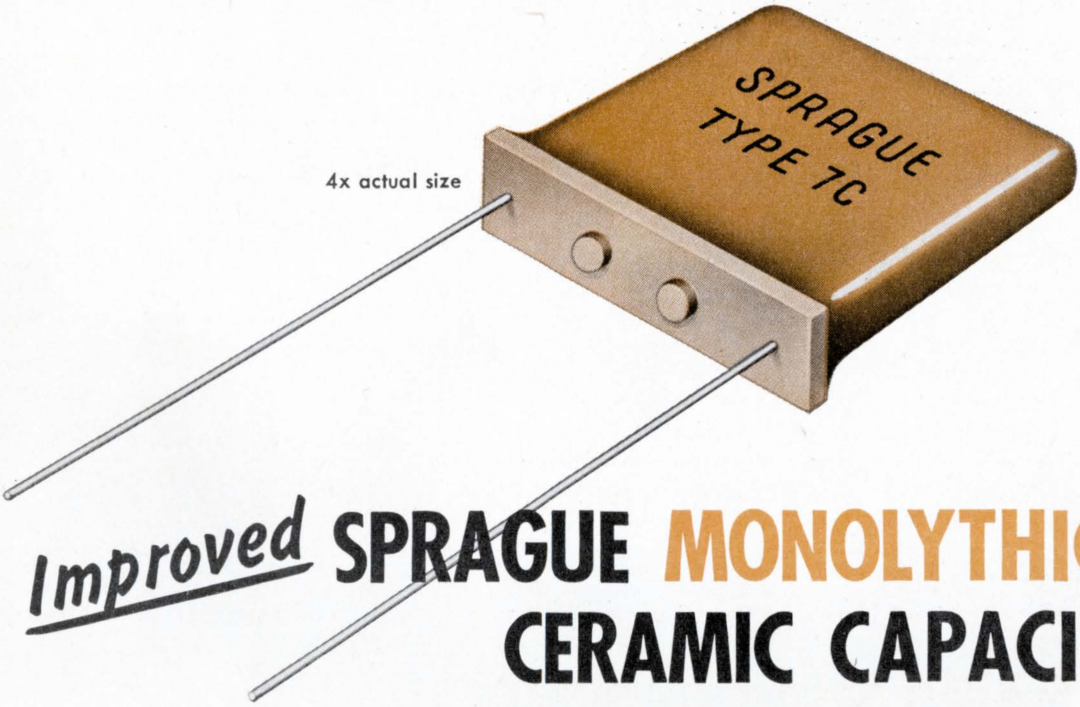
VOL. 28 NO. 5
MAY 1969

THE ELECTRONIC ENGINEER

Something *New* Has Been Added!

4x actual size



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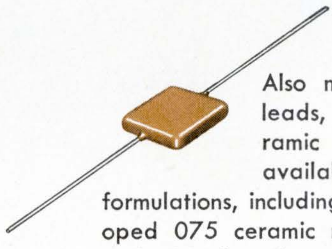
Body Code	EIA Characteristic	Operating Temperature Range	Maximum Cap. Change over Temp. Range	WVDC	Capacitance Range	Capacitance Tolerance
082	NPO	—55 C to +125 C	±60ppm/°C	50 100 200	51 pF to .024 μF	±20% ±10% ±5% ±2%
075	N750	+25 C to +85 C	—750±120 ppm/°C	50 100 200	.001 μF to .082 μF	±20% ±10% ±5% ±2%
		—55 C to +125 C	Meets MIL-C-20 Char. UJ			
067	X7R	—55 C to +125 C	±15%	50 100	.0018 μF to 1.5 μF	±20% ±10%
023	Z5U	+10 C to +85 C	+22%, —56%	50	.01 μF to 3.3 μF	+80,—20% ±20%



Also made with axial leads, Monolythic® Ceramic Capacitors are available in four body formulations, including a newly-developed 075 ceramic material, as described in the adjacent chart.

• • •

For complete technical data write for engineering bulletins on Monolythic Ceramic Capacitors to: Technical Literature Service, Sprague Electric Co., 233 Marshall St., North Adams, Mass. 01247.

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EE

The Electronic Engineer

May 1969 Vol. 28 No. 5

COVER
Because of IC voltage regulators becoming plentiful and priced right, designers now face a new make-or-buy decision for power supplies. When you should "roll your own" or buy complete power supplies is well covered in the article on page 47 by Steve Thompson, our western editor. Steve points out what is available in regulator units, both monolithic and hybrid, and their strong and weak points. Our cover has some good examples of products made by General Instrument, Bendix and Beckman.

←Circle 5 on Inquiry Card

EE

The Electronic Engineer

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Chilton BPA

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EE EDITORIAL

One electronic world

As recently as four years ago, the chief engineer for microelectronics of an important French firm told me that American electronic magazines were being very instructive in publishing articles on integrated circuits. "But," he remarked sadly, "we feel kind of hopeless when we find out that most of those circuits are available only in the United States." He was referring, specifically, to the new TTL integrated circuits that had appeared in the U.S. market, and to the DTL ICs that his American electronic engineer counterparts were using to good advantage to design the next generation of digital equipment.

This situation no longer exists. Your French, German, or Australian colleagues can today get the same circuits and components that are available to you, from thin-film resistors to high-level TTL integrated circuits. They pay only a slightly higher price than you do, and are catching up fast in learning how to use them.

To be sure, the technological gap that has accounted for the United States' supremacy in electronics still exists, since most components are developed and manufactured here first. But that gap no longer has much effect on the *availability* of those components. Save for customs regulations (which are relaxing slowly), and thanks to the light weight of modern components, a manufacturer of integrated circuits or of crystal-can relays can air-freight his products just as easily to Amsterdam, Holland as to Amsterdam, N.Y.; as easily to Melbourne, Australia as to Melbourne, Fla. We are fast approaching "one world" (to borrow Wendell Wilkie's visionary phrase)—the one world of electronics.

This was evident by comparing the recent IEEE Show, held in New York from March 24 to March 27, with the Salon International des Composants Electroniques, held immediately afterward in Paris, from March 28 to April 2. Those American manufacturers who exhibited at both shows displayed almost exactly the same wares at each.*

What is the importance of this one electronic world to you? What difference does it make to you if the same components you use are available half-way around the globe? The difference is that, while the availability gap is evaporating, the salary gap is not. An hour of design work costs far more in the United States than anywhere else in the world. If talents and components are equal, it will be cheaper to produce certain types of electronic equipment elsewhere than here. You can see this trend already embodied in such popular items as the Sony-Tektronix 7-lb portable oscilloscope (designed and manufactured in Japan), in some Hewlett-Packard instruments (designed and manufactured in Germany), and in many IBM peripherals for the System 360 computer (designed and manufactured in several European countries).

The obvious way the American electronic engineer can stay competitive is to enlist the aid of the computer, as more and more of our readers are doing As for our magazine, the unification of the electronic world will be reflected in our making available to you useful information, regardless of where it originates from. The new electronic world will have no place for chauvinism, or even provincialism. And it will be a world worth participating in.

Alberto Socolovsky
Editor

*The European manufacturers who exhibited in Paris concentrated on "best selling" instruments such as counters, digital voltmeters, and digital panel meters, and on popular components, such as DTL digital circuits, operational amplifiers, and voltage regulators, rather than on state-of-the-art items. The Paris show also featured a large percentage of "production" booths, particularly for printed circuits.

Have you noticed . . .

. . . the new columns in the last few issues of our magazine. One, called "Welcome" (page 54), gives you the latest information on new companies or new divisions in the electronics industry. Another, called "Product Seminars" (page 34), lists seminars sponsored by electronic companies for users of their products.

If you want better designs,

Fairchild MSI lets you design a system in the time you used to spend designing a circuit. A few MSI building blocks will do more work than a hundred ICs. We have versatile, compatible off-the-shelf devices that function like shift registers, counters, decoders, latching circuits, storage elements, comparators, function generators, etc. Just about all you need for any digital application. *Like a scanning keyboard encoder:*

If you'd like a simple method of converting keyboard switch closures to a binary code, you need only 5 of our CCSL building blocks and the logic diagram on the right. (Conventional design techniques would require about 30 conventional ICs to do the same job.) Besides simplicity, this design provides fast rollover, insensitivity to contact bounce, and eliminates ambiguity when several keys are depressed.

The two major elements of the design are a 64-position matrix and a six-bit synchronous counter. (The counter is composed of a 9316 four-bit binary counter and a 9020 dual JK flip-flop.) The three Most Significant Bits of the counter output address the 1-of-8 decoder (9301) forming one side of the matrix, sequentially driving its outputs "low". The three Least Significant Bits address the 9312 scanning multiplexer (the other side of the matrix), sequentially looking at its eight inputs. With this arrangement, all multiplexer inputs are scanned once for every change in the decoder output.

Each intersection of the decoder outputs and the multiplexer inputs can be used as a key position. If one of the keys is depressed, a "low" from the decoder is detected by the multiplexer and converted to a "high" on its negation output. This triggers a one-shot that inhibits the counter from advancing further and provides a "data ready" signal. The duration of the one-shot is set to cover any possible contact bounce. The output of the counter can now be used as the encoded signal, and the matrix can be arranged so that any key closure provides any binary code from 000 000 to 111 111.

The code that appears corresponds to the first key depressed. As long as that key remains down, the retriggerable one-shot continues to receive reset pulses that hold the counter at the count independently of any other switch closures on the board. Once that key is released, the counter resumes its scanning after the one-shot time period has run out.

The addition of a few more MSI elements would add even greater capability to this design. As an example, the addition of another 9312, 9316 and 9601 can result in a single serial binary PDM output group in response to each key depression. Additional control inputs could be used to restrict the range of the scan counter if only certain keys should be enabled in a certain mode as is the case in key punch machines. Addition of a 9304 Read-Only Memory would allow the selection of any code output with a single keyboard design. A single monolithic parity generator could be added to provide parity at very little additional cost. Or, you might want to add two Read-Only Memories to drive a character display and a normal output simultaneously.

Our universal CCSL logic blocks let you build circuits that you couldn't even consider with less complex or less flexible ICs. We now have 15 off-the-shelf MSI devices that you can use to lower costs and increase performance. More are on the way. Write for additional specs and application notes. We'll put you on our list for future mailings, too.

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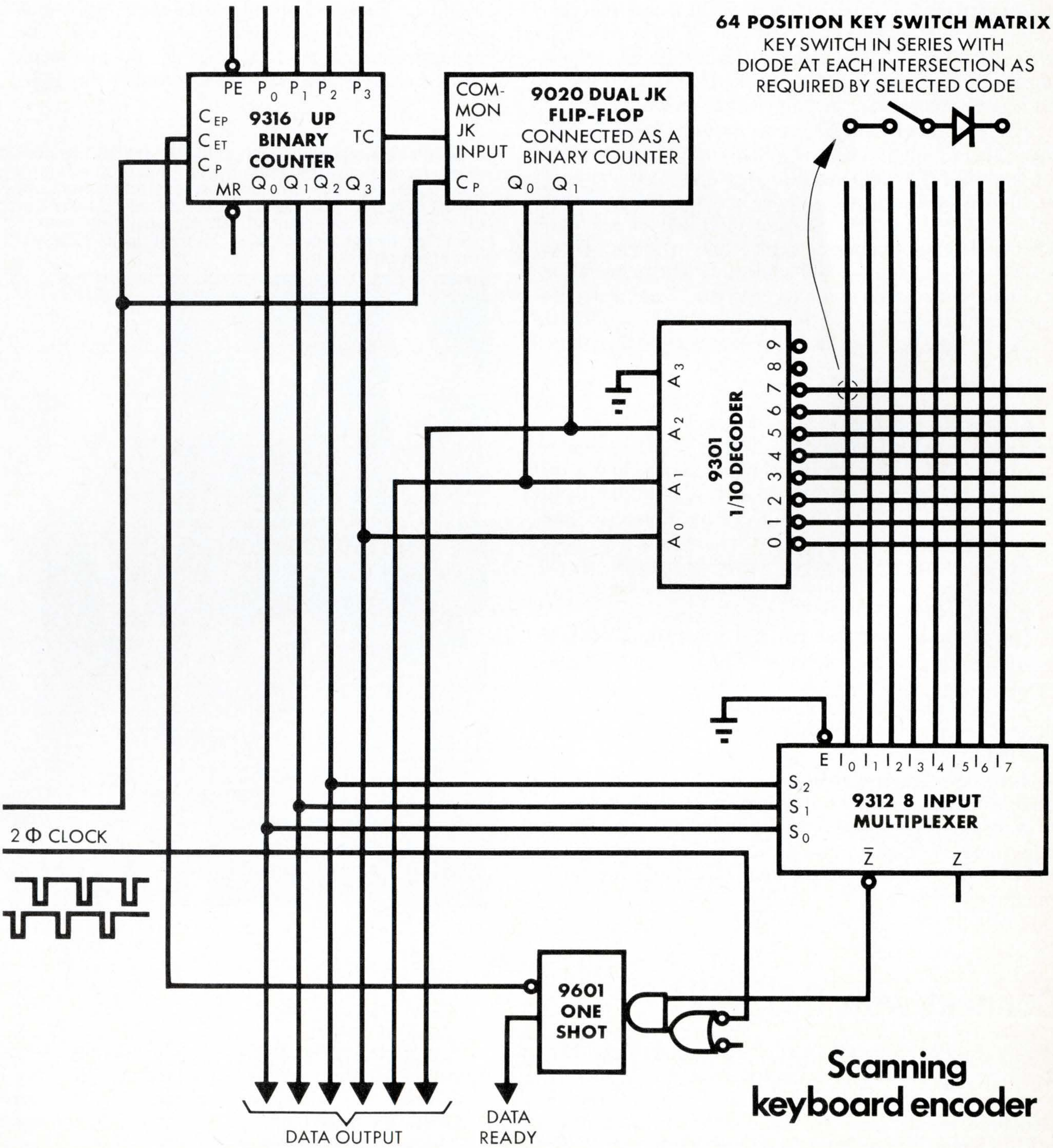
use fewer components.



Scanning keyboard encoder

LSI: Better late than never

Few are the companies that can deliver one year later than contracted for, yet still manage to please the customer (in this case the Avionics Lab at the Air Force's Wright-Patterson base). Texas Instruments, in delivering the hardware for the first system to make full use of large-scale-integration techniques, has pulled it off.

The integrated subsystems in question were 34 arrays: 16 arithmetic units, six input/output blocks, and 12 control-logic components. Average complexity of the transistor-transistor-logic devices was 200 gates per chip, well beyond the 100-gate threshold of LSI (see **The Electronic Engineer,** Feb. 1969, p. 53). These arrays replace over 1700 individual first-generation ICs in an updated version of an avionics computer. The equipment itself is a 16-bit machine with a 2-MHz clock rate, part of the Air Force's MERA radar system.

Countdown

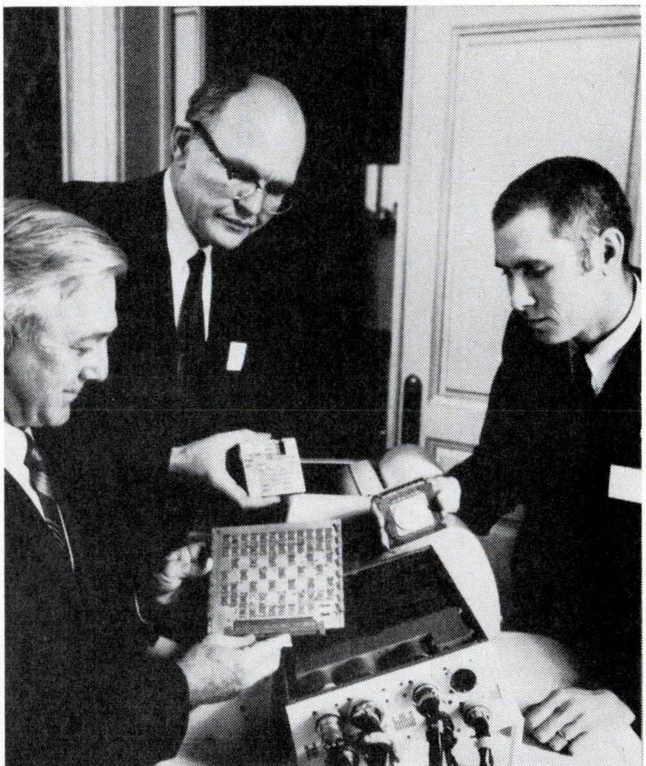
Besides the obvious benefit of smaller size, the LSI approach imparted other advantages: a 50:1 savings in parts, a 6:1 reduction in interconnections, and a reliability improvement of 50:1. And it reduced the build time (for the computer) to half of what it used to take with standard ICs.

TI achieved a number of other objectives, all of which pertain to its ability to provide other customers with LSI products:

- The fabrication of standard LSI wafers that contain both flip-flops and various-input (1, 3, 5, and 7) gate circuits.
- The establishment of an automatic probe system that determines the exact location of every functional gate and flip-flop on a wafer.
- A working, computer-programmed, multi-level interconnect generator system for fast turnaround time.
- A compatible, 3-level metallization scheme that is applicable to other arrays.
- An automatic test program for checking array functioning.

TI would not reveal if and when any of the arrays would be marketed on an off-the-shelf basis. But one company official was quick to point out, "We already have standard LSI products, such as 100-gate memories, and other arrays will be introduced later this year."

A decade of integrated circuit achievement. IC inventor Jack Kilby (center), Texas Instruments, holds the first all-IC "computer," a 1961 unit that demonstrated practicality of the IC concept. Flanking Air Force officials display portions of new all-LSI computer: at left is subsystem board composed of first-generation ICs; at right is a 250-plus gate array that replaces it.

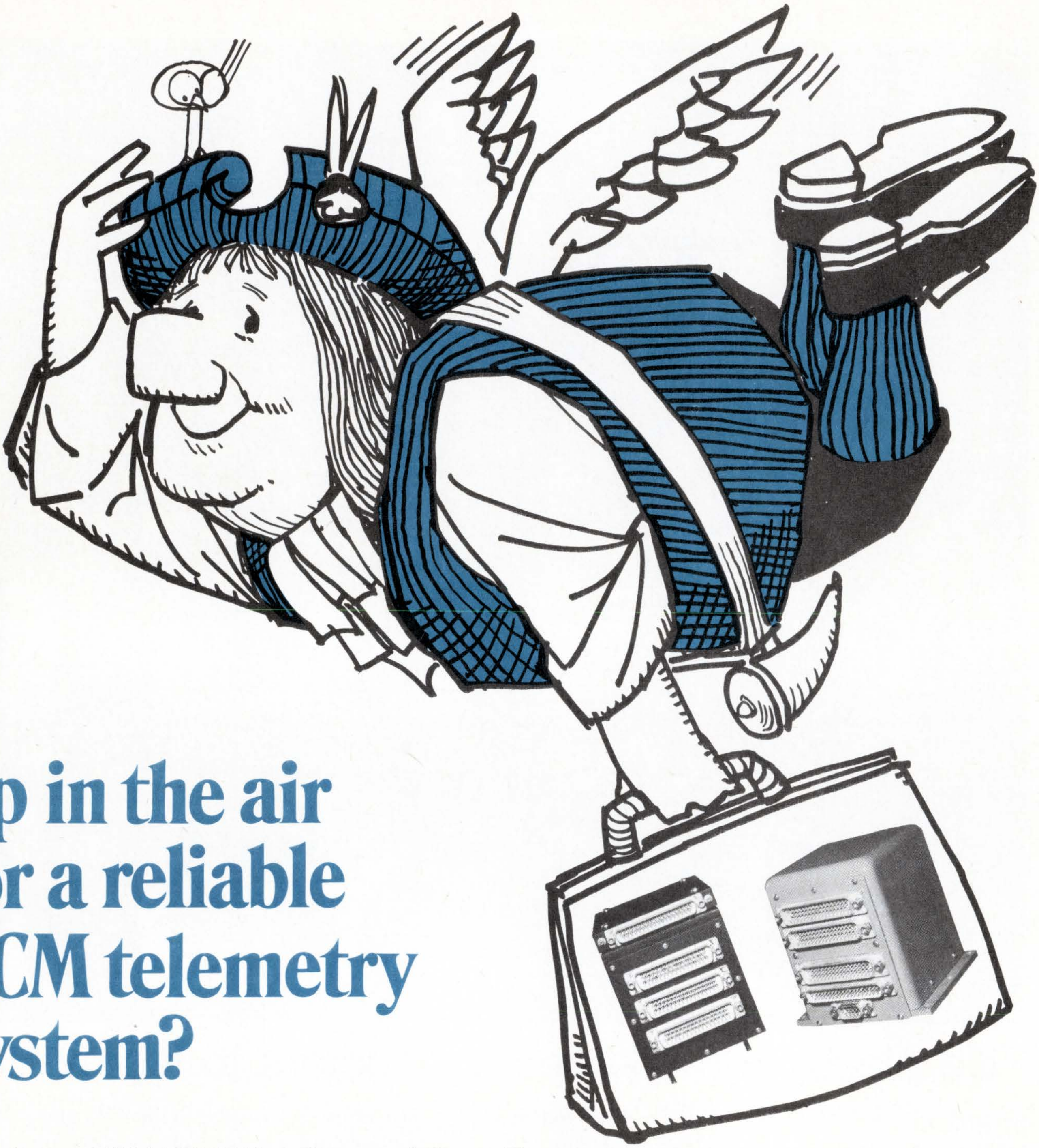


Connect with this idea

Here is an idea from NASA that looks interesting. It is a non-arcing electrical connector concept. While the connector has not yet been built, R. E. Holmen of Douglas Aircraft, working under contract to Marshall Flight Center, believes it is a practical idea.

A connector plug, as shown, will minimize or eliminate arcing during mating or demating. The plug has a high resistivity outer mating surface, such as a carbon rod with an inert binder. When the plug is inserted (*Continued on page* 13)

Circle 10 on Inquiry Card



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A new idea in light beam deflection

Faster and faster memories are being sought by computer manufacturers. Many ideas and schemes are being tried. One of these is an experimental device that can switch the position of a light beam in 35 millionths of a second. This type of high-speed deflector has potential in optical memories to randomly position a laser beam for data recording and reading.

The deflector works on the principle of total internal reflection, which minimizes loss of light. A converging light beam entering a prism is totally reflected at a right angle to its original path and brought to a focus.

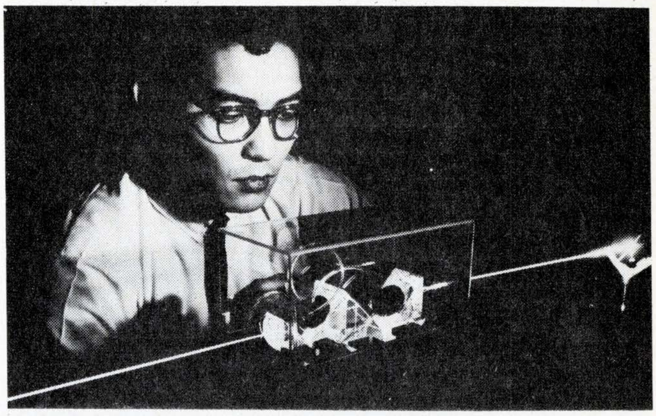
To change the position of this spot, a glass plate is moved into contact with the prism's reflecting surface. This effectively makes the prism larger. Light entering the prism now passes through the interface to the back of the plate and is reflected to a new focal position.

The glass plate is moved in and out of contact with the prism by a ceramic piezoelectric disk bonded to the plate. When a voltage (300 V) is applied to the disk, the ceramic material expands, causing the thin glass plate to bend away from the prism.

The disk need only move the plate about 35 x 10^{-6} in. to prevent the light beam from crossing the boundary and entering the plate. Grooves ground into the plate allow it to bend more readily, and surface depressions promote a "peeling" action that makes lifting the plate easier.

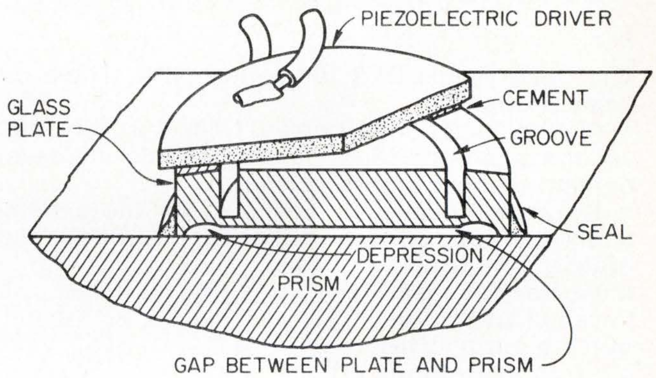
At IBM's San Jose laboratories, prisms and plates have been combined to form multistage deflectors that produce high-quality images at several locations on a recording surface. Since the number of spots increases geometrically with additional prisms and plates, deflectors capable of addressing more than a thousand locations are feasible.

Development was done at IBM Systems Development Div. in San Jose, Calif.



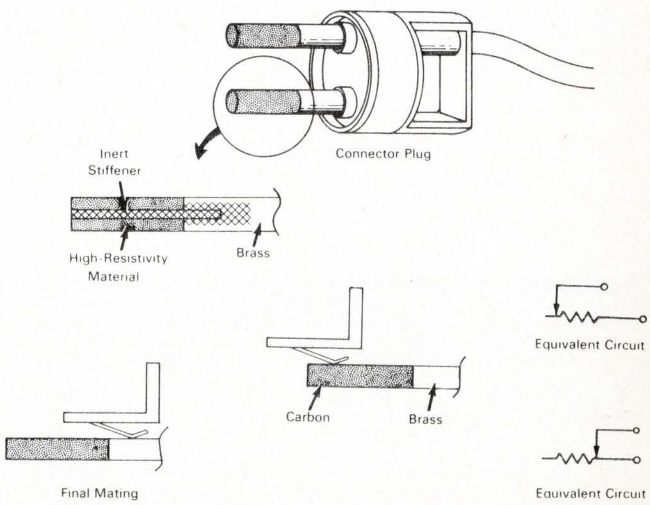
Light deflector switches a laser beam from one spot to another in 35 x 10^{-6} seconds by moving a glass plate in and out of contact with a prism. Glass is moved with piezoelectric material.

By rapidly moving a glass plate in and out of contact with a prism you can vary the position of a light beam. The glass plate is mounted to piezoelectric material. Applying a voltage to the piezoelectric "driver" causes the material to change dimensions, thus moving the glass. The sketch shows the glass moved away from the prism. Deep groove in glass plate, and depressions, facilitate bending of glass away from prism. The gap is exaggerated in sketch.



(*Continued from page* 10)
into a receptacle, the high resistivity material limits current to below arcing level. As the contact mates further into the connector, less and less resistance is in series with the current, until contact is made with a good conductor.

The carbon rod can be very hard and should be machinable. Because this rod has very little shear strength, it needs an inert stiffener.



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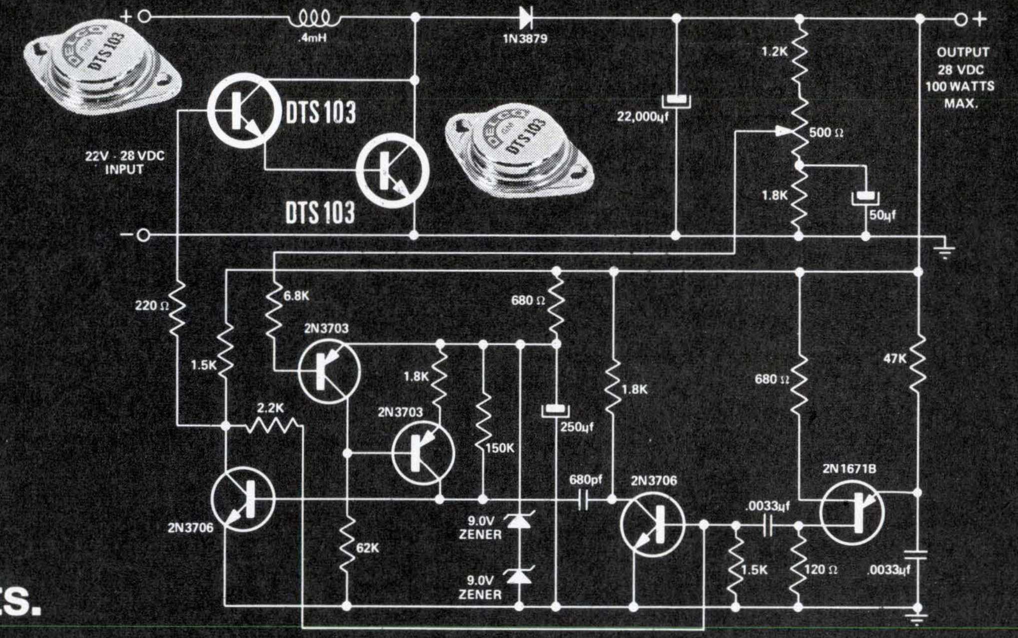

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In the direct coupled audio amplifier above right, the DTS-107 displays the excellent frequency response, gain linearity and transconductance of this family. This circuit is covered in our application note No. 43.

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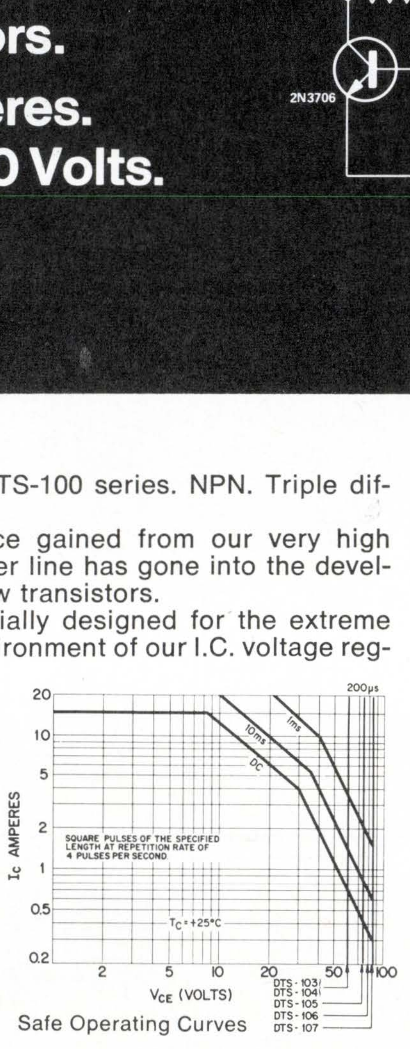
Like more information? Just call us or your nearest Delco Radio distributor. All our distributors are stocked to handle your sample orders.



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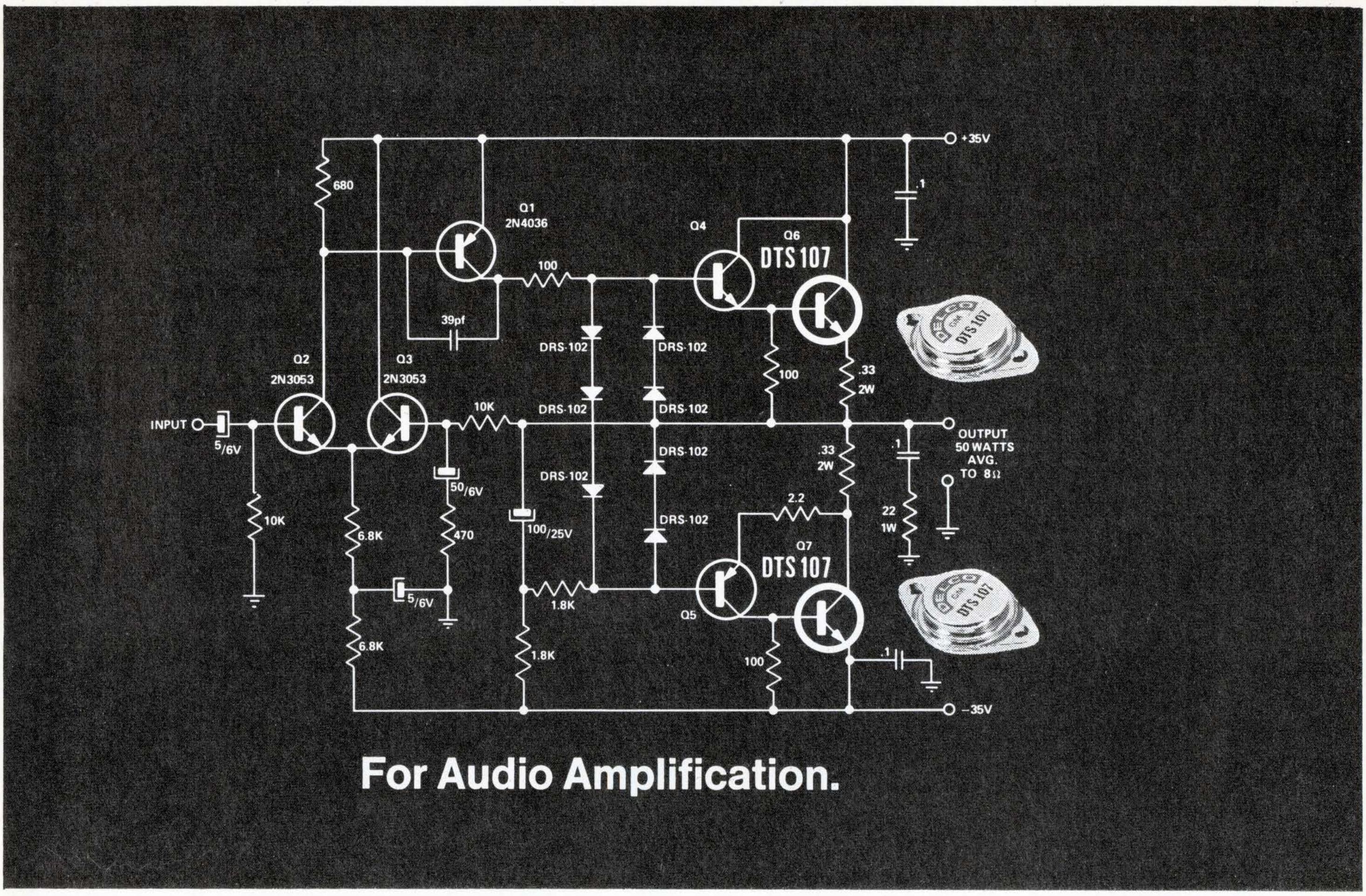

	Ic Cont. Amps.	Ic Pulsed Amps.	VCEX @ .5mA Volts	VCEO @ .25mA Volts	VCEO(sus) @ 250mA Volts	hFE @ 5A	hFE @ 20A (Min.)	VCE(sat) @ 10A (Max.)	ft MHz (Min.)	Pt Watts (Max.)
DTS-103	15	20	80	60	60	20-55	5	1.8	4	125
DTS-104	15	20	80	60	60	50-120	10	1.5	4	125
DTS-105	15	20	100	80	75	20-55	5	1.8	4	125
DTS-106	15	20	110	90	80	20-55	5	1.8	4	125
DTS-107	15	20	120	100	85	20-55	5	1.8	4	125

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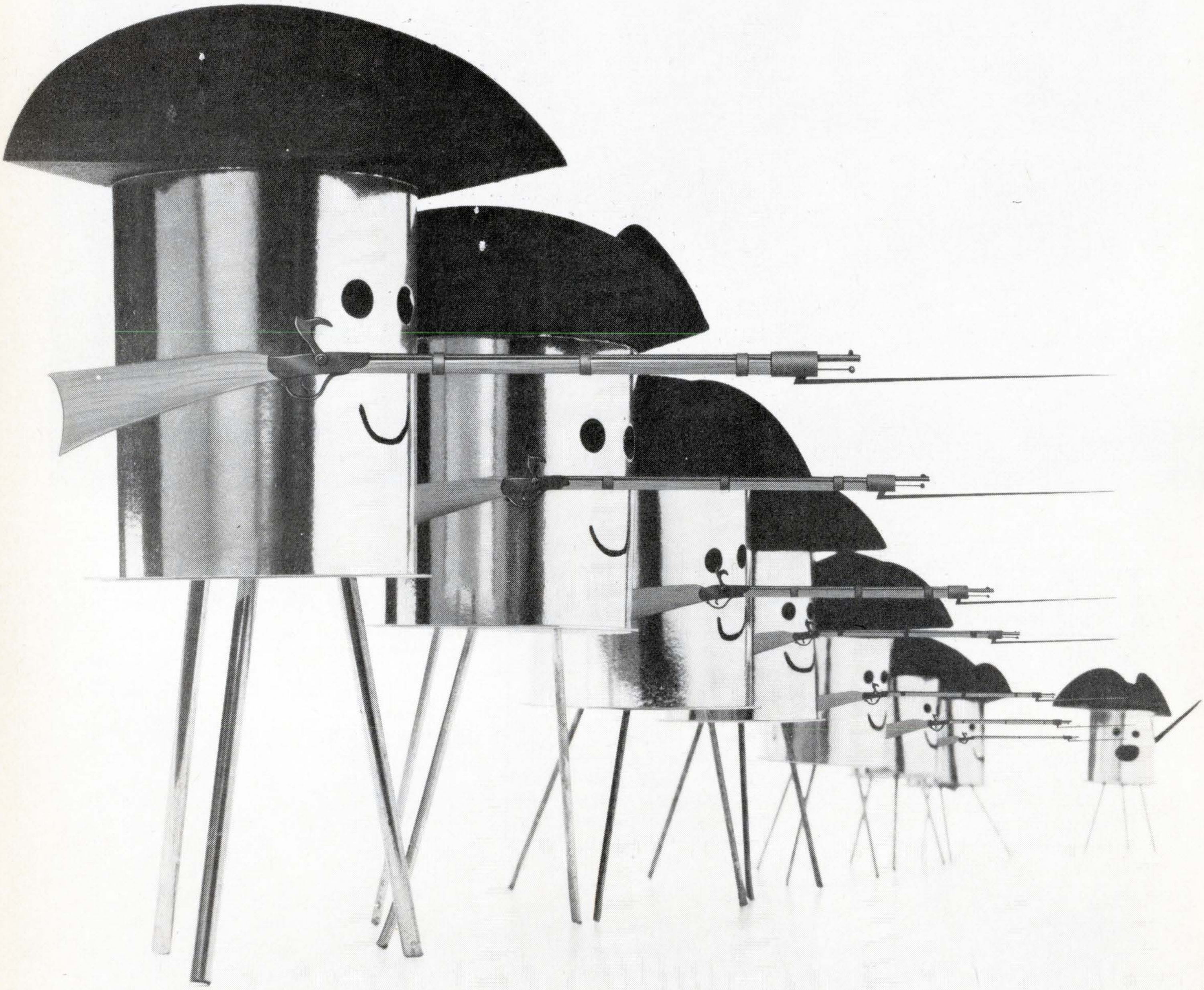

Will fire when it sees the whites of their eyes.

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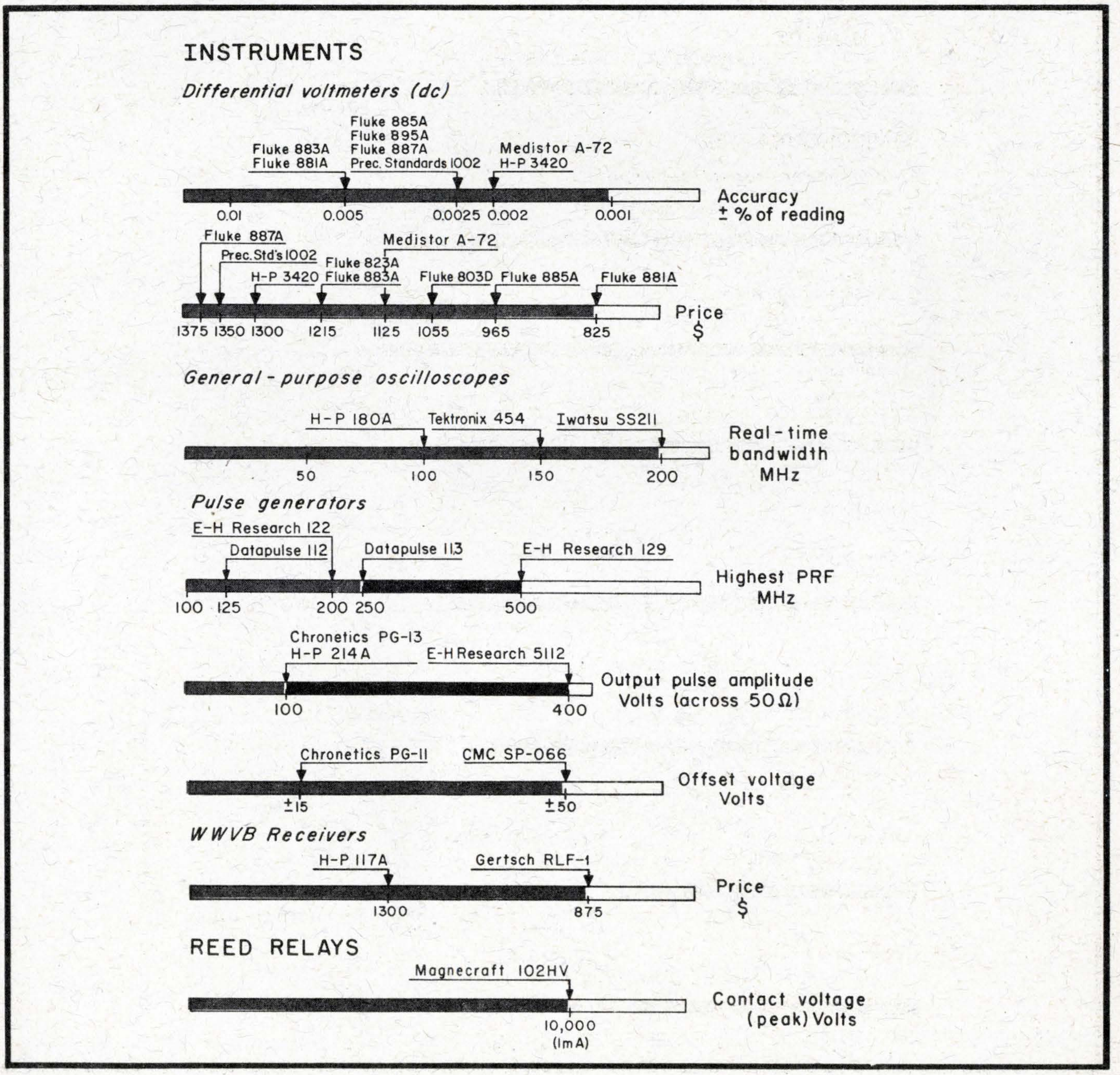
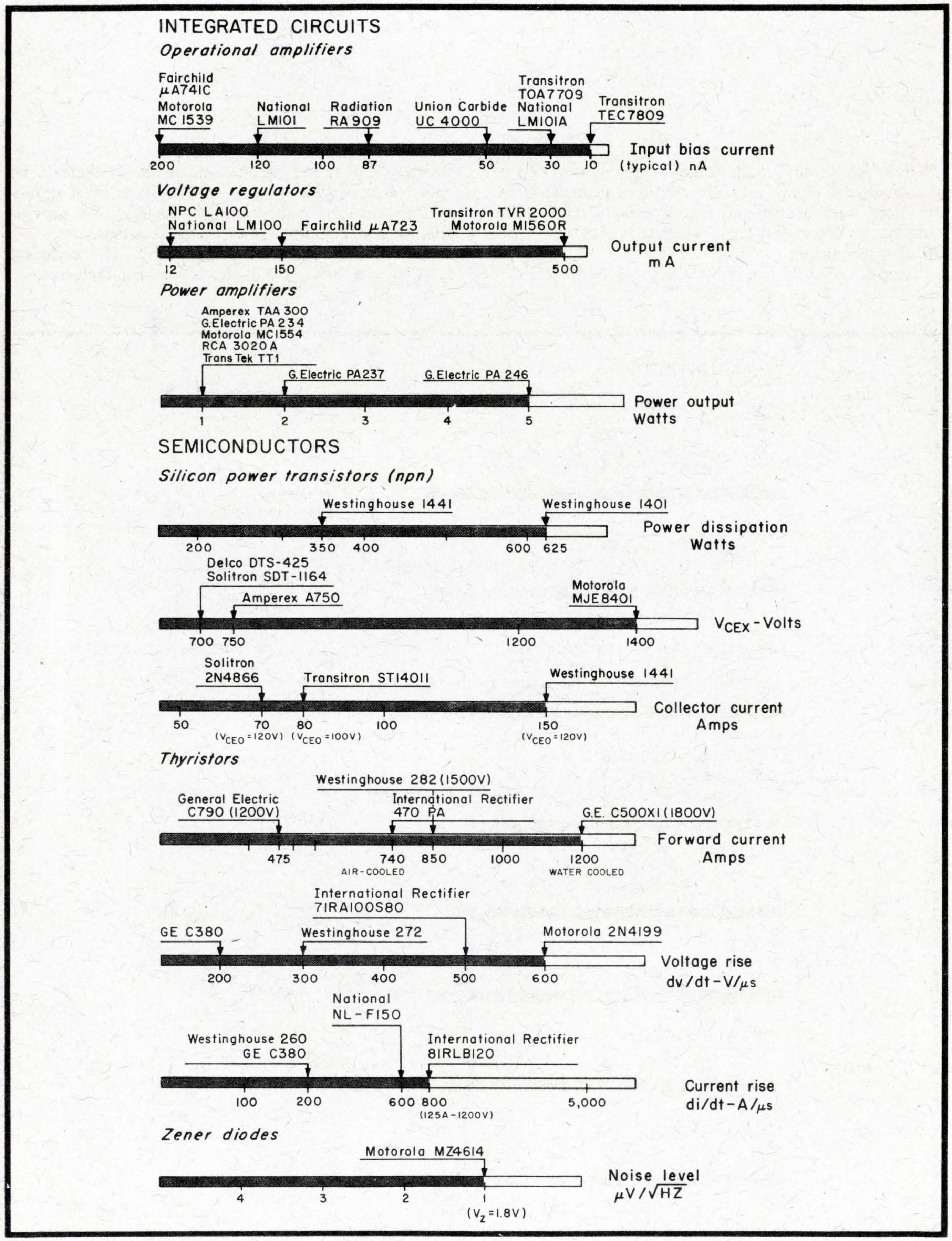
Do not use these charts to specify. Get complete specifications first, directly from the manufacturers.

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Operational amplifiers
Fairchild μA741C
Motorola MC1539
National LM101
Radiation RA909
Union Carbide UC 4000
Transitron TOA7709
National LM101A
Transitron TEC7809
200
120
100
87
50
30
10
Input bias current (typical) nA
Voltage regulators
NPC LA100
National LM100
Fairchild μA723
Transitron TVR 2000
Motorola MI560R
12
150
500
Output current mA
Power amplifiers
Amperex TAA 300
G.Electric PA 234
Motorola MC1554
RCA 3020A
Trans Tek TT1
G. Electric PA237
G.Electric PA 246
1
2
3
4
5
Power output Watts
SEMICONDUCTORS
Silicon power transistors (npn)
Westinghouse 1441
Westinghouse 1401
200
350
400
600
625
Power dissipation Watts
Delco DTS-425
Solitron SDT-1164
Amperex A750
Motorola MJE8401
700
750
1200
1400
VCEX - Volts
Solitron 2N4866
Transitron ST14011
Westinghouse 1441
50
70
80
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150
(VCEO = 120V)
(VCEO = 100V)
(VCEO = 120V)
Collector current Amps
Thyristors
Westinghouse 282 (1500V)
General Electric C790 (1200V)
International Rectifier 470 PA
G.E. C500X1 (1800V)
475
740
850
1000
1200
AIR-COOLED
WATER COOLED
Forward current Amps
International Rectifier 71RA100S80
GE C380
Westinghouse 272
Motorola 2N4199
200
300
400
500
600
Voltage rise dv/dt - V/μs
National NL-F150
Westinghouse 260
GE C380
International Rectifier 81RLB120
100
200
600
800
5,000
(125A - 1200V)
Current rise di/dt - A/μs
Zener diodes
Motorola MZ4614
4
3
2
1
(Vz = 1.8V)
Noise level μV/√HZ

EE SPEAK UP

I'll help the doctor . . . if the doctor helps me

Sir:

I'm writing in response to the article "Help the Doctor" in the Nov. 1968 issue (p. 50) of **The Electronic Engineer**. In particular I'm responding to the short questionnaire on page 53.

Q. Would you like to be employed full time in medical electronics?

A. Yes. I've answered at least 6 ads for medical EE's. Each of the companies wanted an EE with medical experience to work at 1K to 2K above the starting salary of an engineer. My present salary is commensurate with 16 years of experience.

Q. How much spare time each week would you be willing to contribute to help a physician at a nearby hospital, diagnostic clinic, or research center?

A. As much time as that physician would be willing to contribute to maintain the health of my family.

I've seen a number of idealistic articles recently in the electronics trade journals, to the effect that the EE has a great philanthropic role to play in medical electronics. Since I don't know a single doctor earning as little as double my salary, I find this rather amusing. I note with interest that when my health insurance fails to cover a medical bill, I have to pay the rest. Also when doctors work in clinics that service the poor, their salaries are paid nevertheless. Thus your questionnaire seems to be aimed at taxing the less rich to help the more rich. It's an interesting idea. I suppose you would contend that it's mankind which benefits. However the doctors don't make out so badly either.

