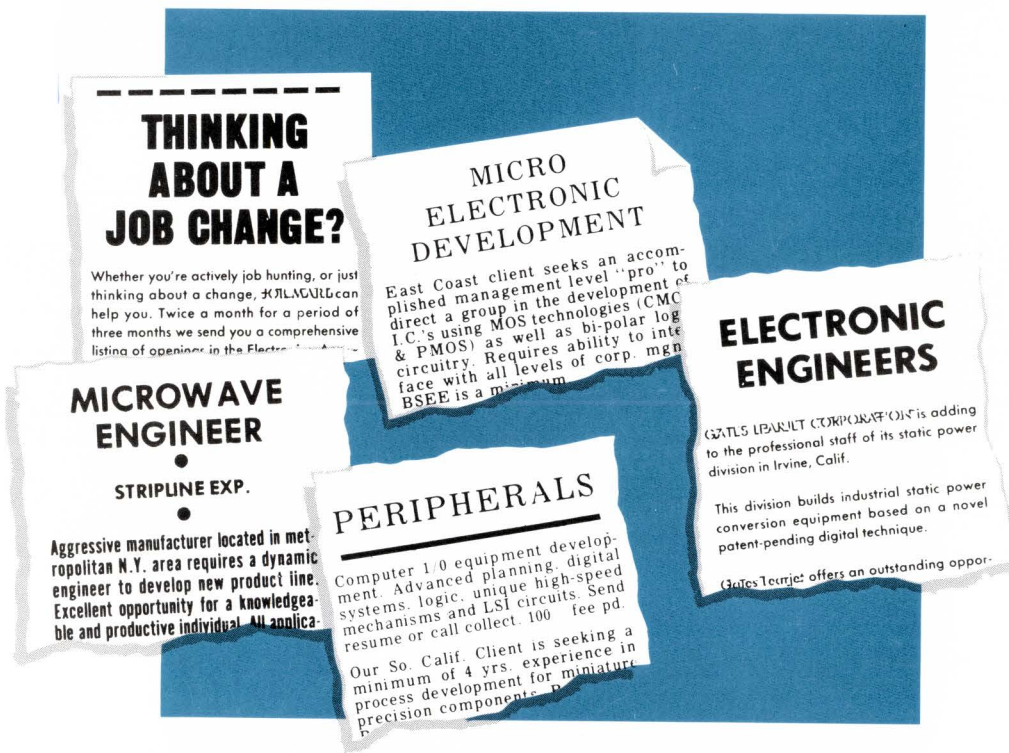
VOL. 29 NO. 10
OCTOBER 1970

CHILTON'S

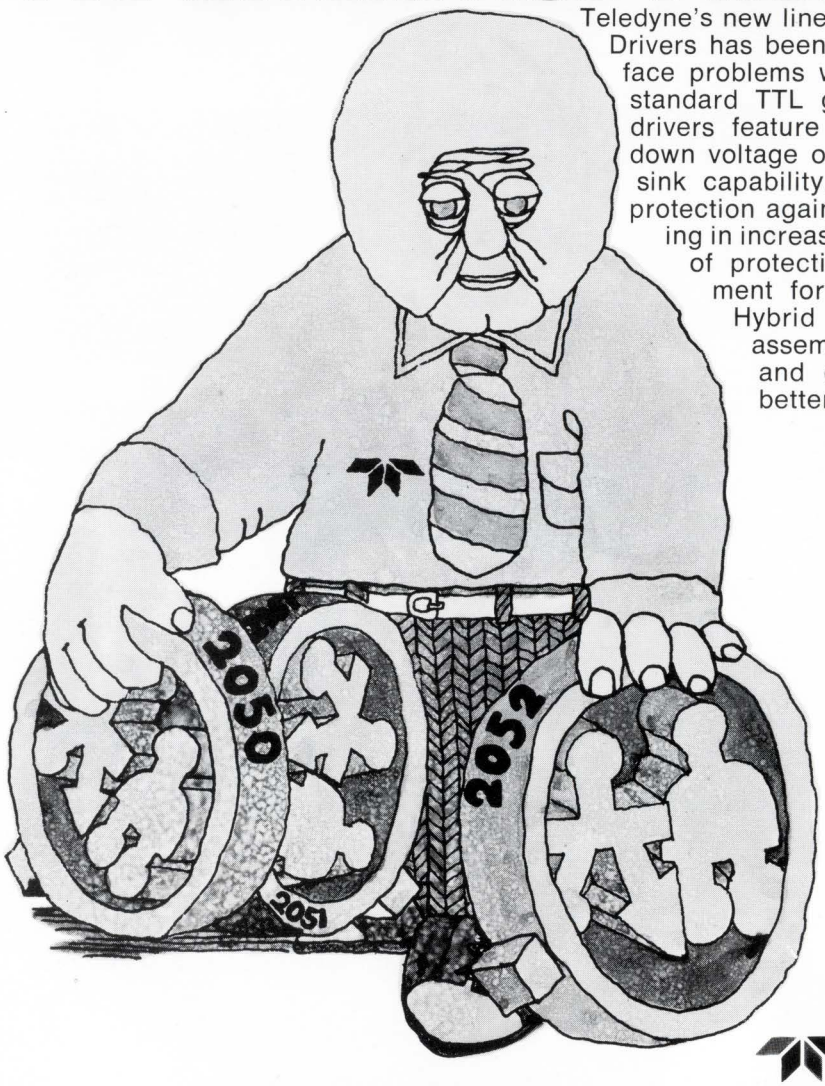
THE ELECTRONIC ENGINEER



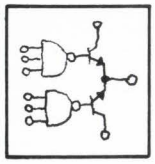
Aerospace engineers **can** find new jobs today in other electronics fields.

Testing complex MOS
Optoelectronics course — applications
Trimming hybrid resistors

TELEDYNE SEMICONDUCTOR HAS A NEW LINE OF 100V HYBRID DRIVERS FOR YOUR TTL INTERFACE PROBLEMS

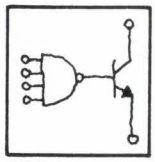


Teledyne's new line of 100V Hybrid Microcircuit Drivers has been designed to solve all interface problems where output capabilities of standard TTL gates are exceeded. These drivers feature a maximum output breakdown voltage of 100V with 250 mA current sink capability. Our 100V rating provides protection against voltage transients, resulting in increased reliability and elimination of protection circuitry. As a replacement for Discrete Components, the Hybrid Microcircuit Drivers reduce assembly problems, save space and optimize performance at a better price.

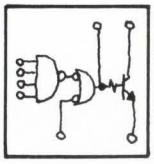


2050 CE
Dual Hybrid Microcircuit Driver

- ☐ Separate or Parallel Operation
- ☐ 500 mA current sink capability



2051 BE
Single Hybrid Microcircuit Driver



2052 BE
Hybrid Microcircuit Driver

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- ☐ Replacement for 40V - 2001 Hybrid Lamp Driver

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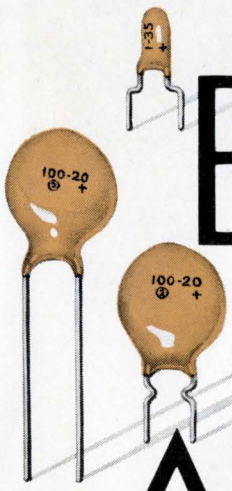

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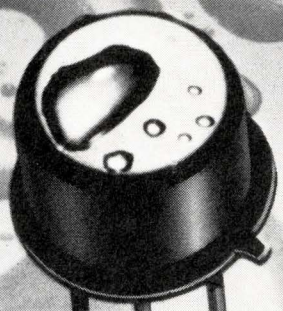

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Max. gate trigger current	200μa	200μa	200μa
Peak On-voltage	1.7V max. @ 1 Amp.	2.2V max. @ 4 Amps.	2.5V max. @ 4 Amps.
Package	TO-18 can, 0.5" leads	TO-5 can, 0.5" leads	TO-5 can, 1.5" leads

CHILTON'S
THE ELECTRONIC ENGINEER

October 1970 Vol. 29 No. 10

Departments

COVER

This month's cover story tells how three aerospace engineers found new jobs in other electronics fields. In his interview, each man explains the situation he was caught in when trying to make the change from aerospace. Medical electronics, engineering consulting, and space technology products are the new fields represented. Each man explains the adjustments facing today's aerospace engineer changing fields, and why he thinks the aerospace man can make these adjustments successfully.

FEATURES

THE ELECTRONIC ENGINEER

Vol. 29 No. 10 October 1970

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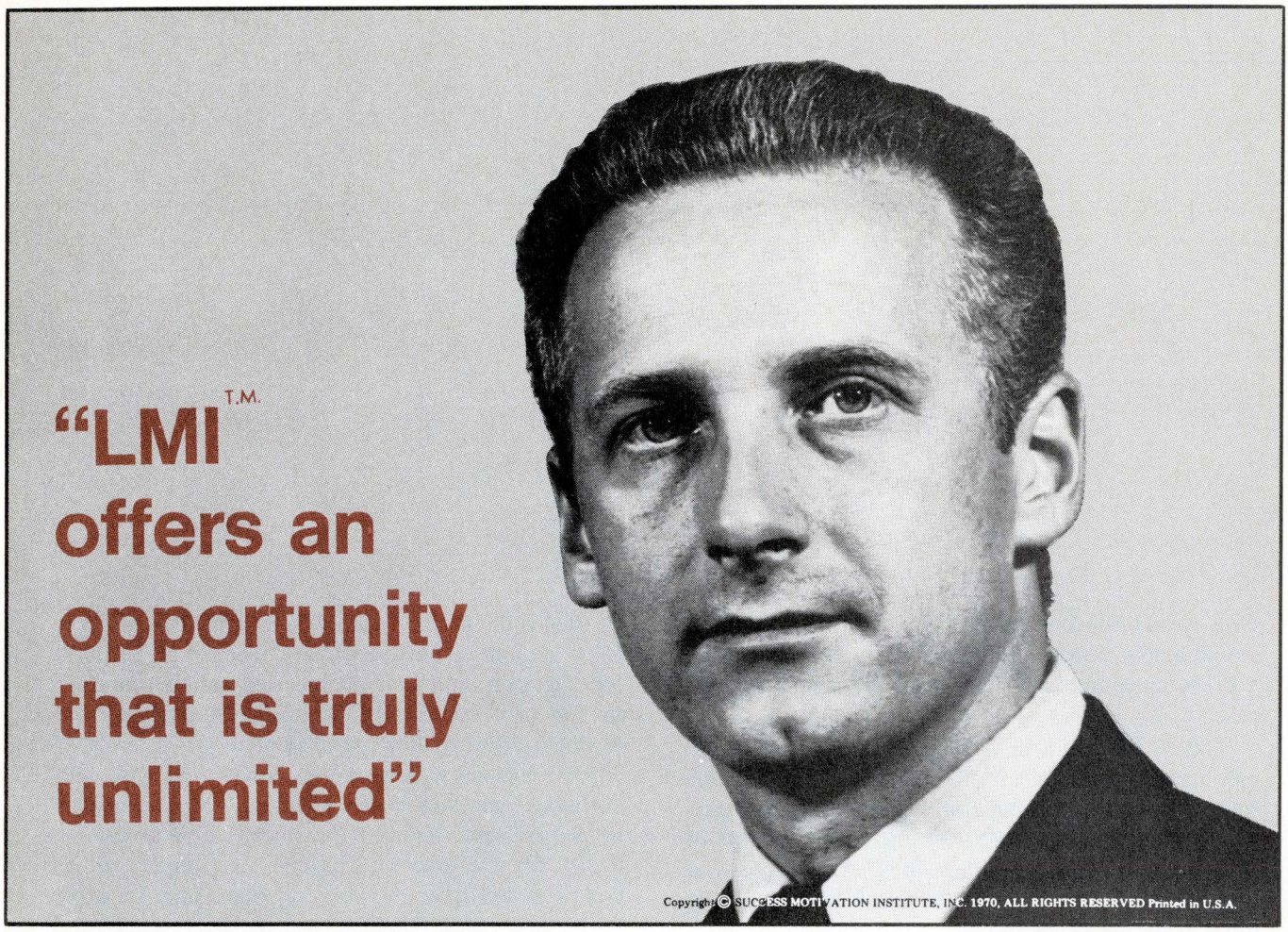

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A CALL FOR

One would think that by 1970, the United States would know how to handle a crisis . . . especially a crisis of technology. Unfortunately, that's not the case.

Today, the engineer is trapped in the vise of unemployment—one year after placing man on the moon. Harsh words, but true. The aerospace industry alone has laid off 25,000 engineers, 10,000 of them EEs. Will they get other jobs? And, those who do, will their jobs be in electronics? Unfortunately, only a relatively lucky few will—mostly in areas unrelated to defense and space.

