, Mass. Phone: (617) 745-4500
SEE AT BOOTHS 2C25-36.

Circle No. 628

Microwave products

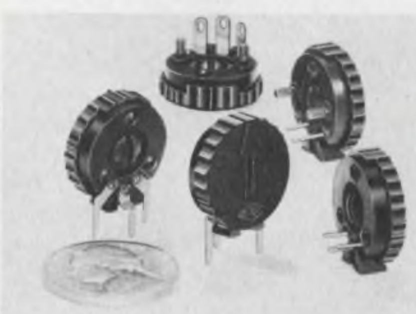
Broad band 3-port waveguide circulators covering 3.95-12.4 GHz in four bands and 2-W TWT amplifiers are available. The circulators display a 0.3 dB maximum insertion loss and a 1.20 vswr. Minimum isolation is 20 dB, and the units are designed for 10 kW peak power rating. The amplifiers have a solid-state supply.

Huggins Laboratories, 999 E. Arques, Sunnyvale, Calif. Phone: (408) 736-9330.

SEE AT BOOTHS 2G17-19.

Circle No. 629

Miniature pots



Trimmer needs in printed-circuit test, measurement and communications equipment are met by a new miniature closed-construction potentiometer. It features a rotational life in excess of 25,000 cycles and is 0.696″ in diameter and 0.250″ deep (including knob). Designated the Model 9, its range is 100Ω to 10 MΩ (1/5 W) in the linear version and 200Ω to 1 MΩ (1/10 W) with a non-linear taper. 20% tolerance is standard; 10% optional.

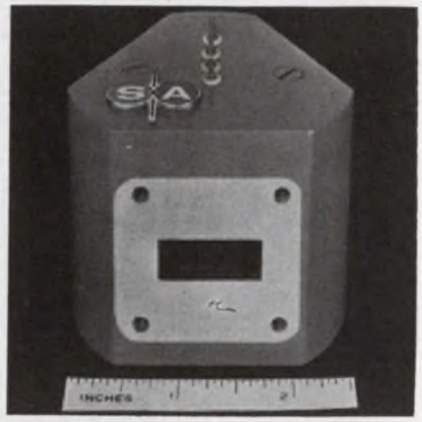
P&A: \$0.30 (in quantity); 2-6 weeks. Centralab Div. of Globe-Union Inc., P. O. Box 591, Milwaukee, Wisc. 53201.

SEE AT BOOTH 2J32.

Circle No. 630

ON READER-SERVICE CARD CIRCLE 795

Three-port circulator



Latching, ferrite, three port circulators of waveguide and strip transmission line styles are available.

The pictured X-band model X-662-02 operates at 9.0-12.0 GHz. Isolation is 20 dB, insertion loss—0.5 dB over the band. Switching time of one μs is practical.

Strip line S-band models have similar specs over more than half-octave ranges. Low-level energy accomplishes switching.

Scientific-Atlanta, Box 13654, Atlanta, Ga. Phone: (404) 938-2930.

Circle No. 609

Laser source

Laser pulsing with this gallium-arsenide source gives at least one watt peak power at room temperature (0.1-1.0 kHz).

Current pulses of 100 A for 100 ns are generated. Output light has a wavelength of about 9000 Å and bandwidth about 150 Å. The beam is collimated (or focused) by means of a lens. A 3/8-in. rod is provided for optical bench mounting.

Price: $750. Austin Eelectronics Corp., P. O. Box 9312, Austin, Tex. Phone: (512) 45-4096.

Circle No. 610

Octave-pass MW mixer

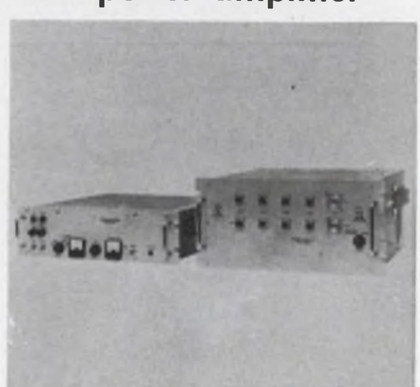
Series 20810 miniature single-ended mixers feature low noise figure and good local oscillator isolation in compact construction.

These units are available to cover octave bandwidths from 1.0 to 12.4 GHz and have easily replaceable diodes. Over-all noise figure, including a 1.5 dB IF amplifier noise level, is typically 8 to 12 dB, depending on frequency range.

P&A: $175-$225; 4 weeks. Omni Spectra, inc., 19800 W. Eight Mile Rd., Southfield, Mich. Phone: (313) 444-8890. TWX: (810) 232-1611.

Circle No. 611

TWT power amplifier



Five bands cover 1.0-18.0 MHz in the Model 135 Multiband amplifier. Output power is 18 W to 12.4 MHz, 8 W beyond. Small signal gain is 35 dB per band. Type "n" RF connections and waveguide are provided.

Changing bands requires only plug changes and screwdriver adjustments. Options include AM and/or serrodyne modulation inputs, and non-standard voltage and frequency provisions.

Alto, 4083 Transport, Palo Alto, Calif. Phone: (415) 321-3434.

Circle No. 612

We call them Microstacks®. They are being used in the lunar excursion module of the Apollo program, the Agena satellite, and the Minuteman missile.

They take tough temperature requirements in stride. Memory cores remain stable over a wide temperature range.

They can take a beating too. They're not built like conventional memory stacks. The "X" and "Y" axis of all the memory planes are continuously wired, then assembled in a folded array. This design, which we originated, eliminates more than 80% of the solder joints and reduces size and weight. Stacks are ultra-reliable when packaged to meet Mil Spec shock, vibration, humidity, and other extreme-environment conditions.

When specifications call for a new core, or stack configuration, nobody can match Indiana General's design, development, and production capabilities. We make and sell more ferrite memory cores than anyone in the world. In fact, we invented them. Many of our competitors are licensees.

If you have a military application for a high-reliability, low-power, miniaturized memory stack we'd like to send you our new Microstack Bulletin. Write to Mr. Thomas Loucas, Manager of Sales, Indiana General Corporation, Electronics Division/Memory Products, Keasbey, New Jersey.

INDIANA GENERAL

Our memory stacks play it cool when Mil Specs make things hot.

1G30-1G34

(remember these numbers)

What, more numbers? *These* refer to *Electronic Design's* booth at IEEE. We hope you will include our exhibit in your show itinerary; you'll find it a worthwhile stop. Editors will be on hand to answer questions about the magazine . . . to discuss the industry . . . to save you steps at the Coliseum. Take the time to tell us about your current projects, problems, ideas . . . design plans . . . technical information needs. (Here is an opportunity to apply for your own subscription if you are currently a pass-along reader.)