Robert Bruce,
Senior Engineer
Sperry Systems
Syosset, N. York

The author replies: Robert Bruce certainly has a point. Unfortunately his cynicism prevents him from seeing a rather obvious answer to his own argument.

Anyone who knows anything about the medical profession also knows that any reasonably clever physician, driven only by the pursuit of the dollar, can readily build a $30,000 to $100,000 practice, which depends upon nothing more electronically sophisticated than an ordinary stethoscope and a pad of prescription forms. Such physicians have little or no interest in electronics.

"Is there an EE in the house?" addresses itself to **research** physicians, many of whom gave up the opportunity

(Continued on page 22)

The great digital systems kit!

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COLLECT DATA FASTER WITH A NEW 12-BIT 90, 135 OR 180 KHz MINIVERTER™

These three new MINIVERTERS™ combine multiplexer, sample-and-hold amplifier and analog-to-digital converter with throughput rate choice of 90KHz, 135KHz or 180 KHz. And each unit goes faster when short cycled; for example, the 180 KHz MINIVERTER runs at 360 KHz with 8-bit resolution.

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These new high-speed data acquisition instruments are more of the fast-moving products in our great digital systems kit for 1969. Write or call today. Raytheon Computer, 2700 S. Fairview St., Santa Ana, Calif. 92704. Phone (714) 546-7160. Ask for Data File DK-169.

RAYTHEON

(*Continued from page* 20)

to go into lucrative private practices in order to fulfill their own idealistic desires to help humanity by addressing themselves to the crucial and perplexing problems of modern medicine. Many of these researchers, after years of training and additional years of experience, receive salaries that would barely interest a starting engineer. Interestingly, these are the scientists who come up with the significant breakthroughs that open up whole new areas of medicine. These humanitarians are the Curies, the Jenners, and the Salks of western civilization, and frequently they leave their children nothing more tangible than a legend.

"Is there an EE in the house?" didn't order engineers to march down to their local hospital and work full-time for nothing. The article merely presented the problems of one research physician in the hope of inspiring engineers to give the electronics needs of that physician and his colleagues a little thought. And it (politely, I hope) asked those engineers who wish to spend a few hours a week helping these men to accept telephone calls and correspondence from them. So far, over 70 electronic engineers have written this magazine offering their services. Here are some of their comments:

". . . I was deeply moved by the problem Doctor Levy has been having. . . . If it is at all possible, I would like to help."

"In response to your article . . . , I would like to offer my assistance which might be of benefit to the medical profession."

A medical electronics firm writes: "Our company policy is such that part of our responsibility in engineering is to help or work with any doctor who calls us for information. We have also found that we gain unlimited satisfaction because of this policy."

"I have just read the article in your magazine and would like to add my name to the list of available engineers."

". . . I am interested in working part time without compensation in a hospital, clinic or research center. I feel it is my responsibility to contribute whatever I can in this important humanistic field."

"It seems that sufficient talent (both medical and electronic) exists to handle these medical problems, but to date there has been little communication between disciplines. Perhaps this gap can best be bridged by trade magazines. At any rate, your magazine is to be commended for making the attempt. We each have important vested interests in terms of our families, friends, and ourselves to help advance the state-of-the-art of medicine to as high a level as possible. I would contribute a reasonable portion of time to a local research center, etc, toward any worthwhile effort."

"I have read with great interest your article on medical electronics. The plight of Dr. Levy in obtaining help with electronics applications will no doubt bring a flood of offers to help, and I want to add my name to the list. If I am not able to help someone directly with electronic problems, I feel certain that one of my engineering friends in the various companies in this area certainly will be able to do some good. They cover just about every imaginable specialty you could ask for."

"I have just read the article in the November issue of **The Electronic Engineer.** Needless to say, I am moved by the struggle of Dr. Levy and am anxious to join in similar efforts."

"I must say that Dr. Levy is a man of remarkable courage and knowledge. Indeed, the task of designing a disk interface is no small one. I also respect his problem of decoupling digital spikes from his low-level analog inputs. We are constantly faced with this problem in my discipline of hybrid computers. Finally, yes, I would be willing to help a physician at a nearby hospital clinic or research center if I can contribute. I could probably spend about 4-8 hours per week in my spare time. I can be reached at work any day or at home on Monday nights."

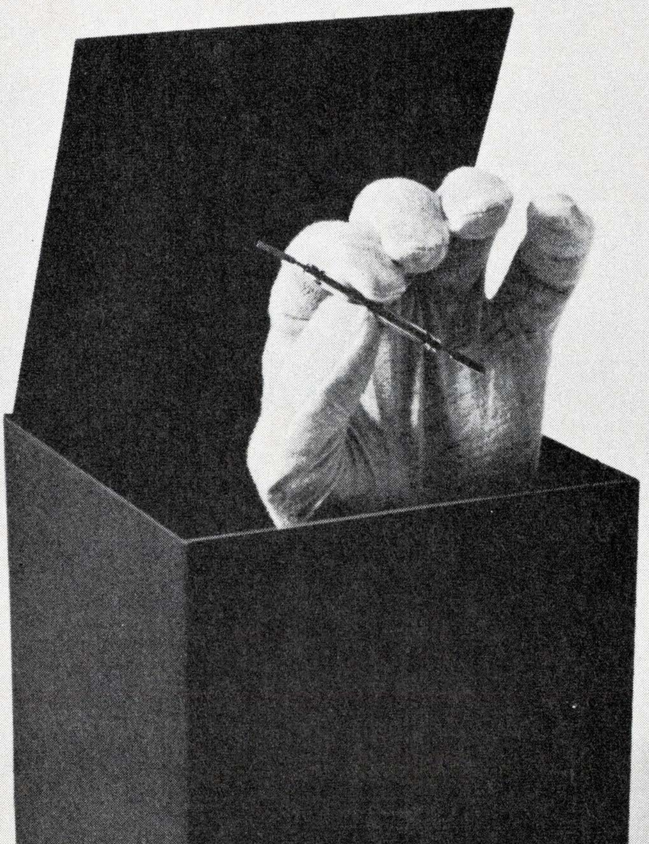
These are only a small sample of the letters that have come so far to the editorial office of **The Electronic Engineer.** Perhaps the most interesting one, from an electronic engineer who has had considerable experience in medical electronics, was more inspiring than the article that ellicited it. The letter was written by a Czechoslovakian engineer who escaped to the United States during the recent Soviet invasion. As a chief project engineer for 15 years in Prague Research Institute of Medical Electronics, the man has designed many special purpose medical instruments, such as a blood-circulation meter, a pulse-rate meter, and others. He writes a lengthy letter stating his qualifications, then adds: "My favorite branch is physiology, especially physical culture research. Otherwise I am able and surely capable to cowork in other medical branches. I wish to cooperate by phone, mail or perhaps by personal assistance." (signed) Vladimir Lorenz, 3816 Cabrillo Street, San Francisco, Calif. 94121.

The names of all volunteers, including those who would like to work full-time in the field of medical electronics, has been compiled into a list, which **The Electronic Engineer** will actively make available to organizations and publications that reach research and clinical physicians who are likely to desire help with their electronics. Already, the New York Academy of Medicine and a magazine, **Clinical Trends,** have requested copies of the list, and the former has expressed a desire to establish a clearinghouse for biomedical engineering information and aid.

Electronic engineers who are bothered by the nagging discomfort of altruism, with overt symptoms of humanitarianism, are still more than welcome to send their name, address, telephone number and a brief description of their area of expertise to the editor of this magazine: Alberto Socolovsky, **The Electronic Engineer,** Chilton Co., 56th and Chestnut Streets, Philadelphia, Pa. 19139.

—Roger Kenneth Field

EVERY BLACK BOX SHOULD HAVE A DJINNI.



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Send for our free switch lab. No big deal, just a reed switch and a magnet and a couple of catalog sheets. But with them, you may come up with machine, flow or systems control uses no other engineer has conjured up yet. Just write Hamlin, Inc. "Baghdad on the Lake," Lake Mills, Wisconsin 53551.

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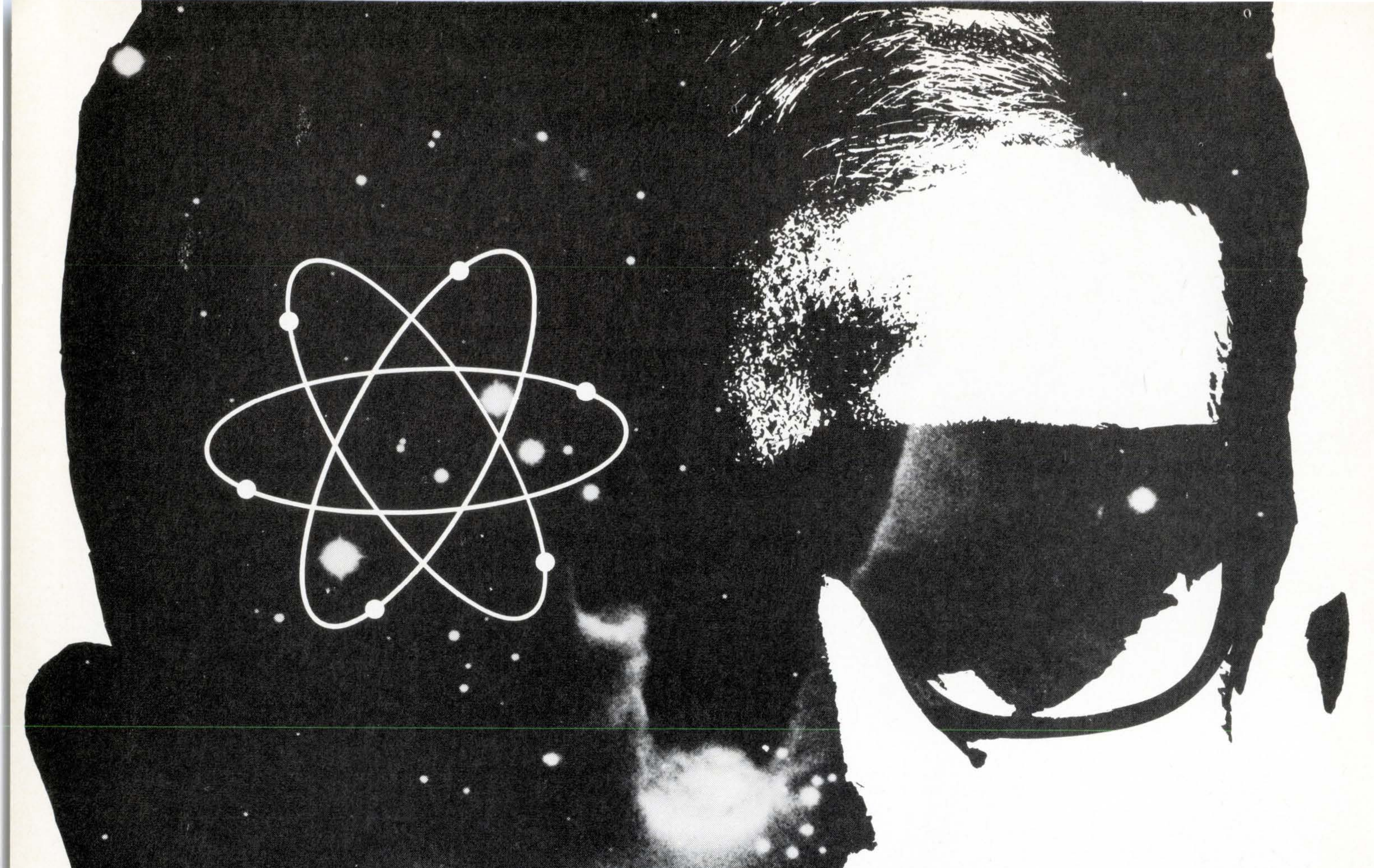

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EE CAREERS

MAY

11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31

May 14-16: Spring Joint Computer Conf., Sheraton Boston Hotel, War Mem. Audit., Boston, Mass. Addtl. Info.—Norman Bryden, Honeywell EDP, 60 Walnut St., Wellesley, Mass.

May 19-21: Nat'l Aerospace Electronics Conf. (NAECON), Sheraton Dayton Hotel, Dayton, Ohio. Addtl. Info.—M. G. Coleman, Gen'l Precision Inc., 33 W. 1st St., Dayton, Ohio 45402.

May 20-22: 23rd Annual Power Sources Conf., Shelbourne Hotel, Atlantic City, N. J. Addtl. Info.—Galen R. Frysinger, Power Sources Div., U. S. Army Electronics Command, Fort Monmouth, N. J. 07703.

May 26-28: IEEE Conf. on Laser Eng'g and Applications, Washington Hilton Hotel, Washington, D. C. Addtl. Info.—Lewis Winner, 152 W. 42nd St., New York, N. Y. 10036.

May 27-28: The Influence of Microelectronics on Management Decisions, Mayflower Hotel, Washington, D. C. Addtl. Info.—Paul A. Newman, NSIA Headquarters, 1030 15th St., N.W., Suite 800, Washington, D. C. 20005.

JUNE

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June 3-5: '69 Microwave Exposition/East, Statler Hilton Hotel, New York, N. Y. Addtl. Info.—Technical Industry Expositions, Inc., 100 Avenue of the Americas, New York, N. Y. 10013.

June 6-7: Product Assurance Conf. & Technical Exhbt., Hofstra Univ., Hempstead, N. Y. Addtl. Info.—B. Held, Grumman Aircraft Eng'g Corp., Bethpage, N. Y. 11714.

June 9-10: Chicago Spring Conf. on Broadcast & TV Receivers, Marriott Motor Hotel, Des Plaines, Ill. Addtl. Info.—Larry Maloney, Philco-Ford, 1820 Pheasant Trail, Mt. Prospect, Ill. 60634.

June 9-11: Int'l Communications Conf., Univ. of Colorado, Boulder, Colo. Addtl. Info. — A. J. Estin, Radio Standards Eng'g Div., NBS, Boulder, Colo. 80302.

June 17-19: Electromagnetic Compatibility Symp., Berkeley Cartaret Hotel, Asbury Park, N. J. Addtl. Info. — Harry Estelle, Honeywell Inc., 1162 Pinebrook Rd., Eatontown, N. J. 07724.

JULY

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July 7-11: Conf. on Nuclear & Space Radiation Effects, Penn State Univ., Univ. Park, Pa. Addtl. Info.—S. E. Harrison, Martin Marietta Corp., Baltimore, Md.

July 20-25: Eng'g in Medicine & Biology and Int'l Fed. for Medical & Biological Eng'g Conf., Palmer House, Chicago, Ill. Addtl. Info.—Box 1969, Evanston, Ill. 60204.

July 28-Aug. 1: '69 Research Conf. on Instrumentation Science, Hobart and William Smith College, Geneva, N. Y. Addtl. Info.—Thomas E. Tremellen, Mgr., Education & Research Services, Instrument Society of America, 530 William Penn Pl., Pittsburgh, Pa. 15219.

'69 Conference Highlights

WESCON—Western Electric Show and Conv., August 19-21; San Francisco, Calif.

NEREM — Northeast Electronics Research and Eng'g Meeting, Nov. 5-7; Boston, Mass.

Call for Papers

Nov. 5-7, 1969: Northeast Electronics Research & Eng'g Meeting (NEREM). Submit 35-40 word abstracts (3 copies) and 600-1000 word condensed versions (3 copies) before **July 1, 1969** to Program Chairman, IEEE NEREM-69, 31 Channing St., Newton, Mass. 02158.

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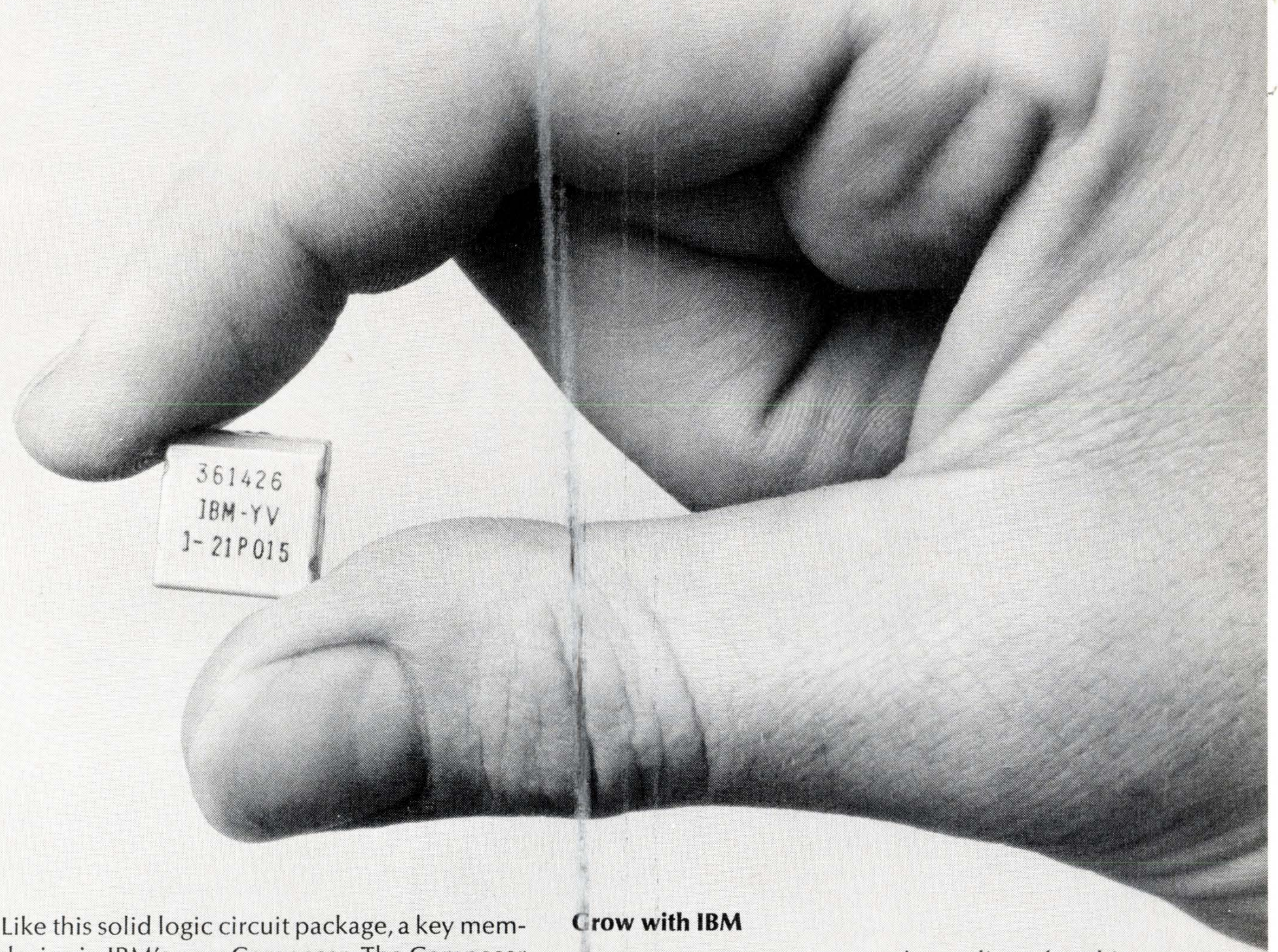

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A case history

Project management, military style

To control the large Omega project, the Navy has delegated authority and responsibility to a project manager

By **S. Peter Kaprielyan,** Editor*
Missile & Space Div., General Electric Co., Valley Forge, Pa.

After 15 years of long-range development, the Omega Navigation System was designated as a Project on June 18, 1965. Prior to this Captain Mavis X. Polk had served as the functional project manager of Omega—but was in charge of several other projects as well. Then, in May 1966, the Navy's chain of command was reorganized, and Omega became one of the immediate beneficiaries: it was spotlighted as a project requiring **intensified management** under the direction of Admiral Galantin, Chief of Naval Material.

In current DOD parlance, "intensified project management" means the focusing of responsibility and authority in one individual—the project manager—who has executive and delegated authority over all phases of planning, direction, and control, and over all the resources allocated to the project. Thus, with the reorganization, Captain Polk became manager of the Omega Project exclusively, so that he could devote all his energies to the new navigation system.

Before a task or program is chartered as a Project by the Navy, it must qualify as a clearly definable task, within the compass of our national security objectives, and must meet these standards:

- national priority, or urgent military necessity
- top-level interest
- high cost—over $25 million for R&D or more than $100 million for production
- high degree of complexity
- multiple agency or service interest
- advanced technology
- high risk of slippage in schedule or cost overrun

Omega meets the above requisites by virtue of its significance, scope, and price tag.

Project authority and responsibility

Project management authority for Omega is delegated by the Chief of Naval Material through the project Charter. According to this Charter, the project manager directs the planning, control, and utilization of resources. He is responsible for establishing the system design interfaces, and meeting the system's technical performance requirements. He also has directive authority over the project efforts of in-house and contractor organizations.

In cases where action is required beyond the authority granted him by the project Charter, the project manager must refer the action to the Chief of Naval Material, together with his recommendations for alternatives.

"We can look at this matter of authority another way," explains Captain Polk. "The project Charter stresses that the project manager as a responsible executive is *expected* to act on his own *initiative* in matters affecting the project. Therefore he can assume, with some discretion, that he has authority in all areas affecting his project—unless he is expressly directed otherwise."

Since the Omega system is global in scope, Captain Polk also has working relationships with many foreign countries. He is authorized through special agreements to work directly with his counterparts in those countries, on matters related to transmitter installations and operational tests.

Omega organization

The Omega Project Office, located just outside of Washington in Rosslyn, Va., is strictly a management organization that consists of eight professionals. Be-

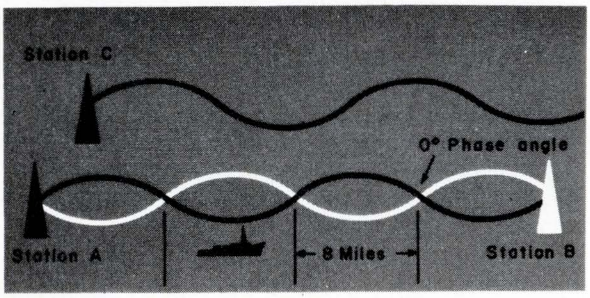
*Adapted from *Aerospace Management,* Vol. 2, No. 1, Spring/Summer 1967, pp. 29-33.

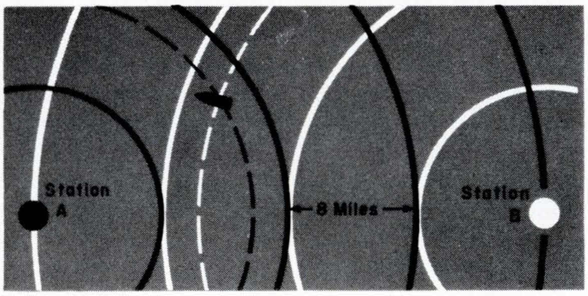
sides the project manager, there are seven specialists in navigation systems operation, aircraft receivers, construction management systems, and electronics. Then, under the overall guidance and direction of the project manager, this staff works with specifically assigned people in the various naval Systems Commands (see Fig. 1).

As Captain Polk explains, "We utilize the people in the other parts of the Navy to give us the technical, contractual, and administrative assistance we need." Although these support personnel are not located in the Project Office, they are assigned to the project and are directed by the project manager. In all, there are about 55 persons assigned to Omega, including representatives of NASA, the FAA, the Air Force, the Army, and various foreign governments.

To staff the project, Captain Polk has the freedom to "shop" for the skills he needs among the Navy's contracting agencies. But selecting project personnel is not as easy a task for him as it usually is for the project manager in industry, who in many cases merely goes to upper management or to the personnel department and requests that certain persons be hired.

Navy managers, in contrast, must go through the merit promotion system. What Captain Polk does is let the Navy agencies know that he has at least one applicant in mind who is completely qualified—and he then asks them to find him the best applicant. "I have





The Omega navigation system

Omega is a hyperbolic (or circular) carrier phase measurement system. To get a navigational fix, the Omega receiver needs signals from three transmitting stations, which operate in the frequency band from 10 to 14 kHz, giving a wavelength of 16 miles. Based on phase difference measurement, the transmissions create a world-wide pattern of eight-mile grids, or lanes. By measuring the phase angle differences between any two pairs of the three signals, you can determine the position of a vessel with accuracy of, at worst, two miles.

The above drawing (right) shows how this works—but for simplification only shows two signals. What you see there for a position fix of two signals would be repeated with one of these two signals, plus a third signal, to determine your position "vertically" on this drawing.

To explain further, here is how the Omega receiver works: Suppose a ship is within range of stations A, B, and C. First a signal is received from A and stored in the receiver. Then a signal is received from B which when compared to that from A, results in display of a number on the receiver. That number represents one line of position on the Omega grid chart, available from the U. S. Naval Oceanographic Office. Finally, a signal is received from C which is then compared to the signal from either A or B to acquire a second numerical display from the receiver. This second line of position intersects with the first on the grid chart to mark the ship's position.

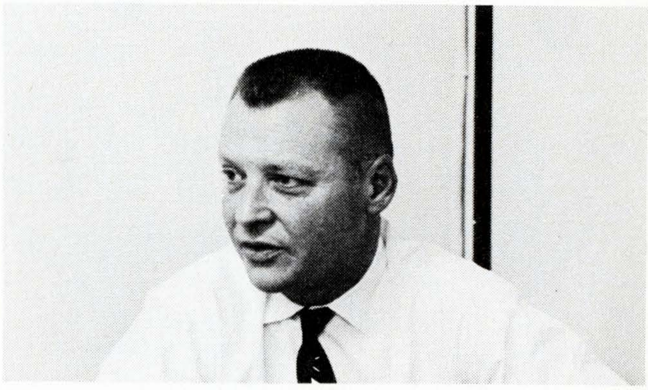
The four transmitting stations now operating are located in Norway, Hawaii, Trinidad, and Forrestport, N. Y. (the Forrestport station will soon be moved to the Northcentral part of the U. S.). The other four stations planned will be located in Japan, the Indian Ocean area (near Madagascar), Argentina, and Australia or New Zealand. When Omega becomes fully operational in 1972, the U. S. Coast Guard will assume the responsibility for operating the eight transmitting stations.

had it happen that I have gotten better applicants than the ones that I had in mind," he states. "I've taken them. But at least I have set a standard which I wouldn't drop below."

Running the show

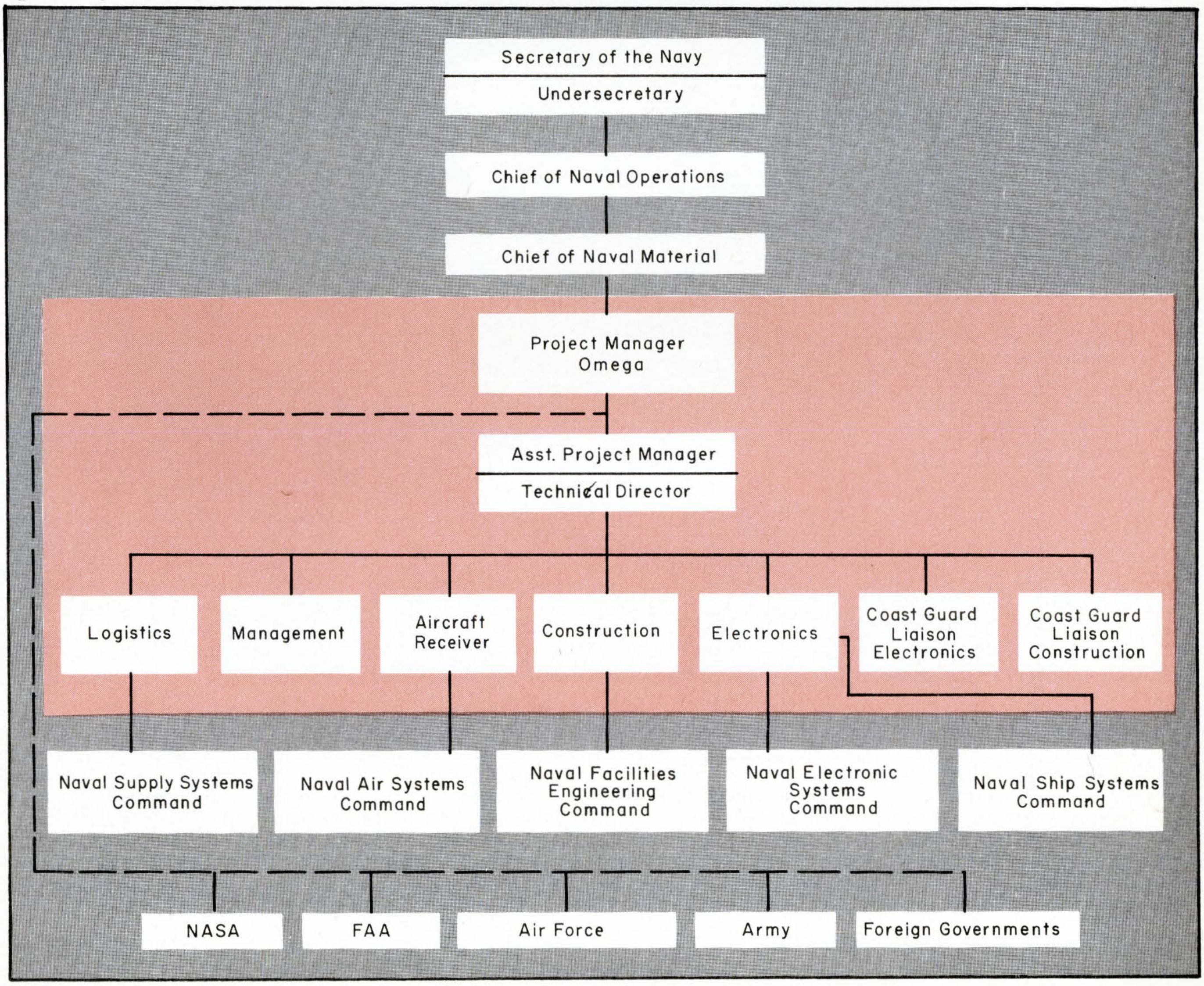
Basically, Captain Polk set up a host of schedules to be maintained. There are overall schedules, and schedules for each of the facets his group is working on. Each contractor, in turn, has schedules.

To make his job simpler, and to keep on top of the project at all times, Captain Polk broke down the project into key **decision points.** For each of these decision points he assigned someone in his Project Office.



"It's darn hard for EEs not to get their hands dirty."

Fig. 1. Project management organization for Omega.



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Staff members are responsible for taking care of their particular aspects of the project, for informing the project manager what they have done, and for warning him if they are in trouble. Then a minimum of once a week the project manager gets a report from all of them—in the form of PERT charts, GANTT charts, Line of Balance, and so forth. These reports then go into the overall schedule as they affect the decision points. To ensure that each decision point is "covered" at all times, there is at least one person in the Project Office who stays informed on what another staff member is doing.

Captain Polk finds one of the hardest jobs in project management is charting all of the daily operations and changes. "To be perfectly honest with you," he comments, "I have not been able to ascertain how to schedule and how to chart the day by day operations, because the decisions you make are bouncing back and forth. So what we've tried to do is put down the broad decision points—as broad as possible—and let the individuals responsible for them make sure that we come to these points."

By delegating authority and responsibility for the various decision points to staff members, Captain Polk gives himself enough time to perform such key tasks as budget justifications, state department negotiations, and discussions with foreign countries. Above all, he does not get bogged down in details but can grasp the overall picture—and can thus make quick and wise decisions.

As far as actual management tools go, Captain Polk and his staff use PERT, GANTT, Line of Balance, and other forms of charts, although they don't endorse any one method. And since the scheduling of the project is fairly straightforward, they don't use a computer system, except for standard accounting procedures and for technical assistance.

Communicating progress

Among the main functions of the Project Office are those of documentation and communication. It is the project manager's responsibility to maintain complete documentation on training procedures, spare parts, equipment delivery, chronological history, working agreements, specifications, pertinent references, and reports.

To facilitate management decision-making, action, and support, both vertically and laterally, the Project Office issues various reports:

- an annual Technical Development Plan
- a semi-annual Project Master Plan
- a comprehensive verbal report to the Chief of Naval Material every six weeks, stating ten of the toughest problems facing the program, their nature, and their proposed remedies
- a monthly Program Evaluation Report summarizing the ten most critical items

"Besides these formal reports," explains Captain Polk, "we have a meeting of all project managers in Admiral Galantin's office each Monday afternoon, for informative off-the-record discussions. These man-to-man talks," he says, "are known on occasion to become very spirited."

What it means to the electronics industry

In the next six years, the Navy will spend about $100 million to outfit surface ships, submarine, and aircraft with Omega. Northrop Corp. and International Telephone & Telegraph are the only firms who have Navy contracts for receivers at the present time. Northrop is making a general purpose shipborne receiver and is also working on a contract for the developmental model of the airborne receiver. ITT is making a more sophisticated, special purpose surface receiver and a submarine unit as well.

Tracor, Inc. has a commercial receiver which it's selling to both commercial and military users, and Pickard & Burns Div. of Continental Electronics Mfg. Co. is making a receiver which is essentially the same as Northrop's surface receiver. Ryan Aircraft, now part of Teledyne, has also manufactured some receivers. Lear Siegler, along with the Naval Research Laboratories, made the prototype of the receiver that's under contract to Northrop, and is now working on an airborne receiver.

There are other companies working in the field too, and these will probably come out in the open just as soon as the Navy starts letting some additional contracts.

In summarizing its significance to industry, Omega's project manager comments, "My Drew Pearson prediction is that it will have greater commercial use than it will Navy use. . . . My own estimate is that we're talking about a minimum of a billion-dollar receiver market worldwide—and probably as high as a three-billion-dollar market."

EEs and project management

To make project management work, there must be one individual—the project manager—who can isolate himself from the details and thus concentrate on the total picture. But one of the greatest temptations to face project managers and their management staff is the urge to get involved in technical details to the extent that they slip into the role of project engineers.

As Captain Polk observes, "When an engineer tries to manage a big project, if he tries to remain the project engineer, the project runs into trouble. Almost without exception, we've gotten into trouble (with both contractors and project staff) on overruns, misschedules, misdeliveries, because when a technical problem comes up the project engineer becomes so involved in it that the scheduling, the plans, the designs, the ordering of materials, and the other things you have to do to get out on time and within your budget are not accomplished.

"Electronic engineers," he adds, "are one of the hardest groups to get to drop the technical involvement. . . . It's darn hard for them not to get their hands dirty."

(Editor's note . . . Here is a challenge to all of us—whether we're project managers, project engineers, or design engineers who plan on getting into management. Because of our training, we are used to working on technical details, and sometimes get bogged down in

Continued on page 32

Project management (concluded)

them. To be successful managers, as Captain Polk suggests, we must retrain ourselves to concentrate on the total view, and to leave the details to our fellow EEs who are working in the technical realm.)

As manager of a large electronics project, one of Captain Polk's first tasks was training the "obstructionist engineers" in his Project Office to concentrate on their management functions, and to keep the design work in the hands of the design engineers. Another problem was getting them out of the habit of explaining things in very technical terms. "Technical people," comments Captain Polk, "have to be able to explain to management people in the terms management understands. They've got to communicate." When he forced his staff to do this, he uncovered a few cases where an engineer himself didn't understand a problem, but had hidden this fact by using technical jargon.

Attributes of a project manager

Among the attributes Captain Polk considers vital for effective project management, he ranks first the ability to communicate with people, and to understand personalities and problems up and down the line of authority.

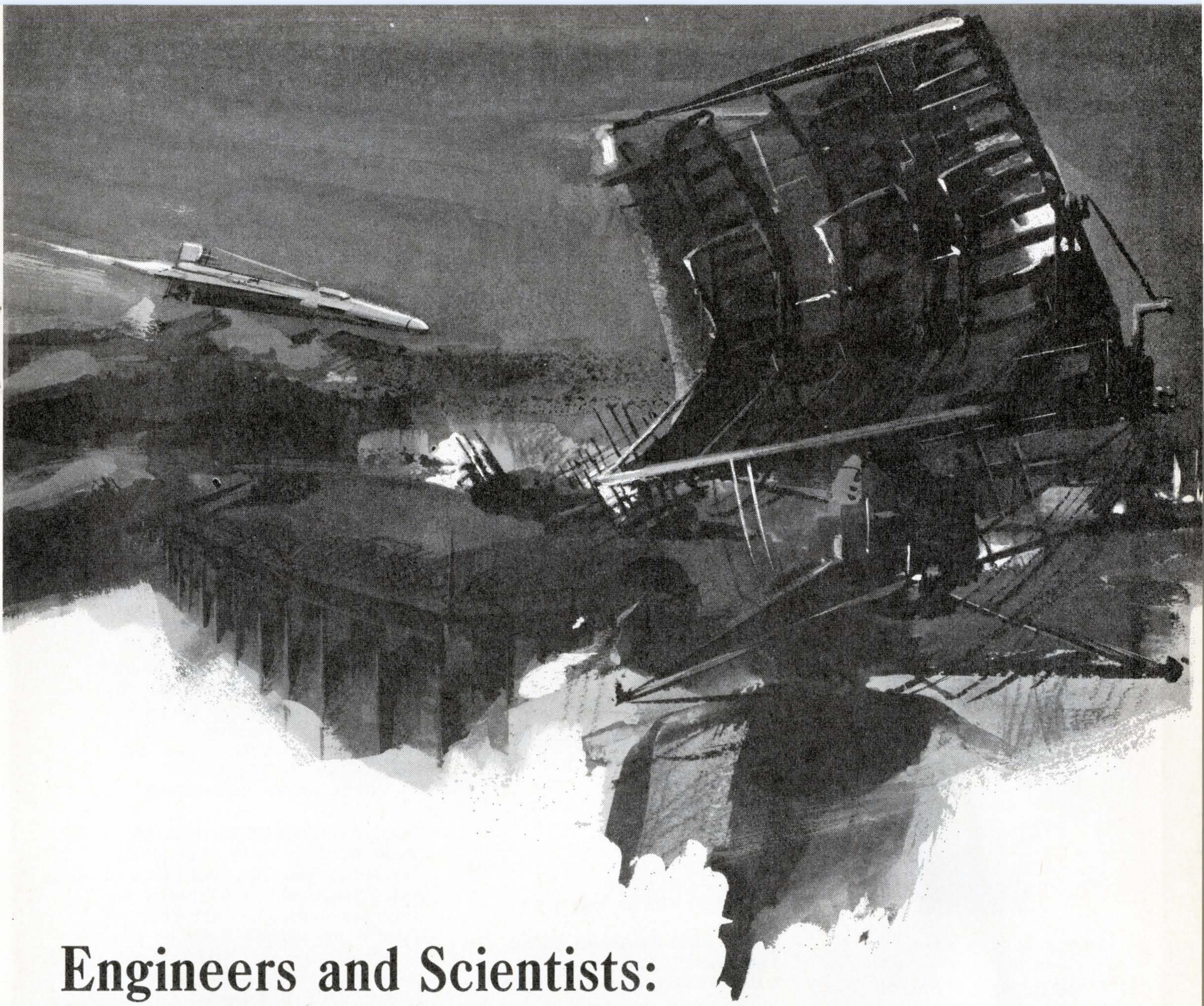
He also feels that for a project such as Omega, a basic technical orientation is a must for his Project Office—but that operational experience is the vital resource for solving the project's human engineering problems. For example, he has one person on his project team who is basically a navigator, and who looks at the equipment from the user's point of view. If he can misuse the equipment, it goes back to the drawing boards because there's a good possibility sailors will misuse it too.

Not a panacea

In the past few years, project management has received much fanfare—and has become perhaps the most common method for handling large electronic projects. But not everyone is convinced that it is the best way to handle such projects. Captain Polk, who has used the approach successfully for the Omega Navigation System, is himself not sure that it is the best way to go (although he feels it makes more sense in private industry, where there is more flexibility).

He summarizes, "To me project management in one respect means that our functional organization has broken down, that we couldn't take care of our work and had to set it up separately. I disagree with it on the basis that it takes away from the functional organization's capability, resources, priorities, and people. I don't know when we're going to get sophisticated enough—either in government or industry—to get away from project management. In the Navy, for example, if we would very critically, totally match our resources of people and money against what we have to do, we wouldn't need project management because we would have the resources to do the job."

INFORMATION RETRIEVAL
Project management, Careers



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EE PRODUCT SEMINARS

This new column lists product seminars that electronic companies offer to users of their products.

"PDP-8 Family Programming (Paper Tape System)"; May 12-16 and 19-23; June 2-6, 9-13, 23-27; Maynard, Mass. $300 (free for one person per computer purchase). General operation and software. Training Dept., Digital Equipment Corp., Maynard, Mass. 01754.
Circle **401** on Inquiry Card

"PDP-9 Programming," May 19-30 and June 16-27, Maynard, Mass. $500 (free for one person per computer purchase). Operation of the PDP-9 computer; the MACRO-9 assembler; utility programs; FORTRAN IV, the combining of FORTRAN IV and MACRO-9 programs, and the Science Library; the I/O monitor and related programming techniques; etc. Training Dept., Digital Equipment Corp., Maynard, Mass. 01754.
Circle **402** on Inquiry Card

"Series 600 Expanded Capability Test Equipment," May 26-28, Sunnyvale, Calif. Tuition-free for customers (up to two employees—$90 for each additional person). R. D. Warner, System Training Manager, Fairchild Instrumentation, 974 E. Arques Ave., Sunnyvale, Calif. 94086.
Circle **403** on Inquiry Card

"Series 4000 Integrated Circuit Test Equipment," June 2-13, Sunnyvale, Calif. Tuition-free for customers (up to two employees—$300 for each additional person). R. D. Warner, System Training Manager, Fairchild Instrumentation, 974 E. Arques Ave., Sunnyvale, Calif. 94086.
Circle **404** on Inquiry Card

"Repair and Maintenance Training Session," June 2-6 and July 7-11, Amsterdam, N. Y. Tuition-free. Covers EMC-25 and EMC-10 receivers, EFC-125 programmer, SPD-125 spectrum display, various antenna models, and FSS-250 spectrum surveillance system. Dale Samuelson, V.P., Fairchild Electro-Metrics Corp., 100 Church St., Amsterdam, N. Y. 12010.
Circle **405** on Inquiry Card

"Non-destructive Testing: Radioisotope Course," June 2-6, Cleveland. $300. Picker Industrial, Marketing Dept., 1688 Arabella Rd., Cleveland, Ohio 44112.
Circle **406** on Inquiry Card

"Resistance Welding and Reflow Soldering," June 3, Monrovia, Calif. $5. AC and dc resistance welding fundamentals, metallurgical considerations, welding techniques, weld schedule development, soldering, packaging techniques. E. F. Koshinz, Unitek/Weldmatic Div., 1820 S. Myrtle Ave., Monrovia, Calif. 91016.
Circle **407** on Inquiry Card

"Process Automation," June 9-20, Phoenix. Tuition-free. Theory, application, and operation of automated process control systems. Motorola Instrumentation and Control Inc., Field Service Office, Box 5409, Phoenix, Ariz. 85010.
Circle **408** on Inquiry Card

"Energy Conversion (Electric Power)," June 16-20, North Wales, Pa. Tuition-free. D. S. Luppold, Administrator, Technical Training, Leeds & Northrup Co., Sumneytown Pike, North Wales, Pa. 19454.
Circle **409** on Inquiry Card

"Fundamentals of DC Electrical Measurements," June 16-20, North Wales, Pa. Tuition-free. Quantities measured —dc voltage, voltage and current, low resistance, resistance, and ratio resistance; instruments—L&N dc pots, dc Wheatstone and Kelvin bridges, universal ratio set, and associated equipment. D. S. Luppold, Administrator, Technical Training, Leeds & Northrup Co., Sumneytown Pike, North Wales, Pa. 19454.
Circle **410** on Inquiry Card

"Dewetting," June 26-27, Mount Vernon, N. Y. Tuition-free. F. J. Farrell, Electrovert, Inc., 86 Hartford Ave., Mount Vernon, N. Y. 10553.
Circle **411** on Inquiry Card

"Precision DC Measurements & Standards," July 21-25, North Wales, Pa. Tuition-free. D. S. Luppold, Administrator, Technical Training, Leeds & Northrup Co., Sumneytown Pike, North Wales, Pa. 19454.
Circle **412** on Inquiry Card

"Blow Holes," July 24-25, Mount Vernon, N. Y. Tuition-free. F. J. Farrell, Electrovert, Inc., 86 Hartford Ave., Mount Vernon, N. Y. 10553.
Circle **413** on Inquiry Card

EE COURSES

"Project Management Seminar," May 26-28 (Washington), June 23-25 (San Francisco). $300. Why project management; the project manager; the nature of electronic engineering projects; project management organization; project definition; network systems (PERT/CPM); project management functions and tools; work authorization; resource management; multi-project management; project management systems; time, cost, and performance evaluation; applications and problems; outlook for the future; case studies. Co-sponsored by The Electronic Engineer and Booz, Allen and Hamilton Inc. John E. Hickey, Jr., Seminar Coordinator, The Electronic Engineer, 56th and Chestnut Streets, Philadelphia, Pa. 19139.

"Modern Aspects of Control and Information Engineering," May 26-June 6, Purdue Univ. $300. For engineers and scientists working in the field of guidance, estimation, and control. Short Course Programs, Room 116, Memorial Center, Purdue University, Lafayette, Ind. 47907.

"Pulse Code Modulation Telemetry Systems," June 2-6, Purdue Univ. Theory and state of the art of telemetry systems for transmitting analog and digital data over noisy digital channels. Prof. Paul A. Wintz, PCM Telemetry Systems, School of Electrical Engineering, Purdue University, Lafayette, Ind. 47907.

"Vibration and Shock Testing," June 2-6, Syosset, L. I., N. Y. $200. Concentrates on modern practices and equipment with a minimum of vibration and shock theory and mathematics. Tustin Institute of Technology, Drawer Q, Santa Barbara, Calif. 93102.

"Optimization of Engineering-Economic Systems," June 9-13, Univ. of Colorado — Boulder. Principles of mathematical optimization techniques with applications to the engineering-economic environments; optimization with engineering constraints. Assoc. Dean George J. Maler, Engineering Center AD 1-1, University of Colorado, Boulder, Colo. 80302.

EE COURSES

"Advanced Device and Circuit Modeling," June 9-11, Univ. of Michigan. $180. Summary of device physics and integrated circuit processing methods; use of computers in current modeling practice; device, circuit, and process modeling using digital, hybrid, and special purpose computers.

"Computer Graphics for Designers," June 9-20, Univ. of Michigan. $450. Principles of graphic manipulation and applications of computer graphics as aids in improved design methods.

For further details on the above two courses, write: Engineering Summer Conferences, The University of Michigan, Chrysler Center—Dept. 54, Ann Arbor, Mich. 48105.

"Structure of Programming Languages," June 10-14, Cornell Univ. $200. Machine language, multiprogramming, assemblers, macros, Lisp, Algol, PL-1, and simulation languages. Dir. of Continuing Education, College of Engineering, 251 Carpenter Hall, Cornell University, Ithaca, N. Y. 14850.

"Communication Systems and Time-variant Electromagnetic Propagation Media," June 16-July 3, Univ. of Colorado, Boulder. $300. Theory, design analysis, and performance evaluation; optimization of communication, data, and instrumentation systems utilizing randomly time-variant transmission channels. Prof. Samuel W. Maley, Electrical Engineering Dept., College of Engineering, University of Colorado, Boulder, Colo. 80302.

"Automation in Electronic Test Equipment via Built-in Test, On-line, and Continuous Monitoring," June 16-20, NYU. $265. History and state of the art in automatic test and checkout, role of automation in Apollo-Saturn, evolution of multiplexing and data conversion techniques related to the NELC automatic test system, the NELC-ATS computer operational program, on-board checkout, MADREC to MADAR, use of digital computers for built-in self-test, built-in and self-test for airborne weapons, micro indicators for built-in test equipment, advances in recording and display technology applicable to checkout systems, automatic test based upon pattern recognition displays, etc. Mrs. Mari Fields, School of Engineering and Science, New York University, Research Building No. 2, 401 W. 205th St., New York, N. Y. 10034.

EE COURSES

"Iterative Analog Computation," June 16-20, Detroit. $325. Concepts of digital logic as applied to analog simulation and computation, basic concepts of hybrid computation, techniques of programming and operating parallel analog/hybrid computers. Ed Sharpe, Electronic Associates, 185 Monmouth Pkwy, West Long Branch, N. J. 07764.

"21-110 Mass Spectrometer," June 16-20, Monrovia, Calif. $225. Intended for those responsible for operation and maintenance of a CEC Type 21-110B or 21-110C gas ion source mass spectrometer. Coordinator of Training and Technical Publications, Bell & Howell, 1500 S. Shamrock Ave., Monrovia, Calif. 91106.

"PDP-8 Family Programming (DECtape/Disk System), June 16-20, Maynard, Mass. $300 (free for one person per computer purchase). Mass storage system software, including Monitor, PAL-D Assembler, Disk DECtape Editor, Disk/DECtape On-line Debugging Program, Peripheral Interchange Program, program interrupt, data break, disk and DECtape programming. Training Dept., Digital Equipment Corp., Maynard, Mass. 01754.