So what are we to do? Well, for one thing, don't look for another editorial complaining about layoffs in this issue of **The Electronic Engineer**. Instead, we have devoted the next four pages of this magazine to an analysis of the causes of the layoffs, a suggestion for a constructive program to solve this mess, and a call for action to authorize this (and other) editor(s) to speak on your behalf in Washington where it will do the most good.

Unusual for a technical magazine? Perhaps. But no less important. After all, what good are articles on integrated circuits and computer-aided design for a man without a job? We editors of the electronic press have always tried to help you technically, by worrying about how you *do* your job. Today, it is even more important for us to worry whether you *have* a job.

Why the layoffs

The Pentagon has cut the defense budget for Fiscal Year 1971 by $7 billion compared with FY 1969. When you add the effect of inflation, which cheapens the remaining dollars, the effective cut (again compared with 1969) is almost $13 billion. Of this money, two-thirds will go for cancelled or aborted military contracts, which won't be replaced. If we assume a median annual income of $17,000 for engineers and that engineering salaries amount to 5% of a contract price, we have a payroll cut of about $430 million, equivalent to the salaries of 25,000 engineers. And that is just for defense and aerospace contractors. In addition, these cancellations have sent ripples of layoffs throughout the industry. By the time we evaluate their impact, other contracts will have run out and there may be none to replace them. That is, we are only seeing the beginning of an employment crisis among engineers.

For the more than 10,000 electronic engineers affected, and for the many more who will join their ranks in the next months, we see almost no chance for them to find jobs in electronics. At most, we estimate that the non-defense industry can absorb a few thousand, and that another two thousand or so will find openings in the new military contracts that have survived the cutbacks. For the others, for the six or seven thousand who will not find jobs, as well as for the many who will lose the ones they still have, there is nothing that suggests they will be able to find employment in the electronics industry.

And their plight, a plight we believe affects not only their future but that of the nation, is what prompted our call for action.

E pluribus unum

Certainly we believe in free enterprise, and feel confident that the electronics industry in the United States will be in good shape five years from now but, what about the rest of 1970 ? Or, worse yet, next year? The immediate prospects are for more unemployment among engineers, scaring many away from technology, or making them look for greener pastures in Western Europe, where electronics is still booming.

ACTION

Last month, I commented on an open letter to President Nixon, by Mr. Benjamin Friedman, Chairman of the Board of Solitron Devices Inc. Mr. Friedman called the President's attention to the engineers' plight, and to the great need the United States has for their talent if it intends to stay at the forefront of technology. In our editorial, **The Electronic Engineer** made a commitment to pick up the banner raised by Mr. Friedman. We also said that we intended to seek the cooperation of our editorial colleagues from other magazines in the electronics field to draft an action plan which we would take to the government.

While we are still holding preliminary meetings with other electronic editors, we editors are already compiling a list of specific proposals for us to take to Washington. The object of these proposals is to help the hard hit industry bridge the gap between the present slump and the time when it will be able, on its own, to absorb not only the talent available today, but also the new engineers who will be graduating in the next few years. This can only be done by giving it the incentive to develop the technology and products that will maintain this country's leadership in electronics.

What we propose

Therefore, the following is the essence of the points we want to propose to President Nixon and to Congressional leaders in Washington:

☐ That, in cooperation with industry representatives, the government identify a set of specific electronic products and systems of immediate need—such as data terminals, video recorders, and equipment for data communications—for which it will sponsor industrial development, much as the Japanese government helps its electronics industry develop specific products with marketing and user research, low cost loans, and help with exports.

☐ That, in cooperation with professional groups from engineering, medicine and education, the government draft standards for medical electronics and for educational equipment, which will foster the development of technologically sound equipment for such specialties over the next five years.

☐ That, a similar cooperation and commitment be made to develop, over the next ten years, the instruments and systems necessary to control and combat environmental pollution.

We are convinced that the country that produces the equipment for communications, medicine, and pollution control, to name but a few areas, will be ahead in the 70's. Hence, the government must take practical steps to encourage industry to employ our available engineering talent to develop such products.

While we draft these proposals, we need your support. If your editors are going to speak in your name and for your sake, we need to show a tangible proof that you approve of our actions. Turn the page, read and fill one of the coupons, and mail it to us. Pass the others to your fellow electronic engineers, and ask them to join in this crusade.

There is nothing to lose, and much to gain. If we accomplish nothing, at least we would make your representatives in Washington aware of your colleagues' plight. If we succeed in convincing the government to endorse one or more of our proposals, our industry will be the better for it, and many jobs will be saved. One of them may be your own.

Alberto Socolovsky
Editor

FIGHT for your future ...*TODAY*

If you agree with the editors of *The Electronic Engineer* that now—*today*—is the time to rally to the support of the tens of thousands of engineers who are unemployed because they have been separated from government-related electronics projects . . .

AND, if you believe—as do the editors of *The Electronic Engineer* and of the cooperating magazines—that the technological superiority of the United States in the world marketplace is being jeopardized . . .

AND, if you agree that the defense capability of this country may well be whittled back to the point where it will be regarded as a second-class power . . .

AND, if you are convinced that the federal government should reorder national priorities and encourage and even subsidize the research and development and production that will employ scientists and engineers in such critical areas as communications, transportation, pollution, oceanography, nuclear power generation, defense, health and education . . .

THEN . . . Please fill in your name and address on just *one* of these ballots, put it in a stamped envelope and mail it to the editors of *The Electronic Engineer*. When you do you will be not only helping your less fortunate colleagues, but also demonstrating your confidence that the American System of Free Enterprise can and will provide practical solutions to the critical problems it faces in this century.

THEN pass along to your fellow engineers the extra ballots on this page. If they agree with your convictions—and this urgent need—ask them to sign up and send *their* ballots to the editors of *The Electronic Engineer.*

You'll be glad you did. Because these ballots (the tens of thousands of them) will be taken to Washington and presented to President Nixon and to Congressional leaders as solid proof that electronic engineers speak with one voice at this critical time in our history.

Thank you for your help.

The Editor
The Electronic Engineer
One Decker Square
Bala Cynwyd, Pa. 19004

Yes, I endorse your program to help stabilize and insure the growth of the electronics industry while at the same time insuring the technological leadership of the United States.

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IT HAPPENED LAST MONTH . . .

The editors of THE ELECTRONIC ENGINEER have sifted through the various technical and significant happenings of the past month and selected the items that would be of the most interest or use to you.

WESCON shows its strength . . . Attendance at WESCON dropped about 20% compared to the last Los Angeles showing in 1968. However, the consensus of the exhibitors was very definitely positive. Many expressed the opinion that those attending were the people they really wanted to reach. The quality of this year's WESCON and the favorable reaction of most exhibitors reflects the consistently good performance of the WESCON staff.

Things look better . . . Many WESCON exhibitors claim that their component and equipment sales are increasing, leading to the conclusion that we have "bottomed out." Several companies interviewed said that foreign sales were good, thus acting as a buffer during the slowdown.

Keyboard lights up . . . There are snap switch, reed switch, mercury switch, magnetic and Hall effect keyboards. And now, there is also an optoelectronic keyboard. Developed by TEC, Inc., Eden Prairie, Minn., the new bounce-free keyboard works with light for code generation. Physically, the keyboard looks and feels like any other one, but works with a light beam and shutter.

Metric system in the United States . . . Increased use of the metric system in the United States is inevitable, claims the Electronic Industries Association. Based on a membership survey, EIA said a majority would favor a conversion plan that called for government legislation with targetted changeover dates and voluntary participation. However, the survey also indicated that there is no great enthusiasm among electronic companies for or against establishment of the metric system in this country. A majority of those responding indicated they have stepped up their use of the system over the past 10 years, but 90% said they have no plans to make more changes toward its use. There was unanimous agreement that without a coordinated program or encouragement from the Federal government no significant change toward metrication would ever occur.

Computer surge predicted . . . A recent Department of Commerce survey predicted domestic electronic computer shipments would rise by 15% in 1971 to $4.6 billion. In addition, it noted that greater emphasis than ever would be put on foreign markets as a last frontier for sizable computer and peripherals sales. This emphasis would result in more exports and the setting up of overseas subsidiaries. Sales for 1970 were pegged a $4 billion, down 5% from 1969. Secretary of Commerce Maurice Stans forecasts "a renewed upswing in business activity" for the entire economy.

A mighty foundation? . . . Dr. C. Lester Hogan, president of Fairchild Camera and Instrument Corp., called for the formation of an industry-supported "foundation for human survival." Speaking at a WESCON symposium on "Applying Technology to Public Problems," Dr. Hogan enumerated the following functions for the proposed foundation: a clearinghouse for problems of the day, a data base for individual business responses, and an interface with government agencies. "It is time that business ceased pushing the burden of responsibility off on government or individual enterprises alone and shoulder the responsibilities as one," said Fairchild's spokesman. In addition to enlarging industry's activity in social problems, he called for increased Federal Government action, particularly against pollution of air and water, and the "terrible environment of the ghettos." The Fairchild president stated that "these commitments are more important than the space program and they will have more far-reaching significance."

Improved graphics . . . Following a 1-year feasibility study for NASA, CBS Labs. recommended the use of electron beam recording (EBR) wherever computer-processed information is called for, such as the Earth Resources Technical Satellite program in NASA's case. Capable of generating 20,000 TV lines on 70-mm film from magnetic tape or computer output, the EB recorder, according to CBS representative Robert Rutherford, makes it unnecessary "to make compromises for optical and film grain size variations."

"House of Wax," revisited . . . Unlike a few bad movies made in the 1950s, a new movie project is in the offing to make a truly three-dimensional movie that will be viewed without the funny glasses. Joseph Strick, producer of the movie versions of James Joyce's "Ulysses" and Henry Miller's "Tropic of Cancer," has entered into a 5-year licensing agreement with Holotron Corp. to make commercial movie holograms, using lens-less, three-dimensional photography by laser beams. There are, however, several obstacles to this first non-laboratory making of moving holograms. The showing of a holographic movie uses a behind-the-screen projection system that limits an audience to less than 100 viewers. Also, because of the demands of laser light, filming has to be within the confines of a studio.

GaAsLITE Update

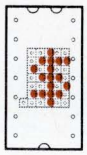
Being a quick and thorough survey of what's available in solid state displays.

The MAN 1:

A seven-segment light-emitting all-semiconductor alphanumeric readout.

Put the attention-demanding red light from electrically excited GaAsP to work in your digital displays for industry, computer peripherals, or avionic/marine instrumentation. Our MAN 1 is shock-resistant and long-lived. Offers styling advantages because it's flat, parallax-free and visible within 150°. Reads out all numbers plus A, C, E, F, H, J, L, O, P and U. Available now. Any quantity.

- Brightness: 350 foot-Lamberts @ I_F=20 mA, 3.4V, per segment.
- Pulsed forward current=100mA, 10% duty cycle/per segment.
- Compatibility: directly interfaces with off-the-shelf IC decoder/drivers.
- Price: 1,000 quantities, $11.00 (all prices are suggested resale figures).



The MAN 2:

An alphanumeric display made up of 36 discrete LEDs which can form 64 ASCII characters and a decimal point.

The IC-compatible 5 x 7 X-Y array gives you a bright red (peak emission 6500Å), high contrast display suitable for keyboard verifiers, avionics or computer terminals or other displays. Since the 36 dots can make 2^{36} bits available, the MAN 2 can be very useful in film annotation work.

- Per-diode brightness: 300 foot-Lamberts @ I_F=10 mA, 1.7 volt per diode.
- Pulsed forward current (50 μsec 20% duty cycle) 100 mA
- Light turn-on and turn-off 5 ns typical
- New reduced price: 1–9 quantities, $40.00.

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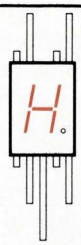

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- Pulsed forward current=50 mA, 10% duty cycle per segment.
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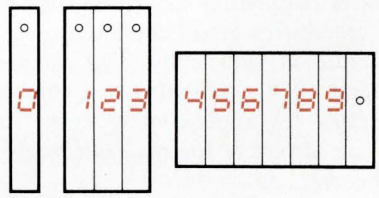

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For additional technical information write Monsanto Electronic Special Products, 10131 Bubb Road, Cupertino, California 95014. (408) 257-2140.