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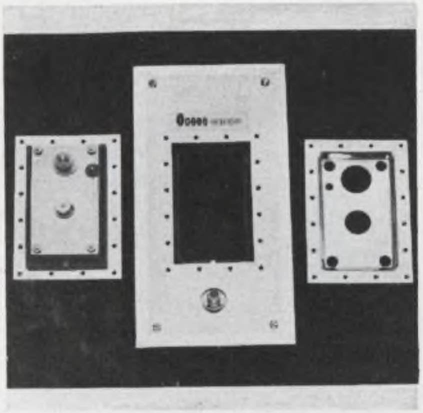


Stripiine oscillator

The GSG-1102 strip transmission line triode plug-in oscillator is designed for stripline circuits. The package plugs into a 1-1/2 by 2-1/2 inch hole in the stripline boards.

Output power is 25 watts peak, grid pulsed, or 20 milliwatts cw. The GSG-1102, weighing 2.5 ounces, is tunable over the frequency range 2.2 to 2.3 GHz. Other models are available for L and S bands.

Terra Corp., Albuquerque, N. M. Phone: (505) 255-0157.

Circle No. 605

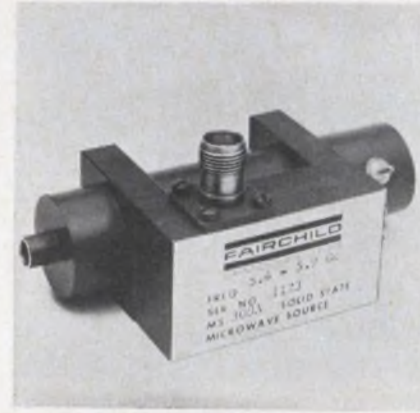
Microwave detector

A 100 dB dynamic range and bandwidth of 2-3 GHz give the HS-7162 diode detector a sensitivity of 100 mV ±3dB/mW in the square law region. Input vswr is less than 1.3:1. Inputs from less than 0.1 mW to 50 watts (cw) may be detected.

The detector has a hot cathode operating at 6.3V, 135 mA. Size is 9-1/2 x 1 inch and weight is 16 oz.

P&A: $490; 30 days. Huggins Labs., 999 E. Arques, Sunnyvale, Calif. Phone: (408) 736-9330.

Circle No. 606



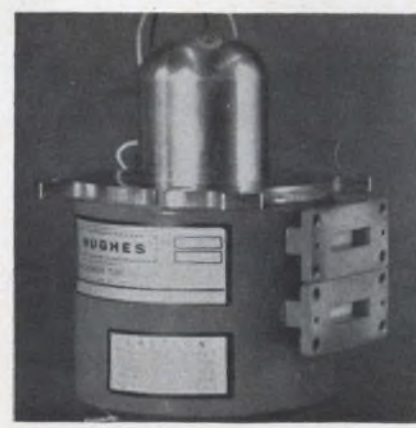
C-band sources

Two solid-state C-band microwave signal sources provide 5 mW min power out. Designated M306A and M308A, they offer less than 2 Hz rms residual FM noise. Frequency ranges are 4.4-5.0 GHz for the M306A and 5.4-5.9 GHz for the M308A.

Spurious harmonics are 60 dB below the output, and operating temperatures −55 to +100°C.

P&A: $400; stock. Fairchild Semiconductor, Mountain View, Calif. Phone: (415) 962-2530.

Circle No. 607



100 W klystron

A new compact klystron amplifier is a high-gain unit operating in the X-band with 100 W of CW power.

Metal-ceramic construction gives the klystron very low noise under extreme vibration conditions. It was designed for operation in airborne and missile environments.

The unit weighs 4-1/2 pounds, and measures 3 x 3 x 5-ins.

Hughes Microwave Tube Div., Hughes Aircraft Co., 11105 S. La Cienaga Blvd., Los Angeles, Calif. Phone: (213) 391-0711.

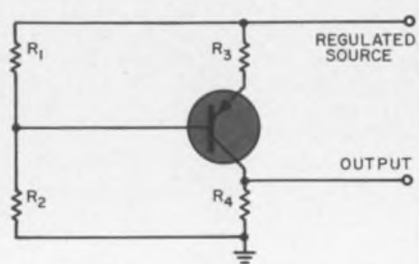
Circle No. 608

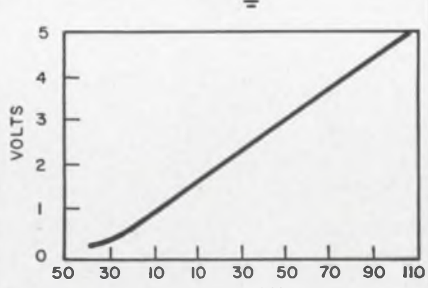
Stable transducer has high output

Problem: Design a small, stable and lightweight temperature transducer with relatively linear output that requires no amplification of its output signal.

Solution: A compact, lightweight transducer that uses the temperature-dependence of a planar silicon transistor's base-to-emitter voltage to provide a zero-to-five-volt signal proportional to temperature.

The major element of the transducer is the transistor whose base is held at a constant voltage by a regulated source operating through a voltage divider, R_1 and R_2. The regulated source is also connected through the emitter resistor R_3. The output of the transducer is developed across the collector resistor R_4, to register the voltage change with temperature.





The transducer's output is sufficient for telemetry purposes to the extent that no preamplification is required.

It is disk-shaped and approximately 1/2 inch in diameter by 1/3-inch thick. Its weight, with 36-inch leads, is about 6 grams.

Twelve of these transducers are presently providing temperature data on various experiments and components now flying aboard the Orbiting Solar Observatory (OSO-B2).

Title to this invention has

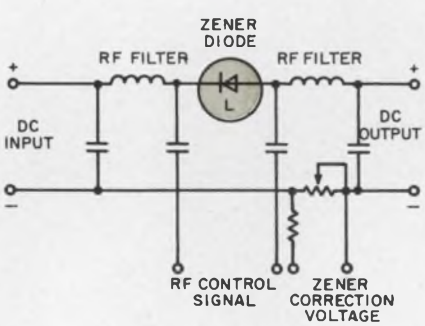
been waived under the provisions of the National Aeronautics and Space Act (42 U.S.C. 2457 (f)), to Ball Brothers Research Corporation, Boulder Industrial Park, Boulder, Colorado. Source: William H. Follett of Ball Brothers Research Corporation under contract to Goddard Space Flight Center (GFSC-446).

Zener diode switches large dc currents

Problem: Design a simple circuit to control the switching (gating) of large dc signals.

Solution: A high-current zener diode is connected in series with the positive input terminal of the dc supply to block the flow of direct current until a high-frequency (RF) control signal is applied across the zener diode.

The zener diode, being a high-impedance device, prevents the flow of direct current, as long as the zener voltage is not exceeded. When the RF control signal



is applied to the dc blocking capacitors across the zener diode, its impedance drops to a very low value and therefore permits essentially full direct-current flow from the dc input to output terminals.

The RF filters and blocking capacitors isolate the dc lines from the RF lines. The zener correction voltage input compensates for the small dc voltage drop across the diode during the conduction state.

