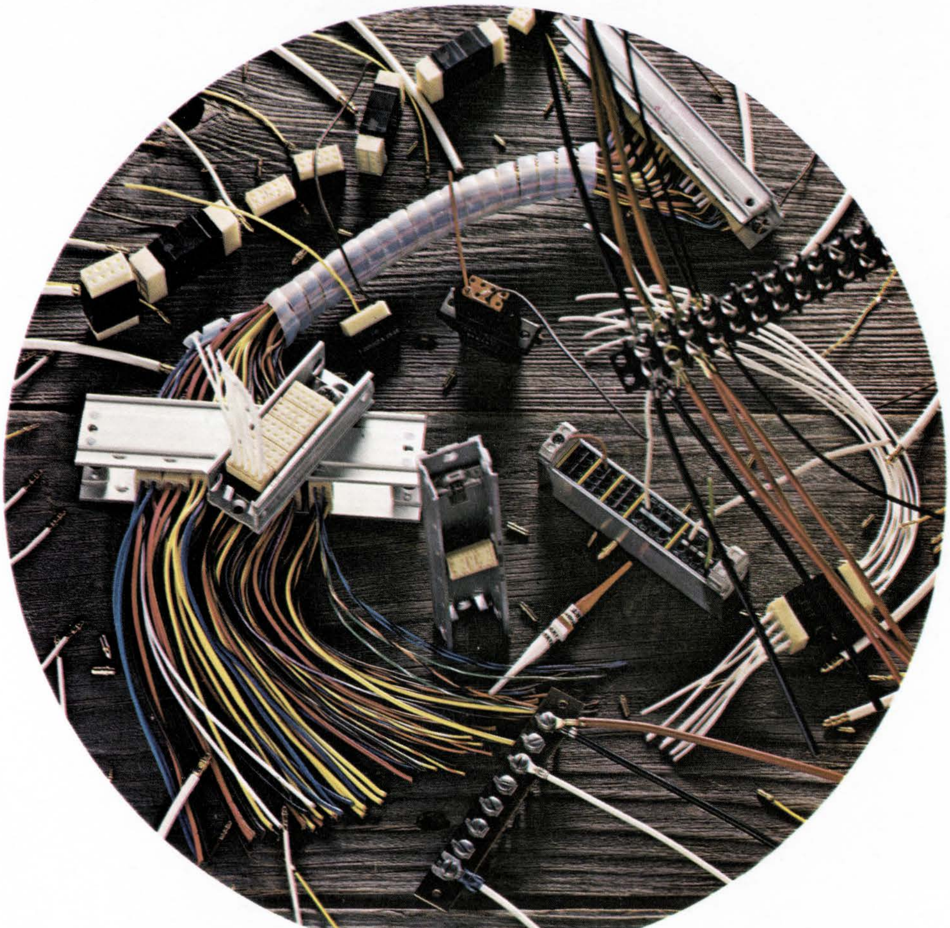
VOL. 28 NO. 4
APRIL 1969

THE ELECTRONIC ENGINEER



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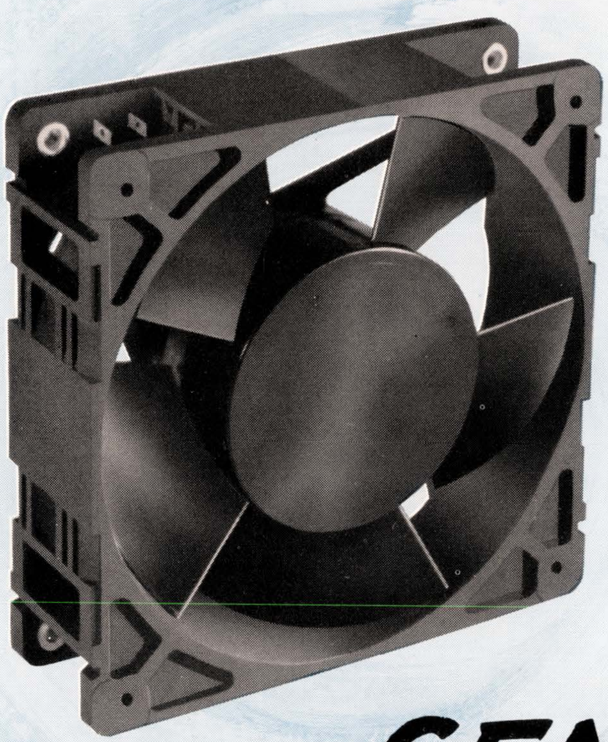

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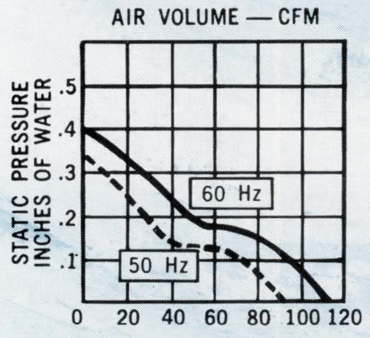

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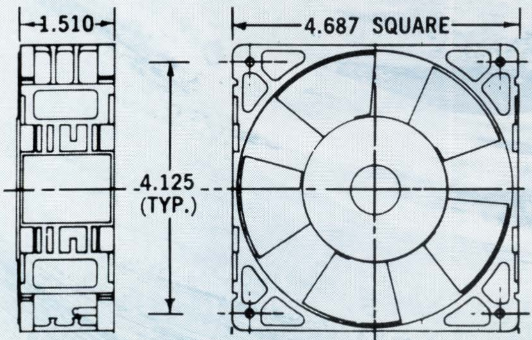

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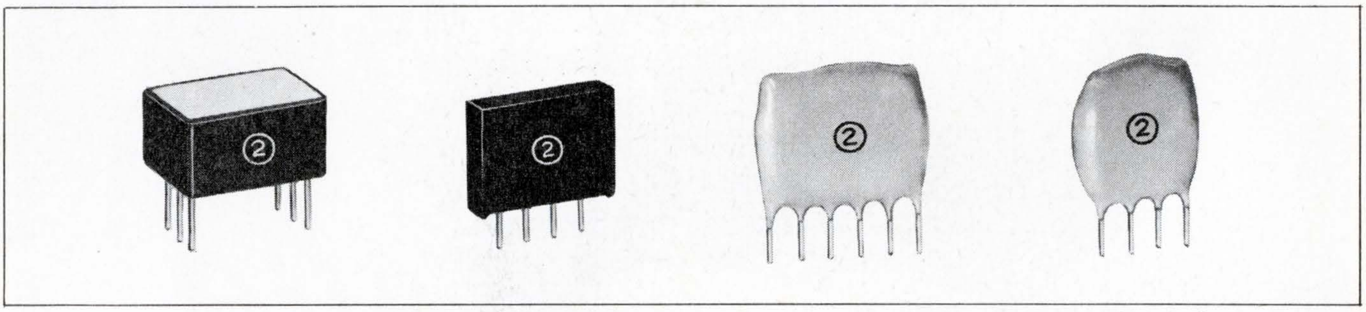

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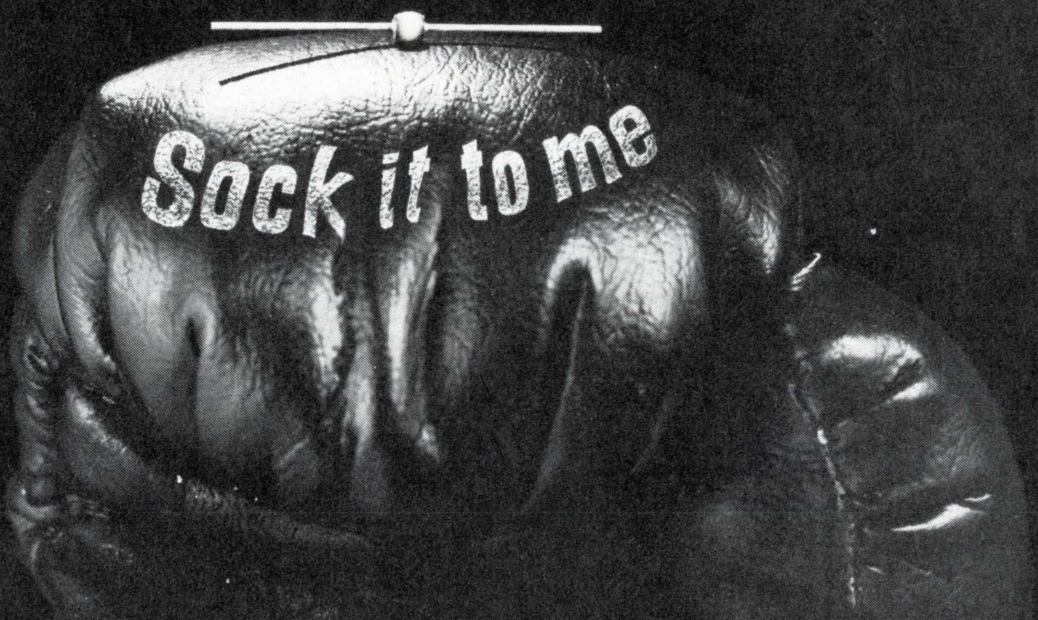

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EE

The Electronic Engineer

April 1969 Vol. 28 No. 4

COVER
The Naval Air Development Center, Johnsville, Pa., has recently completed the evaluation of terminal junctions for aircraft. NADC has performed extensive testing and accumulated performance data which form the basis of the new all-service MIL-T-81714. These terminal junctions are actually the first step towards a universal connection system that will spread rapidly into commercial applications. The photograph shows connectors by AMP and Burndy, plus a relay by Deutsch—Filtors that has incorporated the new terminals. You can also see a couple of the type of connections they replace — terminal boards. For more details, see p. 49.

EE

The Electronic Engineer

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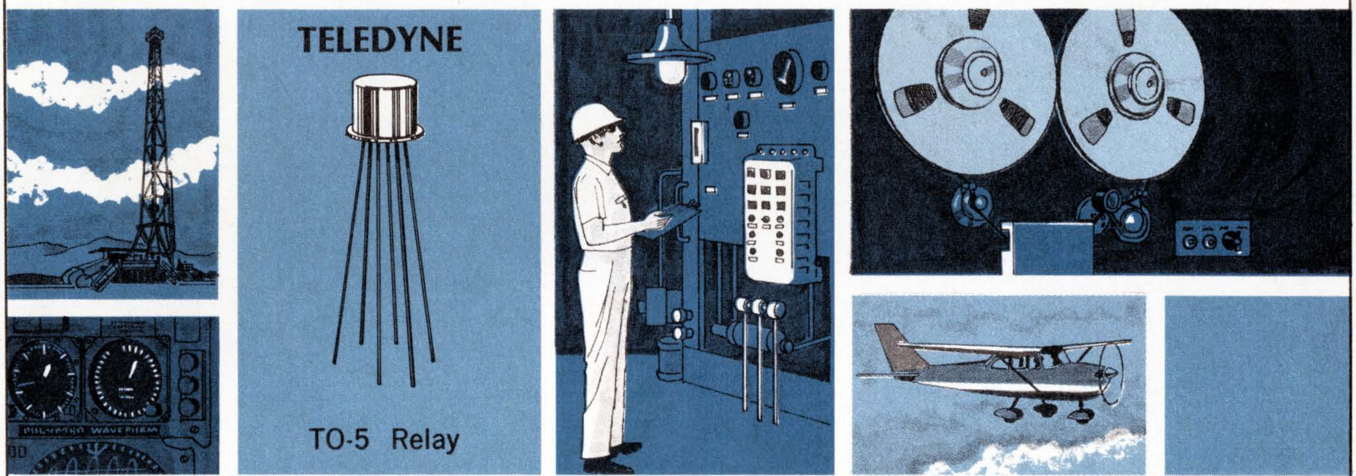

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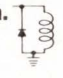

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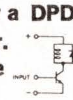

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EE EDITORIAL

Where digital ends and linear begins

Ever since the days of Samuel Morse, the trend in communications has been to rush analog equipment onto the path freshly plowed by digital means. No sooner had the inventor of the telegraph managed to digitize the English alphabet at a reasonable speed, when the fledgling communications industry was already trying to transmit the human voice by analog means. Once the electronic engineers of the turn of the century learned how to modulate a current, both telephone and radio communications were born.

This trend has been repeated over and over again—as soon as a job can be done digitally, designers start to work on an analog solution. Integrated circuits are no exception. They were first applied to digital computers (which process data) and then to digital communications systems such as PCMs (which transmit data digitally), and proved so successful that ICs dominate the applications of semiconductors to digital systems. These applications became so important that for a moment—back in 1964—we thought that integrated circuits would never again find another market as big as computers.

As it turns out now, it looks like they will. And the reason is the trend we described above, towards analog means of communications. Have you seen a Coast Guard helicopter contact its ground station, or someone get paged via a miniature two-way radio; or have you sat down at a teletypewriter to use a time-shared computer, or made a computerized reservation at a motel chain? If so, then you have seen some of the applications for the new breed of linear integrated circuits being developed today. There are so many potential applications besides the few mentioned above, that the total market for communications ICs may well surpass the one for digital ICs in the mid 1970's. What is even more interesting, it seems that most of the complex (medium-scale-integration) circuits of the 70's will be linear—rather than digital.

What is a communications IC? How does it differ from the most popular linear IC: the operational amplifier? Why did it wait until now to be ready, when the applications existed before? A communications IC is basically a gain block that incorporates a gain control function such as AGC. Most of its gain circuits are direct takeoffs from circuits used in monolithic op amps. And it took so long to develop for two reasons. First, communications circuits are complex, as far as ICs go; most of those appearing in the market have complexities equivalent to medium-scale-integrated (MSI) digital circuits. And second, when you consider that these circuits pack more than 80 dB of gain in a chip about 100 mils square, you can see that to keep it stable is a problem that plagues both the manufacturer and the user. According to J. Lightsey Wallace, Chief Engineer of the Teleproducts Dept. of Atlantic Research Corp., you may have to spend a great deal of time learning just how to mount the chip to keep it from oscillating.

But communications ICs are here, and we have only seen the beginning of the exciting applications they will make possible.

You do not have to design an op amp today, because you can buy very good ones that cost less than what it would cost you to make them. The same will soon be true of i-f amplifiers for a-m, fm, video, and single-sideband; for audio amplifiers built into microphones; and for the myriad of applications that electronic engineers will figure out, and which we hope these pages will help spark.

Alberto Socolovsky
Editor

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DTS-431	300 mJ	200V	0.3A
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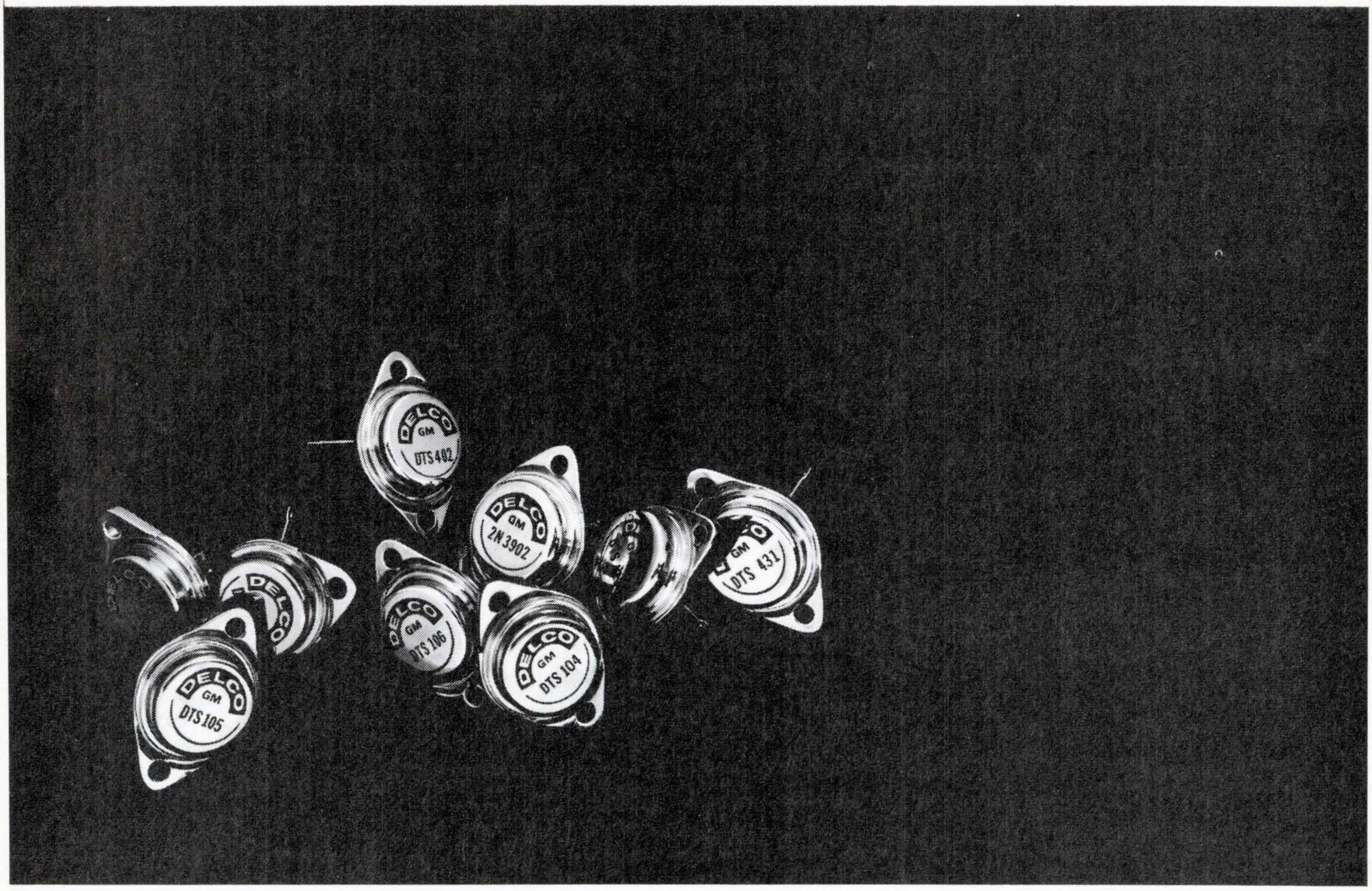


 Circle 8 on Inquiry Card

Radiation or reliability: Which comes first?

Hardening components so that they can function in a radiation environment often requires measures that conflict with high reliability practices. The accompanying table shows those areas where cross-purposes exist.

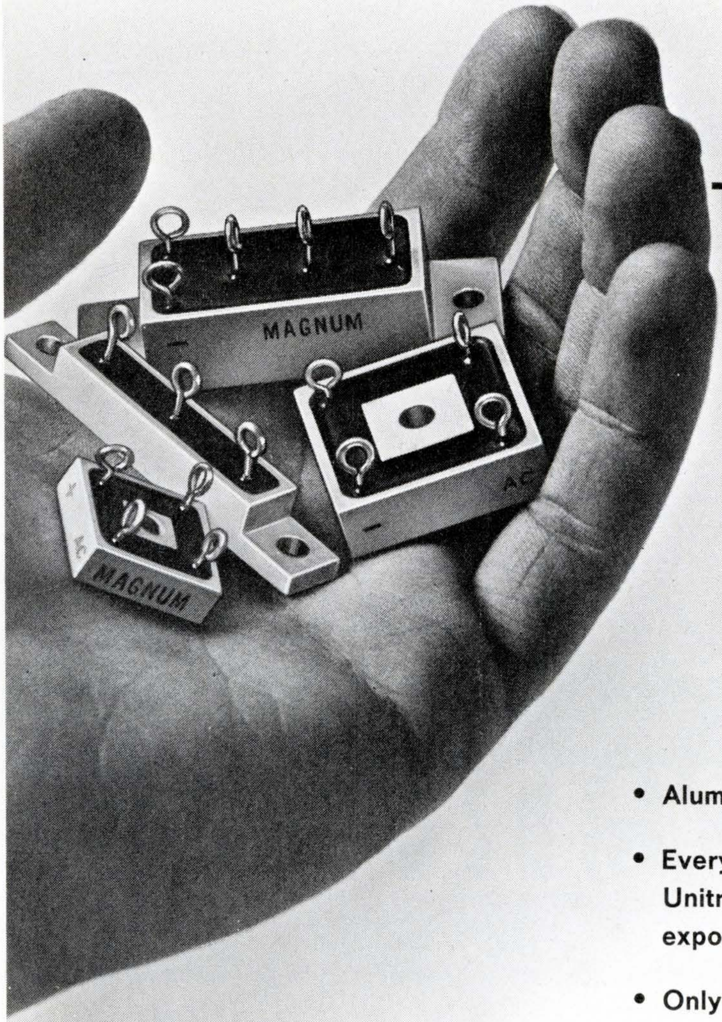
Gary E. Schmitz, Univac advanced technology specialist, maintains component selection should first be guided by the radiation requirement. Then, says Schmitz, reliability qualification testing should be conducted. Chances in processing or construction dictated by reliability standards can then be made, but in a way that doesn't compromise hardness.

Speaking before the recently-held annual symposium on reliability in Chicago, Schmitz said that materials, resistors, capacitors, and diodes—in that order—are innately hard. But, he added special measures must be taken for switching transistors, digital ICs, power transistors, linear transistors, and linear ICs. Within the latter group, switching devices that function between saturation and cutoff states are less critical because of the operating voltage margins between states. But power and linear devices exhibit less immunity.

(continued on page 13)

Radiation hardening versus reliability

Parameter	Radiation Requirement	Reliability Requirement
Voltage	High doping levels limit the effect of irradiation on material resistivity. Selection of the **lowest** useable voltage rating allows the use of low resistivity, highly doped materials.	Derating factors above operating voltages are recommended for all components in a high reliability system. Operating a device at **too low** a voltage level may cause marginal propagation times.
Current	**Maximum** current density is recommended in the radiation environment.	**Minimum** current, properly derated, is recommended for high reliability systems.
Frequency	The **maximum** f_t available in a device has been found to correlate well with the device hardness level. Gain-bandwidth products greater than 1 GHz are recommended.	For power devices, a **high** f_t unit is more likely to be **unreliable** because it is more vulnerable to secondary breakdown.
Masking	Use of the smallest possible geometries is required to minimize device response to both neutron and transient gamma environments. Both **area** and **volume** should be **minimized.**	The smaller the volume and area of the device's construction, the greater the chance of a positioning or diffusion depth error. Thus **reliability** and **yield** may be reduced.
Base width	**Minimum base width** reduces the area in the base which contributes to the forward biasing exhibited in the base emitter junction during transient radiation. Also, the narrow base region will aid post neutron beta, since there is less chance for electron recombination before attaining the collector region.	Base widths on the order of 0.3 microns have been constructed. The **danger** of **punch-through** in a base of this magnitude is increased. In addition, the use of thin base regions in power devices increases the threat of **secondary breakdown** by limiting current fanout.
Internal base resistance	At some level of transient gamma radiation, the transient current thru the internal base resistance will develop sufficient voltage to forward bias the base-emitter junction and turn the device on. Low values of resistance will thus increase the radiation failure threshold.	The base doping, which determines the internal base resistance, also affects the doping level of the emitter and collector. In some cases, the **lowest** value of base resistance may not allow **optimum** doping for collector and emitter regions.
Bonding	Use of **aluminum bonding** is recommended.	**Full strength** of aluminum bonds may be somewhat **less** than that of other techniques presently used. In addition, ball bonding is not useable. Whether these effects are significant to device reliability remains to be determined.
Materials	**Changes** in packaging, packaging materials, and bonding may be required.	Existing materials have **established** reliability records.



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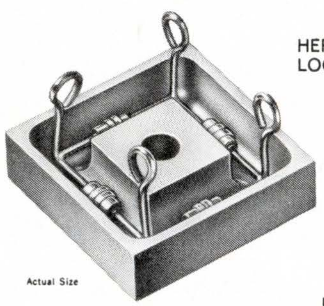

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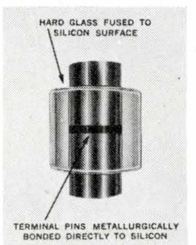

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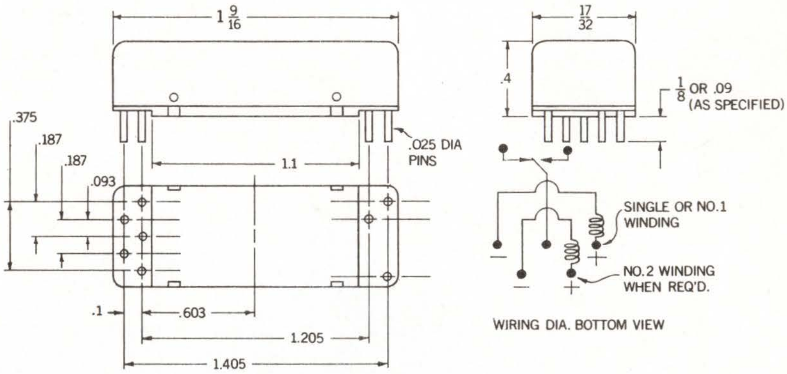

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A stronger magnet at lower cost

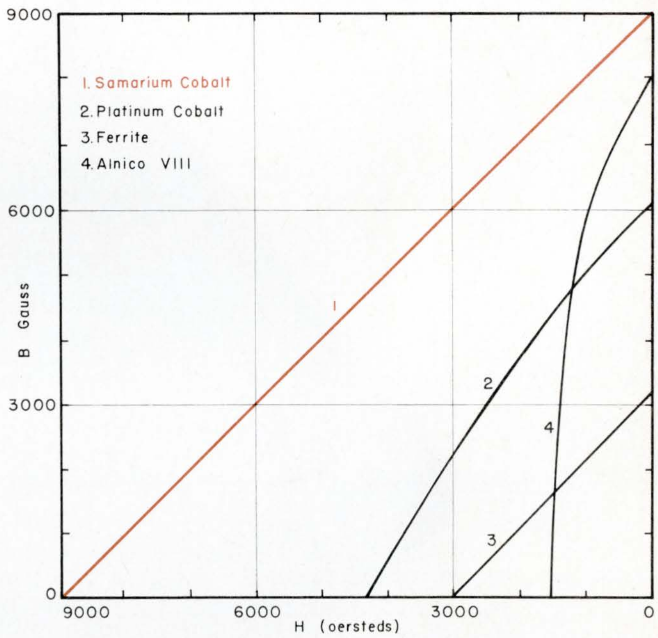
Seeking a substitute for platinum-cobalt magnets used in microwave tubes, Dr. Dilip K. Das has succeeded in developing the strongest permanent magnet material yet known. The material is based on cobalt and the "rare-earth" element samarium. It is said to be four times as strong as most alnicos and twice as strong as platinum-cobalt.

These comparisons are based on the new material's energy product, a figure of merit for magnetic material that takes into account both its residual magnetism after a strong magnetizing field is removed, and its ability to resist subsequent demagnetization in a magnetic field of opposite polarity.

Samarium-cobalt magnets as manufactured by Raytheon have energy products as high as 20 x 10^6 gauss-oersteds. In practice, samples run between 16 and 20 MGOe (million gauss-oersteds). By comparison, ferrites are about 3, the common alnicos around 5, and platimum-cobalt nearly 10.

The new material also exhibits good high-temperature stability, with a Curie temperature exceeding that of platinum-cobalt. Magnets made of the new material perform well in microwave tubes at 265°C, temperature at which platinum-cobalt degrades 50%.

While the processing involved is similar to that used in preparing ferrite ceramic magnets, several steps are unique and proprietary.



Demagnetization characteristics of magnetic materials are compared. The product of B x H, called the "energy product" is a measure of the magnetic material, and is higher as the curve moves to the left.

(*Continued from page* 10)

Power transistors are difficult to harden because of their construction—large geometries, low doping, high voltages. Also, the large areas cause increased transient gamma photocurrents to flow, and the low gain-bandwidth products combined with thick base widths produce post-neutron bombardment beta degeneration. Finally, the higher $V_{CE(SAT)}$ values and large package size impede hardening too.

Discrete and integrated linears cannot tolerate wide parameter changes as well as logic devices do. Linearity must be maintained, and element ratios and stage balances (as in a differential amplifier) must be closely held.

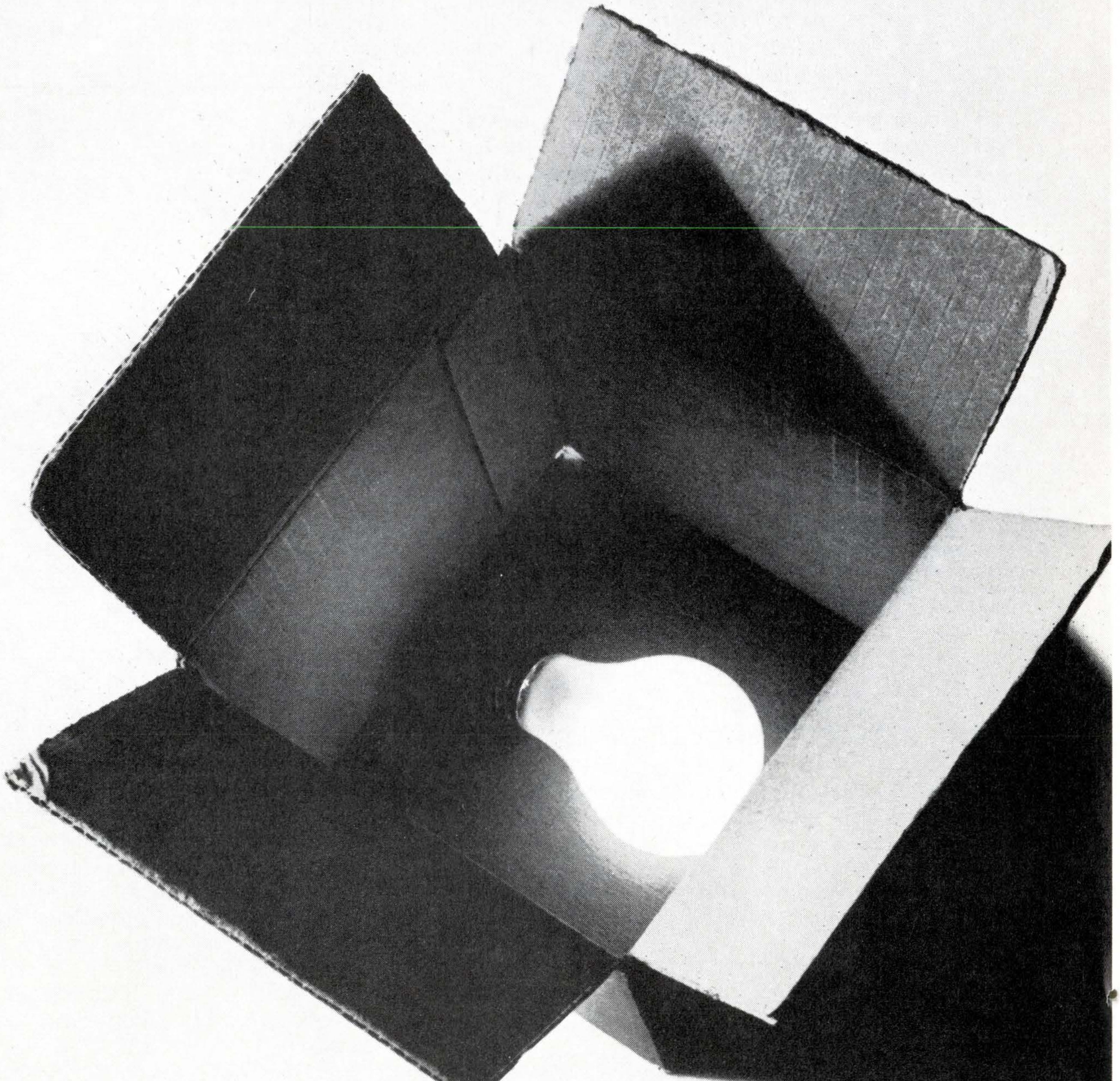
Desirable component characteristics for hardening include small geometries: the smaller the device's active volume, the less the effects of photocurrent flow. High-level doping raises post-neutron resistivity. Low voltages accommodate higher doping levels. Gold doping strengthens saturation characteristics and lessens beta sensitivity to neutrons. High current densities and high gain-bandwidth products improve the device's post-neutron gain capability.

Other hardening measures include dielectric isolation, minimum internal base resistance and base widths, and double-diffused epitaxial construction. Silicon is preferred to germanium because of its higher resistivity.

Testing also presents some problems, depending upon hardness level requirements. For lab testing, high gamma dose rates may be simulated by flash X-ray equipment. Linear accelerators may be used for cases requiring moderate gamma levels and steady-state neutron radiation. And for high neutron delivery rates and high steady-state neutron presence, pulsed reactors can be used.

The rental of radiation test facilities may run $2000 a day or higher, excluding the cost of sending an engineering team along for observation. And in most cases days and even weeks of testing are required. Schmitz advises designers to therefore use hard components that have already proved their mettle, so that the testing of new components be held to a minimum.

Monolithic logic today. Monolithic systems tomorrow. We've got ideas to deliver.



Many wafers ago Raytheon drafted a blueprint for success in the semiconductor industry. It's drawn around some very sharp idea men to nudge the state-of-the-art ever forward. Plus a production line that can turn ideas into products and pour them out en masse and on time. Here's a roll call of results, delivered and on the way.

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Transistors: More than 400 standard and high-rel mil types. Switches, drivers, choppers. And amplifiers—general purpose, low level, high frequency, differential, dual and Darlington.

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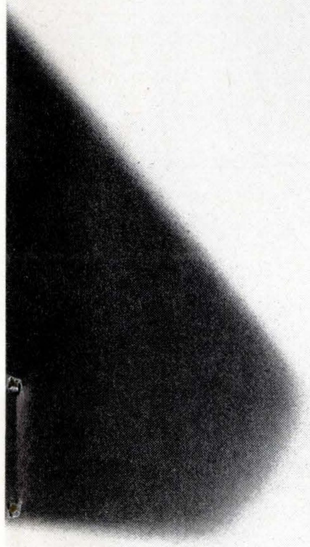

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But the best is yet to come. Here's what's cooking for delivery within one year. Beam lead, of course. Plus 2-layer metal interconnects. 64-bit random access memories. 256-bit read-only memories. Multi-chip memory arrays. Very high speed logic. High speed NPN and PNP single and quad core drivers. Monolithic diode arrays. RF transistors.

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RAYTHEON

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The EE Forefront is a graphical representation of the practical state of the art. You will find here the most advanced components and instruments in their class, classified by the parameter in which they excel.

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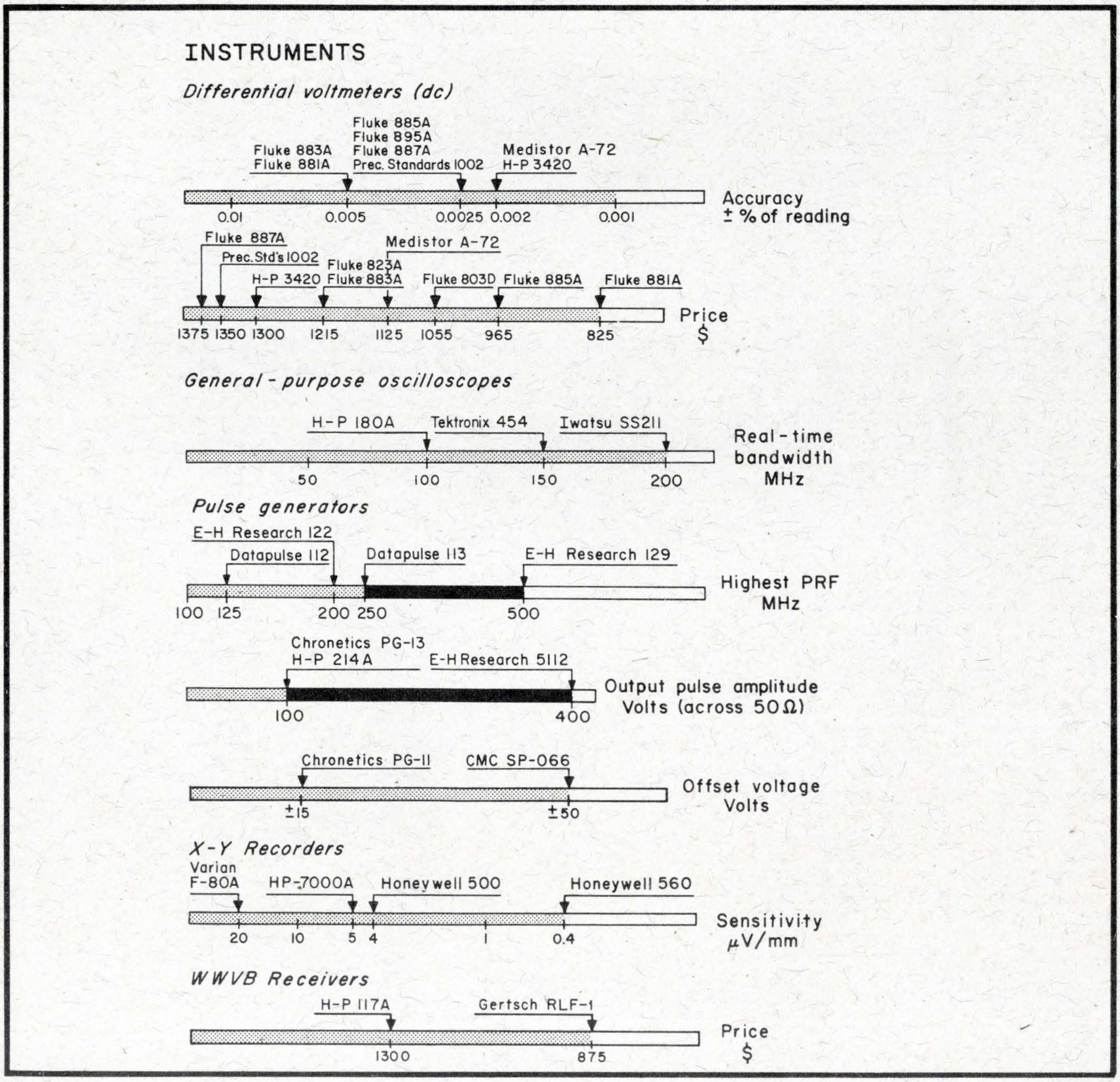
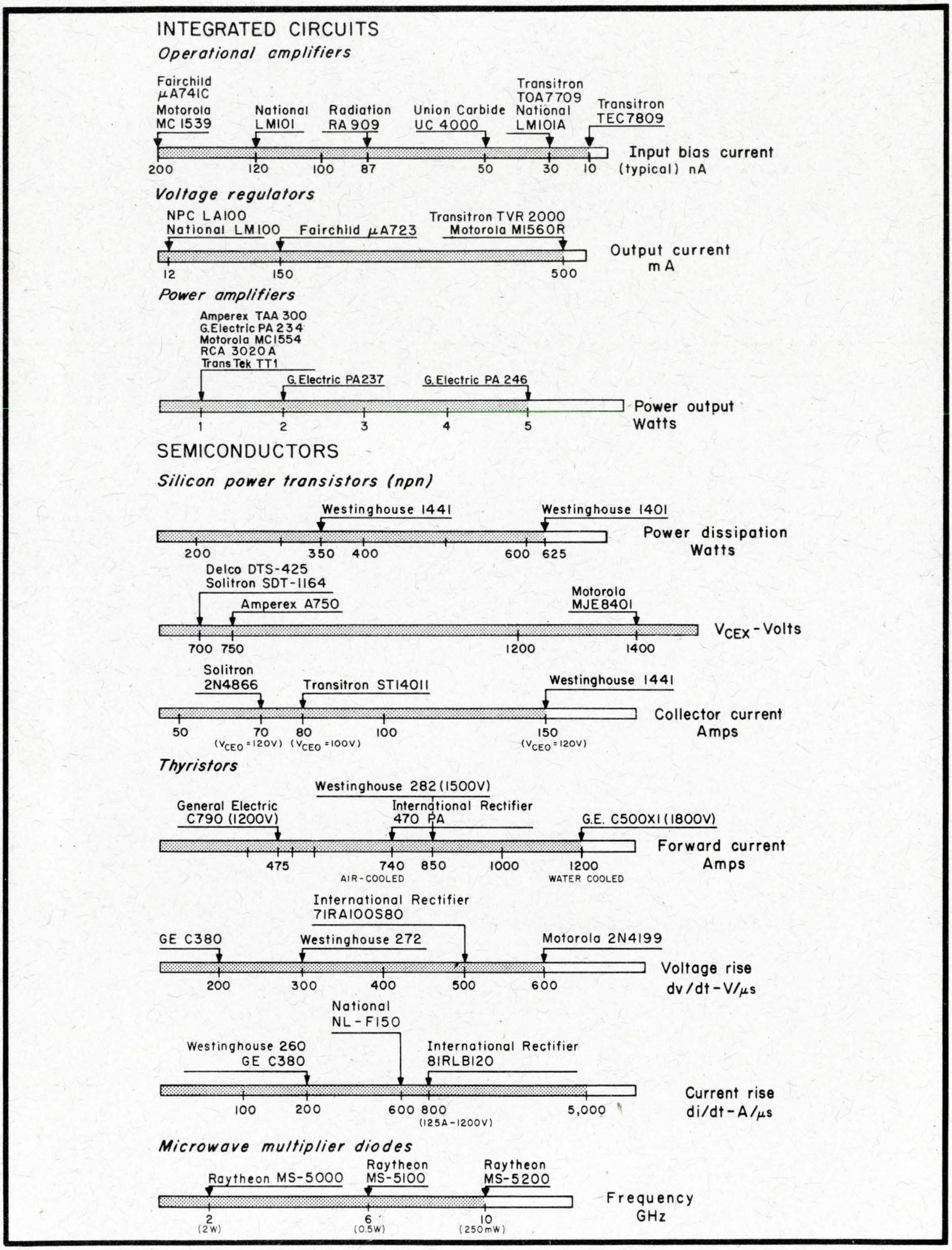
Keep in mind the tradeoffs, since any parameter can be improved at the expense of others. If there is no figure-of-merit available, we either include other significant parameters of the same products, or we provide additional bar graphs for the same products.

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




INTEGRATED CIRCUITS
Operational amplifiers
Fairchild μA741C
Motorola MC 1539
National LM101
Radiation RA 909
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
100
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
Microwave multiplier diodes
Raytheon MS-5000
Raytheon MS-5100
Raytheon MS-5200
2
(2W)
6
(0.5W)
10
(250mW)
Frequency GHz

EE SPEAK UP

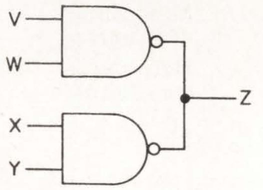
Same logic, less gates

Sir:

After analyzing Mr. Wallace's generally good article "High Speed Binary-BCD Converter," [**The Electronic Engineer,** July 1968] I find that some reduction in the logic is possible.

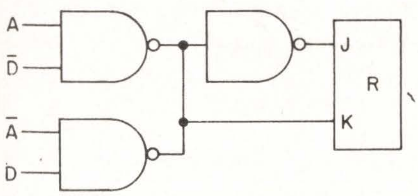
First consider the binary-to-BCD converter as shown in Figure 3 of the article. The K input of flop C_1 is shown as $(A_1\, B_1\, \overline{D}_1)'$; in reality, this input need only be $(A_1\, B_1)'$. The removal of the literal D_1, is, I admit, rather trivial, but notice that this is the only 3 input gate used in the decade, and we are now free to implement the logic entirely with 2 input gates and flops.

Now consider the BCD-to-binary converter shown is Figure 6 of the article. First, the K input of flop C is shown as: $C(K) = (\overline{A}\,\overline{B}\,D)'$. In reality, we may write $C(K) = \overline{D}$ and eliminate the gate altogether. Second, the K input to flop B is given as $B(K) = (C\,\overline{D} + \overline{A}\,\overline{C}\,D)'$, whereas it can be shown that $B(K) = (C + \overline{A}\,D)'$ which would again eliminate a 3 input gate, simplify wiring, etc. Third, the K input to flop A is given as $A(K) = (B\,\overline{D} + \overline{B}\,\overline{C}\,D)$, whereas it can be shown that $A(K) = (B\,\overline{D} + \overline{B}\,D)'$ which is just two 2-input NAND gates with their outputs in the "wired-or" configuration. Finally, the inverter on the J input of flop B may be eliminated if either (but not both) of the literals and its complement are interchanged at the inputs of the gates. Consider the following diagram:



Now Z= $(V\,W = X\,Y)'$ and if we let $V = C$; $W = D$; $X = \overline{C}$; $W = D$ then $Z = (C\,D + \overline{C}\,\overline{D})' = C\,\overline{D} + \overline{C}\,D$ which is the desired input function, B(J).

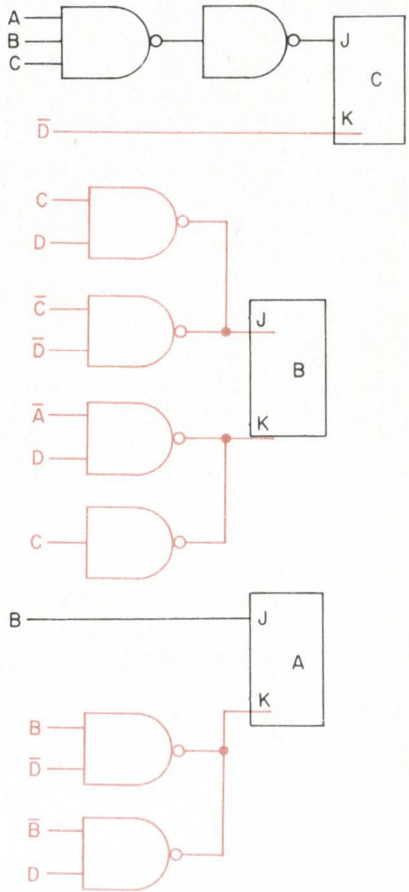
I have redrawn Figure 6 with the above changes shown in color.



(continued on page 20)

EE SPEAK UP

(*continued from page* 19)



Norman E. Tibbetts
Staff Engineer—Instrumentation Lab
Massachusetts Institute of Technology
Hanscom Field
Concord, Mass.