UP TO DATE

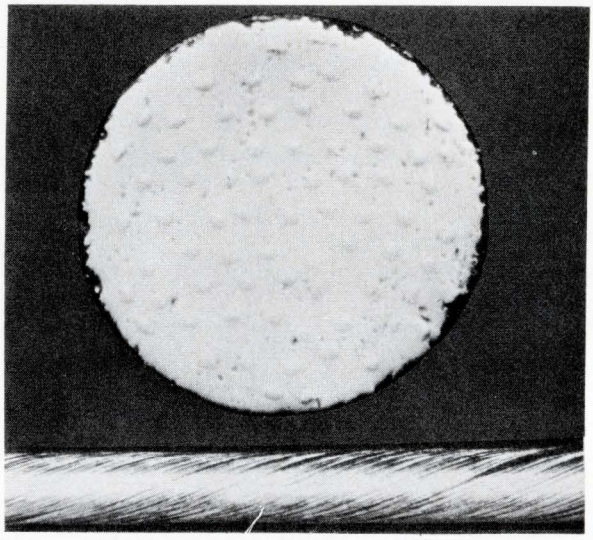
Alloys make conductors super

Almost simultaneously two companies announced the development of multifilament superconducting wires for commercial applications. Whittaker Corporation's Nuclear Metals Division and Norton Company's Supercon Division are both making round conductors that can handle pulsed dc and low frequency ac for magnetic applications. Previously, superconductors were flat-ribbon-like conductors limited to direct current applications.

Superconductivity implies the ability to conduct electrical current without resistance, greatly increasing, therefore, the conducting efficiency of circuits. This phenomenon occurs when the temperature of the conducting material approaches absolute zero (0°K).

Whittaker's wire consists of an intermetallic compound, Nb_3Sn, in a copper matrix. Norton's is niobium-titanium alloy filaments also embedded in a copper matrix. To cite one application, these superconductors extend the advantages of superconductors in nuclear research by allowing varying magnetic fields up to 100 kG with negligible losses.

Since practical applications have been limited by the low temperatures required, a superconductor must meet certain basic criteria for broad commercial significance. It should operate at sufficiently high temperatures—generally around 10°K—so that added efficiency more than compensates for super-cooling cost. These new wires, again, are attractive for magnetic fields up to at least 100 kilogauss.



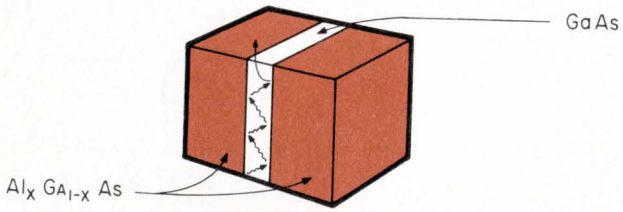
Superconducting wire by Whittaker, 0.002-in. diameter, looks something like a pancake on a griddle when magnified 638 times (top). What appear to be "bubbles in the batter" are actually the ends of individual niobium-tin filaments in the wire's copper matrix. At bottom is a microscopic view of Norton's multifilament superconductor containing more than 400 highly stable niobium-titanium alloy filaments, each only 0.007 in. in diameter, embedded in a copper matrix.

For more information contact Nuclear Metal Div., Whittaker Corp., Box 125, West Concord, Mass. 01781 or Circle No. 225, and Supercon Div., Norton Co., Natick, Mass. 01760 or Circle No. 226.

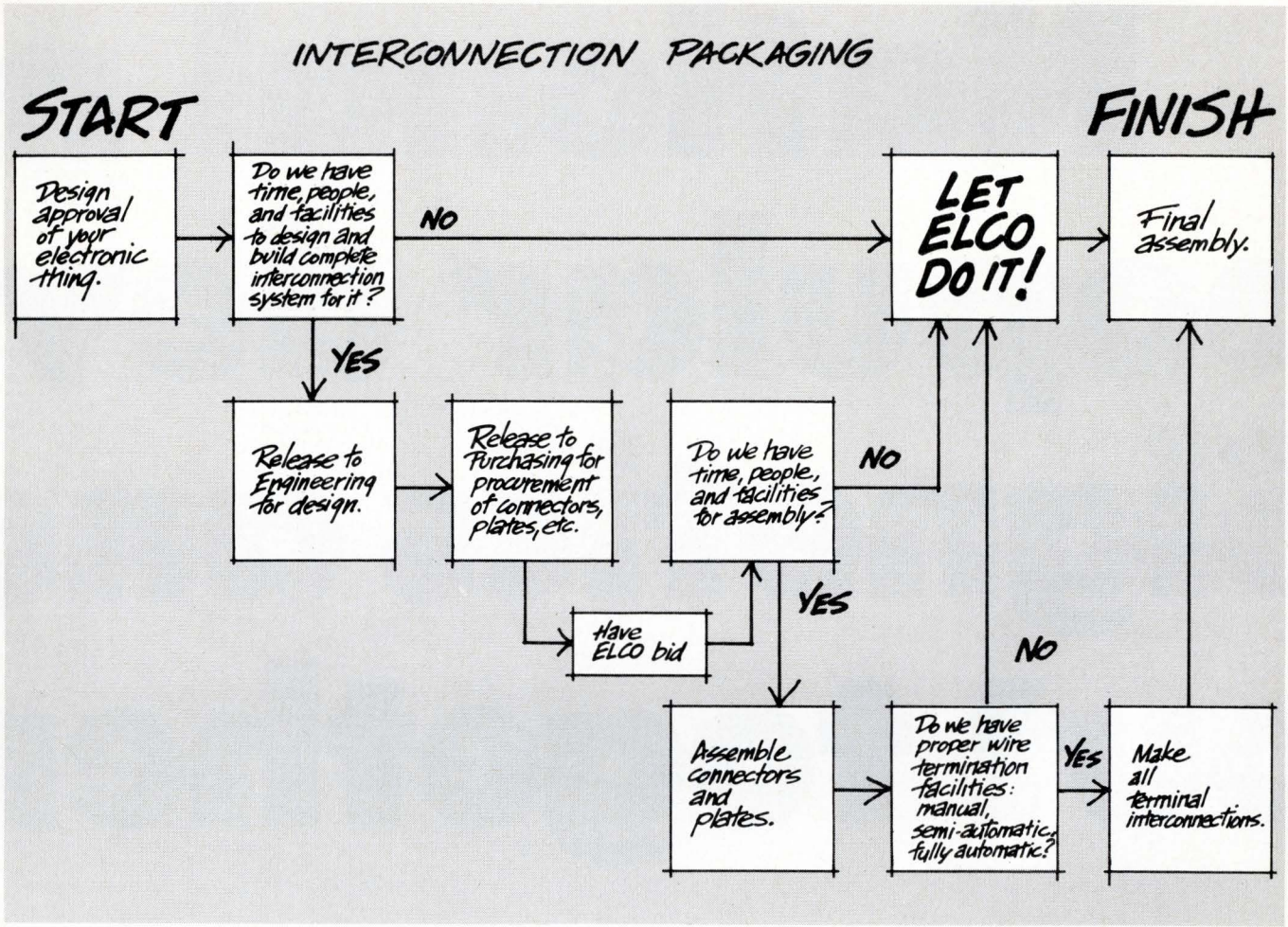
This laser keeps its cool

Scientists at Bell Labs in Murray Hill, N J. have successfully produced a semiconductor laser that will operate continuously at room temperature. Previous semiconductor lasers, because of the large amount of heat generated during the lasing process, had required extensive cooling systems for anything that even approached continuous operation.

Basically a double heterostructure diode, the laser is grown by liquid phase epitaxy. Using this construction process, Bell Labs has produced a laser with a current threshold (the current density required to start lasing activity) of about 270 A/cm². This contrasts with thresholds of about 20,000 A/cm² for other types of semiconductor lasers. When operated at 30% above threshold, the laser has a power output of about 2 mW with a power efficiency of 1½-2%. The wavelength of the emitted light is about 8500 Å.



The heart of the new laser is a sandwich of a very thin layer of gallium arsenide (GaAs) between two layers of gallium aluminum arsenide ($A1_xGa_{1-x}As$). Because the gallium arsenide has a larger index of refraction than the gallium aluminum arsenide, light emitted during the lasing process is confined to the thin GaAs active region. The ability to confine the light in this manner enables Bell Labs to reach the lasing threshold with a much lower current density than would otherwise be necessary. This, of course, reduces the power generated within the device and permits a much cooler operation.



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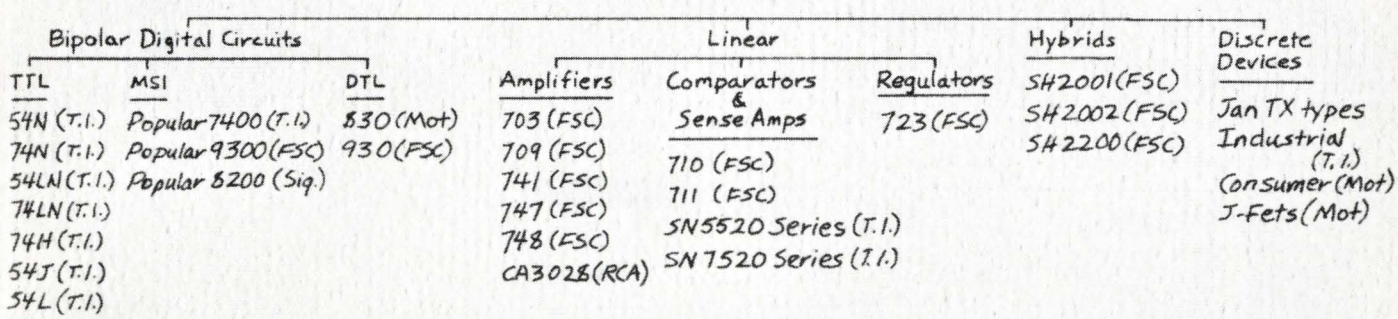

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THE WESTERN COLUMN

The courage of convictions

At a crowded luncheon sponsored by IEEE's Electromagnetic Compatibility Symposium in Anaheim, Ralph Nader demonstrated a great insight into both the problems and challenges facing today's engineers.

Nader believes the crisis facing engineers today is more serious than they realize. Though they focus their time on tasks at hand, they have the burden of knowledge. If they are the first to see social cost implications, shouldn't they sound the alert? But they don't, because their energies are absorbed in a system with no status incentive to sound alarms. Could an automobile designer tell his employer he wants to make the internal combustion engine obsolete? A blue collar worker has more freedom because his contract protects him from arbitrary dismissal. Still, the engineer must view himself as the trustee of the future and future generations.

Nader advocates a consumer protection agency, partly staffed with competent engineers and with powers to act. I asked how he would attract engineering quality when industry could always bid higher. The first members, he replied, would have to be pioneers. An initial source might be the older engineers with valuable experience, but little market value.

An association funded by its engineering members is another idea he supports. It could act as arbiter in disputes involving potential engineering contributions. He credits the success of the AMA, for instance, to its annual $30 million budget and its small, effective AMA-funded staff. And two-thirds of the country's doctors belong.

Imagine the existence of an association that could back an engineer in a legitimate dispute with an employer. Or one that could back its members in such areas as medical electronics, where the recognition of engineers as equals and contributors could end a lot of squabbling and clear the decks for progress. How about promoting the concept of EEs as hospital staff members dedicated to saving lives? Such challenges are backed by Nader.

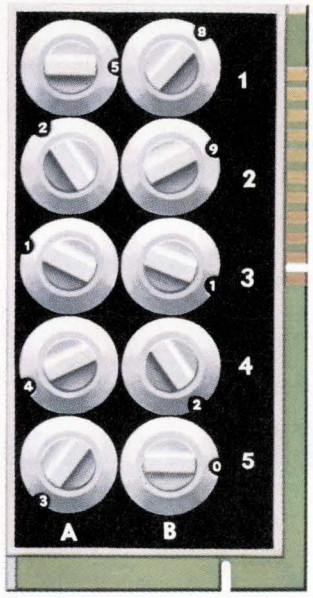
Who but engineers restrict engineers from becoming professionals in the most expanded sense of the word? Does anyone think the task of defining and protecting our environment is anything short of herculean? And who thinks he can do it alone?

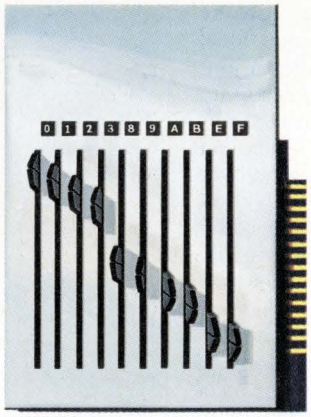
Steve Thompson

Make

Matrix Rotary Switches

Designed for low-cost infrequently changed programming. Small, rugged, ideal for behind panel applications. Switch to switch wiring integral part of assembly to achieve maximum density. Printed circuit edge connectors make external wiring connections easy, fast and economical. Knobs position with positive detent action, eliminate contact bridging and clearly reveal numerical readout. Contact surfaces fully protected, self-wiping for high reliability. Designed to cover wide variety of digital memory, sequencing, X-Y coordinate and input-output switching applications.