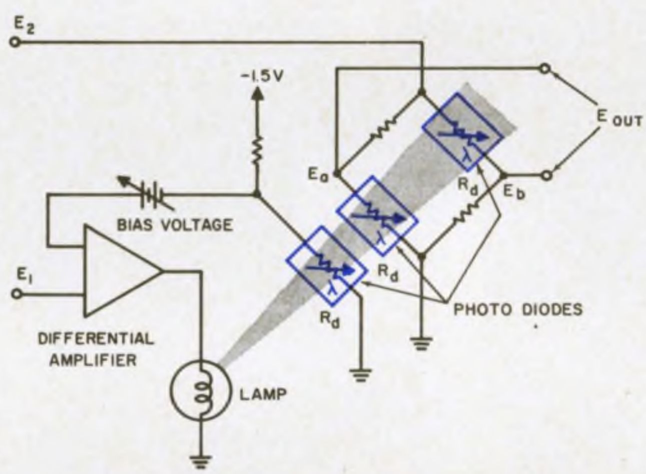
For further information, contact: Technology Utilization Officer, Manned Spacecraft Center, P. O. Box 1537, Houston, Texas 77001 (B65-10350).

Photodiodes increase range of multiplier

Problem: Perform analog multiplication of two or more variables of either polarity over a wide frequency range. To achieve equal performance with previous multipliers would require extremely complex, expensive electronics requiring major adjustments.

Solution: Solid-state photodiodes (shown in color) are placed in the arms of a simple Wheatstone bridge and exposed to a light source whose intensity is proportional to the input signal voltage. The voltage potential across the bridge is proportional to the product of the voltage applied to the light source and the voltage applied to the bridge.

If E_2 is held constant, the resistances of the photodiodes, R_d, vary inversely with the potential of E_1. If E_1 increases, R_d decreases, causing E_a to fall and E_b to rise. This in turn linearly increases E_{out}, which is $E_b - E_a$. If E_1 decreases, then, by the inverse process, a linear decrease in E_{out} occurs.



If E_1 is held constant, then an increase in E_2 causes an increase in E_{out} and a decrease in E_2 causes a decrease in E_{out}. Thus the voltage, E_{out}, is a linear function of the light source and the voltage applied to the bridge; or E_{out} is proportional to E_1 times E_2.

The differential amplifier in the closed loop of the light source compares the output of a photodiode to the input E_1. The output of the photodiode and potential of E_1 are made essentially equal (discounting the bias offset).

A series of multiplications can be carried out or variables may be taken to any desired power by the addition of other photoactivated bridges.

The multiplier operates from direct current. Its frequency is limited by either the light source or the closed-loop difference amplifier.

For further information, contact: Technology Utilization Officer, Goddard Space Flight Center, Greenbelt Maryland 20771. Reference: (B65-10287).

For almost half a century, MYCALEX CORPORATION OF AMERICA has pioneered in the development of materials with unique characteristics for the sophisticated requirements of insulation technology. The combination of properties inherent in MYCALEX® GLASS-BONDED MICA, and in SUPRAMICA® CERAMOPLASTICS has made possible production of components meeting the requirements of reliability and complexity of present, and future design concepts.

MYCALEX products provide this *combination* of characteristics:

Closely controlled insulation values equal to those of other ceramic materials

Moldable or machinable to close dimensional tolerances

Thermal expansion equivalent to that of many metals, permitting molding with metallic inserts without voids, cracks or shrinkage

Arc resistant, non-tracking, non-combustible

Complete, permanent dimensional stability throughout the entire temperature range

Impervious to moisture

High strength, and good impact resistance

Capable of withstanding temperatures from 700 deg. F. to 1500 deg. F., depending on grade.

Can be used for true hermetic seals, in a variety of design situations.

ON READER-SERVICE CARD CIRCLE 805

A comprehensive 36 page catalog provides complete technical and design information. Write or call for your copy.

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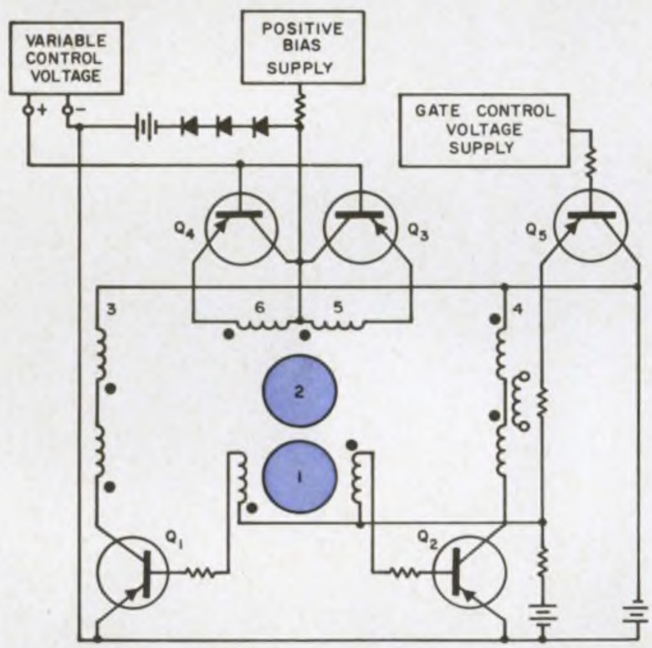
125 Clifton Boulevard, Clifton, N.J.

Magnetic multi for square waves

Problem: Design a variable-frequency magnetic multivibrator which provides a stable square-wave output over wide variations in temperature and in the power supply's potential.

Solution: A frequency-control circuit which operates in a full-wave fashion rather than only over a portion of the multivibrator's cycle of operation. This results in greater stability at the low end of the operating frequency, and in the rejection of undesirable high-frequency modes.

The multivibrator includes an uncontrolled magnetic core, 1, and a controlled magnetic core, 2. A pair of conductive loops, 3 and 4, and one of the controlled transistor switches, Q_1 and Q_2 provide the necessary alternate mode of operation for the multivibrator.



The frequency of the multivibrator is controlled by a full-wave voltage-limiter arrangement of transistors Q_3 and Q_4 and windings 5 and 6.

The operation of the voltage limiter is controlled by the level of the variable control voltage. Changes in magnitude of this variable control voltage change the operating frequency of the multivibrator.

The electronic gate, Q_5, starts and stops the multivibrator. A temperature-compensating circuit consists of the diodes, a fixed bias potential and a positive bias supply.

This circuit may find applications in devices using or concerning clocks, synchronous motor control, stable square-wave variable signal generators, test instruments, power generation control, matching magnetic bearing devices, and radio and television communications.

For further information, contact: Technology Utilization Officer, Goddard Space Flight Center, Greenbelt, Maryland, 20771. (B65-10124).

New Literature

Semiconductor wafers

Beryllium oxide semiconductor wafers and other stock parts are covered in bulletin 166. Several added items including a wafer for the TO-66 configuration are covered. Bulletin 266 covers revised properties of thermalox beryllium oxide ceramic materials. Brush Beryllium Co.

Circle No. 540

Electron beam gun

A six page, illustrated brochure summarizes the theory of electron beam gun technology and its application to commercial research and production tools. Aslo included are descriptions and illustrations of: vacuum equipment; power supplies designed for electron beam devices; sub-contract electron beam welding facilities; and sub-contract production of precision machining of electron beam and vacuum devices. Microperv, Inc.