The author replies:

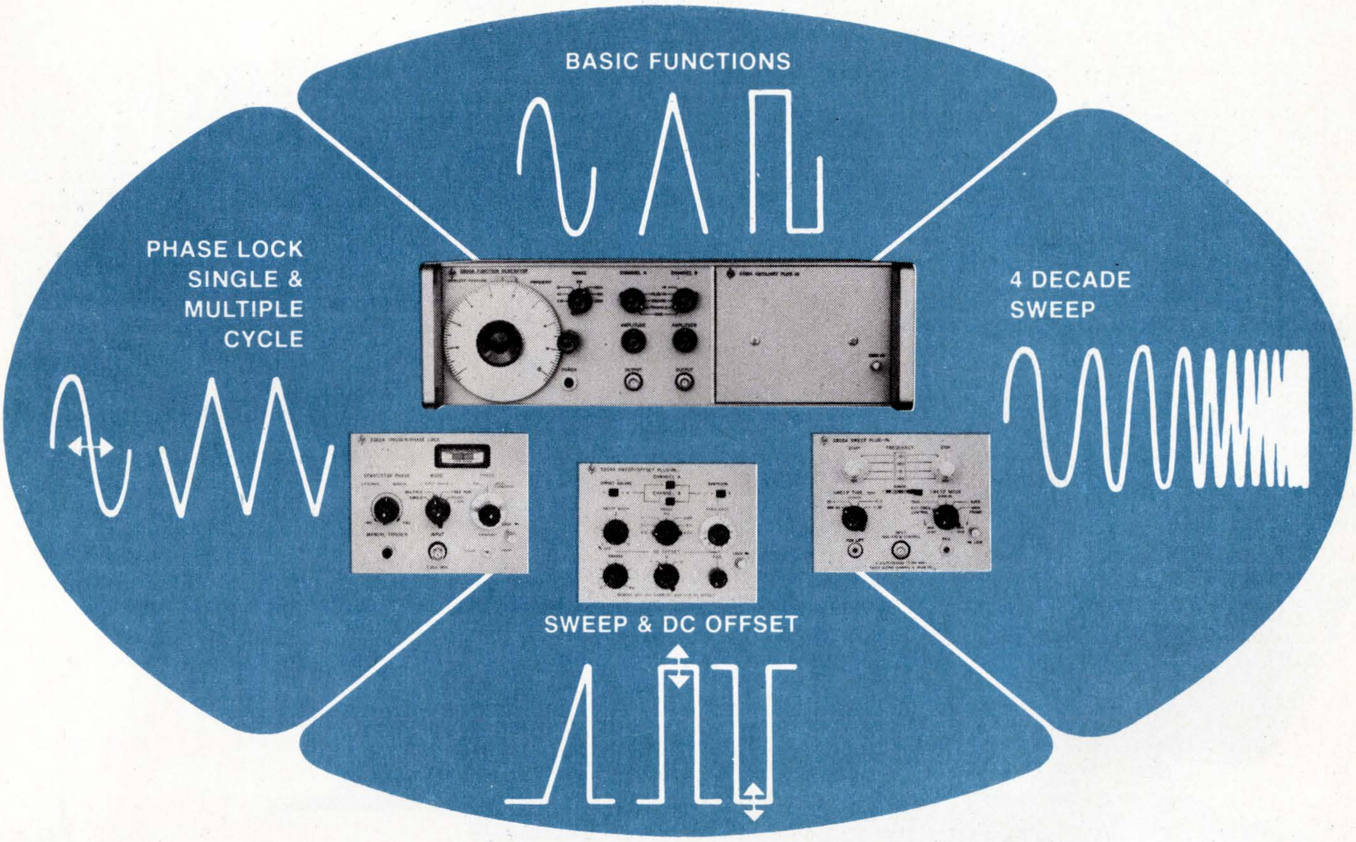
After rechecking the truth tables of figures 2 and 5 in my article I must concur with Mr. Tibbetts' comments. The comment concerning the Binary to **BCD** Converter is especially useful since it allows a reduction in logic from three quad **nand** packages and one dual 3 input **nand** package to 3 quad **nand** packages.

Mr. Tibbetts comments have also pointed out the value of carefully checking a truth table where logic simplifications can be found that aren't readily seen when using Boolean Algebra.

E. L. Wallace
Westinghouse Space and Defense Center, Surface Division
Baltimore, Md.

Letters to the editor are published at the discretion of the magazine. Please say so if you do not want to be quoted. Signed letters have preference over anonymous ones.

Customize this HP Function Generator to fit your Measurements



Start with the basic ability of the HP 3300A Function Generator—add the capability of its plug-ins—and you get a function generator that fits your specific needs. It's equally at home performing ordinary day-to-day lab tests or providing a sweeping signal that can be used to measure the impedance of an ape's brain. No matter what the task, you get the reliability and accuracy you need to get the job done.

The HP 3300A Function Generator gives two simultaneous outputs (sine, square or triangle) across a frequency range of 0.01 Hz to 100 kHz. Mix or match your output signals with individually selectable function and amplitude controls. Price, $650; HP 3301A Auxiliary plug-in, $30.

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The HP 3304A Sweep/Offset plug-in provides a linear sweep adjustable in frequency and width within any decade over the entire frequency range. Variable dc offset of ±16 Vdc is provided for each function including the internally generated sawtooth—makes hard-to-get driving functions readily available. Price, $265.

The HP 3305A Sweep plug-in lets you sweep up to four decades without switching ranges. It sweeps logarithmically in any of three overlapping ranges for narrow or wide band testing between adjustable start/stop limits. Use the manual sweep for close inspection of any portion of the trace or for accurate frequency identification.

The 3305A's continuously adjustable sweep time of 0.01 to 100 seconds is slow enough for accurate response testing of high-Q devices and fast enough for good visual displays of wide band response. For ease of automated testing, either the frequency or the sweep trigger can be externally controlled. Price, $975.

Get the function generator that best fits your measurements. Consult your catalog and order by calling your nearest HP order desk. For data sheets, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

099/15

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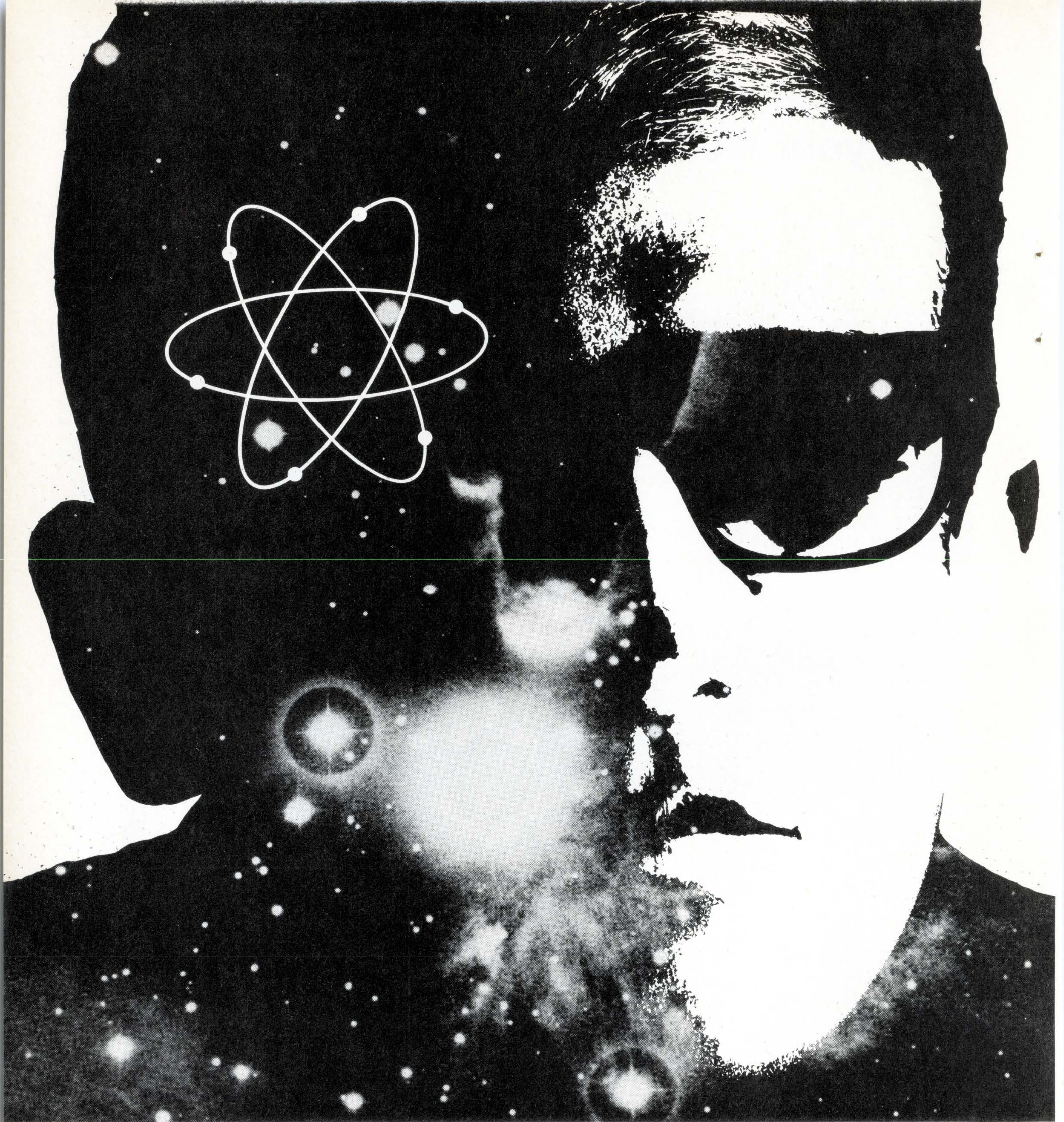
SIGNAL SOURCES



EE CALENDAR

APRIL

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

April 15-18: Int'l Computer Aided Design Conf., Univ. of Southampton, Southampton, England. Addtl. Info. —IEE, Savoy Pl., London, W.C. 2, England.

April 22-23: 17th Annual Nat'l Relay Conf., Oklahoma State Univ., Stillwater, Okla. Addtl. Info.—Dr. Monroe W. Kriegel, Director, Eng'g and Industrial Extension, Oklahoma State Univ., Stillwater, Okla. 74074.

April 22-24: Nat'l Telemetering Conf., Washington Hilton Hotel, Washington, D. C. Addtl. Info.—Charles DeVore, 2243 N. Trenton St., Arlington, Va. 22207.

April 23-25: Southwestern IEEE Conf. & Exhibition, San Antonio Conv. Ctr. & Palacio Del Rio Hotel, San Antonio, Tex. Addtl. Info.—S.W. Seale, S.W. Res. Inst., Box 2296, San Antonio, Tex. 78206.

April 30-May 2: Electronic Components Conf., Shoreham Hotel, Washington, D. C. Addtl. Info.—Electronics Ind. Assoc., 2001 "I" St., N.W., Washington, D. C. 20006.

MAY

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7

May 5-8: Design Eng'g Show and Conf., Waldorf-Astoria Hotel and Coliseum, New York, N. Y. Addtl. Info.—Banner & Greif, Ltd., 369 Lexington Ave., New York, N. Y. 10017.

May 5-8: Int'l Microwave Symp., Marriott Motor Hotel, Dallas, Tex. Addtl. Info.—Julius Lange, Texas Instruments Inc., Dallas, Tex. 75222.

May 6: Digital Communications Symp., Los Angeles, Calif. Addtl. Info.—IEEE Office, 3600 Wilshire Blvd., Los Angeles, Calif. 90005.

May 6-8: 23rd Annual Frequency Control Symp., Shelbourne Hotel, Atlantic City, N. J. Addtl. Info.—Director, Electronic Components Lab., U.S. Army Electronics Command, Att: AMSEL-KL-DT (Mr. M. F. Timm), Fort Monmouth, N. J. 07703.

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.

JUNE

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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.

'69 Conference Highlights

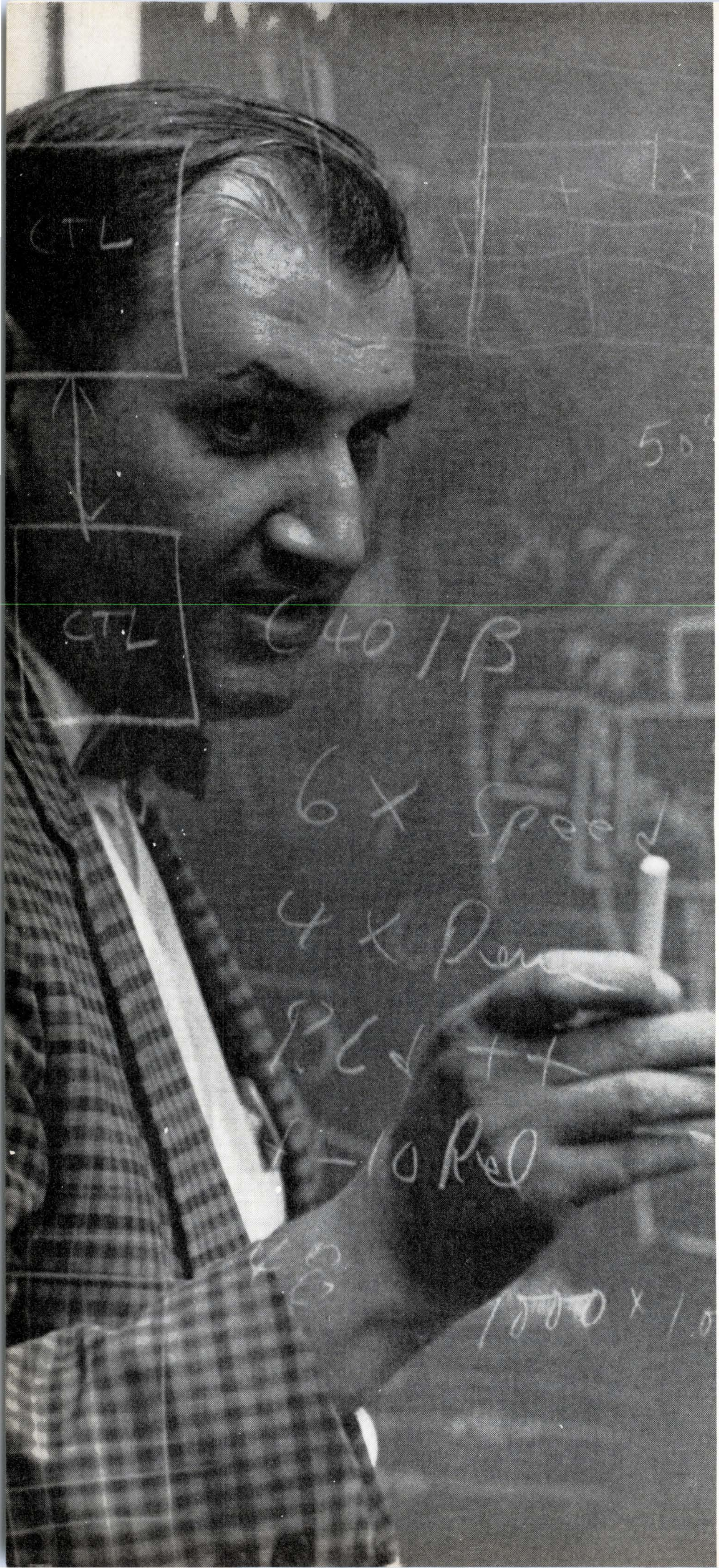
WESCON—Western Electric Show and Conv., August 19-21; San Francisco, Calif.

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

Call for Papers

October 22-23, 1969: 2nd Annual Connector Symp., Cherry Hill N. J. Submit three copies of 200-400 word abstracts by **May 1, 1969** to Technical Papers Committee, Electronic Connector Study Group, Box 3104, Philadelphia, Pa. 19150.

October 26-30, 1969: Joint Conf. on Mathematical and Computer Aids to Design, Anaheim, Calif. Submit a working title by **May 1, 1969** to SIAM—1969 Joint MCAD Conf., 33 S. 17th St., Philadelphia, Pa. 19103.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EE Opinion

The engineer is a loner . . .

both in his relationship to his colleagues and to the community as a whole. This is one of the factors which must be understood—by himself and the community—before he can put his talents to use in solving the problems of the contemporary world.

By Rocco F. Ficchi, Engineer, Systems Assurance
RCA Defense Electronic Products, Camden, N. J.

You engineers never get involved in the community! You avoid key issues! You don't care what effects your designs have on the community! You don't give a damn about the urban crisis!

How often of late have you heard these admonishments? Engineers are not the only ones singled out, but since they are the ones involved in such key issues as air and water pollution, traffic problems, space appropriations, and so forth, they have often borne the brunt of John Q. Citizen's ire.

But there is a more basic reason. The engineer is generally considered a loner—one who likes to be left alone to solve his detailed problems. He is fascinated by "how things work," and, in all fairness, has come up with some pretty clever gadgets which have done away with boring manual tasks. The community thinks of him as a "nice guy" who likes all the "good" things such as education, books, and Little League baseball—but also as one who never speaks up in his community on important issues or gets involved.

To understand the engineer as a total person, and his relationship to the contemporary world, we must first understand the motivational forces which govern his behavior. Once these forces are properly identified and understood, reasonable men can get to work to do something about their effects. If only we can motivate the engineer to involve himself, considerably more intellectual power will be brought to bear on the solution of our contemporary problems.

Why is the engineer a loner?

Before we can answer this question, we must first ask: "What is an engineer and what are his identifying characteristics?" But this is a difficult question to answer, since compared to other professional men, the engineer is completely lacking in identity. The physicist identifies with such giants as Clerk Maxwell or Newton or Heisenberg; the chemist with Davy or Lavoisier or Faraday; the physician with the American Medical Association

In defense of concern

A stereotype exists of the engineer. You're probably familiar with it. This stereotype says that he is unaware of—and unconcerned about—contemporary problems. That his main interest is the special little job he's working on in the lab.

In the May 1968 issue of **The Electronic Engineer,** we asked our readers to tell us what they, as engineers, think about this stereotype. Are engineers really concerned with the world, and how, or is the stereotype frighteningly accurate?

On the following pages you'll see comments from two of our readers. Do you agree with them? Whether you do or don't, we would be interested in your comments. By creating a dialogue among engineers on contemporary problems, hopefully we will stimulate a greater concern for these problems. Indeed, since technological achievements have created many of our problems, it may be that the engineers are the only ones equipped to solve them.

or the ancient tradition going back to Hippocrates. The engineer, in contrast, has no real identity as a professional. The only common experience which he does have with other engineers is educational, and, since this occurs early in life, before his career has begun, it is a poor substitute for a real identity. The engineer then does not have such identity except in a most general way—as an "amorphous professional."

The term "amorphous professional" has been applied because the engineer lacks those identifying characteristics which one associates with other professionals. There are no engineering solutions to problems but economic solutions to engineering problems. The "loner" works on a little piece of a problem, often with great relish, and someone else decides whether his design will "fly."

Unlike other professionals, the engineer has only one client—his employer. He needs this client because it is the only one he has. A physician, on the other hand, may tell some obviously obese patient that he is simply too fat, lose the patient as a result and think nothing of it, because he has many more patients. He regards himself in a total relationship to his patient—economic, technical, and humanistic.

The identity problem of the engineer is also magnified by the various attempts on the part of engineers to form professional organizations. There are some great technical societies, such as the IEEE with over 100,000 members, but the average engineer develops no camaraderie with other engineers through them. Everyone has seen the "loner" walking through the vast areas of the New York Coliseum.

The only common professional experience of engineers—their educational experience—still does not bind them together professionally. Engineers seem to have a much poorer connection with their colleges and universities than do other professionals. They generally are not active alumni; they do not serve on college boards of trustees; they do not receive many honorary degrees; and they do not make substantial financial contributions. And yet the engineer could use his college or university as the primary source of his intellectual activity. In this way, his identity could begin to take shape and the elements of a true professionalism could arise.

But it would have to start with a drastic revision to the engineering curriculum. Engineers would have to take many more courses in the humanities. They would have to be trained as people in the hope that their inherent "loner" complex could be eliminated. After all, that is what education is all about—to teach people to live in civilized society.

The "thing" complex

What impels people to become engineers in the first place? In a 1965 survey[1], about 100 engineers were asked if they decided to study engineering because they enjoy taking things apart to see how they work, and then putting them together again; about half of the respondents agreed that this was their motivation. This "thing orientation" tends to make you impatient with situations that cannot be handled in this fashion; movements involving people certainly do not fit into the "thing" category.

"Everyone has seen the 'loner' walking through the vast area of the New York Coliseum."

This "thing orientation" perhaps may explain why engineers cannot find their identity by associating with large movements, be they political, social, economic, or intellectual. The very notion behind any movement is common interest within a group, and while I don't contend that an engineer is an individualist, he definitely is a "loner."

The lines of logical development are not clear, but it seems that his scientific approach to the world inhibits the engineer's involvement with "people" movements. People simply do not follow the expected clean-out rules of cause and effect. A single action of a person has many causes; multiply these by an interplay of forces within a group of people and cause and effect relationship gets blurred.

The social sciences have attempted to put scientific order into this people interplay, and engineers have usually drifted to these courses in colleges as electives. Social science courses appeal to the engineer because they are somewhat scientific in their approach. There is very little of the philosopher in the social scientist and this gives little humanistic flavor to his endeavors.

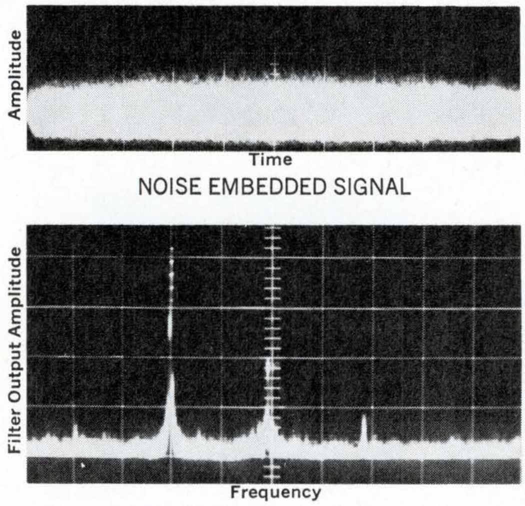
What can we then conclude? The judgment is harsh, but the evidence indicates that engineers are lacking in identity as a professional group. They are indeed "loners." Their lack of identity, the absence of cohesiveness, and an amorphous professionalism form the base upon which all the attitudes of the engineer and his place in the contemporary world are built.

Once the community understands the basis for his attitudes, they'll have a more accurate—and charitable—view of the engineer. And once the engineer himself gains some insight, he may find his view of himself and the community widening—and he can put his considerable talents to work in solving the many technical and social problems facing contemporary society.

[1] Technical Program, 1965 Annual Meeting, New Jersey Academy of Sciences.

INFORMATION RETRIEVAL
Careers

Radar signal processing engineers:



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Several programs are now starting to carry this technique and others further toward operational radar systems.

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An Opinion

The engineer as a part of society

The engineer has isolated himself from the rest of society. The creations of his technology have caused many social problems, yet he remains silent. Before he can solve these problems, however, he must first solve the professional and educational problems of the engineering community.

By Robert A. Sears, Section Head
Sylvania Electronic Systems, Western Div., Mountain View, Calif.

Think about what it would be like if you didn't have a car, or a television, or the other "necessities" of modern life. And can you imagine the modern American housewife without her electric can opener, electric mixer, electric carving knife, vacuum cleaner and host of other gadgets that make her job manageable?

Perhaps even more important, what would your job be like if there were no such thing as the transistor, or the integrated circuit (or, for some, no MSI or LSI)? What if you had no such tools as the computer?

Civilized man has now "advanced" to the point where he considers these and other engineering triumphs, indeed even his gadgets, as necessary to his well being. Yet though the marvels of engineering are many, the engineer is usually not considered a serious voice in the affairs of mankind. He traditionally labors on while remaining oblivious of the world around him, as well as of the use and misuse of his creations.

The silent community

The engineer helped create all these "marvels" of technology.

- Why did he not speak out when the radio and TV first began to "control" our society?
- Where was he when computers began threatening to replace man's ingenuity as well as to pry into his private affairs?
- Where was he when electronic devices began eavesdropping on his neighbors?
- Where was he when water and air pollution first began forming?
- Where *is* he now when all of these problems and countless more threaten our very existence on this earth?

The works of his genius have become the servants of man, yet he himself has been less than that. He has been silent, and while an occasional voice can be heard today, the engineering community in general remains detached from life. Unbelievable, but true; no success can compensate for such a failure. So silent are engineers, in fact, that fewer young people join their ranks each year.

Surely our non-technical leaders have been unable to solve the many problems created by the inventions of our technical community. But before engineers can fully come to grip with these problems, they themselves must first solve two basic problems: how to provide the engineer with the type of education he should (but does not) receive, and how to develop a stronger professionalism at the working level.

Profile of a half-education

With some notable exceptions, the average engineer has had a narrow education. When he receives his BS degree after four or five years of college, he has usually had little more than technical courses in the basic sciences and math plus added courses in his specialty. The few other courses that he has had are usually slanted toward his technical background (e.g., "Technical Writing and Speech," "Engineering Economics," or "Industrial Psychology").

If he doesn't go on for his masters or Ph.D., he usually takes a job with a company that employs many people like himself. That is to say, he does not often deal directly with the public as a medical doctor does, for instance. From this point on, besides working actively on his company assignments, he must deal with the problem of obsolescence. Within ten years after his graduation, technology will have advanced so far that none of the applied courses he studied in college will be applicable to his work. Most engineers realize that they must spend a large portion of their leisure time in technical study if they are to maintain their usefulness on the job.

This, then, is the educational picture of the majority of engineers. I have condemned them for not voicing a strong protest about the misuse of their technical achievements. But note that the unthinkable silence of the engineer has even extended toward the way in which he himself may be treated, for he himself may lose his job despite his training. A tragedy of his own making.

But is the engineer really educated in the classical sense? If you were to check the many definitions of education, you would not be able to find one that includes such a person. As a result of engineering training alone, he clearly has not been educated. Unless he has gone out on his own—this while just keeping up with the latest developments in his field—the engineer has remained narrowly oriented.

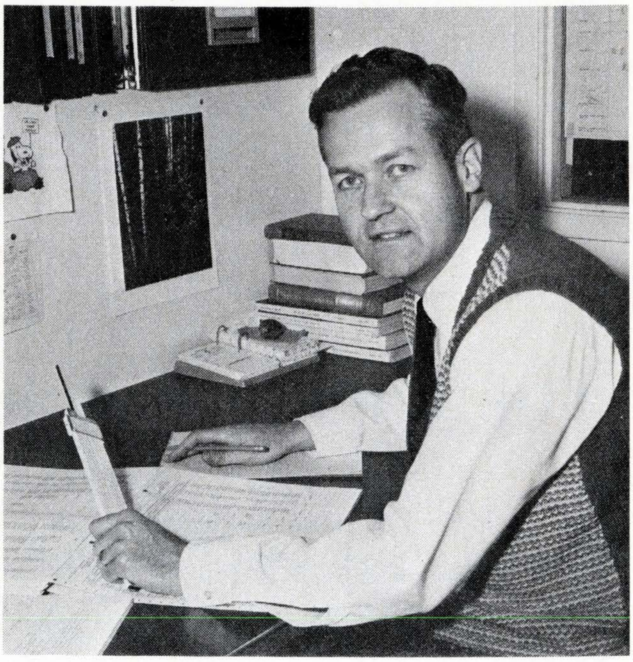
Professional status seeker

Partly because of his "limited" education, the engineer is not seriously considered outside of his own technical world. In fact, it is often non-engineers who point out where he has erred. Ralph Nader's documentary about automobile safety is a classic example.

All too often, however, the engineer himself—by his silence—abdicates his judgment on the use of his achievements to others. The professional attitude, therefore, is gone and, while the average engineer would dearly love to be thought of as a "professional" in his community, he is in fact only a toy-maker, too absorbed in his own tinkering even to be a part of the game.

It is becoming increasingly necessary that those who are responsible for the technological revolution also acknowledge its effect upon society. The time passed long ago when the engineering community could live in its own cocoon.

But what can the individual engineer—who in most cases merely "works for" a large industrial concern—do to exercise his social conscience? First, he should try to identify himself with a company whose higher management is concerned about the social consequences of its objectives. If he does not agree with his employer, or with the aim of the work he is doing, he has already abdicated that which his conscience objects to. It may be impossible for him to find any satisfaction in his work. (How many engineers do you know that never really like their jobs?) In a larger sense it is hoped that those industries that operate without regard for, or to the detriment of, the real needs of society will one day be set right by their employees. Second, and even more important, the engineer must himself show some commitment to the world.



Bob Sears, a Sylvania engineer since 1953, believes that "we won't be able to consider ourselves as professionals until we see the results of what we do."

The engineering profession cannot change simply by having the technical societies alone become a part of the transition from technology to life, although this must take place also. The change must come from the engineering community itself and, therefore, from each engineer.

Relevancy

Why should technology be set apart from society at all? Unfortunately, technology has become so specialized, so difficult for those outside it to comprehend, that it has segregated itself from the rest of society. (Indeed, it is very much compartmentalized within itself. For proof of this one need only look at the monstrous organization charts of many engineering companies.) In this form it continues to flourish and to become ever more separate, and almost entirely controlled from outside of itself.

The word is *relevance*. Either the engineering community understands, and is sympathetic to, the real needs and desires of society, or it will remain as it is—a closed segment of society in need of a conscience. The problems of our modern technological world are many, yet the unbelievable silence of the engineering community remains.

By first solving its own problems—both educational and professional—the engineering voice will gradually come to be heard—and respected—by the rest of the world. And then, hopefully, we will see real progress toward the solution of modern society's urgent problems.

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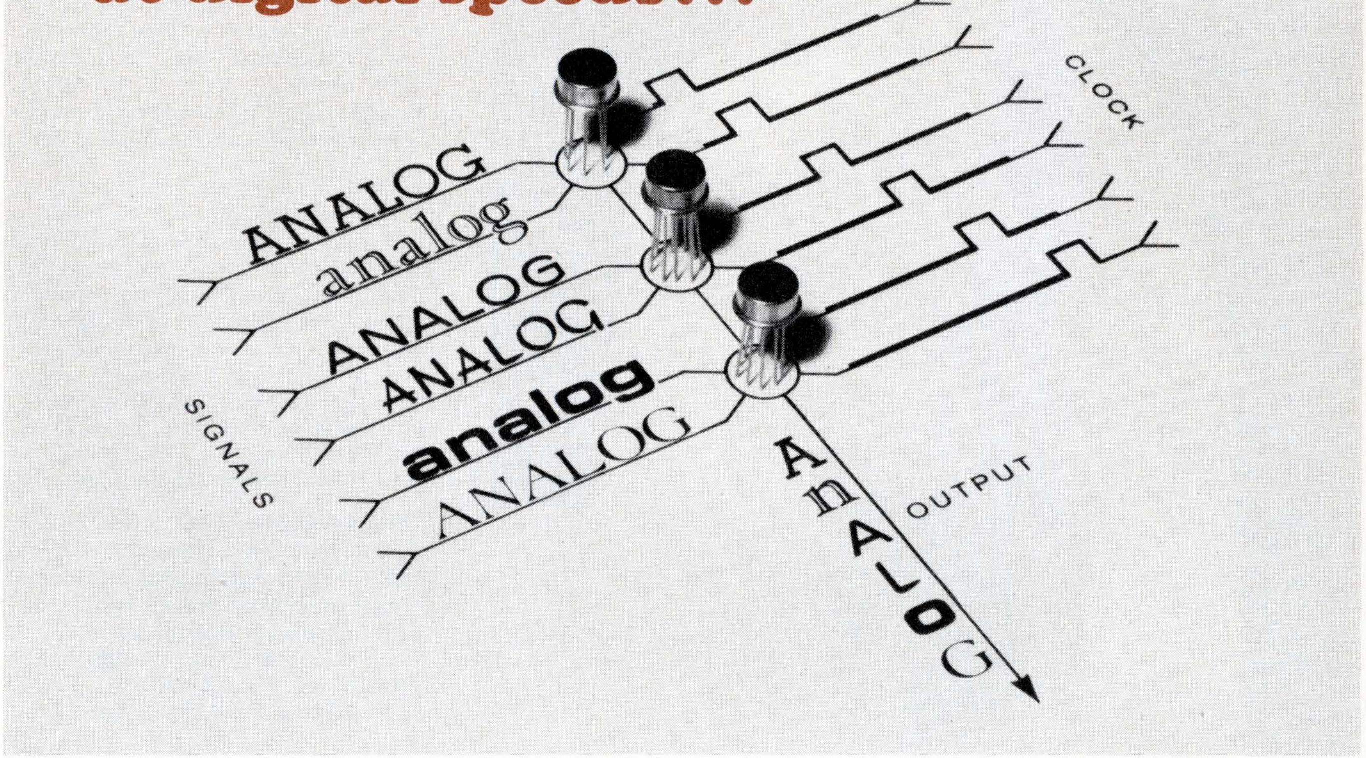

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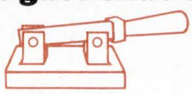

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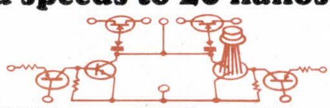

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Circle 20 on Inquiry Card

EE PRODUCT SEMINARS

As a service to you, this new column will list product seminars that electronic companies offer to users of their products. For more details, simply circle the appropriate reader service number on the inquiry card.

"Industrial Hygiene," Apr. 15-17, Cleveland. $50. Introduction to sound and vibration dynamics, scaling and presentation of measurement results, units of measurement, measurement transducers, definition of waveforms, magnitude measurements, signal processing, calibration procedures, typical measurement systems, noise reduction, etc. B & K Instruments, Inc., 5111 W. 164th St., Cleveland, Ohio 44142.
Circle 400 on Inquiry Card

"Process Automation," April 21-May 2 and 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 401 on Inquiry Card

"Microelectronic Soldering & Brazing," Apr. 21-22 (New York), May 12-13 (Palo Alto). New York seminar, $175; Palo Alto, $225. Alpha Metals, Inc., 56 Water St., Jersey City, N. J. 07304.
Circle 402 on Inquiry Card

"Series 500 Integrated Circuit Test Equipment," Apr. 28-May 9, 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 403 on Inquiry Card

"Repair and Maintenance Training Session," May 5-9 and June 2-6, 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 404 on Inquiry Card

"Series 5800 (5000) Dynamic Tester Programming Seminar," May 12-16, Sunnyvale, Calif. Tuition-free for customers (up to two employees—$150 for each additional person). R. D. Warner, System Training Manager, Fairchild Instrumentation, 974 E. Arques Ave., Sunnyvale, Calif. 94086.
Circle 405 on Inquiry Card

"Current and Coming IC Applications," May 14, Chicago. $15. Voltage regulators, MOS in memory applications, operational amplifiers, analog switches using MOS circuits, voltage comparators, communication circuits. Regis P. McKenna, Mktg. Services Mgr., National Semiconductor Corp., 2975 San Ysidro Way, Santa Clara, Calif. 95051.

Circle 406 on Inquiry Card

"Series 600 Transistor Test Equipment," May 19-23, Sunnyvale, Calif. Tuition-free for customers (up to two employees—$150 for each additional person). R. D. Warner, System Training Manager, Fairchild Instrumentation, 974 E. Arques Ave., Sunnyvale, Calif. 94086.

Circle 407 on Inquiry Card

"Operations and Maintenance," May 19-23, Anaheim, Calif. $150. Sine and random fundamentals, study of circuits, sine and random vibration applications. School Registrar, Ling Electronics Div., LTV Ling Altec, Inc., 1515 S. Manchester Ave., Anaheim, Calif. 92803.

Circle 408 on Inquiry Card

"Operation and Maintenance 7600 Magnetic Tape System," May 19-23, Denver, Colo. $180. Introduction to magnetic tape recording, system operation and application, circuit analysis, calibration. C. F. Creswell, Training Center Services, Honeywell Inc., Test Instruments Div., 4800 E. Dry Creek Rd., Denver, Colo. 80217.

Circle 409 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 410 on Inquiry Card

"DC Testing of Power-Apparatus Insulation," May 26-30, Willow Grove, Pa. Part 1, $100; Part 2, $150. Part 1: physical characteristics of insulation systems, test methods and techniques, basic test circuits, interpretation of test results; Part 2: electrical characteristics of insulation systems, test methods and techniques, interpretation of test results. Biddle Technical School, Township Line & Jolly Roads, Plymouth Meeting, Pa. 19462.

Circle 411 on Inquiry Card

EEs GET AHEAD

Liquid crystals make possible better reflective displays

Dr. George H. Heilmeier
Outstanding young engineer

Only 32 years old, George H. Heilmeier has a record of achievements that any seasoned engineer would be proud of. Recognizing this, Eta Kappa Nu has just honored him as the Outstanding Young Electrical Engineer of 1968. The award is mainly for his work on the electro-optic effects in liquid crystals, as well as for his contributions to community and church affairs.

Dr. Heilmeier and his team at RCA Labs, Princeton, N.J., discovered three such effects. The first, called "dynamic scattering," allows electronic control of reflected light, and makes possible flat, low cost, low power displays (see **The Electronic Engineer,** Aug. 1968, p. 17). Such displays use nematic type liquid crystals.

The second is a storage effect found in mixed nematic-choleresttic liquid crystal displays (see **The Electronic Engineer,** Nov. 1968, p. 15), and the third deals with color switching by means of guest-host interactions in certain classes of nematic crystals.

Dr. Heilmeier and his associates are now working with RCA's components division in Somerville to "transfer this technology to the factory," so we can look forward to reflective displays that use these liquid crystals in the not-so-distant future.

Liquid crystals are not his only forté. When he first joined RCA in 1958, Dr. Heilmeier worked on such devices as parametric and tunnel diode amplifiers, mixers, and harmonic generators, and was awarded several patents in this area. He also holds some patents on thin-film devices, including a field-effect transistor with a ferroelectric gate that can be used as a storage device.

The head of device concepts research at the Labs, George Heilmeier earned his BSEE from University of Pennsylvania and his M.S., A.M. and Ph.D. from Princeton.

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TYPE MFF	Epoxy roll-coated metal film resistor. Designed primarily for commercial applications. Meets electrical and environmental specifications of MIL-R-10509F. Small size. Low cost.	**Power:** 1/8, 1/4, 1/2, 1 and 2 watt sizes **Resistance Range:** 10 Ω to 10 Megohms, depending on size and T.C. **Resistance Tolerance:** .1%, .25%, .5%, 1% **T.C.:** ±25, ±50, ±100, ±150 PPM standard
TYPE D	Precision power film resistor molded into an aluminum housing for complete environmental protection and high stability. Wide resistance range, low reactance at high frequencies.	**Power:** 4, 8, 12 watt sizes **Resistance Range:** 50 Ω to 2.6 Megohms, depending on size **Resistance Tolerance:** .1%, .25%, .5%, 1% and 2% standard
TYPE MP	Epoxy-molded metal film package with from 2 to 6 elements. Meets MIL-R-10509F. Available with matched T.C., matched resistance ratio. Excellent H.F. characteristics. Very low noise levels.	**Power:** 50 milliwatts per element at 125° C **Resistance Range:** 30.1 Ω to 80.6K Ω each element **Resistance Tolerance:** .1%, .25%, .5%, 1%, 2%, 5%

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EE COURSES

"Nonlinear Programming," Apr. 16-18 (Washington), May 14-16 (New York), June 9-11 (Minneapolis). $250 for first student and $225 for others from the same organization. Review of mathematical background; introduction to nonlinear programming; applications; gradient, concave, and convex functions; Kuhn-Tucker conditions; economic interpretations; duality and convergence theories; unconstrained methods; linear and nonlinear constraint methods; etc. Registrar, Institute for Advanced Technology, C-E-I-R Inc., 5272 River Rd., Washington, D. C. 20016.

"Project Management Seminar," Apr. 28-30 (Boston), 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.

"Semiconductor Models for Computer Analysis," Apr. 29-30, Univ. of Wisconsin—Madison. $70.

"7th Seminar on Recent Advances in Solid State Circuitry," May 5-6, Univ. of Wisconsin—Madison. $70.

For more information on the above two courses, contact University Extension, University of Wisconsin, Dept. of Engineering, 432 N. Lake St., Madison, Wis. 53706.

"Maximizing Proprietary Rights," May 12-13 (Williamsburg), May 15-16 (Detroit), May 19-20 (Palo Alto), May 22-23, (New York). NSIA members and government personnel, $125; non-members, $150. Subcontractor strategy, modes of protection, perspective on patents, commercial fallout from government-sponsored R&D, data rights and data banks, economics of industrial security, the inventor as an employee, the free-lance inventor. National Defense Education Institute, 11 Arlington St., Boston, Mass. 02116.

EE COURSES

"Non - destructive Testing: X-ray Course," May 12-16 and June 9-13, Cleveland. $300. Picker Industrial, Marketing Dept., 1688 Arabella Rd., Cleveland, Ohio 44112.

"R&D in Venture Management," May 15-16, Univ. of Wisconsin—Milwaukee. Venture management, R&D's responsibility in initiating new products, new design techniques and capabilities as they affect R&D, planning an R&D project, how to rate the effectiveness of research, financial control of venture management, transfer of new ventures to profit centers, and so forth. John Gammell, Asst. Dir., Dept. of Engineering, The University of Wisconsin, 600 W. Kilbourn Ave., Milwaukee, Wis. 53203.

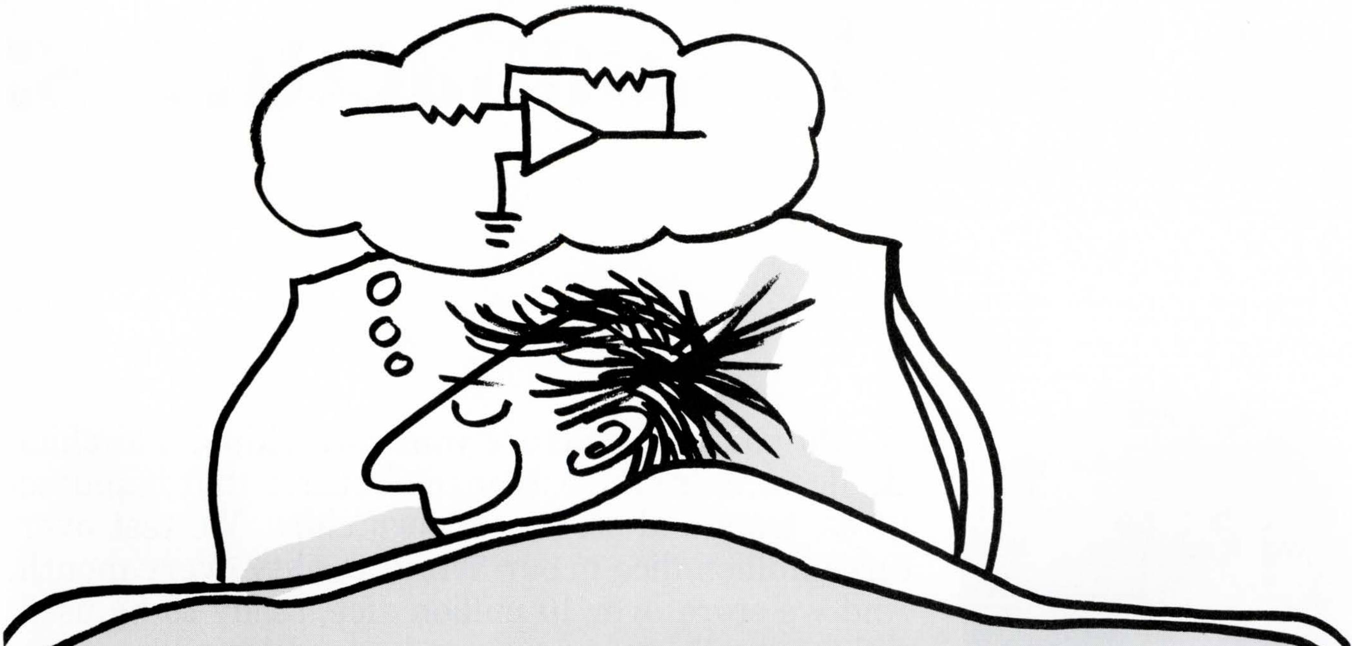
"Market Research Tools," May 19-21, Hopatcong, N. J. $225. Practical market research techniques with which to compete in today's electronic industry. Registrar, The Center for Professional Advancement, Box 66, Hopatcong, N. J. 07843.

"Selected Applications of Computers in Engineering," May 19-30, Univ. of Michigan. Will teach a problem-oriented computer language, the mathematical methods commonly used in programming engineering problems, and will program and solve on a computer several typical engineering problems. $400. Engineering Summer Conferences, The University of Michigan —Dept. ER, Chrysler Center, Ann Arbor, Mich. 48105.

"Analog Simulation and Computation," May 19-23 (Princeton, N. J.), June 9-13 (Dayton, Ohio and Albuquerque, N. M.). $250. Basic techniques of problem-solving by means of simulation and computation with the analog computer; operation of EAI desk-top analog computers. Ed Sharpe, Electronic Associates, Inc., 185 Monmouth Pkwy., West Long Branch, N. J. 07764.

"Scientific Management Techniques," May 20-23, Washington Univ., St. Louis, Mo. $165. Model building, linear programming, simulation, critical path analysis, and basic concepts of operations research as applied to management decision making. Joseph Movshin, Washington University, Box 1048, St. Louis, Mo. 63130.