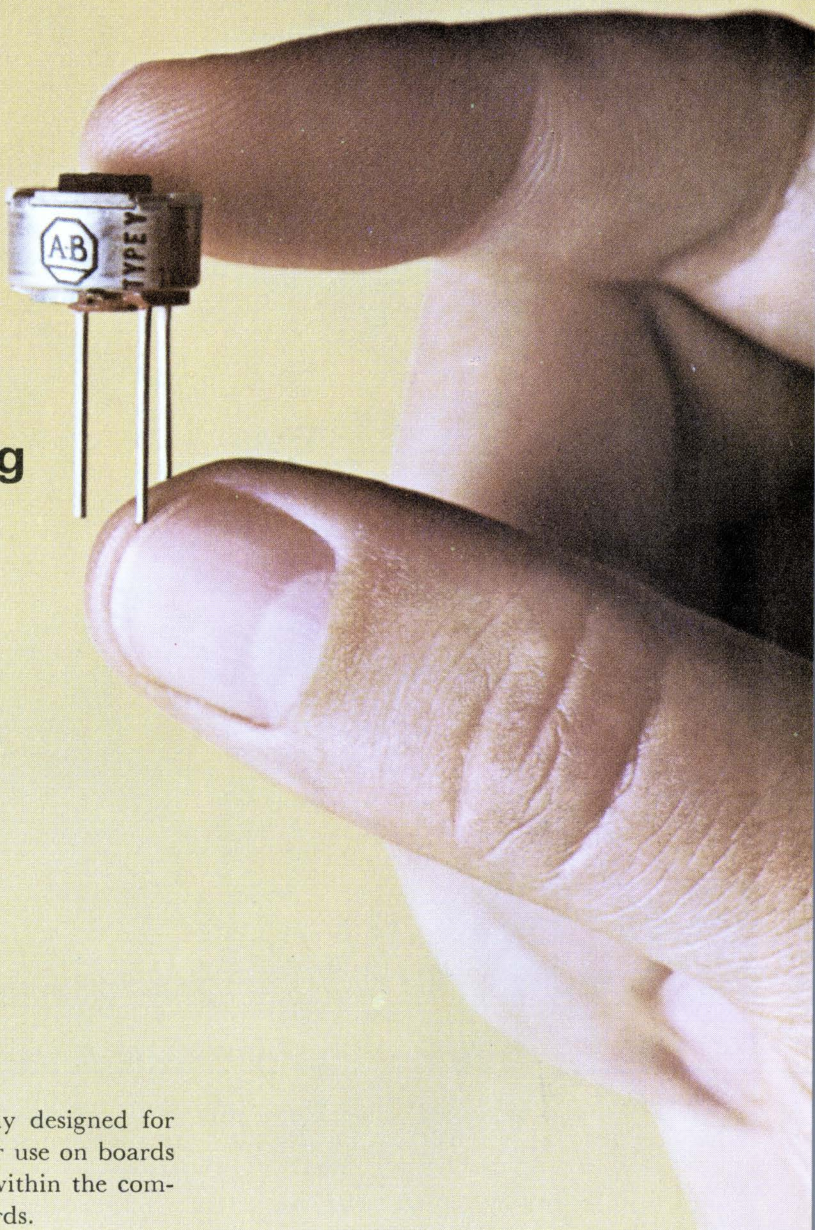
"Series 5800 (4000) Dynamic Tester," June 16-27, Sunnyvale, Calif. Tuition-free for customers (up to two employees—$300 for each additional person). R. D. Warner, System Training Manager, Fairchild Instrumentation, 974 E. Arques Ave., Sunnyvale, Calif. 94086.

LINC Programming," June 16-27, Maynard, Mass. $500 (free for one person per computer purchase). General operation of the LINC computer; use of assembly and editing routines, programming techniques, input/output programming, display and magtape programming, use of Program Library. Training Dept., Digital Equipment Corp., Maynard, Mass. 01754.

"Digital Computation," June 23-27, Los Angeles. $250. Problem-solving techniques of digital computers, using machine and assembly language programs, and FORTRAN IV. Ed Sharpe, Electronic Associates, Inc., 185 Monmouth Pkwy., West Long Branch, N. J. 07764.

LOW PROFILE

hot-molded trimmer for close circuit board stacking



Basic Type Y unit
shown actual size

With wheel for
side adjustment

With attachment for
horizontal mounting and
wheel for side adjustment

With attachment for
horizontal mounting

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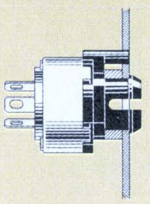

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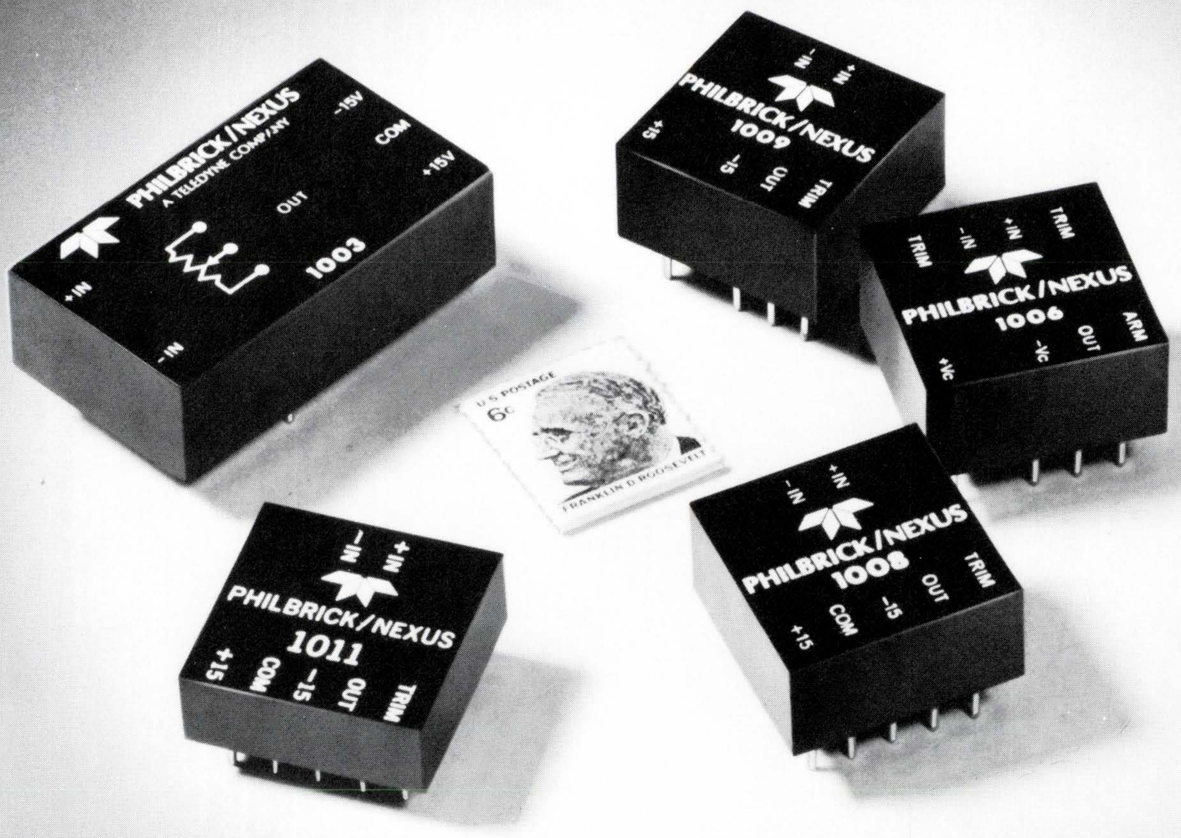

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IC voltage regulators— Do-it-yourself power supplies?

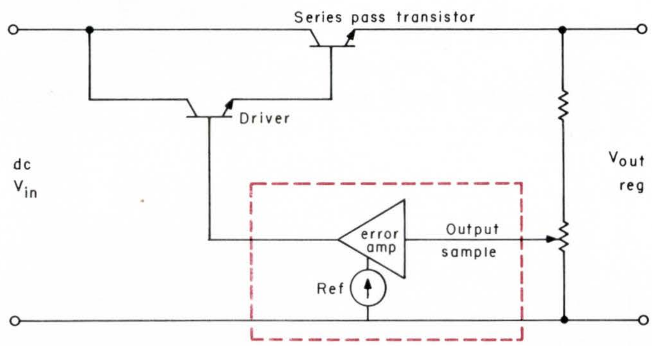
Not yet, say the users. Never, say the manufacturers of power supplies. But, now that you can get good regulators for $5, lots of people are buying them.

By Stephen A. Thompson,
Western Editor

Since National Semiconductor introduced the LM100 monolithic voltage regulator about 2½ years ago, there has been a proliferation of hybrid and IC voltage regulators in the ±40 V range. Generally, manufacturers have found them to be a good product, although Westinghouse and Raytheon no longer make them. Fairchild is selling more μA723 regulators than any other complex IC except its μA741 op amp. Some users buy regulators in 100,000-unit orders.

Regulators are readily available and have been accepted by builders of power supplies, computers, power conditioning equipment, avionics systems, and instruments of all kinds. Op amp users are good customers. In fact, Philbrick/Nexus makes a ±15 V unit, which it sells largely to its op amp customers. Applications range from the usual plus-or-minus series regulation, to current and voltage boosting, shunt regulation, and many more.

The success of these regulators is partly due to the fact that almost every piece of electronic equipment needs a regulated power supply. The predominance of ICs means that most of these supplies must have an output of 5 V or less. At this low voltage, diode drops are important, noise margins are very low, and the dynamic range that the designer has to play with is very small—he must control the supply voltage very accurately.



Typical series voltage regulator circuit. An error amplifier converts the difference between the output sample and the reference into an error signal that controls the voltage dropped by the series pass transistor. Even though most commercial IC regulators include the amplifier, the reference and the pass transistor, most users apply these regulators to drive one or more series pass transistors, either directly or through an intermediate transistor driver.

Choosing a regulator

The design engineer must evaluate each application separately. Some of the key parameters of commercial voltage regulators are compared in Figs. 1 through 5. Most of these products either have counterparts with negative voltage outputs or can be connected for negative outputs. Hybrid regulators are included; however, many of them consist of a monolithic IC regulator, with transistors added to get higher power dissipation and load currents. Other hybrid regulators have no monolithic ICs, they consist of discrete diodes and transistors plus thick-film resistors.

The designer should be aware of many things when choosing a regulator. In addition to low output impedance, the good ones have short circuit protection, overvoltage protection, high reliability, and come with good application notes.

Even though a **low output impedance** is mandatory in a regulator, we have not graphed this parameter because many spec sheets do not list it; those that do, specify operating points at varying frequencies. (Motorola is very proud of the fact that its typical Z_{out} of 25 mΩ is virtually flat with output voltage, so much so that until recently, load regulation did not even appear on its spec sheets.)

In fact, **regulation** is about the most difficult spec to compare. Figure 2 is a plot of those products where regulation was specified in the two most popular fashions— %/V_{out} and % (manufacturers also use %/mA and mV). To insure that regulation comparisons rank with the labors of Hercules, the conditions under which the specs were made are as different as random fingerprints. In the midst of this chaos, Varadyne's 0.005% figure (typical) for its hybrid regulator is clearly the best—about an order of magnitude below anything reported in %.

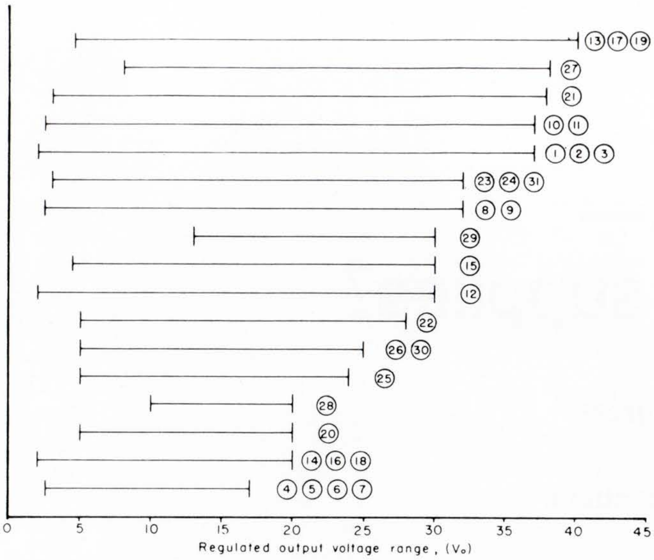


Fig. 1: **Regulated output voltage range** of voltage regulators.

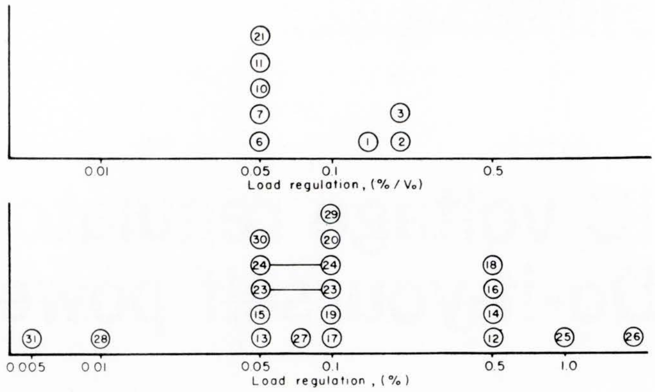


Fig. 2: **Load regulation** in $\%/V_{out}$ and %.

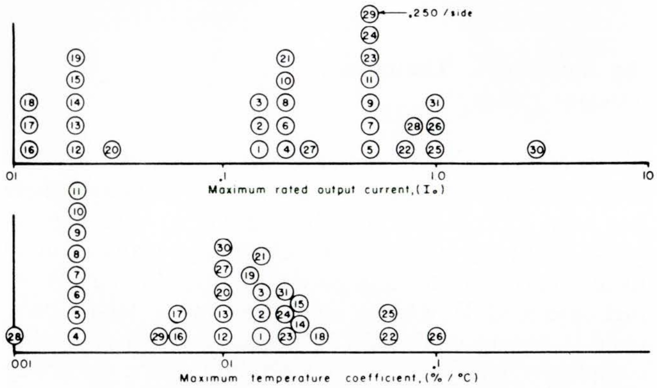


Fig. 3: **Maximum rated** output current of voltage regulators.

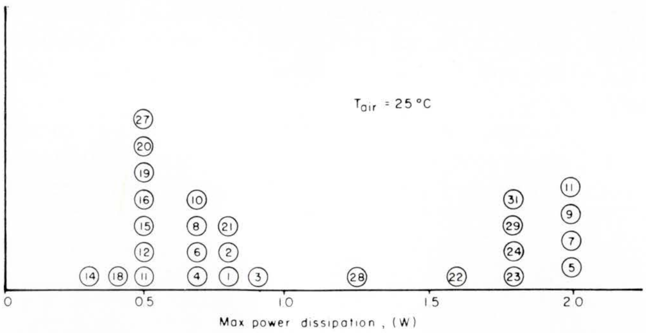


Fig. 4: **Maximum power dissipation** of regulators in free air @ 25°C.

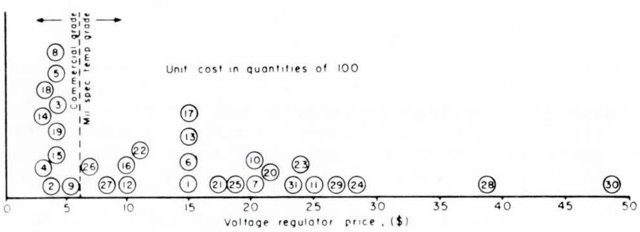


Fig. 5: **Cost** of voltage regulators. Most prices are in quantities of 100.

Regulator identification code

Code	Manufacturer	Monolithics		Package
1.	Fairchild	μA723	MS	TO-5
2.	Fairchild	μA723	C	TO-5
3.	Fairchild	μA723	C	DIP
4.	Motorola	1460G	C	TO-5
5.	Motorola	1460R	C	Cu sink
6.	Motorola	1560G	MS	TO-5
7.	Motorola	1560R	MS	Cu sink
8.	Motorola	1461G	C	TO-5
9.	Motorola	1461R	C	Cu sink
10.	Motorola	1561G	MS	TO-5
11.	Motorola	1561R	MS	Cu sink
12.	National	LM100	MS	TO-5, flat, DIP
13.	National	LM105	MS	TO-5, flat
14.	National	LM300	C	TO-5
15.	National	LM305	C	TO-5
16.	NPC Electronics	LA100	MS	TO-5, flat
17.	NPC Electronics	LA105	MS	TO-5, flat
18.	NPC Electronics	LA300	C	TO-5, flat
19.	NPC Electronics	LA305	C	TO-5, flat
20.	Optical Elect.	8100	MS	TO-5
21.	Transitron	TVR2000	MS	TO-100
		Hybrids		
22.	Beckman	809	MS	1 x .5 x .170
23.	Beckman	801, 3, 5	MS	1 x .5 x .170
24.	Beckman	802, 4, 6	MS	1 x .5 x .170
25.	Bendix	BN4000 ser	MS	TO-3
26.	Bendix	BN4100 ser	MS	TO-3
27.	General Inst.	NC530	MS	TO-5
28.	General Inst.	NC562	MS	
29.	General Inst.	NC572	MS	TO-8
30.	Int'l Circuit Tech.	LM500	MS	1.2 x .65 x .25
31.	Varadyne	J series	MS	1 x .5 x .155

MS: MIL-SPEC temperature range (−55°C to +125°C)
C: Commercial grade (usually 0°C to +70°C)

Power and **current** capability are very important. Many users must add an external pass transistor to boost the output current. The higher the rated output of the regulator, the lower the β of the transistor can be to give the desired amperage. The high-power monolithic regulators incorporate a large series-pass transistor on the chip to give high currents, but this is questioned in National's application notes by Bob Widlar, Director of Advanced Circuit Development. National shies away from it because IC packages can't handle the power. Since the maximum junction temperatures for ICs are lower than those for discrete transistors, the heat sink for a power IC must be much larger than that for a regulator using a discrete pass transistor. In addition, Widlar feels that, when the pass-transistor is on the chip, variations in input voltage or load current cause gross variations in chip temperature. These temperature variations affect the control and reference circuits (located on the same chip) yielding poorer overall performance. He states that a good regulator should have an overall spec of 1%. That is—a total regulated voltage change of 1% when temperature, line, load, and so forth, are lumped together.

Regulators can defend themselves

By far, the most frequent cause of regulator failure is excessive dissipation in the series pass transistor. The most common method of protection is to limit the load current with a **foldback current-limiting** technique. For example, Fig. 6 shows the I-V short circuit characteristic of Beckman's Model 806 hybrid regulator. When the output is shorted, the load current drops as the voltage is pulled down so that the regulator dissipates minimum power. The short circuit current may then be only a fraction of the full load current.

Motorola Semiconductor protects its regulators against excessive power dissipation, or temperature, differently. Mr. Clay Tatom, who manages the firm's linear IC product planning, thinks its system is more fundamental, because it uses temperature—rather than current—to protect against overdissipation (see Fig. 7).

It's make or buy time again

Because IC regulators are now readily available and widely accepted, there may well be a shift in the make-or-buy decision by an engineer who needs a regulated power supply. Also, the system designer will seriously consider point-of-use regulation instead of central regulation. Both these ramifications have technical and economic aspects.

Until recently, everyone thought that he could build a power supply by throwing a transformer and rectifier bridge together—until he realized that he needed regulation. He could then either design, build, and tinker with his own circuitry, or buy a supply to do his job.

Today regulation is a component, like a transformer or a bridge. Armed with a catalog, the engineer can buy regulation in the range of ±40 V, 0.5 A using monolithics, or up to 5 A using hybrids. If he reads the application notes, he can boost his output into the 5 to 10 A range by adding a minimum of components and design. With the exception of power supply manufacturers in general, the consensus is that both the ICs and the application notes are good enough so that the average engineer can build a respectable supply with a minimum of discomfort.

Cost ranges between $3.50 and $6.50 for a commercial-grade regulator, up to $49 for a MIL SPEC unit, and prices have been dropping. Other cost factors are more subtle. Sometimes the choice is between two supplies, one being marginal, the other being too good for the job. Mike Markkula, product marketing manager for Fairchild's linear integrated circuits, points out that now the engineer can get the voltage he wants without the agony of choosing between a $150 or $250 supply to get the tradeoff he needs.

According to Howard K. Cooper, Senior Vice President of the Semiconductor Division of Nucleonics Products Corp., a transistorized voltage regulator needs a sophisticated op amp, a stable reference, a good response time, and a good feedback loop. To design the circuit yourself you might need 20 resistors, ten capacitors, five transistors, tight temperature compensated

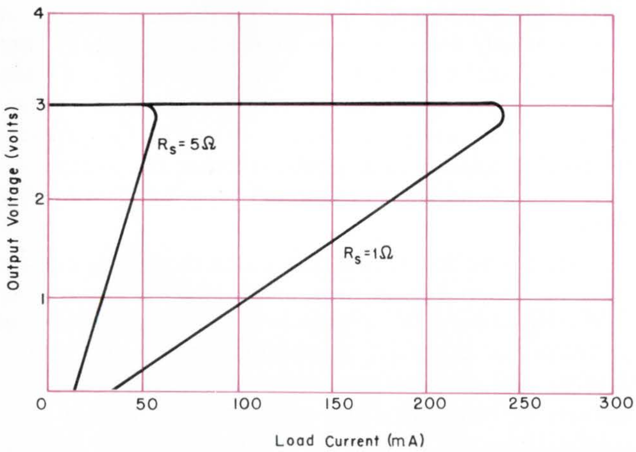


Fig. 6: **Short circuit performance** (foldback) of the Beckman Model 806 voltage regulator, at 3 V, for two values of the current-limit sensing resistor R_s. This resistor determines the maximum load current that can be drawn from the regulator. During overload, the magnitude of the load impedance determines the operating point along the current limiting characteristic curve.

Regulated discussion. Larry Hedberg (left), Manager of Hybrid Microelectronics for Varadyne, Inc., discusses voltage regulator features with Steve Thompson, over a tray of hybrid regulators.

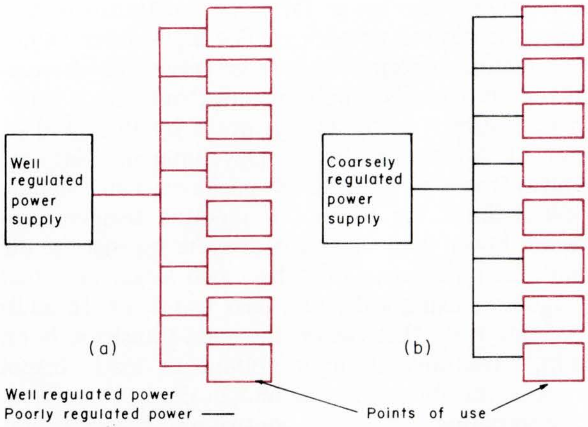
Computers—an outpost of resistance

Except in special cases, computer manufacturers have not yet adopted the local regulation scheme. Some consider it inconvenient, impractical, and expensive to break regulation up into a number like 1,000 small pieces when you compare it with a 100-A central supply. The problem is that the power dissipation of monolithics is limited. Hybrids are more interesting, but still unsatisfactory from a power standpoint. The power supply designer at a computer manufacturer suggests that if the monolithic regulator were built into a chip that you are already using (like a 10 flip-flop chip) then the scheme could be useful.

Jack Fort, manager of circuit design for National Cash Register, points out the problems of distributed regulation. First, it is difficult to supply local reference voltages, because each reference is slightly different, say 5.02 V as opposed to 4.98 V. One end of the reference is tied to what passes for ground. As loads change, ground loops can develop that change the references by changing the level of what you call ground. If, instead of local references, you provide a central one and ship the voltage around to each point, you have defeated one of the original purposes of local regulation—to get better noise immunity. If noise gets into the reference network, it goes everywhere.

Second, trying to divide the loads equally in a large system can be difficult. Each card may be able to handle 500 mA, but it can work out that one card requires 600 mA and another only 200 mA. The average is only 400 mA, but the division is unsatisfactory.

IBM uses central regulation for the great majority of their computers, while only 1% of the logic circuitry utilizes local regulation. John Roberts and George Allen of the IBM's Systems Development Division Labs, Kingston, N.Y., relate that these are cases where circuits require extremely tight tolerances and cannot be located close enough to a well-regulated supply. They consider it an expensive method, but in those cases technical demands override economic ones. IBM has an open mind on the subject of local regulation, but feels that no clear trend has yet developed. They consider that the most economical, reliable, and proven method today is to break the system and regulate it in several blocks, each serving a portion of the logic circuitry.



Comparison of central and distributed regulation. In (a) the power distribution network must be designed for the minimum voltage drop and be well shielded from noise. Noise generated anywhere affects the entire system, and a short at a point of use can cause the supply to shut down or be destroyed. In (b) each load is isolated by its own regulator minimizing the importance of voltage drops and noise in the power distribution network. The regulators also protect the supply from shorts at points of use.

reference devices, and a PC board. Assuming no shortages of parts, the circuit must be invented, tested and reviewed. All of this is now on one IC. With one component and a few holes in a broad, or socket, it's all over. Cooper concludes that while the IC regulator might cost the same as the discrete components, there is no assembly or design time. Actually, IC regulators still need several components outboard, but they are relatively easy to put together.

What do power supply manufacturers use?

All of these factors are important to power supply manufacturers, and there is much evidence that they are becoming large users of IC and hybrid regulators. Bendix and National both count power supply makers as large customers. Ed Renschler, section manager of linear IC applications at Motorola, believes that power supply companies will soon be buying potted regulators instead of making their own.

We contacted several power supply companies and asked them about the impact of these regulators on power supply users, and on themselves as users. There are hard-line manufacturers who say they are going down the line with discrete components. They believe that they can best understand and handle the problems of good regulation, and doubt whether the average engineer can build decent regulated supplies from application notes.

Others, like Sola Electric, find that the choice between designing their own or using ICs is just about a toss-up. Walt Hirschberg, Vice president in charge of product development at ACDC Electronics, points out that PC boards and discretes are still more economical. Such factors as heat sinks are more important than saved space. However, as control circuitry gets more involved and efficiency becomes more important, more ICs will probably be used in power supplies. At present, ACDC uses custom hybrids in a few units.

Hirschberg also feels that the average engineer can build simple regulation. When it comes to high-power supplies, however, he will not design with ICs any more but turn to the power supply manufacturer.

Of 17 manufacturers contacted, only North Electric, Lambda Electronics, and Kepco use IC regulators in quantity in their supplies.

At the IEEE show in March, Lambda introduced a new line of power supplies that use IC voltage regulators. The regulator was designed by Lambda and manufactured by Motorola, using their computer aided design capability. Load regulation of the supplies is 0.01%.

Paul Birman of Kepco equates regulation with amplification. Amplification is easy to get, but temperature stability is more difficult. Kepco uses voltage regulator chips, even though they are more expensive than discretes, because their small size makes temperature uniformity and stability easier to achieve.

Actually, power supply makers are the ones who can benefit most from IC regulators, because they know more about regulation than the average user. We believe that many power supply manufacturers are using them primarily as error amplifiers to drive one or more series-passing transistors. As for the user, he will go to power supply manufacturers in proportion to the degree of sophistication required and the number of units he needs. Power supply manufacturers who have learned how to keep their costs down, will still be able to offer good supplies at a cost lower than most people can build them.

Divide and conquer?

Another class of potential regulator users, the digital systems designers, is faced with a decision about *distributed vs central* regulation. He can buy or build a well regulated central power supply and "bus" power throughout the system, or he can choose to have minimal regulation at the central supply and use ICs to regulate at the various points of use. The advantages of point of use regulation are many, but so are the mitigating circumstances.

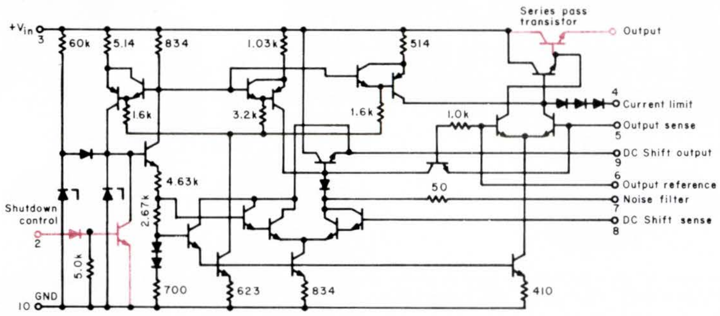
The foremost advantage is that regulation is done as close as possible to the point of use. **Distribution** busses can be a severe headache for the system designer—a poor one degrades a good supply. He may have to use very low-resistance bus lines to keep voltage drops to millivolts, especially if he needs good regulation at any distance from the supply. Many users of big power supplies use remote sensing leads to insure that the regulated voltage is accurate at the load—rather than at the supply—but this can be done only when there is a single load.

Another important consideration is **noise.** Using central regulation, care must be taken to minimize noise in the common network, otherwise the busses will couple switching transients and hum to all points in the system. Individual regulators provide better immunity to noise pickup throughout the system because they remove noise at each load point.

Regulator manufacturers claim several other advantages, such as more reliability, less space, and better temperature coefficients than discretes. In addition, they say, if a system needs several different voltages, such as ±5, ±12, ±15, ±24 volts, etc., the exact voltage desired is available at the point you want it simply by specifying the correct regulator. Since each regulator is short circuit protected, a short in one card will not wipe out the power supply. If you consider the regulator as a component, the number of parts and interconnections in a circuit are reduced together with assembly and design time.

Cost can also be lower. Mike Markkula of Fairchild gives the following example. Suppose you need a 0.1%-regulated, 5 V, 20 A supply. This might cost you $400 to buy. It will cost you under $50 to buy ten μA723's, plus $100 for a course supply. You should be able to buy the discretes needed to boost each regulator's capability to 2 A and put them together for well under the remaining $250. On the other hand, for 0.01% regulation, the cost situation shifts in favor of the power supply manufacturer.

Many digital systems designers buy the local regulation concept and are in the "designing in" stage. Electro Scientific Industries and Datacraft, for example, use course power, regulated at point of use, in some of their



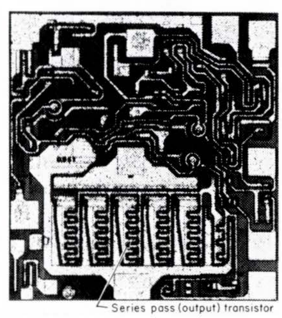


Fig. 7: **Overdissipation protection circuit** in Motorola is MC 1560 voltage regulator. The diode transistor pair D-Q senses the junction temperature of the pass transistor and shunts the bias portion of the regulator when the junction gets too hot. The combined forward voltage drops of the pair at room temperature $V_{fwd} + V_{BE}$ is about 1.4 V. A lower voltage, about 1 V, is applied externally across them. Since the chip is small, any temperature rise due to power dissipation in the large series pass transistor (visible in the microphotograph of the chip) raises the temperature everywhere on the chip in milliseconds. During an overload, the increasing temperature lowers the ON voltage of the diode-transistor pair by about 4 mV/°C. At about 125°C, the pair starts to conduct, shunting the rest of the regulator. An external resistor protects the load from overcurrent.

equipment. A spot survey of computer and avionics manufacturers, who would obviously be affected by the kinds of arguments above, uncovered the interesting views described elsewhere in this report.

Will regulators fly?

Avionics power systems pose a different set of problems. First, an aircraft manufacturer like McDonnell Douglas does not supply dc regulated voltage to the aircraft bus. According to Mr. W. B. Yopp, chief of electrical engineering, they supply power according to MIL-STD 704 which prescribes 3-phase 400 Hz ac for avionics systems, rectified to a nominal 28 V.-(this voltage can vary from 19 to 29 V and still meet MIL-STD 704). This power is bussed around the aircraft; and the regulation problem is left for the equipment designer who must interface with the aircraft power bus.

J. Foutz, supervisor of computer engineering for the Data Systems Division of Autonetics, gave some insight into that side of the problem. The aircraft power system is well specified, and so is the unit (say, an airborne computer). The power supply always turns out to be a custom job, whether it is made or bought, because almost nobody makes power supplies that operate off a MIL-STD 704 input.

Autonetics uses a $40 regulator, adds about $40 worth of components and distributes regulated power around a particular unit. Unless extreme reliability is needed, the high cost of MIL-spec regulators makes point-of-use regulation very unattractive. However, several months ago Autonetics decided that there were enough good regulators on the market, and have designed their last one. From now on they will use monolithic regulators. Mr. Foutz cautions about applications notes: they tend to omit things, like the fact that most of them are bang-bang rather than frequency regulators; or that they are free running—which means that switching-type loads may latch the regulator on and destroy it.

Back to the drawing board

There are still formidable barriers to universal acceptance of point-of-use regulation. Almost everyone agrees it is a great idea to have it, but it will have to prove itself in each new situation. For a small number of loads, it is easy to distribute from a central supply. For a large number, it gets very complicated. In between, the idea is catching on.

Thanks . . .

. . . for the busy design hours they devoted in contributing to this report, to the gentlemen mentioned in the text and to Lyle Pittroff, Beckman Instruments; Dick Schomberg, Electro Scientific Ind.; Monte Lum, International Circuit Technology; Ken Kupferberg, Kepco Inc.; Jim Bright, North Electric; Jack O'Connell, Philbrick/Nexus; John Levin and Steve Rose, Power Designs Inc.; Rux Tucker, Sola Electric; L. J. Torn, Trygon Electronics; and Rene Cote, Varadyne.

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EE WELCOME

Here we welcome new companies or new divisions in the electronics industry. If you want more information, just circle the appropriate numbers on the reader service card.

Ion implantation initiate. On February 20, the recently-formed KEV Electronics Corp. moved into new facilities in Wilmington, Mass., and commenced full-scale R&D and production activities. KEV's goal: to make sophisticated semiconductors (discretes—not ICs) that cannot be made efficiently with diffusion. The process it will use: ion implantation.

Dr. William J. King, president and founder of the firm, is one of the pioneers of ion implantation in this country. He began working with the process while at Ion Physics Corp., a subsidiary of High Voltage Engineering.

KEV plans to produce special purpose diodes and transistor devices in which high resolution and uniformity are especially important. Its first product—expected to be available by early fall—will be a line of voltage-variable capacitors for military and industrial tuners, including those used in TV receivers and am and fm radios.

High-frequency devices—still under development—will make up its second product effort, but these will not be available for another 18 months or so. Further in the future is a line of junction field-effect transistors.

KEV will be working with silicon materials exclusively at first, but long range plans call for the development of devices using III-V and II-VI semiconductor materials such as gallium arsenide phosphide, gallium arsenide, indium antimonide, and indium arsenide.

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Control over telephone lines. The job of designing and manufacturing data communications systems has recently been tackled by Coherent Communications Systems Corp., Wyandanch, N.Y. At present, the Long Island firm is directing most of its efforts to its key product line—multifrequency control modules—which are designed to provide remote control switching or signalling over leased telephone lines. They will be used on facsimile transmission to select a particular machine speed, or to program all network receivers for the same speed. The modules are available in limited quantities.

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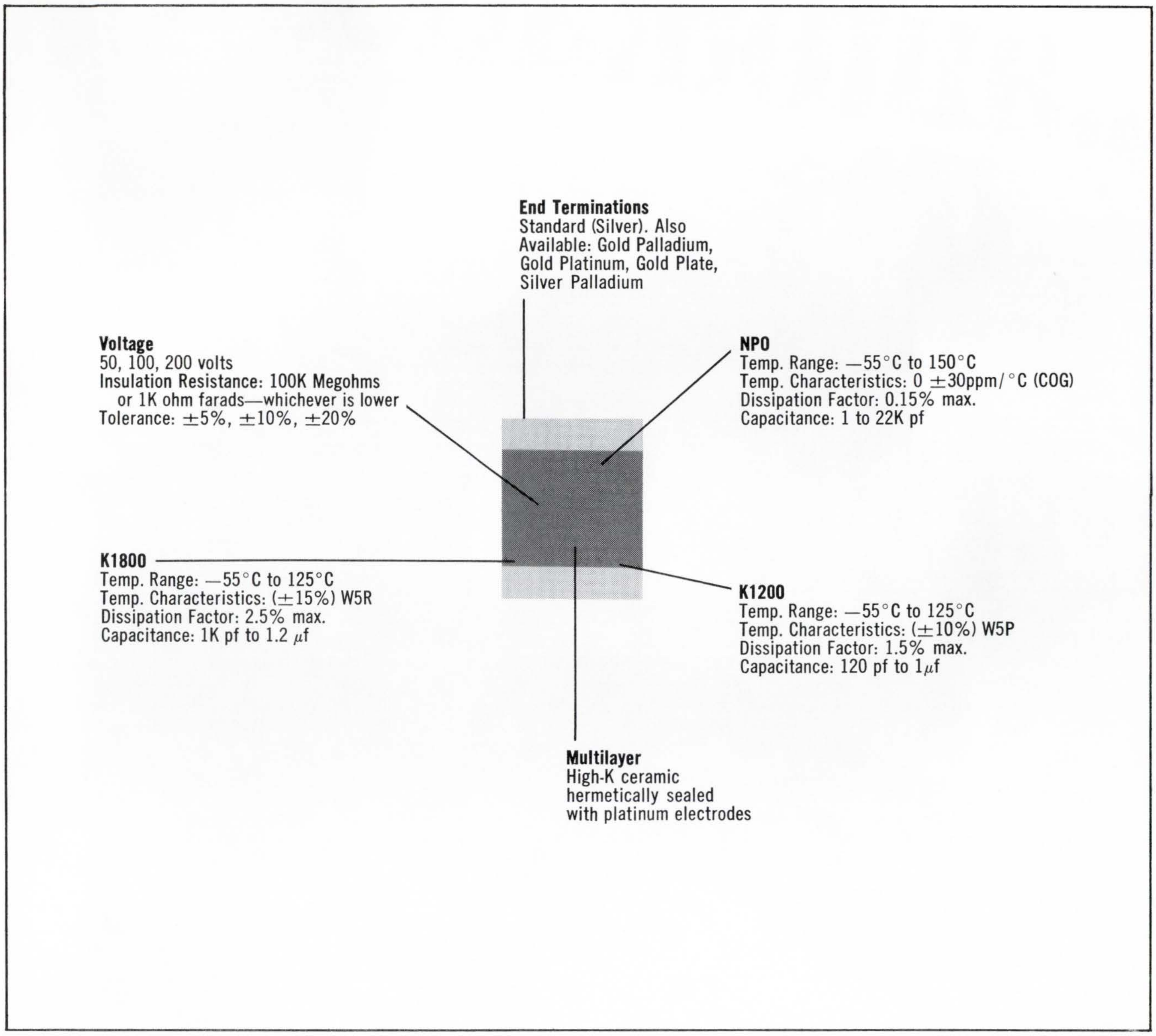

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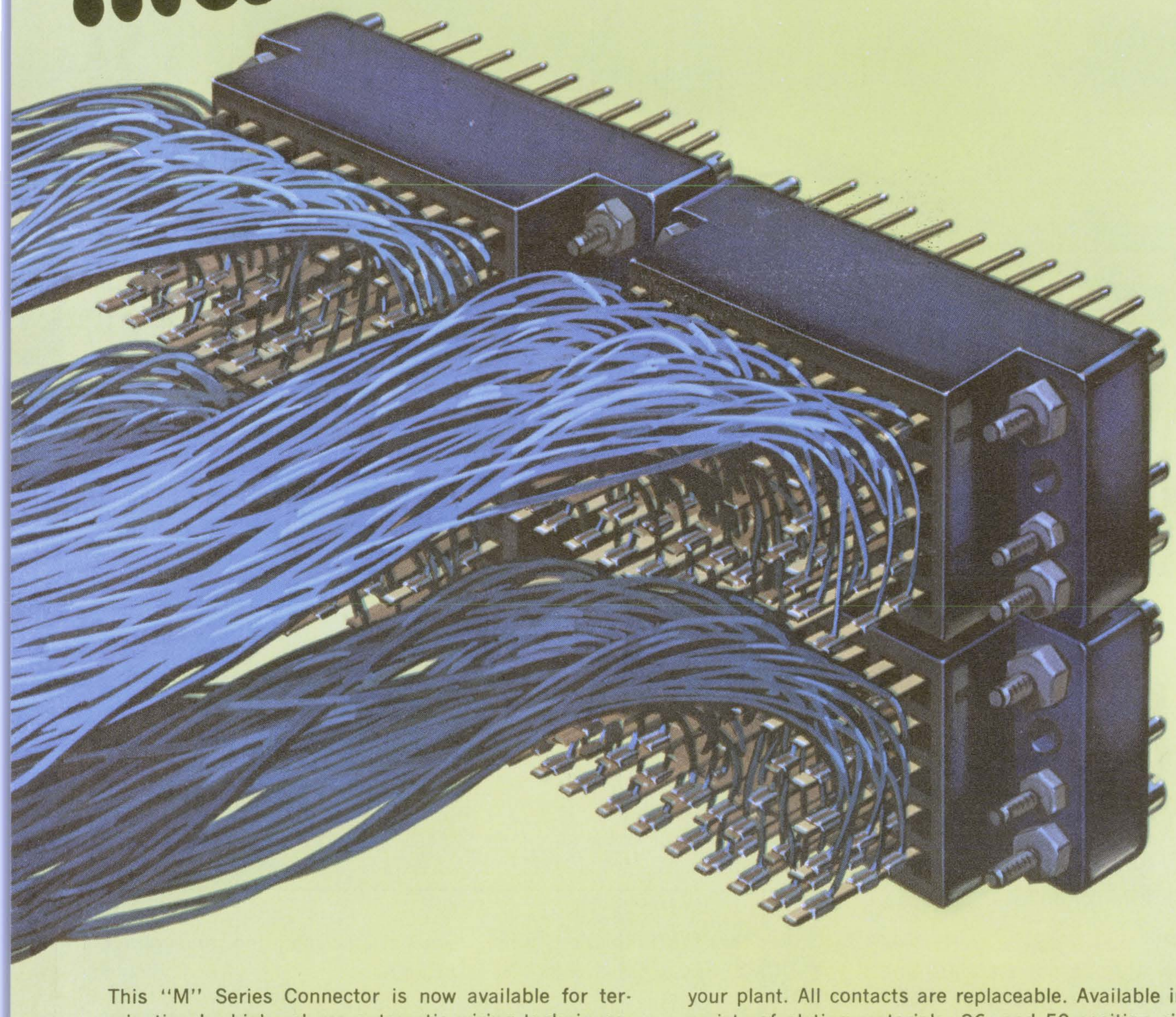

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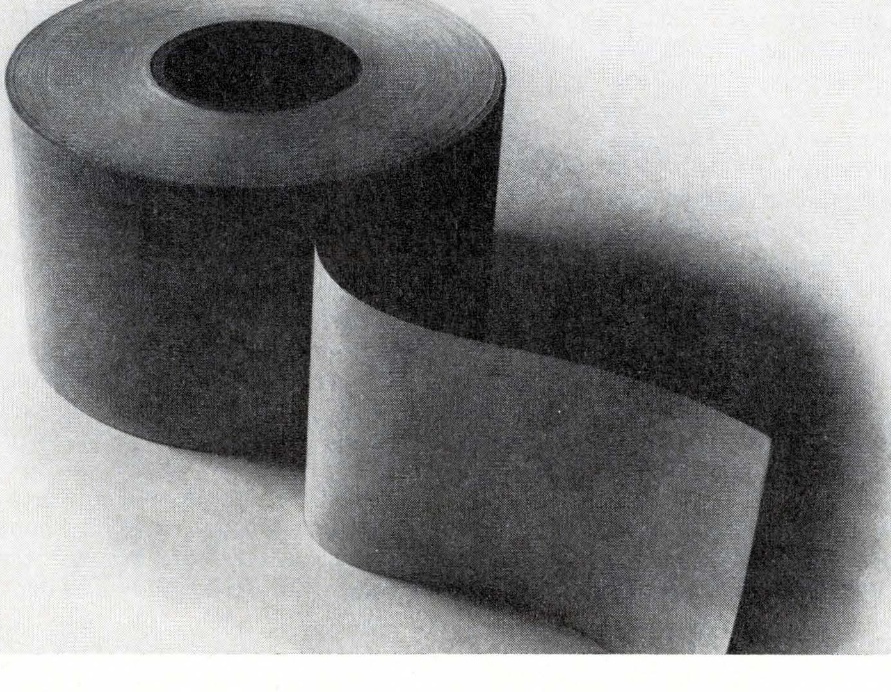


Transmitting data with digital ICs

New integrated circuits make it possible to transmit data under high noise conditions using a simple twisted pair of wires.

By R. J. Widlar and J. J. Kubinec
National Semiconductor Corp., Santa Clara, Calif.

In cases where you must transmit digital data in a high-noise environment, you cannot use ordinary integrated logic circuits because they lack sufficient noise immunity. (Standard TTL or DTL have a noise immunity about 0.5 to 1V). One way to solve this problem is to use high-noise immunity logic. This approach usually demands worse case logic swings of 30 V, which in turn requires high supply voltages. Further, considerable power is needed to transmit these voltage levels at high speed, especially if the lines must be terminated to eliminate reflections.

A better solution is to convert the ground-referred digital data at the transmission end into a differential signal and transmit this down a balanced, twisted-pair line (Fig. 1). At the receiving end, any induced noise, or voltage due to ground loop currents, appears equally on both ends of the twisted-pair line. A receiver which responds only to the differential signal from the line will reject large, undesired signals even with moderate voltage swings from the transmitter.

This article describes such a system. The transmitter provides a buffered differential output from a DTL or TTL input signal. A four-input gate is included on the input of the transmitter so that the circuit can also perform logic. The receiver detects a zero crossing in the differential input voltage and can directly drive DTL or TTL integrated circuits at the receiving end. It also has strobe capability to blank out unwanted input signals.

Both the transmitter and the receiver incorporate two independent units on a single silicon chip. Hence, you have either two complete transmitters or receivers on one chip.

Data transmission

The interconnection of the DM7830 line driver with the DM7820 line receiver is shown in Fig. 2. Except for the transmission line, the design is straightforward. Connections on the input of the driver and the output or strobe of the receiver follow standard design rules for DTL or TTL integrated logic circuits, i.e., 930 series DTL or series 54 TTL.

The transmitter, which has a typical differential output resistance of 15Ω, drives the twisted pair transmission line. These lines normally have a characteristic impedance of about 170Ω. The line is terminated at the receiving end, by a resistor on the receiver chip, to absorb reflections on the line. The transmitter will deliver a differential signal of ±3V into the transmission line while operating from a 5V supply, as is shown by the curves in Fig. 3.

At the receiving end, the terminating resistor is not normally connected directly across the output of the transmission line. Instead, an external capacitor is inserted in series with the resistor. The capacitor significantly reduces the power dissipation in both the line transmitter and receiver, especially in low duty

About the line driver and receiver . . .

The DM7830 line driver input interfaces directly with standard DTL or TTL circuits. It presents a load which is equivalent to a fanout of 3 to the circuit driving it, and it operates from the 5 V, ±10% logic supplies. The output can drive low impedance lines down to 50Ω and capacitive loads up to 5000 pF. The circuit is designed to clamp common mode transients coupled into the line, and short circuit protection is also provided. The integrated circuit consists of two of these drivers fabricated on a 41 x 53 mil-square die using the standard TTL process.

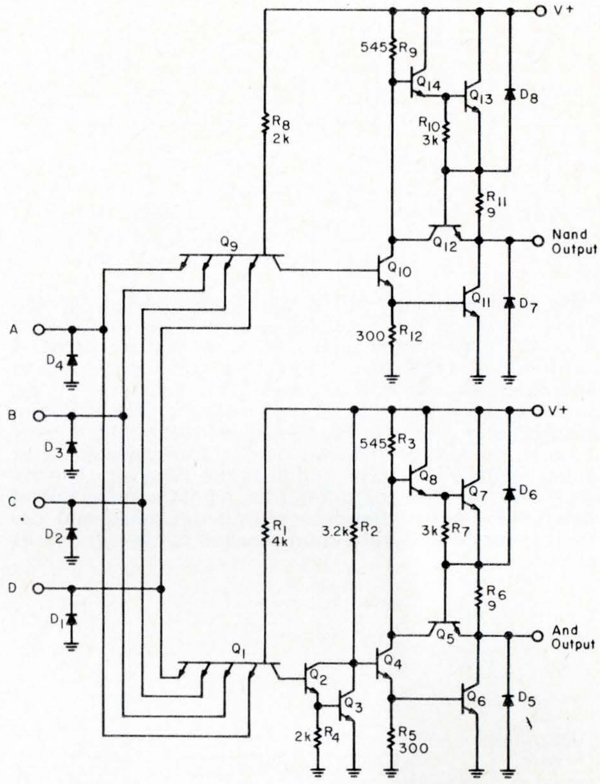
The line driver circuit closely resembles a standard TTL buffer. In fact, it is possible to use a standard dual buffer as a transmitter. But the DM7830 adds output current limiting to protect against shorts, and output diodes to clamp severe voltage transients that may be induced on the transmission line. Also, the circuit has internal inversion to produce the differential output, to reduce the time skew between the outputs and minimize radiation from the twisted pair lines.