Circle No. 541

Large ellipse templates

Large ellipse templates, 2-3/4 to 4 inch size, in 10 projections, are described in an illustrated catalog. Timely Products Co.

Circle No. 542

Pressure transducer

Series 2201 TELEFLIGHT pressure transducers are described in an illustrated bulletin. Using new sensing element, the Series 2201 has no moving parts—resulting in negligibly hysteresis and repeatability error. The new instrument is 1-in in diameter and weighing less than 3.50 ounces, which makes it useful for applications which require minimum size and weight. Taber Instrument Corp.

Circle No. 543

High alumina ceramics

An 8-page "Designer's" brochure aids product designers in the dimensional and property selection of high alumina ceramics. Contents include the basic description of ceramic material which has aluminum oxide (Al_2O_3) as a basic ingredient. Also, comparative properties and scope of uses for electrical-electronic, mechanical, chemical, wear resistant and high heat applications are described. Diamonite Products Mfg. Co.

Circle No. 544

Mercury relay manual

A new edition of the mercury plunger relay manual titled "A New Standard of Reliability in Controls" covers the range of relays made by the manufacturer. A total of 31 different new relays are described in four separate categories. The first three categories cover 100, 50 and 25 amp at 120 Vac in 1, 2 and 3 pole types. The fourth category includes single pole units completely encapsulated in epoxy for 25 and 50 amp. Ebert Electronics Corp.

Circle No. 545

Aircraft instrument data

Five technical data pages describe aircraft instrumentation, accessories and support assemblies. Aircraft altimeters, air speed instruments, a contaminated fuel detector, precision slip rings and a portable, manually operated pump and reservoir package used for jet aircraft lubrication are described. Telectro-Mek, Inc.

Circle No. 546

Gas discharge devices

Product reference bulletin, No. 301, catalogs typical gas discharge tubes and devices now being produced by the manufacturer. Main performance parameters for typical two-element spark gaps, triggered spark gaps, microwave noise sources and miniature microwave noise generators are included. Dimensional drawings are shown for representative two-element and triggered spark gaps covering the most popular voltage ranges. Signalite Inc.

Circle No. 547

Relay literature

Catalogs and promotional literature on a line of relays include data sheets and specification details for ordering. Square D.

Circle No. 256

Relay catalog

Thirty-nine different types of relays and solenoids are illustrated and described in this catalog. The DSC-2 catalog lists most commonly used relay types, arranged by category—telephone, power, general purpose, antenna-coaxial, sensitive, time delay, high voltage, microminiature, relays, and solenoids. Phillips-Advance Control Co.

Circle No. 257

Microwave components

A brochure covers strip transmission line components, waveguide components, command receivers and antennas. Included for each unit are a general description, photograph, major features, specifications and characteristic charts. Radiation Systems, Inc.

Circle No. 258

Ultrasonic transducers

A data sheet describes two ultrasonic transducers for remote control applications. Applications are listed, and performance characteristics are tabulated and graphed. Dynamics Corp. of America.

Circle No. 259

Rocker/slide switches

A new bulletin covers a complete line of switches. Bulletin 78/79-101 is arranged to provide complete specification information on both slide and rocker switches at a glance. Specification guides describe particular switch features. Stackpole Carbon Co.

Circle No. 260

Metal spinning

Advantages of metal spinning over other fabrication methods are covered in a booklet entitled "Why Spin?" Applications of metal spinning in nucleonics, aerospace technology, and parabolic reflector areas are covered. C. W. Torngren Co.

Circle No. 261

Microwave devices

WR series directional couplers and the 90 SR 36 waveguide rotary switch are described in separate data sheets. Electrical and physical specifications for both devices are coupled with ordering information. Microwave Development Laboratories.

Circle No. 262

Fastener catalog

Technical descriptions, specifications, and installation procedures cover a line of single-turn snap-ring fasteners with slotted or wing nut heads. Simmons Fastener.

Circle No. 263

Dielectric capacitors

A four-page catalog covers a newly expanded series of NPO dielectric capacitors. Temperature coefficient, capacitance, Q, insulation resistance and temperature change are graphed in all possible combinaefficient, capacitance, Q, insulation by part No., size, and capacitance. Electro Materials Corp.

Circle No. 264

Magnetic heads

A six-page brochure describes and illustrates this company's capability of producing precision magnetic heads for computer and instrument applications. Applied Magnetics.

Circle No. 265

Communication Systems

Audio communication systems and equipment are described in a new six-page pamphlet. Illustrations and short descriptions are included. Cook Electric Co.

Circle No. 266

Connector catalog

Expandable insert connectors are listed in this new catalog. Pictures and tabulated descriptions cover an entire line. Heli-Coil Corp.

Circle No. 267

Miniature choppers

A 2-page brochure describes three miniature, plug-in choppers, 50 P, 60 P, and 70 P by name. Typical applications are covered together with the units' electronic and mechanical characteristics. Solid-State Electronics.

Circle No. 268

Timing handbook

A twelve-page "Timing Handbook" outlines timing devices ranging from interval timers to multichannel programers, covering military and industrial applications. Complete electronic and mechanical specifications of the manufacturer's units are given. Artisan Electronics.

Circle No. 269

Flow indicators

A four-page bulletin gives data on low-flow indicators. Design features, construction details, connections, dimensional drawings, capacity tables and ordering information for the manufacturer's line are included. Brooks Instruments Div. Emerson Electric.

Circle No. 270

Integrated circuit catalog

A brochure covers the company's complete line of HLTTL integrated circuits. The pamphlet outlines in detail the facilities and processes involved in these state-of-the-art monolithic devices. Included are fold-out selection charts which show comprehensive diagrams and schematics of the logic circuits. Transitron Electronic Corp.

Circle No. 271

Data annotation

A 12-page, two-color brochure details the company's capabilities in data annotation. Conversion, data handling and display are covered. "Modular construction, plug-in commonality, expandability, and reliability" are stressed. Bowmar-Fort Wayne.

Circle No. 272

Semiconductor data

A 60-page condensed catalog includes semiconductor, special products, metal-film resistors, wire and cable products, and precision connectors. Parameters and specifications are coupled with cross-references, selection charts, and outline drawings for all devices. The catalog is thumb-indexed. Transitron Electronic Corp.

Circle No. 273

Instrumentation catalog

Catalog H describes electronic instrumentation for investigations in the fields of biophysics, neurophysiology, geophysics, analog computation, low-frequency phenomena, and limited energy measurements. Electrometers, signal isolation devices, pulse and waveform generators, differential preamplifiers, and other instruments are described. Argonaut Associates.

Circle No. 274

Dipping compound

Isochemsupergel 157, a novelac peracetic dipping compound with excellent moisture and electrical specs is described in a data sheet. Applications and prices are included. Isochem Resins Corp.

Circle No. 275

Thermistors, varistors

General purpose thermistors, varistors, and miscellaneous assemblies are described with graphs and tables in an eight-page bulletin. Mechanical and electrical characteristics of all the devices are listed. Victory Engineering Corp.