Dream OP AMPS



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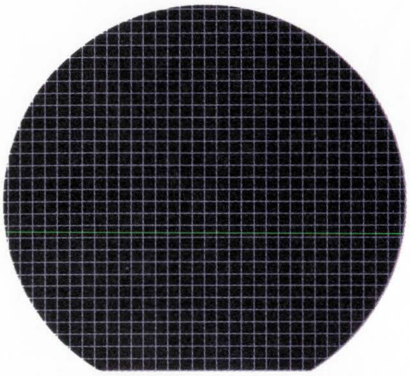
5 revealing questions to ask hybrid manufacturers:



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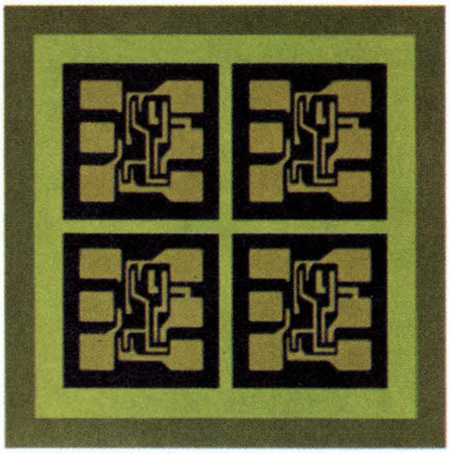

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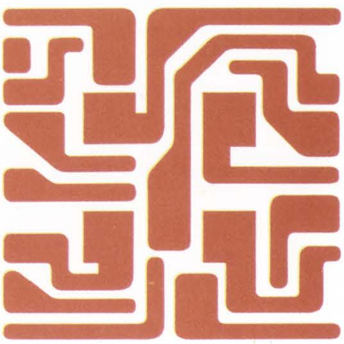

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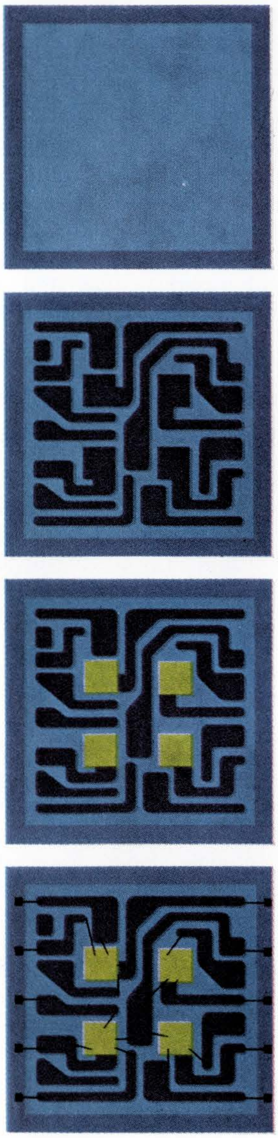

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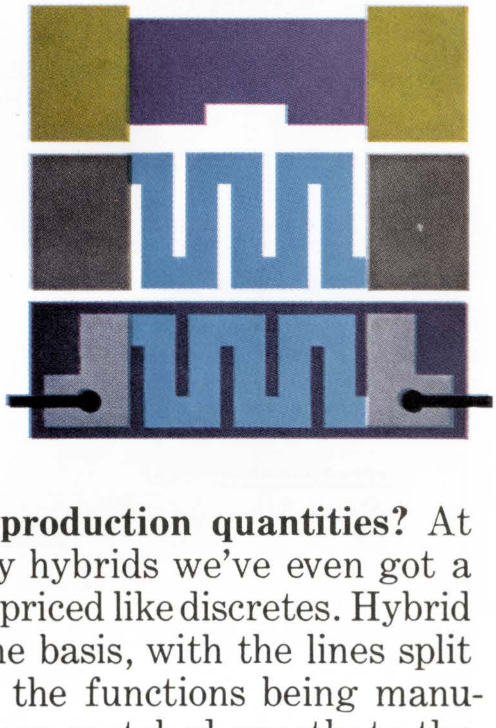

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EE FANOUT

MARK B. LEEDS, Features Editor

Hard line. Raytheon Semiconductor, which holds a profitable position as a second source of integrated circuits, has developed a healthy attitude towards innovation. Aside from being the prime advocate and a pioneer of the beam-lead technology, the company will soon announce a number of proprietary products in other "hot" areas.

Scheduled for introduction later this year is a catalog line of radiation-hardened linear and digital ICs (see EE, Aug. 1968, p. 12). Also on the boards: an emitter-coupled-logic line, high-speed sense amplifiers, and bipolar memories. By mid-year it plans to introduce multilayer 64- and 265-bit bipolar random access memories.

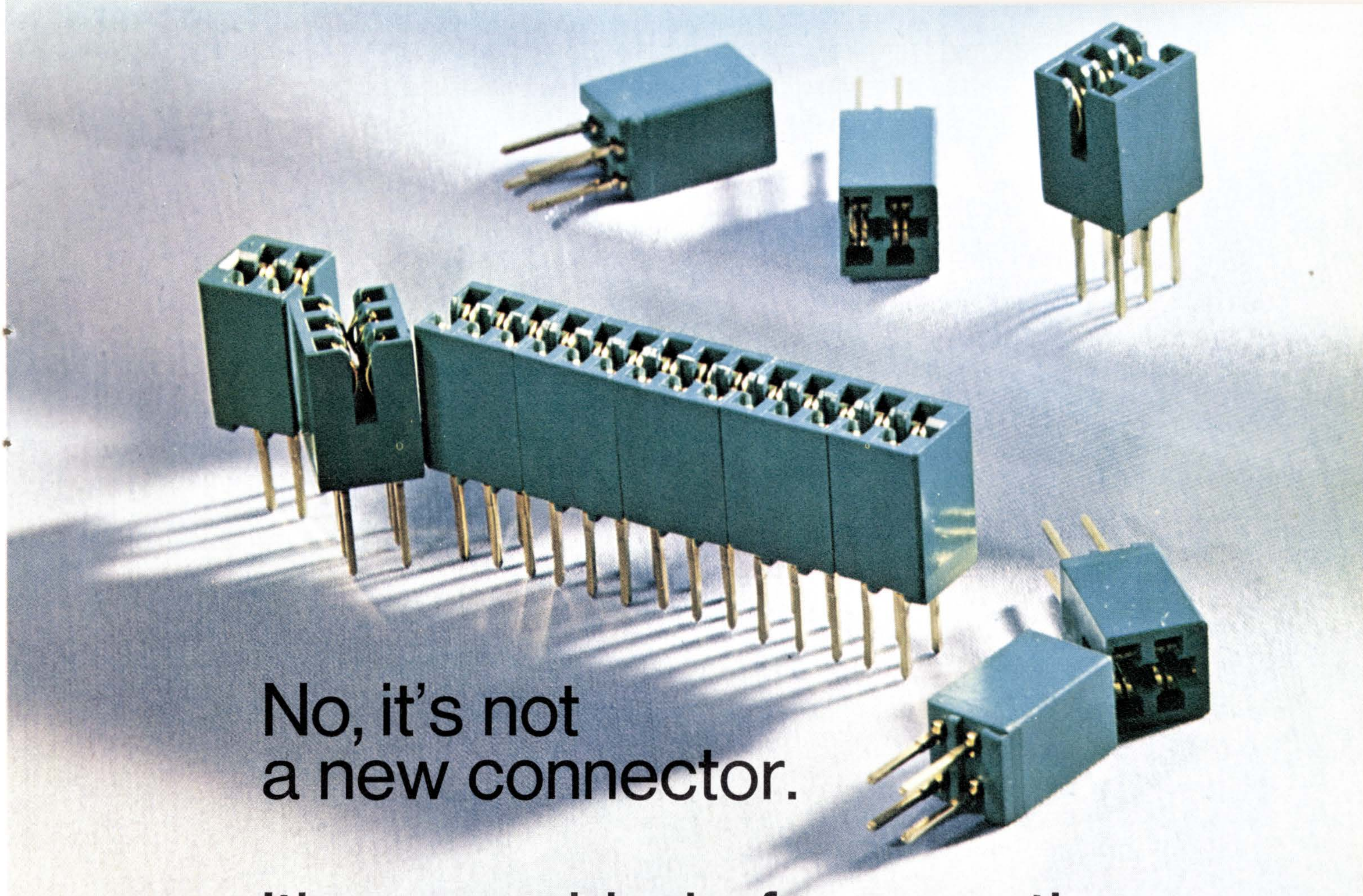
Reed no more. The days of the reed-relay programmed amplifier may be numbered. A Dana Laboratories marketing official predicts the advent of a fully solid-state unit by mid-year. More compatible with other digitized instruments, the amplifier will reportedly sell for $1200-$1500. Its specs include a voltage gain of 1000, a bandwidth of 50 kHz; also, less noise, a faster overload recovery time, and a shorter settling time than with the reed unit.

Frequency synthesizer. Dana will soon unveil a bargain digiphase frequency synthesizer. The instrument, a precise sine wave source, reportedly offers more flexibility per unit of cost than comparable equipments. Designated the series 7000 model, it covers dc to 11 MHz in 1-Hz steps and dc to 100 kHz in 0.01-Hz steps. Pricing is about $4800-$6000, depending on options.

A marketing spokesman says the key to the instrument is its simplistic design, which uses solid-state rf circuitry and IC digital logic in place of complex frequency dividing and counting stages. The unit will compete with Hewlett-Packard's Model 5103A, and similar models from General Radio and Fluke.

The HP synthesizer, priced at about $7000, goes up to 10 MHz in 1-Hz steps. Its switching speed is under 20 μsec and operating temperature range is 0°-55°C; with Dana's model the corresponding figures are 200 μsec and 0°-50°C. Stability is also superior in HP's—2 x 10^{-10} per°C against 1 x 10^{-7} for the 7000.

Looking ahead, Dana is planning to add a 100-MHz source and a compatible tunable tracking voltmeter to the line.



No, it's not a new connector.

It's a new kind of connecting.

The little connectors above are really one connector. You take as many pieces as you need, mix them together, and use them to connect any size of p.c. board to a mother board.

That's not spectacularly new. Connector modules for use in bread-boarding have been around for a while.

But these new Mojo™ Series 6308 p.c. connector modules* are not just for bread-boards and prototypes.

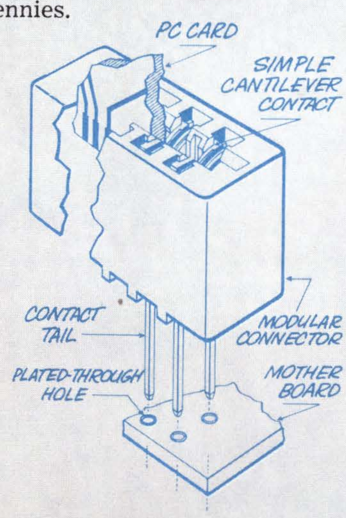
Not hardly.

When used with plated-through holes on the mother board, they are one of the slickest production tricks to come along in quite a while. Contact tails combine a square wire-wrapping post with a specially designed locking feature which, when press-fitted into a plated-through hole, provides a gas-tight and reliable electrical connection.

No, you don't have to solder.

Yes, you can wire-wrap if you want.

And, yes, you'll save time and money in moving from prototype into production. Because connectors of virtually any size can be built up economically from just two sizes of modules, you don't need a large inventory. Or custom connectors. And you only have to insert modules where connectors are required, saving a few more pennies.



And, no, you don't give up a bit of connector reliability. The exclusive swaged single-beam design of the dual-readout contact provides optimum spring rate and deflection characteristics. A preload applied to the contact nose in the insulator makes sure that the contact really holds on to the card, while keeping the contacts well apart when the card is removed from the connector.

Mojo™ p.c. connector modules: Specs in brief

Material
Glass-filled DAP

Contacts
Cantilevered-beam, dual readout, bifurcated nose. .150″ centers. Center modules have 6 contacts. End modules have 4 contacts, molded-in card guide.

Tails
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Press fit, in .048″ dia. plated-through holes, 3/32″ to 1/8″ thick board.

For more information, write, wire, call, or TWX us for our Mojo™ p.c. connector module data sheet. Elco Corporation, 155 Commerce Drive, Fort Washington, Pa. 19034. (215) 646-7420; TWX 510-661-0.

ELCO Mojo™ p.c. Connectors

* Patent pending

EE WELCOME

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

Optoelectronics opener. Dedicated to the production of "electronic products for the growing computer industry," Optron, Inc. was recently formed in Carrollton, Tex. (near Dallas). The firm's basic product—the OP-600—is an npn silicon light sensor for character recognition, tape and card reader, velocity indicator, and encoder applications. This sensor is presently available in production quantities.

Optron's product line is expected to include silicon photo transistors and diodes, optical detector arrays, light emitters, and custom products.

Circle 412 on Inquiry Card

Measurement instruments. Incorporated this past December, Scientific Measurement Systems, Inc., Moorestown, N.J., is ready to market its first product line—medium-priced, semiautomatic integrated circuit testers. Priced between $12,000 and $20,000, the basic Mica 150A tests most standard digital circuits. It is modular in concept, so you can add various functions and significantly change the types of tests it makes.

This IC test line was purchased from Computer Test Corp. The first units are expected to be shipped by early spring.

The new firm's second product line will consist of a statistical averaging computer, whose function it is to recover signals from noisy environments. The prime user of this device will be the biomedical field. Alexander Baker, SMS's president, explains, "If you're able to differentiate a person's nervous system response, for example, against the other extraneous variables (such as noise) that creep in, then you can make some reasonable decision as to how this person is responding as a function of a given stimulus."

This computer, which also has many applications in the physical sciences, is expected to be in production by the end of this year. A third product group—still in the design stage—will be a line of sample-and-hold instruments.

Circle 413 on Inquiry Card

IC testing for hire. Systems manufacturers who are torn between in-house testing or not testing at all now have an alternative. Logic Electronics, formed about four months ago in Malden, Mass., tests and screens microelectronic devices, and integrated circuits in particular. The company uses Fairchild's 5000/5800 test system to perform the testing (both ac and dc). Both linear and digital ICs—in fact, all presently available integrated circuits—can be tested by the new firm. The cost varies according to device complexity.

The one big problem the facility has encountered is alerting the industry to the alternative of in-house testing. Previously, overloaded companies would just not test at all. With Logic Electronics they have a way out.

Circle 414 on Inquiry Card

Memories and computers. Since its formation almost two years ago, Datacraft Corp. has been making a line of magnetic core memories, and has just recently gone into the computer business. Its DC 6024 digital computer is probably one of the highest-speed units (600-ns full cycle time) in the medium-price range.

Particularly noteworthy is the company's software policy. It agrees with Uncle Sam, Control Data Corp., and Data Processing Financial & General Corp.—all three are suing IBM—that the basic cost of a computer should not be "inflated" with software. Datacraft sells, therefore, only a minimum amount of software with its computer, making the unit very competitive.

Says Jon Momberger, the firm's director of marketing, "We have a basic set of software included in the original price. Optional software is priced separately as a product in itself. Thus the user only pays for the software he requires."

Datacraft didn't formulate this policy with IBM in mind, maintains Momberger. "We did it purely because we thought that's what the customer wants."

Based in Fort Lauderdale, Fla., the company also makes a wide range of high- and medium-speed magnetic core memories for applications involving complex computer systems, data transmission storage systems, and CRT displays.

Circle 415 on Inquiry Card

55 #20 contacts, #22 shell.
Area—2.44 sq. in.
Weight—1.3 oz.

55 #23-22 contacts,
#16 shell. Area—1.58 sq. in.
Weight—.9 oz.

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This simplification created other advantages, too. For example, Astro/348 connectors cost less per circuit than other present-day connectors. We expect Astro/348 to become the standard connector family for the next decade.

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Circle 32 on Inquiry Card

EE CABINET

Terminal junctions make their debut

**Wherever you see a terminal today—
whether it is on a terminal board, behind a meter, or on a relay,
there is a potential application for the new terminal junctions.**

Staff report, The Electronic Engineer

A concept of terminating wires that eliminates the hazards of exposed screws or lugs may be the answer to the aircraft industry's interconnection problems. There can be benefits for other industries, too.

Most interconnections are made with terminal boards; but, more than a decade ago, the automotive industry started using terminations that require only crimping and insertion. Their objective was to reduce assembly costs.

This method of termination is satisfactory for private planes, but the high performance commercial planes need a device that offers protection from contaminating environments and accidental shorts, plus reliability.

In a terminal junction, a small metal contact crimped onto a wire fits into a receptacle that provides electrical continuity with positive, mechanical connection; in the sealed version, the wire passes through a resilient silicone or fluorosilicone plastic grommet, bonded to the receptacle holder, before making contact.

Weight and space conscious aircraft builders have good reason to be interested in terminal junctions; the table shows the savings offered by a typical sealed system.

Terminal junctions are not new

As far back as 1962, Matrix Science Corp. proposed an integrated system that used a device intended to replace the standard lug type terminal strip. And Burndy Corp. was marketing Crablock, a terminal strip replacement product of its English affiliate.

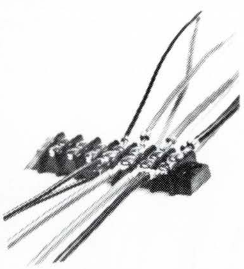
In 1966, the Navy initiated a program to evaluate terminal junctions as a replacement for boards. But only within the last two years have the majority of OEM's and the military considered the concept on a total program basis.

In 1967, the Defense Supply Agency started the wheels turning on a procurement document for sealed terminal junctions. (A procurement document eliminates the time and expense of a development program because it requires the availability of an off-the-shelf item.) To achieve tri-service interchangeability, DSA wanted a single design. Because of its 1966 experience, the Navy was selected to evaluate the available products.

The Naval Air Development Command initiated the program by setting up desirable criteria and inviting interested manufacturers to review them for recommendations. When the criteria were finalized, AMP, Amphenol, Burndy, Deutsch, and Matrix submitted samples.

The evaluation included the standard military tests and emphasized voltage stability. The latter consists of monitoring the voltage drop change through a junction while the wire is wiggled in a set pattern. The test outcome was a key factor; the selected contact design—by Matrix—changed less than 1mV while the others varied 6 or more millivolts.

Some manufacturers trace this superior performance to the rigid electrical connection achieved at the cost of a high insertion force, about 7 lb. In multi-conductor connector design, this force would be too high; but it is perfectly satisfactory for single wires.



Weight and space comparison (approx.)
Terminal board vs. sealed terminal junction

Wire size	Number of connections	Weight (grams/connection)		Volume (cubic inch/connection)	
		Terminal Board*	Terminal Junction+	Terminal Board*	Terminal Junction+
20–24	40	1.90	1.45	0.140	0.075
	80	1.80	1.35	0.125	0.060
16–18	40	1.95	1.95	0.150	0.095
	80	1.90	1.85	0.140	0.080
10–14	40	3.3	3.55	0.190	0.160
	80	3.2	3.40	0.175	0.140

*Includes terminal board hardware and wire terminals.
+Includes mounting frame, modules, and wire contacts.

Most redesigns entail a separate, stronger mechanical connection that provides the needed rigidity and permits the use of copper in the receptacle contact for higher conductivity.

A preliminary, undated specification, designated MIL-T-81714, is now in editorial review; it should appear in final form in June 1969. The word "system" is used in the specification because the military sees this arrangement as having application on relays, switches, splices, and some connectors as well as replacing terminal strips.

The critical detail for an integrated system (i.e., one in which relays, switches, and other devices have receptacles similar to those in the modules replacing the terminal strips) is the wire contact. The specification establishes the exact terminating contact configuration for the various wire sizes.

One manufacturer, Deutsch, has already started on such a system. A relay, made by its Filtors Relay Div., is offered with receptacles that accommodate the firm's proprietary wire contact, although this does not have the same configuration as that detailed in the specification.

The spec allows for various circuit arrangements among the receptacles in a module; i.e., different combinations of receptacles can be connected in common. After analyzing their needs, however, some aircraft builders find that their requirements can best be satisfied by using one type of module, both to simplify the assembly and to reduce the inventory.

Noteworthy use of terminal junctions includes the Apollo program and the F-111. Preliminary testing to anticipated SST stress requirements, however, exposed failure modes in existing designs. Latest advice from Boeing is that the problem will not have to be solved. The junctions will be in a pressurized atmosphere under no greater stress than that which the passengers experience.

Marketwise, conservative estimates show the terminal junction system challenging 50% to 60% of the terminal board business, but no more than 10% to 15% of the connector field.

Acknowledgements

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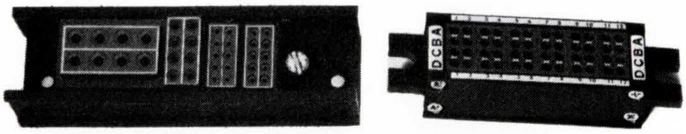
M. Benson, Boeing Co., Seattle, Wash.
N. Shappell, Boeing Co., Eddystone, Pa.
W. M. Reese, Narco Avionics Div., Ft. Washington, Pa.

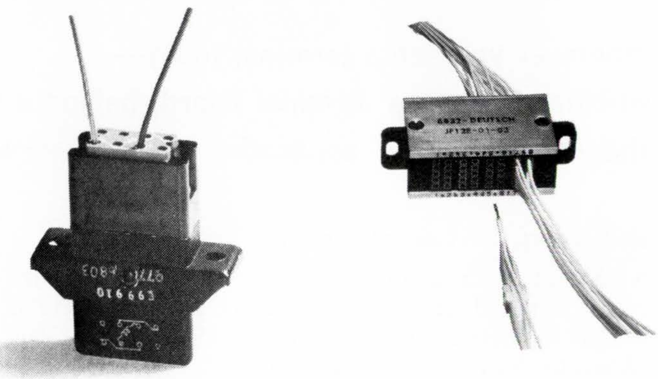
For further information on the manufacturers and their products, circle the following numbers on the Inquiry Card:

AMP Incorporated — **Circle number 316 on Inquiry Card**
Burndy Corporation — **Circle number 317 on Inquiry Card**
Deutsch-Filtors Relay Div — **Circle number 318 on Inquiry Card**
Matrix Science Corporation — **Circle number 319 on Inquiry Card**
Microdot Inc. — **Circle number 320 on Inquiry Card**

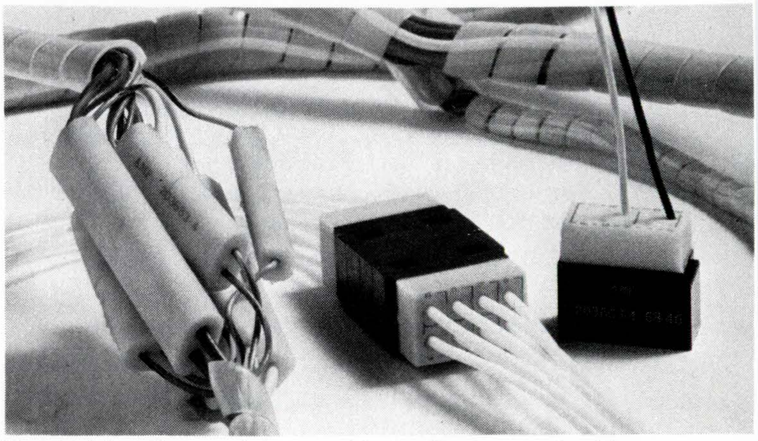
INFORMATION RETRIEVAL
Connectors, Packaging, Wires and cables



The military specification permits use of modules accommodating different wire sizes in the one mounting frame (left); however aircraft manufacturers prefer to standardize on one wire size and one type of module. (Photos courtesy of Matrix Research and of Microdot.) Microdot is sole licensee of Matrix.

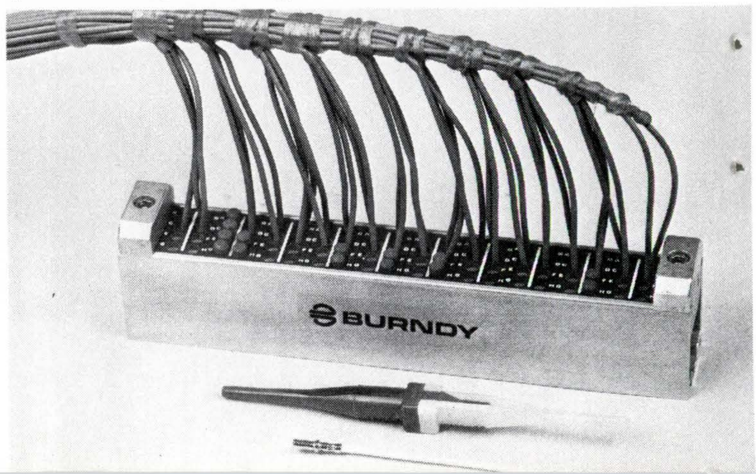


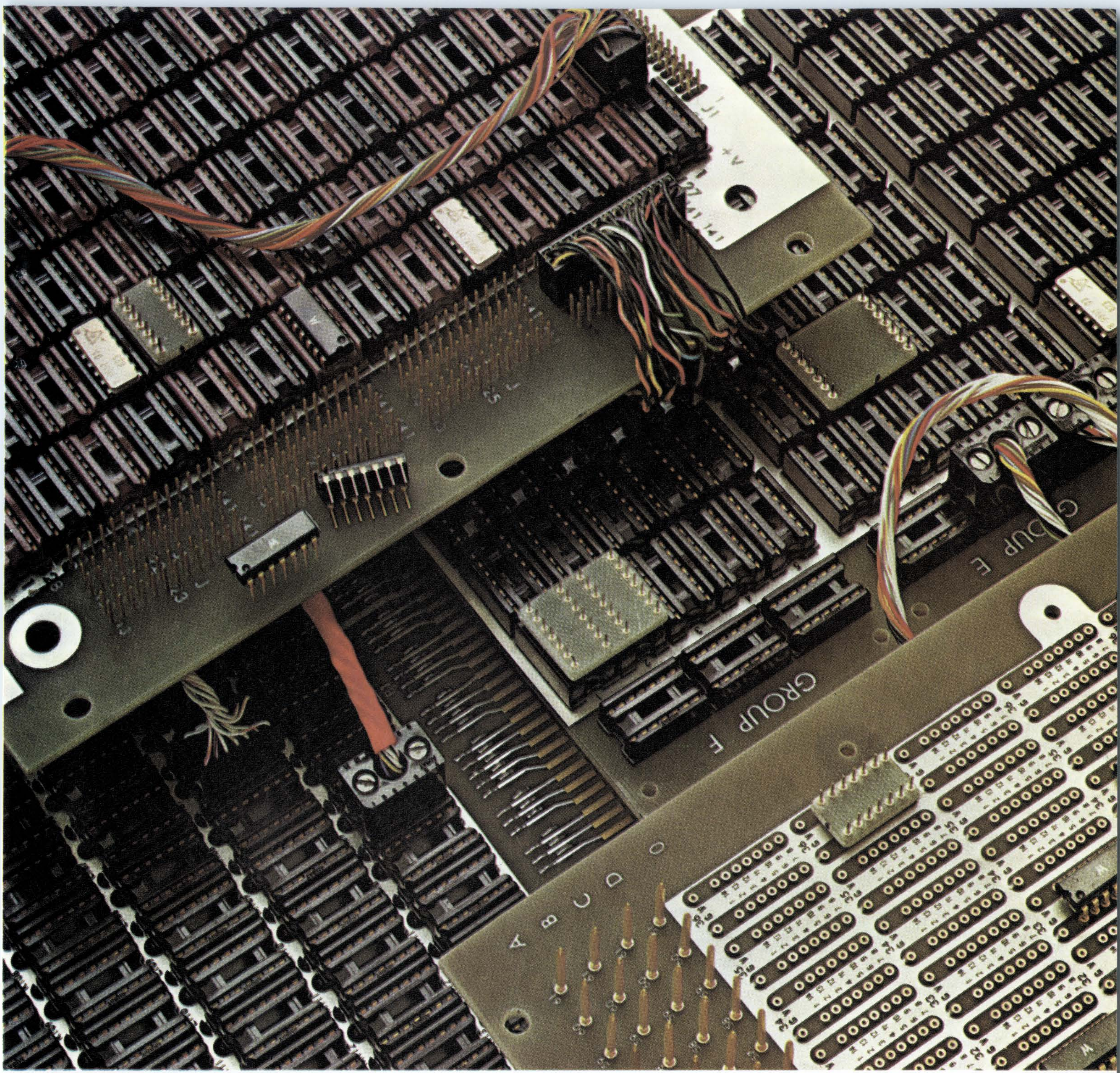
Weight and volume savings rendered by terminal junctions (when compared with terminal strips) become appreciable as the wire becomes finer. The protective grommet's sealing action on the terminal junction (right) eliminates the contamination and shorting hazards of the exposed terminals. **Terminal junctions on relay** offer fast connection and environmental protection. It is the first step towards an integrated termination system. (Photo courtesy of Deutsch-Filtors.)



Terminal junction modules provide feedback or a feedthru capability for terminating wires; splices are also available. (Photo courtesy of AMP, Inc.)

Plastic tool helps the operator to insert the terminated wire properly into the socket, and to remove it without damaging the junction. (Burndy is developing a metal-tipped tool that will last longer than the plastic one). Note the plastic plugs that cover the unused holes to keep the system sealed. (Photo courtesy of Burndy).





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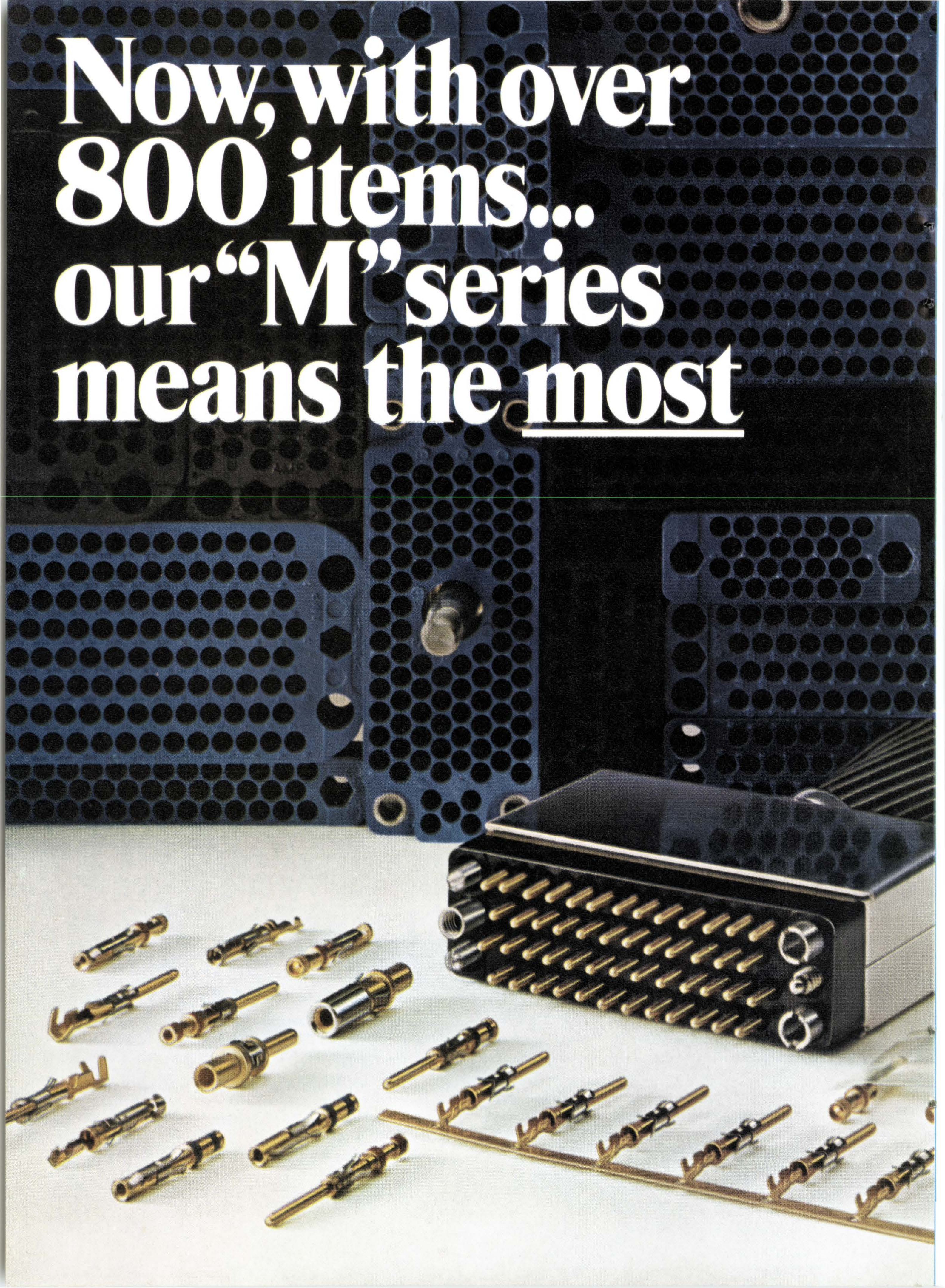
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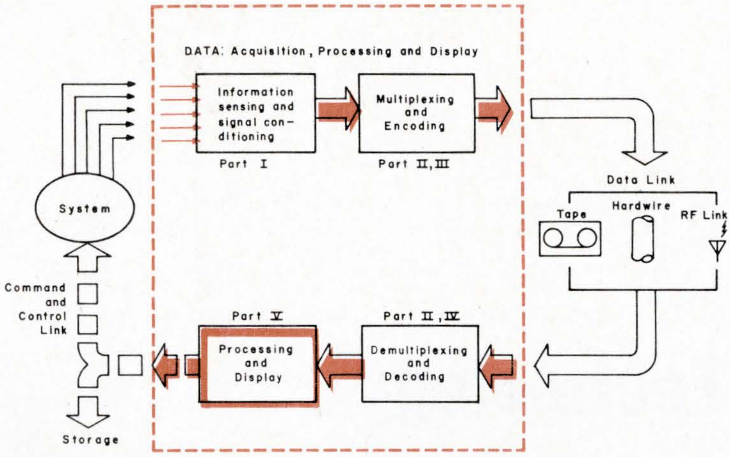
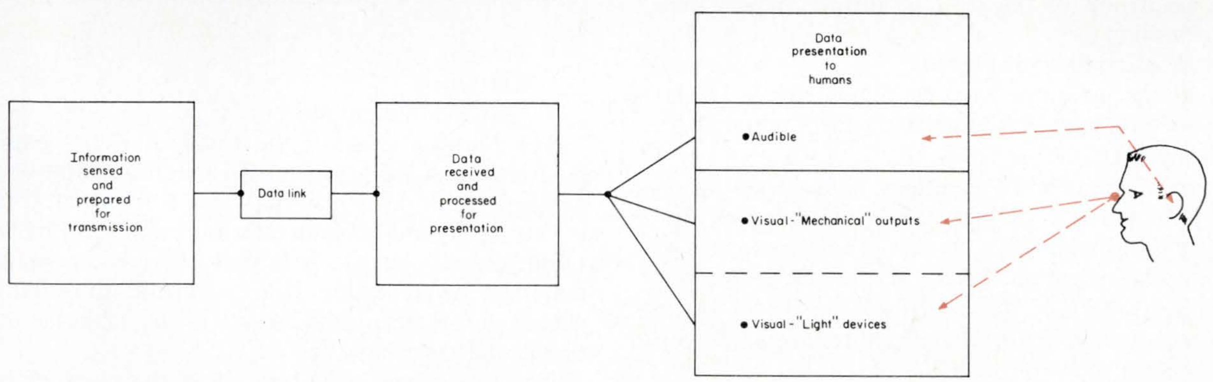


Data: acquisition, processing, and display

This last installment of the Telemetry Course tells how the data is presented for use by a human being. Some type of display is the best method to present alphanumeric or graphic information for quick input to the brain. Various types of displays, from typewriter to very sophisticated "light" displays are discussed. The heavy accent is on quick changing, light type displays. Current displays and those still in early development are covered along with background information about basic physical effects being applied to new systems.

As do all good courses, this one has an examination included with this month's installment. All readers who successfully pass the exam will receive a certificate of successful completion that is suitable for framing. So, don't forget to do your exam and send it to us for marking.



The two most likely senses of the human being to use for putting data into the brain are hearing and sight. Hearing is very time limited and not practical except in "alarm" situations. This leaves sight as the fastest means. As a display for our eyes, there is the mechanical types such as typewriter displays or plotters, and the light types like a cathode ray tube. Because the mechanical types are speed limited and often display limited for some applications, light type displays are the best solution for high speed brain input.

Telemetry course—Part V

Displays— Techniques and Technology

Here is a chance to learn about light type displays, both present and future. To better help you understand how they work, basic principles are included.

Harry C. Morgan, Project Leader
Autonetics, division of North American Rockwell, Anaheim, Calif.

A data acquisition system—to become an *information* system—must translate the encoded data flow into symbols that can be understood by the receiver. These symbolic elements (for humans) could be tactile or aural, but the fastest route to human understanding is visual. A picture is indeed worth a thousand words.

The creation of any display involves three principal elements:

- A source of light,
- Manipulation of the light to form desired visual information,
- Information to be displayed.

This article discusses the basic techniques which implement these three elements, together with representative practical systems.

The first displays were paintings, laboriously hand-drawn by the painter. Uniform illumination "reads out" the picture information by a process of selective specular absorption and reflection. Such a display technique was almost universally used during World War II for battle display boards, updated by hand with chalk or crayon on area maps.

Even in most earlier telemetry systems, the PCM binary data was demultiplexed and then decoded directly to electrical analog signals that were connected to chart recorders, meters, or other simple single parameter output devices. The present trend is to leave the data in PCM form until it gets to the final display transducing element to preserve accuracy, and permit more complex information displays.

Basic display techniques

Two of the basic elements in display creation—a light source and its manipulation—are usually achieved by physical or physical-chemical effects.

Electrostatic and magnetic effects: Because light is electromagnetic in nature and atoms are positively charged heavy nuclei with orbiting negative charges (electrons), an interaction occurs between them. This is the refraction, diffraction, reflection, etc., of light by material objects such as glass. Strong magnetic or electric fields applied to the objects affect their optical properties. Some optical effects that have been observed are:

- Faraday effect
- Kerr effect
- Cotton-Moulton effect

The **Faraday effect** is the rotation of the plane of polarization of light transmitted parallel to the lines of magnetic force in a material. The amount of rotation is very small and is greatest in ferromagnetic materials (iron, nickel, cobalt). It is best observed in magnetic materials by reflection from magnetic thin films on glass and has been used to aid in the manufacture of digital shift registers.

The **Kerr effect** is the rotation of the plane of polarization of light transmitted by transparent isotropic materials such as glass, water and carbon disulphide by an electric field. In solids such as glass, response time may be in the order of several seconds, while the on-off time constant in many non-polar liquids may be less than 10^{-11} seconds. The Kerr electro-optical shutter is based on this principle and can modulate a light beam at frequencies of 10^{10} Hz or more.

The **Cotton-Moulton effect** is a magnetic field analog of the Kerr effect. It is much smaller than the Faraday effect and light must be perpendicular to the magnetic lines of force to separate the two effects.

Electroluminescence: Electroluminescence is the direct interaction of electrons with atoms to produce light. Examples of such light sources are "electro-luminiscent" light panels, gaseous glow tubes (neon lights, mercury arc lights, Nixies®), cathode ray tubes and light emitting diodes. Electroluminescence occurs when an electron orbiting an atomic nucleus is excited into a higher energy orbit (further away from the nucleus). This is an unstable state, and after a very short time (if not interfered with by atomic collision) the electron falls back into its lowest energy state and emits an electromagnetic quanta (visible light, infrared, etc.). In a gaseous light source, this is an accurate description of the interaction.

In electroluminescent solids or liquids the nearness of adjacent atoms distorts the electron orbits so that the interaction of adjacent atoms complicates this simple picture and multiple energy transitions can occur. These multiple transitions usually broaden the frequency of the light output so that it is no longer a single frequency color.

Laser light sources: In a laser light source, a source of energy (termed "pump source") excites a large number of atoms so that one of their orbital electrons is raised to a higher energy state and then all of the atoms are triggered by a second energy means to emit light at the same time. When the electrons fall back to their original energy level, light is emitted. The electromagnetic waves in the emitted light are in exact phase with each other, and the light is called "coherent". The laser output may be modulated in much the same way as radio waves.

Electron beam deflection: The most common display system today is the cathode ray tube (CRT). A fine electron stream generated by an electron gun is manipulated in two dimensions (x and y) by two orthogonal pairs of electrostatic reflection plates. The manipulated electrons "paint" a picture on a layer of fluorescent material. The brightness of the image may be controlled by varying the number of electrons reaching the screen, so it is possible to produce tonal images with this method.

Mechanical deflection: If a pencil thin beam of light is reflected from the surface of a mirror or refracted by passing through a glass prism, it can be moved around on a screen by mechanically moving the mirror or prism. Two mirrors or two prisms disposed so that the light spot on the screen can be moved in two directions constitute the elements of early TV systems. Mechanical deflection systems are seldom used in modern display systems except where a simple movable element or symbol is overlaid on a more complex display screen.

Electrochemical photographic techniques: photographic techniques are frequently used in display systems. They economically implement the display of large quantities of fixed or slowly changing data, such as area maps. An image is first formed on light-sensitive emulsion by means of a lens and light source. The latent image in the film, consisting of ions generated by the interaction with light quanta, is chemically developed.

Electromechanical: An electrostatic field applies a mechanical stress to any dielectrical material in which it exists. If the material is a solid, little atomic movement takes place. If the material is a liquid, or can be made a liquid temporarily, enough material displacement occurs to change the optical path of light which passes through it. Sheets of thermoplastic materials or oil films distorted by electrostatic fields have been used in several practical display systems. This system is often called the Schlieren projection display system.

Special elements: There are several more complex physical effects that have been used in displays. The photochromic display, developed by NCR, (RCA also has done work, see page 13, June 1968 EE) is in a sense similar to the photographic technique except that the information can be erased at will. A photochromic material is one which is transparent in its low energy or normal state. Upon exposure to ultraviolet light (300-400 mμ wavelength) the material becomes relatively opaque to visible light. This opaque state is unstable and gradually changes back to the normal transparent state in any time from a fraction of a second to an hour, depending on the particular photochromic material. The application of heat of 500-600 mμ wavelength illumination switches the material back to the transparent state. As generally used in displays, the photochromic material is a thin film on a glass or plastic slide which can be optically projected upon a screen. Information can be written upon this slide in time serial or in time parallel analogous to photographic techniques.

A new material for displays was announced by RCA. As recorded in the November 1968 issue of The Electronic Engineer, liquid crystals are used in experimental alpha-numeric displays. A quasi-emulsion of two liquid crystals (nematic and cholesteric) has two optical states: transparent or reflective. The normal condition is reflective. Under the influence of an electric field (audio frequency AC), the nematic molecules line up in an orderly manner, permitting the trapped clumps of emulsified material to break up and turn transparent. While further development is needed before this principle can be used, simple and inexpensive alpha-numeric and two-dimensional "matrix" style displays are anticipated.

Display systems

Fig. 1 shows the elements of a conventional multiple display system. The telemetry digital data is decoded to an analog electrical voltage, then distributed to the various output meters, chart recorders, or multi-channel recording oscillographs by a demultiplexer. Each output display device is manually observed and data recorded for computation, often a very laborious process.

Many present telemetry data systems preclude the observers scanning several different display elements because data are rapidly changing real-time information. In the continental air defense command display, for example, many data sources are integrated onto a map of North America. Potential aircraft or missile threats are displayed in real time on the map, together with data concerning their altitude, speed, identity, etc.

A great deal of information must be displayed so that decisions can be made rapidly based on timely information.

Some of the techniques

A very basic display technique is the projection of a photographic transparency optically. (Fig. 2). This is nearly always used for non-real-time data, where the time used in developing and processing the photographic film is tolerable. Many display systems use this optical projection system but, for the transparency, substitute an element which can be developed in real time. Some of the most common systems are:

- Iconorama
- Kalvar film
- Eidophor oil film
- G.E. thermoplastic film
- Photochromic systems
- Pockel-electro optical crystals

The **Iconorama** system uses a slide covered with an opaque metal coating. A servo actuated scriber traces lines and symbols through the coating in real time. Brightness and contrast are excellent, and Iconorama has been used for aircraft tracking applications. Updating requires that the slide be changed and the new information be written on the new slide.

Kalvar film is one of several dry diazo materials used instead of photographic film to shorten the development time. Ultraviolet light creates a latent image in the form of microscopic pressure centers in the diazo material which is on a transparent film base. To develop the image, the diazo material is softened by heating to about 240°F. The pressure centers expand into gas pockets, permanently distending the material. These gas pockets refract and scatter the light from the light source and create a dark spot on the screen.

Fig. 3 shows a typical **Eidophor** oil film display. A pattern of electrical charges is put on the oil film by scanning a stream of electrons over its surface, as in a CRT. The oil film is illuminated from the side by a mirror disposed at 45° to the projection system. A series of reflective and transparent strips on the mirror perform the function of the light stop.

The areas of the oil film that received the charge are distorted (see section on electro-mechanical techniques) and reflect light through the transparent strips of the mirror onto the display screen. Reflections from uncharged (and undistorted) areas of the film are stopped by the opaque strips.

Due to the vapor pressure of the oil, a vacuum must be maintained at all times, making this an expensive system.

Fig. 4 shows the elements of a GE thermoplastic film projection system that is similar to the Eidophor system. The pattern of reflective bars and transparent strips here is on the hypotenuse of a right-angled glass prism. The already deformed thermoplastic film is separated from the prism by a specific thickness of transparent material. This buffer material must have a refractive index near that of the prism and the film and must be in optical contact with both to prevent total reflection. The thermoplastic film can either have an electric charge pattern put on it by an electron gun or in a manner similar to the Xerox printing process, using a uniform electric charge changed by light. Heating immediately after exposure deforms the thermoplastic to fix the latent image.

Pockel electro-optical crystals twist the plane of light passing through them when they are stressed by an electric charge on their surfaces. The effect is similar to the Kerr effect but has a short time constant and larger twist angle for the same applied voltage. The material most often used is potassium dihydrogen phosphate (KDP). Fig. 5 shows how an electron beam scanning system places a charge pattern on the surface of a plane parallel KDP crystal. Polarized light from a light source illuminates the KDP crystal. A second polarizing screen between the KDP crystal and the projecting lens is optically turned 90° from the first screen to stop all of the light passing through a crystal with no charge pattern upon it. A charge pattern causes the crystal to twist the plane of polarized light varying amounts depending upon the charge density, resulting in an enlarged visual image of the charge pattern upon the screen. One major drawback of this system is that the vapor pressure of the KDP requires a vacuum pump running continuously.

Varian has just announced an experimental new photographic film or paper whose latent image can be developed electrically instead of chemically. While few details were released, Fig. 6 shows how such a system might work. The "film" could consist of three layers, two electrodes and an electrolyte. Light would release photoelectrons into the electrolyte. Under the emf of the battery, the electrolyte would plate material from the backing electrode upon the transparent surface electrode to form an image. Since an image could develop only with an electromotive force present, no shutter would be needed. The film could be immec iately projected. While not mentioned in the press release, it would seem that the process should be reversible. If the polarity of the applied voltage were reversed at the same time that the film is flooded with uniform illumination, the developed image should plate back upon the backing electrode. This process should therefore have considerable display potential.

Fig. 7 shows the basic elements of a 3D optical projection system that has been used for both slide

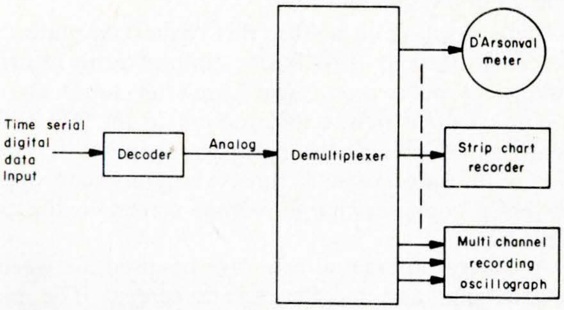


Fig. 1: Here are the elements of a conventional multiple display system that you can expect to see with some systems.