LINE RECEIVER

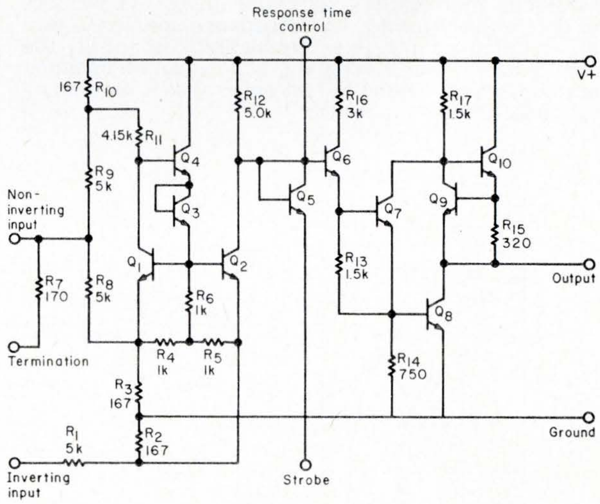
The DM7820 receiver converts the differential output signal of the line driver into a single ended ground-referred signal to drive standard digital circuits on the receiving end. At the same time it must reject the common mode and induced noise on the transmission line. Two receivers are on one chip, 41 x 49 mil-square.

It was considered important that the receiver operate from the +5 V logic supply without requiring other supply voltages. This complicates design because the receiver must handle ±15 V input signals which are considerably greater than the operating supply voltage. However, the large common mode range over which the circuit must work can be reduced with an attenuator on the input of the receiver. In this design, the input signal is attenuated by a factor of 30. Hence, the ±15 V common mode voltage is reduced to ±0.5 V, which can be handled easily by circuitry operating from a 5 V supply. The differential input signal, which can go down as low as ±2.4 V in the worst case, is also reduced to ±80 mV. Hence, the circuit must be designed with a fairly accurate zero crossing detector. This necessitates using linear design techniques for the receiver circuit, even though it can be manufactured with standard digital processing.

Both the line driver and the receiver are available from National Semiconductor.



The DM7830 Line Driver



The DM7820 Line Receiver

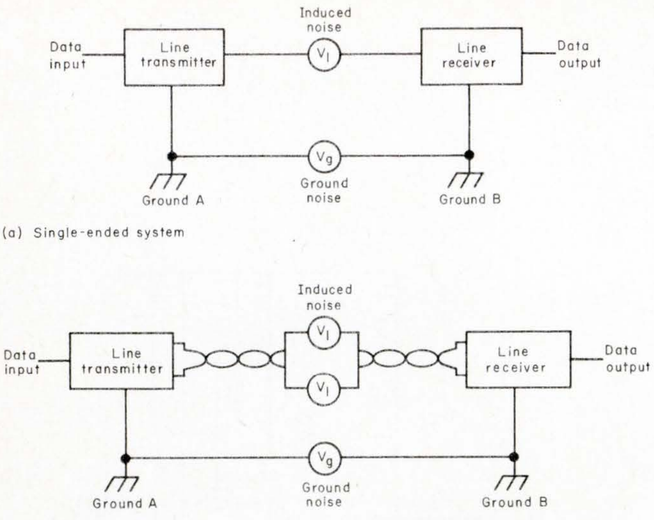


Fig. 1: When ground is used as a signal return as in Fig. 1a, the voltage seen at the receiving end will be the output voltage at the transmitter plus any noise voltage induced in the ground or signal line. Hence, the noise immunity of the transmitter-receiver combination must be equal to the maximum expected noise from both sources. The differential transmission scheme in Fig. 1b solves this problem. Any ground noise or voltage induced on the transmission lines will appear equally on both inputs of the receiver. The receiver responds only to the differential signal coming out of the twisted-pair line. It therefore rejects the noise and delivers a single-ended output signal referred to the ground at the receiving end.

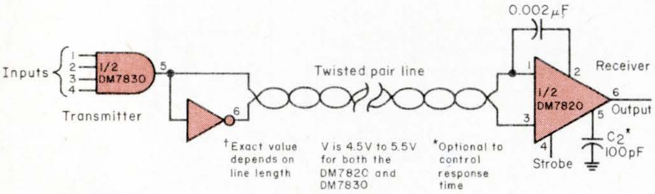


Fig. 2: Interconnection of the line driver and the line receiver. Transmitter has four NAND inputs and drives the twisted-pair line differentially from a low impedance source. C_1 provides dc isolation of the line terminating resistor in the receiver to reduce power dissipation, and C_2 can be included to make the system immune to fast noise spikes. Grounding strobe terminal disables receiver.

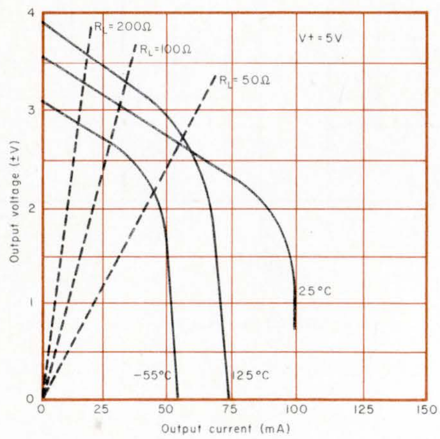


Fig. 3: Output characteristics of the line driver under load show the differential voltage delivered to the transmission line for different characteristic impedances. Curves show that the maximum current available from the driver is limited to prevent damage if transmission line is shorted.

cycle applications, by terminating the line at high frequencies, but blocking steady state current flow in the terminating resistor.

Since the line-termination resistor is included on the receiver chip, precise resistor values cannot be guaranteed without adversely affecting manufacturing yields. Fortunately, relatively large mismatches between the line impedance and the termination resistor do not adversely affect performance. Fig. 4 shows that termination resistances which are a factor of two off the nominal value (170Ω) do not cause significant reflections on the line. The lower termination resistors do, however, increase line attenuation.

Fig. 5 gives the line-transmission characteristics with various termination resistances when a dc isolation capacitor is used. The line is identical to that in the previous example. The transient response is nearly the same as the dc terminated line. The attenuation, on the other hand, is much lower, being the same as an unterminated line. An added advantage of using the isolation capacitor is that blocking the dc current from the termination resistor reduces the average current drain of the driver and the power dissipation in both the driver and receiver.

As was the case with the termination resistance, the value of the dc isolation capacitor is not too critical. A good design guideline is to make the RC time constant of the termination resistor/isolation-capacitor combination 2 to 3 times the electrical line length.

When there is a difference in ground potential between the transmitter and receiver, the waveforms observed at the receiving end will be somewhat different than those in Fig. 5. This difference comes about because the output resistance of the driver is not constant under all conditions. The high output of the transmitter looks like an open circuit to voltages reflected from the receiving end of the transmission line which try to drive it higher than its normal dc state. This condition exists until the voltage at the transmitting end becomes high enough to forward bias the clamp diode on the 5V supply. Much of the phenomena which does not follow simple transmission line theory is caused by this. For example, with an unterminated line, the line capacitance is charged by the reflected signal to where the clamp diodes are forward biased, increasing the signal swing at the receiving end. This increase then decays at a rate determined by the total line capacitance and the input resistance of the receiver.

The abnormal behavior of the transmission lines with non-zero common voltages is, however, of little practical concern. It occurs only when a dc isolation capacitor is used in series with the termination resistor, and results in a received signal which is larger than that which would be observed under normal conditions.

The power dissipated in the receiver is usually low. However, with large common mode input voltages, dissipation increases markedly, as shown in Fig. 6. This is of little consequence with common mode transients, but the increased dissipation must be taken into account when there is a dc difference between the grounds of the transmitter and receiver. It is important to note that Fig. 6 gives the dissipation for one half the dual receiver. The total package dissipation will be twice the values given when both sides are operated under identical conditions.

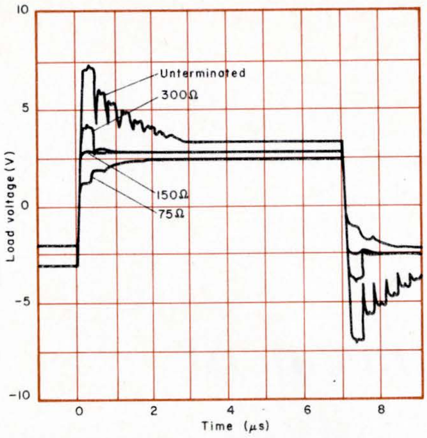


Fig. 4: Transmission line response with various termination resistances shows that response degradation is small for relatively large mismatches. The line used was a twisted pair 150 ns long with a 170Ω characteristic impedance.

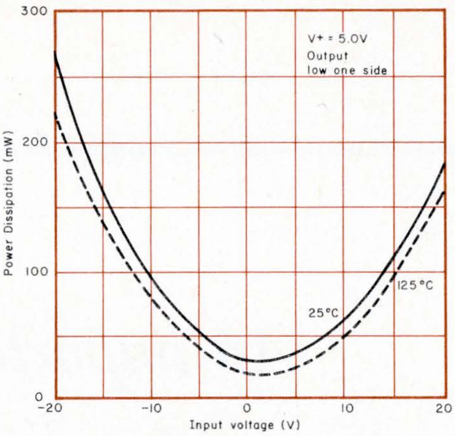


Fig. 6: Variation of internal power dissipation in the receiver with changes in common mode input voltage illustrates that dissipation can increase markedly for large dc ground differences between transmitter and receiver.

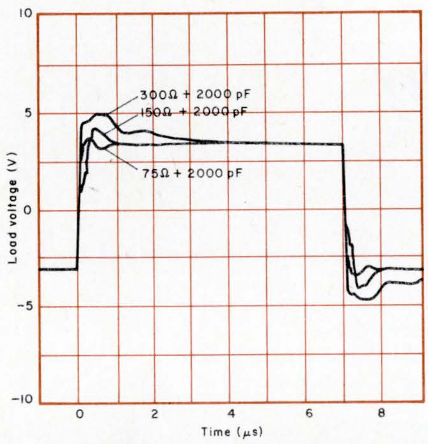


Fig. 5: Line response for various termination resistances when a series dc blocking capacitor is used. Capacitor increases signal swing and reduces power dissipation.

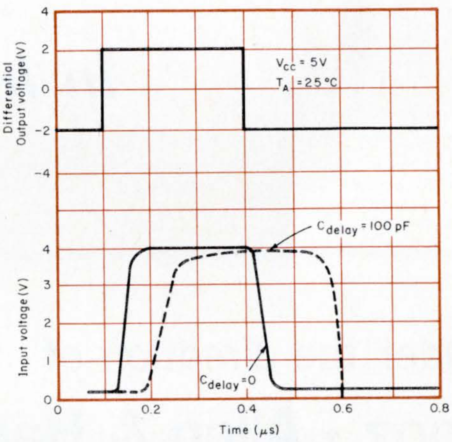


Fig. 7: Response time with and without an external delay capacitor (C_2 in Fig. 2). This capacitor gives added immunity to fast noise when only slow signals are expected.

Fig. 7 gives the response time, or propagation delay, of the receiver. Normally, the delay can be increased, by the addition of a capacitor between the response-time terminal and ground, to make the device immune to fast noise spikes that might be coupled differentially into the input. The additional delay obtained will generally be longer for negative going outputs than for positive going outputs.

Strobe capability is also provided on the receiver. With a logic zero on the strobe terminal, the output will be high no matter what the input signal is. With the strobe, the receiver can be made immune to any noise signals during intervals where no digital information is expected. The output state with the strobe on is also the same as the output state with the input terminals open, as would be the case when the transmitter was disconnected from the receiver.

Results

To summarize, the best termination is an RC combination with a time constant about equal to three times the transmission line delay. Even though its value is not precisely determined, the internal termination resistor of the integrated circuit can be used because the line characteristics are not greatly affected by this resistor.

An RC termination can cause problems only when the data transmission rate approaches the line delay and the attenuation down the line (dc terminated) is greater than 3 dB. This would correspond to more than 1000 ft. of twisted pair cable with No. 22 copper conductors. Under these conditions, the noise margin can disappear with low-duty-cycle signals. If this is the case, it is best to operate the twisted-pair line without a termination to minimize transmission losses. Reflections should not be a problem as they will be absorbed by the line losses.

INFORMATION RETRIEVAL:
Integrated circuits, Systems
Digital design

An important announcement

to the engineer

who is on the way up

in his company

Under the direction of

Booz • Allen & Hamilton, Inc.

Because of a wide and enthusiastic response to the Project Management Series which has appeared in the pages of this magazine, the editors have arranged a series of professionally directed seminars which will take place in key cities throughout the country. These Seminars on the "Management of Engineering Projects" are open to all qualified engineers who wish to participate.

The purpose of the Seminars is to develop within each participant an improved capability to manage effectively both large and small electronic projects. The Seminars will provide the practical knowledge to those responsible for electronic projects to do a better job of planning and executing those projects. There will be particular emphasis on the methods used to reach an objective while remaining within the prescribed product specifications, budget and schedule. The tested methods used in the Seminars will help the individual electronic engineer or manager increase his personal skills, sharpen his capability and broaden his understanding of Project Management problems.

Electronics engineering projects require the use of new management concepts which are often difficult for the traditionally-oriented manager to understand and accept. Because they cut across many functional (specialist) and organizational lines, these projects do not fit comfortably within the lines of authority in the traditional organizational structure. Even more important, these projects are scheduled to achieve *certain specified results at a particular point in time.*

WHAT THE PROJECT MANAGEMENT SEMINAR CAN MEAN TO YOU

These new Seminars in Project Management offer the electronic engineer an opportunity to broaden his knowledge and responsibility and to acquire skills similar to those of the general manager. These courses are unique in that they help the engineer solve the severe complexities inherent in the project assignment which in turn places an unaccustomed burden on the project manager.

Because the project manager's job is not easy nor even well-defined, he is in urgent need of professional management guidance and training to help him perform his mission successfully. The forthcoming Seminars in PROJECT MANAGEMENT will provide a practical insight into the concepts, techniques and tools necessary to succeed. Actually,

ROM
at the top

From code conversion to micro-programming, the monolithic read-only memory proves to be a versatile component.

By John Linford, Manager, Computer Memory Systems, Applications Section, Motorola Semiconductor Products, Inc., Phoenix, Arizona

The monolithic read-only-memory is coming on strong. Available in both bipolar and metal-oxide-semiconductor forms, with bit capacities reaching into the thousands, the IC ROM is extremely versatile. It can handle all sorts of logic jobs, including detection, decoding, generation, distribution, and translation. Moreover, it can also serve as a complete arithmetic unt.

A read only memory (often called fixed-constant memory, non-alterable memory, or fixed-program memory) is a digital storage device containing information that cannot be altered during normal operation. Integrated circuit ROMs now on the market have information stored during the manufacturing process that cannot be electrically altered. When utilizing them, the system designer obtains the usual advantages of integrated arrays — such as increased system reliability, lower system cost, higher speed and reduced package count. In addition, the designer obtains a custom circuit without paying the full engineering and production tooling costs for an individual circuit. This is true because the storage pattern is inserted during a single step during processing; hence the user can obtain a given function at a price based upon the development of a single mask and the related processing. Thus, custom circuits become economically feasible with smaller production quantities. Another important plus for custom logic circuits built from ROMs is the short lead times involved. Automatic mask generation can now generate the simple metal cut masks needed for ROMs, thus permitting some semiconductor houses to deliver circuits in 2 to 6 weeks.

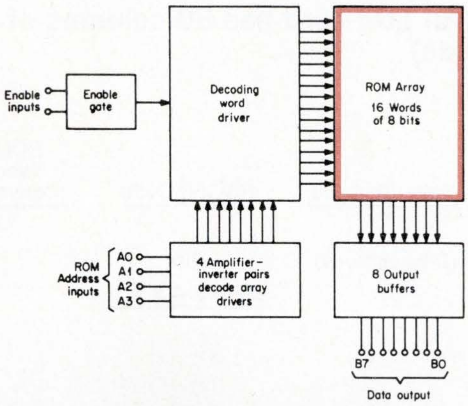
Perhaps the biggest disadvantage of IC ROMs is the fact that the IC manufacturer must presently insert the storage pattern and hence the time required to change the pattern is longer than if the customer did the programming using other types of ROMs. Aware of this problem, some manufacturers have designed automated systems to generate the masks and the test pattern for a custom ROM. A turn around time of two weeks is the goal of this endeavor.

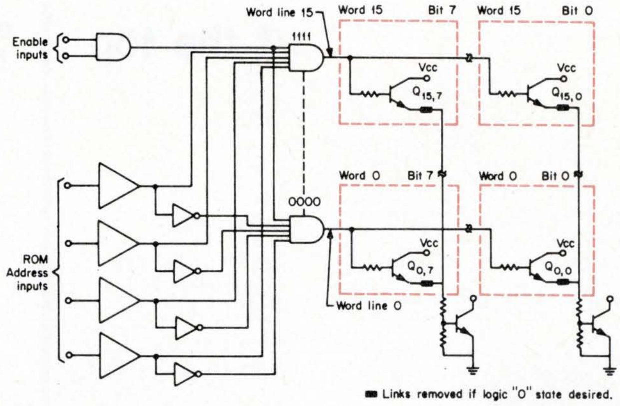
Mind your '1s' and '0s'

Standard wafers are processed with "I's" in all ROM locations. This standard processing includes passivation with a glass coating to protect the surface of the wafer. A masking operation now opens slots over the 128 metal link connections. The final photo-resist masking now etches away the bit links wherever a zero is desired. The cut mask needed for this information insertion can be generated automatically at reasonable cost.

Bipolar read-only memories with worst case access times of 50nsec are presently available with 128 and 256 bits. MOS ROM arrays with approximately 2μs access times are offered in sizes of 2048 bits and higher. Bipolar ROMs arrays with access times of 100nsec and bit capacities of 1024 bits are expected to be available by mid 1969. (*Text continued on page* 70)

Read-only memory

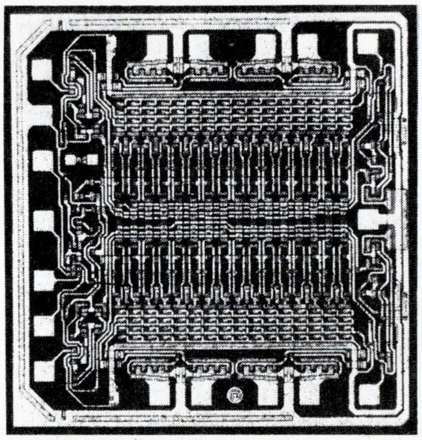




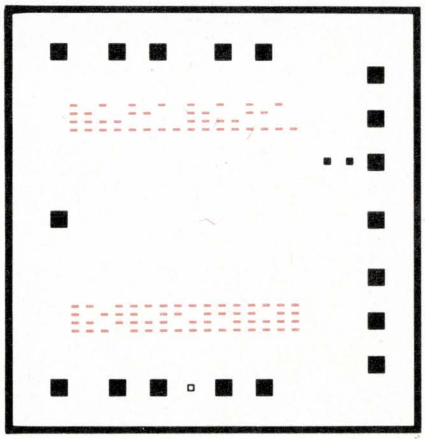
Block diagram and schematic

The versatile read-only-memory. This 128-bit integrated-circuit ROM generates as many as eight functions from a 4-bit binary code. The block diagram and schematic show enable inputs, address gates, decoder driver, array, and output buffers. The actual monolithic measures 88 by 85 mils. Each bit is initially in the logical '1' state, as established by the metal interconnection. The slots in the passivation mask determine which metal links will be removed to change the 1's to 0's.

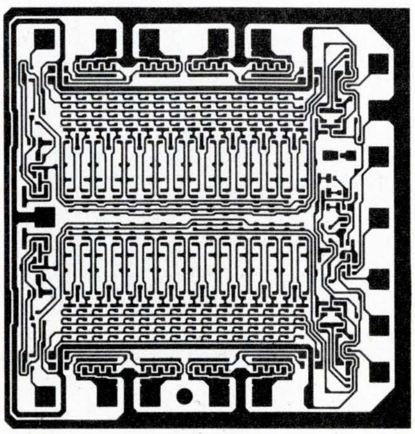
The schematic shows a bipolar, 128-bit ROM (Motorola XC170) organized as an array of 16 words of 8 bits each. Four address bits provide binary coded inputs to select the desired word. The chip also contains four enable inputs useful for address expansion. A word line is enabled (in high or 1 state) when all enable inputs are driven high. With the connections as shown in the schematic word-line 0 will forward-bias the word-line buffer transistors $Q_{0,0}$ through $Q_{0,7}$. The current from the word-line buffer transistors, $Q_{0,0}$, for example, will forward-bias the base-emitter junction of the bit-0 output buffer transistor Q_{B0}, producing a zero output. Under these conditions, the presence or absence of the metal link connections between the emitters of the word-line buffer transistors and the resistors connected to the base of the output transistors (between $Q_{0,0}$ and R_1 for bit 0) determines the presence of a stored "1" or a "0" for each bit. If the link is present and the output is low, a 1 is stored for that particular bit. Hence, the circuit is initially constructed with all 1's stored and is programmed for the desired 0's by etching away metal links.



Monolithic chip



Metalization mask



Passivation mask

ROM

at the top

From Hollerith...

Hollerith punched tape code for numerical control (An EDP card has 80 columns of this 12 bit code)

Symbol	Hollerith Code	RS-358 Code	ROM # Used for Conversion
	(Bit positions)	Bits 8 7 6 5 4 3 2 1	
A	12-1	1 0 0 0 0 0 1	1
B	12-2	1 0 0 0 0 1 0	1
C	12-3	1 0 0 0 0 1 1	1
D	12-4	1 0 0 0 1 0 0	1
E	12-5	1 0 0 0 1 0 1	1
F	12-6	1 0 0 0 1 1 0	1
G	12-7	1 0 0 0 1 1 1	1
H	12-8	1 0 0 1 0 0 0	3
I	12-9	1 0 0 1 0 0 1	3
J	11-1	1 0 0 1 0 1 0	1
K	11-2	1 0 0 1 0 1 1	1
L	11-3	1 0 0 1 1 0 0	1
M	11-4	1 0 0 1 1 0 1	1
N	11-5	1 0 0 1 1 1 0	1
O	11-6	1 0 0 1 1 1 1	1
P	11-7	1 0 1 0 0 0 0	1
Q	11-8	1 0 1 0 0 0 1	3
R	11-9	1 0 1 0 0 1 0	3
S	0-2	1 0 1 0 0 1 1	2
T	0-3	1 0 1 0 1 0 0	2
U	0-4	1 0 1 0 1 0 1	2
V	0-5	1 0 1 0 1 1 0	2
W	0-6	1 0 1 0 1 1 1	2
X	0-7	1 0 1 1 0 0 0	2
Y	0-8	1 0 1 1 0 0 1	3
Z	0-9	1 0 1 1 0 1 0	3
0	0	0 1 1 0 0 0 0	2
1	1	0 1 1 0 0 0 1	2
2	2	0 1 1 0 0 1 0	2
3	3	0 1 1 0 0 1 1	2
4	4	0 1 1 0 1 0 0	2
5	5	0 1 1 0 1 0 1	2
6	6	0 1 1 0 1 1 0	2
7	7	0 1 1 0 1 1 1	2
8	8	0 1 1 1 0 0 0	3
9	9	0 1 1 1 0 0 1	3
:	8-2	0 1 1 1 0 1 0	4
%	0-8-4	0 1 0 0 1 0 1	4
(	12-8-5	0 1 0 1 0 0 0	3
)	11-8-5	0 1 0 1 0 0 1	3
+	12-8-6	0 1 0 1 0 1 1	4
—	11	0 1 0 1 1 0 1	1
/	0-1	0 1 0 1 1 1 1	2
Space	No punches (all zeroes)	0 1 0 0 0 0 0	2
BS	11-9-6	0 0 0 1 0 0 0	4
HT	12-9-5	0 0 0 1 0 0 1	3
LF	0-9-5	0 0 0 1 0 1 0	3
CR	12-9-8-5	0 0 0 1 1 0 1	4

NOTE: 8th bit is parity bit

. . . to punched tape

Hollerith to RS-358 numerical control code

ROM 1

Address-enable function. (These connections are made to the enable input)

$$(\overline{0})\ (\overline{8})\ (\overline{9})\ [(\overline{11})\ (12) + (\overline{12})\ (11)]$$

Address Input A_0 B_0
Address Input A_1 B_1
Address Input A_2 B_2
Address Input A_3 11

Symbol	Hollerith Code	ROM #1 storage location A_3, A_2, A_1, A_0
A	12-1	0 0 0 1
B	12-2	0 0 1 0
C	12-3	0 0 1 1
D	12-4	0 1 0 0
E	12-5	0 1 0 1
F	12-6	0 1 1 0
G	12-7	0 1 1 1
—	11	1 0 0 0
J	11-1	1 0 0 1
K	11-2	1 0 1 0
L	11-3	1 0 1 1
M	11-4	1 1 0 0
N	11-5	1 1 0 1
O	11-6	1 1 1 0
P	11-7	1 1 1 1

one word unused

ROM 2

Address-enable function (Uses all 16 ROM words in ROM #2) $(\overline{8})\ (\overline{9})\ (\overline{11})\ (\overline{12})$

Address Input A_0 B_0
Address Input A_1 B_1
Address Input A_2 B_2
Address Input A_3 0

ROM 3

Address-enable function (Uses 12 ROM words in ROM #3) $(\overline{6})\ (\overline{4})\ (\overline{2})\ [(8)\ (\overline{9}) + (\overline{8})\ (9)]$

Address Input A_0 8
Address Input A_1 12
Address Input A_2 0
Address Input A_3 5

ROM 4

Address-enable function (Uses 5 words in ROM #4)

$$(\overline{8})\ (\overline{9})\ (\overline{6}) + (8)\ [9 + 2 + 6 + 4]$$

2, 5, 6 coded as

Address Input A_0 }
Address Input A_1 }

2—01
5—10
6—11

12, 11, 0 coded as

Address Input A_2 }
Address Input A_3 }

12—01
11—10
0—11

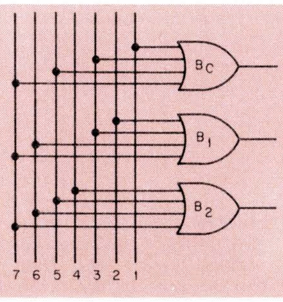
The Hollerith punched card code is popular in digital systems. But there are other codes—for example, the EIA RS-358 code for information interchange in perforated tape numerical control machines—and to go from one code to the other requires a translation. This is easy to achieve with read-only memories.

In the translating circuit below, the Hollerith code has 12 bits while the RS-358 is an 8 bit code. Since the output code from this translation is of 8 bit length, each word of a 16 word, 8 bit read only memory can make the translation to the output code. A problem arises in addressing the ROM from the 12-bit Hollerith code since the ROM is designed to be addressed with a straight 4-bit binary code. However, certain characteristics of the Hollerith code can be used to advantage in solving this problem. First note that only one of the bits in the group 1, 2, 3, 4, 5, 6, 7 is activated at a time. Hence, the input code can be compressed by reducing these 7 inputs into the 3-bit binary code indicated below:

Thus, by using only three 4-input OR gates, the input code is reduced to 8 bits (the original 12 less the 4 realized by the above compression). Furthermore, the address enable inputs of the ROM can be used to similar advantage permitting a block of characters and their Hollerith equivalents to be translated into RS-358 code by means of a single ROM.

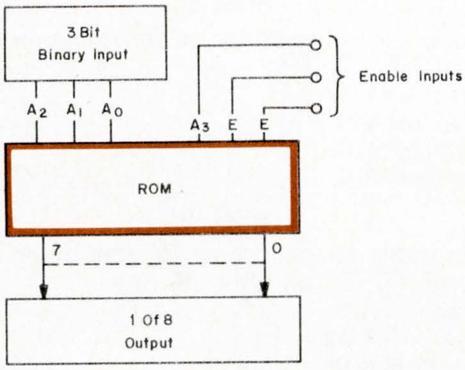
In the case illustrated here, for example, ROM #1 converts 15 characters. The inputs 1, 2, 3, 4, 5, 6, 7 are compressed into three bits B_2, B_1, B_0 that serve as three of the address inputs, input 11 is the fourth address (A_3), and $(11 + 12)\ (\overline{0})\ (\overline{9})\ (\overline{8})\ (\overline{11})$ is the enable function. Hence, the Hollerith codes illustrated serve as the address inputs to the ROM, showing the word location where the desired RS-358 code can be stored.

The remainder of the character set can be divided in a similar manner and be arranged to address additional ROMs. This method can be expanded to translate from Hollerith to other output codes as well.



Hollerith code bits 7 6 5 4 3 2 1	New, compressed code bits B_2 B_1 B_0
0 0 0 0 0 0 1	0 0 1
0 0 0 0 0 1 0	0 1 0
0 0 0 0 1 0 0	0 1 1
0 0 0 1 0 0 0	1 0 0
0 0 1 0 0 0 0	1 0 1
0 1 0 0 0 0 0	1 1 0
1 0 0 0 0 0 0	1 1 1

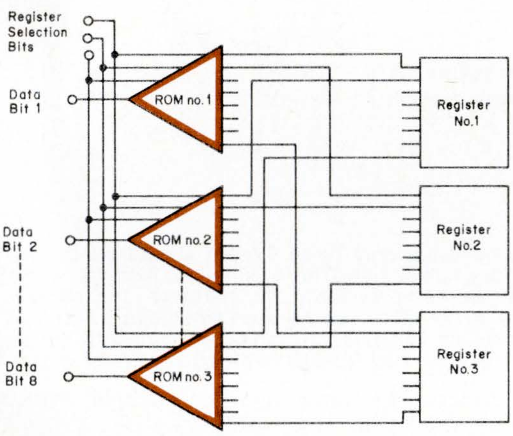
ROM applications: Decoding . . .



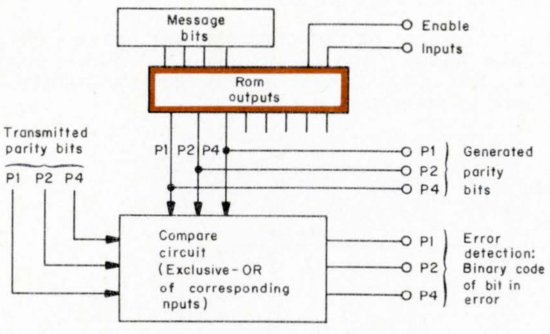
ROM Storage Pattern

Input				Output (Bit No.)							
A_3	A_2	A_1	A_0	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	0
		⋮					⋮				
0	1	1	1	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	1
1	0	0	1	0	0	0	0	0	0	1	0
1	0	1	0	0	0	0	0	0	1	0	0
1	0	1	1	0	0	0	0	1	0	0	0
1	1	0	0	0	0	0	1	0	0	0	0
1	1	0	1	0	0	1	0	0	0	0	0
1	1	1	0	0	1	0	0	0	0	0	0
1	1	1	1	1	0	0	0	0	0	0	0

Decoder. Read-only-memory converts BCD format into 1-out-of-8 code. The three binary-coded inputs drive address lines A_0, A_1 and A_2. Address line A_3—as well as "chip enable input"—may be used for enable gating. A logical '1' stored in the memory results in a low output for the corresponding bit output; hence inverters will be required for applications that need high output states. If the storage pattern is inverted—'1's replace '0's and '0's replace the '1's—these extra inverter stages aren't necessary, but the utility of the chip enable inputs is lost. For such a setup the enable inputs must be connected "high" to permit outputs to remain low when not selected. With eight additional ROM chips configured in like fashion a one-out-of-sixty-four decoder subsystem is achieved.



ROM data distributor routes inputs to one of N outputs as directed by the address on the control lines (1-of-8 distribution is shown). If the data line (address input line A_3 in decoder above) is in the '1' state, the output line specified by bits A_0, A_1, A_2 contains a '1'. Here eight memory chips distribute 8 bits of data to the one register, specified by the selection bits, out of the eight registers. If, instead of registers, eight output lines were the ultimate destination, the wired-OR output feature of the ROM could be connected in common to achieve this. Such a matrix, which resembles a crossbar switching system, may have its interconnection system generated in two ways: a basic storage pattern like that of the decoder above can provide external control (with the chip outputs wired accordingly), or internal (to the ROMs) control, whereby a separate pattern is generated for each storage chip.

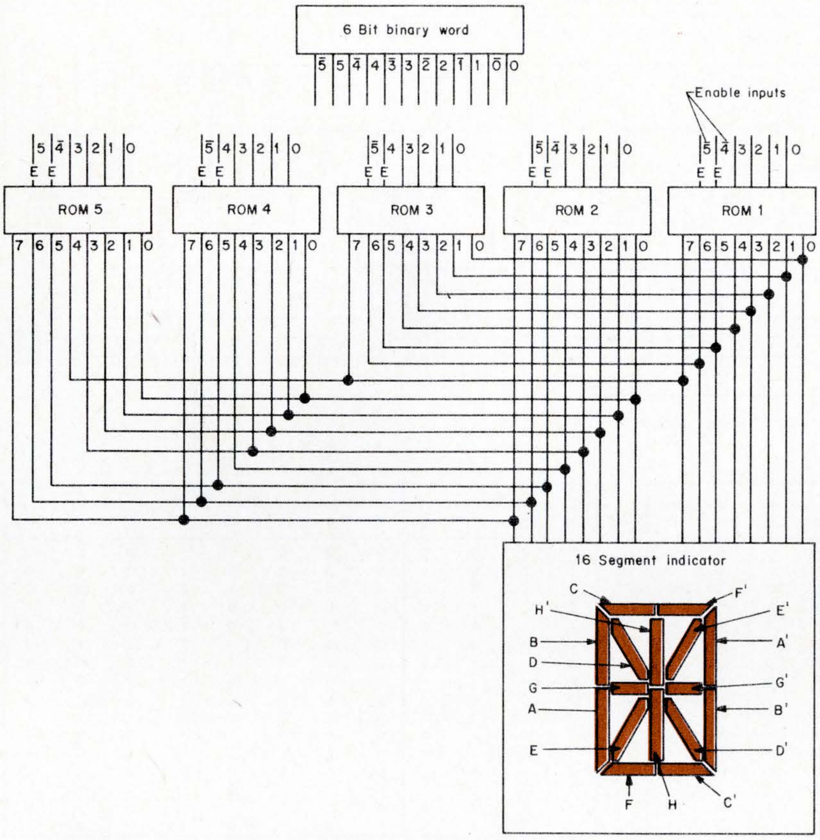


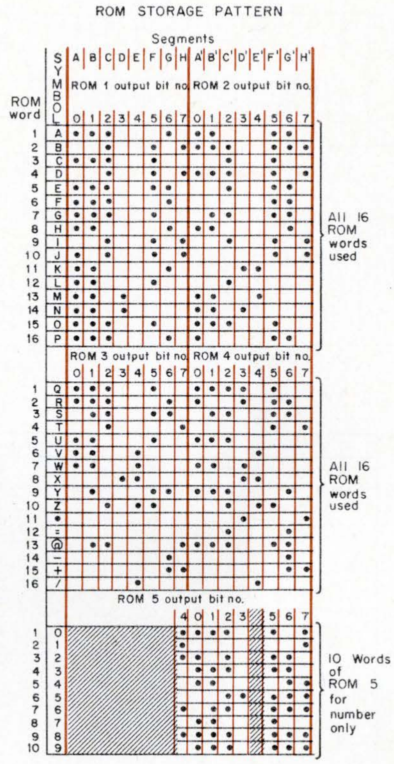
Storage Pattern

Input				Output (Bit No.)							
A_3	A_2	A_1	A_0	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	1	1	1	0	0	0	1	1	0
0	0	1	0	1	1	0	1	1	0	1	0
0	0	1	1	0	0	0	1	1	1	0	1
0	1	0	0	1	1	1	0	1	1	0	0
0	1	0	1	0	0	1	0	1	0	1	1
0	1	1	0	0	0	1	1	0	1	1	1
0	1	1	1	1	1	1	1	0	0	0	0
1	0	0	0	1	1	1	1	1	1	1	0
1	0	0	1	0	0	1	1	1	0	0	1
1	0	1	0	0	0	1	0	0	1	0	1
1	0	1	1	1	1	1	0	0	0	1	0
1	1	0	0	0	0	0	1	0	0	1	1
1	1	0	1	1	1	0	1	0	1	0	0
1	1	1	0	1	1	0	0	1	0	0	0
1	1	1	1	0	0	0	0	1	1	1	1

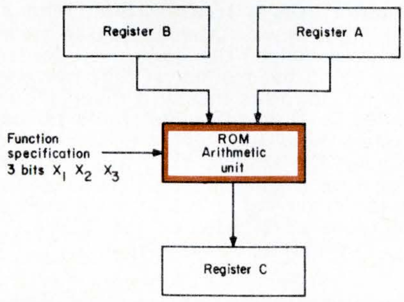
Detection of single errors in a binary word with the Hamming code. This code adds parity bits to the original word to locate erroneous bit number. One read-only-memory chip generates the three parity bits P_1, P_2 and P_4 as a function of the four data bits, which serve as address bits. Each of the 16 memory locations is programmed to contain the proper parity information for P_1, P_2 and P_4 for the corresponding combinations of input variables. Errors are detected by comparing the generated parity bits with the transmitted parity bits; the comparator output identifies the erroneous data bit. Note that only three of the eight storage bits are required to generate P_1, P_2 and P_4 for the four message bits; bit 0 is a simple odd parity bit. Bits 4-7 are designed for use with longer message words.

. . . Code translation . . .

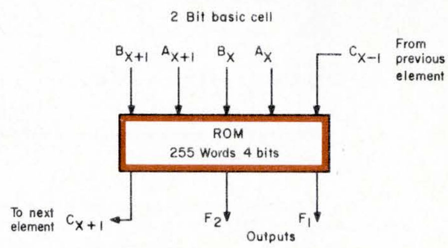




Binary to 16-segment alphanumeric decoder. The ROM translates a 6-bit binary word into a code used to drive the 16 lamps of the indicator. Dots in storage pattern indicate a bit location in which a '1' is stored. Since only five 128-bit ROMs are used for translation, we use two ROMs to generate the alphabetic characters A to P, two more ROMs for Q to /, and one ROM for symbols 0 through 9, restricted to 7 of the segments in the right half of the indicator. When an ROM output bit number is connected to the segment listed directly above each bit, the patterns programmed into the two ROMs will illuminate the symbols corresponding to each row. For example, the display of symbol A requires illumination of segments A, B, C, G—controlled by ROM #1—and A', B', F', G', controlled by ROM #2. Thus, one stored word in each of two ROMs is used to display the symbol A.

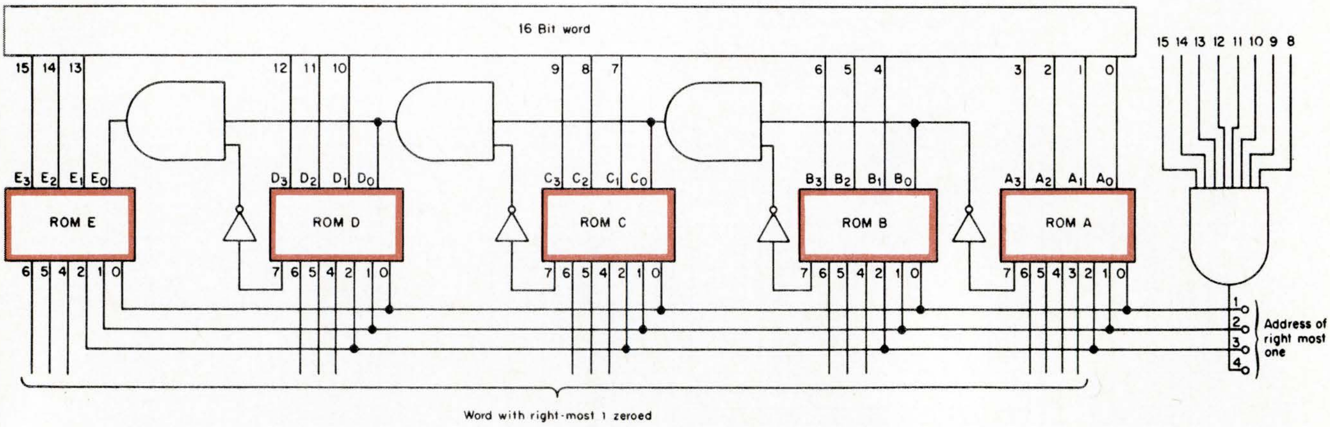


X_1	X_2	X_3	Y_1 Y_2 Y_3 Y_4 Y_5
0	0	0	Add
0	0	1	Subtract
0	1	0	Word zero
0	1	1	Parity
1	0	0	And
1	0	1	Or
1	1	0	Equal
1	1	1	Exclusive - or



Logic function generator employs two ROMs as an arithmetic unit. Here a 256-word, 4-bit read-only-memory provides eight different functions over two input bits. Registers A and B each feed 2 bits into the memory. A 5th input provides the carry, borrow, etc., command from the previous element in an iterative parallel machine, or from a storage element of a serial machine. Three additional address inputs ($256 = 2^8$) are available for function specification. A set of typical 8 functions would be ADD, SUBTRACT, WORD ZERO, PARITY, AND, OR, EQUAL, and EXCLUSIVE-OR. Others can also be accommodated. For example,
a single input high function: $F = A_0 + A_1 + A_2 + A_3$,
a single input low function: $F = A'_0 + A'_1 + A'_2 + A'_3$,
a 4-input exclusive-OR: $F = A_0 \oplus [A_1 \oplus (A_2 \oplus A_3)]$,
all inputs high: $F = A_0 A_1 A_2 A_3$,
all inputs low: $F = A'_0 A'_1 A'_2 A'_3$
For each of the function specification combinations, the ROM can be programmed to provide the appropriate outputs on F_1, F_2 and the carry output.

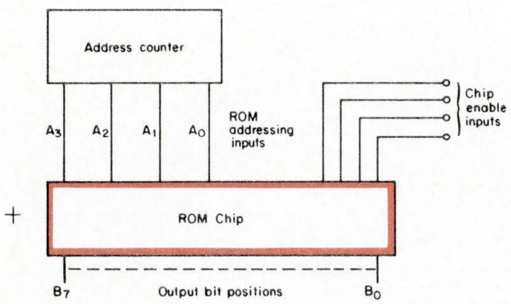
. . . ROM applications: arithmetic . . .



Input				Output (Bit no.)							
A_4	A_2	A_1	A_0	7	6	5	4	3	2	1	0
0	0	0	0	1	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0	0	1
0	0	1	0	0	0	0	0	0	0	1	0
0	0	1	1	0	0	0	1	0	0	0	1
0	1	0	0	0	0	0	0	0	0	1	1
0	1	0	1	0	0	1	0	0	0	0	1
0	1	1	0	0	0	1	0	0	0	1	0
0	1	1	1	0	0	1	1	0	0	0	1
1	0	0	0	0	0	0	0	0	1	0	0
1	0	0	1	0	1	0	0	0	0	0	1
1	0	1	0	0	1	0	0	0	0	1	0
1	0	1	1	0	1	0	1	0	0	0	1
1	1	0	0	0	1	0	0	0	0	1	1
1	1	0	1	0	1	1	0	0	0	0	1
1	1	1	0	0	1	1	0	0	0	1	0
1	1	1	1	0	1	1	1	0	0	0	1

Input				Output (Bit no.)							
A_3	A_2	A_1	A_0	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	-	0	0	0
0	0	0	1	1	0	0	0	-	0	0	0
0	0	1	0	0	0	0	1	-	0	0	0
0	0	1	1	0	0	0	0	-	1	0	1
0	1	0	0	0	0	1	0	-	0	0	0
0	1	0	1	0	1	0	0	-	1	1	0
0	1	1	0	0	0	1	1	-	0	0	0
0	1	1	1	0	0	1	0	-	1	0	1
1	0	0	0	0	1	0	0	-	0	0	0
1	0	0	1	0	1	0	0	-	1	1	1
1	0	1	0	0	1	0	1	-	0	0	0
1	0	1	1	0	1	0	0	-	1	0	1
1	1	0	0	0	1	1	0	-	0	0	0
1	1	0	1	0	1	0	0	-	1	1	0
1	1	1	0	0	1	1	1	-	0	0	0
1	1	1	1	0	1	1	0	-	1	0	1

Detection of the right most (least significant) bit, performed with read-only-memory. The pattern for chip A indicates that if address input lines to a particular chip possess all zeroes, then the next chip in the chain is enabled. Hence, the first chip with a '1' on any of its address inputs will control the output. The circuit is iterative, with each cell different from the next. The output consists of the original word with the right-most 1 zeroed. The new word can then be examined for the next right-most 1, or otherwise processed. Each chip must calculate the right-most 1 address if enabled, and also furnish bits for the new 16-bit word. Chip A—since it is the right-most chip—merely removes the right-most 1 if it exists in the first four bits, and furnishes 4 bits for the new word. The pattern: if address input A_0 is enabled (all bits examined by cells to the right of this cell are zero), then the chip output for bits 3-6 should be the input address with the right-most 1 bit zeroed. If input A_0 is zero, the present input passes on to the output without alteration.

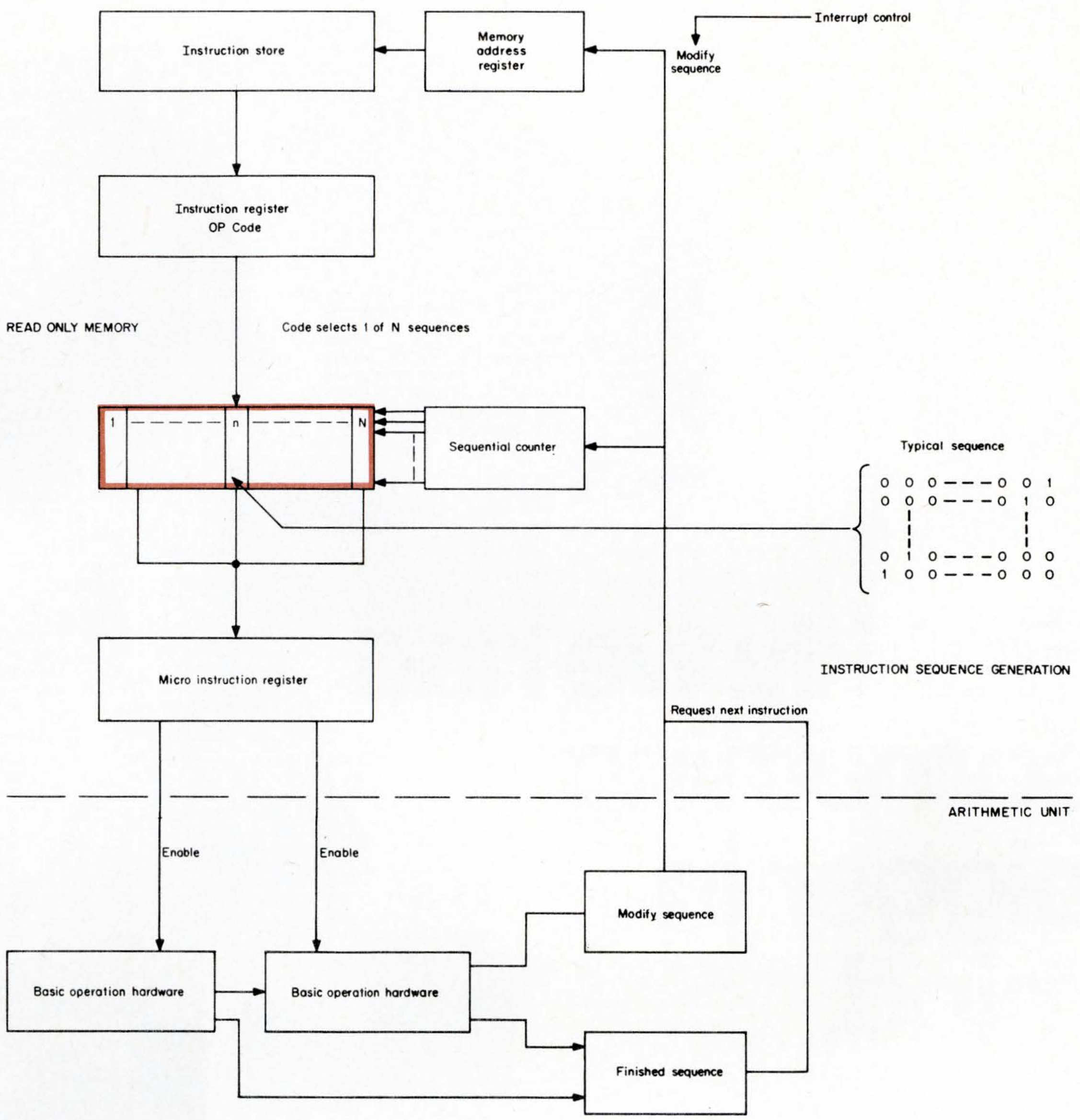


Sequence generator uses a 16-word, 8-bit read-only-memory. The 4-bit binary counter addresses each of the 16 words in sequence. The code used for each 8-bit word depends on the number of different operations to be performed. Thus if only 8 distinct operations are required, a 1-out-of-8 code would be used. A translation stage employing other ROM chips can be used to convert the storage code to a 1-out-of-N code if additional operations are required. The same scheme works for longer sequences that are multiples of eight. This expansion is based on the ROM's chip-enable-inputs and wired-OR capabilities.