Circle No. 276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720 power supplies

A bulletin describes the "L" series of 720 power supplies, with up to 1800 watts output. All units are overload protected, with automatic recovery when the fault is removed. Deltron, Inc.

Circle No. 277

Technical training

Training schools for process, industrial, and aerospace studies are described in this 12-page bulletin. Enrollment information is included with course descriptions, and an illustrated tour of the program. General Electric.

Circle No. 278

Scintillation counting

A technical bulletin entitled "Combustion of Samples for Liquid Scintillation Counting" is available. The two-color bulletin describes techniques for sample combustion, problems encountered, and solutions. It is profusely illustrated with drawings and photographs. Nuclear-Chicago.

Circle No. 279

Lighted switches

A 16-page catalog lists the Twist-lite series of illuminated pushbutton switches and word indicators. Circuit and dimensioning diagrams are given, together with ordering information per MIL-S-22885. Master Specialties.

Circle No. 280

Solid-state devices

An illustrated 8-page booklet, SF-7002, describes the company's line of switches, limiters, duplexers and phase shifters, including electrical and mechanical specifications. Microwave Associates.

Circle No. 281

Fastener catalog

This 24-page, 2-color catalog illustrates and gives specifications for 15,000 sizes of stainless steel fasteners. Star Stainless Screw Co.

Circle No. 282

Magnetic pickup data

An 8-page bulletin describes applications for the manufacturer's line of electromagnetic proximity switches and pickups. Electro Products.

Circle No. 283

Ceramics newsletter

A bi-monthly newsletter called IITRI CERAMICS is available on a regular basis. The first issue has a feature on mechanical property measurements and design with brittle materials. A list of publications pertaining to design using ceramic materials includes several available from the IIT Research Institute.

All items appearing in the newsletter are available for republishing in whole or in part. IIT Research Institute.

Circle No. 284

Resistor catalog

Catalog 100 is a complete listing of the manufacturer's resistors. A section on construction and design is included, as is selection and ordering information. Ohmite.

Circle No. 285

Capacitor catalog

A new 34-page OEM capacitor catalog gives detailed descriptions of testing procedures for each basic capacitor type. Capacitors are listed by size and voltage rating. Curves are given showing frequency characteristics and temperature coefficient.

Low voltage, semiconductor ceramic, temperature compensating, antenna coupling, line bypass, polystyrene, and R-C combination units augment the standard disc and tubular listings. Centralab Div. of Globe-Union.

Circle No. 286

Flat-Braid Shielding

Flat-braid cable shielding for reduced size and weight is discussed in a 4-page brochure. Tables of weights, sizes, and mechnical and electrical properties are provided. Raychem.

Circle No. 287

How to service relays

A 20-page booklet with illustrations on how to adjust and maintain relays is available. It contains information in relay terminology, what tool to use, maintenance of the armature assembly, tensioning, gauging, current values and timing for most types of relays. P. K. Neuses.

Circle No. 288

Plastics brochure

Three engineering plastics (Lexan, polycarbonate resin, and PPO polyphenolene oxide) are discussed in an 8-page brochure. Specifications and properties are tabulated. General Electric.

Circle No. 289

Motor catalog

Servo motors of all types are included with special purpose motors, stepper motors, synchronous motors and design formulas in this new 31-page catalog. Kearfott Div., General Precision.

Circle No. 290

Coil guide

The "Guide To Coil Construction" is a 20-page discussion of the major categories and types of coils. Construction considerations, MIL specs and the Underwriters Laboratory aspects of fabrications are covered. Wabash Magnetics.

Circle No. 291

Armored cables

A 36-page catalog gives details on C-L-X armored cables. Complete descriptions are included, for all sizes and constructions of stock and special cables, together with prices and ordering information. Simplex.

Circle No. 292

Noise-figure measurements

An 18-page book covers the theory and techniques of noise figure measurements. The book also acts as a catalog for the manufacturer's instrumentation in that field. Airborne Instr. div. Cutler-Hammer.

Circle No. 293

Wire cable catalog

A wire rope and cable assembly catalog covers physical properties, specifications and application data. Microlin miniaturized cable, eletromechanical cable and plastic jacketed cable are features. Bergen Wire Rope Co.

Circle No. 294

Receiving-tube guide

Vol. 32, No. 3 of Sylvania News is a replacement guide for industrial receiving tubes. It lists direct replacements for frequently encountered types in CATV, broadcast, mobile communications, and aviation equipment. Sylvania.

Circle No. 295

MW switch catalog

Hermetically sealed coaxial switches are described in a 12-page catalog. Diagrams and specifications for 23 microwave switches are accompanied by an ordering guide and technical details on the variations of voltages, rf connectors, and power terminations that are available with each type. Electronic Specialty.

Circle No. 296

Recorder brochure

A 12-page paper details the workings of the integrated vibration data recorder. Complete specifications for the 98-channel unit are accompanied by graphs, photographs, and tabulations of parameters. Data Control Systems.

Circle No. 297

Microscopes/microtomes

A line of microscopes and microtomes for clinical and industrial use is described in a 28-page brochure. Adjustments, special features and usage are included. Reichert.

Circle No. 298

Integrated circuit memory

An 11-page brochure on the integrated circuit "VersaSTORE" memory gives block diagrams, interface circuit diagrams, timing charts and specifications. The memory has capacities of 256 to 4096 words of up to 24 bits. Decision Control.

Circle No. 299

Microwave tubes

A quick reference guide to principal specifications of more than 200 of the most widely used microwave tubes has been compiled.

This 28-page catalog and cross-reference lists klystrons, magnetrons, crossed field amplifiers, traveling wave tubes, and backward wave tubes. Within each family, tubes are listed by frequency. Raytheon.

Circle No. 300

Instrument reference

A new catalog contains photographs, descriptions, specifications and prices for a complete line of instrumentation. Handy definitions, check-lists, and applications are included in the 56 page book. Keithley Instruments.

Circle No. 301

Teflon materials

A 24-page catalog lists over 40 stock parts and products of Teflon, with complete information on sizes; thicknesses and tolerances. It includes rod, tubing, tape, film, instrument balls, gaskets, packing, seals, rings, insulators, terminals, jacks, plugs and Teflon-metal laminates as well as information on the company's custom molding, machining, extruding and compounding operations. Tri-point Industries Inc.

Circle No. 302

Switch catalog

Bulletin 70 shows a wide variety of lighted control-panel switches. Included are 28 Vdc and 115-230 Vac switches in assorted colors and sizes, including two-color and two-level button combinations. Micro Switch—Honeywell.

Circle No. 303

Analog instruments

A 24-page clip-bound catalog covers a complete line of analog instruments and electronic solid-state counters. Specifications and illustrations are coupled with pricing and applications information. Anadex.

Circle No. 304

Knob catalog

This brochure features aluminum instrument knobs, with construction details and ordering information. Included are dual concentric and fine tuning types, as well as other configurations. Atomite Electronics.