Matrix Slide Switches

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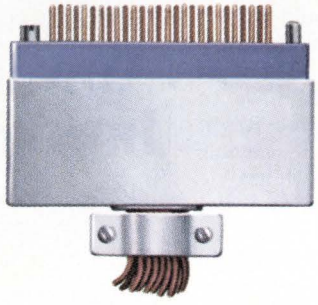

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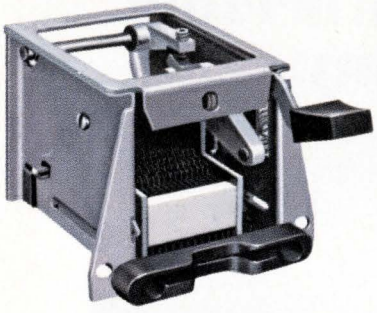

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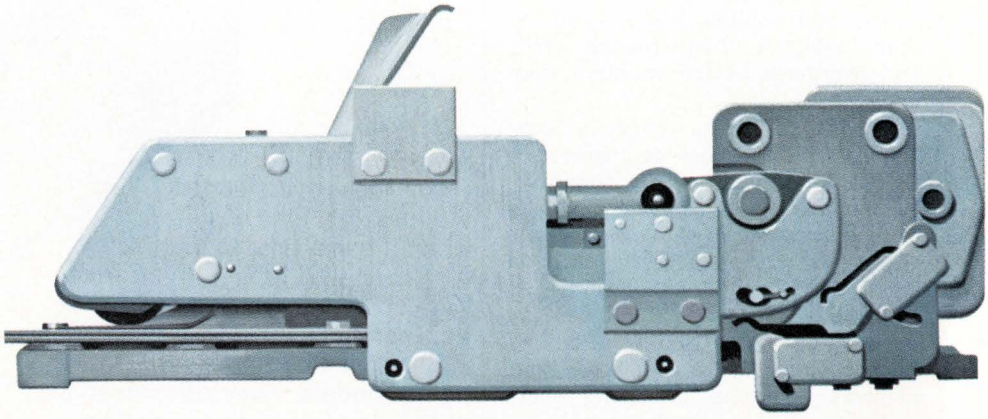

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CALENDAR

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

Oct. 16-17: 25th Midwest Conf., American Society for Quality Control, Minnesota Section-Region 12, Minneapolis, Minnesota. Addtl. Info.—Roger Lundmark, 4700-76th Avenue North, Minneapolis, Minn. 55429.

Oct. 21-22: Third Annual Connector Symp., Cherry Hill Inn, Cherry Hill, N.J. Addtl. Info.—Ed Brautigan, Program Chairman, Third Annual Connector Symp., Box 3104, Phila., Pa. 19105.

Oct. 21-23: 1970 IEEE Ultrasonics Symposium, San Francisco, Calif. Mail an original and one good copy of your paper by August 1 to: Dr. W. J. Spencer, Bell Telephone Labs, Inc., 555 Union Blvd., Allentown, Pa. 18103.

Oct. 26-28: Electronic & Aerospace Systems Convention (EASCON), Sheraton Park Hotel, Washington, D.C. Addtl. Info.—Richard Marsten, NASA Hdqrs., Code SC, Washington, D.C. 20546.

Oct. 26-29; 25th Annual ISA Conf., Civic Center in Philadelphia, Pa. Addtl. Info.—Daniel R. Stearn, Public Relations Mgr., ISA, 530 William Penn Place, Pittsburgh, Pa. 15219.

Oct. 28-30: Int'l Electronic Devices Meeting, Sheraton Park Hotel, Washington, D.C. Addtl. Info.—E. O. Johnson, RCA, 415 S. 5th St., Harrison, N.J. 07029.

Oct. 29-30: Joint Engineering Management Conf., Drake Hotel, Chicago, Ill. Addtl. Info.—AIEE Hdqrs., 345 E. 47th St., New York, N.Y. 10017.

NOVEMBER						
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Nov. 4-6: IEEE Northeast Electronics Research and Engineering Meeting (NEREM) Sheraton-Boston Hotel, Boston, Mass. Addtl. Info.—IEEE Boston Office, 31 Channing St., Newton, Mass. 02158.

Nov. 15-19: Magnetism & Magnetic Materials Conf., Diplomat Hotel, Hollywood Beach, Fla. Addtl. Info.—J. K. Watson, Univ. of Fla., Gainesville, Fla. 72601.

Nov. 16-18: 1970 Hybrid Microelectronics Symp., Century Plaza, Beverly Hills, Calif. Addtl. Info.—Ronald A. Delaney, Alloys Unlimited, 320 L.I. Expressway So., Melville, N.Y.

Nov. 17-19: Fall Joint Computer Conf., Astro Hall, Houston, Texas. Addtl. Info.—L. E. Axsom, IBM Scientific Ctr., 6900 Fannin, Houston, Texas 77025.

DECEMBER						
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Dec. 7-9: National Electronics Conference and Exhibition (NEC/70), Conrad Hilton Hotel, Chicago, Ill. R. J. Napolitan, General Mgr. Oak Brook Executive Plaza II, 1211 W. 22nd St., Oak Brook, Ill. 60521.

'70 & '71 Conference Highlights

NEREM—Northeast Electronics Research Engineering Meeting, Nov. 4-6; Boston, Mass.

NEC—National Electronics Conference, Dec. 7-9; Chicago, Illinois.

IEEE—International Convention & Exhibition, March 22-25; New York, N. Y.

WESCON—Western Electronic Show & Convention, Aug. 24-27; San Francisco, Calif.

Call for Papers

May 10-12: 1971 Electronic Components Conference, Washington, D.C. Abstracts of 250 words minimum, plus a list of the papers, salient concepts and features, should be sent by November 15 to Mr. Moss, P. R. Mallory and Co., 3029 East Washington St., Indianapolis, Ind. 46206.

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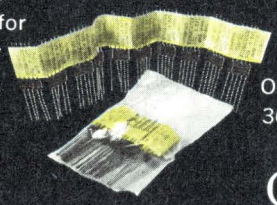

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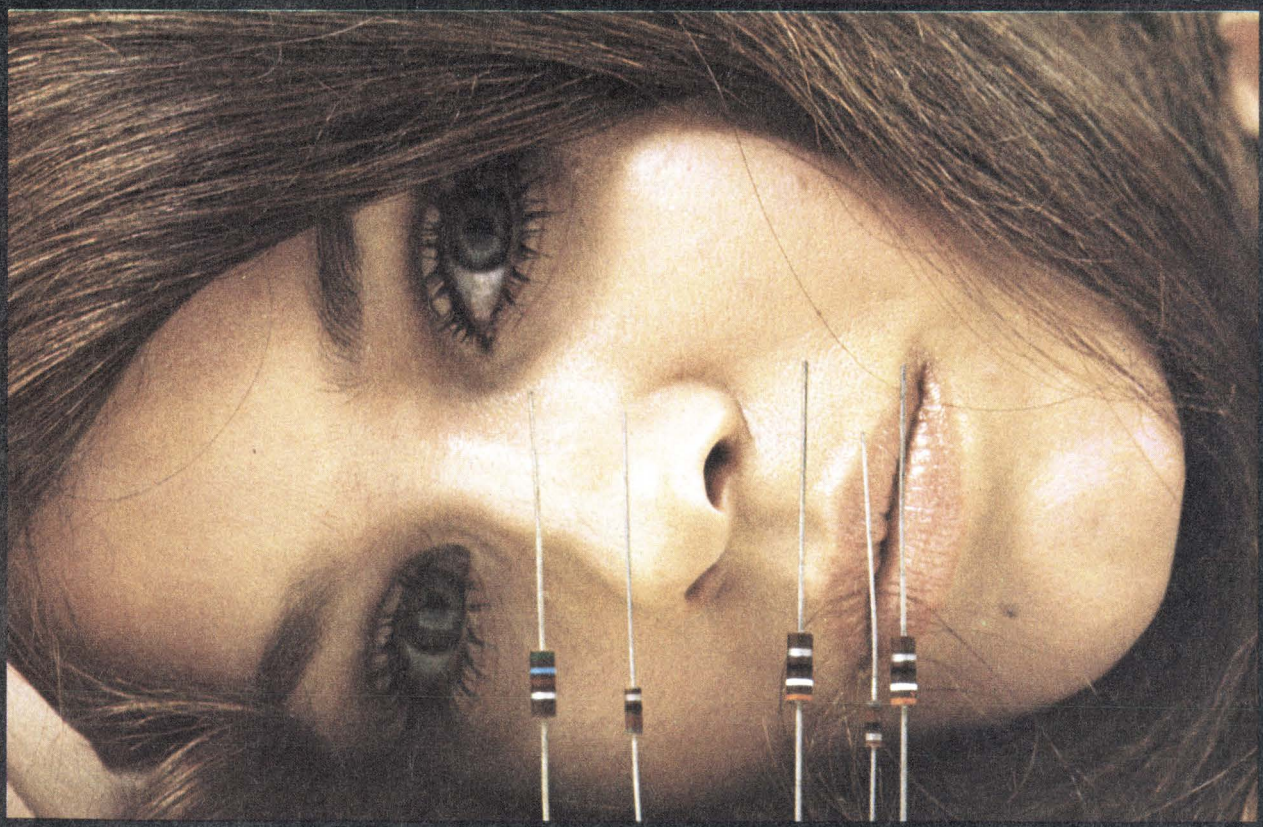

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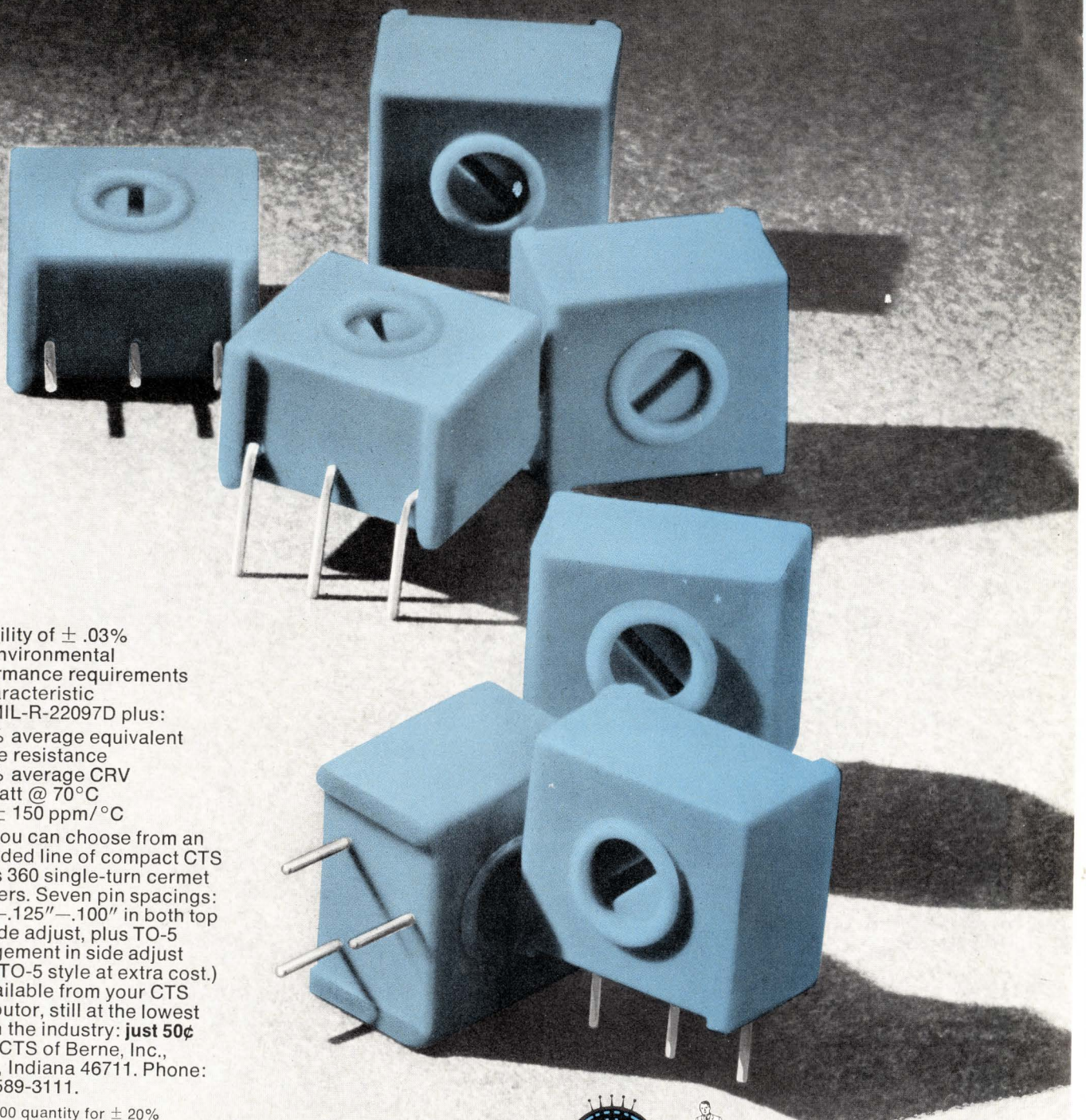

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WHERE ARE THE NEW JOBS FOR EE's?