The smaller bit size ROMS will find their greatest use in code conversion functions. On the other hand, the larger size ROMS will find considerable use in sequence generation. Such applications utilize the code translation function of a ROM cell. In addition, by sequential addressing of ROM words we can generate sequences of coded information.

Since the generation of sequences is a basic concept to digital systems, ROMS can be used to generate the control sequences within both stored-programs and wired-program machines. In a stored-program machine, sequences appear in various levels of the system structure. Two such examples are sequences of instructions (subroutines), and the gating sequences necessary to

. . . Microprogramming



Microprogrammer uses a read-only memory technique to manipulate computer data. An instruction has been read from the memory and gated into the instruction register. The operations code (OP CODE) of the instruction causes a certain section of the instruction sequence store (the ROM) to be addressed. The sequential counter is now activated, gating the first word within the addressed section into the micro-instruction register. The micro-instruction sets a basic operation (such as a gating function) within the arithmetic section of the computer. The sequential counter then advances and a second micro-instruction is read-out. With this approach, the arithmetic unit alters the sequence within an instruction or the normal sequence of instructions. Instructions may be altered and new instructions added by replacing that particular section of the micro-instruction sequence store. Thus, we modify only a small portion of the control logic to make alterations—as contrasted with the total modification required by the control logic of a conventional machine.

process a single instruction. Many wired-program machines contain or can be organized to contain sequencing circuits. In addition, machines designed with ROMS can be reconstructed or modified to accomplish a different task much easier than with other memories—as in microprogramming. Several of these applications are illustrated in this article.

INFORMATION RETRIEVAL:
Computers, Digital design, Semiconductors, Integrated circuits, Systems

Anyone can think small.

Frankly, we had something bigger in mind.

We built our second generation DPM* to fit into seven square inches of panel. *That's less than any other digital panel meter requires.* But we didn't stop there. The Model 1290 mounts completely from the front of the panel. *The entire chassis pulls out from the front for servicing or replacement.* Even the Nixie** tubes are pluggable! Think of the convenience in continuous systems operation. Despite the smaller package, Model 1290 has all the features our original DPM is so widely acclaimed for—3-digit plus 100% overrange display, 0.1% ±1 digit accuracy, circularly polarized window filter, dual slope integration, full-buffered storage display and BCD output. Many of these standard Weston features are still "optional at extra cost" on competitive units. Our new compact is styled for tomorrow, available today, and priced below $200 in quantity. Anything else in the industry is just small talk. WESTON INSTRUMENTS DIVISION, Weston Instruments, Inc., Newark, New Jersey 07114.

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Instrumentation: The systems approach

Instead of performing isolated measurement tasks, instruments are taking on more and more of the complete data job.

Two bywords which summarize the approach today's electronic components are taking—*integration* and *systems-orientation*—also reflect the latest trends in instrumentation. Instead of isolated measuring tasks, instruments are performing a host of related functions, taking on more and more of the complete data job.

This systems trend has had a big impact on data gathering, data analysis, and data use. It is changing the engineer's role in that closed loop. He now requires new guidelines to evaluate and apply instruments.

There are many factors he must take into account: How do all the separate instruments interrelate in a system? What are the advantages and limitations of the systems approach? Which will best suit him—programming features or manual control? What is the computer's role? And many, many others.

Evolution, not revolution

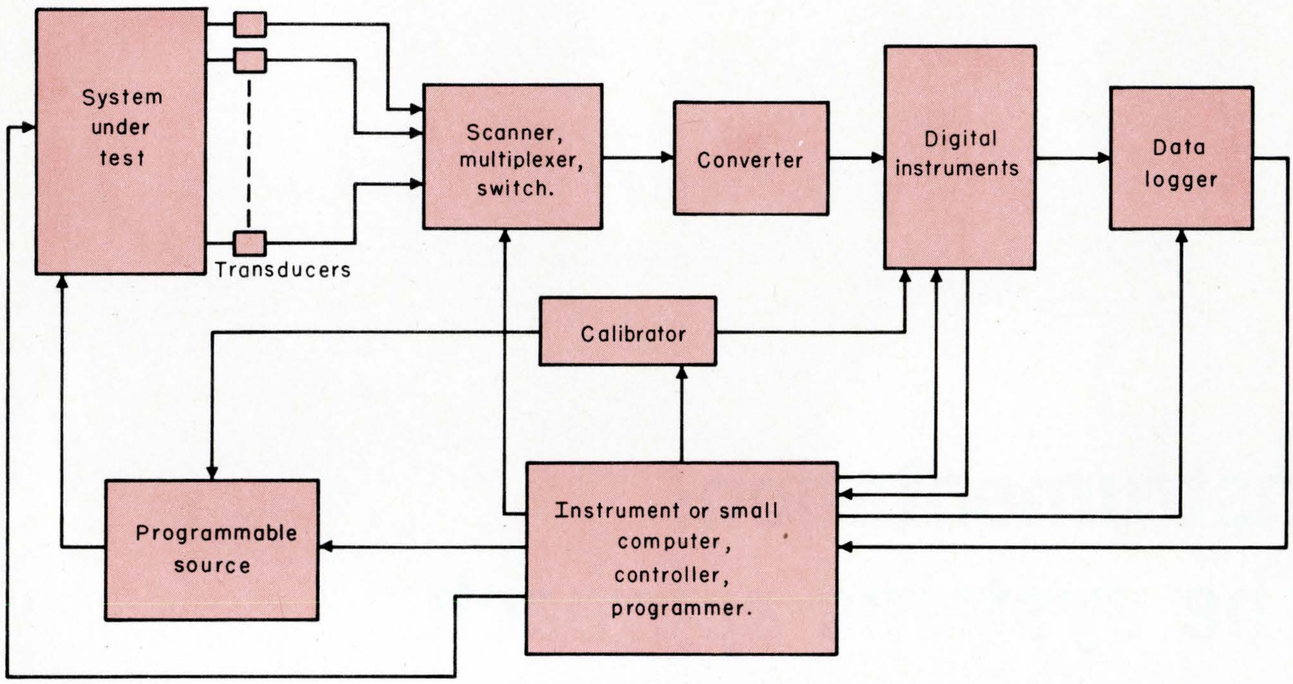
The systems push isn't radically new; it has been evolving for more than a decade. Today, instrument systems account for about 15% of all instrument business. By the mid-1970s its share may well be 50%. And manufacturers are pleased to admit systems activity comes as an addition to the traditional business, not at its expense. However, some feel systems growth will eventually hurt individual instrument sales.

A marketing official of Teradyne believes "the real systems trend involves the extent to which the manufacturer is responsible for seeing that all the parts work together. It means designing the entire system electrically and mechanically, and marketing it as a unit." Others submit the approach is characterized by systems-like features (such as programmability) added to individual instruments.

Whereas many instrument systems in the past were designed by users, more today are being built by manufacturers: instrument firms; systems firms; even computer companies; and conglomerates in all three areas.

Barton A. Weitz, product marketing manager at Dana Laboratories Inc., maintains the systems trend is reflected by the nature of the building blocks used. "The number of different blocks required is decreasing

Sample and hold



A representative sampling of individual system-type instruments, small computers, and data systems is compiled on these and the following pages. Information includes price, maker and model number, and salient features. Equipment is classified into instrument class (e.g., DVMs, computers, data-acquisition systems, etc.). The data is merely a rough guide to off-the-shelf hardware. EE's editors suggest you write to the various manufacturers to obtain full information.

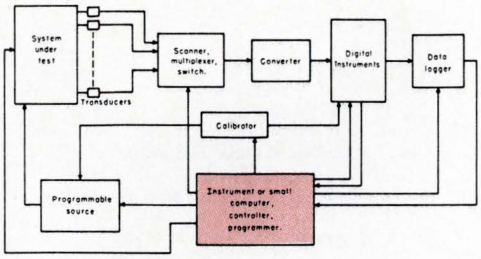
and more of the calculating and control functions are being handled by one instrumentation computer," he argues.

Detailed examinations of these and other issues will be presented in a forthcoming series of articles. For your immediate concern, we have compiled charts that will show you a sampling of the hardware available for systems use. They may also be used to help you evaluate individual equipment and instrument complexes.

For good measure

The following is a checklist of items to consider before you purchase an instrument. They reflect the systems thrust, and will help you get full value for your measurement dollar.

- How much of the complete measurement job (beyond mere "reading") does the instrument provide?
- How easily does it interface, electrically and mechanically, with other associated instruments?
- Does it combine the features and capabilities of two or more older instruments, to ease the measurement task?
- Can it measure systems variables as well as component and circuit parameters?
- Is the data generated in a directly usable form?
- In terms of dials, controls, adjustments, calibration, and so forth, is the equipment easier to operate?
- Does it have provision for environmental testing?
- Will it save time and labor, freeing skilled personnel for more vital work?
- How easily can it be controlled automatically, such as by a computer or control mechanism?
- How difficult will the programming be?
- Is there a more-universal, less-costly system available to do the job you intend for an instrument 'hodgepodge'?
- What kind of assistance does vendor offer?
- Does the instrument have both analog and digital capabilities?
- Can operation be manual, as well as automatic?
- How easily can the gear be modified (e.g., by plug-in modules or circuit boards) to suit it to tasks?
- What are the relative costs of building your own system as against purchasing one?

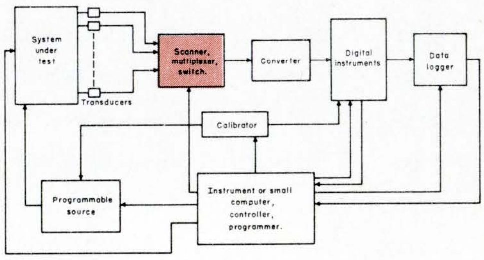


SMALL COMPUTERS

MINIMUM PRICE ($)	MAKER & MODEL #	DATA WORD SIZE (BITS)	MEMORY SIZE (E denotes Expandable)	MEMORY SPEED (μsec)
6600	Data Tech. Corp. DT-1600	8	4096 words, E	8.0
6900	Interdata 2	8	1000 bytes, E	3.0
7500	Varian 520/i	8	4096 bytes, E	1.5
8000	Motorola MDP-1000	8	4096 words, E	2.16
8500	Dig. Equip. Corp. PDP-8L	12	4096 words, E	1.5
9200	Bus. Info. Tech. BIT-480	8	1000 characters, E	8.0
9200	Interdata 3	16	4000 bytes, E	1.5
9700	Honeywell H-316	16	4096 words, E	1.6
9950	Hew.-Pack (HP) HP-2114A	16	4096 words, E	2.0
11,000	Burroughs L2000	64	1024 words, E	5000
12,100	Varian 620/i	16	4096 words, E	1.8
12,800	Dig. Equip. Corp. PDP-8i	12	4096 words, E	1.5
13,000	Interdata 4	16	4000 bytes, E	1.2
13,900	Data Mach. Inc. Data-6201	16	4000 words, E	1.8
14,900	Dig. Equip. Corp. PDP-12	12	4096 words, E	1.6
15,000	Raytheon 703	16	4000 words, E	1.75
16,000	Dig. Equip. Corp. PDP-8	12	4096 words, E	1.5
16,500	HP 2115A	16	4000 words, E	2.0
16,900	Honeywell DDP-416	16	4000 words, E	0.96
19,000	Raytheon 706	16	4096 words, E	0.9
22,000	HP 2116A	16	4000 words, E	1.6
23,950	Syst. Eng. Labs SEL-810A	16	4000 words, E	1.75
25,000	Honeywell DDP-516	16	4000 words, E	0.96
25,880	IBM 1131	16	4096 words, E	3.6
<30,000	Elec. Assoc. Inc. EAI-640	16	4000 words, E	1.65
<30,000	Syst. Eng. Labs SEL-810B	16	4000 words, E	0.8

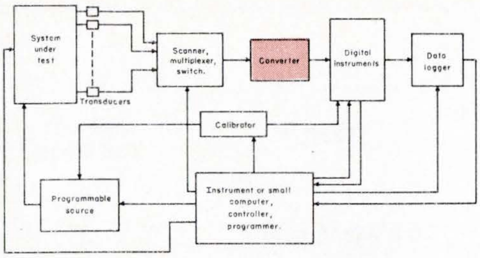
PROGRAMMERS

PRICE ($)	MAKER, MODEL #	TYPE	FOR
325	Tektronix 263	CRO-Control	6 Measurements
375	Monsanto 570A	General	1-10 Programs 64 bits/Prog.
1200	HP 6933A	D to A Interface	18 Lines, Analog Program
1550	Tektronix R250	Power supply Pulse Gen.	Auxil. Prog. Patch Panel
1600	Tektronix 262	CRO-Control	8 Meas.
2000	Tektronix 241/R241	CRO-Control	15 Meas.
2175	Jerrold PC-6	Event	FCC Freq. Tests
4000	Tektronix 240/R240	CRO-Control	Storage, Branching, Ser to Par Conv.
—	Moore series 575C	A & D	Pressure



SCANNERS, MULTIPLEXERS

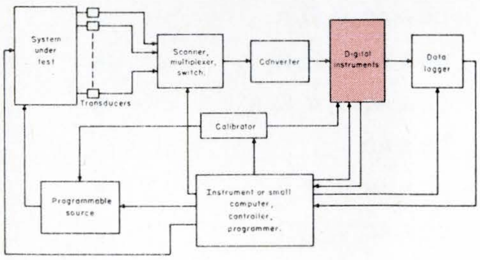
PRICE ($)	MAKER, MODEL #	NO. OF CHANNELS	OUTPUT	DISPLAY DIGITS	INPUT RATE
825-1550	Scanivalve Aerospace line	48	BCD & 0-30mV	—	0-10,000 psia
1975	HP 2901A	25 3-wire inputs	Programmed	2	12 chan/s
2000 up	Non. Lin. Syst. 2300 series	32	BCD	3	2.5ms/Chan; 1μV-750 V
2150-4875	Scanivalve 48CBM	48-576	BCD & 0-30 mV	—	0-500 psia
2575-19,150	Scanivalve 64CBM	64-768	BCD & 0-30 mV	—	3-15 psig
2975	Beckman 3701	10	8 bits	—	320 bits
3500	GR 1770	100	—	—	—
3500	HP 2912A	1000	Prog.	3	40 chan/s
4475	HP 2515A	12 digits	BCD	—	10 meas/ms
5100	HP 2911 A,B,C	600	Prog.	3	30 chan/s
6975	Beckman 3700	100	100mV-10 V	4	5,000 samp/s



CONVERTERS

PRICE ($)	MAKER, MODEL #	TYPE	OUTPUT	LINEARITY %	INPUT RATE OR CAPACITY
250	EAI 6203	ac to dc	4 DEC	0.2	20 Hz-100 kHz
250	Dig. Equip. Corp. A613	D to A	---	---	12 bits
450	Beckman 4027	A to Bin.	10 Bits	0.1	10/s.
495	Beckman 4060	Bin to Dec	4 BCD	---	13 bits
650	Monsanto 503A	D to A	1 mA	0.25	BCD
755	Gen. Radio 1136	D to A	1 mA, 0.1 V	0.1	9
2250	HP 2410B	ac, Ω to dc	0-1 Vdc	---	10^7 Ω, 0-750V
2400	HP 3461A	ac, dc Ω to d	---	.004	5 ranges
2900-3100	Interdata 7-750 series	A to D	8-12 bits	---	64 channels
---	Moore Synchro	D to A	3-15 psi	0.1	1
---	Non Lin. Syst. 2610	Serial	6 Digits 7 options	---	18 characters
---	Raytheon Mini	A to D	Computer	.05	10-13 bits 256 chars.
---	Raytheon MDAC	A to D	Comp.	.05	10-13 bits 48 chan.
---	Raytheon MDAC	D to A	Comp.	.05	10-13 bits
---	Raytheon DAC60	D to A	±10V	.05	10 bits
---	Interdata 7-760 series	D to A	8-12 bits	---	16 chan.
---	Datawest 301	A to D	Bin.	.01	15 bits

* A= Analog; D = Digital; Bin = Binary; Ω = OHMS; DEC = Decimal; BCD = Binary-Coded/Decimal



DIGITAL VOLTMETERS

PRICE ($)	MAKER, MODEL #	ACCUR. (%)	RANGES	TYPE *	DISPLAY (Full Digits)
240	EAI 6201	0.1	5	DC; V	3
245	Fairchild 7020	0.1	–	DC	–
389	Darcy DM 330	0.1	–	DC & AC; V, A, Ω	3
595	HP 3430A	0.1	5	DC; V, R	3
695-1380	DTC 350 Series	0.01	4	DC & AC; V, Ω, R	4
765 up	Non-Linear Syst. X-3A Series	–	9	DC & AC; V, A, Ω	3

(Digital voltmeter listing continued on following page.)

(Digital voltmeter listing continued from previous page.)

PRICE ($)	MAKER, MODEL #	ACCUR. (%)	RANGES	TYPE *	DISPLAY (Full Digits)
795	United Syst. Corp. 251	0.01	4	DC; V	4
835	Simpson 2701	1.5	6	DC & AC; V, A, Ω	3
950	HP 3439A	0.05	5	DC & AC; V, A, Ω, R	3
995	Darcy DM 440	0.01	–	DC & AC; V, A, Ω, R	4
995	DTC DT-321	0.01	3	DC; V	5
1115 up	Non-Linear Syst. X-2 Series	0.02	4	DC & AC; V, Ω, f, R	4
1150-1795	Dana 4400 Series	0.01	4-5	DC & AC; V, Ω, R	4
1160	HP 3440A	0.05	5	DC & AC; V, A, Ω, R	3
1175-1725	Systr.-Donn. 9200 Series	0.01	5	DC & AC; V, A, Ω, R	4
1195-1795	Systr.-Donn. 9300 Series	0.01	5	DC & AC; V, A, Ω, R	4
1225	DTC 322	0.01	3	DC; V, R	5
1250	Heath EU805A	0.05	–	DC	–
1445	DTC 323	0.01	5	DC; V	5
1590	Vidar 501	0.025	–	DC	–
1740	Cimron 6653A	0.01	–	DC & AC	–
1790-2585	Dana 5400 Series	0.01	2-5	DC & AC; V, Ω, R	4
1830	DTC 324	0.01	5	DC; V, R	5
1850	DTC 326	0.01	10	DC; V, Ω, R	5
1850	Systr.-Donn. 6413 Series	0.025	4	DC; V, f	5
1900	DTC 327	0.01	8	DC & AC; V, Ω, R	5
1,950 up	Singer 3570 series	–	6	dc & ac, V.	4
2355	DTC 325	0.01	8	DC & AC; V, Ω, R	5
2390	Vidar 502	0.025	–	DC	–
2485	Fluke 9500A	0.05	–	AC	–
2575	Fairchild 7100A	0.01	–	DC & AC	–
2750	DTC DVX-315	0.003	13	DC & AC; V, Ω, R	6
2785 up	Non-Linear Syst. X-1	0.005	5	DC & AC; V, Ω, R	5
2850-3540	Dana 5500 Series	0.01	2-3	DC & AC; V, Ω, R	5
2975	HP 3459A	0.001	3	DC & AC; V, A, Ω, R	5
2990	Cimron 6753	0.1	–	DC & AC	–
3150	HP 3450A	0.003	6	DC & AC; V, Ω, R	5
3600	HP 3460B	0.004	4	DC & AC; V, A, Ω, R	5
3800	HP 3460B	0.004	4	DC; V	5
4100	HP 2401C	0.01	8	DC & AC; V, A, Ω, R, f, T	5
4100-5300	Dana 5700 Series	0.008	3-5	DC & AC; V, Ω, R	5
4390	Cimron 4600	0.001	–	DC & AC	–
4500	Fairchild 7200	0.005	–	DC & AC	–
4600	HP HO4-3460B	0.005	4	DC & AC, V, A, Ω, R	6
4800	HP 2402A	0.01	4	DC & AC; V, A, Ω, R	5

*V=VOLTAGE; A=CURRENT; Ω =OHMS; R=RATIO; f=FREQUENCY; T=TIME OR PERIOD

OTHER DIGITAL METERS*

PRICE ($)	MAKER, MODEL #	ACCUR. (%)	READS	DISPLAY (Full Digits)	MEASUREMENT TIME
175	API 4301	0.1	DC; mV, V, A	3	1/5 s
199	DTC, DT-340	0.1	DC; V, Ω, R	3	1s
245	Honeywell, VT-100	0.2	DC; V, Ω, R	3	1s
225-300	Time Syst. Corp. 701,3,4,11	0.1	DC; mV, V, A	3	–
245-320	Time Syst. Corp., 700,710	0.1	DC; mV, V, A	3	0.2s
295-395	Syst.-Donn., 9000 series	0.1	DC; V, A, Ω	3	1/6s
340	EAI, 6200	–	DC & AC; V, f, T	3	0.2s
345,395	Beckman, 4025, 4026	0.1	DC; V, A	3	0.2s
350	Triplett, 500	0.1	DC & AC; mV, V, A	3	1/6s
375	DTC, DT-360	0.1	DC & AC; V, A, Ω	3	0.2s
550	HP 4260A	–	Impedance Meter	3	–
1575	Keithley 418A	2.0	Picoamp meter	5	4s
2450	Keithley 419	1.5%	Picoamp meter	4	0.3s
2500	Boonton 700A	0.25	Capacitance and inductance meter	4 4	0.3s 0.3s
–	DTC DVX-315A	0.003	DC; V, Ω, R	5	–
–	Simpson 2800	0.1	DC; V, A	3	0.2s

*Panel type unless otherwise indicated.

DIGITAL FREQUENCY METERS

PRICE ($)	MAKER, MODEL #	RANGE	ACCUR. (%) OR RESOL.	DISPLAY (FULL DIGITS)
425	Beckman 4038	10^6 events/sec 10 Hz-1 MHz	0.01	4
450	Beckman 4038	10^6 events/sec 10 Hz-1 MHz	0.01	4
1000	Syst.-Donn. 6013	2 Hz-5 MHz	–	4
1450	Syst.-Donn. 6014	0.2 μs - 10^6s, 0-10 MHz	–	6
1650	CMC 738	10 Hz-100 MHz	–	7
4650	Syst.-Donn. 6316	0-100 MHz	0.01	7
4750	HP 5240A	0.3-12.4 GHz	1 count	8

DIGITAL COMPARATORS

PRICES ($)	MAKER, MODEL #	TYPE	RANGE	ACCUR. (%)	OPER. SPEED
475	Beckman 4070	Dig. limit	4 Dec	–	100 μs
540-925	Auto Dyn. 66 series	Dig. limit	4-8 Dig.	–	1 μs
795	Monsanto 504A	Dig. limit	5 Dig.	–	1 μs
850	Monsanto 104A	Dig. limit	5 Modes, 1-10 V	<1%	<1 μs
1625	GR 1781	Dig. limit	11 digits	0.1	–
1800	HP 3434A	Dig. limit	100mV-1000 V, 1K-10 M Ω 100 μA-1A	0.02	0.2s
2000	Non Lin. Syst. 5510	Dig. limit	6 Dig.	–	–

(Digital comparator listing continued on following page.)

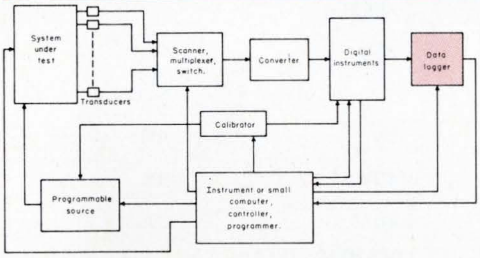
(Digital comparator listing continued from previous page.)

PRICES ($)	MAKER, MODEL #	TYPE	RANGE	ACCUR. (%)	OPER. SPEED
2650	HP 2539A	Dig. limit	12 compar.	–	<3 ms
4975	GR 1681	Imped.	2 Ω-20 M Ω, 20 pf-800 μF 400 μH-1000 H	0.005	0.5s
4975	GR 1680	Cap Bridge	0.01 pF-1000 μF	0.1	0.25-50 s
–	Marconi TF2412	Dig. limit	5-9 Dig.	–	25 μs

DIGITAL COUNTERS, TIMERS

PRICE ($)	MAKER, MODEL #	NO. OF FULL DIGITS	RANGE
70-110	Janus 6011 series	5	500 mV-30 V, 0-3 MHz
120	Wang IC-1	4	1-9999 items
275	EAI 6202	3	0-10 MHz 1 μs - 1000 s
325-395	Eldorado 200 series	4-5	100 KHz-15 MHz
345	Monsanto 103A	4	5 MHz-12.5 MHz
345-395	Time Syst. Corp. 410 series	5-6	2 Hz-2MHz
375	Beckman 4050	6	24 hr. clock
395	Syst.–Donn. 114	4	1Hz-12.5 MHz
450	Simpson 2724	4	5Hz-20MHz
525	Simpson 2725	5	5Hz-20MHz
550-1650	Eldorado 1600 series	5-8	25-500 MHz
575	Monsanto 100A	5	5Hz-12.5 MHz
595	Itron 650	6	0-20 MHz
675	Monsanto 101A	5	5Hz-12.5 MHz
675	Monsanto 505A	5	24 Hr. clock
740	CMC 608	5	2Hz-15 MHz
750-1975	Syst.-Donn. 7000 series	7	0-12.5 MHz
780-935	Ortec 431A, B	6 decades	4 MHz
850	Monsanto 104A	5	5Hz-8MHz
895	Monsanto 106A	5	5Hz-5MHz
950-1050	HP 5331A, B	5	0-10 MHz, 10 μs-1s
950-1825	Eldorado 1400 series	4-7	15-500 MHz
995	Time Syst. Corp. 300	7-8	0-20 MHz
1195	CMC 608	6	0-20 MHz
1200-1425	Ortec 708 series	6 decades	0.15 - 11 days
1285	Monsanto 110 A	7	0-50 MHz
1300	CMC 614	5	2Hz-2.5 MHz
1300	HP 5214L	4	2Hz-300 KHz
1300	HP 5325A	6	0-12.5 MHz
1350	Syst.-Donn. 153	6	3-3 GHz
1370 up	Non. Lin. Syst. 2200 series	5	24 hr., 100 and 400 day clocks
1395	GR 1191	7	0-500 MHz

PRICE ($)	MAKER, MODEL #	NO. OF FULL DIGITS	RANGE
1500	Time Syst. Corp. 272	5	1 Hz-10MHz
1650	Syst.-Donn. 6034	6	0-10 MHz, 0.2 μs - 10^6s
1675	HP 5590A	6	1-9999 units
1750	Eldorado 700 series	8	1ns-10 s
1995	Time Syst. Corp. 210	7	0.1 Hz-20 MHz
2100	GR 1159	6	0.6 Hz-20 MHz
2150	HP 5323A	6	0.125 Hz-20 MHz
2275	Syst.-Donn. 7035	7	0-500 MHz
2480-3100	HP 5245L, M	8	0-50 MHz
2495	Monsanto 1510A	6	0-3 GHz
2750	Nanosec. Syst. 1714	7	0-500 MHz
2850	Monsanto 1500A	8	0-125 MHz
2950	Syst.-Donn. 6018	7	0-100 MHz
3350	Syst.-Donn. 6038	9	0-100 MHz
4250	Eldorado 900 series	7	6.5 GHz
4750	Syst.-Donn. 6316A	9	0-12.4 GHz
6500	HP 5360A	11	0.01 Hz-320 MHz
—	Beckman 6148	8	0-100 MHz
—	HP 5323A	6	0.125 Hz-20 MHz

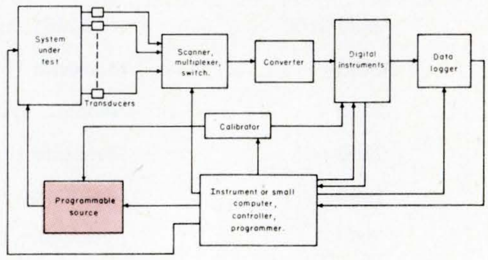


DIGITAL RECORDERS

PRICE ($)	MAKER, MODEL #	COLUMN CAPACITY	PRINT RATE	INPUT	OUTPUT
750-775	HP565A	11	5 lines/s	10-line DEC code	---
1085	HP562A	11	5 lines/s	4 or 10-line BCD	---
1150-1135	HP561B	11	5 lines/s	10-lines DEC code	---
1199	Beckman 3725	---	20 samp./s	---	4 Dig.
1760-3035	TI-170	---	---	Pressure G&GES	Printer, Computer
2700-4800	Ampex SP-700	33 Chan.	2-7.5 in./s	0-5Hz, 0-2.5 kHz FM, voice	Tape
10,354	Beckman 3710	---	20 samp./s	---	4 Dig.
11,934	Beckman 3720	---	5 samp./s	---	4 Dig.
17,475	Beckman 3730	---	100 samp./s	---	4 Dig.
21,500	Beckman 3750	---	5000 samp./s	---	4 Dig.
22,500	Beckman 3740	---	1000 samp./s	---	Computer
---	Janus 4120	---	---	14 DEC.	BCD Record.
---	HP 5050B	18 Col.	20 lines/s	Voice Counter	16 col. paper

DATA PRINTERS

PRICE ($)	MAKER, MODEL #	INPUT	CAPACITY
760 up	Hickok PR4900	BCD	10 col.
995	Beckman 3115	BCD	9 Digits, 2 Lines/s
1675-1935	GR 1137A	BCD	12 Col.
1700	Non Linear Syst. 2504	BCD	12 Col., 2-6 lines/s
1900	HP 5050B	BCD	18 Col. 20 lines/s



DIGITAL SOURCES/GENERATORS (FREQ SYNTH, TONE, PULSE, POWER, WAVEFORM, SWEPT, VOLTAGE)

PRICE ($)	MAKER, MODEL #	RANGE	INCREM	V_{OUT}	ACCURACY, PURITY OR DISTORTION
400	Exact 200	2 μs-1 s	2μs	10-30V	< 5%
425	HP 6181B	250mA @ 100 V	1mA	250mA	100 ppm
425	HP 6177B	50 mA @ 50 V	1mA	500mA	100 ppm
595	Monsanto 3100A-016	0-1.3 MHz	0.01 Hz	-20dBm	---
650	HP 3300A	0.01Hz-100 kHz	1%	35V	< 1%
750	HP 1900A	25 Hz-25 MHz	15ns	---	< 5%
770	HP 8003A; option 0	10 ns-2s	30ns	5V	4%
995	Wavetek 150	0.01 Hz-1 MHz	1 Hz	10V	3%
1195	Wavetek 155	0.01 Hz-1 MHz	1 Hz	10 V	3%
1250	Monsanto 300A	50 ns-200 ms pulses	25 ns	0.2-10 V	---
1285	Data Royal F270A	0.01 Hz-1.1 MHz	0.1%	16 V	< 1%
1295	HP 8717A	0-32 V @ 500 mA	0.01	---	4%
1435	Data Royal F280A	0.01 Hz-1.1 MHz	0.1%	16 V	< 1%
1500	HP 6130B	50V @ 1A	1 mV, 10mV	-10 to +10 V -50 to +50 V	0.2-2mV
1600	HP 8690B	400 kHz-40 GHz	1%	5-40 mW	1%
1975	HP 8601A	0.1-110 MHz	0.01%	-2-110 dBm	1%
2250	HP 675A	10 Hz-32 MHz	1 kHz	13 dBm	---
2495	DTC DF120	0-2MHz	1 Hz	2V	< 30dB
2530	Datapulse 110FP	5 Hz-50 MHz	10 ns	10V	---
2650	HP 3722A	150 μHz-50 kHz (noise)	0.003Hz	10V	---
2995	Wavetek 157	100 μHz-1MHz	1Hz	10V	3%
3450	Datapulse 110FP/G2	5 Hz-50 MHz	10 ns	10V	---
3950	Monsanto 3100A	0-1.5 MHz	0.01 Hz	-20 dBm	< 1%
4775-5395	Dana series 7000	0-11 MHz	0.01 Hz	1V	90 dB
6120	Datapulse 110FB/A2	5 Hz-50 MHz	10 ns	10V	---
6500	HP 5105A	100 kHz-500 MHz	0.1 Hz	---	< 1%

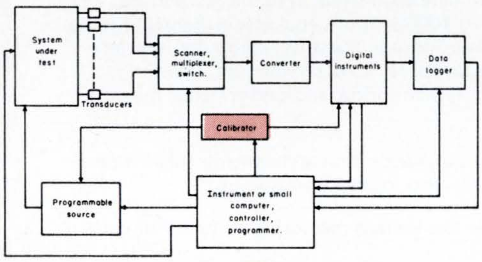
(Digital sources listing continued on following page.)

(Digital sources listing continued from previous page.)

PRICE ($)	MAKER, MODEL #	RANGE	INCREM	V_{OUT}	ACCURACY, PURITY OR DISTORTION
7200	HP 5102A	50 Hz-1 MHz	0.01 Hz	1 V	>74 dB
7800	HP 5103A	50 Hz-10 MHz	0.1 Hz	1 V	>64 dB
8150	HP 5100B	0-50 MHz	0.1 Hz	1 V	>90 dB
9750	HP 5105A	100 kHz-500 MHz	1 Hz	0 dBm	>90 dB
---	Wavetek 150 CP	1.2 - 12 kHz	1%	10	1%
---	GR1164	10 kHz-70 MHz	10 Hz	---	<1%
---	Rohde & Schwarz SMDH	0-50 MHz	1 Hz	---	---
---	Fluke 644A	0-40 MHz	1 Hz	---	---
---	Adret 300	6.1 Hz-2 MHz	0.1 Hz	10 μV-1 V	---
---	Freq. Eng. Labs. 700A	12-2.4 GHz	---	---	>70 dB
---	Microdot 412-525	400 MHz-2.35 GHz	0-300 kHz	0.1 μv-1 V	0.0003%
---	Wavetek 1001	500 kHz-300 MHz	100 kHz	1 V	30 dB
---	Wavetek 1501	450-930 MHz	5 MHz	0.5 V	---
---	Chronetics 1012	0-20 MHz	40 ns	9.9 V	<5%

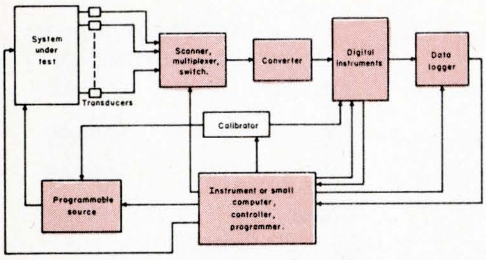
WORD GENERATORS

PRICE ($)	MAKER, MODEL #	WORD LENGTH	BIT RATE	OUTPUT CHANNELS
680-7460	Datapulse 200 series	1-100 bits	1 Hz-15 MHz	6-12V multi
2495	Datapulse 310 series	70 ns-5μs	0-10 MHz	Dual pulse
3500-4500	Eldorado 600 series	8 digits	1 ns-10 ns	---
3600	TI 6360	1-100 bits	10 MHz	1
3800	TI 6351	3-16 bits	10 MHz	3
4150	TI 6358A	1-100 bits	10 MHz	1



DIGITAL CALIBRATORS

PRICE ($)	MAKER, MODEL #	RANGES	STEPS	OUTPUT	ACCUR. (%)
1150	Cohu 324AN	1-100 V	10μV	1±122	0.003
3000	Fluke 3330A	10-1000V 1-100 mA	---	1000V	0.005
4500	HP 745A	10 Hz-110 kHz	1 mV-100μV	0.1 mV-100 V	0.02
5000	Cohu 326	1-1000V	100μV	0±1111V	0.003
---	Cohu 313	1-1000V	10μV	0±1111V	0.01
---	Microdot 1203	200 Hz-2.35 GHz	---	0.1 μV-1V	0.0008



INSTRUMENT SYSTEMS

PRICE ($)	MAKER, MODEL #	FUNCTION, CHARACTERISTICS
890-9950	Julie RVD, A10, SM, VOR series	Automated/programmable test sets. Cover 1 ppm accuracy of dc voltage, current, resistance, ratio. Includes sources, dividers, bridges, balancers, loggers, printers
895	Luft 77-P	Master controllers. Controls, automates operations. Also for data acquisition
975	Julie PRB-205S	Primary resistance measuring system. 0.00001% accuracy. Self-calibrating.
3000 up	HP 2310 elements	A-to-D subsystem for data acquisition and control. 16-64 inputs. Includes pacer, computer-interface
5000 up	HP 8410A	Network analyzer. Full characterization; 0.11-12.4 GHz; direct readout
5000 up	Vidar Vicom line, 5200 series	Systems for telecommunications, FM multiplex recording, data logging. 70 channels. 20 signals per track. High and low levels. Processor controlled.
5000-30,000	Honeywell PDC-100	Power demand control systems. Cyclical control of 4 M Watts or less. Programmed.
6000 up	Vidar 5400 series	Digital data acquisition systems. To 1000 channels; 35 samples/s. Portable, programmable.
7000 up	NLS S-1, S-2	Portable multifunction data aquisition systems. 200 3-wire inputs. 4 readings/s.
8980-14,925	HP 2010 K, L	Data acquisition system to measure, display, and record analog inputs. Can perform in noisy environments.
9500	Automation Dynamics AC410	Automatic logic circuit tester. 3000 ckts./min. Includes memory, printer.
9950 up	Non-Linear Systems S-1 series	Portable multifunction data acquisition systems. AC and dc, resistance and ratio. To 10003-inputs. Includes switching, timing, programmer, comparator, printer, recorder, computer intertace. For temperature, gage, pressure, flow, component, linearizer, communication, control, monitoring, and performance measurements.
10,000-23,000	HP 2300 series	Computer systems for data acquisition and control. Include computer, teleprinter, reader, and interface subsystem.
10,000 up	GR 2990-9138, 9	Automatic capacitance and leakage measuring system. For component quality control.
10,000 up	Automation Dynamics series 363	Universal automated logic test system. Dynamic static testing. Includes computer, interfacers, software. 400 ckts./s.
10,354 up	Beckman 3700 series	Data acquisition recording system. 100 inputs; 5000 samples/s. rate. Automatic ranging; universal output modes.
10,555	HP 5561A	Nuclear counting system with sample changer.
11,405-13,825	HP 2012 series	Data acquisition system. Handles 10-1000 3-wire channels.
11,950	HP 5401A	Multichannel analyzer; 20 MHz range, expandable memory, 1024 channels. Contains CRO, processor, A/D converter, interface.
12,000-28,250	TEK S-3110, S-3120	Digital measurement system for dynamic testing of assemblies, circuits, components. Includes programmer, memory, tape reader. Can store 1600 measurements.

(Instrument systems listing continued on following page.)

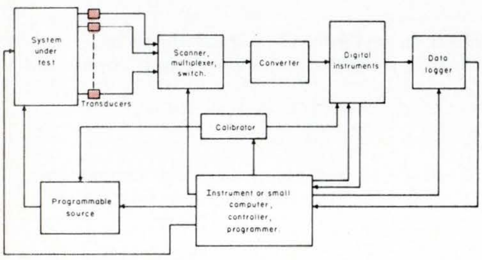
(Instrument systems listing continued from previous page.)

PRICE ($)	MAKER, MODEL #	FUNCTION, CHARACTERISTICS
13,850	TEK S-3111	Digital measurement system for dynamic testing of assemblies, circuits, components. Includes programmer, memory, tape reader.
< 25,000	HP 5481A	Signal averager. Includes analyzer and computer, all interfaces and software.
25,000	Honeywell SPEC-Purpose	Programmed batch blending system. Card readers, digital dial, or sequence selectors control blending of 5-20 ingredients cyclically.
30,000 up	IBM 1800	Data acquisition and control system. 20,000 samples/s. A&D inputs and outputs.
30,000 up	GR 1921	Real-time analyzer. 3.15 Hz-80 kHz. Computer.
30,300	HP 5405A/5406A	Analyzer systems. Single and multi parameters. Contains A/D converter, display, analyzer, software-controlled memory.
30,000-70,000	Redcor 685 series	Data acquisition system. 60,000 samples/s. Includes computer software.
35,000-42,500	TEK S-3130, 3131, 3132	Digital measurements system. 1600 meas. storage; 100 meas./s. Dynamic. Programmed.
40,000	Singer EMA-910	Field strength measurement and surveillance system. 1-26.5 GHz. Programmable.
42,500	TEK S-3130	Digital measurement system for dynamic testing of assemblies, circuits, components. Includes programmer, memory, tape reader. Can store 1600 measurements.
47,600 up	Teradyne T200 series	Computerized semiconductor test system. Includes computer, software.
48,500 up	Teradyne J259 series	Computer-operated circuit test systems. DC measurements on components, circuits, boards, modules. Includes software, computer.
53,000 up	EAI Pace	Analytical lab data processing system. Includes computer, interfacers, teletype.
54,000 up	HP 9500A	Computer-controlled stimulus/response test system. For components, modules, assemblies. DC-500 MHz. Includes computer, teleprinter, interfacers.
75,000-95,000	HP 8540A	Automatic network analyzer. Full characterization; 0.11-12.4 GHz. Includes computer control.
86,000 up	HP 2060A	Logic module test system. Includes computer, teleprinter, punched tape reader. Can perform 10,000 tests/s.
–	Stoddart Series VII	Automated RFI/EMI data acquisition for 20 Hz - 10 GHz. Includes programmer.
–	EAI Quad series	Lab mass. Spectrometers and gas analyzers. Analysis, process control, materials studies.
–	Microdot 1204	RF power calibrator system. 10 MHz-2.2 GHz.
–	Microdot 4221, 1203	FM calibrating system. 10 MHz-18 GHz. For receivers, transmitters.
–	Sanders Assoc. BFN	TWT test station. 1.7-12 GHz. Programmed. Covers amplifiers, oscillators, other microwave devices.
–	Sanders Assoc. BEH	Programmable test station for radar, communications equipment. 1.7-8.0 GHz; Printer output.
–	E-H Research Labs. 8321	Automatic core test system. Programmed. 130,000 cores/hr.
–	Marconi Autotest	Programmable system for communications devices. 20 Hz-150 MHz
–	Anadex CD-2381Q	Data acquisition and logging system. For multi-channel automatic scanning; 60 channels. Programmable.

(Instrument systems listing continued on following page.)

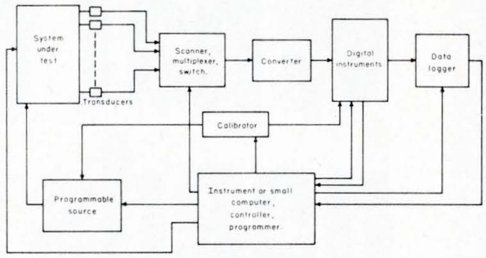
(Instrument systems listing continued from previous page.)

PRICE ($)	MAKER, MODEL #	FUNCTION, CHARACTERISTICS
—	GR 2990-9116	Automatic measuring system. For measuring temperature, time, device change events. Card punch output.
—	Boonton 001-5, 171K	Test systems for unleaded (chip) components. 10,000 pieces/hr. Programmed.
—	Quindar QATS-20	Analog telemetering system. Fire pulse ranges. Calibrated. Computer compatible output.
—	Servo Corp. 887/889 series	High-power microwave swept leveled system. 1-18 GHz; 7-14 watts.
—	Honeywell 7899	Automatic signal spectrum analysis and display. For EMI/RFI measurements, 20 Hz-1GHz. Programmed.
—	ESI Model 70	Meter calibration systems. Programmable. Calibrates deflection meters.
—	ESI Model 293	Universal impedance measuring system. Measures. R,L,C. performance factors.
—	ESI 721, 951, 1071	Automatic data acquisition systems. Cover temperature, ac and dc ratios, computer compatible.
—	Raytheon Multiverter	Data acquisition and processing system. 96 channels. Contains multiplexer, sample and hold amplifiers, A/D Converter, power supplies.
—	Ballantine series 3570	Digital measuring systems for broadband ac voltage measurements. 30 Hz-10 MHz. Computer controllable.
—	Panoramic HCA-1	Alarm systems control unit for communications. Facility monitoring. 60 kHz-3.1 MHz.



DIGITAL ENCODERS

PRICE ($)	MAKER, MODEL #	COUNTS/TURN OR RANGE	BITS
195-467	Baldwin 260 series	5000	14
195-1448	Baldwin 200 series	5000	14
495-6500	Baldwin 670-690 series	10-50,000	17-20
2370-17,895	Baldwin 500 series	36,000	11
—	Baldwin 87-A series	1024	10
—	Moore 7800 series	3-30 psi	1-50 mA dc -5 to +5 V dc



MISCELLANEOUS

PRICE ($)	MAKER, MODEL #	FUNCTION
455-655	Dana series 2800	Guarded diff. data amplifiers
470-3250	Wang 320	10-14 Dig. calculations (gen'l, trig, log, exp.)
675 up	Simpson 2700	Digital System Unit (DVM, ranging modules)
1050	HP 8707A	400 kHz - 40 GHz rf sweep & control
1200	HP 2411A	Guarded data amplifier
1250	Heathkit EU-805A	Universal dig instrument (DVM, counter, compar, timer, memory)
1550-1650	Tekronix 3S, 3T series	Programmable CRO sampling plug-ins
1595	Beckman 3108	Analog to Teletype coupler
1790	Julie RVD-106	Programmable divider
2250	HP 8405A	1-1000 MHz vector voltmeter
2500	Wang 379-8	Universal Interface (Dig. instrum. to counter)
2950	HP 8441A	Preselector Bandpass Filter
3050	HP 155A/1550A	Program Oscilloscope
3200	HP 3590A	20 Hz-620 kHz Spectr. Analyz.
3700	HP 5260A	13-12.4 GHz Freq. Divider
3800	HP 2801A	0.0001 °C Resol. Quartz Therm.
4450	HP 4470A	Transistor Noise Analyzer
5000	HP 3370A	Gas Chromatograph Digital Integrator
5500	HP 8051A	1-400 series Loudness Analyser
8950	HP 8054A	Real Time Audio Spect. Analyzer
9950	HP 5480A	0-50 kHz Sig. Analyzer
125000 up	TI 553	Computer Controlled Dynamic Test System
---	Non. Lin. Syst. X-5	Digital Pressure Meter
---	Datawest 380	128 Channel High Speed A to D Interface
---	Princeton App. Res. RIM series	Instrument Systems Modules
---	Marconi DA1444	Controller for programmable instruments
---	Hickok DMS 3200	Digital Measuring System Modules

INFORMATION RETRIEVAL
Instruments and measurements, Computers and peripherals, Data acquisition and processing, Systems design

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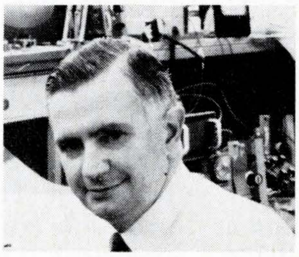
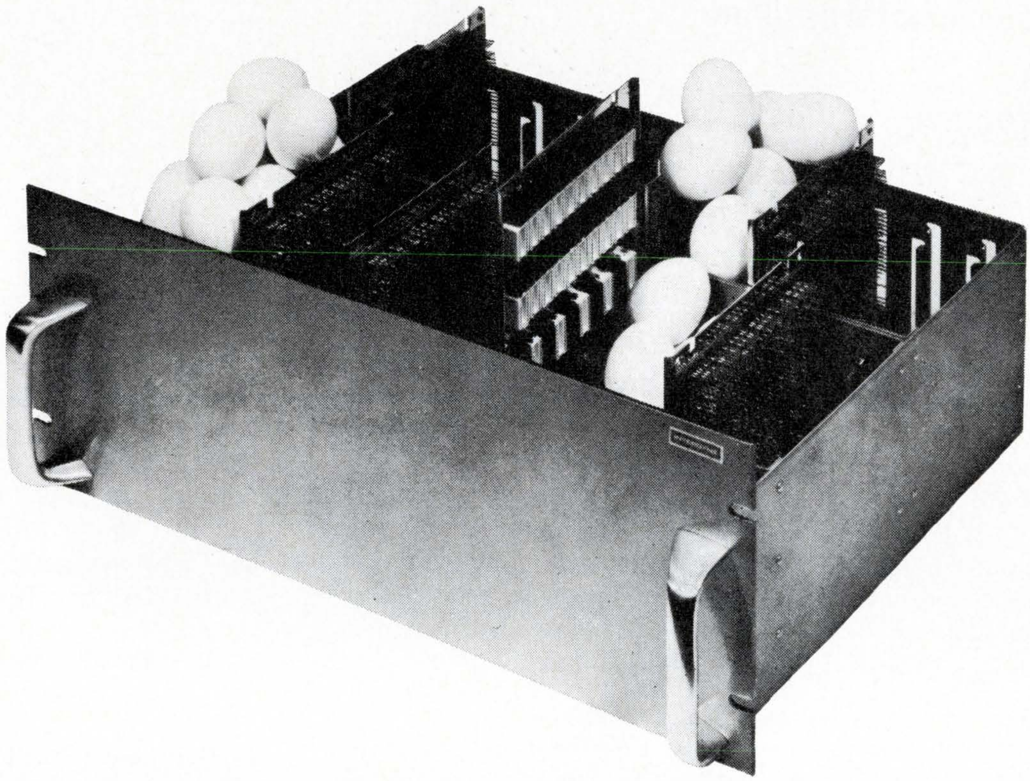
Here's how you voted

The winning Idea for the December 1968 issue is, "Regulated supply has two outputs."