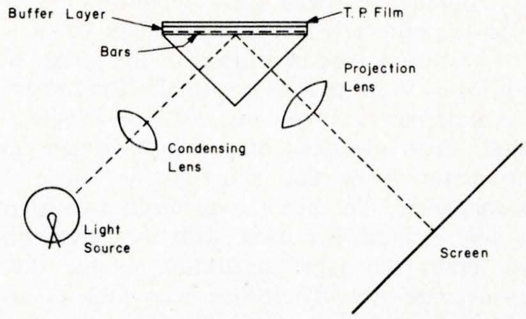


Fig. 4: The GE thermoplastic film projection system is similar in idea to the Eidophor system.

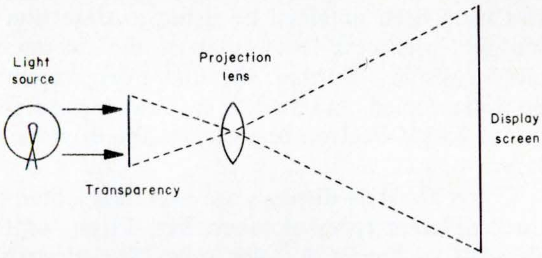


Fig. 2: A very basic display technique is the projection of a photographic transparency. This is a 2D system for non-real-time data.

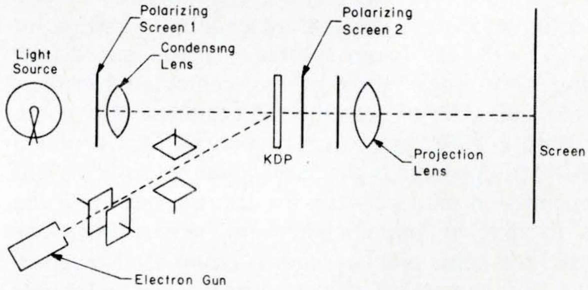


Fig. 5: Pockel electro-optical system most often uses KDP as the "optical" material. Electrical charges on the surface of KDP control the light passing through.

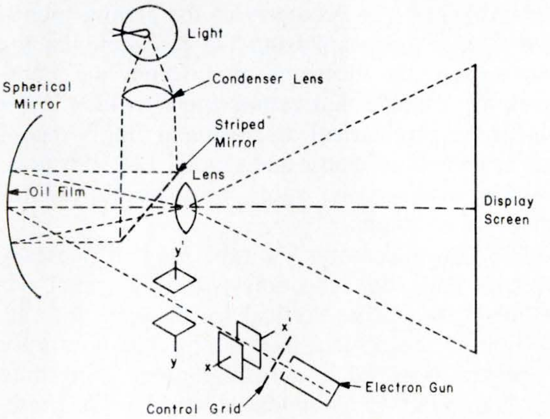


Fig. 3: This shows, basically, the Eidophor oil film display system. Because of the vapor pressure of the oil, a vacuum must be maintained.

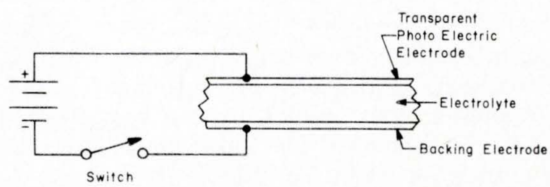


Fig. 6: An experimental system by Varian has a new photographic film or paper whose latent image is developed electrically.

and movie projection. In essence it consists of two duplicate projectors side by side. One transparency is illuminated with vertically polarized light, the other with horizontally polarized light (polarized 90° with respect to the other). (The screen cannot be of a diffusing or scattering type of surface or the image polarization is lost.) Viewing is with special polarized glasses, with the polarizer in one lens vertical, in the other horizontal. Each eye sees only one projected image, but the brain fuses the two into a single three dimensional view. To take the pictures, two identical side by side cameras are used, with the center line of the two lenses the same separation as the distance between average eyes. There has been little or no use of 3D in display systems, but a feasible system would increase the information content of displays tremendously.

Multiple optical overlays

In complex displays, it may be necessary to combine several different displays into a single view. Fig. 8 shows how a beam splitter can combine three black and white color separation transparencies into a single color display. The 3 way beam splitter is made up of four precision right angle glass prisms cemented together. The two small sides of both the right and left prisms are coated with a 50% transmission coating. One problem with this arrangement is the large light loss (75%) in the transmission path between the transparency and the screen. In spite of low efficiency, this arrangement has been used for color pictures, and is being used reversed in color TV cameras (with transparencies and lights omitted and TV camera tubes used where the lights are indicated in Fig. 8). With the addition of 50% mirrors, the arrangement of Fig. 8 can be used to project six overlay images, as shown in Fig. 9.

A similar arrangement (Fig. 10) combines an electronic TV type of display with a projected display, map, drawing board, etc. The TV screen and the display screen should be at the same distance from the 50% mirror.

Electronic displays

Investigations are being carried out today into the use of matrix displays. These would use arrays of individual light sources, like neon tubes, electroluminescent panels or light emitting diodes. Each light source would be individually addressable by X and Y lines. At present, these arrays are too costly and the addressing too complex for most applications, but they're not too far off in the future.

The principal display element used today is the cathode ray tube. The deflecting system for the electron beam scans the rectangular fluorescent screen in a series of non-overlapping horizontal lines. A control grid regulates the intensity of the beam and the resulting fluorescent spot. The control signal is the time serial picture information which determines the light intensity of one picture element at a time. The persistence of the phosphorescence of the spot after excitation should be long enough to prevent image flicker but not long enough to interfere with the generation of the next picture element in the same position.

Radar displays do not use this basic scan pattern, but are constrained by their basic "time of echo return" to a radial or polar scan. Scan converter tubes are used to convert their picture information to the TV scan by means of a double electron gun arrangement in opposite ends of the same vacuum tube. The guns scan opposite sides of a common charge storage screen in the center of the tube.

A charge storage screen can be used between the electron gun and the fluorescent screen. The picture can be written on this screen, and then continuously read out by a lower voltage "read" electron gun. The picture can be erased by this same "read" gun if pulsed at a higher potential. A dark-trace half tone storage oscillograph tube of this type has been made by Hughes Aircraft Co.

TV style displays are limited in size because of resolution and accuracy. Pictures as large as 12 by 16 feet have been obtained by using a projection system, but the brightness is 1/8 that of the average motion picture display. Further, the fluorescent screen has to be water cooled, and there is an x-ray hazard due to the use of 75 kV electron beam to get the brightness necessary.

Color TV style displays are presently obtained using three different types of tubes. Fig. 11 shows the basic elements of the RCA color tube. The electron beams from three separate electron guns are deflected and focused by a common deflecting and focusing system. A metal mask with precisely arranged holes in it is placed close to the fluorescent screen. Each hole in the mask corresponds to a set of red, green and blue fluorescent spots on the display screen. The electron guns and spots are with their centers on the circumference of a circle in a plane vertical to the plane of the paper and at 120 intervals. The geometry of the arrangement is such that if only the beam from the red gun hits the mask and screen, the electrons go through the hole in the mask at an angle that causes them to hit the red spot. The same geometrical arrangement holds true for the green and blue guns and spots. At normal screen viewing distance the spots combine to create a full spectrum of colors.

The Lawrence color TV tube (Fig. 12) uses a single electron gun and deflection system. Parallel wires are arranged in a plane vertical to the plane of the paper in front of the screen. Red, green and blue fluorescent strips are arranged in a similar plane. Alternate wires are connected to common electrodes. If there is no potential between two adjacent grid wires, the electron stream hits the green strip. If the upper wire is sufficiently positive with respect to the lower wire, the electron stream is deflected up to hit the red strip. If the polarity between the wires is reversed, the electron stream hits the blue strip. Enough wires and strips are

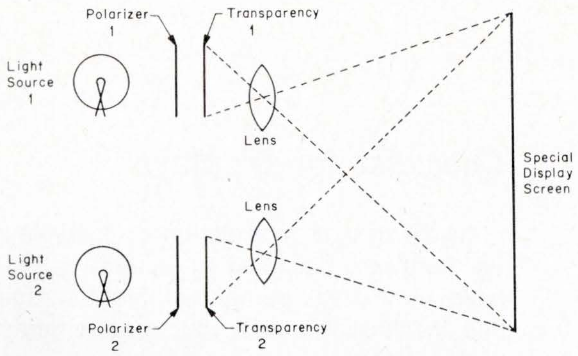


Fig. 7: This is a basic 3D optical projection system that has been used for both slides and movie projection. There has been very little use of this in displays, but it would increase information content in some applications.

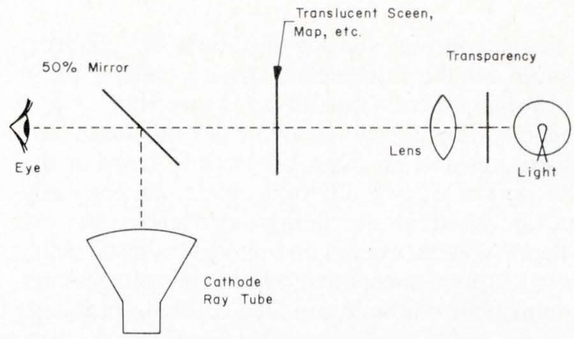


Fig. 10: An electronic TV type display can be combined with a projected display, map or a drawing board, etc. With this system changing information can be combined with more permanent data.

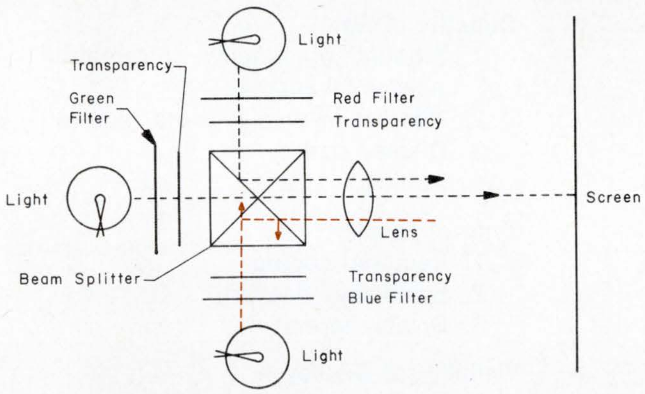


Fig. 8: Optical overlay for converting black and white transparencies to color, and displaying several sources on the same viewing surface.

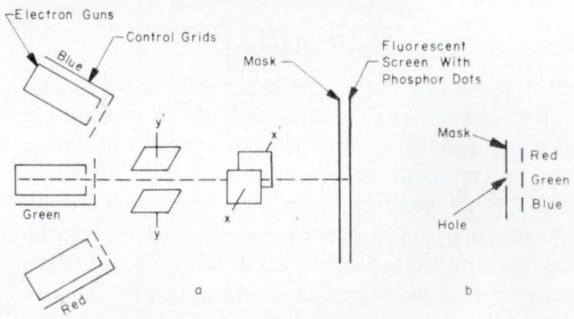


Fig. 11: Colored CRT displays are becoming common for presenting data. This sketch shows the basic elements of an RCA color tube, such as used for TV.

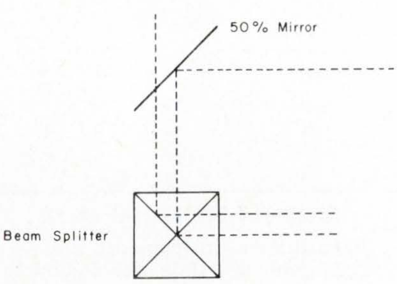


Fig. 9: With the addition of 50% mirrors the arrangement in Fig. 8 can be used to project six overlay images.

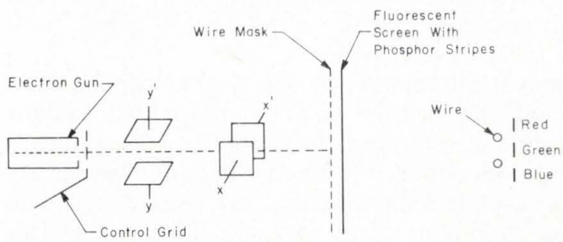


Fig. 12: The Lawrence color tube uses a single gun and deflection system. A potential on the wires in the grid determine which color is activated.

used so that at normal viewing distances the different excited spots on the fluorescent strips combine as in the RCA tube to produce the full color spectrum.

The recently announced Sylvania color tube uses only one electron gun and no mask or wires in front of the screen. Phosphors of two different colors, dielectrically separated, are used in the fluorescent screen. A low electron beam voltage excites one phosphor, and a high voltage excites both phosphors. Midrange voltages mix the basic phosphor colors to produce colors in between. Four or more specific colors can be produced for display purposes.

A significant development in displays is their marriage to computers. (More about this later this year in several planned feature articles.) A computer has been used to generate a normalized perspective of the ground under an aircraft. Radar, altimeter, and navigation aids supply input information to a computer which then generates the natural appearing display for the pilot.

Permanent or "hard copy" displays

The most useful displays are inherently self-erasing, but there are many display situations where a permanent and continuing record is desired, or periodic updating or display replacement is not objectionable. In these instances, films of various types or printers are used. Ink and Xerox process printers reproduce both pictorial and alpha-numeric data; most used with digital data systems output alpha-numeric information only.

Advanced display technique

There are many new displays under development at the present time. Nearly all of the major aerospace and computer companies have very active programs. Two display areas that are receiving research and development are 3D color TV and display memories (to reduce bandwidth). 3D color TV has received little or no attention, but has the potential of adding considerable information and realism to displays. There is one 3D color TV display tube design which does not require any extra devices by the viewer to get the 3D effect, but it requires much development.

Redundant information in TV systems can be eliminated, and only new information transmitted. At any one instant, much of the information on a TV screen is static and does not need to be continuously transmitted. Relatively simple logic circuitry has been designed to recognize, send and accept only new information. This reduces power and bandwidth requirements by a large factor, but is still expensive.

Checklist for Displays

In the design or selection of a display, the hardware designed or bought is dictated by a great number of factors. Use this checklist to match your requirements to the hardware:

Data Rates & Response Times
1. Updating response time
2. Rates of change of display data
3. Display access time
4. Display request rates

Quantity of Data
1. Amount of display information needed/available
2. Number of display units required
3. Display size
4. Audience size

Type of Display
1. Required coding
2. Symbology needed
3. Display format

Visibility of Display
1. Luminance
2. Ambient lighting
3. Contrast
4. Resolution

Quality of Display
1. Accuracy
2. Distortion
3. Flicker

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1. The most popular transducer type for temperature measurement is the:
(a) variable capacitor. (b) variable inductor.
(c) thermocouple. (d) thermistor.
a. ☐ b. ☐ c. ☐ d. ☐

2. A true form of digital transducer
(a) doesn't exist. (b) is the shaft-angle encoder.
(c) is the strain gage. (d) is the linear potentiometric transducer
a. ☐ b. ☐ c. ☐ d. ☐

3. Which isn't a common signal-conditioning step:
(a) excitation of passive sensors. (b) calibration and balance. (c) functional end-to-end testing.
(d) noise suppression.
a. ☐ b. ☐ c. ☐ d. ☐

4. Which is not a characteristic of frequency division multiplexing?
(a) sampled rather than continuous data from all sources. (b) close time correlation among channels. (c) accommodation of time division multiplexing. (d) preservation of dc response.
a. ☐ b. ☐ c. ☐ d. ☐

5. Desirable VCO characteristics do not include
(a) a floating input. (b) a high common mode rejection ratio. (c) a high input impedance.
(d) audio limiting.
a. ☐ b. ☐ c. ☐ d. ☐

6. Which of the folowing is not a common source of data degradation in VCOs:
(a) impedance mismatch. (b) output noise.
(c) intelligence distortion. (d) amplitude modulation and distortion.
a. ☐ b. ☐ c. ☐ d. ☐

7. The key to demultiplexing is:
(a) filtering. (b) limiting. (c) calibration.
(d) detection.
a. ☐ b. ☐ c. ☐ d. ☐

8. Which, the pulse averaging detector or the phase-lock loop detector, is preferable for threshold performance.
(a) the phase-lock loop. (b) the pulse averaging. (c) either, since they are equal. (d) neither one.
a. ☐ b. ☐ c. ☐ d. ☐

9. Which of the following is not an important discriminator specification:
(a) dynamic signal input range. (b) harmonic distortion. (c) tape speed compensation.
(d) output impedance.
a. ☐ b. ☐ c. ☐ d. ☐

10. To prevent aliasing errors in TDM systems, the sampling rate must be:
(a) 1/10 the signal bandwidth. (b) 5 times the signal bandwidth. (c) controlled by a high impedance device such as a FET. (d) equal to the signal bandwidth.
a. ☐ b. ☐ c. ☐ d. ☐

11. For high resolution, high speed, accurate encoding, which would you choose?
(a) optical encoder. (b) CRT spacial encoder. (c) time parallel encoders. (d) synchro to digital encoder.

a. ☐
b. ☐
c. ☐
d. ☐

12. Which of the following sets of errors does not pertain to multiplexing systems?
(a) digitizing, staticd, dynamic and aging.
(b) static, dynamic, aging and RMS. (c) aging, vironmental, dynamic and digitizing. (d) en-environmental, digitizing, static and dynamic.

a. ☐
b. ☐
c. ☐
d. ☐

13. Synchronization in PCM decommutators is done to the
(a) bit, word, frame and sub-frame. (b) bit, word, frame, and clock. (c) bit, frame, sub-frame and clock. (d) bit, frame, channel and clock.

a. ☐
b. ☐
c. ☐
d. ☐

14. The prime contributor to bit errors in detectors is
(a) bit jitter (b) additive input noise. (c) base line variation. (d) amplitude change.

a. ☐
b. ☐
c. ☐
d. ☐

15. A method not used to optimize the transfer of data from decommutator to computer is
(a) temporary storage. (b) redundancy removal. (c) direct interface. (d) PCM simulation.

a. ☐
b. ☐
c. ☐
d. ☐

16. Which of the following is typically not a PCM data waveform
(a) non-return to zero. (b) return to zero. (c) bi-phase. (d) integrate and dump.

a. ☐
b. ☐
c. ☐
d. ☐

17. The Iconorama and Eidophor systems are basically similar because:
(a) they require heat to work. (b) they are a film technique. (c) light passes through them. (d) both require a vacuum.

a. ☐
b. ☐
c. ☐
d. ☐

18. Audible input of data to the brain is not used primarily because:
(a) sounds are difficult to generate. (b) the eye is faster input "device." (c) not practical in noisy areas. (d) none of the above.

a. ☐
b. ☐
c. ☐
d. ☐

19. A photographic transparency display is nearly always used for:
(a) severe environments. (b) high ambient light levels. (c) rapid data processing. (d) non-real-time data.

a. ☐
b. ☐
c. ☐
d. ☐

20. Arrays of individual light sources (such as neon tubes, light emitting diodes) are not used much at present because:
(a) they require too much space. (b) they are too small to see with good clarity. (c) of complex addressing and cost. (d) they are too slow.

a. ☐
b. ☐
c. ☐
d. ☐

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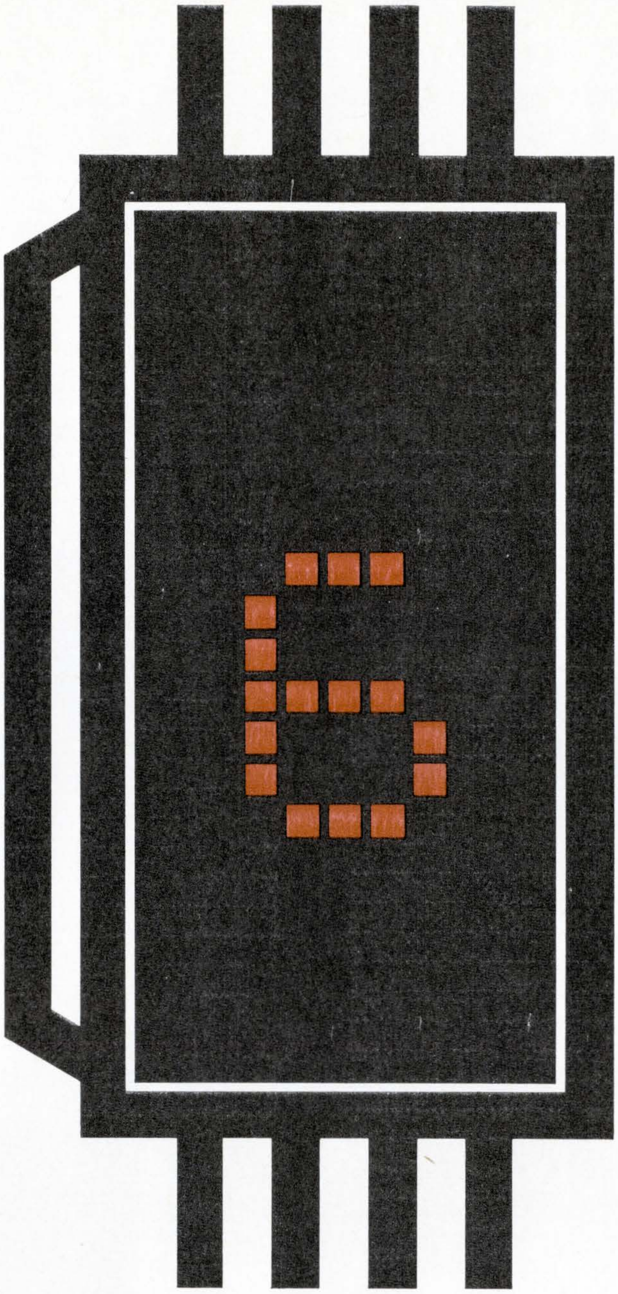

Surprise package
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Discrete components to solve your stripline problems

Discrete passive components can improve your microwave stripline design. Here's how!

By **Tom Osiecki,** Erie Technological Products, Erie, Pa.

The Microwave Integrated Circuit is currently receiving much attention. But, however beneficial MICs may be, many serious problems must still be solved before they can be produced in volume. Until then, for production requirements, engineers will be more likely to use a proven stripline technique. Thus, the development and availability of passive devices compatible with such techniques is important—not only to solve today's stripline shortcomings, but also to provide the basis for designing smaller, better performance devices for MIC applications.

When designing strip transmission line equipment, you can use discrete passive devices as:

- dc blocks (coupling capacitors)
- rf shorts (bi-pass capacitors)
- rf terminations (resistors)
- bias circuitry

When used in place of normal strip transmission line techniques in these applications, they have certain advantages:

- higher nominal values because of increased volumetric efficiency, which results in a further reduction in equipment size
- excellent electrical performance because you have a wider choice of dielectric materials and inherent design subtleties
- more design freedom (you can quickly and easily change component values), and increased reliability

DC blocks

In this application the capacitor blocks the dc signal and passes rf energy with a minimum of insertion loss and a low voltage standing wave ratio (VSWR). The insertion loss is a function of the loss tangent of the dielectric material, the device's complex impedance, and its physical construction. The device's impedance and geometric configuration determine its VSWR. Typical stripline techniques for achieving the dc blocks are shown in Fig. 1.

With a discrete device, the required surface area for a given capacitance value can be greatly decreased.

RF short

An rf short provides a low impedance path to ground for unwanted rf energy. Thus, the inductance associated with the capacitor must be at a minimum and the capacitance must be large. Various methods for achieving the rf short are shown in Figs. 3 and 4.

A large reduction in the required surface area can be obtained if you use the discrete rf short instead of the stripline approach. For example, if you wanted a capacitance value of 300 pf, you would need 33 in.^{2} with the stripline method (Fig. 3), 0.05 in.^{2} with the discrete rf short for stripline (Fig. 4a), and 0.01 in.^{2} with the rf short for microstrip (Fig. 4b).

RF termination

The rf termination dissipates the unwanted rf energy in the form of heat. (A typical application may be to terminate one port of a stripline directional coupler).

Prime features of an rf termination are its VSWR and its power handling capabilities, with VSWR being a measure of the impedance match between the stripline center conductor and the rf termination. A mismatch results in reflected power—all rf energy is not dissipated in the load.

In a stripline structure, the resistive element cannot be fired directly on the substrate (typically teflon-glass) because of the high temperatures involved in the firing cycle.

←Circle 37 on Inquiry Card

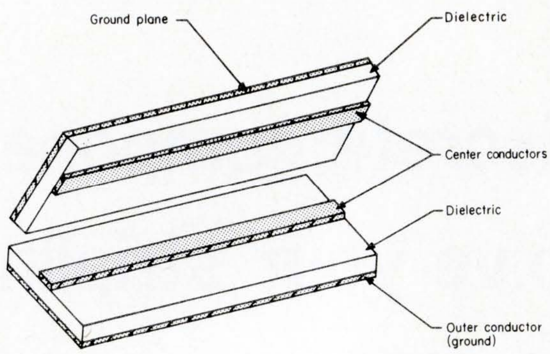
Stripline

Strip transmission lines are being widely used in today's microwave industry. They are cheaper, more reliable, lighter, and smaller than conventional microwave design techniques.

"Stripline," the first strip transmission line technique, consists of a center conductor and two outer conductors, with a dielectric in between. This material has a relatively low dielectric constant (typically 2.5-3.5) and a low loss tangent that is stable at high frequencies.

In stripline, capacitance and inductance depend upon the running length and width of the center conductor, and upon the dielectric constant. Thus, the center conductor is etched to the desired circuit configuration. Reasonably large values of capacitance and inductance can be obtained to provide the passive functions of the dc block, rf short, and inductance.

In the illustration, if the top half of the stripline is removed, we have what is commonly termed "microstrip"—essentially one-half of the stripline. Microstrip is the basic building block for what is often referred to as "MIC's" or Microwave Integrated Circuits (thin-film hybrids, thick-film hybrids, or monolithic integrated circuits).



However, discrete rf terminations exist which electrically and mechanically match the stripline. Such a termination is shown in Fig. 5. VSWR of the rf termination is a function of the:

- width of the center tab lead with respect to the stripline's center conductor
- resistor's resistance and response to frequency and temperature
- geometric configuration of the resistor pattern on the substrate
- reactance of the resistor pattern
- method of terminating the resistor
- physical configuration of the outer case

The microwave device manufacturer can control these variables and match the impedance of the rf termination to that of the stripline (50Ω, 75Ω, 100Ω, and so forth). Typical VSWR of the devices is 1.1:1 up to 4 GHz. Wattage can be as high as 20 W when a device is properly heat-sinked.

Mechanically, the devices can match the stripline's geometry. If an aluminum coverplate is used on the stripline, the rf termination is provided with a spring to make contact to the coverplate.

Bias circuitry for stripline

When designing active components (diode switches, frequency multipliers, and so forth) in the stripline approach, you must find a way to effectively feed the bias signal to the active devices. The result is often a specially designed device that is unique to that particular application. However, devices can be made that will meet the requirements of most applications. The following explanation is for one application of these bias networks.

Parallel diode switch

Two important parameters or characteristics of the electronic switch are its *isolation* and *insertion loss.*

Isolation is a measure (in decibels) of the attenuation of the signal when either leg is in the OFF or nonconducting state.

Insertion loss is a measure (in decibels) of how much the signal is attenuated when either leg is on the ON or conducting state.

Ideally, isolation is infinite and insertion loss is zero. This means that if the circuit is in the OFF state, absolutely no power should be transmitted and when the circuit is in the ON state, maximum power should be transmitted.

One way you can achieve electronic switching is to use a parallel diode switch. In the actual switch design, the positioning of the diodes in the switch are very important, as is the use of $\lambda/4$ stubs. However, my intent here is only to describe the bias circuitry and diode characteristics in conjunction with the switch. A simple circuit of the parallel diode switch is shown in Fig. 6. To keep it simple I have not shown capacitors and other necessary circuit elements.

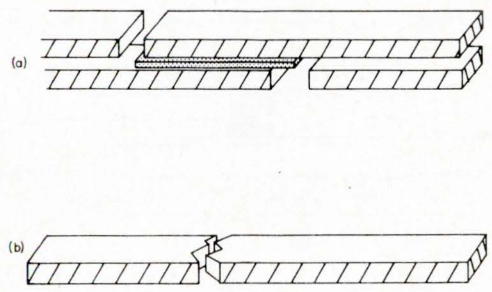


Fig. 1: Coupling capacitance techniques in stripline. The dc block (1a) is achieved by inserting a thin sheet of dielectric between the center conductors of the stripline. A disadvantage of the method is that only low capacitance values are possible if you want to keep a reasonable size. Also, this method is not reliable because there is pressure contact between the center conductor and the dielectric sheet—during temperature cycling the dielectric tends to crack. Another way to achieve the dc block is shown in (1b). The capacitance is attained simply by putting a gap in the center conductor. Here again, only a low capacitance value is possible.

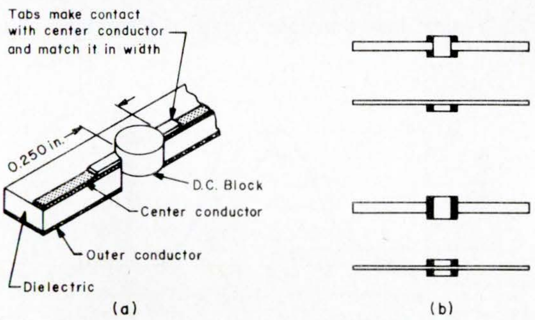


Fig. 2: Discrete passive device (dc block) mounted on stripline (left). This type device has soft copper tabs which match the stripline's center conductor. The tabs can be either soldered or spot welded. Low inductance is inherent in the design and the insertion loss is typically 0.25 dB max. from 0.5 to 4 GHz. VSWR is typically 1.1:1 up to 4 GHz. Discrete devices for microstrip dc blocks (right).

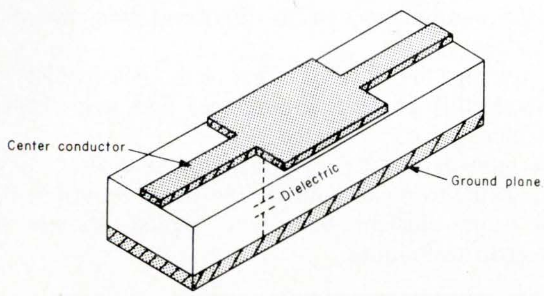


Fig. 3: Stripline method for achieving the rf short. The center conductor's width is increased and the rf short is essentially the capacitance between the center conductor and the outer conductor (ground plane). In this approach, due to the large separation between plates (typically 0.0625 or 0.125 in.) and the dielectric material's low dielectric constant (2.5-3.0), the capacitance attainable is small.

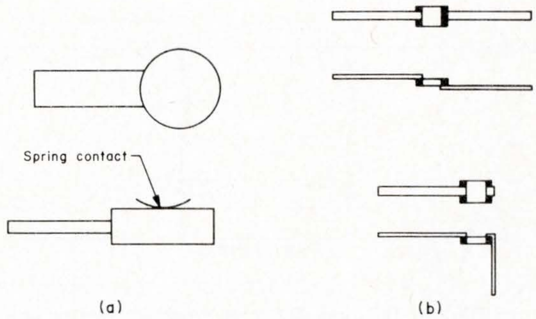


Fig. 4(a): Two discrete rf shorts (one encapsulated and one not encapsulated) for stripline (left). They have low inductance, high capacitance spring contacts or tab terminals to the ground plane, and are much smaller than the stripline approach. (4b) Some rf shorts for microstrip (right).

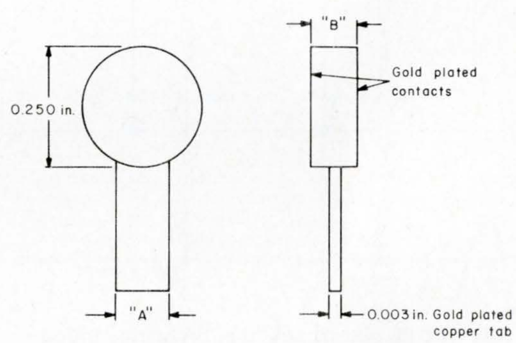


Fig. 5: Discrete rf termination electrically and mechanically matches the stripline. Typical dimensions are A=0.080 in. and B=0.125 in.

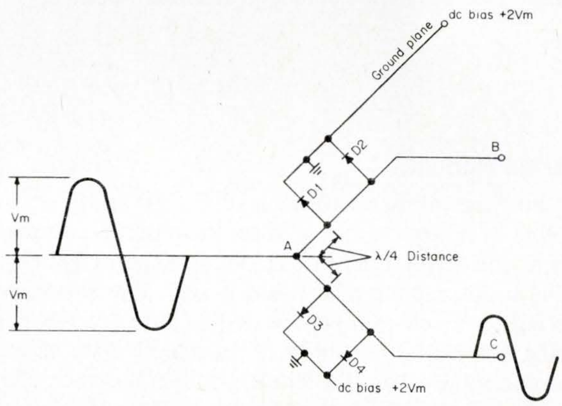


Fig. 6: Simple parallel diode switch. D1 and D2 in leg AB are forward biased and will conduct. Ideally, in this state, they will short any signal in leg AB to ground. D3 and D4, on the other hand, are reverse biased and, as such, will not conduct. In this state D3 and D4 are ideally an open circuit, and the signal will be transmitted through leg AC.

However, the diodes are not an ideal open or short circuit and circuit modifications must be made. Let's analyze leg AB. (The analysis of leg AC is exactly the same.)

D1 and D2 will be alternately reversed and forward biased at a prescribed rate (switching speed of the circuit), causing leg AB alternately to conduct and not to conduct.

When forward biased, D1 and D2 should be a short circuit. However, they are more aptly represented by a series inductance and series resistance as shown in Fig. 7.

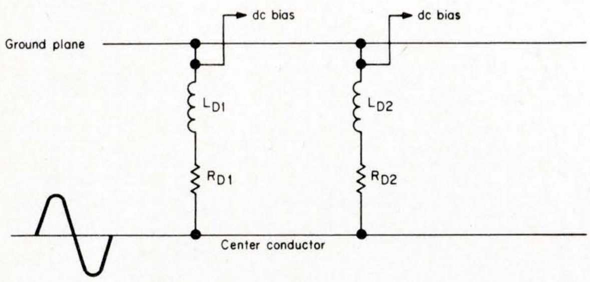


Fig. 7: Diodes D1 and D2 are represented by the series inductance and series resistance. The inductive reactance (X_{LD1} and X_{LD2}) increase with increasing frequency and result in a high impedance path to ground, rather than in a short circuit. The circuit which overcomes this problem is shown in Fig. 8.

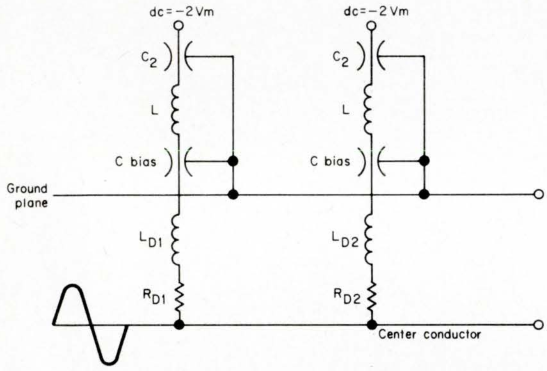


Fig. 8: This circuit overcomes the problems found in the circuit of Fig. 7. The capacitor (C_{Bias}) resonates with the self-inductance of the diode at the transmitting frequency, resulting in an effective rf resistance. A low impedance path now exists between the center conductor and ground.

In addition, L and C_2 form a low-pass filter which prevents the shorted rf signal from entering the power supply or from radiating. At the same time it allows the switching frequency to pass with minimum insertion loss.

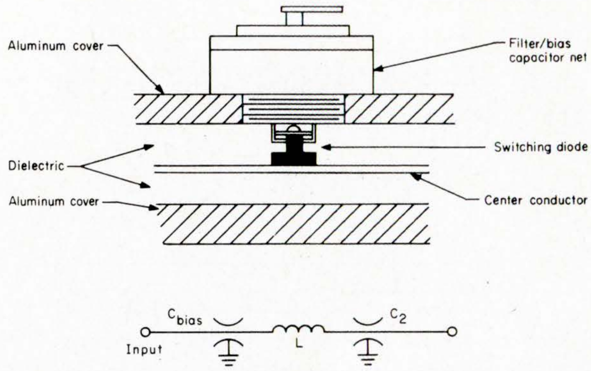


Fig. 9: Filter/bias capacitance network is used to achieve C_2, I, and C_{Bias} (top). It is essentially a low-pass filter with a closely controlled input bias capacitance (bottom).

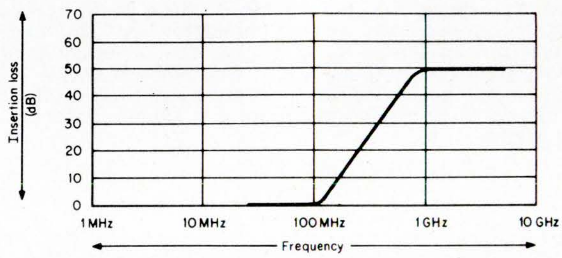


Fig. 10: Typical insertion loss curve of filter/bias capacitor network.

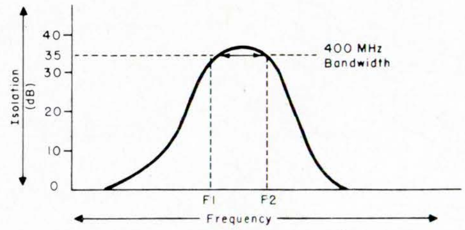


Fig. 11: Typical isolation per diode pair of switch using the filter/bias capacitor network.

Filter network

It has been difficult to achieve C_2, L, and C_{Bias} with stripline techniques, but a discrete passive component such as the one shown in Fig. 9 can accomplish this.

The input capacitance value is such that it will resonate with the self-inductance of the diode at the transmitting frequency, resulting in an effective shunt resistance and eliminating the diode's self-inductance effects. The complete filter network has a cut-off frequency above the diode switching frequency and an insertion loss of >50 dB across the transmitting band, keeping rf energy from entering the power supply. Thus, it passes the diode switching frequency while blocking (attenuating) the transmitting frequency.

Conclusions

The classical component houses are placing greater emphasis on design and development of passive devices for microwave applications. Prime attention is being given to:

- improving device performance at microwave frequencies by developing and investigating new materials for the internal construction of the devices.
- developing critical fabrication techniques to control the parameters needed for good microwave performance.
- solving the interface problem (electrically and mechanically) between the devices and strip transmission lines.

Because of this trend, you can use discrete passive components to make your design more economical, reliable, and efficient than with typical stripline and microstrip techniques.

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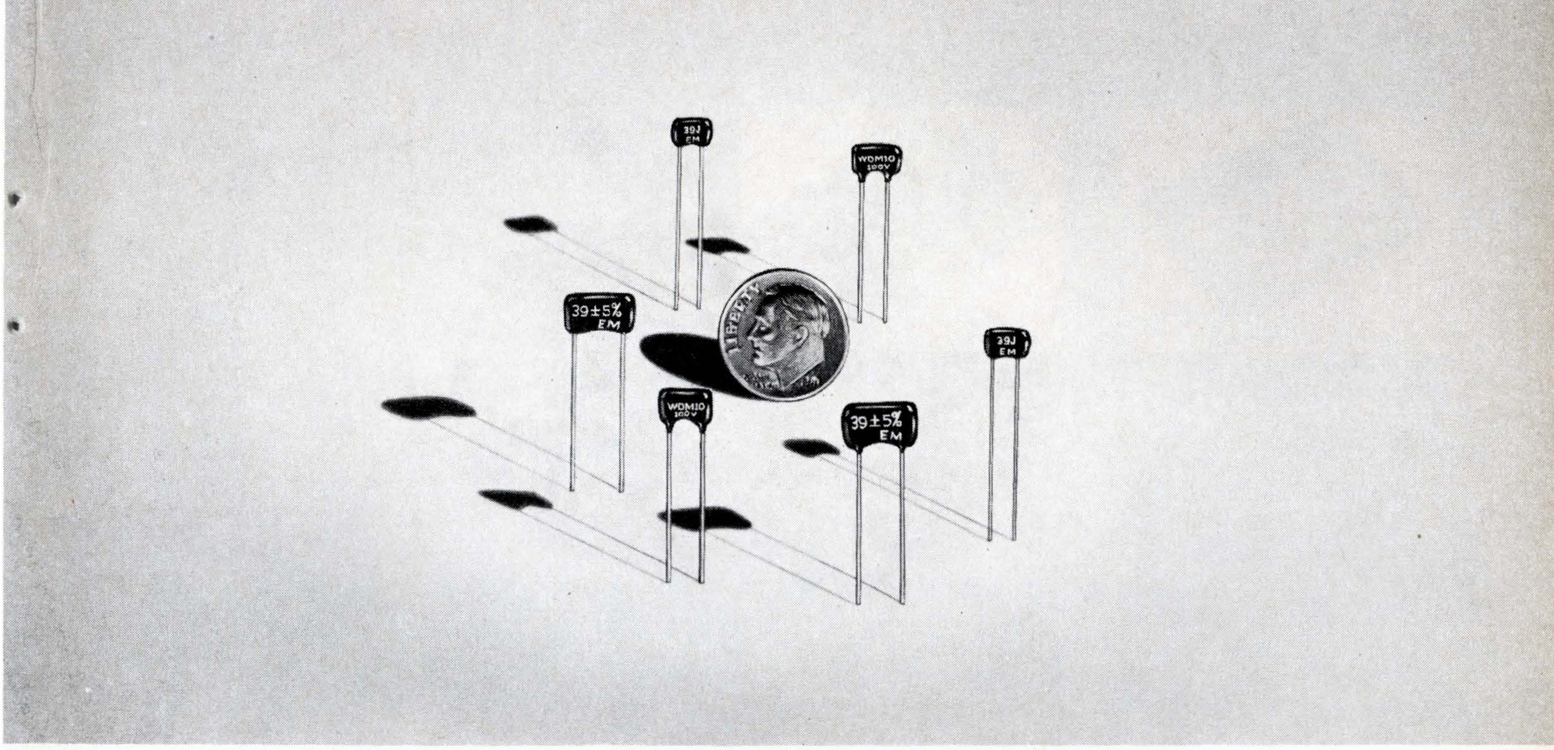

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		F	85pF thru 400pF
DM5	100VDC	C	1pF thru 200pF
		D, E	27pF thru 200pF
		F	85pF thru 200pF
DM10		C	1pF thru 400pF
		D, E	27pF thru 400pF
		F	85pF thru 400pF
DM15		C	1pF thru 1500pF
		D, E	27pF thru 1500pF
		F	85pF thru 1500pF
DM5	300VDC	C	1pF thru 120pF
		D, E	27pF thru 120pF
		F	85pF thru 120pF
DM10		C	1pF thru 300pF
		D, E	27pF thru 300pF
		F	85pF thru 300pF
DM15		C	1pF thru 1200pF
		D, E	27pF thru 1200pF
		F	85pF thru 1200pF
DM10	500VDC	C	1pF thru 250pF
		D, E	27pF thru 250pF
		F	85pF thru 250pF
DM15		C	1pF thru 750pF
		D, E	27pF thru 750pF
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SHP shapes up

It's pronounced "ship"—and it means easier sailing on the sea of naval electronic systems development. The Standard Hardware Program's fleet of standardized, functionally-specified modules lowers costs, eases maintenance, and is not technology-limited.

By Richard W. Kowaliw, Project Engineer,
Challenger Research, Inc., Rockville, Md.

Historically, military electronic systems always have been built with the circuit technologies that happened to be available at the time. The technologies used to construct these systems were designed and packaged to perform no new or unique functions at the individual circuit level—their only differences were in their manner of hardware implementation and overall system packaging approach.

As a result, electronic equipments sitting side by side, containing basically the same circuitry and performing basically similar functions, are too often completely incompatible, bearing little if any physical resemblance to each other. Even when these equipments are part of the same system, but designed and manufactured by different vendors or even different departments of the same company, the incompatibility is still almost inevitable. This reinventing of the "electronic wheel" has occurred so often in the past that the evils of this philosophy will still be around for a good many years. These evils arise from a general indifference to system hardware and its packaging, and normally result in system support problems such as these:

- Maintenance costs increase because the large and complex functional packages require complete and expensive maintenance facilities. This systems approach, because of non-modular construction, prohibits expendable or "throwaway-upon-failure" maintenance philosophy, and creates added demands for more training aids, personnel, documentation, facilities, and so forth.
- Spare-parts costs for these system equipments in many cases exceed the equipment cost over the system life cycle.
- Often you can't replace electronic components, because advances in technology can obsolete what was initially used (once the original supply is used up). As a result, special sources usually must be established to produce needed replacement components.
- Since much of this equipment may be a one-of-a-kind design of a single supplier, getting replacement equipment from a competitive market is, in most cases, impossible.

Such are the problems that result when you implement systems with a dependence upon the electronic technology of the time, and without any concern for the reuse of existing equipment designs.

SHP steps in

In the early sixties the Navy began a study at the Naval Avionics Facility, Indianapolis (NAFI) to determine what could be done to stop continuous reinvention. The principles of functional, modular standardization were pioneered on a predecessor, the MK 84 Polaris fire control system. It had proved that you could successfully implement modular systems by electronic function, reducing the total number of unique module types to a minimum, and thus provide substantial benefits in development, design, and logistical support.

As a result of this study, the Navy started the NAFI Standard Hardware Program (SHP). The goal of the SHP is to develop a family of functional electronic plug-in modules. These modules are to serve as the building blocks from which systems engineers can construct a variety of complex electronic systems, thus also forming a base from which they can build future systems.

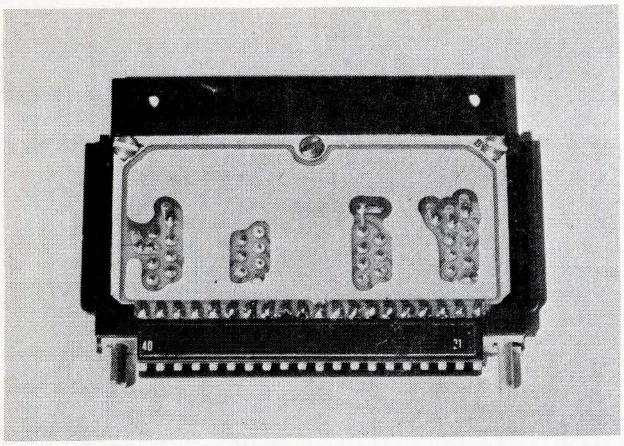

Fig. 1. The basic module configuration in the Navy's Standard Hardware Program is the single-span, single-thickness (1A) module. The functions of the 225 modules in the SHP span both linear and digital applications. Of this number, 87 are Standard modules of which 60 are already documented, qualified (or in process of being qualified), and multi-sourced. The remaining 138 modules are Specials, carried temporarily for information purposes, and aren't representative of the program's objectives.