From aerospace to civilian applications—from layoff to a stable job. Three EEs tell how they fought to switch.

By Deborah P. Wilkins, Editorial Assistant

The next time you buy a hamburger, go to a real estate office, answer a call from an insurance salesman, hop a cab, rent a boat from a marina, or take karate lessons, take a second look at the man in charge: he just might be a former colleague.

Although the combination of a falling economy, declining government contract awards, and inflation tends to force many engineers into jobs they'd prefer not to take, EEs have found jobs as engineers outside of aerospace and defense. While their happy experience is not typical (at least, not yet) among engineers who have recently lost their jobs, EEs with aerospace backgrounds can, like these men, make the adjustment to non-defense areas of the electronics field, and successfully so.

How many layoffs?

The Aerospace Industries Association of America estimates present total aerospace employment at 1,177,000, down 241,000 from a peak figure of 1,418,000 in 1968. Of those laid off, 168,000 aerospace workers lost their jobs in the past year (Sept. 1969—Sept. 1970). The Association's figures are for all workers. Of those, about 20 percent are engineers, and one out of four of these is an EE. With close to 9,000 electronic engineers added to the unemployment ranks in the past 12 months, then, it's no wonder that the competition for non-defense jobs has been fierce. What makes matters worse, however, is that competition isn't the only problem—there is also a subtle form of job discrimination.

David G. Kilpatrick, a member of the IEEE Group on Engineering in Medicine & Biology, heads the biomedical engineering division of a firm which, he freely admits, "is hesitant about hiring aerospace engineers because their skills are too specialized for medical electronics and, even more important, they are unable to adjust to the restricted budgets most companies work with today." And many companies are afraid they will be used as temporary income sources until the aerospace industry recovers.

All is not lost

Fortunately, there is a general feeling of optimism for the future. A spokesman for the Association believes that "the lean years will probably fatten beginning in 1971 when the tri-jet jumbo passenger transports start coming off the line and Boeing's 747 production is in full swing." But even if these hopeful words don't prove true, there are men like Harold B. Rose, technical director at Bio-Optronics Inc., who like Kilpatrick is involved in medical electronics, but feels that "we can bring men with broad aerospace backgrounds into a field so desperately devoid of articulate, capable engineering skill. Regardless of the field of application," he says, "the basic principles of engineering always apply."


Richard Trapani
John Sullivan
Jay Freeman

So, if you're an EE with aerospace or defense background, and you see the writing on the wall, you're probably looking for ways to get into more stable fields. You've acquired valuable skills as an engineer, and if you're like most of the men in your situation, you'll probably want to stay in engineering, aerospace or otherwise. There are still defense contracts being awarded, but they will not take up all the manpower available. Medical electronics, automotive electronics, communications, weather instrumentation, pollution control, and the electronic aids for postal service are only a few of the potential fields open to EEs. As difficult as it may seem to find a job in these areas, it can be done. Here are three men who did it.

A circuit is a circuit!
John Sullivan—Medical electronics

"Don't expect me to tell you that there's anything shockingly different between the aerospace industry and this type of job—there's very little difference." So states John Sullivan who, formerly with Philco-Ford's Western Development Lab in Palo Alto, now works in medical electronics with Smith Kline Instruments.

At Philco-Ford, Sullivan designed a line of digital logic modules for both military and industrial use. "In aerospace I'd sit in a lab and design a circuit and never see the final product. Maybe it would end up in an airplane or a missile, but it was only a small part. Now I work on medical systems; I see the patients in the hospital and the equipment being used. The whole thing is more real and much more rewarding."

Sullivan started his own company after he left Philco-Ford, but "it bombed." He had never been out of work and had never been laid off, so he suffered a real blow when, after sending out 60 or 70 resumés and accepting numerous interviews, it still took him several months to find a job. "What people are looking for today is a blue-eyed, 28-year-old, with 40 years experience in data disc memories. The kids haven't realized yet that we're in a depression. A lot of the older fellows have, and when they've been walking the streets for two or three weeks, they've realized it with a vengeance. Since personal contact makes 40% of the hires in the electronics industry, my advice to men out of jobs is to try anything. Take the interviews you can get and look outside of aerospace. You never know what might turn up.

"As for aerospace engineers being too highly paid—I think that's a myth. There may possibly be a 5 to 10% difference — maybe. What happens is that engineers with many years of aerospace experience are commanding substantial salaries at the time they leave, and this is a problem when looking for a job. But I did find that there were jobs for men with less experience, say five or six years, and with lower salaries."

Comparing the engineering work involved in both fields, Sullivan states, "The belief that there's a difference between design work in aerospace and medical electronics is also a myth. A circuit is a circuit! There's only one difference—in aerospace, management wants to cut the engineering budget as tightly as possible because engineering represents a major portion of the cost. Here it is different. Once we've designed a piece of equipment, the name of the game is to get the cost out of the product—engineering is not the most important factor."

Besides being able to adjust their backgrounds to their new jobs, security is of prime concern to newly placed engineers. "The future here seems to be unlimited. I don't think there's any question that the medical industry is 30 years behind the times from an electronics standpoint, and here we have the chance to really move ahead." Sullivan believes that socialized medicine will be accepted and promoted in our country, heralding a tremendous expansion in the kind of business his company does. "The only way to bring inexpensive medical care to the people is through electronic-mechanical means, such as computers. There'll be automatic clinics," he predicts, "where for a $2 fee you'll walk in one door and out the other with a complete breakdown of your mental and physical condition."

Patient monitoring—such as fetal sensing or the observation of heart functions — is Sullivan's major field. Right now, he is working on a project called Systems^{n}, used in intensive care units to monitor critically ill heart patients—their ECG (electrocardiogram), blood pressure, respiration, temperature, etc. "This system can save the lives of 40% of the people with potentially fatal heart conditions who get to the hospital. If you can catch the arrhythmia condition before it starts, you can save a patient's life. This is what this equipment does. And since a nurse doesn't have time for constant supervision of a patient, we're now going one step further—introducing computers which will constantly monitor a patient."

As for the future of aerospace, Sullivan believes the Vietnam war has had an influence on the industry, the war slowdown being partly responsible for the cutback in defense spending. "But there's another element that's just as important as the cutback itself and that's the resentment of the whole country, the young people

especially, against military expenditures. The real cause of the aerospace problem as related to the recession is the attitude of the people."

Consumer products with space technology
Richard Trapani—Instrument designer

"You always think it's going to happen to the other guy. And yet anyone who doesn't expect it is naive. Aerospace engineering is a dynamic, progressive, and exciting field. You're always on top of the times, so no matter what the hazards, men are going to be attracted to the field."

Richard Trapani used to work on ground support equipment for aerospace at the General Electric Space Systems Division in Valley Forge, Pa. Along with many other skilled EEs, Trapani designed advanced equipment and systems developed during the "aero era." One assignment, for example, was to design an environmental monitoring system using a new type of instrumentation to measure temperature, shock, and humidity. Another project was to design a test console that could determine inaccuracies in a spacecraft's flight control system. He completed both jobs, as well as the design of a portable temperature-controlled water cooler that provided water to a missile system to control precisely the temperature of its components.

From there on it was the same old story—contracts decreased, jobs were lost, and his was one of them. "I applied for other jobs as an aerospace engineer, but there really isn't much hiring going on. Unless you are exactly the man they are looking for and can step right into the job, the door is closed. I had more interviews with consumer-oriented companies and many, surprisingly, thought some aerospace background was good."

With the expansion of General Electric's Space Technology Products (consumer products that are designed using space technology) several aerospace engineers found new jobs which would use their skills in new applications. Trapani was one of them.

"I've found that aerospace ground equipment engineering and consumer-oriented engineering are alike in many ways—each has a variety of projects under way at one time, and each operates under the same basic principles. Time, money, and quality are of the utmost importance to both fields, and both use the same design materials and techniques. If there's any significant difference, it's in the application, not the engineering.

"The instruments I'm working on now can be used individually or can be incorporated into larger systems. The X-ray detector technology uses digital control, analog and digital circuitry, and displays. The instruments are extremely sensitive, light, and portable. And although they use space technology, they're definitely consumer products."

Among the instruments Trapani is referring to are a laser receiver, a nuclear event counter, and a thickness gauge. All use the same basic technology developed for aerospace applications. "When you consider that these instruments do incorporate space technology, it's easy to see that there's room for aerospace engineers in the consumer field."

Soon your dentist may not have to drill to find a cavity. One instrument GE is working on makes sensitive measurements of tooth enamel to determine where a cavity might occur. Again in the medical field, they've developed a nuclear event counter that can locate potentially dangerous tumors.

Film producers might use GE's thickness gauge to determine if the silver coatings on their films are excessive and, therefore, too costly.

How about you?
Does your story match these?
Can you tell an encouraging story?
Or an unusual one?

We hope that the cases of Sullivan, Trapani, and Freeman will shed a ray of hope on the bleak employment picture of aerospace engineers. If you have had a similar experience, and if you're the type who'd rather fight and switch, tell us about it. If you've recently changed from aerospace to a non-defense industry and you're working as an electronic engineer, share your experience with your colleagues in the pages of The Electronic Engineer. Write a brief letter stating the nature of your new job and the company you work for to—

Miss Debbie Wilkins
The Electronic Engineer
One Decker Square
Bala Cynwyd, Pa. 19004

"Sensitive measurement is the key to these instruments, and it's the same factor that was essential to the successful operation of space vehicles."

In spite of the present situation, Trapani still has a soft spot in his heart for aerospace. "Aerospace offered a dynamic challenge to engineers. A good engineer had the opportunity to move up to his best level because the field progressed so rapidly. In a consumer industry the hierarchy is more-or-less secure, even though the work may change. The aerospace layoffs, however, are a necessary evil. There's just no way to avoid the present situation, and in spite of his skill and experience, I'm sure luck is the major factor in a good engineer's finding a new job. Until the country's economy recovers, I'm afraid things are going to stay this way. Even though the aerospace engineer's skills are needed today, the squeeze on business just won't make room for them. Hopefully, this will change soon."

The human side of engineering
Jay Freeman—Management consultant

Long Island has been one of the geographical areas hardest hit by the aerospace layoffs. And probably no one is more aware of this than Jay Freeman, a 32-year-old engineer with a BSEE from CCNY who now works as a management consultant. His experience covers the familiar circuit for electronic engineers on Long Island —Sperry Gyroscope, Reeves Instruments—plus smaller companies such as Compat and Tele-Signal Corp.

"I'm glad to be out of defense-related engineering," he says. "This field today means only a lack of work, of opportunity, and of security. I used to be involved with logic design and with proposals, and I'd use my technical skill to solve problems. But none of my other skills were ever touched—I had very little contact with people. To change from lab work to personal contact was not an easy adjustment, but it was a worthwhile one. I now have an ultimately better future, and, most important, I can establish long-range goals for my career without fear of being cut short."

As a management consultant Freeman is involved with the intangible aspects of engineering—the long-range forecasting of technological developments which would include government participation in industry, determining new products, and the future competition, market, and demand for them. "The work is highly diverse with an emphasis on overview rather than detail. For example, I am exposed to data processing as a tool to aid management. We are presently designing an information retrieval system for data base research in the area of vehicle and highway safety design. My company has had contracts for studies in such eclectic areas as exotic materials, urban planning, and manpower utilization." All of these management studies, says Freeman, are technical, "letting me use my engineering background, but allowing me to develop new skills in the real business world rather than stagnate in the artificial world of the short-lived aerospace contract.

"To make the change, I highly recommend an open mind. Because of the present market situation, you may be forced to take a cut in salary. But the skills acquired in a new area guarantee a better future in the end. Maybe one good thing that's come out of all this is that the economy is forcing people to look outside of their technical lives and find that there are possibilities for them in areas other than aerospace."