Don Purland, our prize-winning author, is a Project Engineer at the Controls Division of Research Inc., in Minneapolis, Minn. Mr. Purland selected the Triplett 600 TVO multitester as his prize.

you <u>can</u> put all your eggs in one basket



From logic diagram to logic drawer . . . (24 positions . . . and wire-wrappable)... that's INTERDYNE's total service concept!

We start with your logic design processed through our computer based design automation programs. Your logic is allocated then partitioned onto INTERDYNE's Modu-Wrap boards. Placement of the boards is optimized, and a pin-vs-signal assignment list is created. Next, we manufacture the modules—a rugged steel chassis 5.8″ wide in whatever length you require, with a 90-pin connector at one end, and row after row of—you name it—14-, 16-, or 24-pin sockets, transistor holders, printed circuit card connectors, component posts, etc. — all neatly packaged with superbly unique power and ground distribution planes. If you prefer, you can by-pass our design automation and create your own modules from our list of available configurations. And, "to wrap it up," we have five fully automatic wire-wrap machines. Each card, and the drawer back panel, are wire wrappable. If you need the flexibility of direct entry packaging and want fast delivery, you'll want to know more about INTERDYNE's Inter-Wrap. Let us show you how you can put all your eggs in one basket. Ask for the MW 2900/5800 Series Brochure and information on the MW 5824 Logic Drawer. Circle Number 115 on the Reader's Service Card.

INTERDYNE

2217 Purdue Avenue
Los Angeles, California 90064
(213) 477-6051

916 Zero-beat detector

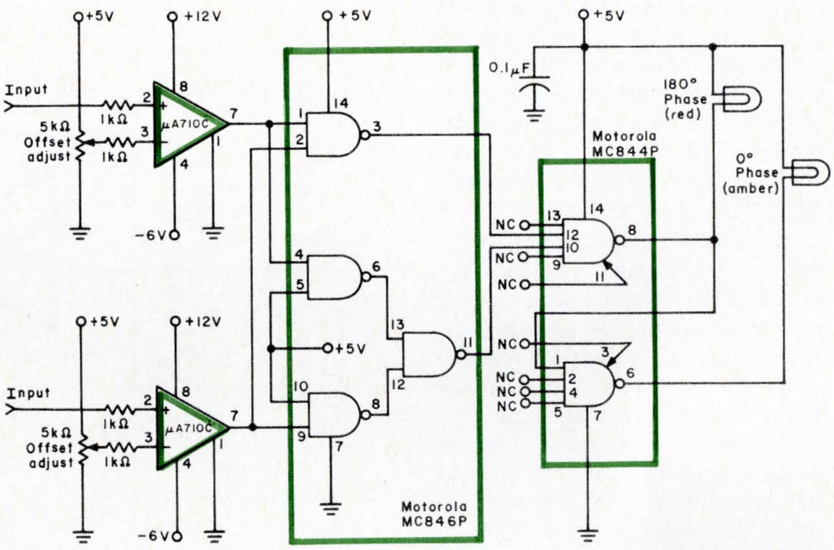
Tim K. Aaltonen
ARZ Assoc., New Rochelle, N. Y.

Keep this circuit in mind if you have to adjust two frequencies to within several cycles of each other.

The particular problem was to zero-beat two 15-kHz signals to within ±5 Hz, quickly and accurately. A dual-trace scope was not accurate enough, while a counter took too long for production-line use.

How to do it? A two-bit comparator solved the problem. It detects a zero-beat between two frequencies. When they match within a few cycles, the lights blink slowly on and off.

The circuit accepts signals of up to 5-V peak amplitude, and is relatively insensitive to amplitude.



917 IC-compatible crystal oscillator

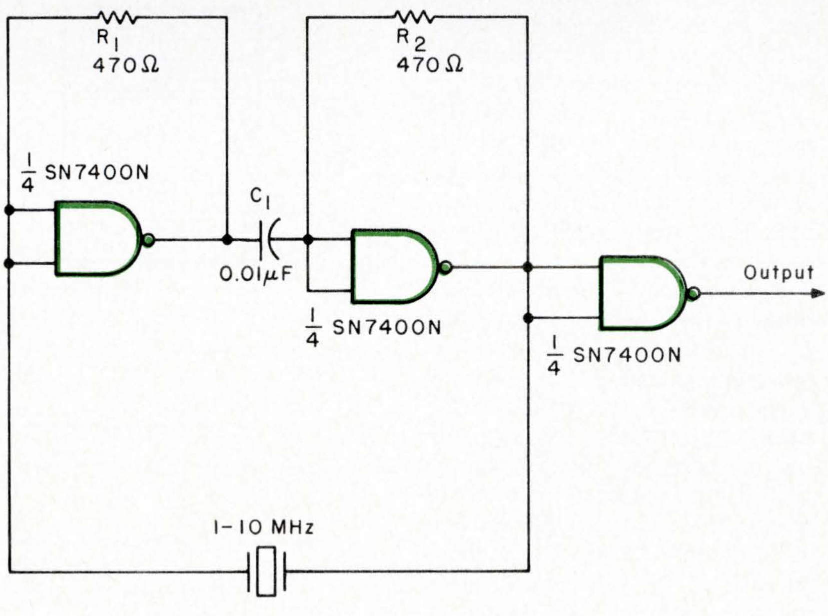
Albert W. Weggeman
Texas Instruments, Austin, Tex.

Here's an inexpensive, reliable, and accurate clock oscillator. Its output is compatible with the type of logic you use to build it.

Resistors R_1 and R_2 temperature-stabilize the NAND gates (T. I. SN7400N). They also ensure that the gates are in a linear region for starting. Capacitor C_1 is a dc block; it must have less than a 10-Ω impedance at the operating frequency.

The crystal, which sets the circuit's accuracy, runs in a series-resonant mode. So its series resistance must be low; AT-cut crystals for the 1- to 10-MHz range work well.

The output waveshape has nearly a 50% duty cycle, with chip-limited risetimes. The circuit starts well from 0° to 70°C.



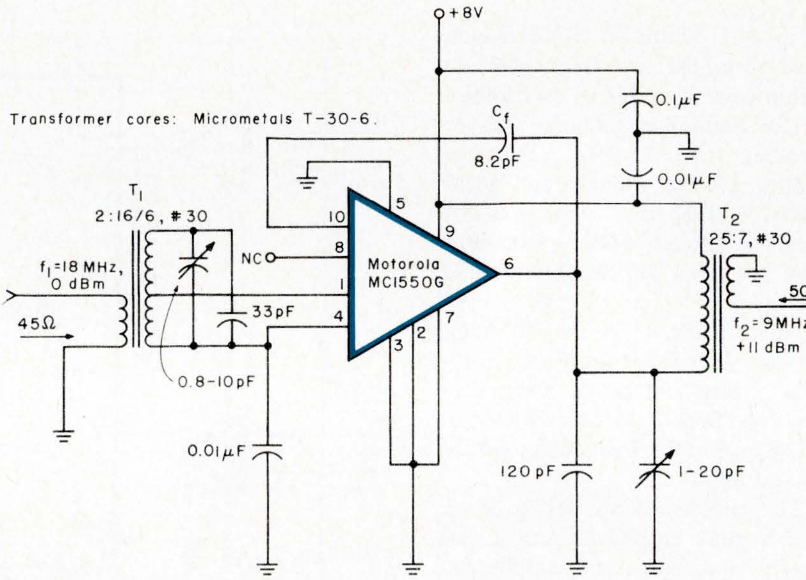
918 Tuned rf frequency divider

Del Crowell
Philco-Ford, Palo Alto, Calif.

You can use this circuit to divide by two, up to 100 MHz. It has 10-11 dB gain with limiting, and a 15 dBm max. output level. From −30° to 75°C, the output variation is less than ±1 dB.

When you drive the Motorola MC1550G into its limiting region in this circuit, it becomes a monostable multivibrator. The base terminal is left open to allow switching. The feedback capacitor, C_f, should have a value that ensures switching at levels about 10 dB lower than your normal input.

The tuned input and output reduces broadband noise as well as harmonically related spurious signals (f_1 - f_2, and so forth). All such spurs are more than 35 dB down.



919 Digital clock has adjustable pulse width

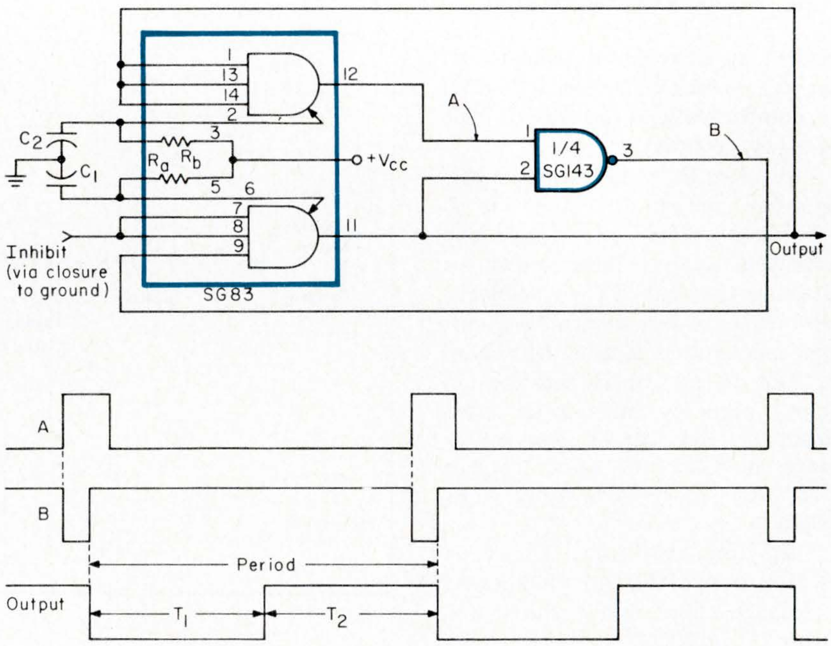
M. R. Rawlings
Collins Radio, Dallas, Tex.

A single Sylvania SG143 NAND gate, an SG83 dual pulse-shaper, and two capacitors give you a clock with adjustable pulse width.

The capacitors, with the SG83's internal resistors (4 kΩ), set the time constant for each phase. (A variable resistor in series with each internal resistor would give you continuous control.)

Total period is the sum of the pulse widths, which are: $T_1 = C_1 R_a / 3$, and $T_2 = C_2 R_b / 3$. The circuit is self-exciting, and has a frequency range in excess of 5 MHz.

(*Note*: This circuit is a variation of one recommended by Sylvania in their New Product Report on the SG80. That circuit's pulse width is fixed at only 20 ns. The author's variant, on the other hand, gives you any width that you need.)



Whether you want a wave analyzer or a spectrum analyzer, the ambidextrous HP 3590A does the job. This flexibility is achieved through the use of automatic amplitude ranging, electronic frequency sweeping, and linear or log X-Y outputs for graphic display.

But this dual capability is only the start of the HP 3590A's measuring ability. Add to this versatility the >85 dB dynamic range, highly selective bandwidths, ac and dc programmability, and a frequency range of 20 Hz to 620 kHz. The sum of all these improvements is increased performance and accuracy at speeds previously unattainable. Why settle for less? With the HP 3590A, you get the measurements you want—when you want them—faster and easier.

To provide the additional advantages of a special balanced input with selectable terminating impedances of 75, 135, 150, and 600 Ω—the new HP 3591A selective voltmeter is now available. Multiply this highly useful input capability by the fact that the 3591A is calibrated to indicate properly in either dB or dBm regardless of the terminating impedance selected. One result—an analyzer capable of making noise and level measurements on balanced voice frequency circuits, or on carrier systems up to 120 channels. And this example is only one of the many applications of an instrument designed with you in mind.

The 3590A mainframe is $3200. The 3591A mainframe is $3350. Three plug-ins are available: 3592A low cost slave and program unit when used in second 3590A, $80; 3593A with 3-digit mechanical display, $1100; 3594A with 5-digit electronic counter frequency display, $1600.

To get complete information on either the HP 3590A or the HP 3591A, call your local HP field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

099/6

Wave Analyzer or Spectrum Analyzer? The HP 3590A is both!

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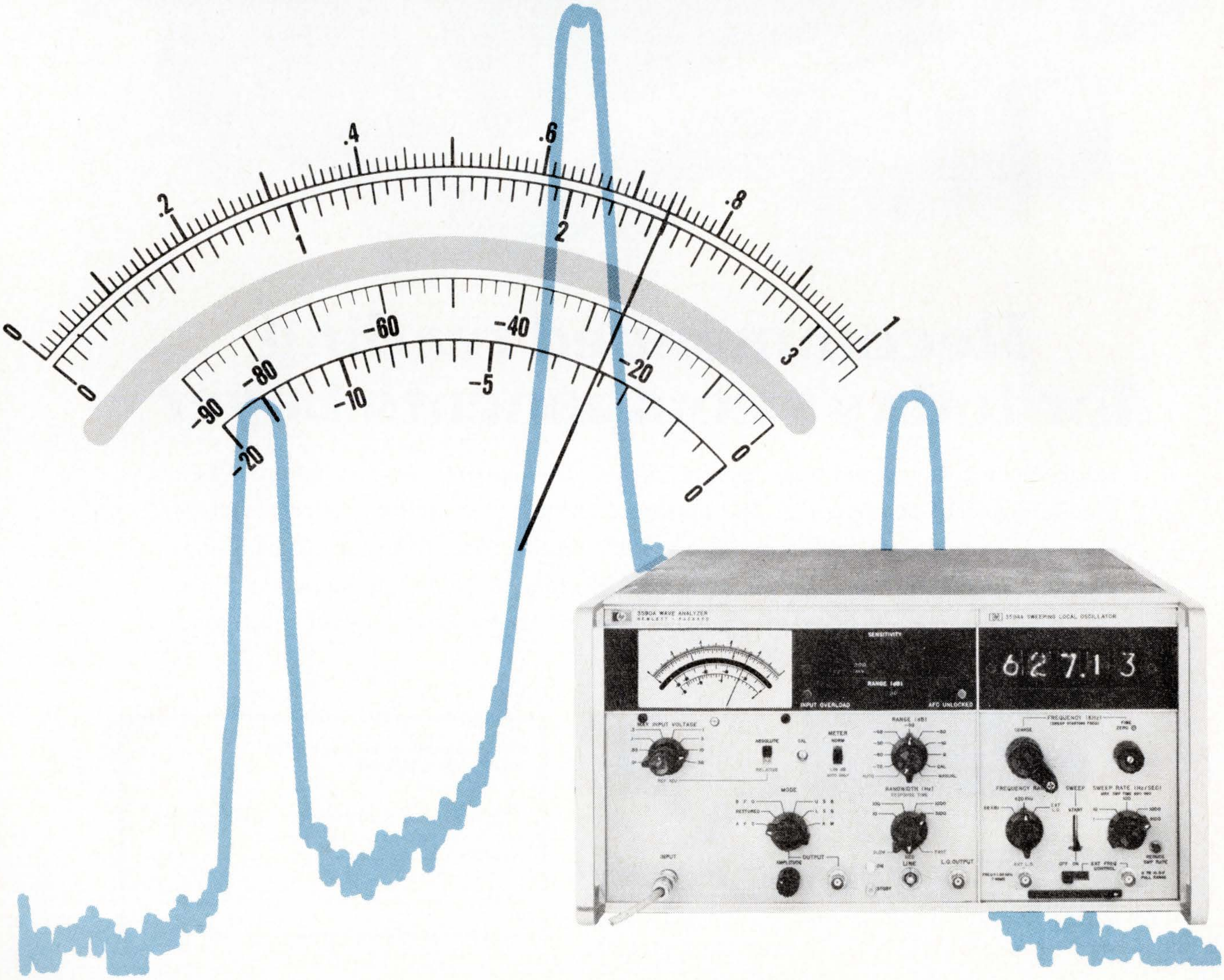
SIGNAL ANALYZERS



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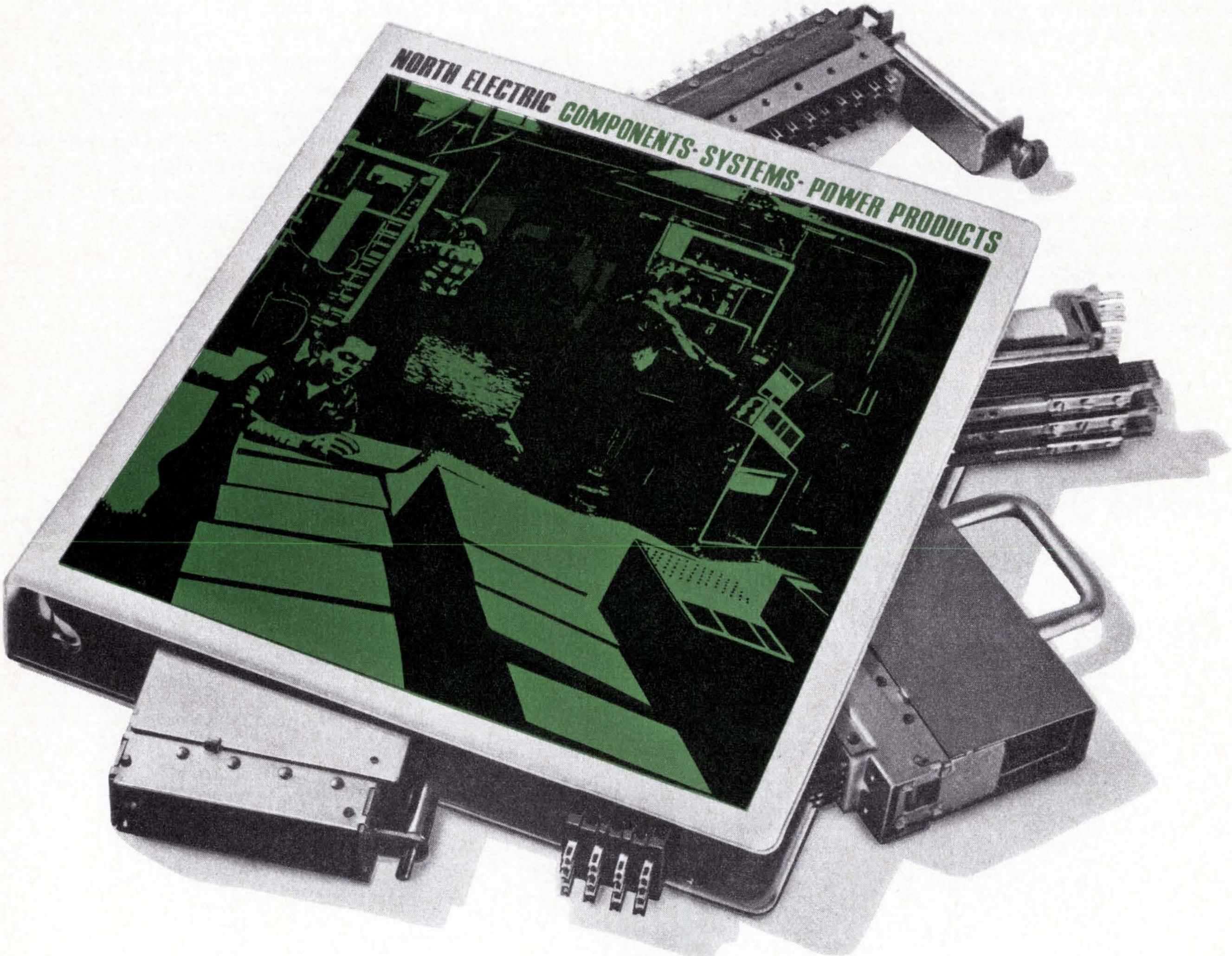
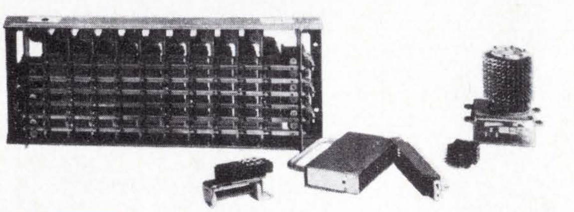


Recommended reading for today's components buyer

North Electric is pleased to present a Full Line Components Catalog featuring their standard line of components. The catalog offers detailed information on the North Crossbar Switches, Connectors, Rotary Stepping Switches, Telephone-Type Relays —and, explains how you can benefit from North's 83 years experience building precision quality components for the electronics industry. Send for your copy today.



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Circuit Design

Designing dc amplifiers. Part 2: Back-to-back amplifiers, Thomas Mollinga, Hollandse Signaalapparaten, "EEE," Vol. 17, No. 3, March 1969, pp. 58-62. The author analyzes two important circuits—the two-way power amplifier and the gyrator—obtained by connecting two dc amplifiers back-to-back. He goes on to explain the conditions that make the circuit either a two-way amplifier or, using two pairs of two-way amplifiers, a gyrator. The article includes design equations and graphs, plus one practical transistor circuit for each configuration.

Designing low-current MOS systems, Burt Mitchell, National Semiconductor, "EEE," Vol. 17, No. 3, March 1969, pp. 66-72. This article is not on "low current MOS systems" but rather on how to drive the clock inputs of multiple-phase shift registers. Such registers—being capacitive and operating fast and at relatively high voltages—draw too much current to be driven by a monolithic bipolar IC. The author describes a hybrid circuit that his company has designed to solve that problem, and explains how to use it as an interface between TTL gates (the scheme applies also to DTL) and two-phase-clocked dynamic MOS shift registers.

Tackle your switching circuit designs, Delbert Johnson, Lear Siegler, Inc., "Electronic Design," Vol. 17, No. 7, April 2, 1969, pp. 70-73. The author describes an easy-to-use technique that can replace conventional worst-case methods of designing transistor switching circuits. It provides optimum coupling between stages and an optimum collector load for the driving stage. With it you can almost arbitrarily select the reverse-bias potential for the base of the transistor that is OFF. Thus, you can include noise and drift in the design. The method can be used for silicon or germanium devices at any power level.

Speed network analysis with topology, John DeFalco, Honeywell Computer Control Div., "Electronic Design," Vol. 17, No. 7, April 1, 1969, pp. 56-61. With topological circuit analysis you don't have to write network equations or evaluate network matrices. But if the networks contain active components (such as transistors), the topographical analysis method becomes quite complex. Thus, it's easy to see why this method has had limited application. Now, however, there is a new technique that handles active nets easily and allows you to analyze your circuits almost by inspection.

A sinusoidal voltage-controlled oscillator for integrated circuits, Alan B. Grebene, Signetics Corp., "IEEE Spectrum," Vol. 6, No. 3, March 1969, pp. 79-82. Since design parameters are dependent upon passive-component ratios only, the circuit described in this article is ideally suited for the loose absolute-value tolerances that are exhibited by the diffused components of ICs. This circuit is an inductorless near-harmonic voltage-controlled oscillator (VCO) that utilizes a compensated Wien-bridge topology with a voltage-controlled Miller integrator as the tuning element. It has a two-to-one control range for frequencies up to 10 MHz, with less than a 1-dB amplitude variation and less than a 10% total harmonic distortion over the entire control range.

Communications

***Transmitting data with digital ICs,** R. J. Widlar and J. J. Kubinec, National Semiconductor, "The Electronic Engineer," Vol. 28, No. 5, May 1969, pp. 58-67. Often digital data (from a computer or telemetering equipment, etc.) must be sent in a high noise environment. Ordinary integrated logic circuits cannot be used on interface devices because they do not have sufficient noise immunity. Noise on wires, such as telephone lines, could be misread as digital information or it could mask digital information on the line. This article describes the operation and use of integrated circuits, and gives design information for overcoming noise on twisted-pair lines.

Power requirements for deep-space telecommunication links, M. H. Brockman, E. C. Posner, California Institute of Technology, "IEEE Spectrum," Vol. 6, No. 3, March 1969, pp. 95-99. Scientific exploration of the solar system through the use of deep-space probes is basically dependent on an adequate telecommunications link between the spacecraft and the earth stations; a key factor is the need for high-power transmission capability. The answer seems to lie with high-power transmitters (earth-based) that have outputs in the 1000-GW range.

Components

What is happening in chip capacitors, Robert H. Cushman, Eastern Ed., "EDN," Vol. 14, No. 6, Mar. 15, 1969, pp. 81-84. Monolithic ceramic capacitors have shown continuing progress. For example, you can now expect to get 1 μF in a 0.1 in. cube. Besides the ceramics, other types are discussed. There are several curves to help place the chip capacitor milieu in perspective.

Magazine publishers and their addresses

EDN
Cahners Publishing Company
3375 S. Bannock Street
Englewood, Colo. 80110

EEE
Mactier Publishing Co.
820 Second Avenue
New York, N. Y. 10017

Electronic Design
Hayden Publishing Co.
850 Third Avenue
New York, N. Y. 10022

Electronic Products
United Technical Publications
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Garden City, N. Y. 11530

Electronics
McGraw-Hill, Inc.
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New York, N. Y. 10036

Electro-Technology
Industrial Research Inc.
Industrial Research Bldg.
Beverly Shores, Ind. 46301

IEEE Spectrum
Institute of Electrical & Electronics Engineers
345 East 47th Street
New York, N. Y. 10017

The Electronic Engineer
Chilton Company
56th & Chestnut Streets
Philadelphia, Pa. 19139

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Components and chips for ICs, Sidney C. Silver, Assoc. Ed., "Electronic Products," Vol. 11, No. 12, Mar. 15, 1969, pp. 18-31. Processing improvements and increasing production efficiency are promoting wider usage of chip-sized discrete components in hybrid ICs. Users seem to be giving more thought to exploiting such of these components as are available, rather than demanding exotic types or blue-sky specs. The article is a survey of what's happening in this component market.

Computers and Peripherals

***ROM at the top,** John Linford, Motorola, "The Electronic Engineer," Vol. 28, No. 5, May 1969, pp. 64-71. Read-only memories are used to store information of a reference nature. For instance, this data could be a program for a large computer, or a series of names and addresses for a subscription service. The article discusses versatile integrated circuit memories that can be used for read-only applications such as decoding, function generation and detection, and arithmetic functions. After a description of these memories, the reader will learn how to apply them to his needs.

Optical techniques light the way to mass-storage media, M. D. Blue and D. Chen, Honeywell Research Center, "Electronics," Vol. 42, No. 5, March 3, 1969, pp. 108-113. Optical means are stepping into the spotlight to challenge magnetic recording measures for the vital mass-storage job. Densities of 100 million bits per square inch are achievable—100 times that of drums, disks and other magnetic equipment. The authors discuss advantages and limitations, the place of optical memories compared to other forms—including semiconductor types, characteristics, construction, and typical performances.

Memories 1969—megabits and microseconds, Harry Howard, Tech. Ed., "EDN," Vol. 14, No. 7, Apr. 1, 1969, pp. 33-48. Here is a survey of modern memory systems, with some predictions of their future capabilities. Capacities and access times are compared for a number of bulk-storage devices. Various semiconductor memories (scratch-pad, ROM, and so forth) are also discussed.

Cryoelectric memories; best hope for large and fast storage units, Robert A. Gange, RCA Labs, "Electronics," Vol. 42, No. 6, March 17, 1969, pp. 108-112. This article, the seventeenth in a continuing memory series, describes Gange's work, which is based on the superconductivity of devices at temperatures approaching absolute zero. Although largely in the experimental state, the technique has promise: faster speed, less noise, easier driving requirements, and greater bit capacities than semiconductor and magnetic memory elements. The article presents the state of art, provides the tutorial base needed to understand functioning, and discusses physical and design trends of cryoelectric elements.

Integrated Circuits

Interface TTL directly with MOS dynamic circuits, Dale Mrazek, National Semiconductor, "EDN," Vol. 14, No. 7, Apr. 1, 1969, pp. 57-59. Low-voltage threshold processing of MOS circuits eliminates many MOS-TTL interfacing problems. The new 2-V threshold levels mean, however, that you must put more design emphasis on the interface itself, to get an optimum solution to its remaining problems. The author holds that MOS-TTL interfacing can be very economical, if its variables are understood.

Analysis tools for microminiaturized circuits, J. G. Christ, J. N. Ramsey, International Business Machines, "IEEE Spectrum," Vol. 6, No. 3, March 1969, pp. 108-118. The high design and performance requirements of computer-grade circuitry and micro-miniaturized packaging concepts give rise to many materials problems, which can be attacked successfully only with advanced, and constantly refined, microanalytical methods. This article describes advanced techniques of X-ray and electron optics, which are proving to be among the most useful of the new analytical methods.

MOS characteristics induce other design concepts, Paul F. Schenck, Fairchild Semiconductor, "EDN," Vol. 14, No. 6, Mar. 15, 1969, pp. 69-74. Low ON-resistance, high OFF-resistance, and zero offset make MOS multiplexing devices attractive in switching and functional logic building blocks. Here are D/A converters with several different codes, instrumentation applications, multiplexing (briefly), and so forth.

Miscellaneous

***Project management, military style,** S. Peter Kaprielyan, General Electric, "The Electronic Engineer," Vol. 28, No. 5, May 1969, pp. 27-32. It is not enough to know the principles of project management. The key is to be able to apply them to the actual management of complex electronic projects. One of the biggest advocates of this approach to management is the government, and this article discusses how Captain M. X. Polk, USN, uses the techniques of project management to handle the complex Omega navigation system project. Captain Polk also provides some revealing insights as to what it's like to run a large project, and some of the problems involved.

Does QA handicap the designer? Paul Baird, Hewlett-Packard, "EDN," Vol. 14, No. 7, Apr. 1, 1969, pp. 71-74. Designers are creative people and, thus, thrive on freedom. Whether or not quality assurance procedures will restrict this freedom is determined by the designer himself.

Power Supplies

***IC voltage regulators—Do-it-yourself power supplies?** Shephen A. Thompson, Western Editor, "The Electronic Engineer," Vol. 28, No. 5, May 1969, pp. 47-52. With the widespread use of integrated circuit voltage regulators, engineers are now raising this question: "Should we buy a separate power supply or should we throw in a couple of rectifiers and then use an integrated circuit voltage regulator to power our equipment?" "Not yet," think the computer designers we put this question to. "Never," say the power supply manufacturers. Yet, the sales of integrated circuit voltage regulators climb rapidly. The reason is explored and discussed in this very timely article.

The economical fuel cell, Galen R. Frysinger, U. S. Army Electronics Command, "IEEE Spectrum," Vol. 6, No. 3, March 1969, pp. 83-90. One of the first applications of economically competitive fuel cells will be as a battery charger, either for replenishing discharge cells or for use with conventional secondary batteries in hybrid configurations. With the fuel cell-battery hybrid system, a minimum number of fuel cells and battery components can service a wide range of lightweight portable equipment at low development costs.

Semiconductors

Forum on SCRs—Part 2, Michael Perugini, Contr. Ed., and George Flynn, Sr. Assoc. Ed., "Electronic Products," Vol. 11, No. 12, Mar. 15, 1969, pp. 44-53. This discussion on the thyristor family of control devices points out factors that heretofore have limited thyristor applications: specification problems, misunderstanding of good specs and empirical design by users, and so forth. But in spite of these things, there is increasing use of such devices, especially those of low-and medium-current ratings. The discussion concludes with the thought that economics is the key: even a small price break should trigger an avalanche of new uses.

Detroit puts electronics in the driver's seat, John Drummond, Associate Editor, "Electronics," Vol. 42, No. 6, March 17, 1969, pp. 84-93. Semiconductors, though led by discretes, are accelerating their share of the increasing electronics' role in the automobile. More and more of the command and control functions are falling under the semiconductor umbrella. Drummond, albeit in a somewhat limited roundup, covers recent innovations as well as expected design changes, using actual examples. Cost and performance figures, as well as criteria for choosing the device tack, are provided.

Multielement self-scanned mosaic sensors, P. K. Weimer, W. S. Pike, G. Sadasiv, F. V. Shallcross, L. Meray-Horvath, RCA Labs, "IEEE Spectrum," Vol. 6, No. 3, March 1969, pp. 52-65. The development of practical solid-state image sensors is expected to introduce a new class of devices with applications extending considerably beyond those of today's camera tubes. Though still far behind camera tubes in both performance and price, solid-state sensors offer some important advantages, such as compactness, geometric accuracy of scan, and versatility of addressing not possible with electron beams. This article discusses the operation of the most common self-scanned sensor types, and gives their relative advantages and disadvantages. It also covers two new sensor designs that use a monolithic silicon approach and a thin-film photoconductor approach.

Test and Measurement

***Instrumentation: The systems approach,** Staff Report, "The Electronic Engineer," Vol. 28, No. 5, May 1969, pp. 73-87. Fewer and fewer instruments now operate on a stand-along basis. Instead, the trend towards system-orientation, whereby a total measurement task is performed by compatible instruments, is growing. This report covers the rationale behind this activity, and details the characteristics of off-the-shelf hardware suited to it. It also includes small computers and entire measurement systems.

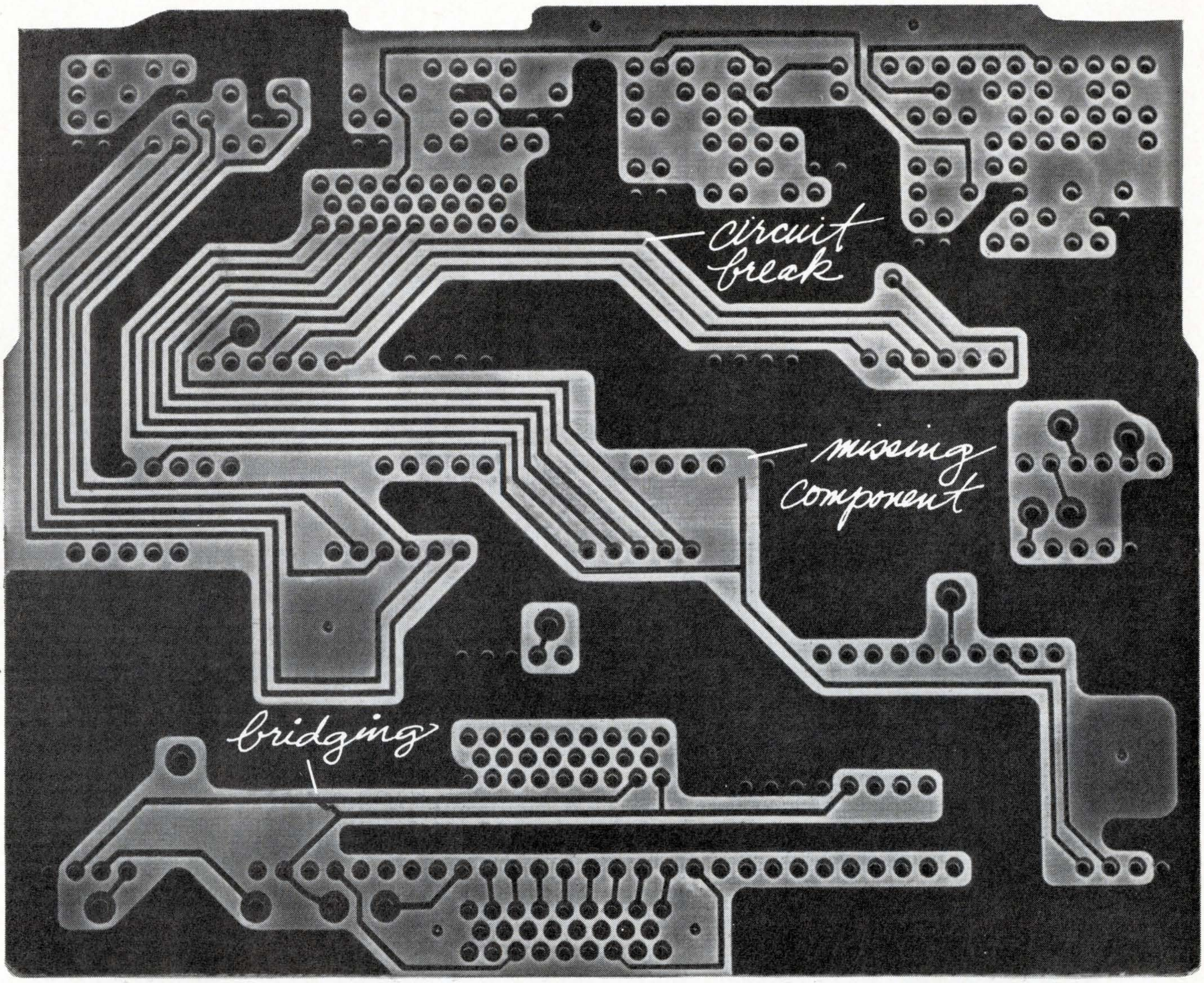
Instruments win top billing with more ICs and digital designs, Gwen Doyle, Asst. Editor, "Electronics," Vol. 42, No. 5, March 3, 1969, pp. 98-105. Recent instrumentation trends are covered. Foremost are the move away from analog indicators, the greater use of integrated circuits, and the push for modular construction—all of which underline the industry's systems-orientation. This roundup of the new face of instruments also includes guidelines for operation, criteria for selecting equipment, samples of representative new products, and price information.

The testing dilemma—how much is enough? George Flynn, Sr. Assoc. Ed., "Electronic Products," Vol. 11, No. 12, Mar. 15, 1969, pp. 32-43. Product testing costs money, so you waste dollars if you test too much. But if you do not test enough, you're going to pay later in customer complaints, rework, and so forth. The pros and cons of source, incoming, and production testing point up the fact that when you decide just how much testing is really enough, the major trade-off involved in the decision is figuring the point in the production process at which you will test.

Applying single-shot time-domain measurements, Thad Dreher, E-H Research Labs, "EDN," Vol. 14, No. 4, Feb. 15, 1969, pp. 66-71. Single-shot measurements let you test simple and complex devices at high speeds, with negligible heating effects. And such measurements can be automated. The author stresses the point that to get the several-hundred megahertz bandwidth you need, the instrumentation's signal-handling portion must be conceived as a low-impedance transmission line. Voltage and time measurements in such circuits are described.

Just how obsolescent are you? Tom Stephenson, Western Editor, "EDN," Vol. 14, No. 4, Feb. 15, 1969, pp. 93-95. Authorities disagree among themselve on what obsolescence is, who suffers from it, and even how serious it is. In this article, the three factions most concerned—the professors, the engineering managers, and the working engineers—present their views on the whys and wherefores of obsolescence.

Tape head selection depends on application, Ron Young, Ampex, "EDN," Vol. 14, No. 6, Mar. 15, 1969, pp. 77-79. You should consider mechanical and electrical causes of error when you select a tapehead for instrumentation recorders. A number of problems are briefly discussed, all of which contribute to interchannel timing errors.



Avco effectively checks integrity of circuit boards with GAF industrial x-ray film.

Use of multilayer printed circuit boards enables Avco Electronics Division, Cincinnati, Ohio, to turn out smaller and more efficient military radio equipment. And GAF industrial 'H-D' Monopak™ x-ray film helps them get the job done right.

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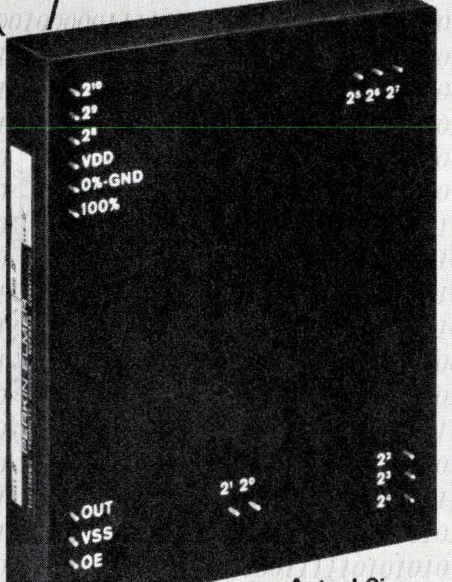

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Output Impedance Without Amplifier — 2000Ω Maximum
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Weight — 3 oz.

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EE NEW PRODUCTS

Leverwheel switches give fast action

In this era of great technological advances particularly, in the solid state area, we tend to overlook "mundane" devices such as, in this case, selector switches. However, somewhere along the line a human must control or put information into equipment. With this thought in mind, Cherry Electrical Products Corp. has made a giant step forward with their leverwheel rotary switches.

You can go from zero through nine in only 60° of rotation, and there is very positive detent action at each number.

This switch is a take-off of the 360° rotation type thumb wheel switches. But with this device, you can locate a position about twice as fast as you can with a normal thumb wheel type switch. Also, it eliminates the decision factor a user faces when, say, he is at position 4 and wants to move to position 8. Here the question is, "shall I push the wheel up or down to get to the next number fastest?" In the lever action switch this need for decision is eliminated. Physically and psychologically, with the 360° thumb wheel type switch, you are inclined to push the wheel in a downward position, which can, in many cases, make it much slower to reach your switch position.

In some cases, you may want to position the switch at the zero position, as perhaps a form of reset before selecting your number. With a lever switch this is a very rapid positive action.

The lever wheel switches come in two sizes: the subminiature size designated L-20 and the miniature size designated either L-11 or L-10, contingent on whether you want a front or back panel mounting switch. Incidentally, the subminiature switch mounting is only from the panel back.

Presently, the leverwheel switches are available with seven standard codes. As an example, codes cover such types as 10-position decimal, BCD complement, BCD plus even parity or BCD plus odd parity.

These switches terminate in a gold plated printed circuit board and they may be stacked together in any number of units. Switches have max rating of 240 V ac or dc, 0.5 A (12 W) per circuit.

In case you have any need or preference for the standard type thumb wheel rotary switches, Cherry Electric also has these in their product line. They are the same basic configuration as the leverwheel rotary switches, but they are available in 10 standard codes. For more information, contact Cherry Electrical Products Corp., 1650 Old Deerfield Rd., Highland Park, Ill. 60035. (312) 831-2100.

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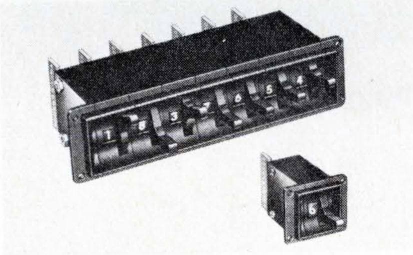
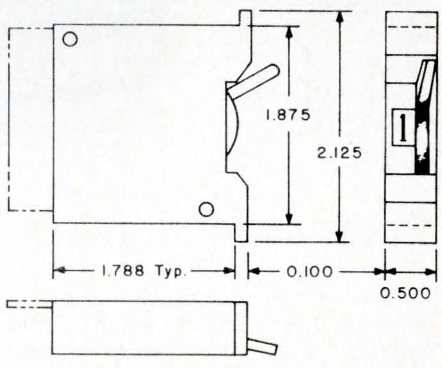
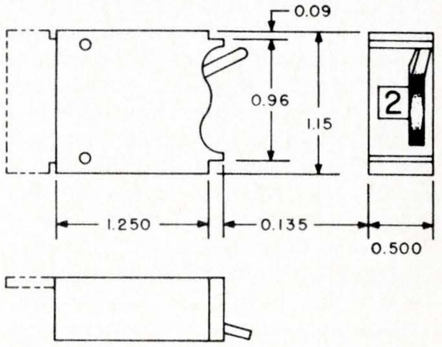


Leverwheel rotary switches can be used singularly, or ganged together. Only 60° of lever movement is needed to go from 0 to 9.



Front-of-panel mounted miniature leverwheel



Back-of-panel mounted subminiature leverwheel

Thumbwheel and leverwheel rotary switch codes

Code	THUMBWHEEL = T				LEVERWHEEL = L			
	Subminiature		Miniature		Subminiature		Miniature	
	Mounting Front	Back	Mounting Front	Back	Mounting Front	Back	Mounting Front	Back
10 Position Decimal	—	T20-01A	T11-01A	T10-01A	—	L20-01A	L11-01A	L10-01A
BCD (Binary Coded Decimal)	—	T20-02A	T11-02A	T10-02A	—	L20-02A	L11-02A	L10-02A
Hexi Decimal	—	T20-03A	T11-03A	T10-03A	—	—	—	—
BCD Complement	—	T20-04A	T11-04A	T10-04A	—	L20-04A	L11-04A	L10-04A
BCD + Comp. + 2 Comm.	—	T20-05A	T11-05A	T10-05A	—	—	L11-05A	L10-05A
BCD + Even Parity	—	T20-06A	T11-06A	T10-06A	—	L20-06A	L11-06A	L10-06A
BC Octal	—	T20-07A	T11-07A	T10-07A	—	L20-07A	L11-07A	L10-07A
Hexi Decimal + Comp.	—	T20-08A	T11-08A	T10-08A	—	—	—	—
Hexi Decimal + Comp. + 2 Comm.	—	T20-09A	T11-09A	T10-09A	—	—	—	—
BCD + Odd Parity	—	T20-10A	T11-10A	T10-10A	—	L20-10A	L11-10A	L10-10A

A complete digital panel meter

In case you haven't been keeping track, the trend in panel meters is definitely toward digital readouts, and for many obvious reasons: accuracy, ease of reading by non-technical people, compatibility with digital equipment and so forth. The latest entry in the field is Triplett, who make the claim of "total capability" for their DPM.

It may seem strange that a company like Triplett was slow in producing such a unit. But there's a good reason for the delay—they spent much time surveying what is available, and what is needed now and in the future. Then they designed their panel meter accordingly. The result: a DPM with standard features that are extra-cost accessories on other panel meters.

Looking over its specs, you'll find that the Model 5000 is a 3½-digit DPM with nonblinking display (six readings per second), moveable decimal point, and automatic polarity and overrange (O/R) indication. It has a 100-mVdc sensitivity, a 100-μV resolution, and an accuracy of ±0.1% full range ±1 digit. Dual-slope integration gives stability and long life.

The Triplett unit has both binary-coded-decimal (BCD) and decimal outputs to drive remote display or printer units. (You do not need converters to operate remote display devices.) A 1000-MΩ input resistance reduces loading and improves the reading accuracy.

Common-mode rejection is 80 dB, so you can make floating measurements with good accuracy. Series-mode rejection is 40 dB. To service the DPM, you simply remove the bezel and take out the chassis through the front panel; the case itself remains mounted to the panel.

Ranges presently available are ac or dc volts from 0.1 to 1000 V, and dc currents from 1 μA to 10 A (the circuit drop is 100mV). The ac version costs slightly more than the dc unit.

Some other features of the new digital panel meter are: automatic zero; display hold provisions; overload protection to 1 kV; and a built-in 8-W ac power supply. The supply is regulated, and operates from 115-Vac, 60-Hz lines. All calibration controls are accessible at the front of the panel. The DPM has an all-metal case for rf shielding. These features, plus others, are at the standard price.

The Model 5000 operates between 0° and 50°C. It measures 2.75 x 4.5 x 5.5 in., and weighs less than 6.5 lbs. User price is $360. For more information, contact Marketing Dept., Triplett Electrical Instrument Co., Bluffton, Ohio 45817. (419) 358-5015.

Circle 284 on Inquiry Card

Digital panel meter has many built-in features that are accessories on others. This unit has both BCD and decimal outputs for driving remote displays or a printer.

Rotary switch has pushbuttons

This is the year for improvements in rotary-type, thumbwheel switches. And one of the latest such improvements does away with the thumbwheel itself!

Chicago Dynamic Industries has a new switch that looks a lot like others at first glance. But there is no thumbwheel; instead, there is a push-button at its top and bottom. You push one of the buttons to add a digit, you push the other to subtract one. This eliminates the decision factor of the normal thumbwheel switch—which way to go to get to the next number.

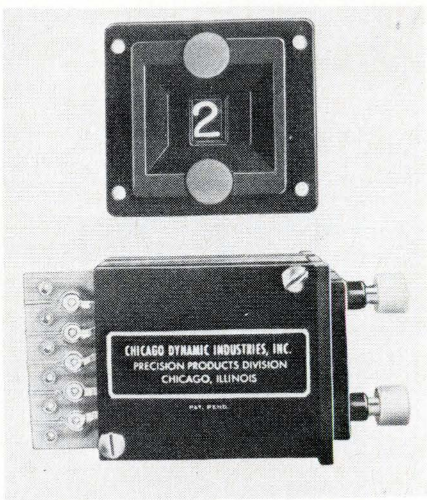
Series MPB/AS-27000 is available in decimal, binary, and binary-with-complement outputs, and with internal lighting if desired. Special codes are available, too.

Terminations at the back of the switch are plain or funneled, as specified. Precision metal contacts are silver, gold, or palladium. The switches can carry 2 A max. at 115 Vac, and have a 0.1-Ω contact resistance. Operating temps. range from −55°-85°C.

As with most switches of this type, you can stack them together.

The MPB/AS-27000 costs about $14 per module, with a 3- to 4-week delivery cycle. For more information, contact J. C. Koci, Chicago Dynamic Industries, Inc., Precision Products Div., 1725 Diversey Blvd., Chicago, Ill. 60614. (312) 935-4600.

Circle 285 on Inquiry Card



Circle 39 on Inquiry Card→

New interconnection system gives 3-D density

V-shaped spring contact enables connector size reduction without sacrificing reliability.

In this age of microminiaturization, it's often not feasible to use conventional interconnection techniques because they are too large. There may not be enough space for the connector; or the longer circuit length, with its unmatched impedance, may be unacceptable.

V-spring the key

A new high-density interconnection technique for parallel, perpendicular, or in-line mating promises to solve these problems. Designated the A-MP Microelectronic Connection System, it is built around an unusual receptacle contact that has two diametrically opposed V-shaped spiral springs. These springs, which deflect at right angles to the mating male pin, are stamped and formed from 0.004 in. beryllium copper. They are only 0.065 in. long with an outside diameter of 0.030 in. and are gold over nickel plated (as are the male pins).