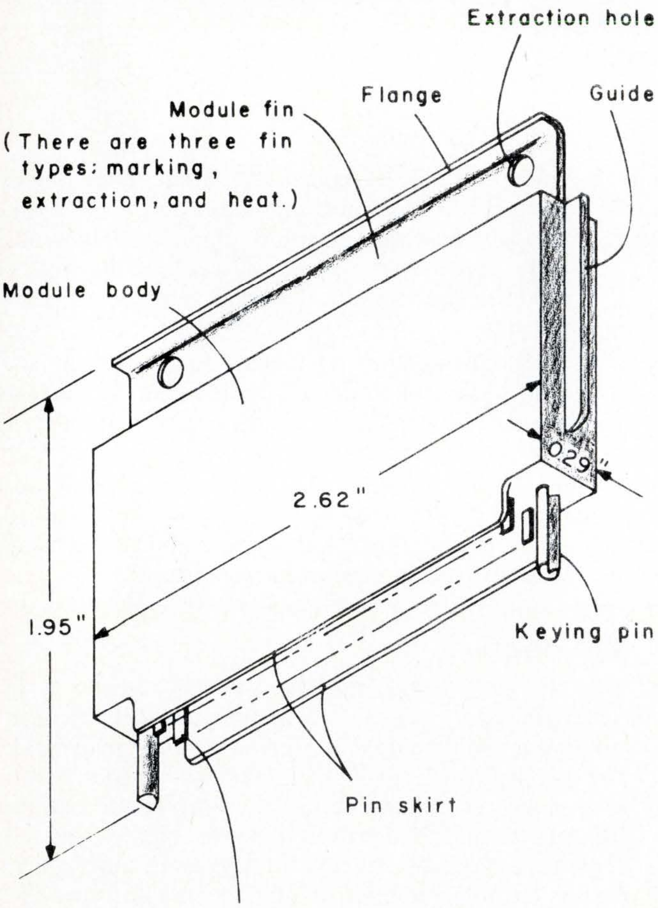

Fig. 2. Module component identification. Each identified part above is required by specification, and serves a purpose pertinent to the mechanical integrity of the module.

Properly implemented, a standardization program such as the SHP provides considerable cost savings, because of:

- **Improved logistics**—A smaller inventory of spare parts and components reduces cost because all systems using SHP modules have common logistics support.
- **Design direction**—Multi-function devices and an established design direction lower costs.
- **Common documentation**—Being able to use the same design and documentation eliminates new documentation efforts and their costs.
- **Testing standardization**—A centralized testing facility can service all systems that use SHP modules, thus lowering testing costs.
- **Smaller maintenance costs**—Fewer instructors, shorter training periods, and fewer training aids help lower costs of training maintenance personnel for servicing SHP modules and SHP systems.
- **Less design time**—The use of SHP modules in a new system can reduce the time needed to go from its development phase to its production phase.
- **Increased reliability**—The SHP systems promise to be more reliable because of the concentration of resources, uniform testing, and mass production.

The purpose of the SHP is to reduce the number of similar electronic functions, and to increase the interchangeability of a select family of modular functions among many Navy systems. The SHP strives to have such modules functionally specified by a comprehensive *specification control drawing* (SCD). The SCD does not dictate the manner of construction or the technology, but only the input/output characteristics of that function. This ensures that the function is not dependent upon any one technology, and is thus obtainable regardless of the progress in the state of the art.

A secondary factor of this functional approach is that it ensures a competitive and innovative environment within industry, because makers have a wide latitude in the design of SHP modules. The SHP approach, in effect, encourages state-of-the-art advances rather than being limited by technological change.

It was known and accepted at the start of the SHP development phase that every circuit function could not be standardized. However, an attempt was made to standardize on as many potentially wide-usage functions as possible. In the program's initial phase, analysis of past systems gave a fallout of mathematical expressions and electronic functions that showed commonality, or potential commonality, in various system applications. Those which could be combined to form more complex functions and mathematical expressions were selected as part of a family of standard electronic functions.

Mechanizing the modules

The basic SHP module configuration is the single-span, single-thickness (1A) module increment, shown in Fig. 1. The amount of circuitry needed to perform a specific electronic function, the maximum number of interface connections required, the size of the keying and retention mechanism, and the maximum tolerable cost for the module to be considered as a throw-away item, determined the dimensions of the module.

Electronic standardization: pros and cons

The Standard Hardware Program (SHP) is, basically, an effort to standardize electronic modules. Past resistance to it and other, similar standardization programs has for the most part come from the builders of military electronic systems. This resistance has resulted from a fear that such programs will either stifle advances in technology, threaten a proprietary position, compromise system performance, or create an added burden on system developers because of the greater coordination involved. These, however, are all realistic factors which must be evaluated before we implement any hardware scheme, let alone a standardization policy.

Also, resistance to standardized electronics often comes from design engineers themselves. Highly trained and skilled personnel, they are primed with the latest facts on the newest, fastest, and most sophisticated electronic technologies—and want the opportunity to use them. So they feel that the selection of modules from a catalog lessens their personal design challenge. This is understandable, but, from the viewpoint of military procurers, not justifiable. The fact is that in many cases, you do not need the newest, fastest, and most sophisticated (and probably the most expensive) electronic technology to implement system hardware requirements.

Even military-program managers themselves, in some cases, resist standardization. They often see it as a threat to the control of their programs, a cause of higher acquisition costs, a possible reason for schedule slippage, or just a general burden because more coordination and interfacing may be needed.

The program organization itself for military systems presents an obstacle, since the program manager does not, in most cases, have to live with and maintain the equipment he develops, once it is deployed. Thus, he may be reluctant (or actually unable) to implement a standard which may be more costly at the acquisition phase, in order to reduce the overall system life cycle cost.

Collectively, the possible drawbacks may seem formidable, but few will stand analysis. For standardization, if properly planned for and implemented, will normally offset most negative factors. Resistance to standardization comes about basically because there's a lack of understanding of its principles and of the program to which it can be applied, or simply because the planning for it is too little and too late.

The Navy is fully aware that across-the-board electronic standardization is not going to be the panacea for all development programs. By its very nature, standardization itself requires many trade-offs to widely distribute its benefits. These benefits are improved logistics, better use of facilities and personnel, and more reliable and easily maintained equipment at a more cost-effective price. These are not only the general goals of standardization and of the Standard Hardware Program; they are *proven* goals, established by precedent. The SHP will reach its goals because it is not oriented to any one system, it allows for the introduction of new functional modules, it encourages proprietary designs but limits them to areas that will not create noncompetitive procurement, and it selects and specifies modules in a way by which they need not become obsolete because of changes in the state of the art.

To date, SHP implementation has been left largely to the various Navy commands and development activities. The recent progress of the SHP, therefore, has been accomplished mainly on a voluntary basis—giving credence and justification to such progress. To further advance the goals of SHP, however, a heightened spirit of cooperation must exist between the Navy and the electronics industry.

Such factors led to the development of a basic module with overall dimensions of 2.62 in. in span, by 1.95 in. high, by 0.29 in. thick. The SHP also accepts modules of multiple-span and multiple-thickness, provided that they maintain standard growth increments of 3 in. in span and 0.3 in. in thickness.

Figure 2 identifies the component parts of a SHP module. The *fin structures* serve the purposes of marking, extraction, and heat dissipation. *Pin skirts* are protective shields for the module connector contacts, and offer a convenient marking surface for orienting and identifying the module. Specially-configured *keying pins* uniquely key the module by their radial orientation. Module *male contacts* in rows of 20 contacts each (on a 0.1-in. grid system) form *module connector* increments.

The basic module configuration (1A) must have either 20 min. or 40 max. contacts. Multiple increment modules may have more contacts with the number increasing in increments of 20 pins.

Each module increment has *guides* at both ends of the module. These guides assist the mating and insertion of the module connector into its interfacing connector and mounting structure. Module guides of appropriate materials also help to conduct heat from the module to the mounting structure.

To provide modules with a potential for wide usage in a variety of systems, it was necessary to reduce the spectrum of military environments to two basic independent classes. Each class consists of requirements for four parameters: fin temperature, humidity, vibration, and shock. Modules that fall into either of the two

Limits of Environmental Classes

Environmental Characteristics			Class I limits	Class II limits
Fin Temperature Range (operating)			0°C to 60°C	-40°C to 100°C
Humidity	95^{+0}_{-5} % relative humidity at 44°C for 96 hours			
Vibration	Frequency Range (cps)		Table Amplitude (plus or minus inch)	5 to 2000 cps from 0.20 inch double amplitude to ±30g peak, sinusoidal; and 50 to 2000 cps at $0.2g^2$/cps, random.
	5 to 15		0.030±0.006	
	16 to 25		0.020±0.004	
	26 to 33		0.010±0.002	
Shock	1/2 sine pulse for 11ms at 50g.			

Fig. 3. Module environmental classes: independent of one another, they are separate and distinct entities.

classes are applicable to most military systems. Figure 3 lists the limits of the two environmental classes to which you may design modules.

Assuring quality

The SHP modules have a high degree of reliability because there is a complete quality assurance program. This QA program has three qualification phases which lead to the acceptance of the module design and of its manufacturer. The first phase is *design qualification:* you must submit each new module design for qualification testing at the SHP Quality Assurance Activity. This is to confirm the design relative to its specification control drawing.

The second phase is *production qualification.* As new module designs go into production, their makers must periodically submit samples from the line to the SHP Quality Assurance Activity for production qualification. This is to initially establish that the manufacturer is a SHP qualified module vendor for the module type, and to confirm his continued ability to produce the module to SHP requirements.

Acceptance testing is the third and final phase: go/no-go testing at the supplier's facility, of a limited number of module parameters, to finally ensure reliability.

Functionally specified vs design disclosed

The SHP Design Review Activity (DRA) accepts new module designs for approval and qualification. It classifies them into one of two categories. The first and most desirable classification is as a SHP **standard module.** This category is for designs that are expected to be used widely in military electronic systems. The modules are usually *functionally-specified* and *non-repairable.* A functionally-specified module specification-control drawing shows only the electronic functional inputs and outputs of the module and its electrical characteristics. Thus the manufacturer can choose the technology appropriate for implementing the function (oscillator, amplifier, shift-register, and so forth).

As a result, a module has a greater chance of being produced through the entire life cycle of the system in which it is used. This method of specification also provides a more competitive environment in which to procure that module function, and gives a more reasonable module cost.

The other SHP category is the **special module.** This is for SHP proposed modules that do not meet the wide-usage criterion of SHP standard modules. Also, they may deviate in some manner from the requirements of design, documentation, or qualification. The module in this category usually is *design-disclosed,* and *repairable,* because it has limited system applicability.

A design-disclosed module SCD shows all design and manufacturing requirements including circuit design and schematics, circuit artwork, parts list, as well as electrical, QA, and test requirements. A SHP special module, however, may be transferred to the SHP standard category if extended system usage occurs.

It's a bull market

Because the Navy strongly supports and endorses the NAFI Standard Hardware program, the application of the SHP to other programs has far surpassed its initial application on the MK 88 Poseidon fire control system. As an example, here is a list of programs which are currently committed to implementing system hardware requirements with SHP modules.

- Mk 88 Mod 0 Poseidon fire control system
- AN/BQR-2 Dimus sonar system
- Mk 113 Mod 9 torpedo fire control system
- AN/BQS-13 sonar system
- AN/SQS-26 sonar system
- AN/BQG-2A, 4A sonar system
- AN/SKQ-2XAN-1 weather station
- AN/SMQ-7XAN-1 telemetry receiver
- Helcar III radar system
- Scanner radar system
- Advanced shipboard interior communications sysstem
- Advanced digital resolver (USAF)
- Walleye missile system

The quantity of SHP modules for use in these systems is expected to increase from 75,000 at the end of fiscal 1969, to more than a million by fiscal year 1975. And this is a conservative projection: it does not account for any new systems currently in the planning stages and tentatively committed to use SHP modules.

Module makers

To date, the following vendors are either qualified, or in the process of becoming qualified, for production of electronic modules according to Standard Hardware Program requirements:

Ballastran Corp., Fort Wayne, Ind.
Globe-Union Inc., Centralab Electronics Div., Milwaukee, Wis.
American Time Products, Woodside, N. Y.
Sylvania Electric Products, Inc., Muncy, Pa.
Texas Instruments, Inc., Semiconductor Comp. Div., Dallas, Tex.
Electro Networks, Caledonia, N. Y.
OECO Corp., Portland, Ore.
Accutronics, Inc., Geneva, Ill.
Polyphase Instrument Co., Bridgeport, Pa.
Raytheon Co., Comp. Div., Quincy, Mass.
Struther-Dunn, Inc., Pitman, N. J.
Giannini-Voltex, Whittier, Calif.

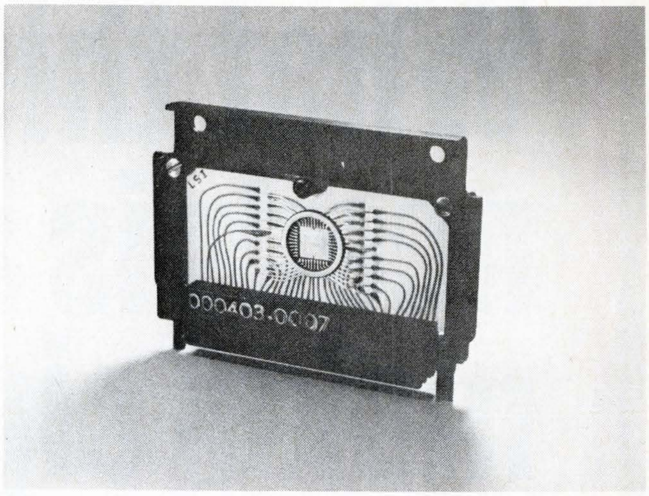

Fig. 4. Not technology-limited, the modules' circuit construction can take any form. For instance, this view of a module's innards shows an LSI device used to fulfill a specified function, whereas the module of Fig. 1 uses ordinary discrete components and PC board construction.

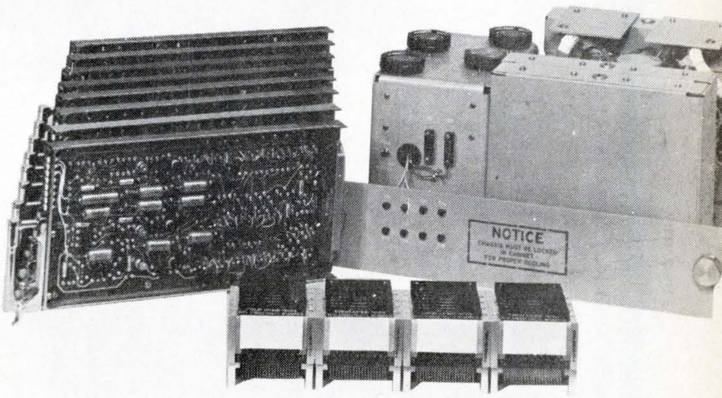

Fig. 5. Packaging evolution of an electronic subsystem. At the upper right is the initial design, while at the upper left it's seen redesigned into transistor page-card modules. The foreground unit shows its final repackaging into Standard Hardware Program modules by NAFI engineers.

If you want more information on the requirements of the Standard Hardware Program, simply address your request to:

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Here's how you voted

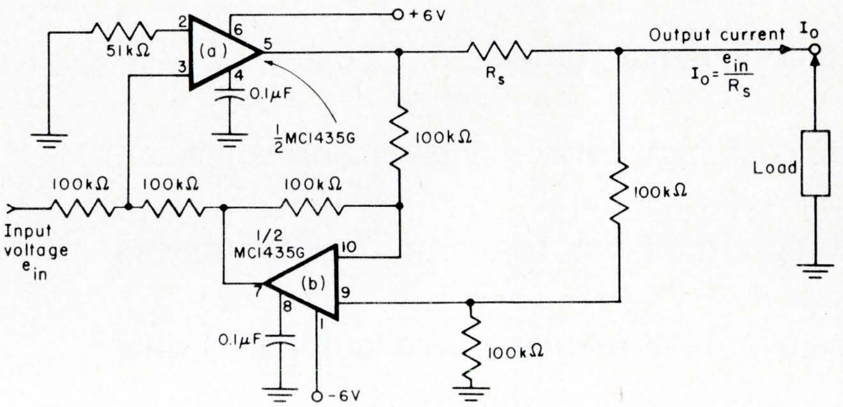
The winning Idea for the November 1968 issue is, "Bi-directional ripple counter counts up or down."

Robert G. Burlingame, the author, is Section Manager, Standard Digital Circuit Applications, at Motorola Semiconductor Products, Phoenix, Arizona. Mr. Burlingame chose the Simpson 270.

912 Bipolar current source

Richard C. Gerdes
Optical Electronics, Tucson, Ariz.

If you need a current source of either polarity to use with a grounded load, try this single-ended circuit. The output current is monitored by sensing the voltage drop across the resistor R_s. One-half of a Motorola MC1435G (b) dual op amp converts this differential sense-voltage into a single-ended voltage, and applies it as negative feedback to section (a) of the 1435.



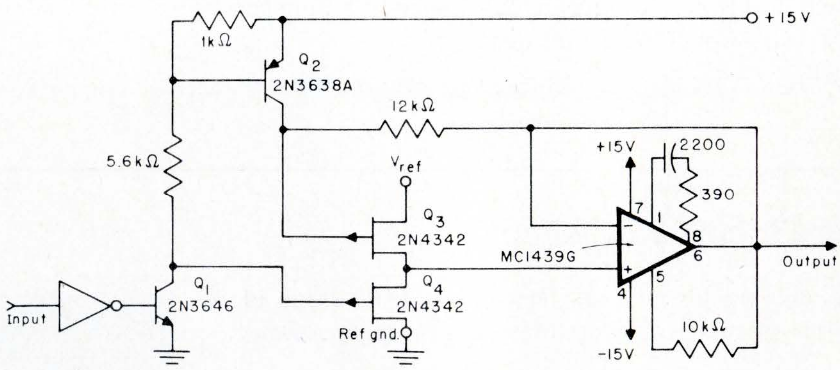
The controlling dc input voltage effectively cancels the feedback voltage, so the residual error voltage is small due to the high open-loop gain of amplifier (a). Section (a) supplies an output voltage of either polarity, forcing a current through R_s and the load.

The circuit monitors the output current and governs the output voltage of amplifier (a) for regulation. Output-current linearity vs input control voltage is good, with errors of less than 1%. Frequency response is limited to that of the open-loop 1435, so the circuit operates from dc to 100 Hz. It is short-circuit proof, and you can get more output current if you use a booster at the output of the (a) amplifier section.

913 Low cost, high performance analog switch

Reuven Peri
Moore Assoc. Div.
The Rucker Co., San Carlos, Calif.

For driving D/A converter ladder networks, this switch has an offset voltage similar to that of bipolar chopper transistors, it doesn't load the reference voltage source, and it has a negligible output impedance. Thus, it compares favorably not only with bipolar chopper transistors, but also with low $R_{DS(ON)}$ FETS.



The FETS, Q_3 and Q_4, switch either ground or the reference voltage, V_{ref}, to a voltage follower. With the input LOW, Q_1 saturates, causing Q_2 to saturate as well. The FET Q_4 then operates with V_{GS} near zero, and with a low $R_{DS(ON)}$. On the other hand, Q_3 is OFF with 15 V on its gate. Thus, the input of the voltage follower is virtually grounded, and the output of the circuit is at reference ground.

With the input to the circuit HIGH, Q_1 and Q_2 are OFF, and FET Q_4 is also OFF, with 15 V on its gate. At the same time, Q_3 is ON with V_{GS} at zero. The output of the circuit is now at the reference voltage, V_{ref}.

The reference voltage may be positive or negative. The most positive value is 15 V $-$ $V_{GS(OFF)Q3}$. This guarantees that Q_3 is OFF when the input is LOW. The breakdown voltages of Q_2, Q_3, and Q_4, and the common mode spec of the op amp, set the negative limit of V_{ref}.

914 Sweep circuit has triggered, free-run modes

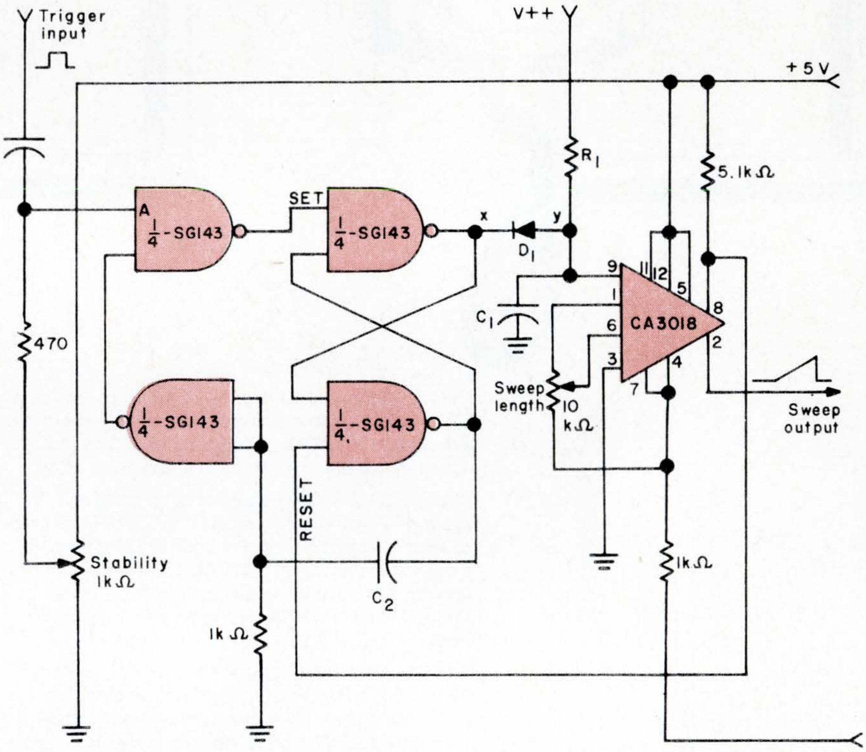
Chuck Ulrick
Collins Radio, Cedar Rapids, Iowa

This linear sweep circuit has many of the features of sweeps used in lab-type scopes. It consists of a control flip-flop, a capacitor charging circuit, a voltage comparator, and a hold-off multivibrator that prevents triggering of the sweep during its recovery time.

Half of the Sylvania SG143 is wired as a set-reset control flip-flop. During standby, it holds the cathode of the clamp diode (D_1) near ground, preventing C_1 from charging through R_1. The RCA CA3018 operates as a Darlington buffer and differential comparator. During standby, it sends a HIGH RESET input to the flip-flop.

If you set the stability control so that input A of the first NAND gate is just below threshold, then positive triggers cause it to set the flip-flop, releasing the clamp. C_1 then charges through R_1. When the comparator sees that this sweep voltage is at the desired amplitude (set by the sweep length control), it resets the flip-flop. C_1 discharges through D_1, forming the retrace.

At the same time, the reset action of the flip-flop sends a positive pulse through C_2 to the hold-off circuit. This gives a LOW output until C_2 discharges through the 1 kΩ resistor. Thus, trigger pulses are not effective during this interval, and each sweep starts only when the circuit is fully recovered.



If you set the stability control so that input A is above the gate threshold, the circuit free-runs. It gives you a continuous train of sweep pulses, each with a period equal to the sweep time plus the hold-off interval.

C_1 and R_1 determine the sweep rate, and, in general, $C_2 = 0.1C_1$. For very long sweeps that need a large C_1, replace D_1 with a pnp transistor emitter-follower. You will have to do this when the gate cannot discharge the timing capacitor in the desired time. Connect the transistor's base to point *x*, its emitter to *y*, and ground the collector.

Sweep linearity depends on the values of V++ and R_1, both of which can be very high. The IC's see only the charging current (produced by V++ and R_1), never the high V++.

915 Use a voltage regulator as a lamp/relay driver

Richard A. Sorensen
General Instrument Corp.
Hicksville, N. Y.

You can extend the application of General Instrument's NC531 voltage regulator into the areas of lamp, relay, and motor drivers—in most cases without adding any components.

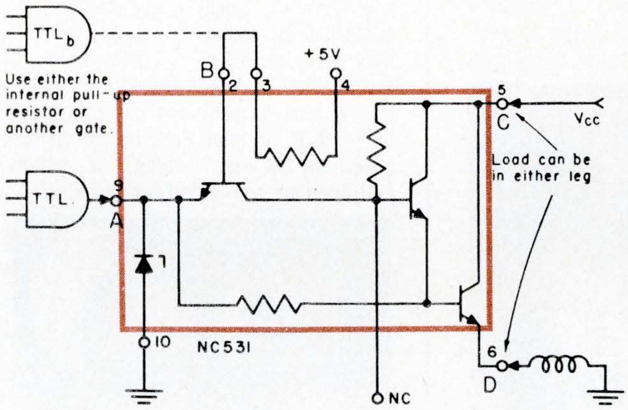
For example, you can connect the 531 as a TTL-compatible lamp and relay driver, as shown in the top diagram. With such a circuit, the input characteristics are similar to those of TTL from the standpoint of voltage, as well as current, levels. A logic *0* input causes the input transistor to conduct, clamping the base of the Darlington amplifier to the logic *0* level + V_{CEsat}. This turns the Darlington pair OFF.

In applications where you must apply a voltage to the load, the zener diode clamps the output of the TTL driver to about 6.2 V, preventing a high driving voltage (such as 28 V) from damaging the gate.

You can further enhance the circuit's versatility by adding another TTL gate (TTL_b). Now you can perform the logic operations shown in the truth table. Note that the load is energized when either an open or a logic *1* is at the input.

As a second example of the circuit's usefulness, you can make it MOS-compatible by connecting the input as shown in the lower diagram. The differences between this and the top circuit's operation are in the input logic levels, and the function of the zener diode. Here, the zener provides the necessary logic levels (noise immunity): logic *0*, $\leqslant$ 6 V; logic *1*, $\geqslant$ 6.5 V.

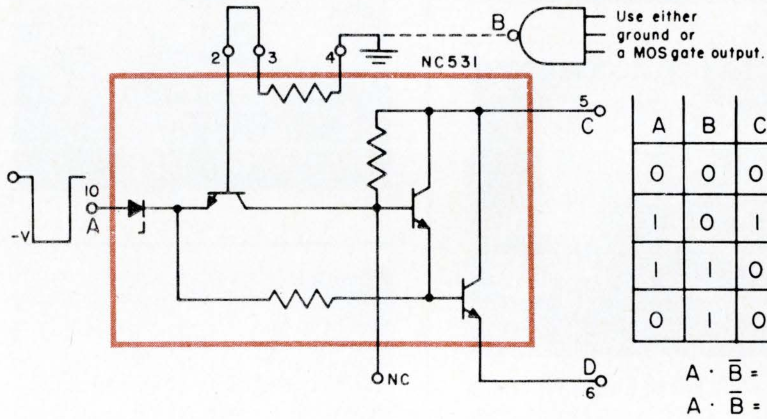
Along with these uses, you can apply normal regulator techniques. For instance, you can add an external pass-transistor for higher-current applications (high-power solenoids, dc motors, and so forth). An external current-limiting circuit would limit higher currents met during "cold-lamp surge." This lets you use higher-current lamps, or multiple lamps, without exceeding the current or power rating of the pass transistors.



A	B	C	D
0	0	0	1
0	1	1	0
1	0	0	1
1	1	0	1

$\bar{A} \cdot B = C$

$\bar{A} \cdot B = \bar{D}$



A	B	C	D
0	0	0	1
1	0	1	0
1	1	0	1
0	1	0	1

$A \cdot \bar{B} = C$

$A \cdot \bar{B} = \bar{D}$

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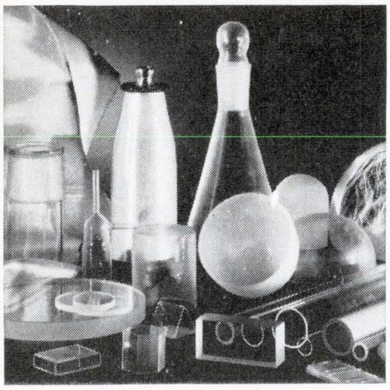

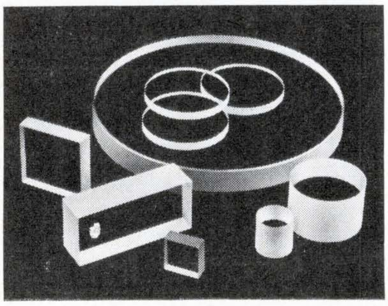

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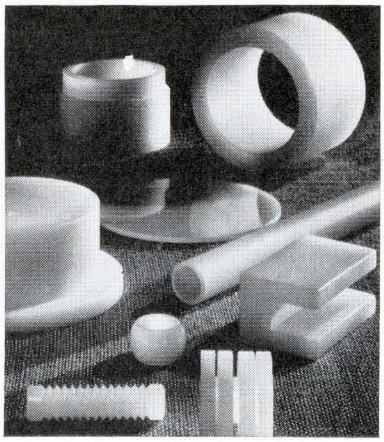

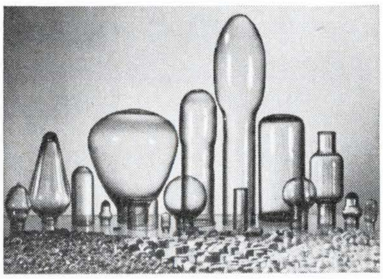

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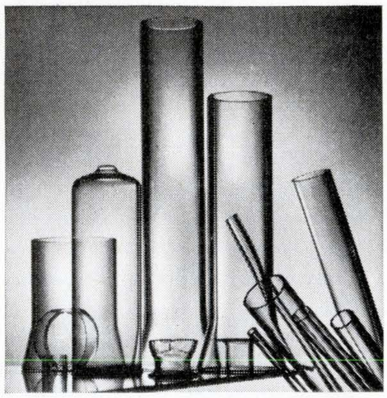

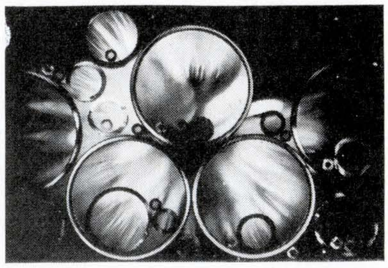

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Amplifiers

Designing dc amplifiers, Part I: Amplifiers with zero input and output levels. Thomas Mollinga, Holandse Signaalapparaten (Holland), "EEE," Vol. 17, No. 2, Feb. 1969, pp. 46-51. The article teaches how to design dc-coupled amplifiers using discrete transistors and resistors. Assuming no base resistance, emitter resistance, or i_{co}, it includes practical design equations for special cases such as power, high frequency, and differential amplifiers.

Charts and Nomographs

Nomographs solve determinants, C. D. Dow, Westinghouse, "EDN," Vol. 14, No. 5, Mar. 1, 1969, pp. 41-45. Determinant theory permits a square array of numbers to represent an equation of linear variables and be equated to zero. This determinant can be linked to a graphical presentation. The author shows how to construct nomographs based on such determinants. With these nomographs, you can rapidly determine the effects of a design change on, say, the input-output relationship for a blackbox network.

Quickly compute rms noise, William N. Waggener, EMR, "EDN," Vol. 14, No. 5, Mar. 1, 1969, pp. 53-55. This article shows you how to compute rms noise in a given bandwidth, by using two nomographs. One nomograph is for shot noise, while the other is for thermal noise.

Circuit Design

Expand basic ladders into complex networks, Monty Walker, Litton Data Systems, "EDN," Vol. 14, No. 5, Mar. 1, 1969, pp. 47-51. Combining resistor-ladder configurations gives you more flexibility in ladder design. To illustrate this point, the author shows you how to apply the advantages of R-2R ladders to BCD ladders. Other examples shown are mixed radix, BCD bipolar, Excess-3 ladders, and so forth.

Design notch networks the easy way, Charles F. White, Electronic Consultant, "Electronic Design," Vol. 17, No. 6, March 15, 1969, pp. 210-212. RC twin-T notch network design often requires odd valued components. This article describes how these filters can be designed using six standard 10% components. Basically, the designer selects four components then fine tunes with the last two parts.

Circuits

Which output circuitry should you use? David C. Davies, Amelco Semiconductor, "EEE," Vol. 17, No. 2, Feb. 1969, pp. 68-71. This article discusses five types of output circuits used in integrated circuits; pullup resistor (or passive pullup) for common emitter circuits, complementary (pnp-npn) transistors, totem pole (npn-npn) or cascode circuits, and two improvements on the totem pole circuit—diode clamping and transistor clamping. In addition to describing the circuits, the author gives a succinct and practical list of advantages and disadvantages for each circuit.

Components

***Terminal junctions make their debut,** Staff Report, "The Electronic Engineer," Vol. 28, No. 4, April 1969, pp. 47-48. Due to the amount and complexity of electronic equipment being squeezed into today's military and commercial aircraft, and the need for reliability, even more dense interconnection systems are required. The newest method or system, accepted in the past few months, has been the terminal junction system before accepting this method of interconnection Johnsville Naval Air Development Center ran extensive tests. The acceptance of this type of connection by Johnsville NADC will ultimately lead to its wide acceptance by other military groups and also commercial aircraft. While the main impetus for refining this type of connection system was for aircraft, the system is suited for other dense interconnection systems or equipment, such as computers.

How to ruin snap switches, Daniel Schwarzkopf, Unimax Switch Div. of Maxson Electronics, "EEE," Vol. 17, No. 2, Feb. 1969, pp. 62-65. In a tongue-in-cheek style, the author covers a number of ways to abuse and destroy a snap switch, ranging from a user who bends the operating lever, to the one who specifies the wrong snap switch for his applications.

Transistor responds to magnetic fields, Robert H. Cushman, Eastern Editor, "EDN," Vol. 14, No. 4, Feb. 15, 1969, pp. 73-78. Here is a description, with some possible applications, of a transistor that is sensitive to magnetic fields. The device has two collectors which divide their currents unequally in the presence of a magnetic field. Sensitivity appears to be similar to that of discrete Hall-effect devices. The inventor believes the current-split (or "bending") is caused by Lorentz-force action of the field on the electrons.

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

Solid-state optoelectronics in '69, Robert E. Koeper, Sr. Editor, "EDN," Vol. 14, No. 4, Feb. 15, 1969, pp. 49-64. Optoelectronic devices now appear with increasing frequency in many types of equipment, and their prices, especially for high-density applications, are dropping. Manufacturers claim that users still do not understand optoelectronic terminology, or how to effectively use these components. After such introductory remarks, the article goes on to survey this new domain, and describes its large variety of emitters, sensors, and assemblies.

Computers and Peripherals

Computer-controlled vehicular traffic, Gordon D. Friedlander, Burndy Library, "IEEE Spectrum," Vol. 6, No. 2, Feb. 1969, pp. 30-43. Many of our major cities are so choked by motor vehicles, and so deficient in alternative means of mass transportation—that the total jam-up of urban travel has evolved from prospective nightmare to grim reality. The answer to this pressing problem may well be computerized traffic control. The author mainly looks at three computer-controlled traffic systems—in Toronto, San Jose, and Wichita Falls—and also briefly covers some others.

Speed inverse Laplace transform solutions, R. G. Durnal, Westinghouse Defense & Space, "Electronic Design," Vol. 17, No. 6, March 15, 1969, pp. 240-245. By using a time-shared computer, Laplace transforms can be neatly resolved. This article tells what you have to do to handle these types of calculations in a computer. The attack is a little different than if you did the work manually.

Computer tuning of hybrid audio oscillators, Frederick H. Hintzman, Jr., Western Electric, "IEEE Spectrum," Vol. 6, No. 2, Feb. 1969, pp. 56-60. The advent of push-button telephone dialing systems has created the need for precision audio tone generators and a rapid, on-line method of accurately tuning them. The author describes an unusual tuning system that is driven by a small process-control computer.

Integrated Circuits

An IC medium-power voltage regulator, W. H. Williams & J. H. Parker, Westinghouse, "IEEE Spectrum," Vol. 6, No. 2, Feb. 1969, pp. 72-78. This article describes a monolithic integrated-circuit voltage regulator for "on-card" applications. The device combines, on a single chip, a temperature-compensated reference voltage, a sense and comparison amplifier, a Darlington series control element, a constant current pre-regulator, a current-limiting transistor, and an SCR.

Typical consumer IC applications, Staff Report, "Electro-Technology," Vol. 83, No. 3, March 1969, pp. 62-66. Various consumer IC applications are discussed and shown schematically. Some recently introduced circuits are also covered.

Integrated circuits in consumer products, Thomas J. Robe, RCA Electronic Components, "Electro-Technology," Vol. 83, No. 3, March 1969, pp. 59-62. The author compares some of the advantages of monolithic and hybrid ICs for use in consumer products. Present and future applications are also discussed.

Materials

Fire-retardant plastics, Mel Mandell, Editorial Director, "Electronic Products," Vol. 11, No. 10, Feb. 1969, pp. 18-32. New demands on the electronics industry—mainly from NASA, the FAA, Underwriters Laboratories, and the National Fire Protection Association—require plastics in electronic equipment be fire retardant. Neither must they create heavy smoke, or drip or emit flaming plastic. Thus, the electronic designer who specifies plastics or assembles containing plastic, must re-educate himself to what these new materials can and cannot do.

Microwaves and Microwave Products

***Discrete components to solve your stripline problems,** Tom Osiecki, Erie Technological Products, "The Electronic Engineer," Vol. 28, No. 4, April 1969, pp. 65-68. Discrete passive components can improve your microwave stripline design. You can use passive devices as dc blocks (coupling capacitors), rf shorts (bi-pass capacitors), rf terminations (resistors) and bias circuitry. The author describes these devices and tells why it is advantageous to use them in place of conventional stripline and microstrip techniques, for certain applications.

Packaging

***SHP shapes up,** Richard N. Kowaliw, Challenger Research, "The Electronic Engineer," Vol. 28, No. 4, April 1969, pp. 71-75. The Navy has a program to standardize circuit modules for electronic equipment. The goal of this program is to develop a large number of plug-in modules, each classified by its function (amplifier, oscillator, flip-flop, and so forth). The SHP modules are different electrically, but similar mechanically. Thus, large complex electronic systems can be built from a relatively limited number of basic modules, much as buildings are formed from many individual bricks.

Semiconductors

There are many ways to fire an SCR, Part II, Wendell W. Ritchey & Ronald H. Randall, Acme Electric, "Electronic Design," Vol. 17, No. 6, March 15, 1969, pp. 234-237. Part 2 describes how to select an SCR for specific applications and gives a rundown on firing characteristics and requirements for proper operation. You can learn how to test the devices yourself, and what type of circuitry should be used to prevent burn-out. This article does not cover the newer avalanche types.

Select the right FET, Sam M. Weaver, Sr. Engr., Texas Instruments, "Electronic Design," Vol. 17, No. 6, March 15, 1969, pp. 194-200. Selecting an FET for your application is no mystery, provided you know what to look for. This article describes the parameters that should be determined prior to finalizing your selection.

Systems

Reduce radar display clutter, Alan J. Brown & Albert Haeberle, Hazeltine Corp., "Electronic Design," Vol. 17, No. 6, March 15, 1969, pp. 204-207. Normally clutter has to be eliminated by a manual control. Here is a method that can handle clutter automatically. The combination of a logarithmic receiver with video processing gives you the gain time control needed.

***Telemetry Course, Part V: Displays—Techniques and Technology,** Harry C. Morgan, Radiation, "The Electronic Engineer," Vol. 28, No. 4, April 1969, pp. 53-62. Part V tells how the data are processed for computation or temporary storage, or for use by a human being. In the latter case, the data must be converted to either alphanumeric or graphic form. This area of man-machine interface will be covered in detail with a description of several new developments. An examination is included in this month's installment. All readers successfully passing the exam will receive a certificate that is suitable for framing.

Build stable rf servo loops, Arpad D. Vincze, Philco-Ford, "Electronic Design," Vol. 17, No. 6, March 15, 1969, pp. 216-224. Part 2 of this article further describes how to design stable loops to reduce both linear and nonlinear temperature drifts. The basic philosophy is to maximize the sampled signal. The design here is better suited to amplifier/multiplier chains than to simple power amplifiers.

Test and Measurement

Measuring wide-bandwidth fm deviation, C. N. Charest, Philco-Ford, "EDN," Vol. 14, No. 5, Mar. 1, 1969, pp. 33-40. The useful measure of deviation bandwidth is the span of frequencies over which there are significant amounts of sideband energy. The author defines "significant" as sidebands with amplitudes at least 1% of that of the unmodulated carrier. To simplify computation and let you use a spectrum analyzer more easily, he has extracted data from tables of Bessel functions, and plotted curves of the number of significant sidebands vs modulation index, for indices as high as 50. The author also explains the practical application of his method for low and high indices.

Measure the sweep linearity of fm pulses, Richard F. Cutler & Raymond C. Monk, Goodyear Aerospace, "Electronic Design," Vol. 17, No. 6, March 15, 1969, pp. 228-230. Here is the solution to measuring the linearity of short, frequency-swept fm pulses. Block diagrams aid in making the test setup.

Miscellaneous

Lethal electric currents, Charles F. Dalziel, Univ. of California, Berkeley, and W. R. Lee, Univ. of Manchester, "IEEE Spectrum," Vol. 6, No. 2, Feb. 1969, pp. 44-50. The key criteria in establishing safe-current requirements are the minimum "let-go" current (in excess of which a person cannot release his grasp on a live conductor) and the minimum current that will cause ventricular fibrillation to occur. This article discusses investigations of both let-go and fibrillating current and presents some of the experimental data presently available.

Trade secrets and the technical man, Charles M. Carter, Warwick Electronics, "IEEE Spectrum," Vol. 6, No. 2, Feb. 1969, pp. 51-55. In the electronics industry, engineers move around quite a bit—taking trade secrets with them. Do you know that if you breach a company confidence (whether intentionally or unintentionally), you may be subject to prosecution? This article is intended to bridge the gap between trade secrets and the technical man. The greatest damages, however, may be collected from a rival firm that knowingly encourages unauthorized disclosures. The article thus points out that corporate programs which include early legal consultation must also be instituted to prevent trade secret transgressions.

Redesigning for profit, Robert Hollingsead, Hollingsead-Prior Enterprises, "EDN," Vol. 14, No. 2, Jan. 15, 1969, pp. 51-52. Money saved in manufacturing costs often means more profit to the producer than does increased sales. Profit studies of items in continuing production point the way to reduced manufacturing costs. Although such product reviews are often better done by outsiders, sometimes you must do it yourself. If so, this article will start you on your way. It tells how to set up a review board and a product analysis study.

On professional salaries, Richard P. Howell, Stanford Research Institute, "IEEE Spectrum," Vol. 6, No. 2, Feb. 1969, pp. 22-29. How much are you worth to your company? Are you satisfied with what you're being paid? This article interprets salary data on about 50,000 scientists, engineers, and faculty members, and outlines some of the naturally-evolved (as opposed to arbitrarily-evolved) forces that determine their salary levels. The author shows how salary is a function of such factors as these: age, degree level, specialty studied, industry, geographical location, sex, number of jobs held, reason for applying for work, marital status, university graduated from, and so forth. One problem pointed out in the article, however, is that its salary figures are too low—the data are three or four years old, and engineering salaries have been increasing about 7% per year since 1964.

EE NEW PRODUCTS

New packaging enhances diode performance

Physical and electrical benefits of fused metal oxide rectifiers are both significant.

Semtech has unveiled its new line of "Met*ox*ilite" rectifiers. The metal oxide mixture, "Met*ox*ilite", is fused to the internal assembly, which consists of tungsten pins metallurgically bonded to the silicon junction. The fused metal oxides now replace metal cans, plastic encapsulations, and other cases used in the manufacture of rectifiers.

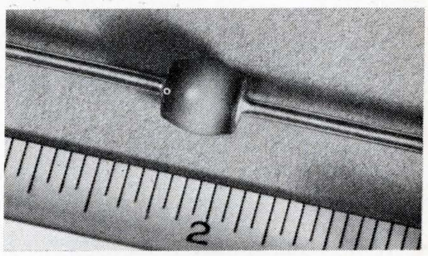
Figures 1 through 5 illustrate various methods of encapsulating silicon rectifiers. The immediate physical result of the "Met*ox*ilite" package is a reduction in volume by two-thirds. The electrical benefits are even more striking.

Reverse current leakage has been reduced an order of magnitude to 1 μA, or lower, at room temperature. At 100°C, it is 25 μA max. Reverse recovery time for the 3-A fast recovery diodes is less than 150 ns. The diodes operate without long-term degradation in the range of −65° to 200°C, and can withstand the thermal shock of being dumped from boiling water into LN_2.

The good electrical performance is due to a sharp reduction in junction surface leakage, which is the largest contributor to reverse current. The new packaging technique protects the surface so that leakage currents can approach theoretical values. Existing surface leakage is stable, and the increased leakage at higher temperature is due mostly to bulk effects.

The cost of the 1-A fast recovery diode ranges from $0.50 to $5.00 for a PIV of 200 V and 1,000 V, respectively, in lots of a thousand. The 3-A would be slightly more. Production quantities are available immediately. Semtech Corp., 652 Mitchell Rd., Newbury Park, Calif. 91320. (805) 498-2111.

(continued on page 86)



This is one of the new 3-A rectifiers showing the "Metoxilite" encapsulation prior to painting and marking. It is 0.165 in. long and 0.180 in. at the widest point.

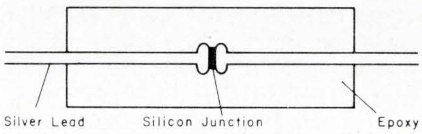


Fig. 1: **Epoxy encapsulation.** Epoxies have higher thermal expansion coefficients than do the junction assemblies. Thermal stress to the internal construction can cause catastrophic or degradation failures by letting contaminants (moisture) penetrate between the lead and the case into the junction area. The silver leads are soldered directly to the junction, creating another thermal mismatch. Temperature excursions can cause relative movement between them or crystallization of the solder. The embrittled solder can crack off the lead (or the base in Fig. 4). With thermal cycling the ohmic resistance of the solder increases, so crystallization manifests itself as an increased forward voltage drop, with a consequent temperature rise at the junction, until failure occurs.