Looking back to when he was in aerospace, Freeman states, "A few years ago I was more militant about all this. I used to have great hopes that engineers would organize themselves into a union which would give them some protection and security, for instance, a pension plan, insurance, and other benefits provided by the labor unions. I wrote letters to editors and argued with people. But now I'm more resigned—jaded. After fighting a brick wall, I redirected my efforts to my own career. It's impossible to change the attitudes of a million engineers—maybe now the harshness of the industrial environment will do it; maybe the younger generation, being more aware, will succeed.

"People have to be hit over the head with a sledge hammer before they wake up. Engineers couldn't foresee the need for protection a few years ago. Now it's too late. There've been no violent incidents to make an interesting newspaper report; the matter was never presented en masse to engineers; people just didn't realize the seriousness of the problem. Now it's very sad to see America's greatest source of brain power facing a severe career crisis."

Freeman believes that the consumer and industrial markets will eventually grow to produce more jobs for more people. "Because the defense market is dropping so quickly, it is overwhelming the jobs created by the consumer market. Aerospace engineers can't afford to wait 10 years, however, for consumer markets to catch up, or for aerospace to recover. They've got to transfer their skills to new jobs, and although the effort is worth it that's a hard thing to do today."

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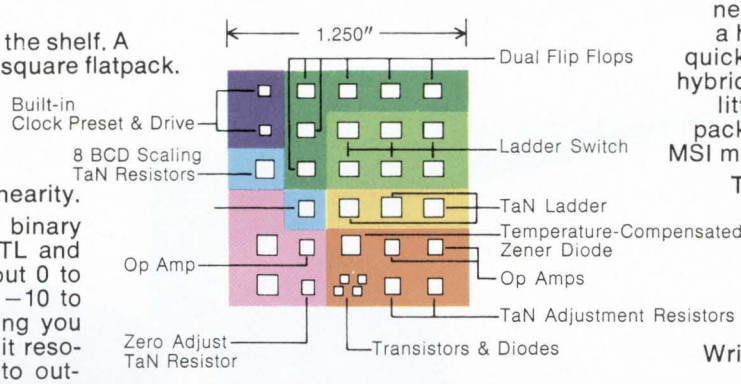

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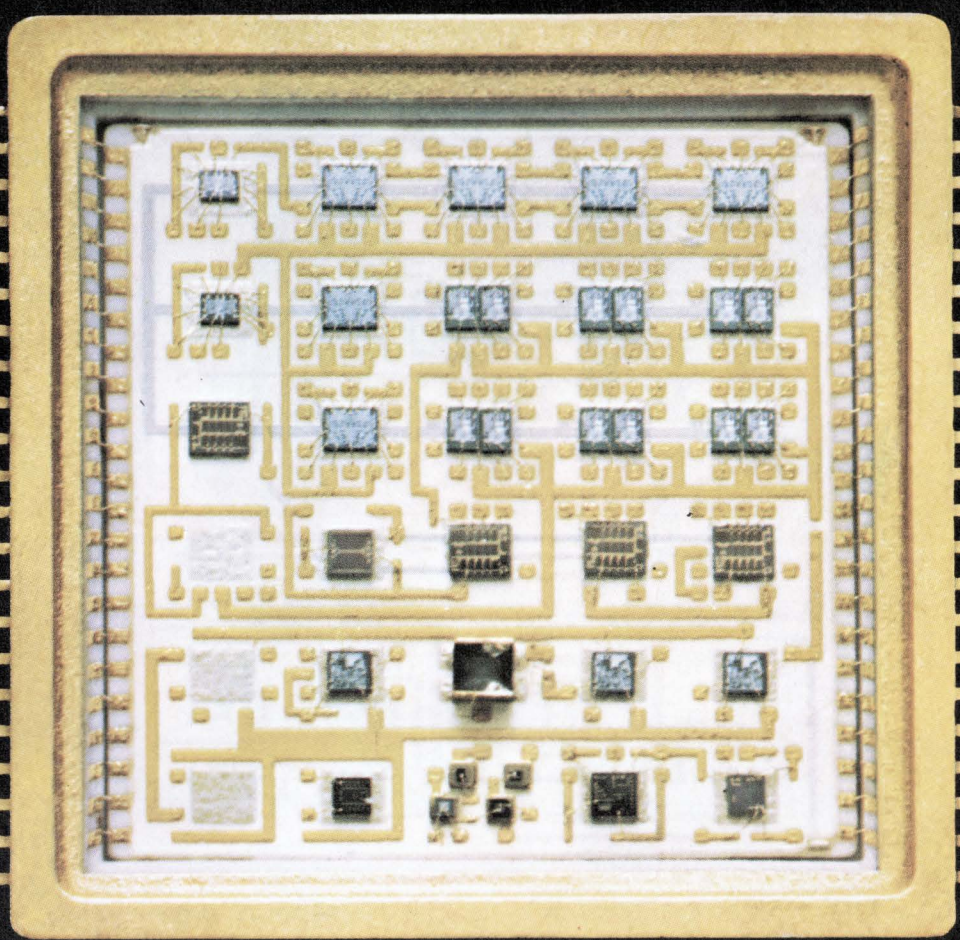

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We asked 37 MOS experts what they really needed in a high speed tester.

When Xintel decided to build the best MOS tester in the world, we knew there was only one way to go about it.

First—find out what the industry really needed by talking to the experts at the manufacturing and large user level.

Then—and only then—would we put our engineers to work designing the product.

So we pooled our Hertz, Diners, Am Ex, Air Travel Cards and took to the road, interviewing every MOS/LSI maker and user we could find.

Our tour took us to National Semiconductor, Fairchild, Intersil, 4-Phase Systems, Signetics, Electronic Arrays, American Microsystems Inc., Motorola, Mostek, Semiconductor Electronic Memories Inc., Advanced Memory Systems, Raytheon, Intel, Monolithic Memories, IBM, Cogar, Philco, General Instruments, MOS Technology, Garrett, Uni Sem, General Digital, RCA, Computer Microdevices . . .

Most of these companies were eager to discuss the problems of testing RAMs, ROMs and complex arrays.

Here is what they told us.

"Building MOS Testers isn't for the Weak, Faint Hearted, or Inexperienced"

No argument here. That's why we put together a team of practical, no-nonsense, systems-oriented guys who know their way around MOS testing like an experienced airline pilot knows his way around the sky.

Men such as Bill Ackley, John Coons, Rod Mack, Ken Watanabe, and Ed Edwards. That's the Xintel MOS squad. A group of real heavy-weights. And each is capable of wearing a number of different hats.

"It should test MOS and Bi-Polar Devices"

Ours will. We can generate and measure a wide range of positive and negative voltages to handle P-channel and N-channel MOS/LSI chips and wafers plus all types of bi-polar ICs.

We can handle Random Access and Read Only Memories, Shift Registers and Random Logic Arrays. Those now in production and those that are just a gleam in the eyes of MOS designers.

"We need to make three kinds of tests"

We coined a new word—Dy-metric®—to describe the operation of the Xintel MOS tester which makes parametric, functional *and* dynamic tests. Most of them simultaneously.

Because timing is so important, our tester uses a fast mini-computer for loading and translating data—plus additional high speed memory capable of outputting complete word patterns at megacycle rates.

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No monster here. Our survey helped separate the wheat from the chaff, the real from the imaginary. Instead of chasing rainbows we designed a reliable, flexible MOS test system. It has many data logging modes for wafer probe, final test, device classification or engineering analysis. Our tester will be working when many of the high priced monsters are dead in the water.

"Keep the software simple"

We've developed a language so your engineers and techs can type, edit, compile and execute tests directly from the Teletype keyboard —using simple English source statements. They can concentrate on testing—not programming.

"Give us plenty of peripherals"

And we have. Disc and core memory for supplying data to the computer—high speed paper tape punch and reader—hard copy output from a TTY or a high speed line printer—plus computer control of functions such as probe-down sensing, off-wafer detection, inking, sorting . . .

"No relays, please"

Reliability and speed of testing of LSI devices requires new methods of switching. Reed relays just won't hack it.

Xintel's MOS tester will use solid-state electronic pin drivers to switch and measure voltages and currents at high speed. And they'll be far more reliable than mechanical switches.

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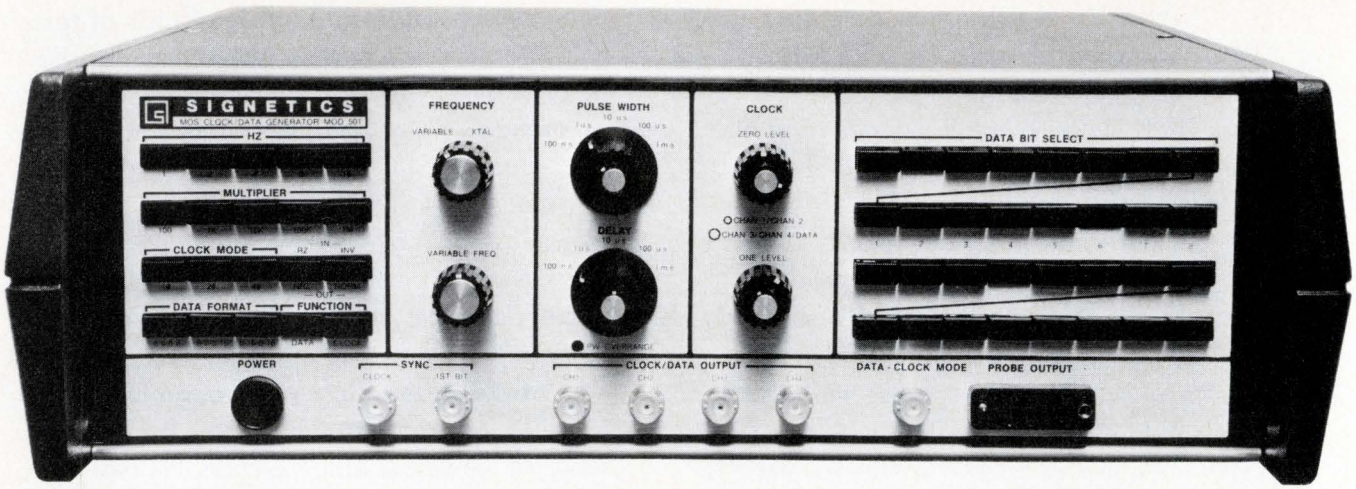

If you think this is an MOS clock, you don't know the half of it.

Half 30-volt clock.

Half data generator.

That's Signetics' brand-new 501 MOS Clock/Data Generator – the first instrument that lets you test MOS without separate multiple pulse and clock generators.

The 501 provides – in one neat package—a complete engineering and production test generator specifically designed for (but not limited to) MOS device applications in either N or P channel devices.

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The 501 provides timing signals while generating words up to 32 bits in length. And you can run the two functions together, or let them go it alone.

In MOS mode, you can choose from three alternatives at clock rates up to 16 MHz: single-phase, two-phase and four-phase—each with 32-bit programmable data output.

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Controls? The 501 has them galore, including NRZ/RZ, normal/inverted, pulse width and pulse delay. There are even separate controls for zero and one levels. And all controls are right where you want them: up front. (If your application requires remote programming capability, just let us know your needs.)

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MOS course—Part 6

Testing MOS

Testing complex MOS: the how and why, p. 42

By Arthur J. Boyle, Technical Editor

This, the final installment of our course, deals with the testing of complex MOS integrated circuits. The following article details the problems of MOS testing and also describes a programmable functional tester for MOS ICs. The problem is, however, that the price tag for the kind of test system described runs well up into the six figure bracket. This, of course, is a significant investment and can only be justified by MOS manufacturers and a few, very large users.

What about the little guy

Small users also face the problems of MOS testing. For a majority of these companies, the full-blown, computer-controlled testers are not economically feasible. To solve their testing problems, these companies, in general, use one of three approaches.

The first of these is to use one of the smaller, manually programmable testers on the market. Even these, however, are not inexpensive and their suitability for a particular application depends on such factors as the flexibility required (number of different circuits to be tested) and the volume.

Another approach makes use of specialized black boxes built by the user himself. These black boxes are really individual, specialized testers for each particular circuit. This approach suffers in that, because of the complexity of the circuits being tested, these black boxes are not cheap. If a number of very different circuits have to be tested, each will probably require its own box.

The third method tests the circuit by inserting it into an already existing operating system. If the system performs correctly, then the circuit is accepted. This approach is attractive if you use several different circuits in the same system. In this case, all of them can be tested with the same test setup. The biggest disadvantage is that this is a low confidence type of testing. In some cases, circuits which are acceptable on the test setup may fail in service for a variety of reasons.

None of these is a particularly bright alternative. One point to remember, however, is that testing is a substitute for experience. Right now, MOS integrated circuits are still new enough that users feel that they must test exhaustively. But hopefully this will change. As users build up confidence through experience, incoming inspections will become less stringent. As the quality control manager for one medium size user puts it, "My aim is to spend as little time testing MOS as I spend testing resistors. Right now I do have to test, but we want to build a list of supplies on which we can depend. Then we can let the manufacturers do our testing for us. This is the only approach that makes sense for a company our size."