Despite their compact size, the receptacle contacts can produce normal contact forces of over 100 grams for each of their two springs. When the mating pin contact is inserted into the receptacle, the spiral spring deflects in a plane perpendicular to the mating axis, making it possible for the overall length of the contact to be short while the springs are still long enough to function without excessive permanent deformation.

When housed in plastic (diallyl phthalate, epoxy or filled polyamide resin) blocks, the dimension in the direction of mating can be as small as 0.350 in. from wire termination to wire termination across the connector halves. This is especially advantageous in applications where the impedance mismatch (or length of the unmatched area) through the interconnection must be minimized. The short 0.065 in. receptacle contact length makes this possible.

Alignment not a problem

A serious drawback of many miniaturized units is that the connector halves must be perfectly aligned during mating to avoid damage to the pins. However, with this system, the angular displacement of the pin (without damage to the spring) is limited only by the inside geometry of the front and rear of the receptacle. This feature, along with the "float" of these terminals in their housings, makes it unnecessary for connector halves to be perfectly aligned.

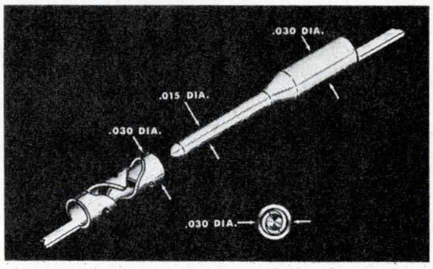
Contacts can be terminated by crimping, welding or soldering. The pin and receptacle terminals snap into place in their respective housings and can be easily replaced if necessary.

Convenience an advantage

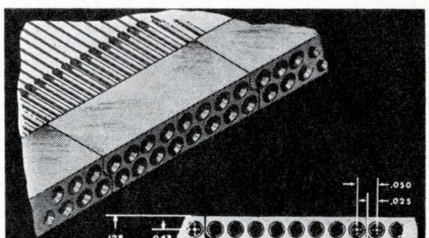
The housings can be mounted (and mated) without accessory hardware. One version can be stacked end-to-end without interrupting the 0.050 and 0.025 in. grid spacing. This is important on computer memory frames and other applications where it wouldn't be convenient to have one connector handle a large number of terminations. Another important application would be where it's necessary to plug a series of small connectors, side by side, into a single larger one.

A variety of configurations is available with contacts on 0.050 in. (true) and 0.025 in. (staggered) grids, including a full 16-position connector only 0.437 in. long. For more information contact AMP Incorporated, Harrisburg, Pa. 17105 (717) 564-0101.

Circle 222 on Inquiry Card



Key to the small size of the new connector system is the female contact at the left. Its two integral "V" shaped springs deflect at right angles to the mating pin contact, producing two points of electrical contact. As the deflection takes place entirely in a plane perpendicular to the mating axis, the overall contact length can be short.



By contouring the ends of the connector housings, they can be stacked end-to-end without interrupting the grid spacings.

Low cost, thin-film Hall generators

A new thin-film process brings down the price of Hall-effect generators—the payoff of three years of research by F. W. Bell, Inc.

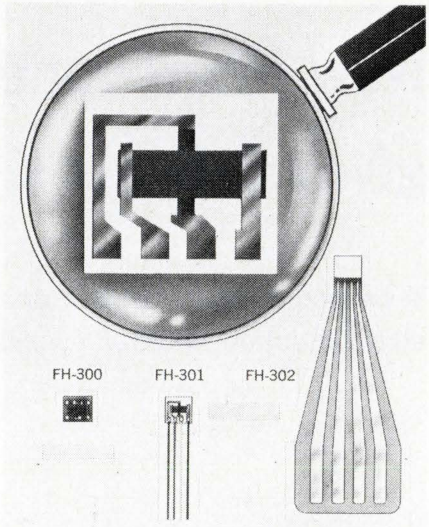
The Ohio firm says that the low prices will open up high-volume applications for these devices in such things as brushless dc-motors, automobile ignition systems, position sensors, and so forth.

There are three basic types: Model FH-300, a 0.1 x 0.125 in. flip-chip device; Model FH-301, the same size as the 300, but with conventional wire leads; and the FH-302, which has a flexible PC lead strip with contacts on 0.1 in. centers. (If needed, you can have PC conductor patterns to suit your particular application.)

Each model has three resistance ranges. These are 10 to 20 Ω, 20 to 40 Ω, and 40 to 80 Ω; the maker promises higher values in the near future. Control currents are 15 to 35 mA; magnetic sensitivity is 12 mV/kG min. for the high resistance range. The devices operate between −55° and 100°C; the temperature-dependance of the indium-arsenide film itself is less than 0.1%/C.

Model FH-300 Hall-Pak is under a dollar in 10,000-pc. quantities, while the 301 and 302 are a bit higher. A test kit with one of each model costs $6.50, plus 50¢ handling. F. W. Bell, Inc., 1356 Norton Ave., Columbus, Ohio 43212. (614) 294-4906.

Circle 279 on Inquiry Card



Second generation op amp is premium quality

Looking for a high quality, general purpose op amp? Then you may be interested in this new hybrid unit.

The 207 is a Bell & Howell item (Control Products Div.), marketed for that company by Data Device Corp. Its input characteristics are markedly improved over those of the 007, an 18-month old predecessor.

For example, the initial voltage offset (max.) was 1 mV on the 007; it's 0.2 mV on the 207. Similarly, the voltage drift is a low 5 μV/°C, max., down from the original 20. And the input bias current is half: 150 nA max. for the 207.

These improvements stem from better thick-film techniques, as well as from advances in circuit layout, according to the maker.

Because of the offset and drift specs, you don't need a balance trimmer-pot, so you save its cost and space. And because the 207 is frequency-compensated, you save on these components as well.

At rated load—2 kΩ—the open-loop voltage gain is 88 dB min., and the frequency for full output is 30 kHz min. Rated minimum outputs are ±10 V, and ±5 mA. Slew rate is 1 V/μs min., and the unity-gain point is 2 MHz typ.

You can take your choice of power supply voltages: anything between ±6 V and ±22 V will do the trick, although the nominal spec is ±15 V. Full-load current is about 7 mA.

The rigors of military life should have little effect on the 207: it's hermetically sealed in a TO-8 case, and specified for use from −55° to 125°C.

For more information on this $125 device, write or call Data Device Corporation, 100 Tec St., Hicksville, N. Y. 11801. (516) 433-5330.

Circle 280 on Inquiry Card

GOLD-BEARING EPOXY

Is highly conductive.

Single-component epoxy compound contains pure gold powder. Conductivity of Epo-Tek 441 is uniform and highly reproducible. Volume resistivity is held to 0.0001 to 0.0005 Ω cm. The material is a smooth paste which is used directly from the jar. It can be used to attach chips in hybrid circuits, and for other applications where a gold epoxy is highly desirable or mandatory. Epoxy Technology, Inc. (617) 926-1949.

Circle 281 on Inquiry Card

GUNN DIODE OSCILLATOR

X-band YIG tuned.

Model OX-100 electrically tunable oscillator provides 10 mW min. of fundamental rf pwr. with 6 dB max. pwr. variations over 8 to 12 GHz freq. range. Incidental FM, 10 kHz Pk-Pk; spurious outputs, −50 dB; harmonics, −30 dB; linearity, ±0.1%. It is well suited for local osc. and freq. diversity master osc. applications. Physical Electronics Laboratories. (415) 323-9092.

Circle 282 on Inquiry Card

FREQUENCY STANDARDS

1, 2, 2.5, 3, 4, 5, or 10 MHz out.

Model YH-522-1 standard has a cast aluminum internal cavity for its oven housing which gives good temperature stability and mechanical immunity to shock and vibration.

Level. 1 V rms min. into 1000-Ω

Stab: $>$ ±1 x 10^{-9}/day after 30 days initial aging.

Freq: $<$ ±1 x 10^{-8} over 0° to 55°C

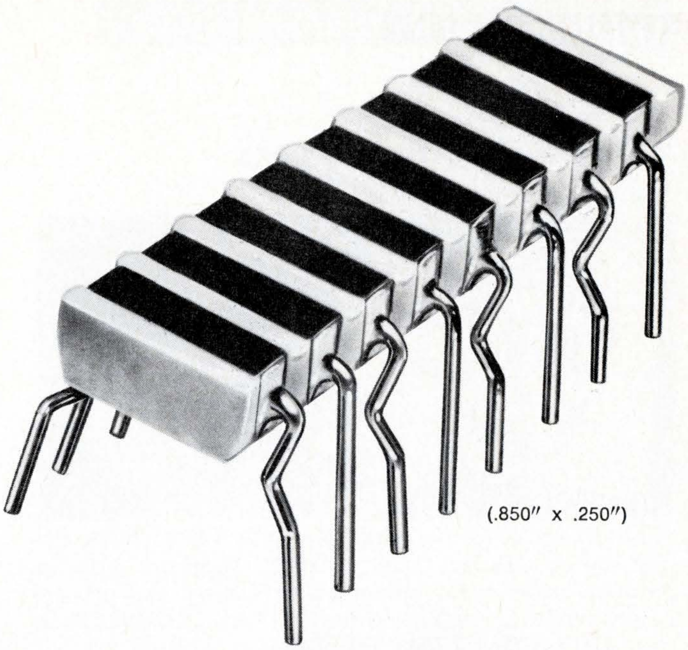
Input: +28 Vdc ±1% reg.

Greenray Industries, Inc.

Circle 283 on Inquiry Card

CTS cermet resistor networks

...with NEW 16-lead dual-in-line package



(.850″ x .250″)

■ Add more circuitry...up to 16-lead dual-in-line packages...with these new CTS space-saver cermet resistor networks. Specifically designed to simplify automatic insertion and reduce your assembly costs. Easy to hand mount, too.

Series 760 DIP Resistor Networks provide ...14 or 16 lead packages...up to 15 resistors per module with an infinite number of circuit combinations...extremely good environmental specifications...5 lbs. pull strength on leads. A natural to combine with active devices to form hybrid circuits. .100″ lead spacing.

Series 750 Cermet Resistor Networks offer ...three basic sizes and an infinite number of circuit combinations...excellent environmental characteristics...5 lbs. pull strength on leads...and are available with or without active devices...lead spacing, .125″.

Check CTS low prices and fast delivery schedule...2 weeks for prototypes; 4-6 weeks for production quantities. See the prices listed below!

More flexibility...CTS packages can be delivered without organic cover coat. You trim for circuit balance in your plant.

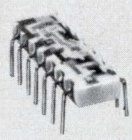
Ask your CTS sales engineer for data. Or write CTS of Berne, Inc., Berne, Indiana, 46711. Phone: (219) 389-3111.

CTS CORPORATION
Elkhart, Indiana

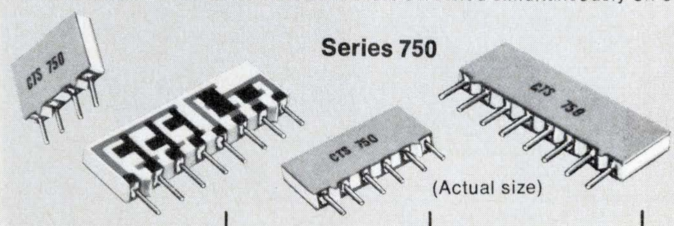
®

	SERIES 750			SERIES 760			
Quantity	4-pin 3 resistors	6-pin 5 resistors	8-pin 7 resistors	9 resistors (14 pin module)	11 resistors (14 pin module)	13 resistors (14 pin module)	15 resistors (16 pin module)
10,000 piece price	14.4¢ ea. (4.8¢/ resistor)	19.5¢ ea. (3.9¢/ resistor)	24.5¢ ea. (3.5¢/ resistor)	41¢ ea. (4.5¢/ resistor)	43¢ ea. (4¢/resistor)	45¢ ea. (3.5¢/ resistor)	55¢ ea. (3.7¢/ resistor)
1,000 piece price	28.8¢ ea.	39.0¢ ea.	49.0¢ ea.	82¢ ea.	86¢ ea.	90¢ ea.	$1.10 ea.

Prices shown are ±2½ % tolerance, ±250 ppm/°C from 50 ohms through 1 megohm standard TC. (Also based on circuits with all resistors screened simultaneously on one side of the substrate.)

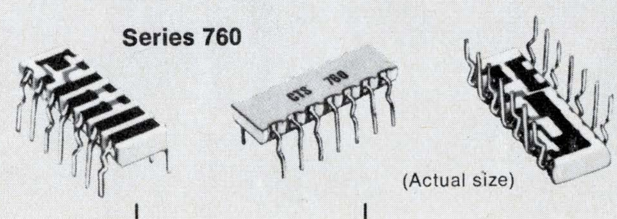


Series 750

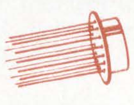


(Actual size)

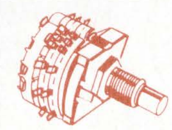
Series 760



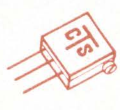
(Actual size)



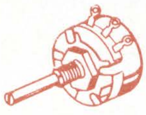
Microelectronic Circuitry



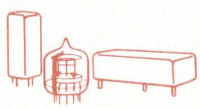
Selector Switches



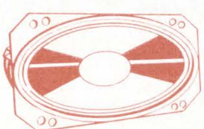
Trimmers



Potentiometers



Crystals, Oscillators, and Filters

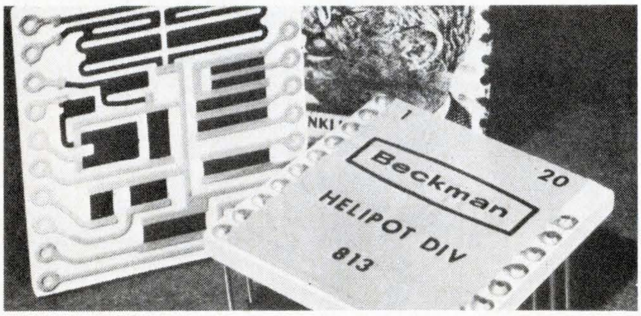


Loudspeakers

Circle 41 on Inquiry Card

THICK-FILM RESISTOR NETWORK

Sets current-source levels.

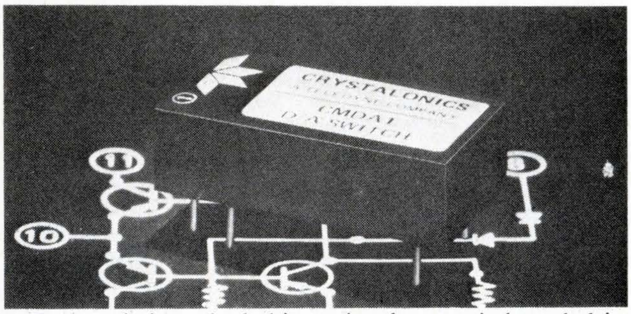


Model 813 is for use with Fairchild's μA722 10-bit current source. Operates −20° to 85°C. There are three application resistors for output buffer scaling, and one for output offsetting for bipolar uses. $14 ea., 100-199. Beckman, Helipot Div., (714) 871-4848.

Circle 201 on Inquiry Card

D/A LADDER SWITCHES

For use with R-2R ladder networks.

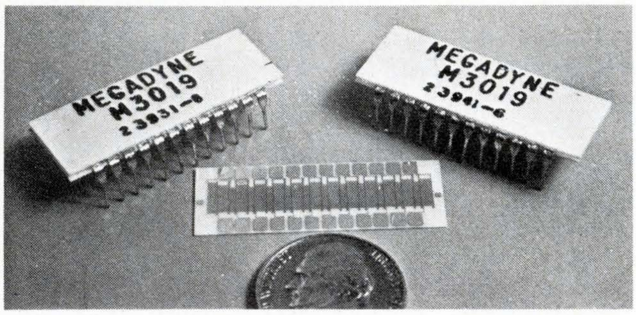


Each unit is a single-bit, series-shunt switch and driver circuit. Type CMDA1 works from DTL/TTL logic, with a −10 V reference. R_{sat} is 5 Ω (typ.). There is 10-bit accuracy with 10 kΩ/20 kΩ ladders. $19.50 ea., 1-99 pcs. Crystalonics, (617) 491-1670.

Circle 202 on Inquiry Card

LADDER NETWORK

For 12- and 10-bit applications.

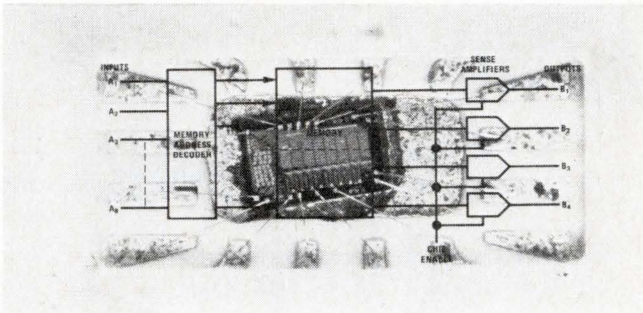


Designed for Fairchild's 3751 A/D converter, the M3019 R-2R ladder has an accuracy better than ½ LSB. Tracking TCR is less than 1 ppm/°C over military temperatures. Package is 0.6-in. DIP. $60 ea., 100 pcs. Megadyne Industries, (716) 328-4242.

Circle 203 on Inquiry Card

MOS READ-ONLY MEMORY

Arranged as 256 x 4-bit words.

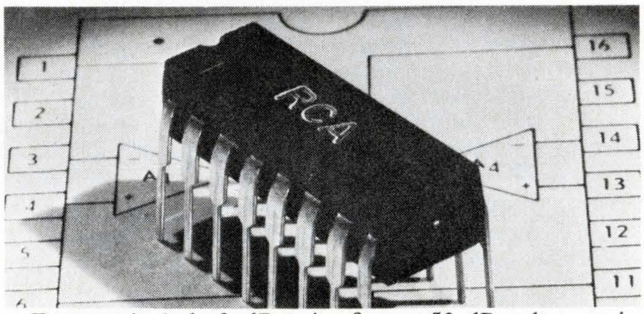


For code conversion, random logic synthesis, table lookup, and so forth. Gate protection diodes on all inputs. Needs no clock. Operates in less than 1 μs. DTL/TTL-compatible. MM421 (−55° to 125°C). $72 ea., 100-999 pcs. National Semiconductor, (408) 245-4320.

Circle 204 on Inquiry Card

MONOLITHIC AC AMPLIFIER ARRAY

Four independent amplifiers on a single substrate.

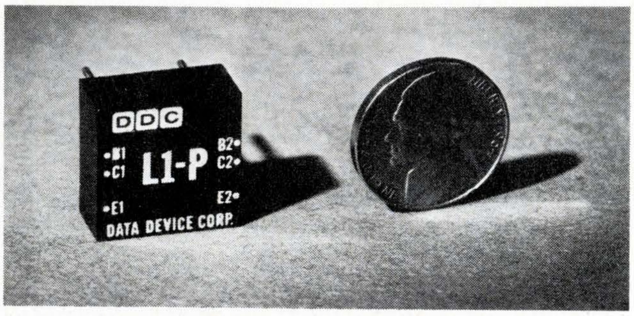


Features include 2 dB noise figure, 53 dB voltage gain, 2 Vrms out, 300 kHz open-loop BW. The CA3048 is a 16-pin DIP, runs from a single-ended supply, and is specified from −25° to 85°C. $2.45 ea., 1000-up. RCA/Electronic Components, (201) 485-3900.

Circle 205 on Inquiry Card

LOGARITHMIC ELEMENTS

Both log and antilog functions.

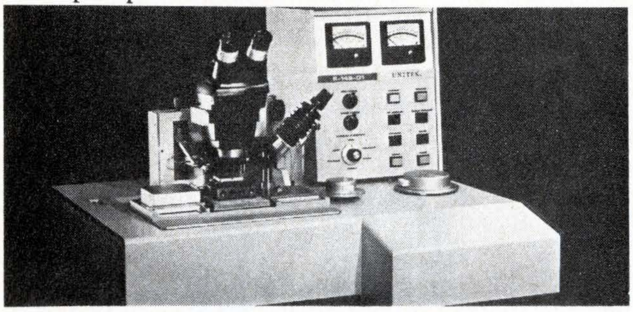


These devices have an input range of 10 pA to 1 mA. Output is 60 mV/decade. Two independent sections have V_{be} matched to 0.2 mV at 10 μA, Model L1-P is for positive inputs, L1-N for negative. $37.50 ea., 1-9 pcs. Data Device Corp., (516) 433-5330.

Circle 206 on Inquiry Card

ULTRASONIC OR THERMOCOMPRESSION BONDER

For flip-chips on substrates to 4 in.^{2}

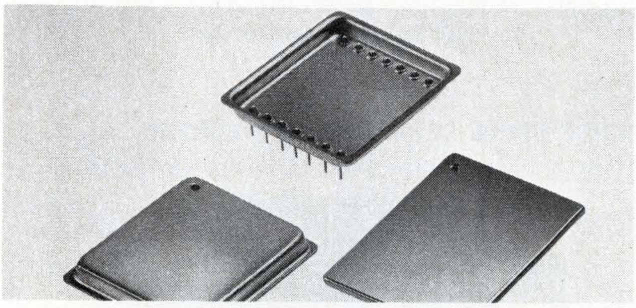


Bond characteristics are controllable and repeatable. Critical adjustments programmed and preset, Model 8-149-01 has gross manipulation; x, y, and rotational micromanipulator also. Split optics. About $10,000. Unitek, Weldmatic Div. (213) 359-8361.

Circle 207 on Inquiry Card

VERTICAL SIDEWALL MICROCIRCUIT CASE

For substrates to 1 x 1 in. and 0.75 x 1.5 in.

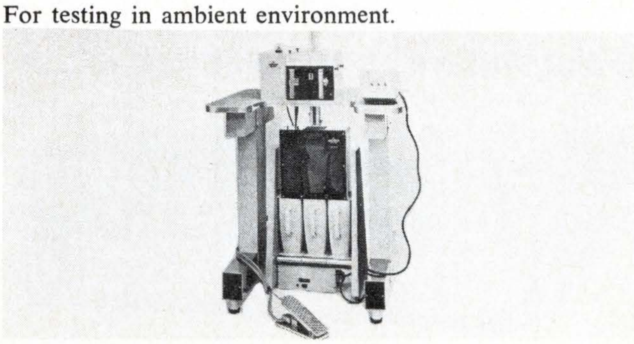


Kovar cases meet MIL-STD-883, MIL-STD-202; have 10 to 40 leads in opposing or triangular patterns. Terminal seals of borosilicate glass. Copper-clad kovar option for cold-welding packages. $2.62 ea., 1000 pcs. Tekform Products, (714) 630-2340.

Circle 208 on Inquiry Card

MECHANIZED IC HANDLER

For testing in ambient environment.

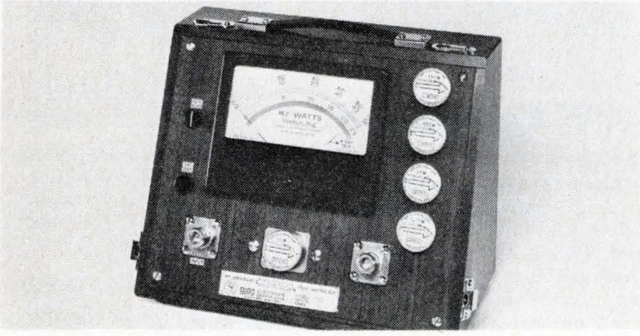


Model 8024 handles 5000 ICs per hour, in carriers, for production/QA testing. Basic set-up includes magazine input, pneumatic transfer to test-position, and "ready-to-test" contact closure for tester. About $2500. Delta Design. (714) 465-4141.

Circle 209 on Inquiry Card

PEAK RF LAB STANDARD WATTMETER

For 50-Ω, pulsed transmission systems.

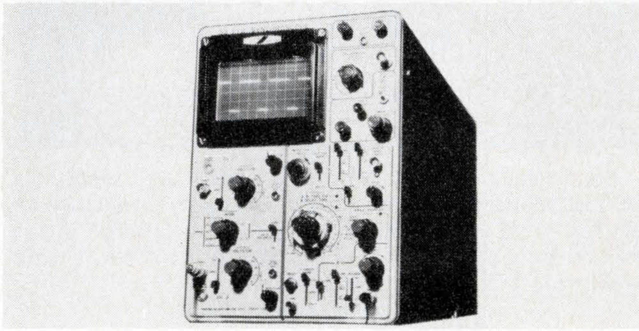


Self-contained Model 4345 samples reflected or forward power. Taut-band meter shows peak power, 250 W to 5 kW, 950-1300 MHz. Accuracy ±6% of reading at 25 calibrated points. Less than 1.08 insertion VSWR. Changeable connectors. Bird Electronics, (216) 248-1200.

Circle 210 on Inquiry Card

WIDEBAND OSCILLOSCOPES

To 200 MHz in real-time.

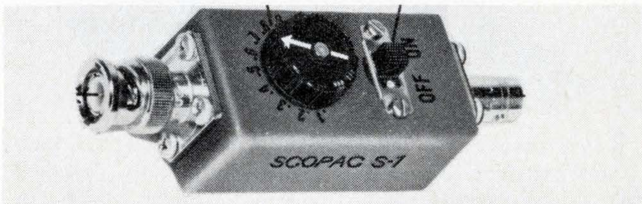


Model SS-112 has a 100-MHz bandwidth, while Model SS-211 is a 200-MHz unit. Both have 10 mV/cm sensitivity, 6 x 10 cm display. A FET probe has 1.75-ns rise-time. The SS-211 is $3120. Made by Iwatsu Electric, Tokyo. Sold by E-H Research, (415) 834-3030.

Circle 211 on Inquiry Card

NOISE SPIKE DETECTOR FOR SCOPES

Converts short duration spikes to square-wave output.



Plugged between scope and probe (BNC connectors), Scopac S-1 detects random, widely-spaced spikes with PRFs from 0.1 to 5 MHz. Threshold control sets minimum detectable level, ±0.1-1 V. Pulse input, 10 V max. $95. Travis Electronics, (617) 332-7447.

Circle 212 on Inquiry Card

11-MHZ SYNTHESIZER HAS 1-HZ STEPS

Digital control, crystal accuracy, spectral purity.

Series 7000 can be remotely controlled with TTL logic, using 1-2-4-8 code. Model 7010 is the basic unit; the 7020 adds analog search and an output attenuator. Model 7030 has analog search and VLF out. From $4775. Dana Labs., (714) 833-1234.

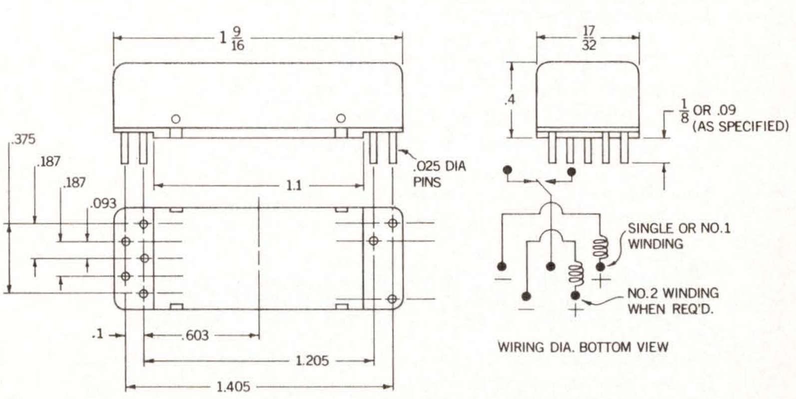
Circle 213 on Inquiry Card

when size makes the difference

Adlake makes the size

Adlake's new AWCM and AWDM Mercury Wetted Contact Relays — Sub-Miniature in size for printed circuit board use (see diagram) provides the answer to the high component density question. Small in size, yet made to Adlake's stringent quality requirements. Depend on Adlake's reliability and this new product to help solve your space problems. Available as contact Form C or contact Form D.

Write, please, for BULLETIN No. MW 5.



Adlake SINCE 1857

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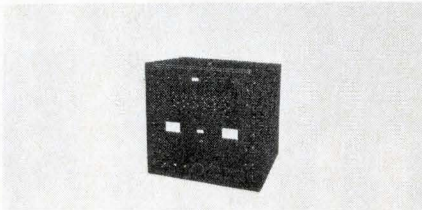
Mercury Relays / Architectural Products / Transportation Equipment / Doors and Entrances / Contract Manufacturing

Circle 45 on Inquiry Card

NEW LAB INSTRUMENTS

AUTOMATIC RELAY TESTER

Cycles to five operations a second.



Models R-4, R-5, R-6 test dry-circuit and pull-in (sensitivity adjustable to 10 μV or dry test). Wide range current/voltage for actuation/contact tests. Counters show faults/total cycles. Fleetwood Labs, (914) 235-0831.

Circle 223 on Inquiry Card

DIGITAL PICOAMMETER

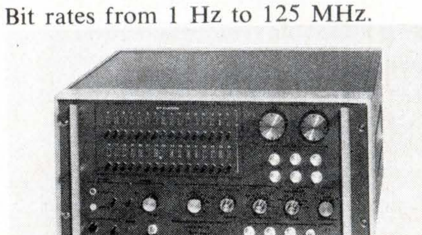
Three digits resolve to 10^{-13} A.

Model 440 has 9 ranges: 10^{-2} to 10^{-10} A f.s. Accuracy, ±0.5% on sensitive ranges, ±0.2% on others. 100% overranging, auto polarity and overload indication. Recorder output; printer output optional. $995. Keithley Instr., (216) 248-0400.

Circle 224 on Inquiry Card

DIGITAL DATA GENERATOR

Bit rates from 1 Hz to 125 MHz.

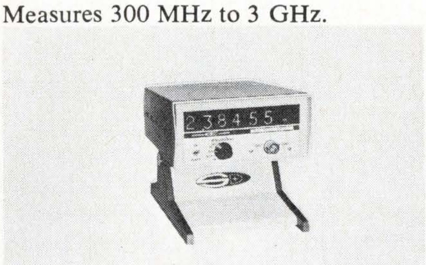


Model WG-100 has output of two 16-bit (or one 32-bit) words. Return-to-zero, nonreturn-to-zero formats. Provides logical complement. Rise/fall times, 1 ns. Output, 5 V/50Ω. Width, 2 ns-20 ms. $11,950. Tau-tron, (617) 458-6871.

Circle 225 on Inquiry Card

MICROWAVE COUNTER

Measures 300 MHz to 3 GHz.

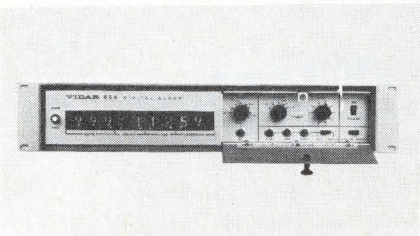


Model 153 uses automatic-computing transfer-oscillator: gives instantaneous measurement of changing inputs. Automatic tracking. Sensitivity, −10 dBm minimum. Oscillator stable to ±2 ppm/mo. $1350. Systron-Donner, (415) 682-6161.

Circle 226 on Inquiry Card

REAL-TIME DIGITAL CLOCK

Shows hours, minutes, and seconds.

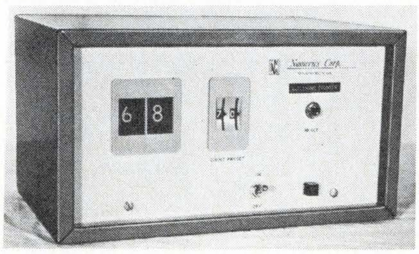


Preselect timed command pulses to occur at one of 70 intervals from 1 s to 25 h. Controls set starting time, select time of day or totalize mode. Nine-digit version shows days or manually-set data. Vidar, (415) 327-6340.

Circle 227 on Inquiry Card

PRESETTABLE COUNTERS

Models with up to six digits.



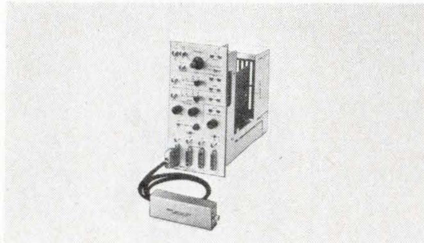
Signals generated by broken light path, magnetic field, etc. trigger these sensing counters. Dial in desired count, unit resets at that point. Counts to 50-kHz max. rate. Timed output signal. Numerics Corp., (617) 851-7229.

Circle 228 on Inquiry Card

NEW LAB INSTRUMENTS

MOS CLOCK

To 10-MHz rate.

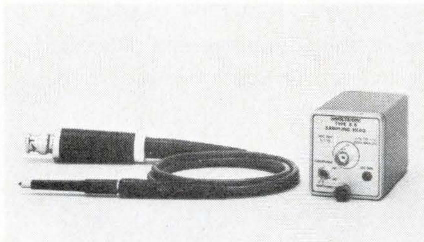


Model SQ532 gives 2- or 4-phase outputs. Level control to −30 V with 0 to −4 V offset. Each phase has extended driver probe: swings 0 to −30 V in 20 ns against 100 pF. TTL write-gate, output strobe. Adar Assoc., (617) 623-3131.

Circle 229 on Inquiry Card

SAMPLING HEAD

Switch selects ac or dc coupling.

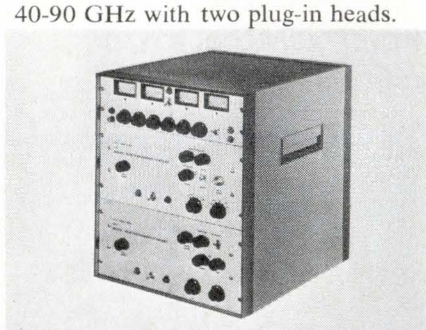


Type S-5 is low-noise (500 μV) with 1-ns risetime, and 1-MΩ/15-pF input. P6010 passive x10 probe (included) raises input impedance, has 20 mV to 2V/div. sensitivity. Max. dc input, ±100 V. $315 f.o.b. Tektronix, (503) 292-2611.

Circle 230 on Inquiry Card

MILLIMETER-WAVE SWEEPER

40-90 GHz with two plug-in heads.

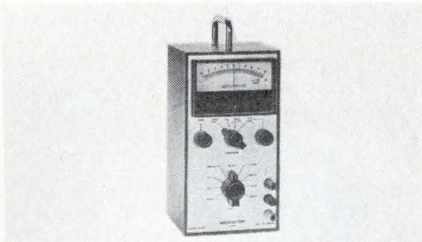


Model 740 system has wide-range BWO. Heads span 40-62 GHz (20mW avg.), 60-90 GHz (5 mW rated). Power supply has voltage sequencing; simplified supply option if sweeping not needed. $10,500. Micro-Now Instr., (312) 282-0846.

Circle 231 on Inquiry Card

NULL DETECTOR

Fully floating and guarded input.



Model A-65C also has isolated recorder output. Full-scale ranges 10 μV to 100 Vdc, ±3% accuracy. Resolution to 0.1 μV; noise level is ±50 nV. Stays zeroed at any source-impedance. Battery/line operation. $295. Medistor Instr. (206) 784-8141.

Circle 232 on Inquiry Card

TRANSFER STANDARD

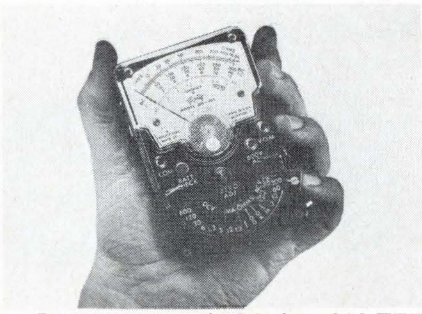
Has 0.001% accuracy without tables.

Model TRS-105 ac to dc thermal transfer standard is self-certifiable. Can reference up to 1 kVrms to known dc voltage. Eleven ac ranges. Overvoltage protected. Needs 100-nv f.s. sensitive null detector. $1500. Julie Res., (212) 245-2727.

Circle 233 on Inquiry Card

VOM WITH FET CIRCUITS

Constant-impedance 10-MΩ dc input.



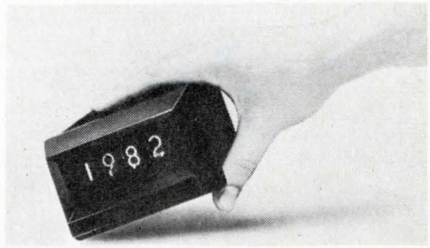
Battery-operated Model 310-FET measures 0.3-600 Vdc in 6 ranges; 3-600 Vac (5kΩ/V); 0-1.2 mA; resistance to 5 MΩ. Battery self-test position. Size 2.75 x 4.25 x 1.125 in., 14 oz. User Net, $70. Triplett, (419) 358-5015.

Circle 234 on Inquiry Card

NEW LAB INSTRUMENTS

DIGITAL PANEL METERS

Range: 100 mV-100 V, 1 μA-100 mA.

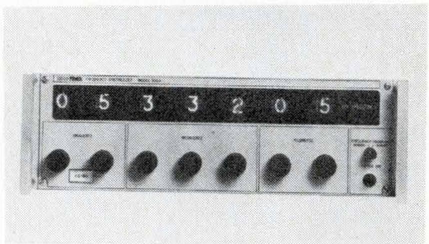


Ten versions of 3-digit DPMs all feature 100% overrange, no-blink display, BCD outputs, programmable decimal points, accuracies of 0.1% of reading ±1 digit. Operate 0° to 60°C. Series 510 are 4 in. deep. Datascan, (201) 478-2800.

Circle 235 on Inquiry Card

MICROWAVE SYNTHESIZER

From 1 to 12.4 GHz.

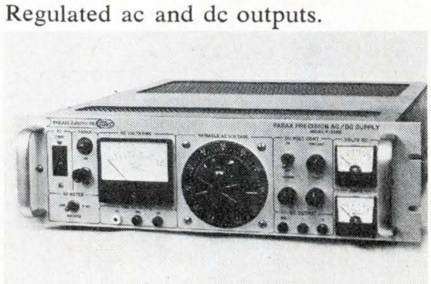


Select frequencies manually, or by 4-wire BCD +5 V to each digit. Stability, 1 x 10^{-8}/day. Power out, 15 mW min. in each of 4 bands. Harmonics, −20 dB, other spurs, −60 dB. Uses external VCO. Model 300A. Micro-Power, (212) 726-4060.

Circle 236 on Inquiry Card

UNIVERSAL POWER SUPPLY

Regulated ac and dc outputs.

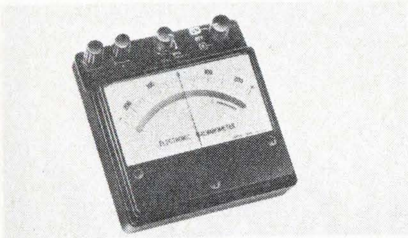


Both ac and dc outputs are superimposed over a 50-dB noise-level filtering. Regulation is 5 mVdc, and 0.25% ac. Outputs are 0-140 Vac, 0-8 Vdc, 500 VA. Fully metered. Model P-5505 costs $875. Wanlass Instruments, (714) 546-1811.

Circle 237 on Inquiry Card

ELECTRONIC GALVANOMETER

For null-reading in dc systems.



Type E11.501 has 10 μV/div. sensitivity (250 μV f.s.) and 3 s response time. Common-mode rejection more than 140 dB at dc, 50/60 Hz. Input resistance, 9 kΩ. 5-V overload protection. Battery operated. $135. Voltron, (213) 681-2751.

Circle 238 on Inquiry Card

LOGARITHMIC RF AMPLIFIER

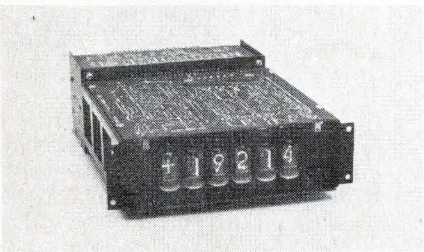
Spans 400 kHz to 130 MHz.

Model 6001 accepts −70 to +20 dBm inputs. Linear output is detected, accurate to ±3 dB. Expand control increases sensitivity. Offset switch for high-resolution measurements. Meter reads in dBm. Telonic, (317) 787-3231.

Circle 239 on Inquiry Card

NEW OPTION FOR DPM

Automatic peak or null retention.



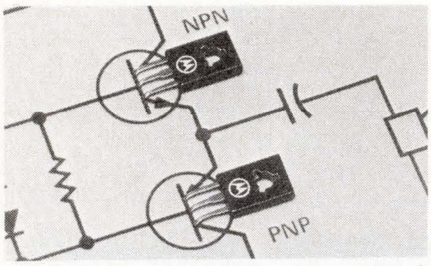
In peak-retention mode, reading changes only when previous value is exceeded. In null mode, reading is changed only for lesser value. All digital circuitry. For Models 3410, 3400, or 3310. Option 09. $175. Electro-Numerics, (408) 248-5020.

Circle 240 on Inquiry Card

EE NEW PRODUCTS

PLASTIC TRANSISTORS

Package is only ⅝ x ½ x ⅛ in.

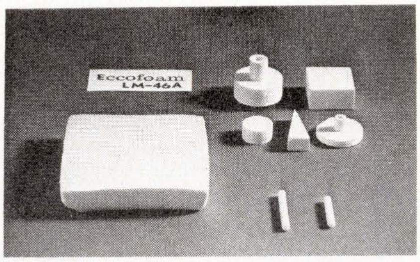


Two pairs of low cost encapsulated silicon transistors are for use in 20 and 35 W complementary audio amplifiers. The NPN MJE205 and PNP MJE105 are 5 A transistors for use in amplifiers delivering up to 20 W. The NPN MJE2801 and PNP MJE2901 are 10 A transistors for use in amplifiers with outputs of up to 35 W. Motorola Semiconductor Products Inc. (602) 273-6900.

Circle 241 on Inquiry Card

GLASS FOAM

Can be used to 1000°F.

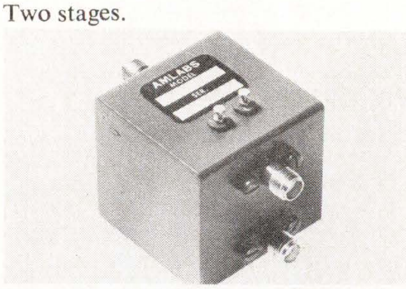


Eccofoam LM-46A is a unicellular, low density (0.330 g/cc), low loss (0.007 at 8.6 GHz), low dielectric constant (1.54 at 8.6 GHz) glass foam that is completely impervious to moisture. Applications include radomes, transmission line windows, dielectric supports in vacuum, non-tracking insulator for HV antennas, and as waveguide dielectric. Emerson & Cuming, Inc. (617) 828-3300.

Circle 242 on Inquiry Card

C-BAND YIG FILTER

Two stages.



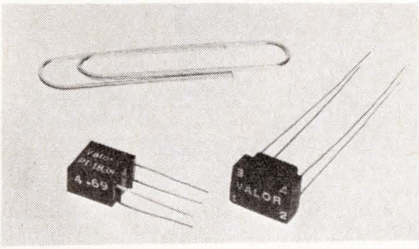
Model C2202 operates from 4.0 to 8.0 GHz. Guaranteed performance (per 2-stage channel) includes 2.5 dB insertion loss, a 3 dB bandwidth of 30 to 50 MHz (depending on customer's requirements), > 60 dB off-resonance isolation, 1.5 dB combined passband-spurious and ripple, and an rf limiting level > ±18 dBm. Advanced Microwave Laboratories. (408) 245-5770.

Circle 243 on Inquiry Card

EE NEW PRODUCTS

MINIATURE TRANSFORMERS

For core memory and transistor uses.

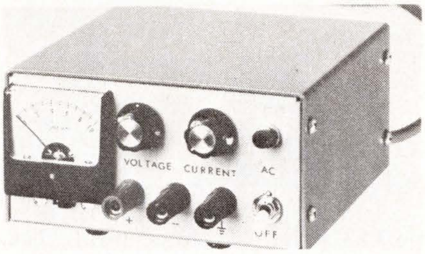


Features include miniature ferrite toroids, winding to winding ins. res. 10,000 MΩ, and low leakage. Model PT 1851 is 0.500 x 0.350 x 0.250 in. with channeled base. Model PT 1838 is 0.365 x 0.235 x 0.280 x 0.325 in. and is adaptable to PC boards where axial leads are preferred, or drop-in type leads are needed. Valor Electronics, Inc. (714) 540-9261.

Circle 244 on Inquiry Card

POWER SUPPLIES

Output ripple is only 0.5 mV RMS.

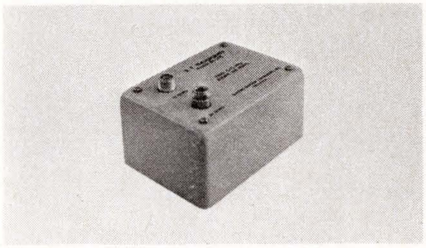


New Power-Pact series of miniature supplies features 0.01% reg. plus front-panel control and metering of output voltage and current-limiting level. Five models are available with outputs of 10, 20, 50, 100, and 150 V at 20 W. Case dimensions are 2½ in. high by 5 in. wide by 5 in. deep. Pacific Radionics. (408) 379-3280.

Circle 245 on Inquiry Card

HIGH POWER BALUNS

Efficiency is 97% or better.



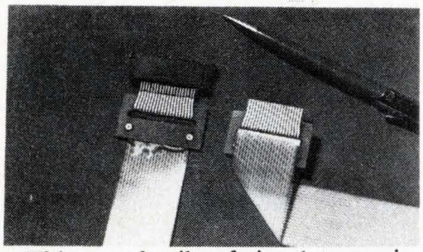
This series of baluns, which includes models up to 200 kW average power, permits use of either balanced or unbalanced line between transmitter and antenna. Frequency range is 1.5 - 34 MHz with impedances of 50, 75, 200, and 600 Ω and insertion VSWR of <1.2:1. The baluns are available either dry or oil filled. Electro Impulse, Inc. (201) 741-0404.

Circle 246 on Inquiry Card

EE NEW PRODUCTS

CABLE ASSEMBLIES

For subsystem interconnection.

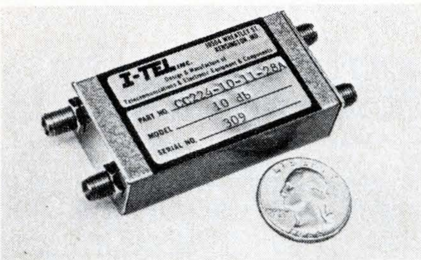


This new family of signal transmission line component assemblies transmit digital pulses through precisely controlled parallel wire cables. Cables are made with TFE Teflon insulation and silver-plated copper conductors. Characteristic impedance can range from 50 to 300Ω. W. L. Gore & Associates, Inc. (302) 368-0651.

Circle 247 on Inquiry Card

DIRECTIONAL COUPLERS

For 1.0 - 12.4 GHz freq. range.

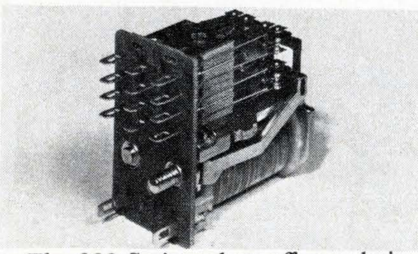


Series 234 couplers are available in five degrees of coupling from 3.0 to 20 dB, with coupling deviation across the freq. band < ±0.5 dB for the 3 dB model and < ±1 dB for all others. Directivity is 10 dB min., typically 15 dB, and VSWR is 1.30. I-Tel Inc. (301) 946-1800.

Circle 248 on Inquiry Card

MINIATURE DC RELAYS

Choice of Form A, B, C or D contacts.

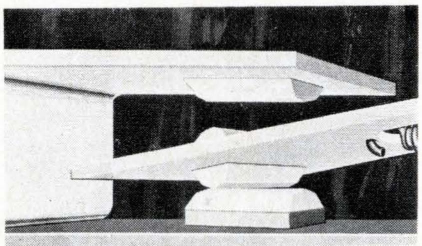


The 900 Series relays offer a choice of Form A, B, C or D contact arrangements in pole sizes from one Form A through eight Form D. Six different contact types are available for loads from dry circuit to 10 A with coils from 3 Vdc to 115 Vdc. Parelco, Inc. (714) 493-4507.

Circle 249 on Inquiry Card

SNAP-ACTION SWITCH

For solid state use.

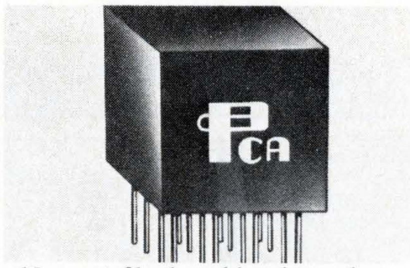


Gold "Crosspoint" contacts are used on E53 series low torque switch. The contacts deliver high force per unit area (contact pressure) and low susceptibility to contact closure interference from foreign particles (as compared with conventional ⅛-in. dia. contacts). Cherry Electrical Products Corp. (312) 831-2100.

Circle 250 on Inquiry Card

BALUN TRANSFORMERS

Feature small size.