Circle No. 305

Infrared components

A 44-page catalog gives specifications for a variety of components and instruments in infrared technology. Also listed are certain new semiconductor developments in allied fields. Santa Barbara Research Center, Hughes Aircraft.

Circle No. 306

Monolithic plug-ins

A four-page technical brochure describes a line of monolithic plug-in integrated DTL circuits. It gives diagrams and schematics for the complete set of logic elements, and includes loading and interface rules. Signetics.

Circle No. 307

Differential voltmeter

This 2-page engineering note describes the model 661 ac/dc guarded differential voltmeter, which operates as a dc potentiometer, dc VTVM and ac VTVM. The note describes the instrument, lists its specifications, and shows the block diagram. Keithley Instruments Inc.

Circle No. 308

Circuit breakers

A four-page condensed catalog covers precision circuit breakers, their selection and application. Thermal and magnetic styles find coverage in these pages—one, two, and three-pole varieties, be they automatic or manually set in type. Tabular material includes dimensions, characteristics, approvals, and typical applications. Glossaries are appended. Texas Instruments.

Circle No. 309

Reed relay catalog

A folder describes five series of reed relays. The 12-page booklet gives specifications, drawings, technical data, and application details. Package configurations, contact ratings, operating parameters, and electrical data are quick-referenced for standard and miniature models. New Product Engineering.

Circle No. 310

Miniature accelerometer

Data sheet T-154, describes the model 610-TX micro-miniature triaxial accelerometer designed for the simultaneous measurement of acceleration phenomena in three mutually perpendicular directions. Complete specifications, electrical and physical, are provided for the instrument. Columbia Research Labs., Inc.

Circle No. 311

Mobile transceiver tubes

A push-to-talk-service guide contains the basic specifications and ratings of the most popular mobile communications tubes. The 3-color pocket-size sheet includes a card for requesting information and catalogs. Amperex.

Circle No. 312

Polymer catalog

An illustrated 16-page brochure describes industrial plastic materials, molding compounds, nylon hose, tubing and plastic costings. Physical properties, applications and stock availability are covered. Polymer Corp.

Circle No. 313

Drafting aids catalog

Drafting aids symbols are featured in a new catalog. The symbols are individually die-cut, printed on adhesive-backed opaque film, and packaged in rolls. Accuracy to ±0.001 in. is maintained in symbols such as integrated circuits, flat packs, welded modules, and PERT diagrams. Bishop Industries.

Circle No. 314

Logic card catalog

A wide variety of analog and digital integrated circuit logic cards is described in this 20-page catalog. Interface and power cards and mechanical accessories are included. Data Technology.

Circle No. 315

Process control systems

A line of miniaturized dc electronic process control equipment is featured in a new 40-page publication.

Graphic and photographic illustrations enhance the catalog's presentation of specifications. Block diagrams show the system's operation. Robertshaw Controls.

Circle No. 316

Aerospace indicators

Catalog No. 15 illustrates and gives specifications for aerospace indicators. Included are tachometers, synchros, special purpose indicators, and ground and shipboard indicators. Engineering data and a MIL-spec index are features. Bendix.

Circle No. 317

Accuracy is our policy

There were two errors in the article "Find the received signal . . . ," published on page 84 of the Feb. 15, 1966, issue of ELECTRONIC DESIGN.

The expression in brackets in the second line of the equation should read (6400 sin d/6400) instead of (6400 sin 6400/d). Mr. Salley's name should read Ernest J. Salley instead of Edward J. Salley.

RF interference

An 18-page report deals with radio interference problems related to the operation of engine-generators.

As a guide for specifying or using noise-generating equipment in areas of strategic radio transmission, this paper lists radio suppression classifications and control limits issued by the various military branches. Shielding methods and materials are considered, as well as test data. Onan Div. Studebaker-Packard.

Circle No. 318

Telemetry receiver

A brochure describes a solid-state radio receiver. Block diagrams and photographs are incorporated with specifications for the receiver, RF heads, spectrum display units, etc. Data Control Systems.

Circle No. 319

Corrosion resistance

Corrosion resistance of alloys is discussed in a 38-page booklet. Comparisons of different alloy corrosion resistances to 13 corrosives are detailed in 33 charts and 63 tables.

Technical explanations are developed on passivity, general corrosion, galvanic corrosion, concentration-cell or crevice corrosion, chemical pitting, intergranular corrosion, and the effect of stress on corrosion. Huntington Alloy Div., International Nickel.

Circle No. 320

Silicones brochure

A 20-page brochure gives a good look at the recent explosive pace of developments in RTV silicone rubbers. Emphasis is placed on the problem solving nature of the new compounds. General Electric.

Circle No. 321

Polyester laminates

A polyester based flexible laminate is described in a new brochure. Printed circuitry, formed circuits, and flat cable applications are described and illustrated. Physical, electrical, and dimensional characteristics are tabulated. Electrical Prod. Div. of G. T. Schjeldahl Co.

Circle No. 322

Application Notes

Power Semiconductors

This 25-page bulletin 671.1 gives applications present and future for SCRs and TRIACs. Full schematics, waveform charts, design descriptions, and application considerations are given. General Electric.

Circle No. 548

Semiconductor abstracts

Application note 200.0 is a listing of application notes, reprinted articles, manuals, and paper presentations pertaining to semiconductors. An abstract of each piece of literature is given with pricing information for five manuals or guides that are for sale. Order forms are included for free and price-tagged literature. General Electric.

Circle No. 549

Gyro handbook

A handbook on floating integrated gyros gives technical information on theory, design and operation of single-axis floated gyros and accelerometers. They are described in terms of internal construction, basic relevant equations, block diagrams, basic errors, and other data. Microsyns and temperature regulations are considered, and information regarding rate gyros, linear accelerometers and special purpose instruments such as pendulous integrating gyros and angular accelerometers is incorporated. Reeves.

Circle No. 550

Electronics Reports

Microelectronic engineering practices as described by John Hopkins University, a physics reliability handbook from Battelle Memorial Institute, and a design for a logarithmic video amplifier by Syracuse University are offered by the National Bureau of Standards Clearinghouse for Scientific and technical information.

Available from Clearinghouse, U.S. Dept. of Commerce, Springfield, Va. with the following nomenclature and prices: AD-624 315 Microelectronic Engineering Vol I, $7 (microfiche $1.75); AD-624 769 Reliability Physics Handbook, $6 (microfiche $1.50); A Logarithmic Video Amplifier, $2 (microfiche $.50).

Circle No. 551

Plastics properties

PLASTEC report 23 "Electrical Properties of Plastic Materials; Data Compiled from Technical Conference Search" is the title of a new report. It presents data on electrical properties of over 20 families of materials, and represents 1600 papers presented at 49 technical conferences from 1960-1965. Several indexes facilitate data retrieval.

Available for $5 from Clearinghouse for Federal Scientific and Technical Information, Springfield, Va.

Printed circuit production

Techniques for printed circuits production and assemblies for reliable applications are detailed in this guide. Charts, graphs and illustrations compare characteristics and performance data of base materials from phenolic paper to epoxy glass. Industrial Circuits Co.