MOS course—Part 6

Testing complex MOS: the how and why

As the circuits get smaller, the testing problems get bigger. Here's a look at just what is involved in "ringing out" those silicon chips.

By Ron Danklefs and Homer Thornton
Redcor Corp., Canoga Park, Calif.

The steadily growing MOS/LSI market emphasizes the need for a more effective means of testing these devices. This testing problem is also complicated by the ever increasing complexity of circuits resulting in lower yield and more difficult testing.

Types of testing

There are two broad types of IC testing. The first is a production go/no go type test usually performed by both the manufacturer and by the users at incoming inspection. Go/no go testing by the manufacturer breaks down further into two subdivisions. The first, at the wafer probe level, tests each die on the wafer before dicing and packaging. Its primary purpose is to screen out the obviously bad devices before the manufacturer invests the cost of additional handling.

After the devices that passed the probe test are packaged, a second series of tests are run. In certain cases, this series includes tests at different severities to classify the final device as a function of speed, voltage, or complexity.

Besides the production go/no go tests, integrated circuits also undergo engineering tests. These engineering tests fall into two categories. The first is a full parameter test of a special test device on the wafer. Here such parameters as P-region resistivity and capacity; metal resistivity and capacity; threshold voltage; saturated resistance; transistor resistance as a function of threshold voltage; leakage; power drain; field inversion; and P, metal, and gate breakdown are measured.

The second type of engineering testing is actually a functional test, similar to those performed at the breadboard stage with standard systems. Equipment for this testing must have provisions for continuous modification of test patterns and extremely good error logging capability.

MOS testing

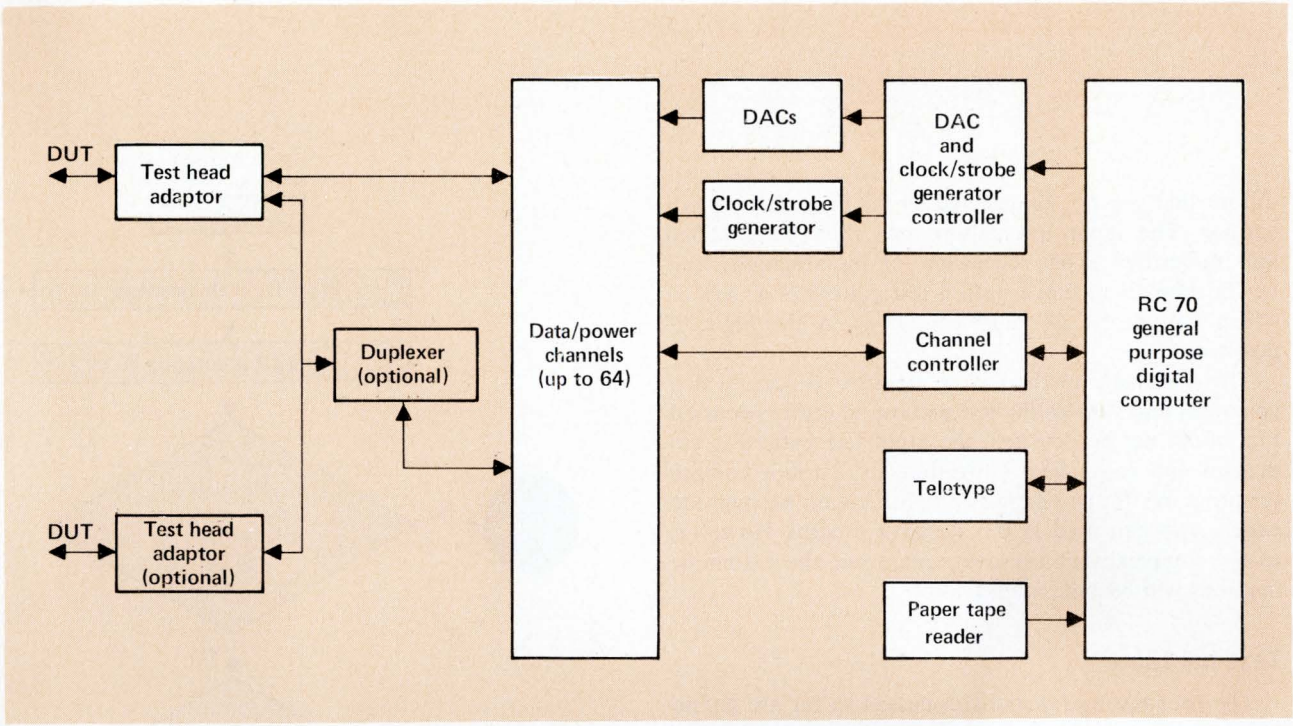
Testing of MOS/LSI is influenced by several factors, the most important being that the circuits perform increasingly complex functions. As this happens, the increased number of inputs, outputs, and internal states requires that the device be tested as a system.

A second factor involved in testing MOS devices is their sensitivity to multi-phase clocks, clock overlap tolerances, and data skew. This factor, coupled with the relatively high voltage swings required on the clock and data lines and the fact that many types of MOS contain dynamic devices in transient states, complicates the test procedure. The MOS devices are also available with high voltage thresholds, low voltage thresholds, MOS to TTL compatibility, and other elements unique to a specific type of device. All of these factors call for an extremely versatile system of test hardware.

The majority of today's MOS/LSI devices are shift registers, random access memories, and read-only memories. Generating test patterns for this type of device is relatively simple because of the limited number of internal states and input/output lines; these test patterns can be generated simply by hand. Devices of greater complexity, such as arithmetic units, central processing units, and complete digital differential analyzers, require much more complex test patterns.

Memory testing

Testing fixed output devices (RAMS and ROMS) is much simpler than testing complex logic arrays. The



Block diagram of the PAFT II system. The system performs parameter testing, such as stress and leakage and functional tests.

test pattern for a read-only memory is essentially the pattern stored in the memory. The test equipment must sequentially or randomly select the address lines to the ROM and compare the actual output of the memory with the expected output for the address applied. The problems of testing ROMs are primarily testing speed and test pattern storage.

Random access memories require a different concept of testing. Semiconductor memories are normally tested in the same manner as core planes. The address lines are sequenced and the information to be written into the cell or read from the cell is controlled by the hardware. The test sequences most commonly used on random access memories are reading and writing all 0s, all 1s, and alternate 1s and 0s. Additional tests include walking a 1 or a 0 and bracketing a given location in memory.

Bracketing a memory location determines if reading or writing in adjacent cells will disturb the contents of the selected cell. This test consists of writing a 1 in a selected memory location, and then writing 0s in all adjacent cells. The 1 is then read to determine if it has been disturbed.

Dynamic MOS random access memories are transient in nature. The data is stored by charging a parasitic capacitor to a certain voltage level. This charge will remain in the memory for a limited period of time before it must be refreshed. Provisions for refresh logic must be made either in the test pattern used or in the test hardware itself. With the refresh provisions in the test hardware, the testing of the RAM becomes simpler.

Test patterns

The simplest form of test pattern is a random input pattern, or one containing all possible logic bit combinations. A device can then be subjected to this pattern and its output compared with the expected output. If they differ, the device is bad; however, if they agree, the device may be good, or it still may have additional faults that were not detected.

The second test method requires a random input bit pattern that is used as the input to two devices. The first is the device under test and the second is a proven device of the same type. The outputs of the two devices are compared and if they agree, the tested device is considered good. Both methods described above are minimum cost approaches that act as low confidence screening for devices.

Software aids

Software aids to test pattern generation consist of logic simulators, logic verifiers, and actual test pattern generation programs. The logic simulator accepts the logic equations implemented in the device to be tested and, in response to a set of input bit patterns, generates the expected output bit patterns for those logic equations. Ideally, each logic equation in the simulator should conform to an actual circuit element in the MOS device. This allows simulation of the possible failure modes of the actual MOS device.

The first step in verification simulates the test pattern and generates the expected output for a functional device. The next steps will be to fault successively each circuit node and, for each fault, generate an expected output. If the expected output of the faulted logic differs from the expected output of the correct logic, the test pattern used will detect that particular fault condition. In this manner, a good verifier lists the fault con-

ditions that will not be detected by the input test pattern verifier. The input test pattern can then be modified and re-verified. This succession of modifications and verifications is repeated until a test pattern is generated which will detect all fault conditions in the logic, if possible.

The automatic method is an iterative process which generates and verifies the test pattern. If errors occurred that could not be detected, the input test pattern is expanded and re-verified. Unfortunately, current computer programs for simulation and verification become too expensive when used in this iterative process. However, as the complexity of LSI arrays increases, the automatic methods will become more feasible.

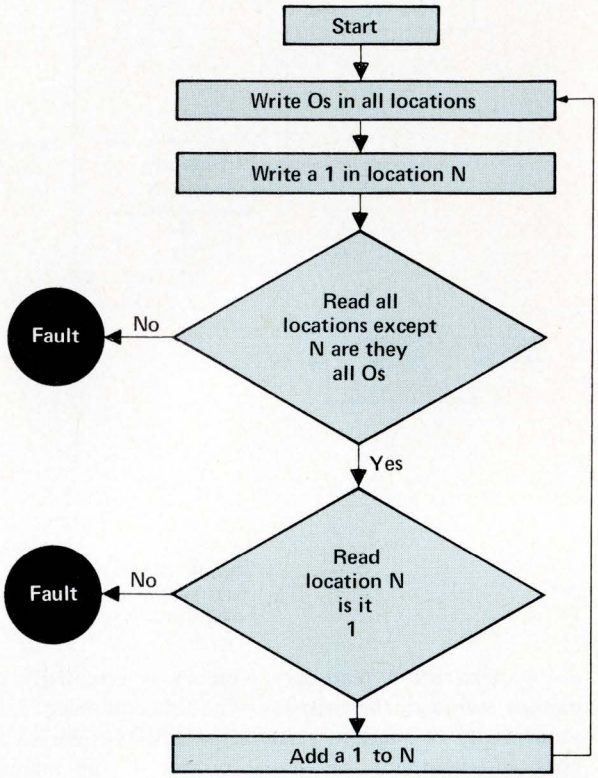
Test hardware

The four testing functions discussed so far are go/no go producton testing, engineering logic design checkout, quantitative production parameter testing, and memory testing. These functions can be incorporated into three unique types of test systems. The first is a generalized or functional tester with a limited parameter test capability. This system performs the wafer probe testing and finished package testing, plus error logging for engineering functional breadboard testing. The second type is a memory tester for RAMs and ROMs. This tester would also have the limited parameter test option and could be used for wafer probing and finished packaged testing. The third type of test system is a high-accuracy, true parameter tester. This piece of laboratory equipment offers extremely high accuracy and resolution for use in determining the numerical values of the processed parameters of the MOS test transistor.

The clock subsystem of any MOS test system must be capable of generating multiphase clocks with high speed, high accuracy, and high drive capabilities. Clock requirements differ considerably for different MOS devices; therefore, the generalized tester must provide a wide range of clock outputs. For present usage, clock frequencies should be adjustable from 1kHz to over 5 MHz, with additional phase control available.

Testing a four phase device at 5 MHz requires four input clock phases, each of which must have a 50-ns pulse duration. This means that all clock and data phases must have a resolution of greater than 50 ns. Since overlap between clocks in certain logic devices is extremely critical, the leading and trailing edges of the clock phases must be adjustable in nanosecond increments. Future MOS devices will require even faster clock frequencies and greater resolutions.