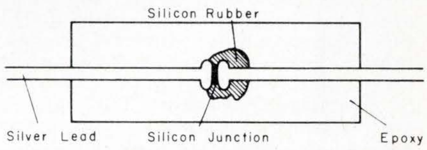


Fig. 2: **Silicon rubber added.** This construction overcomes some of the deficiencies in Fig. 1 by encapsulating the junction area in silicon rubber before final epoxy encapsulation. The silicon rubber protects the junction from contamination and absorbs thermal stress. But during the initial transfer molding, the rubber can be misplaced, leaving the junction unprotected. The rubber also may contain air bubbles, which cause corona failure, especially when the devices are encapsulated in a series string for high voltage applications. It is sometimes recommended that a pair of pliers be used as a heat sink between the case and the silver lead when the lead is soldered into place. Otherwise, heat conducted up the lead can melt the solder at the junction.

(*Continued from page* 85)

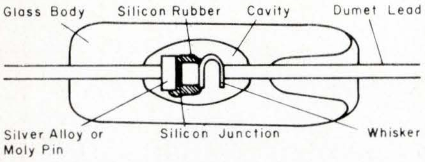


Fig. 3: **Glass encapsulation.** Silicon rubber is again used to protect the junction. The whisker aids in construction and is used to take up thermal expansions. An inert gas fills the cavity. The high temperature expansion coefficient of the potting material can crack the glass body, destroying the hermetic seal. Other encapsulation problems are glass strain and peripheral cracks at the lead entrance. Coronal failure can occur when the gas ionizes in high voltage gradients. The Dumet lead is an iron core, and is copper clad and tin plated.

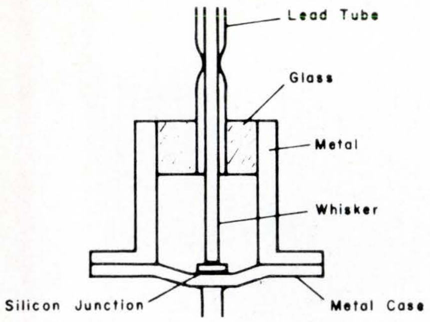


Fig. 4: **Typical "top hat" rectifier.** The whisker is soldered to the junction, forming a "T" assembly. The junction is soldered to the mounting base, which is welded to the top hat assembly, the whisker extending into the tube. The final hermetic seal is made by sealing the tube to the whisker. The base metal usually does not thermally match the silicon. During thermal cycling, there is relative movement between the junction and the base which can crack or crystallize the solder. The inert atmosphere again limits the voltage gradient because of corona possibilities.

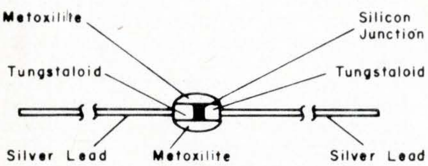


Fig. 5: **Semtech "Metoxilite" rectifier.** The metal oxide mixture is fused to the internal assembly, consisting of tungsten metallurgically bonded to the silicon junction. It is a relatively high temperature process where the fused metal oxide hermetically seals to all surfaces and is thermally matched to the body assembly. It is used in place of expoxy, inert gas, metal cans, silicon rubber, and glass. The new solid package provides good environmental protection against shock, humidity, vibration, and temperature.

Circle 285 on Inquiry Card

DC-TO-AC INVERTERS

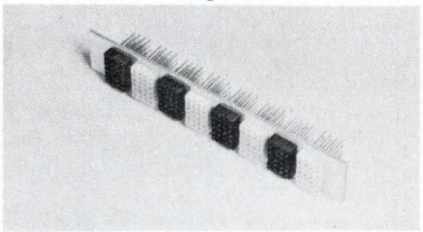
Many versions available.

Batac series SS inverters can convert 12, 28, and 32 Vdc and other dc voltages to 60 Hz and 400 Hz ac. Units bring the long life of brushless ac fans and blowers to dc operations, function reliably in amb. between −30° and +71°C. Rotron Inc., Hasbrouck Lane, Woodstock, N. Y. 12498.

Circle 286 on Inquiry Card

PLATE CONNECTORS

For solderless wrap.

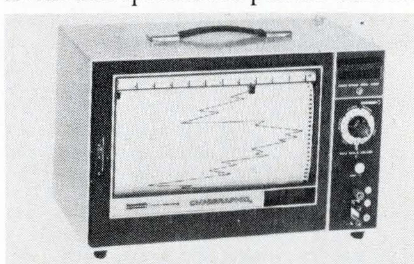


Two new connectors are the 1000 series, for 0.100-in. grid spacings, and the 1200 series, for 0.125-in. grid spacings. Each series includes tuning fork components (types S1000 and S1200) and male blade contacts (types M1000 and M1200). The wrap posts are 0.025 in^2. Teradyne Components, 900 Lawrence St., Lowell, Mass. 01852. (617) 454-9195.

Circle 287 on Inquiry Card

STRIP CHART RECORDER

Event and speed mark pen are built in.

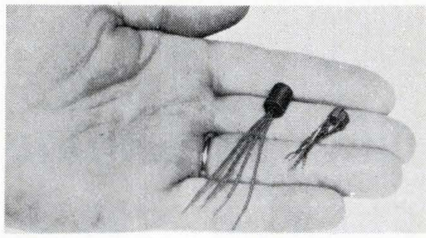


Omnigraphic™ Model 10, a 10-in. recorder, offer's 17 input ranges as standard, with the ability to read dc, mV, V, Ω, μA, and mA. Five chart speeds range from 0.05 to 20 in/min. Houston Instrument, 4950 Terminal Ave., Bellaire, Tex. 77401. (713) 667-7403.

Circle 288 on Inquiry Card

MINIATURE TRANSFORMERS

There are 242 basic units available.

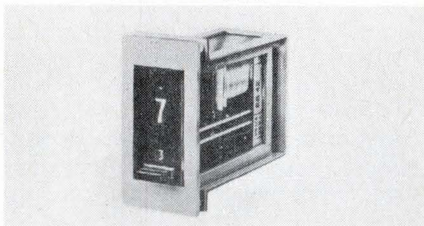


Pico transistor transformers and reactors have about 900 configurations available. Each features high efficiency plus a wide range in freq. response (−5 dB to −4 dB at 300 Hz, and +0.5 dB to +1.5 dB at 50 kHz). Essex International, Inc., Controls Div., Stancor, 3501 W. Addison St., Chicago, Ill. 60618.

Circle 289 on Inquiry Card

ELECTRIC COUNTER

With 25-ips counting speed.

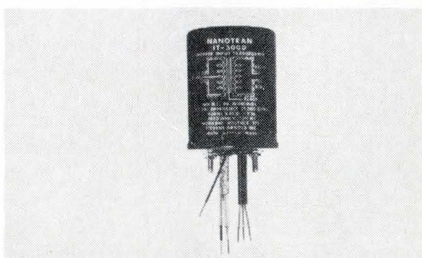


Sodeco ES4, a single-digit, high-speed impulse counter, has a 10-pos. readout switch, a transfer contact, a zero reset contact, and a predetermining switch. It performs many functions including programming, impulse storage, predetermining, counting, and control. Landis & Gyr, Inc., 45 W. 45th St., New York, N.Y. 10036. (212) 586-4644.

Circle 290 on Inquiry Card

ISOLATION TRANSFORMERS

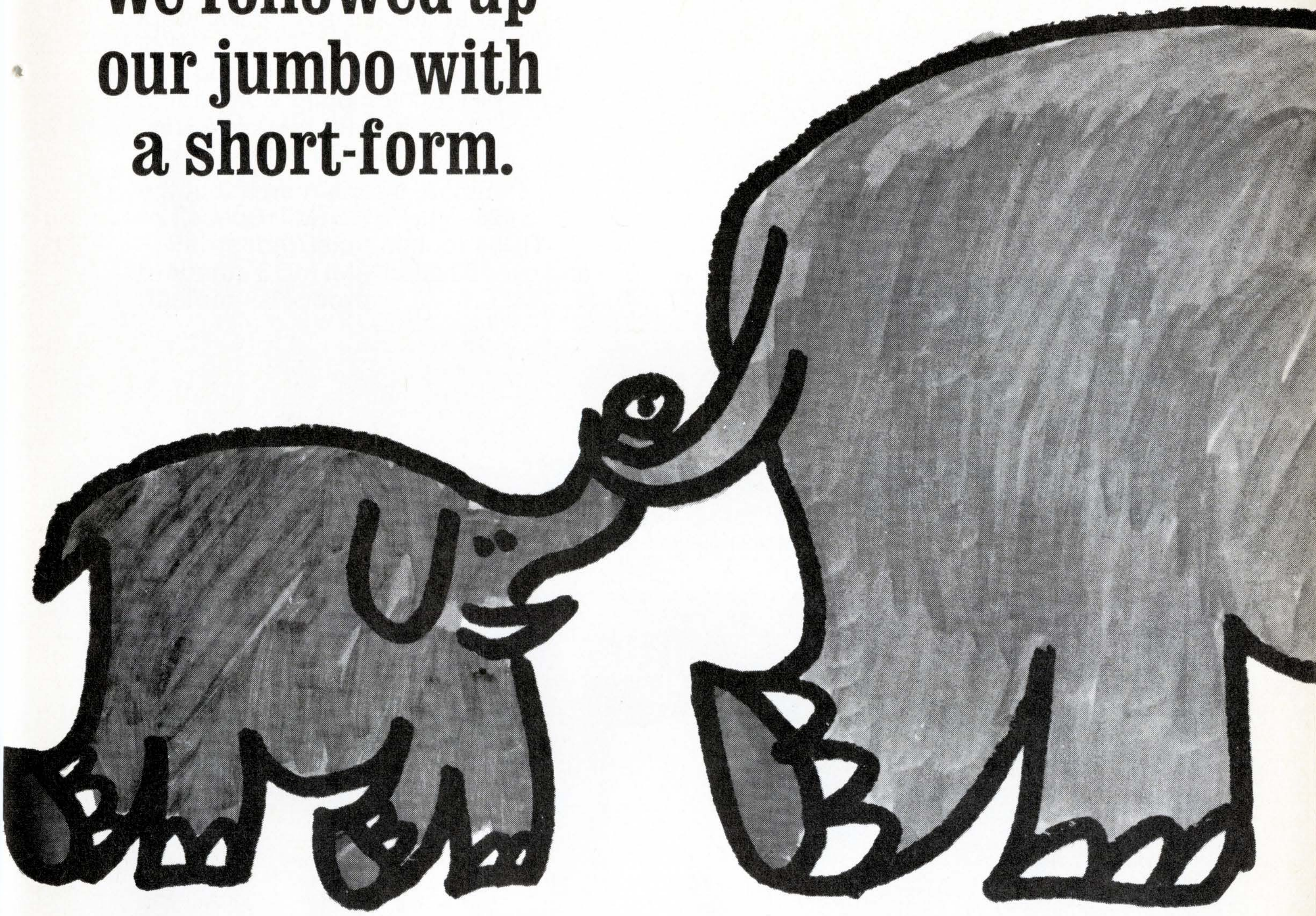
Increase CMR 100 times to 190 dB.



Nanotran transformers are good for high performance isolation uses, including chopper and geophysical applications. The Nanotran shielding principle can also be applied to small power supply transformers. Stevens-Arnold, Inc., 7 Elkins St., South Boston, Mass. 02127.

Circle 291 on Inquiry Card

We followed up our jumbo with a short-form.



Get one free.

We've gathered information on all our coaxial connectors in the standard series from low-cost UHF types to new MIL-C-39012 versions plus subminiatures, crimps, and adapters of all sorts (over 7000 connectors in all) and combined it in brief form with details on Amphenol RF switches. We call it our SF-1 Short-Form Catalog. You'll call it a complete, concise reference on connectors, switches and cable.

For your free copy, circle the reader service number, or write Amphenol RF Division, 33 E. Franklin St., Danbury, Conn. 06810.

AMPHENOL™
THE BUNKER-RAMO CORPORATION

Circle 43 on Inquiry Card

HOW LONG IS 426 BITS?

About 1/10th of an inch square.
Or, at AMI it is 2571 transistors in a TO-5.

- Longest off-the-shelf shift register
- Directly bipolar compatible
- Shift rates to 5 MHz
- Meets full Mil. Specs.

For more information about the 426—the RD15 (Mil. Specs.) or RD65 (commercial/industrial)—and over 60 other AMI MOS standard products, contact:

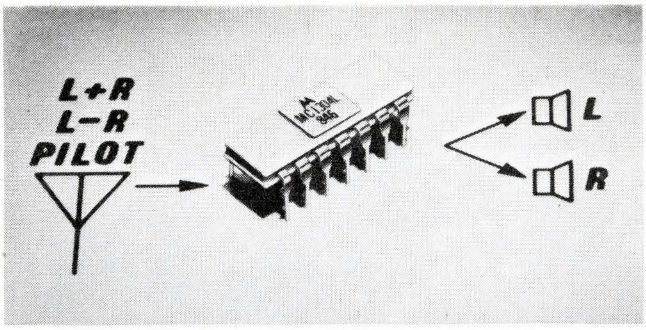
new dimensions with mos technology

American Micro-systems, Inc.

3800 Homestead Road, Santa Clara, California 95051, Tel: (408) 246-0330
TWX: (910) 338-0018

FM STEREO DEMODULATOR

Separation is 40 dB (typ.) at 1 kHz.

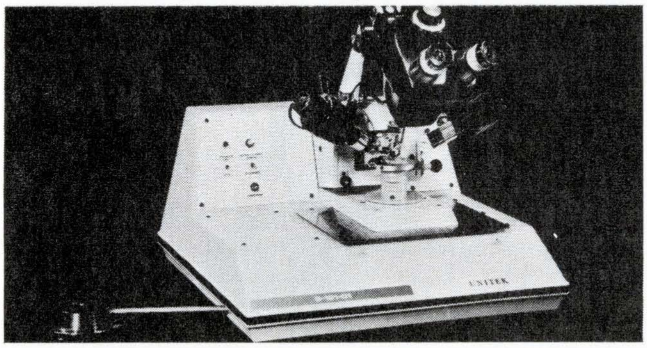


The monolithic MC1304 separates left and right audio, activates a stereo-indicator lamp, mutes interstation hiss, and automatically converts weak stereo to monaural signals. $4.80, 100-up. Technical Information Center, Motorola Semiconductor, Box 20924, Phoenix, Ariz. 85036.

Circle 201 on Inquiry Card

ULTRASONIC WIRE BONDER

For continuous production of hybrids to 4 in.^{2}.

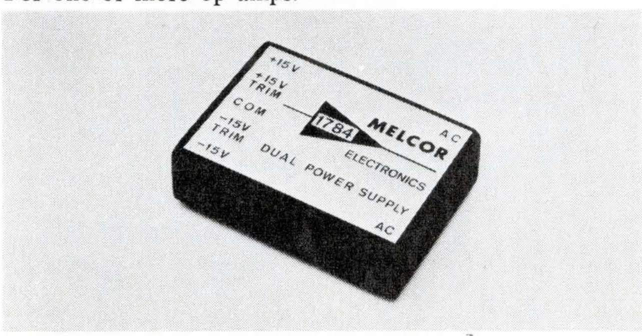


Model 8-151-01 has manual search control for multilevel bonding, adjustable wire looping, and a micromanipulator (x, y, and rotation). Patented bonding mechanism assures flat tool delivery. $3400 fob. Unitek, Weldmatic Div., 950 Royal Oaks Dr., Monrovia, Calif. 91016.

Circle 202 on Inquiry Card

DUAL POWER SUPPLY

For one or more op amps.

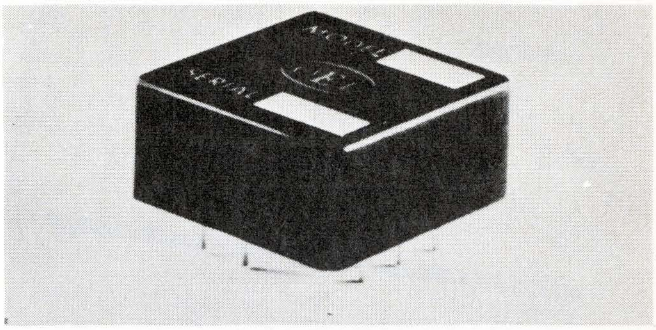


Operating from 115 Vac, either 60 or 400 Hz, Model 1784 delivers ±100 mA at ±15 V. The output is regulated against both line and load variations. For PC board mounting. Price: $78 ea., from stock. Melcor Electronics Corp., 1750 New Highway, Farmingdale, N. Y. 11735.

Circle 203 on Inquiry Card

ANALOG COMPARATORS

Four new models.

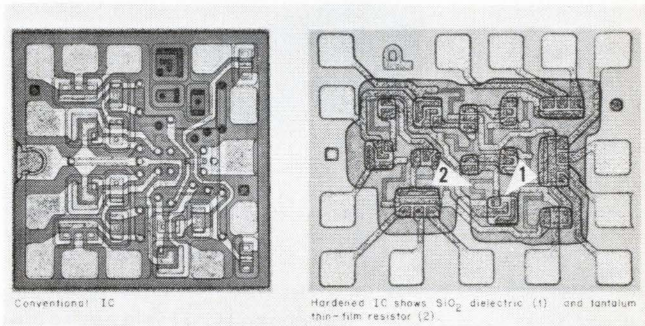


A TTL-, DTL-, RTL-compatible output and 3-μs response put Model 5233 at $255. Model 5372A has 10-V output, 15-μs response, is $145. A 300-μV comparison error, 10-V out Model 5378 is $44; Model 5385 is $74. Optical Electronics, Box 11140, Tucson, Ariz. 85706.

Circle 204 on Inquiry Card

RADIATION-TOLERANT ICS

A level shifter, two 709 op amps, and five DTL circuits.



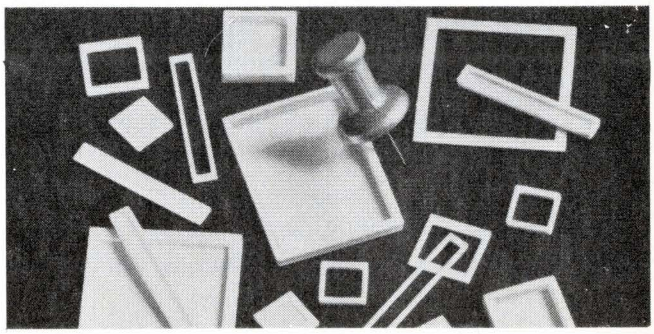
Conventional IC — Hardened IC shows SiO_2 dielectric (1) and tantalum thin-film resistor (2).

These ICs have active elements protected by a "tub" of silicon dioxide, and interconnected with tantalum thin-film resistors. The five DTL circuits are the 930, 932, 944, 945, and 962. Philco-Ford Corp., Microelectronics Div., Blue Bell, Pa. 19422.

Circle 205 on Inquiry Card

HOLLOW FRAMES AND RECESSED LIDS

Of 99.5% alumina; as-fired finishes of 5 micro-in.



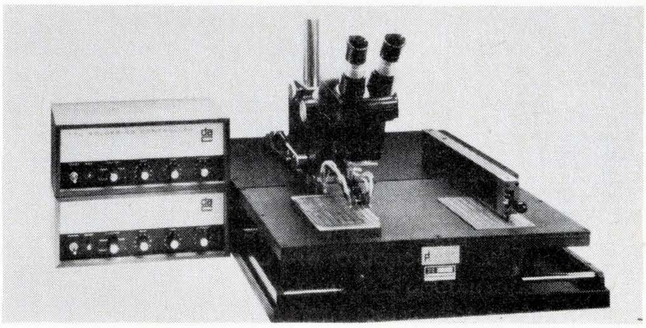
For packaging ICs, resistor networks, etc. frame portions can be as narrow as 0.02 in., with 0.01 in.-thick material. High strength. Pre-glassed edges available. Can be silk-screened. Custom manufactured (2-3 wks.). Cermetron Corp., 10475 Roselle, San Diego, Calif. 92121.

Circle 206 on Inquiry Card

EE NEW MICROWORLD PRODUCTS

FLAT-PACK SOLDERING SYSTEM

Has x-y table, positions within 0.001 in. accuracy.

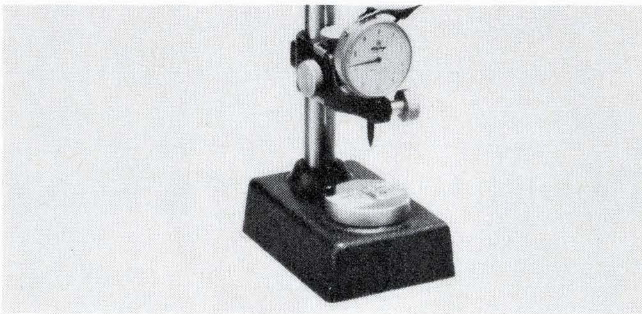


A visible tooling template gives fast positioning of the circuit board (to 8 x 8 in.) under the soldering head. There is a magnetic transfer system for placement. Dual power supplies. $4900. Development Associates Controls, 725 Reddick Ave., Santa Barbara, Calif. 93103.

Circle 207 on Inquiry Card

THICK-FILM CERMET THICKNESS GAGE

Indicates thickness to ±0.0001 in.

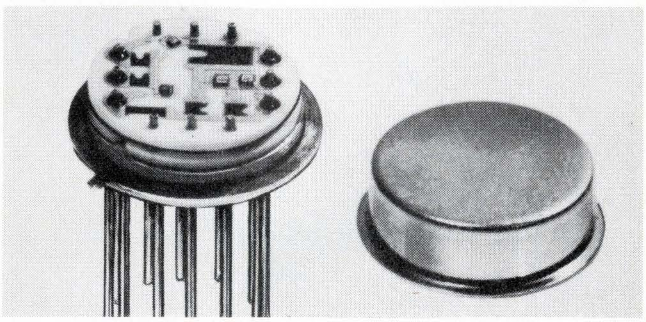


The S-1097 has a total thickness range of 0.025 in. and an accuracy compliant to all Federal regulations. Its contact point is hardened, precision-ground and plated tool steel. Flat, serrated, and domed anvils. Starnetics Co., 10639 Riverside Dr., North Hollywood, Calif. 91602.

Circle 208 on Inquiry Card

HYBRID-CIRCUIT POWER DRIVERS

For lamp/relay drivers, pulse amplifiers, etc.



Useable also as a dual-gate function, these hermetically sealed TO-8 devices operate between 4 and 35 V. Control inputs may be DTL or TTL. Series 850 provides 700 mA output; Series 851, 350 mA; both operate −55° to 125°C. CTS Microelectronics, West Lafayette, Ind. 47906.

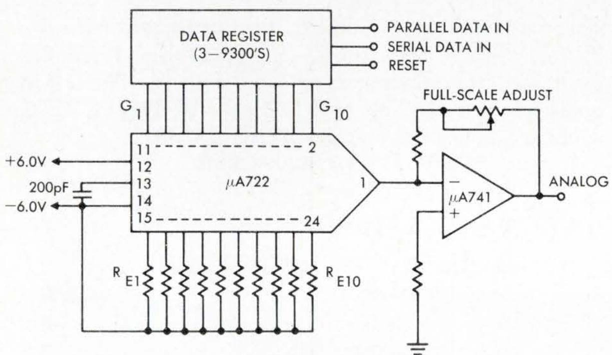
Circle 209 on Inquiry Card

How to build a $1000 A/D converter for less than $200.

Start with the Fairchild μA722 10-bit A/D-D/A Converter Current Source at $65. Add $30 for ten precision resistors*, $15 for a comparator and $25 for logic, then spend $10 tying all these together and testing the completed assembly. For $145 you've just built a successive approximation A/D Converter that will give you a conversion accurate to 8 bits in 10μs. If you need more accuracy and can give up some speed, tailor the resistors and cut your clock rate—you'll get 10-bit accuracy with a 20μs conversion time.

The μA722 is our first linear MSI IC. The chip contains a reference supply and 10 current sources connected to a single summing line through 10 current-steering switches. The built-in reference saves you money; the current steering prevents ringing and yields a switching time of 600ns.

D TO A CONVERTER



Accuracy: 0.25%
Linearity: 0.01%

Besides A/D conversion, you can use the μA722 Current Source for D/A conversion, logarithmic D/A conversion and high-speed hybrid multiplication and division. It will handle more data faster than any comparable system. You can get the μA722 from your stocking Fairchild distributor. Or, if you're not ready for it yet, send for the complete specs and application notes. They'll give you all the design information you need.

To order the μA722, ask for:

PART NUMBER	PACKAGE	ACCURACY	TEMPERATURE	PRICES 1-24	25-99	100-999
U3M7722333	Flatpak	8-bits ±½LSB 7-bits ±½LSB	0°C to +55°C −20°C to +85°C	$97.	$79.	$65.
U3M7722334	Flatpak	7-bits ±½LSB 6-bits ±½LSB	0°C to +55°C −20°C to +85°C	75.	60.	50.

*Packaged precision networks compatible with the μA722 are available off the shelf from major resistor manufacturers.

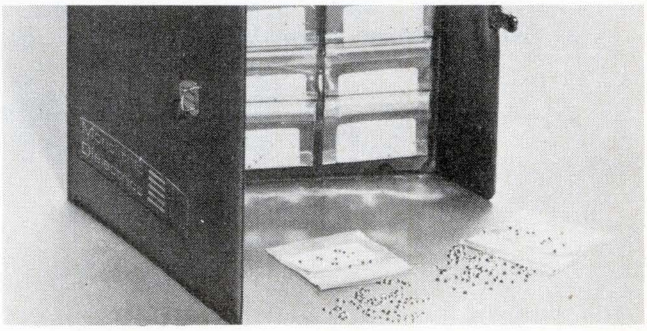
FAIRCHILD
SEMICONDUCTOR

FAIRCHILD SEMICONDUCTOR A Division of Fairchild Camera and Instrument Corporation Mountain View, California 94040, (415) 962-5011 TWX: 910-379-6435

EE NEW MICROWORLD PRODUCTS

CHIP CAPACITOR KITS

To 0.1 μF; for hybrid microcircuits.

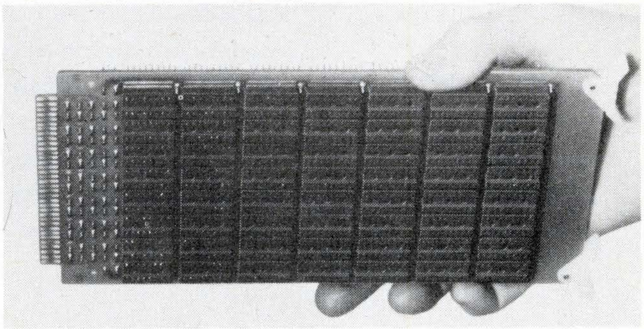


Kit No. 1 has 300 ceramic capacitor chips; ten chips each of all standard EIA values between 1.2 and 270 pF, ±10%, 50 V. Kit No. 2 is set up in the same way, but values range from 330 pF to 0.1 μF. $49.50 ea. Monolithic Dielectrics, Box 647, Burbank, Calif. 91503.

Circle 210 on Inquiry Card

SOCKET CARDS AND CARD FILES

High-density, wire-wrap types for DIP ICs.

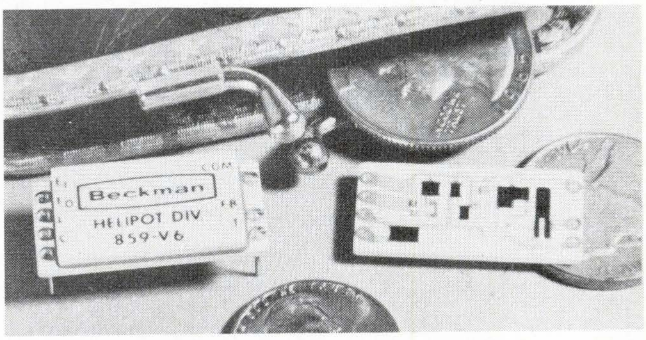


Socket cards hold 24 (4.5 in. sq. unit) or 64 IC sockets (4.5 x 9.25 in.). $46.50 to $100.40 ea., 10-24 pcs. Card files are assembled for automatic or hand wiring. The 19-in. file holds 728 ICs. $48.80 to $177 ea., 10-24 pcs. CTC, 445 Concord Ave., Cambridge, Mass. 02138.

Circle 211 on Inquiry Card

DC VOLTAGE REGULATORS

Hybrid, cermet units have 750-mA load capability.

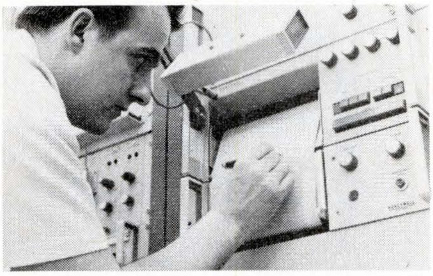


Series 809 (positive output), Series 859 (neg.) have fixed outputs from 5-28 V. Load regulation, 0.003%/mA. Ripple attenuation, 34 dB. I/O differential, 2 V min. $13.50 ea. Tech. Info. Sect., Helipot Div., Beckman Instr., 2500 Harbor Blvd., Fullerton, Calif. 92634.

Circle 212 on Inquiry Card

VISICORDER OSCILLOGRAPH

24-channel analog recorder.



Model 1508A has dc-13 kHz response, remote operation capability. Improvements include high-accuracy timer, additional transmission unit (better speed range), etc. $2575. Honeywell Test Instr. Div., Box 5227, Denver, Colo. 80217.

Circle 213 on Inquiry Card

FREQUENCY SOURCE

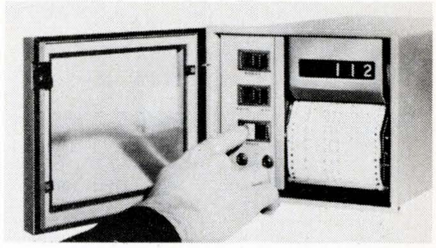
To synchronize oscillators.

Frequency stability and accuracy are 0.005%. Model SS400 gives sync pulses at 200, 400, 800, 1600, and 9600 Hz. Options available include frequency changes. $98, from stock. Polyphase Instrument Co., Bridgeport, Pa. 19405.

Circle 216 on Inquiry Card

DIGITAL LOGGER

Basic unit is 50-channel scanner.

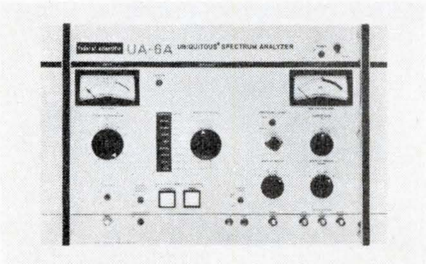


Input voltages, 0-1, 0-10, 0-50 mV. Three-digit print-out, plus two spaces for channel call-out, four for time, three more for external data. Options available. Model DL-1210, $1575. Entex, Box 770, Friendswood, Tex. 77546.

Circle 219 on Inquiry Card

REAL-TIME PROCESSOR

Modular, expands with needs.

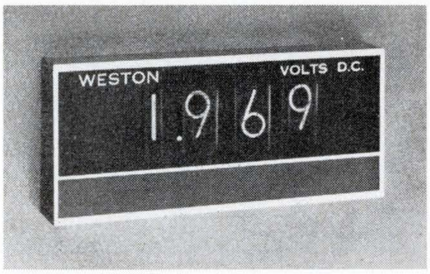


Model UPS-6 universal processing system is built around UA-6A spectrum analyzer (photo). Expand facilities at any time for power spectral density, cross-correlation, etc. Federal Scientific, 615 W. 131 St., New York, N. Y. 10027.

Circle 214 on Inquiry Card

DIGITAL PANEL METER

Front-mounting in seven sq. in.



DPM 1290 specs include three-digit plus 100% overrange display, 0.1% ±1 digit accuracy, 1-2-4-8 BCD positive output logic, and plug-in readouts. Less than $200, 100-pc. lots. Weston Instr., 614 Frelinghuysen Ave., Newark, N. J. 07114.

Circle 217 on Inquiry Card

WORD GENERATOR

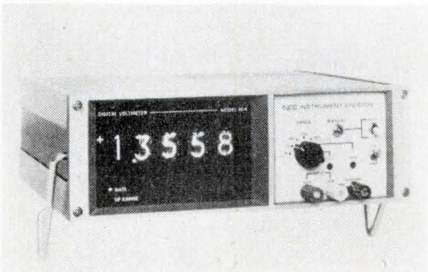
Up to nine plug-ins.

Each plug-in gives a serial word of data to 16 bits, has up to four repeat controls. The 3903 can deliver up to 16,320 bits, repeatable 225 times. Basic cost, $2150. Cimron Div. Lear Siegler, 1152 Morena Blvd., San Diego, Calif. 92110.

Circle 220 on Inquiry Card

DIGITAL VOLTMETER

BCD outputs, remote programming.

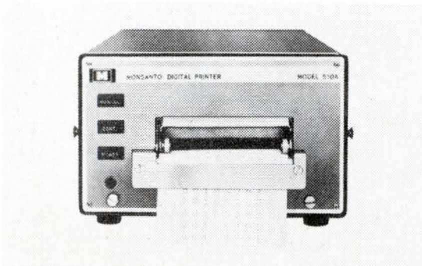


Four dc voltage ranges span 1 to 1000 V. Sensitivity, 1-V range, is 100 μV. Resolution, 0.01% f. s. Accuracy, 0.02% reading ±1 digit at 0-100% f. s. Overranging, 130%. Model 404, $595. Tyco Labs., Bear Hill, Waltham, Mass. 02154.

Circle 215 on Inquiry Card

DIGITAL PRINTER

Up to 8 columns at 4 lines/s.

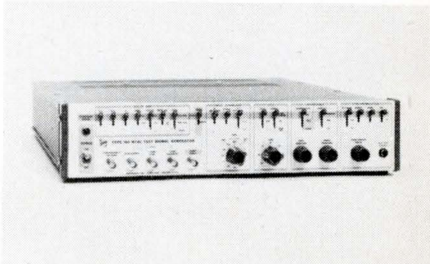


Adjustable to accept either 1-2-4-8 or 1-2-2-4 BCD, positive or negative true. Start Model 510A's print cycle manually or by pulse. Inhibit-command output. $995. Monsanto, 620 Passaic Ave., West Caldwell, N. J. 07006.

Circle 218 on Inquiry Card

NTSC TEST GENERATOR

Lockable to external sync source.

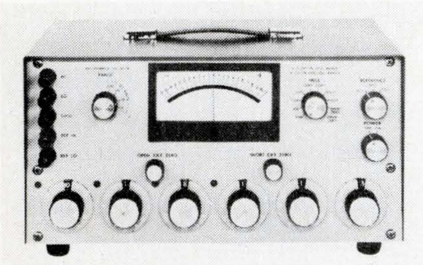


Type 140 is for 525-line, 60-cycle field video systems, Generates color bars, modulated staircase, convergence crosshatch, VITS signals, and EIA color standard and sync. $1600. Tektronix, Box 500, Beaverton, Ore. 97005.

Circle 221 on Inquiry Card

DIFFERENTIAL VOLTMETER

A 5-in-1 instrument package.

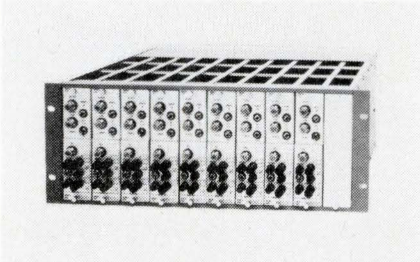


Model 1000 gives dc accuracy of ±0.0025% of reading as a differential voltmeter; ±0.001% as a decade voltage divider; dc ratio to ±0.001%. Reference source and null detector. Precision Standards, Box 8361, San Marino, Calif. 91108.

Circle 222 on Inquiry Card

UNIVERSAL STRAIN GAGE

With conditioning module.

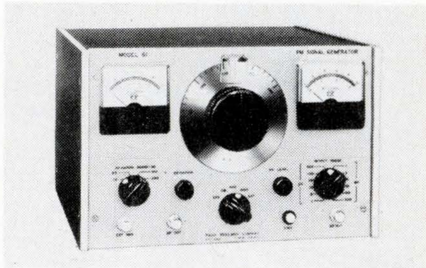


The thermocouple conditioning module plugs in, has bridge completion and calibration network cards. Ten channels, side by side. Switches for power, input/output, remote/local, etc. Incor, 29 Newtown Rd., Plainview, N. Y. 11803.

Circle 225 on Inquiry Card

FM SIGNAL GENERATOR

Metered deviation, 0-250 kHz.

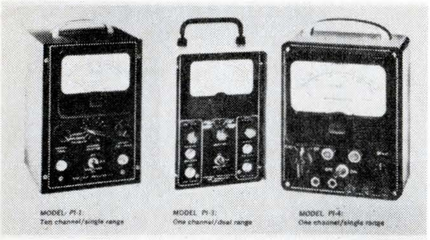


Model 61's frequency range is 85-135 MHz; additional band with adapter, 1-35 MHz. Short-term stability, 0.005%. Output level, 0.1 μV-to-3 mV, metered. $695. Radio Research, 189 Mt. Pleasant Ave., Rockaway, N. J. 07866.

Circle 228 on Inquiry Card

TEMPERATURE INDICATORS

Single- and multichannel units.

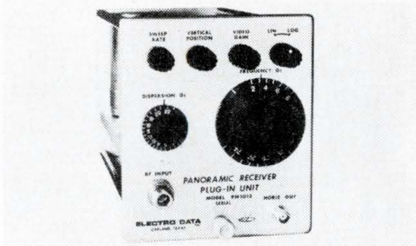


Measurements are accurate to 1% of range (0-500°F, single-channel; 0-500°F, −60 to 140°F dual-channel). Uses 100-Ω CP sensors. Recorder output. Prices start at $120. RdF Corp., 23 Elm Ave., Hudson, N. H. 03051.

Circle 223 on Inquiry Card

PANORAMIC PLUG-IN

YIG-tuned scope module, 1.8-25 GHz.



Model PN1013 changes Tektronix 560 and letter-series scopes to single-sweep panoramic receivers. High sensitivity, broad dispersion, no images or spurs. $2795. Electro/Data, 3121 Benton St., Garland, Tex. 75040.

Circle 226 on Inquiry Card

RESISTANCE DECADE

50 W continuous dissipation.

Three units (four decades ea.) provide ranges of 1-9999, 10-99,990, 100-999,900 Ω with 1% accuracy. Dielectric strength, 2 kV. Dissipates 100 W intermittently. Dale Electronics, Box 609, Columbus, Neb. 68601.

Circle 229 on Inquiry Card

FREQUENCY METER

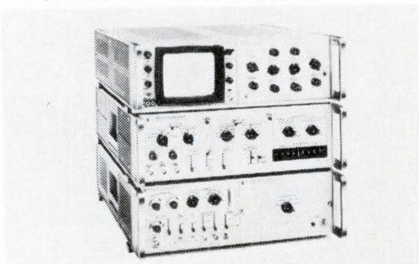
Totalizes to 15 MHz.

The 225A has BCD output; gate times of 1 ms, 1 s, and 10 s. Single-function switch has manual control of totalizing count gate. Automatic trigger control. $450. Eldorado Electronics, 601 Chalomar Rd., Concord, Calif. 94520.

Circle 224 on Inquiry Card

MULTICHANNEL ANALYZER

Very fast A-to-D conversion.

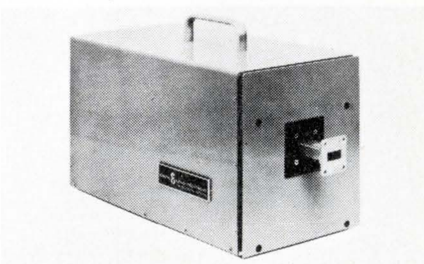


A 200-MHz converter clock–rate and an 8192-channel memory prices the Model 5401A at $17,950. With the standard 1024-word memory, its cost is $11,950. Inquiries Mgr., Hewlett-Packard, 1500 Page Mill Rd., Palo Alto, Calif. 94304.

Circle 227 on Inquiry Card

MICROWAVE NOISE SOURCES

Blackbody standards.



Series 180 sources, precisely temperature regulated, have true blackbody emission spectra. Emissivity, 0.999 ±0.001 (VSWR less than 1.04). 300 - 500°K. Individual calibration. Insco, Box 3770, Santa Barbara, Calif. 93015.

Circle 230 on Inquiry Card

Tired of tweaking up your oscillator level every time you change frequency?

With the HP 654A Test Oscillator you don't have to adjust the output when you change frequencies. The automatically controlled 0.5% level flatness across the entire frequency range of 10 Hz to 10 MHz eliminates repetitive output level adjustments. And, with your system input automatically controlled, you are free to concentrate on system performance measurements.

Pushbutton selection of any of the balanced outputs of 135, 150, or 600 Ω eliminates the necessity of an external balance transformer—and the error due to transformer response. You have the additional advantage of 50 and 75 Ω unbalanced outputs when required.

The combination of an expanded meter scale (−1 dBm to +1 dBm) and a sensitive output level control assures you of extremely accurate output resolution. Put all these capabilities and more into a lightweight portable instrument that combines laboratory precision with field mobility, and you have the HP 654A—the ideal general-purpose test oscillator.

For specialized television applications – Ask for information on the HP 653A. It has the inherent accuracy and ease of operation of the 654A—plus special built-in video capabilities required for A2 type television systems measurements.

Do your part to stamp out unnecessary knob twisting and superfluous equipment—call your local HP field engineer for more information. Or, write for data sheets to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland. Prices: HP 654A, $875; HP 653A, $990.

099/8

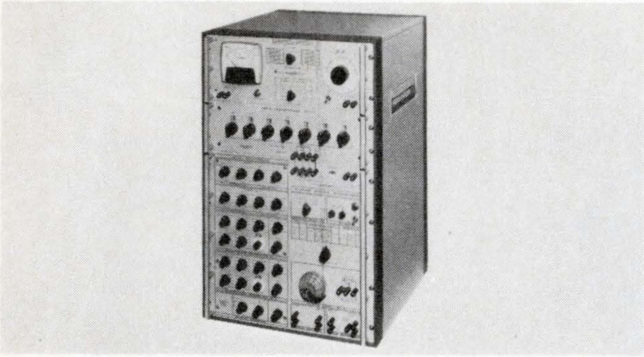
HEWLETT hp PACKARD

SIGNAL SOURCES

Circle 48 on Inquiry Card

PRIMARY PHASE ANGLE STANDARD

Continuous frequency coverage, 30 Hz to 10 kHz.

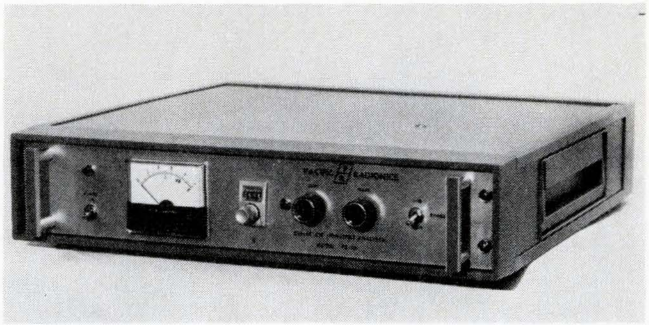


This instrument shifts/measures phase angle to an accuracy of 0.015° at most frequencies within the equipment's range. Model 311/RT-1/717 isn't affected by harmonics. Self-calibrating principle. 125-Vrms max. out. Dytronics, 4800 Evanswood Dr., Columbus, Ohio 43229.

Circle 276 on Inquiry Card

DIELECTRIC CONSTANT ANALYZER

Measures complex properties at microwave frequencies.



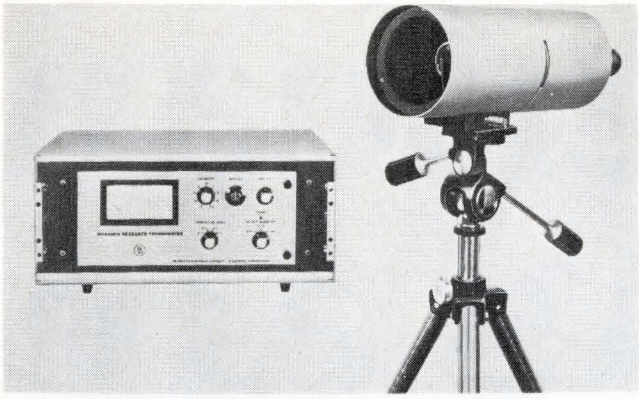
Model PR-101 analyzer measures dielectric constant and loss factor of sample materials that have an E of 26 or less. Accuracies are better than 2% absolute and 0.2% relative. Direct-reading output. Pacific Radionics, 581 Division St., Campbell, Calif. 95008.

Circle 277 on Inquiry Card

 Circle 49 on Inquiry Card

IR RESEARCH THERMOMETER

Makes non-contact measurements.



This infrared thermometer can measure the temperature of objects both near and far. It will also monitor fast-moving objects, or transient heat phenomena as short as 3 ms (55 Hz). Total temperature range is from −20° to 3200°C, in four overlapping ranges. Sensitivity at 20°C is 0.5°C; absolue accuracy is ±1% o.f.s.

The optical head of the Model 12-521 weighs 12.5 lb., while the electronic unit weighs in at 28 lb. The Cassegrain-type reflecting system gives non-parallax target sighting to precisely define the measured area. Input IR energy focuses on a germanium-immersed thermistor detector with a bandpass of 6.5 to 20 μm. The sensitive field of view is 3 milliradians (0.2°); this is about 0.1 in. at 3 ft. A built-in black-body reference cavity gives high measurement accuracy.

The temperature is read out directly in °C on the panel meter. Focus range is 3 ft. to infinity. Model 12-521 costs $9920, with delivery in 60 days. Barnes Engineering Co., 40 Commerce Rd., Stamford, Conn. 06902. (203) 348-5381.

Circle 278 on Inquiry Card

A JOB OFFER

To a personable electronic engineer: would you like to keep up to date with the rapidly advancing field of electronics, attend the best technical meetings, and discuss practical developments with the most progressive companies? The Electronic Engineer, the professional magazine for EEs, needs a competent, hard working EE or physicist with two or three years design experience or familiarity with electronic equipment. Based in New York, you will keep your finger on the pulse of electronics in the East. Although the job involves writing, engineering experience is more important than writing experience.

Send resume to

The Editor

THE ELECTRONIC ENGINEER

Chestnut and 56th St., Philadelphia, Pa. 19139

Circle 50 on Inquiry Card

90% of American TWTA's are overweight.

Here's the skinny:

The 1177 H series of traveling-wave tube amplifiers from Hughes.

Weight: Twenty pounds. (Some reduction.)

Measurements: 3½"x16¾"x11¼". (Some shape.)

The series covers the 2 to 18 gigahertz frequency range with a minimum power output of 10 watts CW. (That's power without any fat.)

Each amplifier contains a PPM traveling-wave tube, a regulated solid state power supply, and a complete air cooling system. All scientifically crammed into the case.