Circle No. 553

Aerospace antennae

A design handbook on high temperature antennae for space vehicle points to the promising use of superalloys. The 150-page handbook prepared by the Cornell Aeronautical Laboratory for the Air Force, includes evaluations of experimental results, design technology is reviewed, requirements of an aerospace system are outlined, and the properties and limitations of high temperature materials are outlined.

Air Force Avionics Lab, Defense Documentation Center (DDC), Cameron Sta. Alexandria, Va.

Circle No. 554

Isolation Efficiency

Bulletin 901 is a family of isolation efficiency curves. The three-color curve permits quick reading of vibration isolation parameters in a flexibly mounted assembly with any combination of static deflection and disturbing frequencies. Lord.

Circle No. 555

Material Selection

Vulcanized fibre, Anilite resin-impregnated vulcanized fibre, Phenolite laminated plastic, and Filamite glass filament-wound tubing are tabulated, graded, priced, and compared. Properties and characteristics are listed in the 15-page data listing. NVF Co.

Circle No. 556

DESIGN AIDS

Weights table

Weights of Tungsten, Columbium, Tantalum and Molybdenum are broken down in a new pocket-size conversion table. It includes round bar, billets, and sheets according to size in inches. Universal-Cyclops.

Circle No. 531

Mica design manual

Mica data manual K-6 consists of four pages of electrical and physical data on mica insulating film and sheet. Data include dielectric strength and loss, dielectric constant, and permittivities, restivities, specific heats and expansions. Physical data are hardness, tensile strength, chemical composition and minimum bending radius. Magnetic Shield Div. Perfection Mica.

Circle No. 532

Conversion tables

A new, ready-reference wall chart, lists conversion tables on the Brinell and Rockwell hardness test readings. The wall chart presents the hardness conversion numbers in bold type, enabling more than one person to refer to it at a time. The chart measures 11" x 22" and is printed on heavy stock. King Tester Corp.

Circle No. 533

Transducers

The first in a series of eight new catalogs gives a simplified chart for selecting transducers. Drawings and introductory material are included. G. L. Collins Corp.

Circle No. 534

Printed-circuit design

A brochure for design engineers covers printed circuit boards. It acts as a manual for the newcomer to the field, and as a reference to those actively engaged.

A reference table gives dimensional tolerances. Other material covers artwork, location and alignment of holes, physical characteristics, conductors, platings, soldering and printed circuit board markings. Lockheed Electronics.

Circle No. 535

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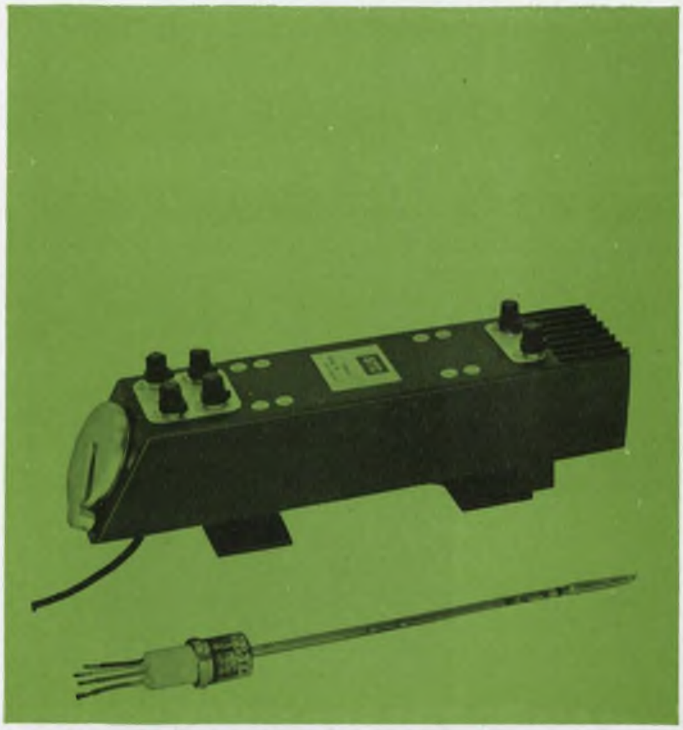

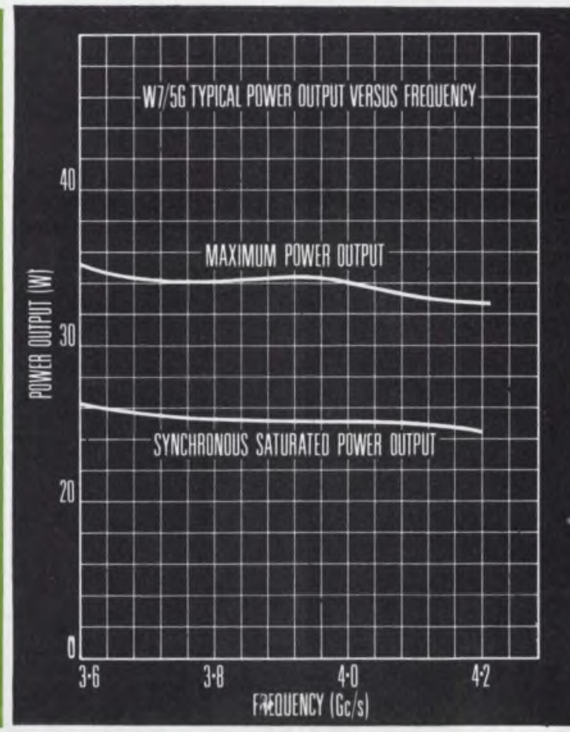

New 30W TWT for the 4Gc/s communications band

STC's new, low-voltage travelling-wave amplifier tube, Type W7/5G, has been designed for use in 1800 channel radio communications links in the 3·6 to 4·2 Gc/s frequency range. It has a typical gain of 43 dB at a working output of 20W. (30W saturated output). This means that, in an existing system which incorporates a tube with a 40 dB gain and an output of 10W, the tube can be replaced by the W7/5G to produce twice the previous output for the same drive power.

The tube operates in a robust periodic permanent magnet mount, Type WM110A. Incorporated in the mount are r.f. input and output waveguide connections (a choice of WG12A or WR229 is offered), mechanical alignment, deflection and matching adjustments; tube ejection control at either end of the mount, a convection cooler and facilities for easy field replacement of tubes.

USA enquiries to:
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March 21-25

IEEE International Convention (New York) Sponsor: IEEE; The IEEE, 345 East 47th St., New York, N. Y.