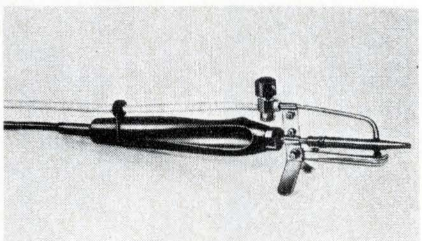


New actafiler broad-band transformers are for low impedance operation on transmission lines, balanced to unbalanced. Only 0.650 in. long, 0.500 in. wide and 0.700 in. high, they have an open circuit inductance of 350 μh, minimum, and a low leakage ind. of 0.5 μh. PCA Electronics, Inc.

Circle 251 on Inquiry Card

DE-SOLDERING TOOL

Works on compressed air.

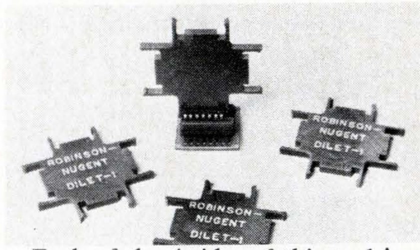


Suction is created by way of the "Venturi" principle, in the "bit" of the tool. The result is a continual cleaning of the tool itself by the high pressure air flow. An ordinary foot pump may be used if a compressed air line is not available, Hunter Associates. (201) 672-0423.

Circle 252 on Inquiry Card

DIL EXTRACTION TOOL

Saves time and trouble.

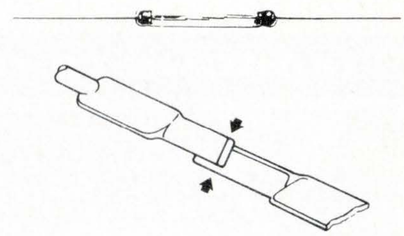


Each of the 4-sides of this tool is a different size to accept any 14 or 16 lead DIP package. DILET-1 helps keep IC leads from becoming bent or twisted; often precludes later time and trouble of straightening in the event leads must be re-inserted. Molded from red polycarbonate. Robinson-Nugent Inc.

Circle 253 on Inquiry Card

REED SWITCH

Bounce minimized.

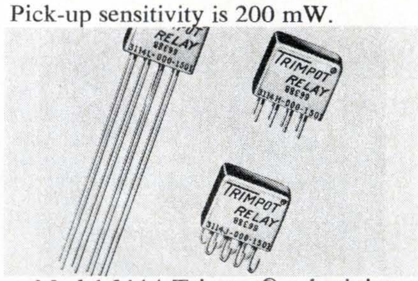


Blades of this magnetic reed are twisted from their normal planes. The closing and opening action is described as sliding or wiping. Bounce of the Tiny Twister^{PP} is about 70 μs (std. about 1 ms) and initial contact resistance, 0.100Ω. Gordos Corp. (201) 743-6800.

Circle 254 on Inquiry Card

DPDT RELAY

Pick-up sensitivity is 200 mW.



Model 3114 Trimpot® subminiature relay is only 0.23 x 0.5 x 0.4 in. It has an oper. temp. range of −65° to +125°C, a coil resistance range of 45 to 980Ω and a contact rating of 2 A at 28 Vdc; 150,000 cycles min., with relay case grounded. Resistance tol. is ±10%. Bourns, Inc. (714) 684-1700.

Circle 255 on Inquiry Card

VOLTAGE BAND MONITORS

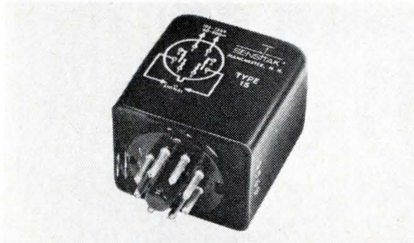
Protect equipment.

VB series monitors have SS voltage sensors that determine pre-selected under or over voltage conditions and de-energize an internal control relay if these limits are exceeded. The monitor can be used to sound an alarm, light warning lights, or shut down the equipment. A time delay accommodates start-up transients. Diversified Electronics, Inc. (812) 424-2288.

Circle 256 on Inquiry Card

NULL SENSING RELAYS

Replace more complex components.

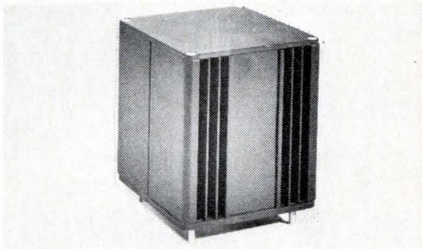


Internal reed switch load contacts respond to phase reversals of input signal. These hybrid modules can often replace more complex, costly, and frequently less reliable components commonly used for transducer sensing, servo-positioning, or sensing and regulating motion displacement in process and machine control systems. Sensitak Instrument Corp. (603) 627-1432.

Circle 257 on Inquiry Card

DC POWER SUPPLIES

Regulation is 0.25%.



The E series modulator supplies combine an FET with a temp. compensated zener diode to provide a stable reference source. Models are available from 5 to 300 V with currents from 0.25 A. Short circuit protection is accomplished by a circuit that reduces the output to essentially zero within 2 μs. Universal Electronics Co. (213) 393-9219.

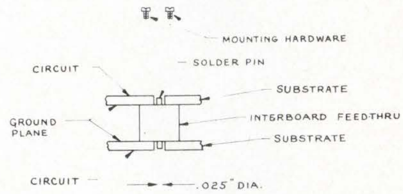
Circle 258 on Inquiry Card

Circle 52 on Inquiry Card

EE NEW PRODUCTS

INTERBOARD FEED-THRU

For microwave ICs.

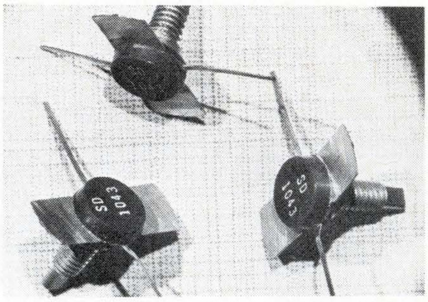


This device lets you stack your MIC boards and feed-thru 50Ω rf signals with a min. of discontinuity, and with considerable savings of space. It brings the circuit from microstrip to coax and back to microstrip and serves as a mounting fixture to hold and align substrates. Tek-wave, Inc.

Circle 259 on Inquiry Card

POWER TRANSISTOR

Has low cross modulation.



This VHF/UHF transistor, built with multi-emitter electrodes also has a heavily diffused base matrix located between the individual emitters. This results in high rf current handling capability and high power gain. The SD1043 is for CATV output amp. applications. Solid State Scientific Corp. (215) 855-8400.

Circle 260 on Inquiry Card

HIGH Q RF COILS

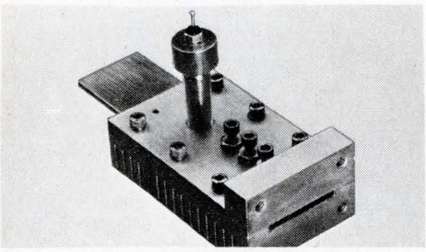
Have very high stability.

These tunable coils come in values of 0.1 to 100,000 μH in a 10% series and are tunable over a ±10% range. Effective use of powdered iron and optimized coil design yields a 50% improvement in Q over similar sized packages, and a minimal TC (about 30 ppm/°C). The 7/16 x 7/16 x ½ in. magnetically and electrostatically shielded package is moisture sealed. Q values of 140 to 160 are typical for inductors of 0.18 to 330 μH. Price is $3.25 to 2.15. Coil-craft, Inc. (914) DE 7-4775.

Circle 261 on Inquiry Card

X-BAND OSCILLATOR

RF output is 250 mW.

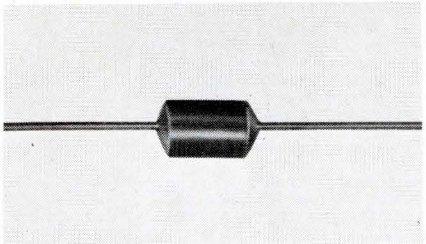


Model 4401OH oscillator features direct dc-to-microwave conversion and has a silicon avalanche diode as the active element. It achieves an rf output of 250 mW min. from a dc supply voltage of 60-80 V at about 100 mA. Frequency range is 8.0 to 12.4 GHz. Hughes Electron Dynamics Div.

Circle 262 on Inquiry Card

WIRE WOUND RESISTORS

Low TC and high stability.

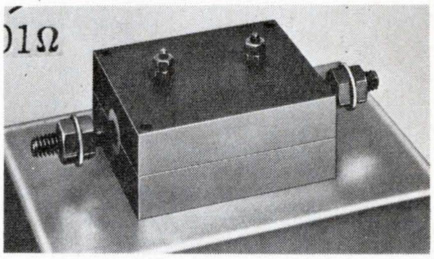


The economy line series "E" precision resistors have low temperature coefficients (std = ±10 ppm/°C), high stab., and close tolerances (±1.0%, 0.5%, 0.25%, and 0.1%). Wattage rating is 60°C amb. and is derated to 0 at 105°C. RCL Electronics, Inc. (201) 763-2820.

Circle 263 on Inquiry Card

POWER RESISTOR

Used for sensing and as current shunt.



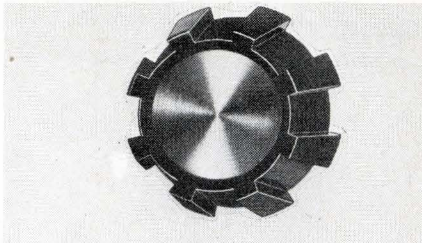
This resistor dissipates high power while mantaining low resistance values at precision levels. SPR-390 has a range of from 0.001 Ω to 0.005 Ω with a temp. coeff. of ±50 ppm/°C from +25° to +125°C. Standard tol. is 1%. Special Resistor Dept., Wirewound Div., Dale Electronics, Inc.

Circle 264 on Inquiry Card

EE NEW PRODUCTS

CONTROL KNOB

For control-panels.

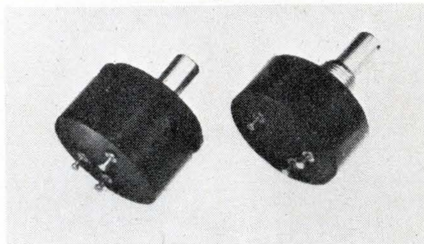


Model #568 knob, is available with or without a 1⅝ to 2½ in. dia. skirt. Skirt comes in spun or bright aluminum and can be lithographed, etched, or debossed. The plastic grip can be furnished clear or in colors. Westmoreland Plastics..

Circle 265 on Inquiry Card

PRECISION POTS

In servo or bushing mounts.



Conductive plastic track of these 30 pots reduces wear-effect for improved reliability. Other advantages are its greater accuracy with resulting lower noise level and smoother control. Minimum no-load oper. life of the servo type pots is 20,000,000 revolutions. Resistance is from 1000 to 50,000Ω. PIC Design Corp. (516) 593-6470.

Circle 266 on Inquiry Card

HV RECTIFIERS

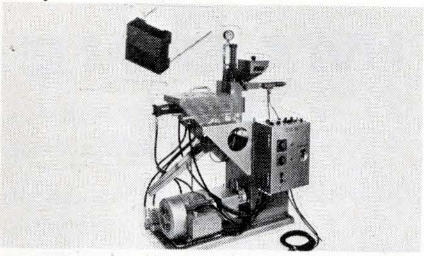
Feature integral heat sinks.

Two new medium power rectifier modules (J531 and J532) dissipate 10 and 20 W respectively in free air (25°C). They may be assembled into many configurations of rated voltage and current. With a ¼ in. min. space between modules they will operate at rated current in 25°C amb. air. Solitron Devices, Inc. (914) 359-5050.

Circle 267 on Inquiry Card

PLASTIC MOLDING MACHINE

Fully automatic.

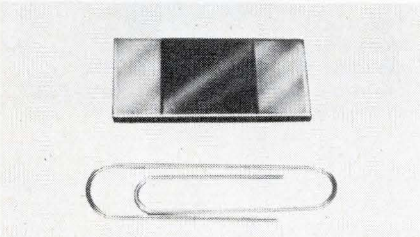


Unisetter 4 transfer molding machine is for production and laboratory use. Small, fast, rugged, and simple to operate, it can be used for molding small precise and intricate parts from thermosetting resins. Schriever Design Co., Inc. (203) 929-5331.

Circle 268 on Inquiry Card

CHIP RESISTORS

For hybrid circuits.

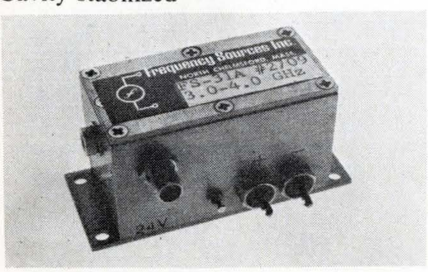


CR05 thick film chip resistors are 0.050 x 0.050 x 0.012 in. Resistance range is 1 Ω to 2 MΩ, temp. coef. −55°C to 125°C ±200 ppm, and diss. 1/10 W at 125°C. The CR05 has a glass seal overcoat, while land areas are platinum-gold. They are available with tolerances of 1, 2, 5, 10 and 20%. EMC Technology, Inc. (215) 563-1340.

Circle 269 on Inquiry Card

MICROWAVE OSCILLATOR

Cavity stabilized



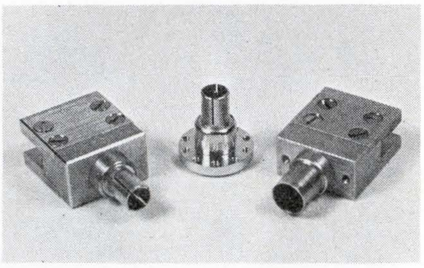
New wide-band mechanically tunable, fundamental freq. SS oscillator can be tuned over the 3-4 GHz freq. range with a single adjustment. Model FS-31A has a min. power output of 10 mW. Frequency stab. is > ±0.05% over the temp. range of −30°C to +70°C. Frequency Sources, Inc. (617) 774-0577.

Circle 270 on Inquiry Card

EE NEW PRODUCTS

STRIPLINE LAUNCHERS

Gold plated with BeCu contacts.

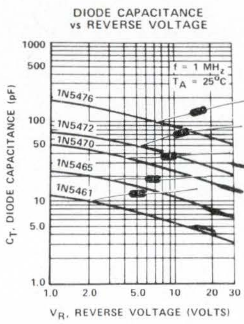


"Push-on" launchers provide quick connect/disconnect to a Type N interface. They are available for strip linewidths of 0.050 to 0.200 in. with clamping plate spacing of ⅛, ¼ and ⅜ in. Maximum VSWR for end-launchers is 1.08 dc to 11 GHz; right angle launchers is 1.15 dc to 5 GHz. Solitron/Microwave ESCA Div. (305) 287-5000.

Circle 271 on Inquiry Card

TUNING DIODES

For UHF control.



High Q, premium diodes, IN5461A, B, C through IN5476A, B, C operate over a 30 V range and are available with a nominal 2% capacitance tol. ("C" suffix units). There are also 5% and 10% ("B" and "A" suffixes, respectively) units available. Nominal capacitance range runs from 6.8 to 100 pF in 16 devices. Motorola Semiconductor Products Inc. (602) 273-8466.

Circle 272 on Inquiry Card

POLYCARBONATE

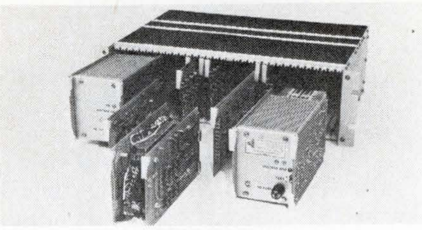
Fiberglass reinforced.

Carbasar uses a combination of long glass fibers with short fibers randomly dispersed in the same molding compound pellet. The combination provides the best benefits of both types of reinforced thermoplastic. The long fibers produce improvements in the resin's physical properties, while the short fibers provide ease in molding and a high surface finish. Rexall Chemical Co., Fiberfil Div.

Circle 273 on Inquiry Card

CORE MEMORY SYSTEM

Has a 3 μs full cycle time.

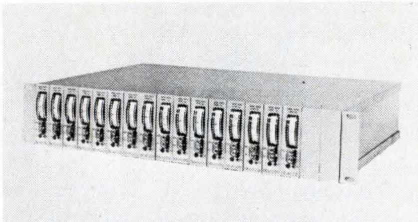


The FI-3 coincident-current ferrite core system has a capacity of 4096 words by 20 bits/word and a 1 μs access time. It is available with address register, sequential counter and memory retention. One timing and control card provides all internal time pulses. Ferroxcube Corp. (914) 246-2811.

Circle 274 on Inquiry Card

LOW NOISE DISCRIMINATOR

Long-term stability is ±0.05%.

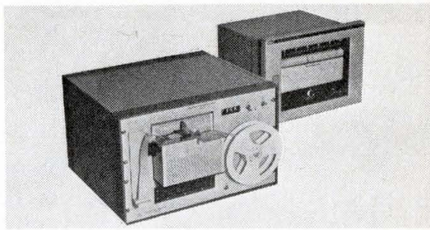


Model 6203 discriminator is for carrier systems transmitting up to eight channels of data over Class A voice links. It has tape speed compensation. Temp. drift is only 0.005%/°C (equal to 50 ppm/°C) and linearity of 0.25%. It requires <0.5 W, or ±20 V, 10 mA/channel to operate. Develco, Inc. (415) 969-1600.

Circle 277 on Inquiry Card

RECORDER LOGGER

Automatic, unattended operation.

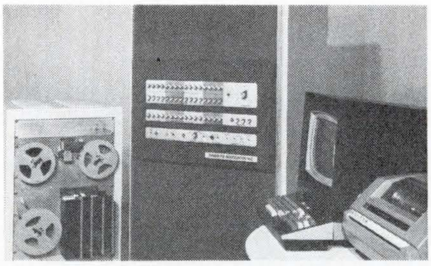


Model 141 multipoint recorder logger connects directly to multipoint recorders, digitizes and records the data for computer entry. It makes a 4-digit record of each data point on punched paper tape in 8-level ASCII or IBM code. Logging is synchronized to the recorder. Control Equipment Corp., Needham Hts., Mass. (617) 444-7550.

Circle 278 on Inquiry Card

COMMUNICATIONS PROCESSOR

Minimizes software needs.



High-speed Sandac™ 200 programmable processor has 256 I/O terminals that can operate simultaneously with peripheral devices such as display terminals. It has up to 131,072 bytes of directly addressable core memory. It is for computerized reservation systems, message switching and other real time data applications. Sanders Associates, Inc. (603) 885-2814.

Circle 275 on Inquiry Card

TELEMETRY SYSTEM

Comes as a two- or three-freq. system.

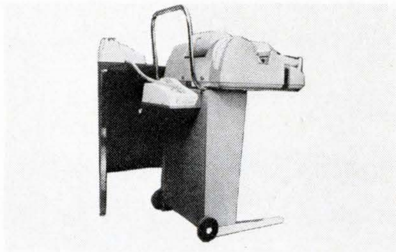
Model 4010/4020 tone telemetry operates over any voicegrade circuit, allowing simultaneous transmission of up to 30 tone channels on a single circuit. Data control and alarm channels may be transmitted simultaneously. Vega Electronics Corp., Santa Clara, Calif. (408) 243-9777.

Circle 276 on Inquiry Card

EE SYSTEMS EQUIPMENT

TERMINAL AND DATA SET

It's completely portable.



Modified Model 33 Teletype and acoustic data set has a range of options including paper tape I/O; automatic control of paper tape reader and / or punch; friction or sprocket feed; automatic form feed; 74 or 88 cols./line; mobile stand; separate or built-in acoustic data set providing originate only or originate / answer mode. ComData Corp. (312) 692-6107.

Circle 214 on Inquiry Card

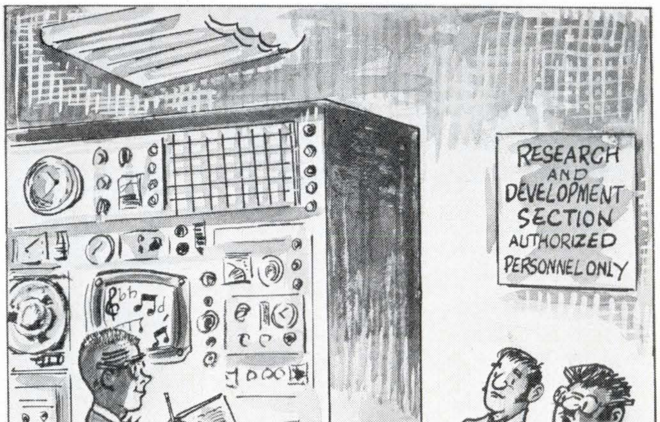
HIGH-SPEED PRINTER

With MOS-LSI logic.

The HSP 3550 chain printer offers up to 192 different characters — numeric, alphanumeric and symbolic— in sets of 48, 64, 96 or 192. Four-character slugs are individually replaceable. It features dual speed, servo-controlled paper feed for maximum throughput and provides IBM compatible vertical format (12 channel). Potter Instrument Co., Inc. (516) 694-9000.

Circle 215 on Inquiry Card

ELROY



Thanks to Joe Dubin for idea.

"Elroy moonlights as a songwriter . . . He astounded the musical world with his originality!"

MINI-COMPUTER

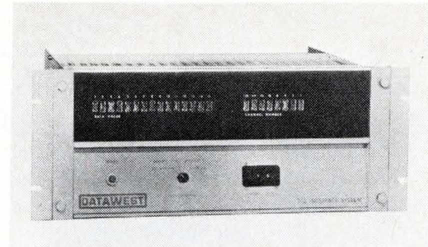
Sells for $9,700.

The model H-316 computer is for scientific and control uses. It is available with over 500 software packages, field-proven on other Series 16 computers. Memory cycle time is 1.6 μs and basic memory size is 4,096 16-bit words expandable to 16,384. The H-316 comes in three versions: pedestal, table-top and rack-mountable. Honeywell Computer Control Div. (617) 879-2600.

Circle 216 on Inquiry Card

A/D INTERFACE SYSTEM

High-speed, high-resolution.

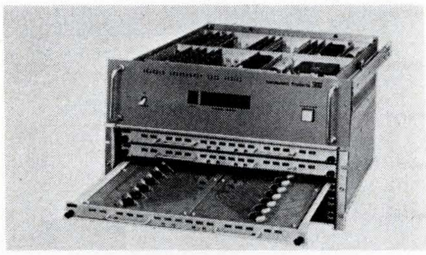


Model 380 system consists of a high level (single ended or differential) multiplexer, a sample and hold amplifier and a binary A/D converter. Its 100 kHz thruput rate applies to both random access and sequential modes of operation. Heart of the system is a Model 301 A/D converter that can digitize an analog signal to a resolution of 15 bits binary, at 250 kHz. Data West Corp. (602) 947-4295.

Circle 219 on Inquiry Card

REED RELAY SCANNER

Complete guarding permits high CMR.



The 3383/1221A high-speed computer programmed scanner can select one out of 10,000 input channels and route input data to one of ten output channels. Input storage registers for direct interface to T^2L positive or negative logic levels are provided. Instrument Products, 3M Co., 300 S. Lewis Rd., Camarillo, Calif. 93010 (805) 482-1911.

Circle 217 on Inquiry Card

ELECTRONIC "CROWBAR"

Protects microwave output tubes.

Acting within 2 μs after a fault is detected, the crowbar places a low-impedance path—a triggered-spark gap or a hydrogen-thyratron—across the tube output, diverting power which might otherwise damage tube elements. Voltages to 150 kV and currents to several thousand amps can be accommodated. Cober Electronics, Inc. (203) 327-0003.

Circle 220 on Inquiry Card

PAM/PDM COMMUTATORS

Sampling rates from 1 to 100,000 Hz.

Series 300 commutators provide an accurate rate, stable IRIG or special format telemetry pulse train in all airborne, missile or satellite uses. Overall accuracy is $>0.1\%$ and back current is virtually eliminated by using MOSFETs as switches (0.2 μA during non-sampling). Offset (5 mV max.) and scatter (1 mV max.) are low. Stellarmetrics Inc. (805) 963-3566.

Circle 218 on Inquiry Card

DATA SET

For dial-up communications.

The FM-18 data set is a low speed modem for linking peripheral units such as CRT displays to a central processor. It operates at any speed up to 1800 bps, when used as an asynchronous modem. A synchronous option is available. The FM-18 is frequency shift keyed for use in full duplex, half duplex, or simplex operations. Rixon Electronics, Inc. (301) 622-2121, Ext. 358.

Circle 221 on Inquiry Card

EE LITERATURE

Reed relays

If you specify reed relays there are several design considerations which you should be aware of. This 16-page brochure discusses these factors, which include dynamic characteristics, dry circuit operation, contact protection, shock and vibration, and relay reliability. It also contains data sheets on several series of reed relays. Self-Organizing Systems, Inc., Box 9918, Dallas, Tex. 75214.

Circle 321 on Inquiry Card

AC instruments

A 24-page catalog contains descriptions, specs, and application data for a line of ac instruments and power conditioners. Products include ac line conditioners, filters, line voltage regulators, closed-loop regulated power

conditioners, single to three phase converters, and so forth. The 1969 catalog also gives definitions of electrical terms and discusses basic engineering concepts. Wanlass Instruments, 1540 E. Edinger Ave., Santa Ana, Calif. 92707.

Circle 322 on Inquiry Card

Instrument reference

A 42-page brochure covers instrument mechanisms—their principle, theory, and application. There is detailed information on electrostatic and permanent-magnet moving coil mechanisms, and notes on special or unique environmental conditions and their impact on instrument design. A reference source to help you choose between digital and analog presentation, and a series of informal sketches of instrument mechanisms, make this a handy reference. Weston Instruments Div., Weston Instruments, Inc., 614 Frelinghuysen Ave., Newark, N. J. 07114.

Circle 323 on Inquiry Card

Electrically conductive products

New techniques for achieving immunity from electromagnetic interference are discussed in a 14-page application guide. Conductive products

described include elastomeric gaskets, adhesives, and caulking, potting, and coating compounds. These provide effective shielding and sealing in electronic enclosures, subassemblies, connectors, waveguides, and switches. Chomerics, Inc., 85 Mystic St., Arlington, Mass. 02174.

Circle 324 on Inquiry Card

Electron-beam evaporation

A 12-page booklet discusses the concept of electron beam evaporation for producing optical and electronic thin film devices. The basics of the technique, and the scope and benefits of its use, are outlined. Airco Temescal, Div. of Air Reduction Co., Inc., 2850 Seventh St., Berkeley, Calif. 94710.

Circle 325 on Inquiry Card

Wide-band amplifiers

A 4-page application note on wideband amplifiers discusses definitions of frequency for full output, gain bandwidth product, and slew rate. It lists precautions to take when you use wideband amplifiers, and gives other helpful data. Data Device Corp., 100 Tec St., Hicksville, N. Y. 11801.

Circle 326 on Inquiry Card

Thermocouples

This 12-page guide tells you how to install and use Chromel® — Alumel® thermocouples. It gives nine rules of good thermocouple practice and lists five check steps to take to isolate the source of trouble when you suspect you're getting erroneous readings. It also covers metallurgical factors which affect thermocouple performance. Hoskins Manufacturing Co., 4445 Lawton Ave., Detroit, Mich. 48208.

Circle 327 on Inquiry Card

Drafting templates

Catalog No. 75 (17 pages) contains photographs and descriptions of over a hundred drafting templates. Of special interest to EEs are the 13 electrical/electronic templates. There are also templates of instrument symbols, mathematical symbols, flow chart symbols for computer diagramming, fluidic symbols, and various mil-spec symbols. Rapidesign, Inc., Box 6039, Burbank, Calif. 91505.

Circle 328 on Inquiry Card

Electronic devices

A short-form catalog covers the company's product lines, which include high energy switching devices, xenon flashtubes, trigger transformers, and triggered spark gaps. The 6-pager also contains data on light instruments, photodiodes, thermoelectric products, and flash and strobe equipment. EG&G, Inc., Electronic Products Div., 160 Brookline Ave., Boston, Mass. 02215.

Circle 329 on Inquiry Card

Electrical tapes

You will find the latest data on a line of pressure-sensitive adhesive tapes in this new catalog. To simplify selection, the Mystik tapes are classified in five functional categories—masking, packaging, electrical, protective, and special purpose. Within each

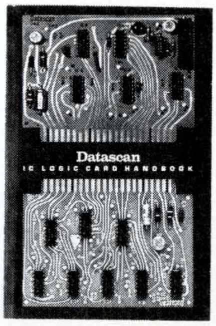
category are tapes which range from light to heavy duty, or for environmental conditions which run the gamut from standard to special to critical. Especially helpful in the 36-pager are a tape reference index and a list of government specification data. Borden Chemical Co., Mystik Tape Div., 1700 Winnetka Ave., Northfield, Ill. 60093.

Circle 330 on Inquiry Card

EE LITERATURE

IC logic cards

You will find 208 pages of data on a line of integrated circuit logic cards in this handbook. Criteria for selecting logic cards and card features are discussed. Then descriptions, circuit



operations, parts lists, specs, outline drawings, and prices are given for each module in the line. The handbook covers three card series—DTL, TTL, and HTL—as well as power supplies, hardware, and accessories. Datascan, Inc., 1111 Paulison Ave., Clifton, N.J. 07013.

Circle 331 on Inquiry Card

TTL logic ICs

Engineering Bulletin No. 25640 contains data on five high-speed TTL logic ICs recently added to the company's 5400/7400 family. Operating and electrical characteristics are included in the 8-page booklet, as are schematics. Sprague Electric Co., Marshall St., North Adams, Mass. 02147.

Circle 332 on Inquiry Card

Fluidic circuits

Data Sheet FAD-IC describes fluidic integrated circuits. Basic advantages of these devices — miniaturization, quick removal and replacement, and lower cost per circuit or gate—are discussed. Corning Glass Works, Corning, N.Y. 14830.

Circle 333 on Inquiry Card

Electromagnetic counters

A 23-page brochure discusses the history of counting and the company's facilities, and describes in detail a line of counters and accessories. Application and technical data and a coil selection chart are included. Hecon Corp., 31 Park Rd., New Shrewsbury, N.J. 07724.

Circle 334 on Inquiry Card

IC wire wrapping

Users and specifiers of wire-wrap devices will be interested in this 8-page folder, which describes the company's integrated circuit wire-wrap packaging and special services. In-

cluded in the source are descriptions, illustrations, and charts on products ranging from individual IC sockets to card files, complete with power planes and card connectors. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. 02138.

Circle 335 on Inquiry Card

Resistors and trimmers

This 1969 catalog contains data on miniature discrete resistors and trimming potentiometers for use in microcircuitry. You will find devices available with thin film, thick film, and wirewound resistive elements to cover a wide range of applications. IRC Div. of TRW Inc., 401 N. Broad St., Philadelphia, Pa. 19108.

Circle 336 on Inquiry Card

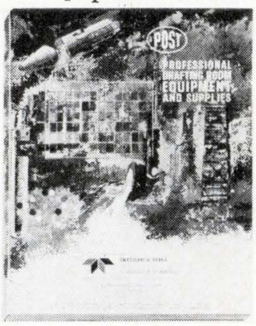
Reed relay series

An informative 24-page catalog covers over 160 reed relays. Topics include: reed relays as analog and digital devices, life and reliability characteristics, dynamic and static characteristics, and mechanical construction. Several series are detailed, including ultra-miniature, micro-miniature, miniature, standard, and mercury-wetted reed relays. Wheelock Signals, Inc., 273 Branchport Ave., Long Branch, N.Y. 07740.

Circle 337 on Inquiry Card

Drafting equipment

A 100-page catalog covers a whole line of drafting equipment for engineers and draftsmen, including drafting furniture, fixtures, accessories and supplies. Equipment for drafting,



materials for engineering graphics, sensitized drafting material, tools for drafting and illustration, and training material are the five product sections of the catalog. Frederick Post, A Teledyne Co., Box 803, Chicago, Ill. 60690.

Circle 338 on Inquiry Card

Circle 67 on Inquiry Card

Circle 68 on Inquiry Card

Microwave components

A 28-page capabilities brochure provides data on a line of metal glaze and microwave components. Among the products described are metal glaze power film resistors and networks, hybrid thick film devices, general microwave components, coaxial components, and stripline devices. EMC Technology, Inc., 1300 Arch St., Philadelphia, Pa. 19107.

Circle 339 on Inquiry Card

Relay rundown

Catalog No. 270 lists various stock relays for custom applications. The 16-pager describes several new products. It also covers a full line of general purpose, coaxial and hermetically sealed, telephone type, dry reed, mercury-wetted, industrial power, and plug-in relays. Latching, high voltage, and PC relays are included too. Magnecraft Electric Co., 5575 N. Lynch Ave., Chicago, Ill. 60630.

Circle 340 on Inquiry Card

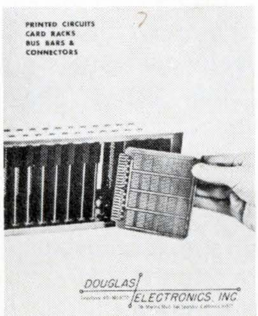
Digital data systems

This 12-page brochure discusses a new concept in automated digital data systems. It describes a complete automated data processing system and has a spec chart of computer-controlled telemetry equipment. Also covered are high-speed central processing units, system software, and support. EMR Telemetry, Box 3040 Sarasota, Fla. 33578.

Circle 341 on Inquiry Card

PC boards

Off-the-shelf IC breadboards, custom designed PC boards, and accessories are the subject of a 24-page catalog.

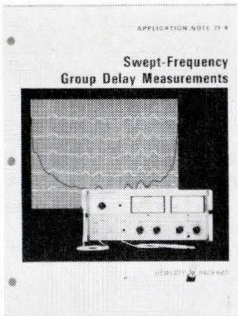


Products include ejectors, connectors, bus bars, card racks, and card rack cases. The catalog also has a checklist to help you prepare specs for custom boards. Douglas Electronics, Inc., 718 Marina Blvd., San Leandro, Calif. 94577.

Circle 342 on Inquiry Card

Delay measurements

How to measure group delay on a swept frequency basis is the subject of Application Note 77-4. The 8-page



booklet discusses modulation frequency needed, accuracy considerations, and explains how the measurement is made. Illustrations and schematics are included. Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304.

Circle 343 on Inquiry Card

Electrical contact tape

Econ-o-Tape®, a weldable electrical contact strip, is the subject of a 32-page brochure. Complete with charts, tables, and engineering data, the publication covers contact material selection, application, and design. Technical Service Dept., Englehard Minerals & Chemicals Corp., 113 Astor St., Newark, N.J. 07114.

Circle 344 on Inquiry Card

Air trimmer capacitors

An 8-page foldout guide provides data on concentric ring air trimmer capacitors. How they are constructed, how they work, and what are their main design features are discussed. Titled "The Inside Story," the reference also compares non-rotating trimmers with conventional air trimmers on a part-by-part basis. Voltronics Corp., West St., Hanover, N.J. 07936.

Circle 345 on Inquiry Card

Industrial amplifiers

A product catalog includes data sheets on a variety of transistorized amplifiers for use in electromechanical analog computers and data conversion equipment. Some of the products are an ac op amp, dual channel booster amps, an AGC amp, servo amps, a summing amp with quadrature rejection, CRT deflection amps, and so forth. Melcor Electronics Corp., 1750 New Highway, Farmingdale, N.Y. 11735.

Circle 346 on Inquiry Card

EE LITERATURE

Power transducers

A 12-page application note (No. 3) covers coaxial rf-to-dc power transducers. Operating and application data for three models are given. Their applications include remote monitoring of antenna power and commercial broadcast transmission power, protecting power-surge sensitive devices, and so forth. Narda Microwave Corp., Commercial St., Plainview, N.Y. 11803.

Circle 347 on Inquiry Card

SS motor protectors

A solid-state device which prevents motor damage caused by excessive temperature in the stator windings is the subject of an 8-page brochure. Complete operating and performance characteristics for the Statorstat motor protector are given, as are schematics and illustrations. Robertshaw Controls Co., 155 Hill St., Milford, Conn. 06460.

Circle 348 on Inquiry Card

Transistors

This 1969 Condensed Catalog covers a line of silicon and germanium small signal and power transistors.

Data for each family of transistors is grouped in separate sections, which contain typical curves, spec charts, outline drawings, and photos. The 52-pager also provides suggested applications. Solitron Devices, Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. 33404.

Circle 349 on Inquiry Card

Zeners and SCRs

An 8-page newsletter contains two separate articles, one of which describes silicon temperature compensated reference diodes (TC Zeners) and their applications. The second article examines the controversy over fast switching SCR circuits involving high inrush current. International Rectifier, 233 Kansas St., El Segundo, Calif. 90245.

Circle 350 on Inquiry Card

Character generator

A 6-page application note discusses the MM420/MM520, a 256-bit serial character generator. The operation, mechanization, and applications of the device—a read-only memory—are detailed. National Semiconductor, 2975 San Ysidro Way, Santa Clara, Calif. 95051.

Circle 351 on Inquiry Card

Screw fasteners

A line of pre-assembled lock washer and screw fastener units are discussed in a 28-page catalog (AS-800). Screw thread data is given along with dimensions for the various types of head styles. Shakeproof, Div. Illinois Tool Works, Inc., St. Charles Rd., Elgin, Ill. 60120.

Circle 352 on Inquiry Card

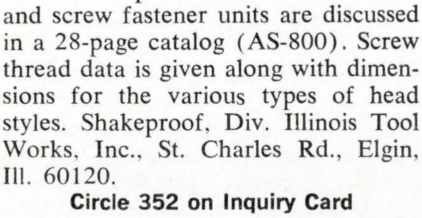
Logic breadboard

The Model 401 logic laboratory, a device for breadboarding logic circuits and systems, is the subject of a 10-page catalog. The unit's concept of movable modules permits the construction of circuits identical in form to their block diagrams. Adtech, Inc., Box 10415, Honolulu, Hawaii 96816.

Circle 353 on Inquiry Card

Fasteners

Shown in an accordion-folded packet is a montage of spring steel and plastic fasteners. The pocket-size port-



folio includes application ideas for various types of fasteners—both popular standards and new types. Tinnerman Products, Inc., Dept. 14, Box 6688, Cleveland, Ohio 44101.

Circle 354 on Inquiry Card

Inductors catalog

A 15-page booklet covers a variety of inductors, as well as coils, rf chokes, and coil forms. Descriptions of each series are given along with spec tables and outline drawings. James Millen Mfg. Co., Inc., 150 Exchange St., Malden, Mass. 02148.

Circle 355 on Inquiry Card

Ferrite devices

Catalog SF-1005 describes, in 12 pages, a line of coaxial and waveguide ferrite devices for airborne, shipboard, and ground-based radar and communication systems. Included in

the 1969 Catalog are electrical and mechanical specs and outline drawings for circulators, isolators, and modulators. Microwave Associates, Burlington, Mass. 01803.

Circle 356 on Inquiry Card

Miniature coaxial cable

An 8-page catalog lists features and specs of a miniature coaxial cable line. It gives illustrated tips on how to cut and trim this cable, and also describes miniature coaxial connectors (including microwave types), cable assemblies, and delay lines. Phelps Dodge Electronic Products Corp., 60 Dodge Ave., North Haven, Conn. 06473.

Circle 357 on Inquiry Card

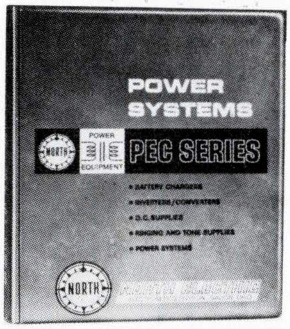
Microcircuit manual

A line of standard hybrid microcircuit products is treated in a 48-page catalog, half of which covers 14 different dc voltage regulators. Digital-to-analog components, power amplifiers, circuit protection devices, a lamp and relay driver, and heat dissipators are also listed. A helpful 12-page section contains application data. To receive the manual, send a letterhead request, including job title or function, to Technical Information Sect., Helipot Div., Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Calif. 92634.

EE LITERATURE

Power systems

A 40-page catalog covers chargers, inverters and converters, dc supplies, ringing and tone supplies, and power



systems for the communications industry. Features, applications, and specs are given. North Electric Co., Electronetics Div., Galion, Ohio 44833.

Circle 358 on Inquiry Card

High-voltage rectifiers

Two 4-page brochures cover two series of Solidpak® high-voltage rectifiers. Technical data, charts, and graphs help describe these devices, which are designed for space, missile, airborne, surface, and under-sea applications. Solitron Devices, Inc., 256 Oak Tree Rd., Tappan, N. Y. 10983.

Circle 359 on Inquiry Card

Switches and indicators

Illuminated push-button switches and matching indicator lights are the subject of Catalog L-169D. Operating data, drawings, and ordering information are provided in the 12-page brochure. Dialight Corp., 60 Stewart Ave., Brooklyn, N.Y. 11237.

Circle 360 on Inquiry Card

Lab humidity chambers

Bulletin 686 covers Vapor-Temp® temperature/humidity chambers, portable cooling units, batch and laboratory ovens, high temperature ovens, and baths. Design, construction, and pricing information are included in the 4-page booklet. Blue M Electric Co., 138th & Chatham St., Blue Island, Ill. 60406.

Circle 361 on Inquiry Card

RF power transistors

A handy folder/wall chart lists key parameters for 24 different rf power transistors. A frequency vs power chart shows frequency/power capabilities for each of these devices. Also included in the quick-reference guide are six package drawings. ITT Semiconductors, Inquiry Services Dept., 3301 Electronics Way, West Palm Beach, Fla. 33407.

Circle 362 on Inquiry Card

Circuit test system

The J259 is a versatile dc measurement system for testing multi-terminal electronic circuits, such as integrated and hybrid circuits, discrete component modules, and many other devices and circuit boards. A 9-page brochure covers this computer-operated system in detail. Teradyne, 183 Essex St., Boston, Mass. 02111.

Circle 363 on Inquiry Card

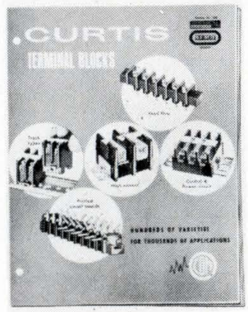
DC test instrument

The 300 PVB, a dc test instrument that combines seven measurement functions in a single portable case, is the subject of a 7-page brochure. Priced at $975, this unit can serve as a potentiometric voltmeter, voltage source, ammeter, guarded Kelvin bridge, resistance comparison bridge, ratiometer, and electronic null detector. Electro Scientific Industries, Inc., 13900 N.W. Science Park Dr., Portland, Ore. 97229.

Circle 364 on Inquiry Card

Terminal blocks

Catalog No. 369 (24 pages) covers a line of terminal blocks. Among the new products listed are electrotinned tubular connectors and continuous jumpers. Illustrations, dimensions, de-



scriptions, ratings, and prices are included. There's also a handy terminal block selection chart. Curtis Development & Mfg. Co., 3250 N. 33rd St., Milwaukee, Wis. 53216.

Circle 365 on Inquiry Card

A COMPREHENSIVE SUMMATION
Microwave Semiconductor Devices and Their Circuit Applications

Edited by H. A. Watson. Published 1969 by McGraw-Hill Book Co., 330 West 42nd St., New York, N. Y. 10036. Price $22.50. 609 pages with 294 illustrations; indexed.

As is usual in material of this sort, there is a fair amount of mathematical analysis sprinkled throughout. But the text remains very readable, because the math is held to that which is necessary to make a point.

Well organized into five major divisions, the text opens with Part 1 serving as a short, to-the-point summary of the key parameters of microwave devices. It divides them into two classes (with some overlap, of course) by device behavior (non-linear resistance or reactance, controllable impedance, and so forth) and by structure (pn junction, Schottky-barrier, IMPATT, Gunn, and so forth).

The five chapters of Part 2, "Semiconductor Physics," take you step-by-step from the Schrödinger wave equation and atomic structure, through crystals, electrical conduction, and junction theory to semiconductor surfaces and ohmic contacts. Such material is often a stumbling-block for many readers. But this text reads more easily than most others.

The meat of the book—as suggested by its title—is in Part 3, "Microwave Diodes and Circuits." Here are 388 pages of detailed discussion on varactors; pin diodes; Schottky-barrier devices; switches, limiters, and phase shifters; detector and mixer diodes and circuits; tunnel diodes; IMPATT diodes; and bulk GaAs devices. Besides explaining how all of these semiconductors operate, Part 3 also shows the whys and wherefores of their important uses.

And lest we forget the faithful transistor, Part 4 is a two-chapter disquisition on microwave transistors that includes a detailed study of the design and construction of a 4-GHz amplifier.

Part 5, "Present Trends," compares a number of devices with regard to noise performance, power output capabilities, and reliability. This part concludes with some estimates about future performance.

To sum up, you will find that this volume emphasizes basic principles. It includes a sufficient number of real-device descriptions and applications to orient both device and circuit designers, and shows the physical and technological limitations on performance. The text has a wealth of references.

Advertisers—May 1969

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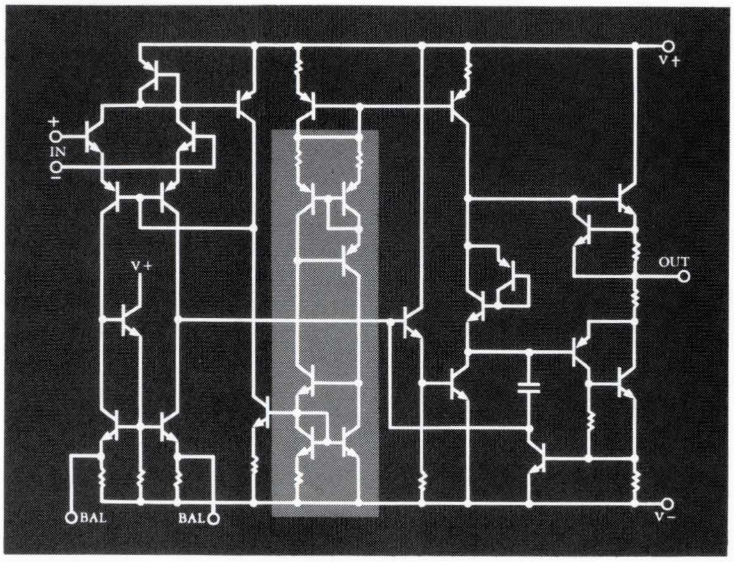
Op amps, like girls, are pretty much alike.

Now meet Miss Universe.



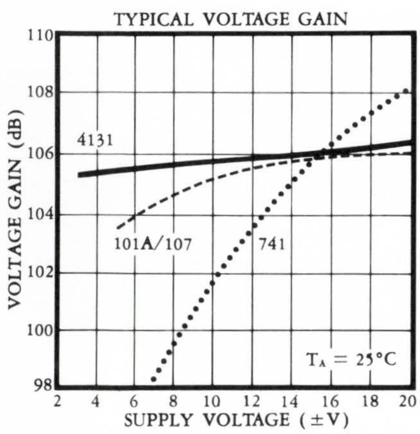
Now, we're not ones to thump the tub much. But this month we're unveiling our RM4131 fully compensated op amp, a pin-for-pin replacement for the good old 709, 101A, 107 and 741, and we felt you ought to know. It's not that the RM 4131 has anything the others don't have. It just has a potfull more of everything.

Figures don't lie.
Here are all the significant figures. Read 'em and weep, you other guys. And they don't even mention things like the RM4131 only needs a 10k ohm trim pot for balancing, not a 5 meg pot like some we could name.

Specification	741	107	4131
Slew rate (v/μs) 2k load	0.5	0.5	2.0
Min. voltage gain (dB) @ ±3 volts	80	80	94
Typ. bandwidth (MHz)	0.8	0.8	4.0
Max. power consumption (mW) @ ±20V, 25°C	120	120	64
Max. bias current (nA) @ 25°C	500	75	50
Max. offset current (nA) @ −55 to 125°C	500	20	20
Max. offset voltage (mV) @ −55 to 125°C	6.0	3.0	3.0

Take slew rate.
Compare our 2.0 v/μs typical slew rate to 0.5 v/μs for the others. And our slew rate is guaranteed 1.5 v/μs minimum across the whole ±3 to ±20-volt supply range, while the others peak sharply at ±15 volts.

And voltage gain.
Time now for a graph. Notice that the 107 shows specified gain only down to ±5 volts. At ±3 volts our RM4131 has 94 dB gain, compared to about 80 dB for the others.



Or bandwidth.
Naturally, frequency response jumps, too. At 25°C, the RM4131 is down 3 dB at 50 kHz, and hits unity gain at 4 MHz. Compare this to 8 kHz and 800 kHz respectively for 107s and 741s. Need we say more? Well, we will anyway.

How come?
Briefly stated, the RM4131 does all these neat things because of (1) that patent-pending current regulator in the gray patch above. It preserves gain at low voltages. And (2) our handy knack with small geometries, which gives frequency response a kick in the back porch. Plus (3) a winning way with latest process technologies, such as our new silicon nitride passivating layer for superb surface stabilities and high-beta transistors.

And how much.
Price for 100-999, full military version (−55°C to +125°C) is $20. Commercial versions are also available. So for evaluation quantities of our optimum op amp, see your Raytheon distributor. Or send for data from the company that's delivering the ideas in linear ICs. Raytheon Semiconductor, Mountain View, California. (415) 968-9211.

RAYTHEON

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