The 1177 H is perfect for bench or rack mounting in a lab. There's also a handle so you can carry it if you want to. (Try carrying most TWTA's.)

The traveling-wave tube is protected by a space age solid state power converter.

It's non-fat protection. Because this type gives you well regulated TWT electrode voltages without using the large filter capacitors found in 60 hertz power supplies.

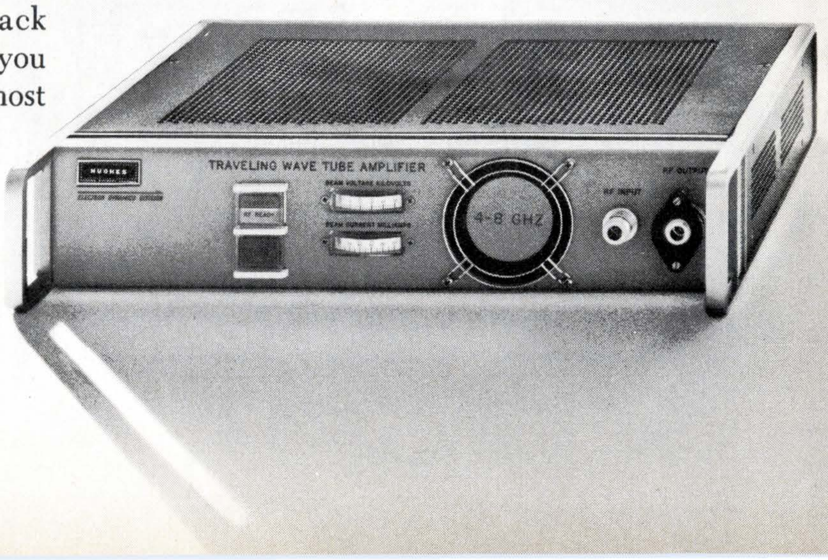
If you like your power lean. And your package on the slender side. Write.

We found a diet that works.

Write Electron Dynamics Division of Hughes, 3100 West Lomita Blvd., Torrance, California 90509.

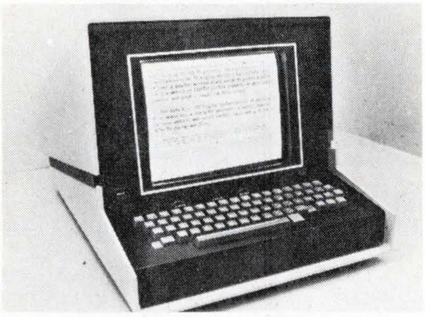
HUGHES

HUGHES AIRCRAFT COMPANY
ELECTRON DYNAMICS DIVISION



DISPLAY SYSTEM

Is computer-driven.

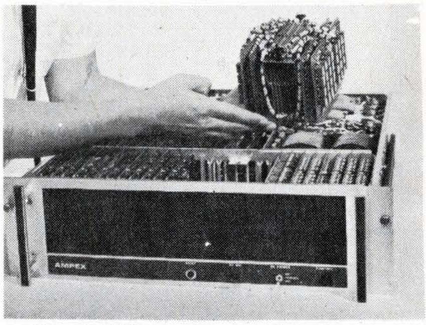


This television display system (TDS) can store and simultaneously display up to 128 different TV pictures. Basically, it consists of a disc memory, a time-shared control unit containing addressing logic and a character generator, a control terminal, and video terminals. The terminals (photo) can be used for computer data entry and retrieval and for data display. Each picture has over ¼ million dark and bright picture elements (a 512 x 480 picture-element matrix) on which alphanumeric and graphic images can be written. Data Disc Inc., Display Div., 1275 California Ave., Palo Alto, Calif. 94304. (405) 326-7602.

Circle 231 on Inquiry Card

COMPACT CORE MEMORY

Needs very little space.

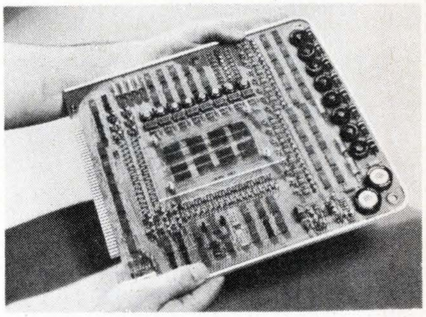


The RGX is a complete memory system available in capacities of up to 4096 words by 48 bits or 8192 words by 24 bits. The new memory offers a cycle time of 900 ns and a data access time of 350 ns. The memory, power supply and an optional self-testing unit are in a single module 5¼ x 19 x 21 in. Other optional items include address register outputs, data parity generation and check, zone control and sequential sequential-interface operation. Unit is equally adaptable to domestic or international use, offering the choice of 115/220 Vac, 50/60 or 400 Hz input power. Contact Gregg Parry, Ampex Corp., 401 Broadway, Redwood City, Calif. 94063.

Circle 233 on Inquiry Card

MEMORY SYSTEM

System contained on single PC board.



The Memcard™ system is a 1024 by 8 core memory with plug-in convenience for easy maintenance or replacement. The compact system is complete—including address registers, power on/off, core memory and associated electronics—all on one 12 x 12 in. board only ½ in. thick. System features cycle times of 1.5 μs. Automatic power-on, power-off protection is a data save feature if power is interrupted. The 3-wire, 3D memory, contained on a plane in the center of the PC card is comprised of 8 mats, each containing 1,024 cores. Memory Products Dept., Sanders Associates, 95 Canal St., Nashua, N. H. 03060. (603) 885-2816.

Circle 235 on Inquiry Card

HIGH SPEED TERMINAL

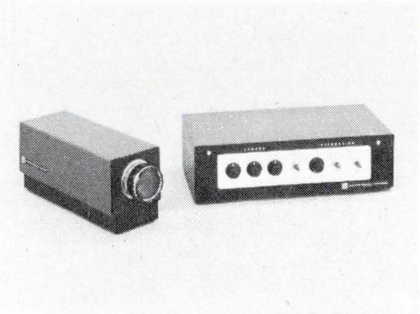
"Ink" printer is now available.

High-speed terminal prints at speeds up to 1200 wpm. The Inktronic® units operate 12 times faster than conventional data communications equipment. Since only a voice grade telephone line is required, the Inktronic terminal is viewed as a "natural" for computer time-sharing applications. Unlike regular typewriters and teleprinters, the Inktronic sets do not rely on "impact" printing. Instead, characters are formed on ordinary paper by electronically deflecting spurts of ink. Teletype Corp., 5555 Touhy Ave., Skokie, Ill. 60076.

Circle 232 on Inquiry Card

LOW LIGHT LEVEL TV

No image smear.

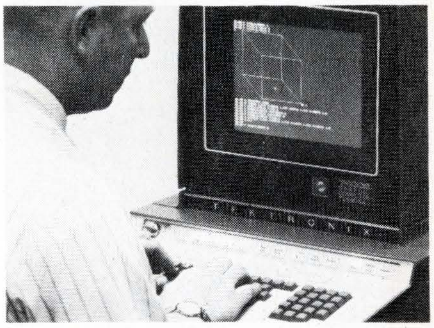


Model MB-25 is a B&W closed-circuit TV camera for use under low light levels. It has a single stage image intensifier in front of an SEC vidicon. It guarantees complete lack of image smear from scene motion and negligible halation around bright spots. The camera has an AGC system which produces good images with light levels ranging all the way from starlight to daylight. Integration on the SEC target is possible, facilitating use of the camera in lieu of film. Commercial Electronics Inc., 1271 Terra Bella Ave., Mountain View, Calf. 94040.

Circle 234 on Inquiry Card

GRAPHIC COMPUTER TERMINAL

Self-contained, desk-top display.



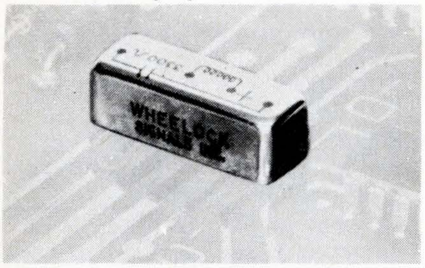
All of the elements to communicate with a computer are housed within the T4002 console. System components are: display unit, terminal control, character generator, keyboard and input/output interface. An 11 in. direct-view, storage tube is the display media. High-density, alphanumeric and complex graphics are presented without flicker or drift. Screen will accommodate up to 35 lines of alphanumeric characters with 80 symbols/line. Initially 2 types of interfaces are available. Tektronix, Inc., Box 500, Beaverton, Ore. 97005.

Circle 236 on Inquiry Card

←Circle 51 on Inquiry Card

REED RELAY

Driven directly by ICs.

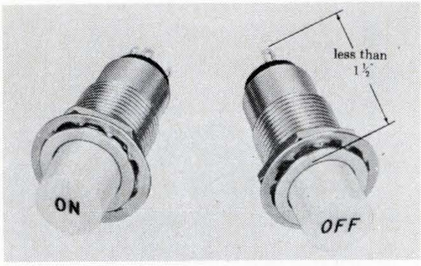


Series 442S 5-V relays require about 60 mW per pole to operate. They occupy only 0.05 in^3/pole, and are only 0.258 in. high. Available in 1- to 4-pole models with contacts rated at a full 7 W, they weigh 1.9 g/pole. Operating temp. range is $-65°$ to $+85°C$. Wheelock Signals, Inc., 273 Branchport Ave., Long Branch, N. J. 07740. (201) 222-6880.

Circle 237 on Inquiry Card

ILLUMINATED SWITCH

Weighs just 0.8 oz.

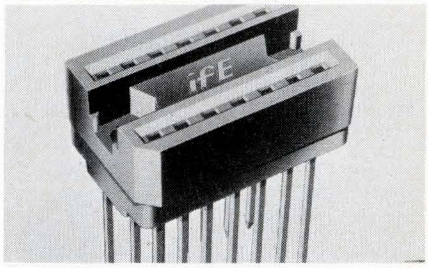


New line of miniature switches are 1½ in. from the front of the panel to the rear of the contacts. They come in momentary action up to SPDT and operate with either 115 Vac or 30 Vdc at 1 A res. or ½ A ind. Lens take either a std. T1¾ or ALC-100 neon bulb. Electro-Mech Components Inc., 1039 East Valley Blvd., San Gabriel, Calif. 91776. (213) 283-9213.

Circle 240 on Inquiry Card

DIP SOCKETS

Have solid 0.025-in^2. terminals.

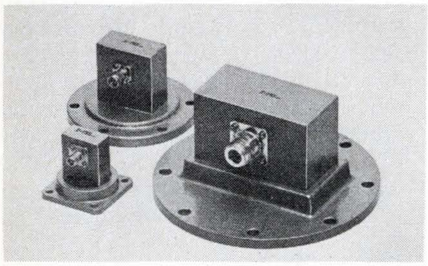


These 14-lead sockets have large tapered entry channels for quick lead insertion into dual leaf contacts. Polysulfone body provides anti-rotate pockets for hex nuts for easy assembly to the chassis. Contacts are beryllium copper with std. gold and tin contact plating. Plastic Mold and Engineering Co., 265 Wampanoag Trail, Box 4265, East Providence, R. I. 02914.

Circle 243 on Inquiry Card

WAVEGUIDE ADAPTORS

VSWR of 1.25 from 2.6 to 18.0 GHz.

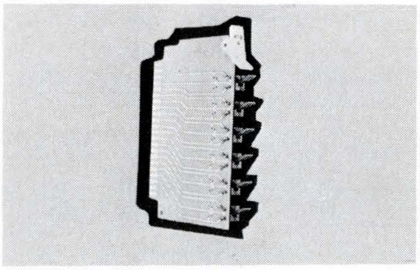


Series WCA waveguide-to-coaxial adaptors have zero transition loss from rectangular to coaxial connectors of "N" to 3 mm (SMA) types. There are 18 models covering six frequency ranges. I-TEL Inc., 10504 Wheatley St., Kensington, Md. 20795. (301) 946-1800.

Circle 238 on Inquiry Card

TOGGLE SWITCH IC CARD

Contains six DPDT switches.

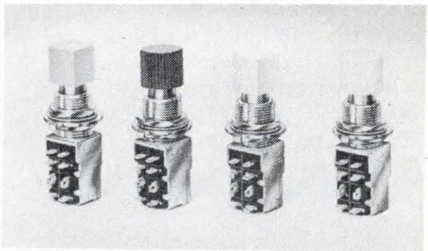


MTS-6 eliminates the need for front-panel mounted switches in small systems. All control wiring can be mounted on the back plane, providing savings in space and cost. Computer Products Div., Wyle Laboratories, 128 Maryland St., El Segundo, Calif. 90245. (213) 678-4251.

Circle 241 on Inquiry Card

LIGHTED PUSHBUTTON

Handles 6 A at 125 Vac.



Snap-action switches have DPDT action enclosed in a miniature case, but separate connections to the lamp can still be made. Standard T-1¾ grooved lamps are replaceable from the front without tools. Alco Electronic Products, Inc., Box 1348, Lawrence, Mass. 01845 (617) 686-3887.

Circle 244 on Inquiry Card

Nd YAG LASER

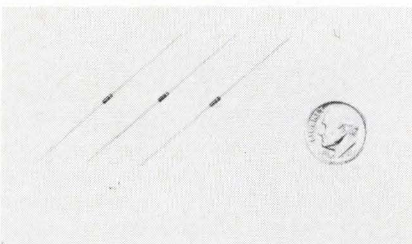
Has continuously adj. output.

Model 610 is for use where a high-power, cw, 1.06-micrometer source is needed. It emits >1 W in the TEM_{00} mode and >5 W in multi-transverse mode operation. Optical length of the cavity is about 38 cm. Output beam dia. is 3 mm. Sylvania Electronic Systems-Western Div., Electro-Optics Orgn., Box 188, Mountain View, Calif. 94040. (415) 966-2312

Circle 239 on Inquiry Card

METAL FILM RESISTOR

Dia. 0.050 in., length 0.130 in.

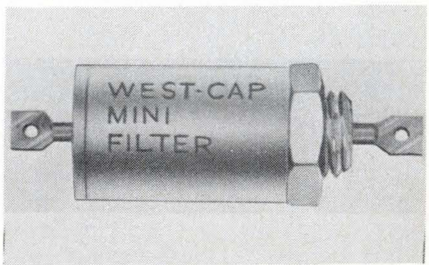


Type MRE-1/20 molded resistor conforms to all environmental requirements of MIL-R-10509F in tolerances to $\pm 0.1\%$ and temp. coeff. as low as 0 ± 25 ppm/°C. Resistance range is 25Ω to 25 KΩ. Wattage rating is 1/20 W at 100°C and 1/40 W at 125°C. American Components, Inc., Eighth Ave. at Harry St., Conshohocken, Pa. 19428. (215) 828-6240.

Circle 242 on Inquiry Card

RFI LOW PASS FILTER

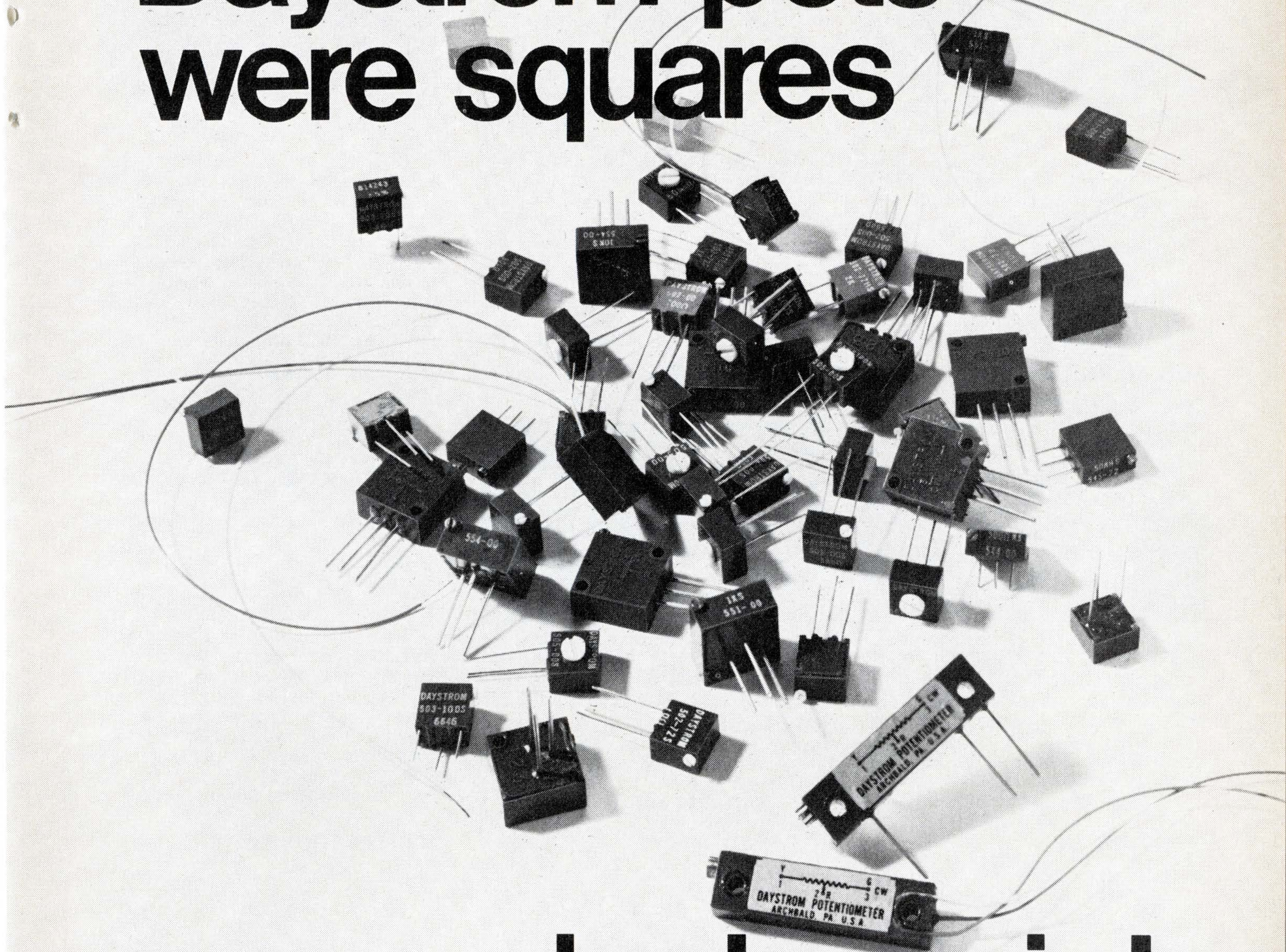
Low dc resistance, high attenuation.



Miniature CF filter series is available in the working voltage range of 50 to 200 Vdc and 0.06 to 15 A. Hermetically sealed steel case is 0.560 x 0.375 in. Operating temp. is $-55°$ to $+125°C$. Plating is gold, silver, or tin with various mounting styles available. San Fernando Electric Mfg. Co., 1501 First St., San Fernando, Calif. 91341. (213) 365-9411.

Circle 245 on Inquiry Card

If you thought all Daystrom pots were squares



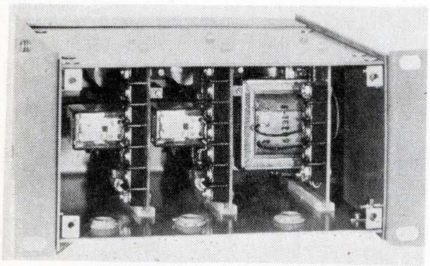
...look again!

Rectilinear components are still a necessary requirement in many circuit applications. That's why Weston has rounded out its high-performance potentiometer line with two new rectilinear models. RT-12 styles 534 and 535 are designed for both general-purpose and military applications. They feature the same ±5% tolerance, 10 ohm to 50K range, and slip clutch stop protection that are standard with Daystrom Squaretrim® units, plus 24-turn adjustability and humidity proofing. Also new this year . . . models 553 half-inch and 543 three-eighth-inch Squaretrim potentiometers in military and commercial versions. Save board space as well as money with our field proven 501 Series multi-turn and 504 Series single-turn 5/16" Squaretrims offering values to 20K in a 0.02 cubic inch case. All Squaretrim Diallyl-Phthalate cased pots give you Weston's patented "wire in the groove" construction and your choice of flexible leads, pin and screw configurations. Whether your trimmer needs are military, industrial or commercial, you'll find the answer in this complete new low-cost line. Write today for data sheets and evaluation samples. DAYSTROM potentiometers are another product of WESTON COMPONENTS DIV., Archbald, Pennsylvania 18403, Weston Instruments, Inc., a Schlumberger company

WESTON®

SINGLE & DUAL ALARMS

With 0.1% accuracy.

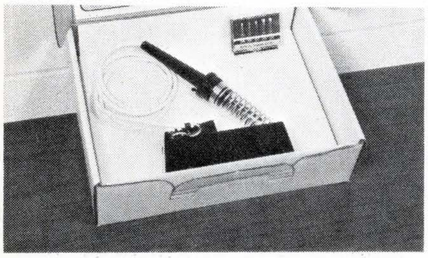


Single and dual current and voltage alarms have a relay contact that is actuated when the input voltage or current signal reaches the value of an adjustable internal set point. Units have good temp. stab. and are immune to line fluctuations. Deltron Inc., Control Div., Wissahickon Ave., North Wales, Pa. 19454.

Circle 246 on Inquiry Card

SOLDERING TOOL

Test and trial kit.

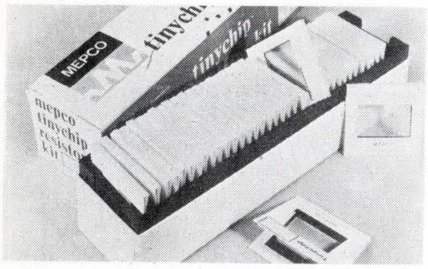


This 30-day, no-cost kit permits inplant evaluation of Model W-TCP low voltage soldering station. The EK-1 evaluation kit contains six interchangeable tips of various sizes and temperature ranges, as well as a customizing guide. Weller Electric Corp., 100 Wellco Rd., Easton, Pa. 18042.

Circle 247 on Inquiry Card

RESISTOR KIT

Forty resistance values.

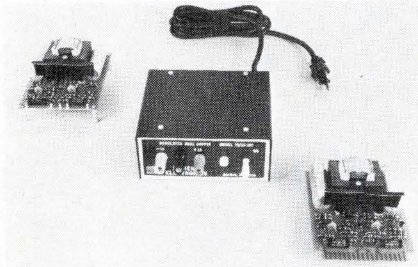


"Tinychip" resistor kit contains 400 resistors with values ranging from 56 Ω to 100 kΩ. The chips are packed in individual compartments in a storage/selection tray with the resistance values marked on each envelope. Complete kit costs $149.50. Mepco, Inc., Columbia Rd., Morristown, N. J. 07960.

Circle 248 on Inquiry Card

OP AMP POWER SUPPLY

Dual 15-volt PC plug in.

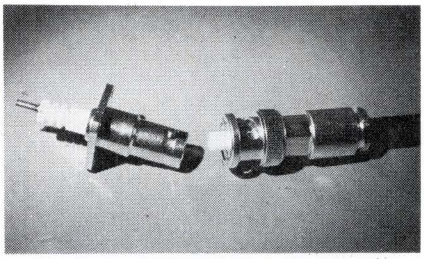


Model SEI-15/15-100 is an all silicon SS device. Basic unit provides 100 mA on each output; is short circuit proof; has 1-mV pk-pk ripple voltage; and is regulated to ±0.01% line, 105 to 125 Vac 60 Hz, and ±0.02% load, no load to full load. Salient Electronics, Inc., Blue Barns Rd., Rexford. N. Y. 12148. (518) 393-4590.

Circle 249 on Inquiry Card

HV COAX CONNECTORS

Deeply recessed center contact.

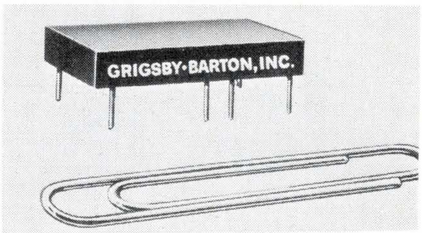


New series features a center contact deeply recessed in Teflon dielectric that withstands 7500 V rms at 60 Hz. Handling safety is provided by the polarized and deeply recessed center contacts. Star-Tronics, Inc., Moulton St., Georgetown, Mass. 01830. (617) 774-0577.

Circle 250 on Inquiry Card

DIL REED RELAY

Available as SPST.

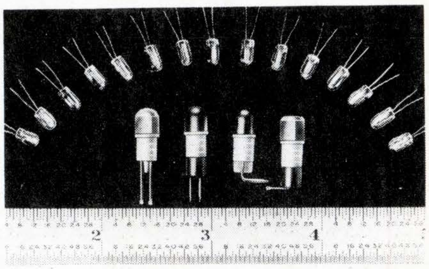


Input of the 14-pin GB811 is 5 Vdc for direct transistor logic drive. Package contains a reed relay, and a diode to suppress back emf. Contact rating is 3 W and breakdown volt. 200 Vdc. Electrostatic shielding is provided between coil and reed switch. Grigsby-Barton, Inc., 107 N. Hickory, Arlington Heights, Ill. 61312. (312) 392-5900.

Circle 251 on Inquiry Card

INDICATOR LIGHTS

Standard line expanded.

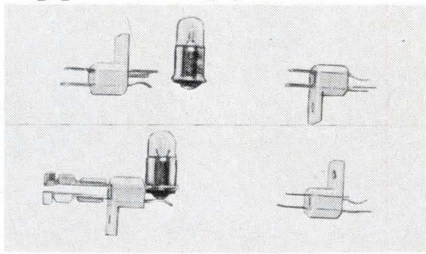


"Bright-Eye" high intensity series now has lamps that increase life expectancy average from 60,000 to 100,000 hours. Ratings range from 1.5 to 28 V, with current ratings as low as 0.010 A. New high temp. epoxy heat barrier is also available. Shelly Associates, Inc., 111 Eucalyptus Dr., El Segundo, Calif. 90245.

Circle 252 on Inquiry Card

SNAP-ON SOCKET

Engages and disengages easily.

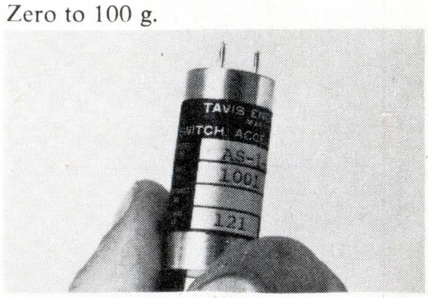


Self-mounting snap-on Klipsocket™ fits all T-1¾ midget flanged based lamps from 1-28 Vac or dc. It clips on quickly and fits snugly. Universal brackets can be ordered to fit in any one of four ways. Chicago Switch, Inc., 2035 Wabansia Ave., Chicago, Ill. 60647. (312) 489-5500.

Circle 253 on Inquiry Card

ACCELERATION SWITCH

Zero to 100 g.



Model AS-1 instantaneous acceleration switch is for use with 12- to 40-Vdc supplies. It combines a basic inertial element with integral SS logic circuitry. Circuits are opened or closed within 1 ms, when peak acceleration exceeds the set point. Tavis Engineering Co., Bootjack Rd., Mariposa, Calif. 95338.

Circle 254 on Inquiry Card

Camera Shy?

Don't be. Here's a truly compact CCTV camera (2⅞" head) that delivers over 1,200-line horizontal resolution.

The Fairchild TCS-950B
It's ideal for those who have shied away from high resolution cameras because of their large sizes and price tags. Fairchild's new TCS-950B gives the sharpness and clarity of over 1,200-line horizontal resolution and 700-line vertical resolution. With the smallest head on the market and exceptionally compact design, the TCS-950B is perfect for data transmission, microscopic component inspection, flight simulation, photo interpretation, medical observation and a multitude of other applications.

If your CCTV needs are varied and sometimes unusual, you should also consider the versatility available with the TCS-950B:

- Switchable scan rates (either or both scan directions).
- Interlaced or sequential frame scan.
- Video polarity reversal.
- Scan polarity reversal.
- Militarized construction.

Reliability of the TCS-950B is ensured by Fairchild's solid-state Micrologic® circuitry. For its size and high resolution performance, it's one of the lowest priced cameras on the market.

New: The TC-177. You'll get remarkably stable, crisp, high-contrast video signals from this self-contained camera. Features Micrologic® circuitry, 800-line resolution (standard); 2:1 interlace, EIA sync remote control, high resolution (over 900-line), video polarity reversal and other options available.

For specifications and performance data, contact:

FAIRCHILD

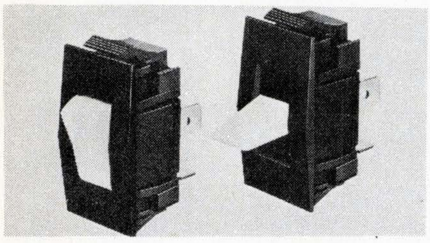
SPACE AND DEFENSE SYSTEMS
A DIVISION OF FAIRCHILD CAMERA AND INSTRUMENT CORPORATION
30 PARK PLACE, PARAMUS, NEW JERSEY 07652
TEL. 201-262-7000 / TWX 710-990-6610

84B

Circle 53 on Inquiry Card

MINIATURE SWITCHES

Optional snap-in mounting.

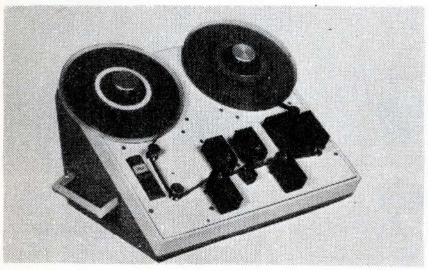


Rocker switches and paddle switches are simply pressed into the opening and held in place by snap-in hardware tension. Besides speeding and simplifying installation, the snap-in design provides for a cleaner panel appearance, with no exposed fasteners. McGill Mfg. Co., Inc., Electrical Div., Valparaiso, Ind. 46383.

Circle 255 on Inquiry Card

MAGNETIC TAPE CLEANER

Cleans at the rate of 200 ips.

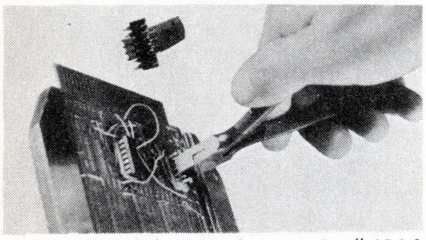


Model 27 provides a way to rehabilitate either new or used tape where particles of dirt, lint, dust, or threads may cause "dropout," costly error, and time loss. Tension is constant throughout operation. Tape is automatically stopped at end of censor. Virginia Panel Corp., Box 1106, Waynesboro, Va. 22980. (703) 942-8376.

Circle 256 on Inquiry Card

IC PLIERS

For 10- and 14-lead flatpacks.

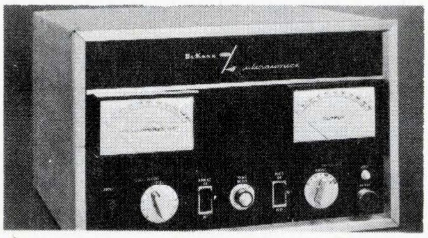


Coated fulcrum jaws of #4916 pliers allow them to be used freely with live circuits. Jaws permit instant removal of ICs when de-soldering; eliminate bent leads and short circuits, and handle all IC flatpacks with precision and speed. Techni-Tool, Inc., 1216 Arch St., Philadelphia, Pa. 19107. (215) 568-4457.

Circle 257 on Inquiry Card

ULTRASONIC AMPLIFIER

A 10-kHz to 100-kHz freq. range.

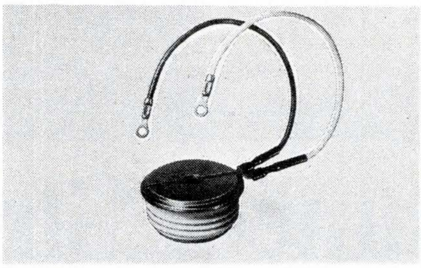


Model No. 40A-300, with a continuous output up to 300 W of power, is especially effective in R&D. The switching device allows you to change impedance to match a wide range of transducers. Input source can be any signal generator with an output of about 1 V. DuKane Corp., St. Charles, Ill. 60174.

Circle 258 on Inquiry Card

THYRISTOR

All-diffused design.



Type 282, "Full Capacity" thyristor is to replace parallel SCRs. Because of the all-diffused design, the thyristor's full inherent capacity is realized. Characteristics include a guaranteed dv/dt, low thermal imp., high surge current capability (to 7000 A), and high transient voltage capability. Westinghouse Semiconductor Div., Youngwood, Pa. 15697. (412) 255-3693.

Circle 259 on Inquiry Card

DC POWER SUPPLY

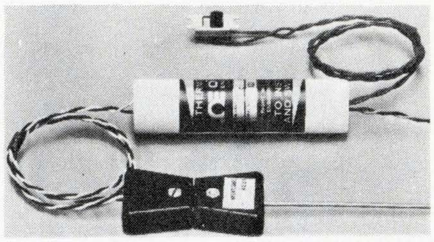
Operates up to 500 IC logic gates.

Model 903 is an encapsulated PC card mounting unit. It develops a 5-V, 500-mA output and is 2.5 W x 3.5 L x 1.25 in. H. The supply's output voltage will recover to the full 5 V within microseconds of step changes in load voltage. Analog Devices, Inc., 221 Fifth St., Cambridge, Mass. 02142.

Circle 260 on Inquiry Card

REFERENCE JUNCTION

For extreme environmental uses.

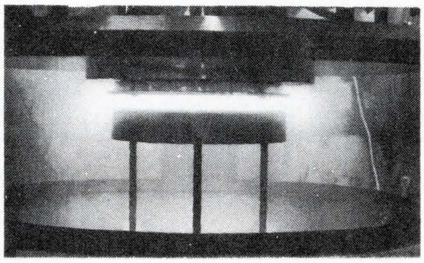


Self-powered thermocouple junction eliminates the need for ice baths and ovens. A pair of external "switch" leads provides instantaneous operation. Model XCJ comes in 16 different calibrations. Cases are cylinders 3 in. long by 3.4 in. in dia. All leads are 14 in. long. Omega Engineering Inc., Box 4047, Stamford, Conn. 06907.

Circle 261 on Inquiry Card

PLASMATOMIC SPUTTERING

Triples coating rates.

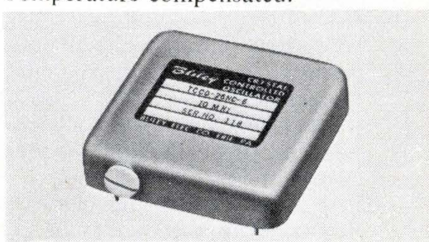


Physics of the plasma has been changed to intensify the generation of ions which cause the sputtering process. Three advantages are higher deposition rates, greater uniformity in coating and films, and a "getter" effect which enhances film purity and process equilibrium. Materials Research Corp., Scientific Instruments Div., Orangeburg, N.Y. 10962.

Circle 262 on Inquiry Card

CRYSTAL OSCILLATORS

Temperature compensated.



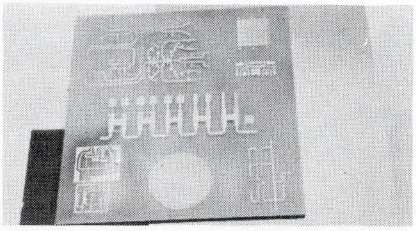
Two oscillators for std time base frequencies at 1 MHz (Type TCCO-26M-5) and 10 MHz (Type TCCO-26NC-6) have guaranteed stab. of 2 ppm over 0-60°C range. Low cost std module has pin terminals for PC board mounting and operation on 12 Vdc supply. Bliley Electric Co., 2545 W. Grandview Blvd., Erie, Pa. 16512.

Circle 263 on Inquiry Card

EE NEW PRODUCTS

DIELECTRIC MATERIALS

For microwave stripline cicuitry.

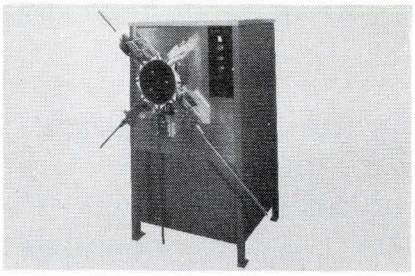


Heavy, aluminum-backed Z-Tron material consists of a "sandwich" of copper cladding over Z-Tron laminated to aluminum. Designed to be photoetched by standard procedures, it comes in any practical thickness from 1/32 in. The Polymer Corp., Reading, Pa. 19603.

Circle 264 on Inquiry Card

IC SORTER

For incoming/outgoing inspection.

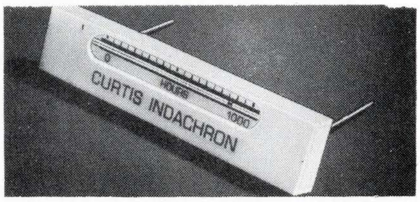


Type 852 sorter, operating with suitable test equipment, automatically tests and sorts over 5000 DIL ICs/h, magazine to magazine. Devices fed from the magazine are transferred to an index table, then advanced to a probe station for dc or dynamic testing. Daymarc Corp., 40 Bear Hill Rd., Waltham, Mass. 02154. (617) 894-2105.

Circle 265 on Inquiry Card

ELAPSED TIME METERS

Costs <$2 in quantity.

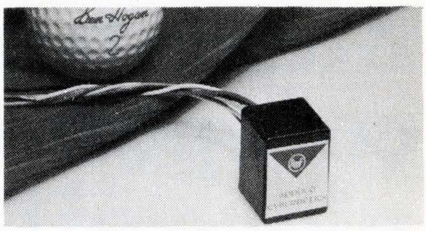


The "Indachron" indicator with an active 1-in. scale is only 1⅝ in. long by 0.160 in. high. The L-Series can be mounted either on PC cards or to a chassis. Any time scale is available in either ac or dc models. Curtis Instruments, Inc., 200 Kisco Ave., Mt. Kisco N.Y. 10549. (914) 666-2971.

Circle 266 on Inquiry Card

PREAMPLIFIER

Micro powered micro-module.

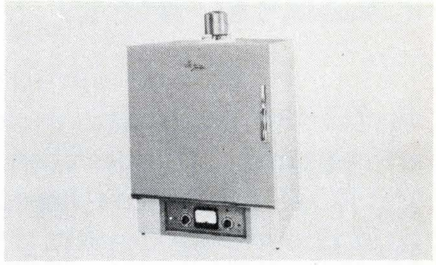


This Cybertran preamplifier has fixed and variable gain from 0 to 40 dB, low noise, quiescent current drain <10 μA with ext. battery, input impedances to 1000 MΩ, and freq. response to 500 kHz. American Machine & Foundry Co., 1025 N. Royal St., Alexandria, Va. 22314.

Circle 267 on Inquiry Card

HIGH TEMP. OVENS

Feature low-skin temp.

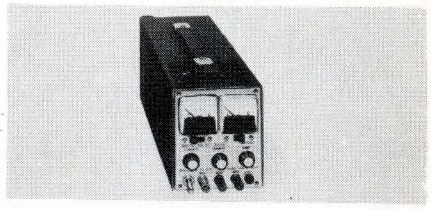


New LST (Low Skin Temperature) ovens have a safe ext. temp. of <50°C even when operating at 300°C. The ovens provide over 5 ft³ of load area in a stainless steel chamber. The Temp. range is from 40° to 350°C. Electronic control is accurate to within ±0.15%. Hotpack Corp., 5137 Cottman Ave., Philadelphia Pa. 19135. (215) 333-1700.

Circle 268 on Inquiry Card

MINIATURE POWER SUPPLY

Has plug-in IC cards, ±0.01% reg.

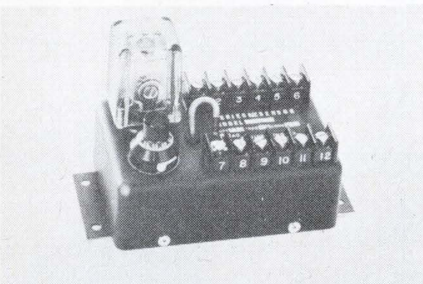


PVC dc supply with 50-W oputput is for a stable source of regulated dc power in the low current line. Rated from 0 to 10, 20, and 50 V and 4, 2, and 1 A output, respectively, it's ideal for IC development through relay driving. NJE Corp., 20 Boright Ave., Kenilworth, N. J. 07033.

Circle 269 on Inquiry Card

RESISTANCE SENSOR

For close tolerance control.

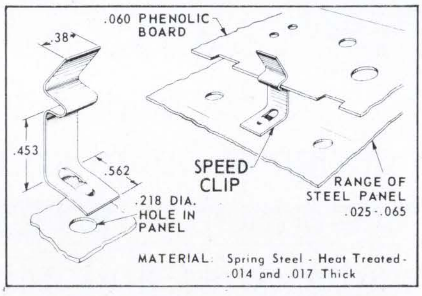


This resistance sensing relay can be operated by resistance temperature detectors, thermistors, strain gauges, pressure transducers, accelerometers, photo cells, position indicators, or any other resistance-type transducer with an operating point or range between 1 Ω and 95 Ω. It is an adjustable set-point trip relay and is available with either an electro-mechanical relay (2 form C contacts) or SS switching (with zero cross-over switching to eliminate RFI). Prices range from $70 to $98 R. Corbett, Sales Mgr., Mag-Con Engineering Co., 85 Richardson St. S.E., St. Paul, Minn. 55112. (612) 633-8820.

Circle 270 on Inquiry Card

SPEEDY FASTENER

For many applications.

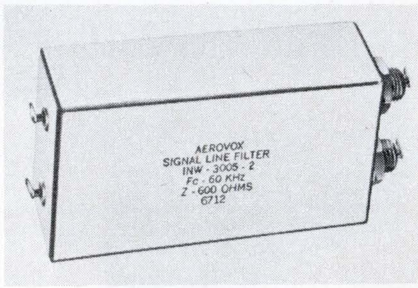


Special latch-type Speed Clips® were developed to secure PC boards to chassis in radio, TV and other applications. These one-piece, self-retaining fasteners are attached to the chassis by merely snapping the lip and catch into a hole in the panel, anchoring it securely to the panel. The board is then snapped into the recessed part of the upper leg where it is held fast. The long lip provides a lead for easy insertion of the board and also simplifies removal for servicing. This clip serves the dual purpose of fastening and spacing. Tinnerman Products, Inc., Dept. 14, Box 6688, Cleveland, Ohio 44101.

Circle 271 on Inquiry Card

WAVE FILTER

For 600 Ω line-to-line applications.

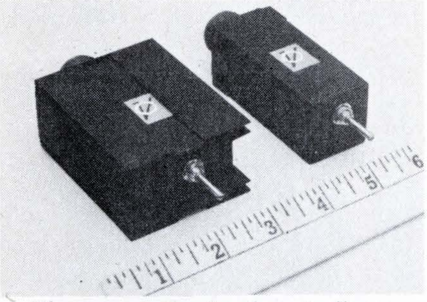


The INW-2, a 600 Ω dual-section filter for line-to-line service, is for communications equipment. The electric wave operates between −55°C and +85°C, and is rated to carry 150 mA of current at either 250 Vac or 600 Vdc. It is intended for applications in telephone, Teletype, audio and digital transmission lines and high-speed data circuits, and can be provided in a wide choice of pass-bands to suit specific requirements. The INW-2 meets the electrical, mechanical and environmental requirements of MIL-F-18327. Aerovox Corp., Filter Dept., New Bedford, Mass. 02741.

Circle 272 on Inquiry Card

POWER CONTROLLERS

Interference free.

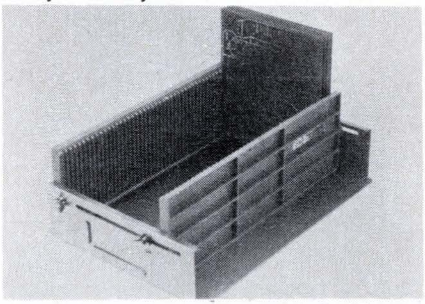


These ac power level controllers use zero crossover switching to prevent large current transients which occur with phase switched SCRs. Half cycles of power passed to the load are so evenly spaced that light dimmer application is possible with 400 Hz power. Panel-mounted Model SPC-300-1 (left) can dim 1000 W of 400-Hz lighting. It comes in both airborne ($233) and commercial versions ($204). Model CSO-300-1 ($173) is an SCR trigger, mountable on 1.5-in. centers. Omnionics vercor, 1111 Mountain View Dr., N.E., Marietta, Ga. 30060. (404) 427-8259.

Circle 273 on Inquiry Card

PC BOARD RACKS

They are adjustable.

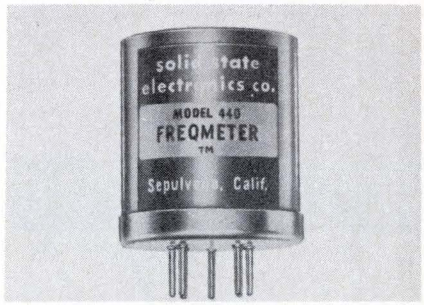


This new line of racks facilitates storing, stocking and transporting PC boards and/or assemblies. Racks come in 6, 8 and 20 inch widths, designated respectively as Models No. SMI-74-6, SMI-74-8 and SMI-74-20. Each rack has grooved guide rails which hold up to 45 cards and are adjustable from one inch to full width. Plastic guide rails are mounted on an aluminum base for strength. A card index slot on the aluminum frame permits all racks to be uniformly indexed by content and history. Siks Manufacturing Inc., 143 East 233rd St., Bronx, N. Y. 10470. (212) 892-8566.

Circle 274 on Inquiry Card

FREQUENCY-TO-DC CONVERTER

Solid state, operates −55 to +85°C.



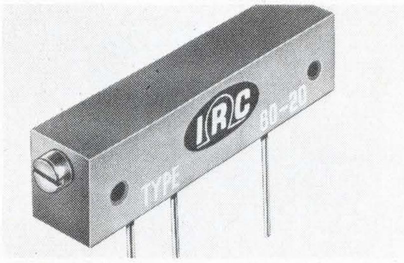
The Freqmeter linearly converts frequency or repetition rate of signals to a proportional dc voltage. This is accomplished with 4 standard models over an input frequency from zero to 100 kHz. Output is virtually insensitive to supply voltage, temp., input amplitude or waveforms. Units will also indicate the average freq. of random signals. The output may be used to drive meters, galvanometers, recorders, oscilloscopes, computers, digitizers or other indicating devices. Contact Edward Y. Politi, Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343.