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April 25-28

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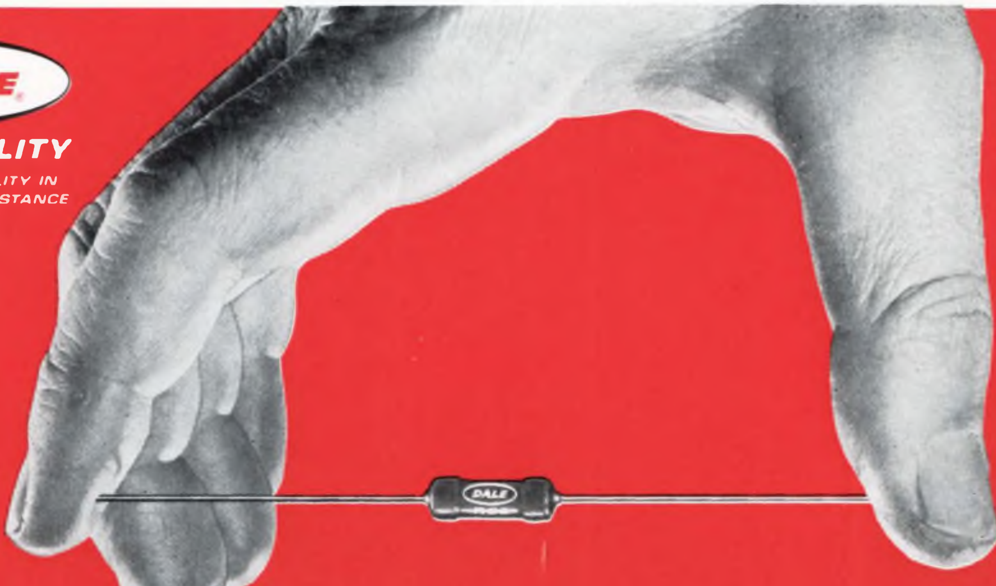

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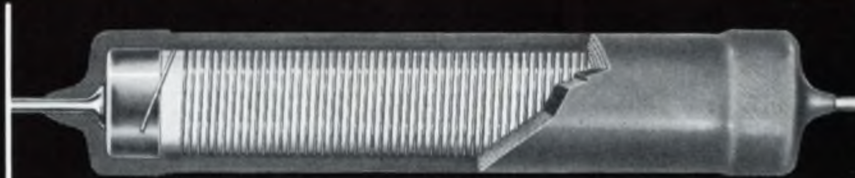

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- **Wattage Sizes:** ¼, ½, 1, 2, 2.5, 3, 5, 7, 10
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- **Resistance Range:** .1 ohm to 273K ohms
- **Load Life Stability:** 1% max. Δ R after 1000 hours at full rated power
- **Moisture Resistance:** .5% max. Δ R after MIL-R-26C moisture test
- **Dielectric Strength:** 500 volts, RS-¼ through RS-1B; 1000 volts RS-2 through RS-10
- **Thermal Shock:** .5% max. Δ R after MIL-R-26C thermal shock test
- **Insulation Resistance:** 100 megohms minimum
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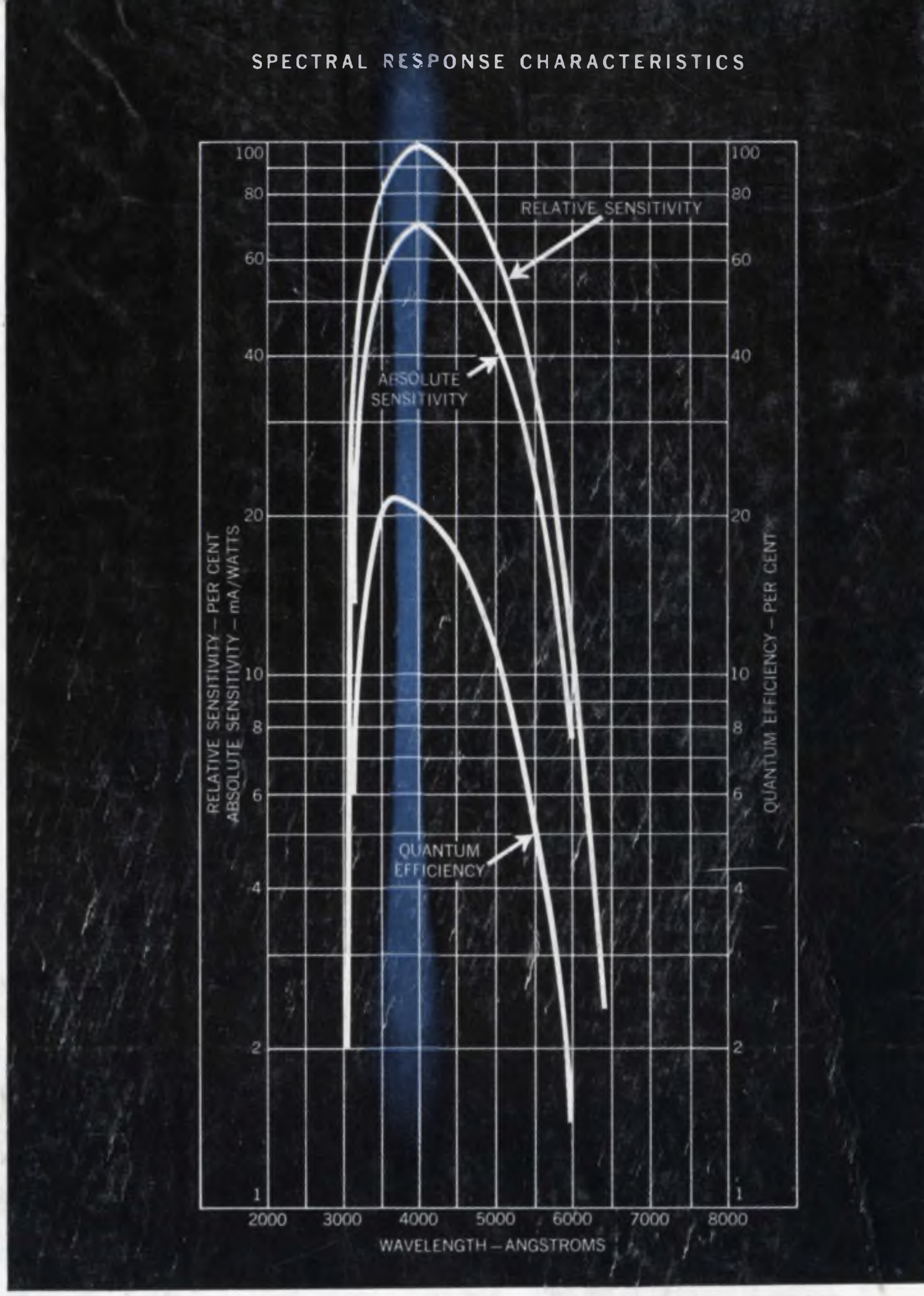

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THE RCA LINE OF BIALKALI CATHODE PHOTOMULTIPLIERS*

Nominal Size	No. of Stages	Prototype	Bialkali Variant
¾"	10	4460 7767	C70042G
1½"	10	4461	C70114F
1½"	10	6199 4438	C7151S
2"	10	6342A	C7164N
2"	10	8053	C70109F
2"	10	——	C70150
2"	10	——	C70144
2"	12	7850	C70101B
2"	12	——	C70101C
3"	10	8054	C70030E
3"	10	——	C70145
3"	10	——	C31009
3"	10	——	C31012
3"	14	——	C70045D†
5"	10	8055	C70043G
5"	14	——	C70133

*All types shown are constructed with CuBe dynodes.
†Side-on type.

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