Circle 275 on Inquiry Card

EE NEW PRODUCTS

WIREWOUND TRIMMER

Several lead configurations available.

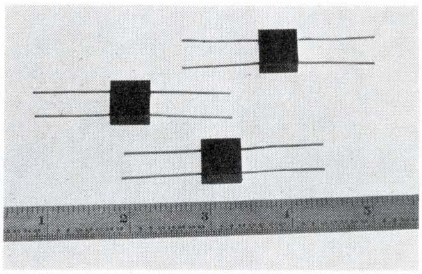


Type 60 has many features of the more expensive MIL types. It meets MIL Std. 202 tests for load life, humidity, shock, and vibration. It has a res. range from 10 Ω to 50 kΩ; tol. is ±10% with a power rating of 1 W at 70°C, derated to 0 at 125°C; temp. range is −55° to +125°C. IRC Div., TRW Inc., 2801 72nd St., N., St. Petersburg, Fla. 33733.

Circle 279 on Inquiry Card

SILICON BRIDGES

Sizes as small as 0.5 x 0.5 x 0.250 in.

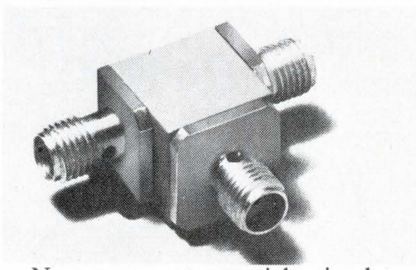


New 2-A single phase, full wave rectifier bridge features controlled avalanche and reverse recoveries from 50 to 400 ns. Each leg of the bridge has a double glass seal for hermeticity. Available in mechanical form factors for PC boards, cordwood, and other mountings. MicroSemiconductor Corp., 11250 Playa Court, Culver City, Calif. 90230. (213) 391-8271.

Circle 280 on Inquiry Card

X-BAND CIRCULATOR

Weighs about 1 oz.



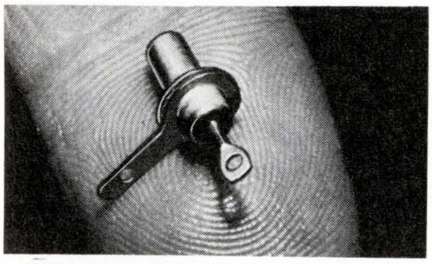
New compact coaxial circulator (MA-7K164) has high isolation of 20 dB minimum, with ~ low loss of 0.3 dB maximum over the frequency range of 8.5 to 9.6 GHz. Peak power is 1 kW and VSWR 1.2 maximum. Microwave Associates, Burlington, Mass. 01803. (617) 272-3000.

Circle 281 on Inquiry Card

EE NEW PRODUCTS

GAS-FILLED DIODES

Protect MOS-FETs.

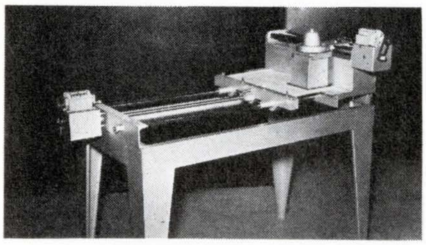


Metal diodes protect elements in applications where fast firing, low leakage current, and relatively low firing voltage are needed. Inherent firing voltage is 80 to 89 V. While the puncture voltage of MOS-FETs is generally lower than 85 V, this 85-V diode protects lower puncture voltages by appropriate biasing of the diodes. Victoreen Instrument Div., 10101 Woodland Ave., Cleveland, Ohio 44104.

Circle 282 on Inquiry Card

PHOTOGRAPHIC DUPLICATOR

For PC boards.

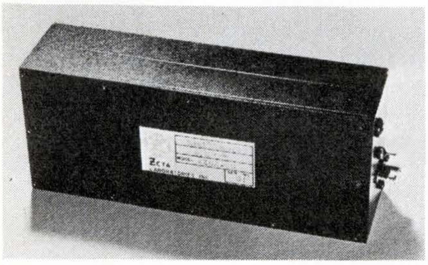


This printer makes it practical for small quantity users to make their own high quality multiple silk screen positives for PC boards. Using a negative or Mylar film, it prints five automatic exposures per minute on a roll of paper or film. Klann Inc., Box 2398, Waynesboro, Va. 22980. (703) 942-8351.

Circle 283 on Inquiry Card

X-BAND TRANSMITTER

It's crystal-controlled.



Model 4202 transmitter provides 200 mW output at 9.0 GHz. Frequency stab. is ±0.003% over temp. range of −20° to +65°C; input is 7 W at 28 V. All spurious and harmonic outputs are 75 dB below the carrier. Zeta Laboratories, Inc., 616 National Ave., Mountain View, Calif. 94040. (415) 961-9050.

Circle 284 on Inquiry Card

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, *About a new management discipline of growing importance*

Sponsored by

The Electronic Engineer Magazine

these form the content of the Seminars and that is why they are being made available to those engineers who wish to participate.

The Seminar material is based on Booz • Allen & Hamilton's extensive consulting experience in project management which included the development of project plans and control systems for over 1,000 projects involving the expenditure of many billions of dollars. Active participation in the Seminars can not only improve your own skills but will also make you a more valuable asset to your company.

INQUIRE NOW

Seminars are now being formed for the following locations and dates:

Boston April 28-30 at Somerset Hotel

Washington May 26-28 at University Club

San Francisco June 23-25 at Fairmount Hotel

Reservations are very limited, so please register early to avoid disappointment.

Professional personnel from Booz • Allen & Hamilton, one of the world's largest management consulting organizations, will personally instruct and supervise the Seminars which are sponsored by The Electronic Engineer. For further information regarding dates, fees and other pertinent particulars, please write to:

J. E. Hickey, Managing Editor
The Electronic Engineer
Chestnut & 56th Streets
Philadelphia, Pa. 19139

A brochure containing all the important details will be sent to you by return mail.

EE

The Electronic Engineer

EE READ THESE BOOKS

Introduction to Automata

By R. J. Nelson. Published 1968 by John Wiley & Sons, Inc., 605 Third Ave., New York, N. Y. 10016. Price $12.95. 400 pages.

A unified scientific discipline has emerged from mathematical inquiries related to digital computer circuits, programming, language translation, and nerve networks. Its name: Automata. It deals with the mathematical ideas which underlie such subjects as the abovementioned in terms of one central model.

This book, an introduction to Automata, is mainly for mathematicians and philosophers, as well as for scientists and engineers. Yet, the detailed mathematical treatment is self-contained, and hence non-mathematicians will be able to follow it. One limitation of the book, however, is that it does not discuss empirical questions.

Transmission Lines for Digital and Communication Networks

By Richard E. Matick. Published 1969 by McGraw-Hill Book Co., 330 W. 42nd St., New York, N. Y. 10036. Price $14.50. 360 pages.

This is a comprehensive book for engineers who are seriously involved in transmission lines for high frequency and high speed pulse applications. Even so the author's approach allows those not acquainted with transmission lines to easily acquire the basic concepts using nothing more than simple ac circuit analysis.

It is a good reference source for those who are already operating in this field. At the end of each chapter are few questions with the answers supplied to help you find the high points of that chapter.

Non-linear Systems

By Dragoslav Siljak. Published 1969 by John Wiley & Sons, Inc., 605 Third Ave., New York, N. Y. 10016. Price $22.95. 618 pages.

The book presents new analytical and graphical methods for parameter analysis design of high-order non-linear systems common in practical situations. This text is for graduate-level courses on system analysis and design.

It presents, in self-contained form, results of research on parameter analysis and design of non-linear dynamic systems. The results are based upon methods developed in Russian and Belgrade school of Automation and System Analysis.

By applying the proposed methods, in this book the designer is able to choose the parameter so that the non-linear system has the desired response characteristics.

Principles of High Resolution Radar

By August W. Rihaczek. Published 1969 by McGraw-Hill Book Co., 330 West 42nd St., New York, N. Y. 10036. Price $19.50. 487 pages.

While the book develops a comprehensive theory covering this subject, it is written so that it can be readily understood by the non-specialist also. The author avoids the use of complicated mathematics so as not to mask the underlying principles, hence making the book even more meaningful. Those involved in radar development works will find this a useful publication for their own library.

Introductory Topological Analysis of Electrical Networks

By Shu-Park Chan. Published 1969 by Holt, Rinehart & Winston, Inc., 383 Madison Ave., New York, N. Y. 10017. Price $15.95. 482 pages.

The introduction in this book to topological analysis electrical networks requires only a first course in circuits as a prerequisite.

A large number of illustrative samples are included throughout the book to aid the reader in understanding concepts involved. Definitions and theorems are precisely stated with proofs included within the scope of the material.

Most chapters contain an introduction outlining the coverage of that chapter and have a summary section which tabluates the important results for your future reference.

Designing with Linear Integrated Circuits.

Edited by Gerry Eimbinder. Published 1969 by John Wiley & Sons, Inc., 605 Third Ave., New York, N. Y. 10016. Price $10.95. 301 pages.

The book is a collection of chapters written by various recognized leaders in the integrated circuit application field. It covers large numbers of linear circuit applications that an engineer is likely to encounter.

Semiconductor Power Circuits Handbook

Compiled by the Applications Engineering Dept. of Motorola Semicoductor Products Inc., P.O. Box 9555, Phoenix, Ariz. 85001. 264 pages. Price $2.00.

Semiconductors: From A to Z

By Philip Dahlen. Published 1969 by Tab Books, Blue Ridge Summit, Pa. 17214. 272 pages Price $7.95.

Transistor and Diode Laboratory Course

By Harry E. Stockman. Published 1969 by Hayden Book Co., Inc., 116 W. 14th St., New York, N.Y. 10011. Price $3.95. 117 pages.

Handbook of Coaxial Microwave Measurements

By David A. Gray. Published 1968 by General Radio Co., West Concord, Mass. 01781. Price $2.00. 163 pages.

Electronics Reference Data Book

By Norman H. Crowhurst. Published 1969 by Tab Books, Blue Ridge Summit, Pa. 17214. Price $7.95. 227 pages.

Mechanics: Point Objects and Particles

By Terry Tiffet. Published 1968 by John Wiley & Sons, Inc., Publishers, 605 Third Ave., New York, N. Y. 10016. Price $14.95. 546 pages.

EE LITERATURE

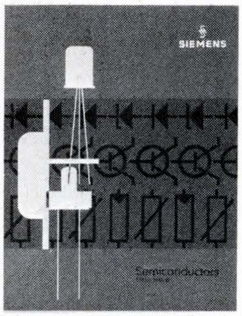
Light measurement

Application Note 580-3, titled "Light Measurement Terminology," provides simplified formulas and definitions of photometric and radiometric terms. The note deals with source configurations (line, point, or plane) and the various types of photometric and radiometric measurements that can be made of these sources. EG&G, Electronic Products Div., 160 Brookline Ave., Boston, Mass. 02215.

Circle 321 on Inquiry Card

Semiconductor source

A 32-page buyer's guide covers standard and industrial semiconductors. The 1968/69 catalog provides data on a range of semiconductors



from silicon and germanium devices to Hall effect devices and digital ICs. Complete specs are included. Siemens America Inc., 350 Fifth Ave., New York, N. Y. 10001.

Circle 322 on Inquiry Card

Digital instrumentation

A literature package, titled "Ortec Digital Modules—Economical Route to Computer-Compatible Data Collection," discusses digital data handling instruments. An applications note and a selection guide are included in the 30-page package, as are several spec sheets. Ortec Incorporated, 219 Midland Rd., Oak Ridge, Tenn. 37830.

Circle 323 on Inquiry Card

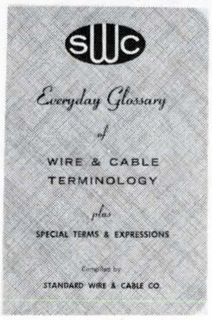
Templates

A line of time-saving drawing, designing, and sketching templates for engineers is described in a 1969 catalog. Included are prices, descriptive literature, and an order form. Plasticoid Products, Inc., Powder Hollow, Hazardville, Conn. 06036.

Circle 324 on Inquiry Card

Wire and cable glossary

This 1969 edition of a wire and cable glossary will help you in dealing with wire and wire problems. The 66-



page pocket-size booklet alphabetically lists terms, expressions, and units used in the electrical wire and cable industry. A wire data chart is also included. Standard Wire & Cable Co., 3440 Overland Ave., Los Angeles, Calif. 90034.

Circle 325 on Inquiry Card

Fluidic switches

The "Sensiflex Fluidics Manual" describes a line of fluidic switches and their applications. It provides details on how to utilize the proved advantages of fluidics, gives complete specs, and includes a series of case histories. Gagne Associates, Inc., 50 Wall St., Binghamton, N. Y. 13901.

Circle 326 on Inquiry Card

Power ICs and discretes

This 25-page condensed catalog makes it easy to select the best power integrated circuit or discrete power device for a particular application. Product descriptions, specs, and outline drawings are given for both lines of power devices. Bendix Semiconductor Div., South St., Holmdel, N.J. 07733.

Circle 327 on Inquiry Card

Transistor and dice guide

A handy 4-page guide features dice and wafer specifications. It provides electrical specs, dice geometrics, and substitution recommendations for a line of silicon, planar, epitaxial unencapsulated transistors. Packaging tips are included. National Semiconductor Corp., 2950 San Ysidro Way, Santa Clara, Calif. 95051.

Circle 328 on Inquiry Card

DTL integrated circuits

A handy DTL interchangeability guide cross references the part numbers of ITT's hermetically-sealed DTLs with the part numbers of five major manufacturers. The listings are divided into three main sections by package types: 14-lead ceramic dual in-line, low profile TO-5 style, and 14-lead ¼ by ¼ ceramic flat packs. ITT Semiconductors, Inquiry Services Dept., 3301 Electronics Way, West Palm Beach, Fla. 33407.

Circle 329 on Inquiry Card

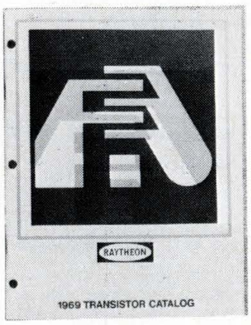
Control systems

The Series 16 data acquisition system is a standard hardware-software package which performs basic data acquisition functions. Its contemporary, the Series 16 direct digital control system, is a modular hardware-software functional package for the process control industry. System descriptions, function data, and software and application information are supplied in two 12-page brochures. Honeywell, Computer Control Div., Old Connecticut Path, Framingham, Mass. 01701.

Circle 330 on Inquiry Card

Silicon transistors

This 74-page catalog covers almost 400 types of high-reliability silicon transistors. Tabulated specs of transistors for a variety of applications are given in the 1969 edition. Also included are new listings and specs of



poly chip devices, npn/pnp complimentary duals, uhf high power amplifiers, and NASA approved types. Maximum ratings and electrical characteristics are provided for each unit. Raytheon Co., Semiconductor Operation, 350 Ellis St., Mountain View, Calif. 94040.

Circle 331 on Inquiry Card

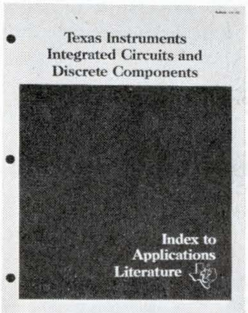
Traveling wave tubes

A short-form catalog describes the division's products. High-power and medium-power traveling wave tubes, TWT amplifiers, backward-wave oscillators, solid-state devices, and lasers are covered. Hughes Electron Dynamics Div., 3100 W. Lomita Blvd., Torrance, Calif. 90509.

Circle 332 on Inquiry Card

Component applications

This 8-page booklet contains abstracts of over 50 application reports and notes related to solid-state devices and integrated circuits. All literature



is cross-referenced both by circuit type and product type. Texas Instruments Incorporated, Inquiry Answering Service, Box 5012, MS 308, Dallas, Tex. 75222.

Circle 333 on Inquiry Card

Analyzers and generators

Featured in a 28-page catalog are several plug-in spectrum analyzers, with various ranges of operation. Sweep generators, audio two-tone generators, a signal alternator, and a plug-in power supply are also covered. Nelson-Ross Electronics Inc., 5-05 Burns Ave., Hicksville, N.Y. 11801.

Circle 334 on Inquiry Card

Transistor selection guide

A complete rundown of the company's power transistors is given in an 8-page folder. Selection is facilitated by the use of charts which are set up according to construction of the transistors. Outline drawings, a numerical listing of the devices, and characteristic curves are included. Transitron Electronic Corp., 168 Albion St., Wakefield, Mass. 01880.

Circle 335 on Inquiry Card

Nut fasteners

"How to select the proper nut fastening . . . " is the subject and title of this 12-page pocket-size guide. The booklet features a handy index which describes various applications and their requirements and explains the best nut fastening for the purpose and the reasons why. Reference AS-1101 also reviews the company's many nut products. Shakeproof Div., Illinois Tool Works Inc., St. Charles Rd., Elgin, Ill. 60120.

Circle 336 on Inquiry Card

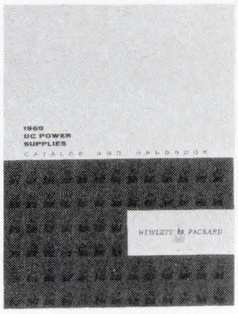
Microminiature relays

Bulletin No. 90 provides details on TO-5 size microminiature relays. These hermetically sealed DPDT relays are rated 1 A at 32 Vdc and meet applicable requirements of MIL-R-5757. Specifications, along with environmental and quality control procedures, are discussed in the 4-page bulletin. Hi-G Inc., Spring St. and Route 75, Windsor Locks, Conn. 06096.

Circle 337 on Inquiry Card

Power supplies handbook

You'll find the complete HP line of dc power supplies listed in this 82-page catalog. To help you choose the supply that best meets your needs, a selection guide and condensed listing are included in the 1969 catalog and



handbook. The handbook portion discusses power supply circuit principles, operating features, performance measurements, and special applications of regulated dc power supplies. Hewlett-Packard Co., Jersey Div., 100 Locust Ave., Berkeley Heights, N. J. 07922.

Circle 338 on Inquiry Card

Lock-in amplifiers

A 4-page application note describes four applications of lock-in amplifiers. These include amplifier crosstalk measurement, sensitive bridge null detection, op-amp open-loop gain measurement, and low-level impedance measurement. Note T-192A also covers the theory of operation of the lock-in amplifier. Princeton Applied Research Corp., Box 565, Princeton, N.J. 08540.

Circle 339 on Inquiry Card

Frequency components

A 6-page condensed catalog describes the manufacturer's capability in the frequency control field and its frequency components now available to the electronics industry. Listed are a variety of precision quartz crystals, crystal oscillators, crystal filters, and tone-code modules. Motorola Communications and Electronics, Inc., 1301 E. Algonquin Rd., Schaumberg, Ill. 60172.

Circle 340 on Inquiry Card

Pressure transducers

Detailed in an 8-page brochure is a family of absolute, gage, and differential pressure transducers. The devices are available over the pressure ranges from 1 to 10,000 psi. A selection guide, data on construction and options, and illustrations are included. Genisco Technology Corp., Instruments Div., 1533 26th St., Santa Monica, Calif. 90404.

Circle 341 on Inquiry Card

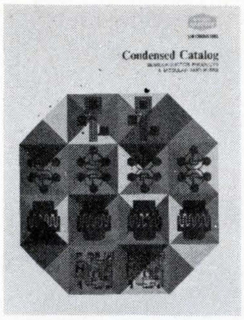
Static relays

A static relay is an all-electronic device used to perform many of the functions of conventional electro-mechanical relays, but at an increase in speed and operating life. Catalog 169 covers a line of static relays. Especially useful in the 4-pager is a performance comparison chart, which objectively compares the features of these devices to those of conventional types of relays. Flight Systems, Inc., Box 25, Mechanicsburg, Pa. 17055.

Circle 342 on Inquiry Card

Semiconductors

This 16-page condensed catalog is color-coded to help you quickly select from among the manufacturer's semiconductor products and modular amplifiers. Four product sections cover



field effect transistors, dual transistors, integrated circuits, and modular op amps. Especially helpful is a color-keyed transistor guide which visually relates all products listed to specific applications. Union Carbide, Semiconductor Dept., Box 23017, 8888 Balboa Ave., San Diego, Calif. 92123.

Circle 343 on Inquiry Card

Power sources

A 12-page catalog briefly describes a product line of high and low voltage dc regulated power sources. Included is a group of NIM configuration power sources for those using nuclear instrumentation. Power Designs, Inc., 1700 Shames Dr., Westbury, N.Y. 11590.

Circle 344 on Inquiry Card

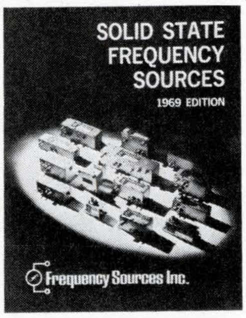
Fasteners

If you buy fasteners to MS, NAS, or AN specs, this 102-page price book will be a handy tool. Prices are listed for bolts, screws, clamps, clips, grommets, handles, hinges, keys, nuts, pins, retaining rings, rivets, spacers, springs, studs, terminals, and washers. Items are arranged numerically according to spec number. Supplementary data include tables of government specification materials, platings, and finishes; illustrations of screw head and point styles; and a table showing weights of rivets. Century Fasteners Corp., 20 Grand Ave., Brooklyn, N.Y. 11205.

Circle 345 on Inquiry Card

SS frequency sources

This 20-page 1969 catalog covers a line of microwave solid-state sources. These include voltaged tuned, cavity stabilized, crystal controlled, mechanically tuned, crystal stabilized (phase lock), and avalanche diode sources.



The catalog gives specs for more than 80 models, as well as application information and curves useful to the design engineer. Frequency Sources, Inc., Kennedy Dr., Box 159, North Chelmsford, Mass. 01863.

Circle 346 on Inquiry Card

RF components

A 6-page catalog gives specs and applications of double-balanced mixers, hybrids, power dividers, single-balanced mixers, switches, and balanced transformers. A spurious chart shows the relative amplitude of intermodulation products, and a two-tone graph shows third order products as a function of input level. Relcom, 2329 Charleston Rd., Mountain View, Calif. 94040.

Circle 347 on Inquiry Card

Electrolytic capacitors

Bulletins 2237 and 2239A (16 pages each) discuss axial lead aluminum electrolytic capacitors. Design and performance data and several pages of standard listings are given for the Type 056 capacitor and the Type 556 computer grade capacitor. Sangamo Electric Co., Capacitor Div., Box 128, Pickens, S.C. 29671.

Circle 348 on Inquiry Card

Delay line serial memories

"Serial Stores Using Delay Lines" is the title of a guide to delay line types of serial memories. The booklet presents the theory of operation and covers the capabilities and limitations of glass, quartz, and wiresonic type digital stores for specific applications. Factors to consider for choosing the correct type of ultrasonic store for buffer applications are listed. Tables provide data such as delay shift versus temperature and price per bit. Andersen Labs., 1280 Blue Hills Ave., Bloomfield, Conn. 06002.

Circle 349 on Inquiry Card

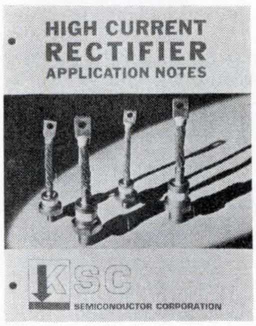
Terminal systems

Ten pages of tech data cover three different terminal systems: integrated, standard, and relay terminal systems. Application information, advantages, physical and electrical characteristics, and illustrations are given for each. Dorne & Margolin, Inc., General Commercial Products Div., 1735 Goldbach Ave., Ronkonkoma, N.Y. 11779.

Circle 350 on Inquiry Card

High current rectifiers

Characteristics and application conditions for a series of high current rectifiers are discussed in a 6-page



application note. Included in the note are ratings, specs, mechanical outlines, and operating curves. KSC Semiconductor Corp., KSC Way (Katrina Rd.), Chelmsford, Mass. 01824.

Circle 351 on Inquiry Card

Power controls

SCR power control units using two different methods of proportional control—phase angle and synchronous firing—are discussed in a 9-page catalog. Their respective advantages and disadvantages are explained through text, tables, schematics, and illustrations. Magnetics Inc., Industrial Control Div., Sandy Lake, Pa. 16145.

Circle 352 on Inquiry Card

Closed-loop modules

Circuit design using closed-loop modules vs open-loop modules is discussed in a 6-page data sheet. Described is a module line compatible with monolithic dual in-line packaging. Operating and performance characteristics are included. Redcor Corp., Box 1031, Canoga Park, Calif. 91304.

Circle 353 on Inquiry Card

Connectors and splices

Catalog No. 441-7 describes Coaxiclamp™ connectors and splices for 50-Ω semi-rigid coaxial cable. The 6-page folder presents design features, performance data, assembly drawings, spec tables, tooling data, and so forth. AMP Incorporated, Harrisburg, Pa. 17105.

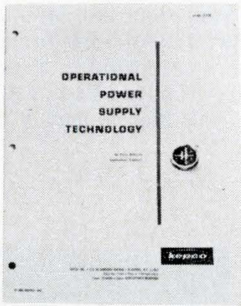
Circle 354 on Inquiry Card

Circle 70 on Inquiry Card

EE LITERATURE

Power supply technology

"Operational Power Supply Technology," a 12-page monograph, discusses the capabilities of modern dc regulators for the control of voltage



or current. It reviews the operational analogy for power supplies and contains many illustrations on the application of feedback theory for the purpose of control. Kepco, Inc., 131-38 Sanford Ave., Flushing, N.Y. 11352.

Circle 355 on Inquiry Card

Electronic components

An 18-page general line catalog covers a variety of components, including connectors, sockets, coaxial cable, switches, and twin lead. All are standard, off-the-shelf products. Photographs, line drawings, electrical characteristics, and mechanical specs are given in Catalog GL-1. Amphenol Distributor Div., The Bunker-Ramo Corp., 2875 S. 25th Ave., Broadview, Ill. 60153.

Circle 356 on Inquiry Card

Miniature rotary switches

A 16-page catalog covers several series of miniature rotary switches. Included are recent modifications such as units designed for printed circuit applications, plus switches with specially coded outputs. Technical specs are given for switches ranging from single-pole, 24-position to 12-pole, 2-position types. RCL Electronics, Inc., 700 S. 21st. St., Irvington, N.J. 07111.

Circle 357 on Inquiry Card

Computer catalog

The SPC-12 automation computer is the subject of a 20-page technical bulletin. The publication is written to aid automation engineers and system designers in configuring automatic control systems from functional off-the-shelf building blocks. Data on the computer's functions, options, and specs are given. Automation Products Div., General Automation, Inc., 706 W. Katella, Orange, Calif. 92667.

Circle 358 on Inquiry Card

EE LITERATURE

Data compression

An 18-page booklet contains three separate bibliographies covering the published literature on data compression. The first bibliography covers material on pretransmission compression (data compression prior to transmission). The second covers pre-processing compression (data compression after transmission but prior to processing), and the third lists literature on error correction coding. SDS Publication 988019 is available from Scientific Data Systems, 701 S. Aviation Blvd., El Segundo, Calif. 90245.

Circle 359 on Inquiry Card

Microwave absorbers

This 6-page folder will provide the design engineer with a variety of information on high loss dielectrics and electromagnetic absorbing materials. Product and application descriptions are given for the full Eccosorb® line. Especially useful are a properties chart and an application selector table. Emerson & Cuming, Inc., Microwave Products Div., Canton, Mass. 02021.

Circle 360 on Inquiry Card

Time-delay relays

A 24-page guide offers information for selecting the right solid-state time-delay relay. Engineering data, selec-

tion tables, and dimension diagrams for relays, voltage sensors, and dry reed time delays are included, as are schematics and specs. Potter & Brumfield, Princeton, Ind. 47570.

Circle 361 on Inquiry Card

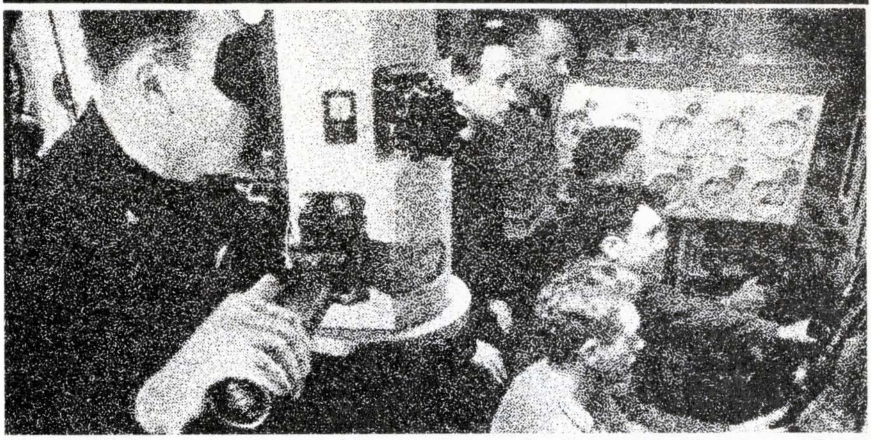
Delay lines

A 12-page catalog gives definitions and formulas for delay time, rise time, pulse attenuation, pulse amplitude, characteristic impedance, and bandwidth. Intended as a manual for specifying delay lines, it covers a variety of the manufacturer's standard devices. JFD Electronics Co., Components Div., 15th Ave. at 62nd St., Brooklyn, N.Y. 11219.

Circle 362 on Inquiry Card

MB Environmental Dynamics

Anaylsis Instruments · Signal Conditioning · Electrohydraulics · Pressure Measurement · Vibration Systems



Zero Drive* system ideal for quieting studies and on-board monitoring applications

The Zero Drive data acquisition system was developed to overcome the limitations of conventional data transmission systems utilizing charge and voltage amplifiers. By effectively eliminating impedance, it eliminates cable noise and makes it possible to obtain signals over a broader frequency range than ever before. Because cable effects are eliminated ordinary two wire cable can be used.

Data from any self-generating transducer—pressure, shock, vibration, acoustic—can be transmitted without loss of signal strength. All that is required at the transducer is a small, solid state "Line Driver" which eliminates the need for live equipment or amplification at or near the signal source. No power is used, no noise is introduced, no cable problems arise. At the console, the N400 amplifier—a standard, off-the-shelf unit--provides a high level, calibrated output for use with control systems, tape recorders and/or other data acquisition/reduction equipment.

**Patent Pending*

Reader Service No. 101

Series 500 systems measure pressure accurately, electronically

Incorporating high accuracy ($\pm 0.5\%$) Series 500 transducers and N928 or N929 indicators, MB pressure measuring systems are all electronic. Employing the bonded strain gage principle, Series 500

transducers have no moving parts, no linkages, no silicones or other fluids. As a result there is no wear, no maintenance. The systems measure static and dynamic pressures—without snubbers. They have proved ideal for pressure measurements in the laboratory as well as in OEM and field applications.

The N928 and N929 have built-in solid state transducer power supplies and operate on normal AC lines. An additional feature of the N929 is a high/low alarm setting which also permits it to be used as a controller.

Reader Service No. 103

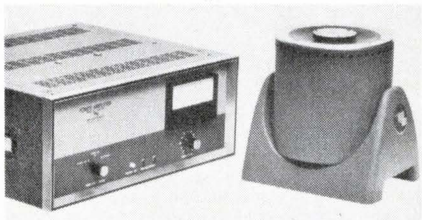
Spectrum analysis described

A new, basic-to-advanced technology description and application review will be found in an MB brochure which describes the T-1000 Spectrum Analyzer. Credited as the world's most accurate analyzer, the T-1000 offers broad applications in determining Fourier Series; PSD Analysis; Fourier Spectrum; and Random, Transient and Complex Signal Analysis, all of which are covered in Bulletin No. 214.

Reader Service No. 104

Use of small vibration test systems considered unlimited

The range of known materials and products being tested and evaluated on MB PM Systems is so vast that no limit is foreseen on their expanding use. Wire, automotive transmissions, human arteries, plastics—these are but a few of the known test subjects. Any R&D lab can establish its own vibration test facility for under $1,500 with a PM shaker and amplifier.



Reader Service No. 102

MB ELECTRONICS

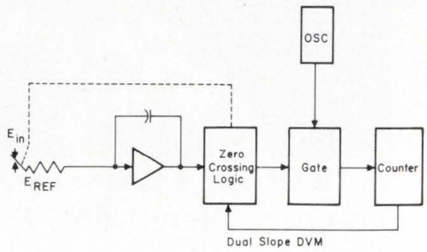
A textron COMPANY

P.O. BOX 1825, NEW HAVEN, CONNECTICUT 06508
Tel. (203) 389-1511 Twx 710 465-3283 Telex 0963-437

EE LITERATURE

Instrumentation guide

Electronic engineers will find this 308-page hard-cover book a useful guide for selecting instrumentation. Along with photographs, diagrams, and spec lists, the 68/69 handbook provides product descriptions, technical data, and application notes on the company's wide range of instruments.



Signal sources, signal conditioning instruments, signal monitoring instruments, analog recording instruments, data acquisition systems, and precision measuring instruments are described. There is also data on biomedical monitoring and recording systems, RFI/EMI surveillance and analysis units, and instrumentation cabinets. Honeywell Inc., Test Instruments Div., 4800 E. Dry Creek Rd., Denver, Colo.

Circle 363 on Inquiry Card

Ultrasonic cleaning

The principles of ultrasonic cleaning are outlined in an 8-page booklet. The publication discusses various cleaning methods and the equipment needed for each. It describes ultrasonic generators and transducers and explains cavitation, frequency selection, power density, modulation, and automatic tuning. Guides to the purchase and evaluation of cleaning equipment are also included. National Ultrasonic Div., Phillips Manufacturing Co., 7334 N. Clark St., Chicago, Ill. 60626.

Circle 364 on Inquiry Card

FET selection guide

A complete line of field-effect transistors is listed in a 6-page fold-out guide and cross reference chart. The more than 100 JFET and MOSFET types are categorized by application: multi-purpose amps, rf amps and mixers, general switching devices, choppers, matched pairs, and tight (2:1 ratio) I_{DSS} ranges. A handy chart cross-references the industry's types to the company's nearest equivalent. For bulletin SG-15, write on your company letterhead to Motorola Semiconductor Products, Inc., Box 20924, Phoenix, Ariz. 85036.

E-E LITERATURE

Video transmission

"Video Transmission Techniques," a 51-page booklet, will familiarize you with the technicalities of video distribution. It describes the problems encountered in routing video through cable, and presents the solutions. Diagrams, text, photos, charts, and tables are included, as is an appendix containing a handy 6-page glossary. Dynair Electronics, Inc., 6360 Federal Blvd., San Diego, Calif. 92114.

Circle 365 on Inquiry Card

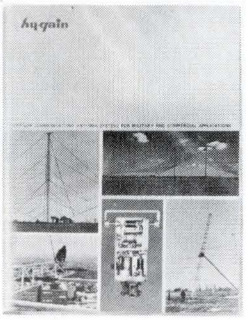
Condensed keyboards

"Condensed Keyboard Guide," a 15-pager, reviews the major features of the division's new wired and encoded solid-state keyboards. The booklet describes the use of the Hall effect to produce an analog control voltage. Product descriptions and a review of encoding techniques and interface outputs are included. Micro Switch, a division of Honeywell, Inc., 11 W. Spring St., Freeport, Ill. 61032.

Circle 366 on Inquiry Card

Antenna systems

Antennas and antenna systems covering the frequency range of 2 MHz to 1100 MHz are the subject of a 64-



page catalog. Most of the items are available for off-the-shelf delivery, in kit form, as systems, or installed. Hy-Gain Electronics Corp., Box 868, Lincoln, Neb. 68501.

Circle 367 on Inquiry Card

Industrial fasteners

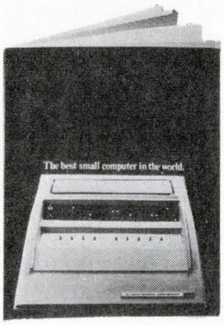
This 8-page bulletin gives descriptions, specs, and special features of a line of die cast, zinc alloy industrial fasteners. These fasteners come in a range of sizes and threads in wing nut, cap nut, thumb nut, thumb and wing screw types. Their advantages, along with the die casting method itself, are also discussed. Gries Reproducer Co., 400 Beechwood Ave., New Rochelle, N. Y. 10802.

Circle 368 on Inquiry Card

EE LITERATURE

Computer catalog

The Nova, a 16-bit word general purpose computer priced at $7950, is the subject of a 16-page brochure. Over half of the machine's circuits are MSI. The booklet includes a discussion



of new small computers and describes the hardware, input, output, facilities, instruction set, and software for the Nova. Data General Corp., 275 Cox St., Hudson, Mass. 01749.

Circle 369 on Inquiry Card

Sample-and-hold circuits

This application note explains the terms used in defining sample-and-hold circuits. Aperture time, dielectric absorption, and settling time are covered, and the interrelation of acquisition time, drift, and capacitance is shown graphically. Data Device Corp., 100 Tec St., Hicksville, N.Y. 11801.

Circle 370 on Inquiry Card

Crystal controlled oscillators

Photographs, line drawings, electrical characteristics, and mechanical specs for a line of miniature precision crystal controlled oscillators are given in a 12-page catalog (501-5M-1268). Also included is a cross-referenced selection chart. McCoy Electronics Co., a subsidiary of Oak Electro/Netics Corp., Mt. Holly Springs, Pa. 17065.

Circle 371 on Inquiry Card

EE LITERATURE

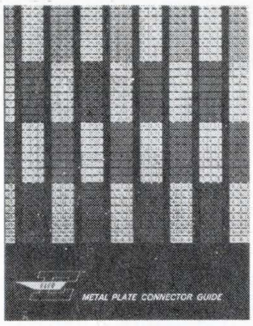
AC induction motors

A line of compact aerospace induction motors for aircraft, missiles, ground support, and industrial applications is the subject of Bulletin A-5138 (10 pages). Tables and drawings show specifications and variations for several types, and photos and notes illustrate a wide range of applications. Kearfott Products Div., Singer-General Precision, Inc., 12690 Elmwood Ave., N.W., Cleveland, Ohio 44111.

Circle 372 on Inquiry Card

Metal plate connectors

This 1969 "Metal Plate Connector Guide" describes the lines of standard components in the Variplate™ back panel interconnecting system. It also gives valuable hints on back panel design. There is an in-depth discussion on the plate concept and a capability profile on the company's in-house wiring service. Components covered in the 32-pager include voltage planes, power bus bars, ground planes, input/output connectors, PC card-edge connectors, hermaphroditic contact connectors, fork and blade connectors, and PC card guides. Elco Corp., Willow Grove, Pa. 19090.



Circle 373 on Inquiry Card

Thermoplastic fabrication

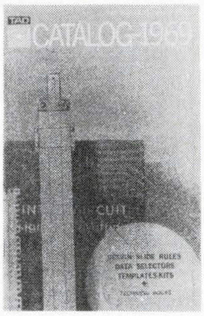
A new thermoplastic fabrication service is the subject of a 4-page folder. The publication lists typical modern thermoplastic resins and discusses the company's capabilities. Synthane Corp., 12 River Rd., Oaks, Pa. 19456.

Circle 374 on Inquiry Card

EE LITERATURE

Designers' aids

In this handy 32-page booklet you'll find descriptions of a variety of time-saving devices and reference books. Listed in the 1969 catalog are design



slide rules and calculators, drafting templates, handbooks, manuals, technical books, curves, kits, converters, and other aids to make your job easier. Tad Products Corp., 639 Massachusetts Ave., Cambridge, Mass. 02139.

Circle 375 on Inquiry Card

Coaxial attenuators

Criteria for selecting the right microwave attenuators for a particular application is the subject of this 12-page issue of "Narda Probe". The prime article describes how to select and specify coaxial attenuators and the various trade-offs that may be made to get the optimum component at the lowest cost. The Narda Microwave Corp., Commercial St., Plainview, N.Y. 11803.

Circle 376 on Inquiry Card

Microwave systems

This 4-page brochure (ETD-5208) is aimed at helping design engineers meet the challenge of new generation microwave systems. It discusses some of the capabilities and applications of GE microwave devices, and describes several of these units. General Electric Company, Bldg. 6, Rm. 206, Schenectady, N. Y. 12305.

Circle 377 on Inquiry Card

Drafting aids

Electrical and electronic component drafting aids are listed in Catalog 104. Included in the 68-page publication are shapes, symbols, and tapes for use in master artwork preparation, assem-

bly layouts, and schematic drawings. Printed wiring artwork techniques and a variety of other aids are described. Bishop Industries Corp., 7300 Radford Ave., North Hollywood, Calif. 91605.

Circle 378 on Inquiry Card

Computer products

This quick-reference pocket catalog (No. CO95) covers a full line of computer products. The 18-page guide will provide you with description and specs of magnetic tape drives, core memories, memory stacks, and bulk cores. Ampex Corp., Mail Stop 7-14, 401 Broadway, Redwood City, Calif. 94063.

Circle 379 on Inquiry Card

Visual image processing

An informative 12-page brochure simplifies the subject of visual information processing using examples of image analysis operations. Some of the applications discussed are interpreting seismograms and oscilloscope traces, reading cinetheodolite film, and enhancing photos that have indistinct shapes. Information International, 11161 W. Pico Blvd., Los Angeles, Calif. 90064.

Circle 380 on Inquiry Card

EE LITERATURE

Frequency synthesizers

Application Note 96 describes the theory, performance, and applications of fast-switching "direct" frequency synthesizers. These devices can derive up to 5 billion spectrally-pure discrete frequencies from a single standard-frequency oscillator. One section of the 26-page note discusses spectral purity and how to measure it. Another section covers the programmable fast-switching capabilities of direct synthesizers, and what limitations there are on switching speed. Inquiries Mgr., Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304.

Circle 381 on Inquiry Card

Motor generators

An 8-page brochure describes the advantages of using motor generators as computer power sources. Product description, photographs, and performance curves are provided. Georator Corp., 315 Tudor Lane, Manassas, Va. 22110.

Circle 382 on Inquiry Card

Standard components

A 40-page catalog covers a line of standard components. These include shielded, non-shielded, and variable inductors; delay lines; ceramic, film and paper, and tantalum capacitors; wire-wound and thin-film resistors; and precision potentiometers. Nytronics, Inc., 550 Springfield Ave., Berkeley Heights, N.J. 07922.

Circle 383 on Inquiry Card

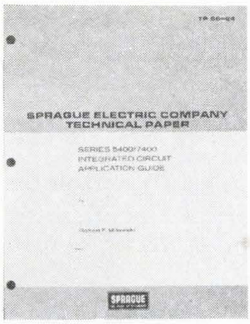
DC operational amplifiers

A 16-page catalog (C1008) gives detailed specs and typical applications for a complete line of dc solid-state op amps. There are also sections on terminology and measurement techniques. Products described include high performance economy models, microminiature units, high voltage and current models, minimum bias current and minimum drift models. Melcor Electronics Corp., 1750 New Highway, Farmingdale, N. Y. 11735.

Circle 384 on Inquiry Card

IC applications

The Series 5400/7400 integrated circuits—comprised of high speed TTL ICs and complex functions—are the subject of a 32-page booklet. The ap-



plication guide (TP 68-24) describes standard gate and flip-flop circuits in the series and explains their basic operation. It also includes a section on how to get the most from an integrated circuit technical data publication. Sprague Electric Co., Technical Literature Service, Marshall St., North Adams, Mass. 01247.

Circle 385 on Inquiry Card

Temperature transducers

Kit 4500 contains six bulletins (16 pages in all) on a family of temperature transducers. The bulletins describe design features and performance specs of immersion and surface type temperature transducers, each individually configured for specific applications. Electronic Instrumentation Group, Bell & Howell Co., 360 Sierra Madre Villa, Pasadena, Calif. 91109.

Circle 386 on Inquiry Card

Standard relays

The SC-4 RBM Standard Controls Catalog, a 20-pager, lists over 450 electronic relays and contactors. Replete with pictures, prices, technical data, and specs, it covers ac and dc general purpose relays, power contactors, industrial contactors, glass reed relays, and time delay relays. Essex International, Inc., Controls Div., 131 Godfrey St., Logansport, Ind. 46947.

Circle 387 on Inquiry Card

Advertisers—April 1969

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INTEGRATED CIRCUIT
HIGH STABILITY
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MODEL
UPM-16

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WITH BUILT-IN OVERVOLTAGE CROWBAR

	MODEL UPM-16	MODEL UPMD-56
Output:	5 or 6VDC at 5A 0-6V remotely programmable (current derated)	5 or 6VDC at 10A 0-6V remotely programmable (current derated)
Stability:	1MV per 8 hours	1MV per 8 hours
Regulation:	0.01% +2MV	0.01% +2MV
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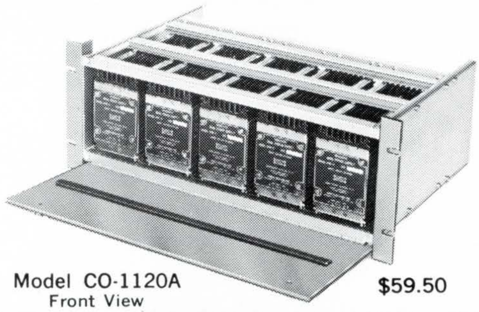
Ripple & Noise:	1MV peak-to-peak	1MV peak-to-peak
†Price:	$169.00	$225.00

Front Loading Power Supply Bin

Accommodates up to 5-UPM modules or 2-UPMD modules plus 1-UPM module or any combination thereof. The bin may be mounted within a standard 19 inch equipment cabinet.



Model CO-1120A
Front View

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Circle 2 on Inquiry Card

All New Cermolox Designs for VHF-TV and FM Broadcasts

Working in VHF-TV? Try RCA-8792, RCA-8806 and RCA-8807... new broadcast tubes from RCA that meet the high linearity and high gain requirements of up-to-date, reliable VHF-TV. If FM service suits you, choose RCA-8792, 8793 and 8794. All are Cermolox® tubes, developed from proved, in-use designs. They feature new lows in feed-through capacitance and screen and cathode inductance plus superb IM values. Available at surprisingly low cost, many of these RCA broadcast tubes lend themselves well not only to VHF-TV and FM, but to SSB, CW, and UHF Linear service as well. Investigate these RCA tubes for your needs. See your local RCA Representative or your RCA Distributor for details, including prices and delivery.

For technical data on specific types, write: RCA Electronic Components, Commercial Engineering, Section Q 19C, Harrison, N.J. 07029.

RCA-8807 (top), 20 kW Peak Sync.
RCA-8806 (center), 12.5 kW Peak Sync.
RCA-8792 (lower), 1 kW FM 1.5 kW Peak Sync.

RCA