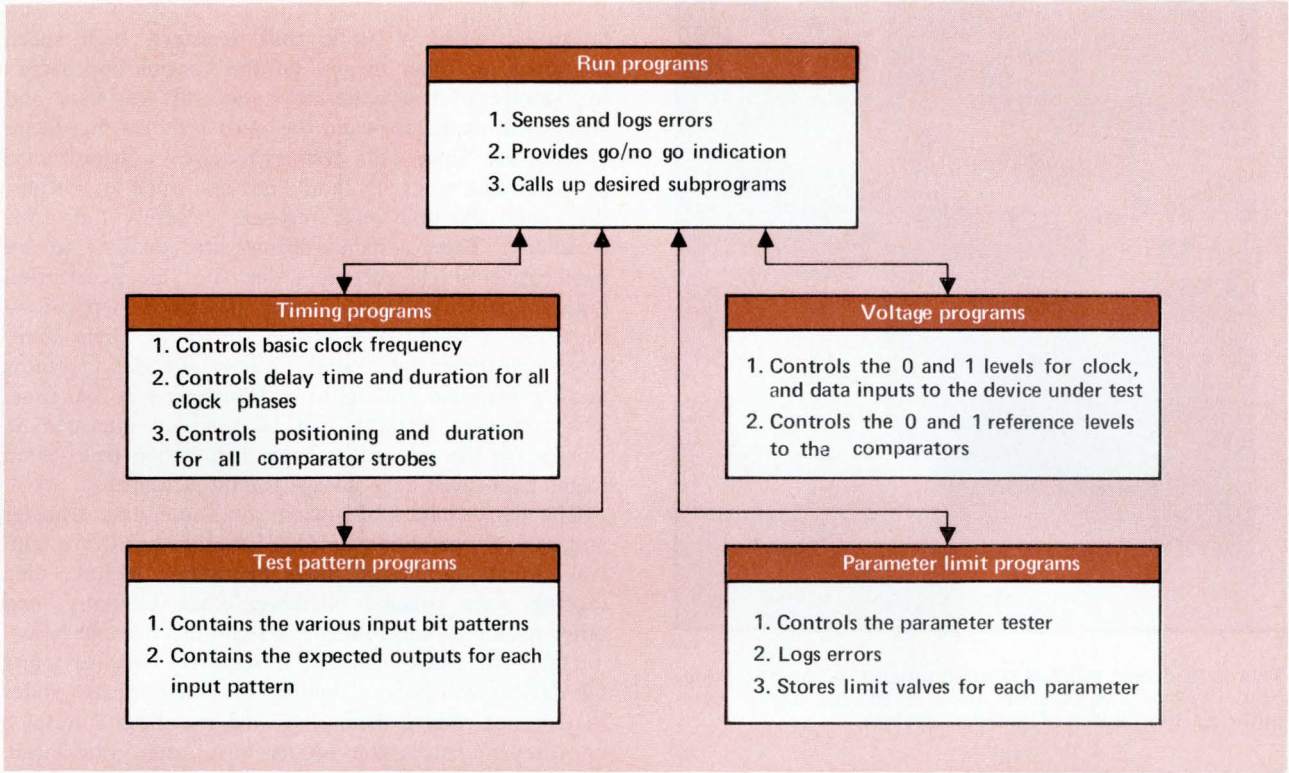
If different devices are to be tested by the same system, it is necessary to have program control over the clock subsystem. The system should provide program control over basic clock frequency up to the maximum resolution, and over all clock phases, all data phases,



A typical test for a read/write memory consists of walking a 1 through all locations in the memory. The same approach can be used to walk a 0 through the memory.

and all output data strobes. The leading and trailing edges of all clock phases should have a minimum resolution of 2.5 ns with even higher resolutions desirable. The envelope waveform of the data input must also be adjustable to the same resolution. The positioning and duration of the output data strobe should also be programmable with the same degree of resolution. Since all MOS devices do not require a nanosecond clock resolution at this time this feature should be available as an option so as not to increase the basic cost of the system.

The clock inputs to the device under test must be capable of swinging in excess of 30 V to test high threshold MOS devices. For testing different devices, the clock amplitude must be adjustable, preferably under program control. Since functional testing should be done at the limits of the device test specifications, the accuracy of the clock and data voltage amplitudes should be better than 50 mV over the entire range of the clock voltage. The high clock frequencies, high voltage swings, and high pulse resolutions on the clock and data inputs necessitate a very high rise and fall time for the clock pulses. The additional requirement that no input line to the device may forward bias the substrate (which normally is at 0 V) means that the clock and data drivers must have no overshoot in excess of 0.3 V above the substrate voltage. All of these re-



The software system for a programmable functional tester should include at least all the functions shown.

quirements necessitate a clock and data driver capable of driving 10 to 20 pF loads for existing small MOS devices. This requirement may increase to a 50 to 100 pF load for large, four-phase devices, developed in the future.

The test system should present a high input impedance and a low capacitive loading to the output of the device under test. Current devices normally have an output impedance of between 1 and 3 kΩ and should look into a 1- to 10-MΩ input impedance. Capacitive loading should be less than 25 pF. A comparator matches the voltage output of the device against a 0 logic level, and a 1 logic level. The results of this comparison are conditioned by the expected output and an error indication strobe. These comparators should have a better than 50-mV resolution at the device under test output, and a data strobe or data window of less than 25-ns duration. One or more data strobe(s) is used to determine if the waveform envelope of the output were within the time and voltage specifications.

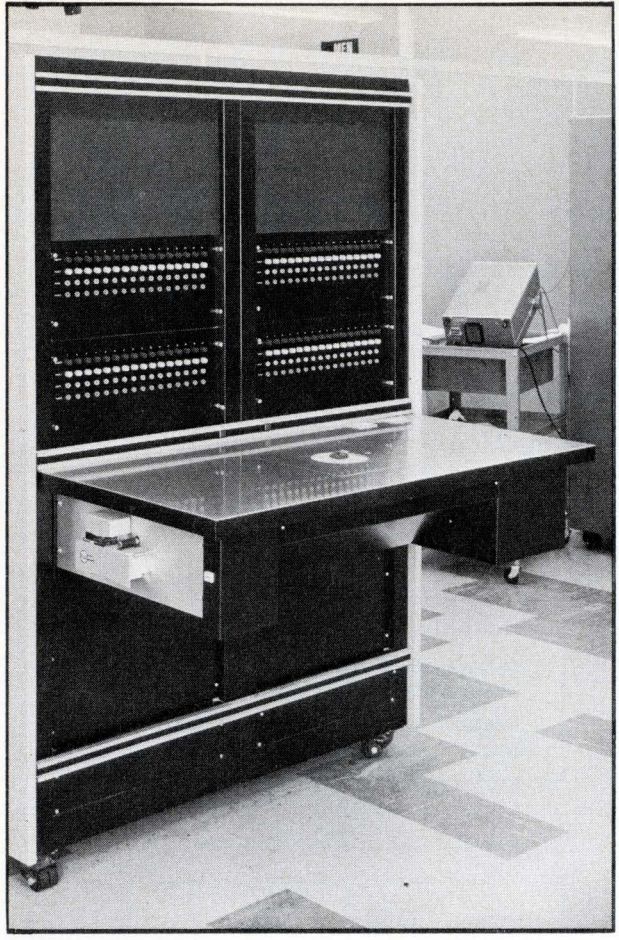
The outputs of the device should be loaded resistively and capacitively to their maximum ratings before the test. The loading resistors and capacitors can be mounted on the adapter board which contains the connector or probe pins.

The MOS functional tester and the MOS memory tester should include an optional parameter limit tester. This parameter limit tester is definitely required when the tester is used with a probe station and is desirable when testing packaged devices. The parameter limit tester will test probe down continuity, leakage limits, and present a stress voltage to the device input pins.

Probe down sensing can be conducted by forward biasing the pn junction of the MOS device input or output pin. If the substrate of the MOS devices is grounded, a 5 V applied through a current limiting resistor will detect if the pin is making connection with the device-under-test input or output. This particular test will only work if the input or output goes through a zener device or a p region but in most MOS devices all input and output pins do go through or make a connection to a p region.

Leakage measurements may be conducted on all input pins by applying a compliance voltage through a current-limiting or dropping resistor to each input pin. A comparator then measures the voltage level at the input pin. This leakage limit test is not the high accuracy measurements that are performed for parameter testing.

Each pin has a different value of leakage. Typical leakages may range from 1 μA for an input line to 100 μA for a clock input. To accurately measure these



This Is Redcor's PAFT II (Programmable Automatic Function Tester). The system uses a RC-70, 16-bit computer as the center of the test system.

limits, a resolution and accuracy of about 100 nA is required of the parameter limit tester.

The input pins are also stressed to determine if the device meets the breakdown requirements. The maximum compliance voltage for stressing should be in excess of 100 V for high threshold MOS processes with the actual value adjustable and controlled by the hardware.

Programmable functional tester

The functional tester presents a data bit pattern to all inputs and then compares the output with the expected outputs. The drivers, clocks, and comparators condition the inputs and outputs for handling by the logic in the test system. Since LSI testing requires a large number of controlled operations and a large data storage capacity for test patterns and expected outputs, a generalized changeable control and data storage device is necessary. The least expensive and most versatile device of this sort is the general purpose computer.

The use of a computer with the functional test system allows a large amount of versatility in test operations. The test system capability is limited only by the software furnished by the equipment manufacturer or generated by the user.

Additional test system logic and data storage are required where speed of operation precludes the use of the computer control and computer memory. To achieve data pattern inputs and outputs in excess of 2 MHz for functional testing, auxiliary data storage must be provided outside the computer. This data storage may be in the form of static shift registers, high speed memories, or other means. Of the various approaches for storage of test patterns, static shift registers and read/write memories seem the most practical hardware approaches. Since MOS testing requires a wide range of input test rates, dynamic devices, such as drums, discs, and dynamic shift registers, severely limit this capability. These dynamic devices are adequate for an inexpensive, single purpose tester. For the generalized programmable functional tester described here, however, they severely limit system capability. This auxiliary, high-speed data storage allows the data patterns and the expected outputs to be transferred in real time. The computer memory can be used as intermediate storage for the test patterns which are then transferred to the high-speed data storage for the actual test.

The performance of various real-time data transfer and control operations necessitates other hardware control circuits. Some of these operations include data logging, data channel blanking, clock blanking, and other means of controlling the real-time test operation.

Data and clock blanking is required because many LSI devices will have a number of indeterminate states that do not resolve themselves into meaningful outputs until several successive inputs have been introduced. The blanking channels cause the tester comparator circuits to ignore the outputs on these selective channels until they become meaningful. Clock blanking provides dead time to test the data retention ability of certain transient devices. The computer should control all of these hardware functions. The computer will have the option of setting up or inhibiting all test functions.

With a computer-controlled system, the software determines the full capabilities of the test system. The software for a programmable functional tester should provide for all test setups, control and parameter testing, data logging, and complete control of all setup and testing operations.

For reasons of economy and to utilize the full capability of a complete programmable function tester, multiple test stations are a necessity. These test stations may be a combination of probe stations and test sockets for packaged devices. Since an automatic probe station requires from 100 to 300 ms to step from one device on the wafer to the next, the tester can be multiplexed between several stations. This multiplexing results in minimal loss in test time for each probe station. If a manual insertion socket is used for testing packaged devices, the socket can be multiplexed with no effective decrease in testing time.

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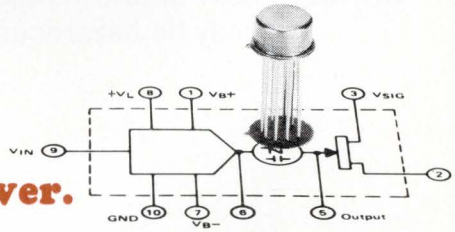

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Circle 21 on Inquiry Card

HYBRID resistor trimming: an industry report

DANGER: Use of untrimmed hybrid resistors may be hazardous to your circuit

By Stephen A. Thompson
Western Editor-Los Angeles

Who trims film resistors? Everyone. Why? Because the process of manufacturing film resistors is inherently inaccurate. With luck, the many processing and material composition factors affecting deposited resistor values can be held to a cumulative $\pm 10\%$ in tightly controlled production but $\pm 20\%$ is more likely. Any circuit requiring a better accuracy must be adjusted.

The resistor trimming process breaks down into several applications. Trimming thick and thin films are fundamentally different processes. Volume and accuracy are major factors when deciding which of several trimming methods to choose. The major confrontation today is between the more established technique of air abrasive trimming (AAT) and the upstart —laser trimming (LT). It is estimated that AAT is used in as much as 95% of trimming applications—especially in thick films. Lasers are the only clear challenge to this dominance, with no other serious contenders.

Trimming for the beginner

All trimming methods rely on mechanical or chemical alteration of the resistor. Implementation varies widely in complexity, accuracy, and ingenuity.

The cheapest, crudest methods mechanically remove the resistive material to raise R (resistance) to an acceptable tolerance band. For instance, erasers can actually be used on soft resinate ink resistors.[1] The next step up the technology ladder may be a scribe and vibrating tool. The most sophisticated of the methods utilized by low-volume, low-overhead operations, uses rotating diamond phonograph needles or dentist drills.

Characteristics common to these processes are minimal fixturing, high tool wear, poor tolerances, chipped resistors and substrates, and operator dependency, i.e., unreliability.

Bonding pad adjusting

This method attacks trimming by layout and calculation rather than tools. Resistors are strung together so that the final value can be adjusted to spec by shorting segments or lifting bonds. Hewlett-Packard uses this technique on critical matched-bias resistors.

The ultimate in calculation would be accurate matching components so that trimming could be eliminated. Hewlett-Packard matches some parts to substrates and matches some amplifiers to transistors, but trimming remains the easiest way to adjust the total circuit.

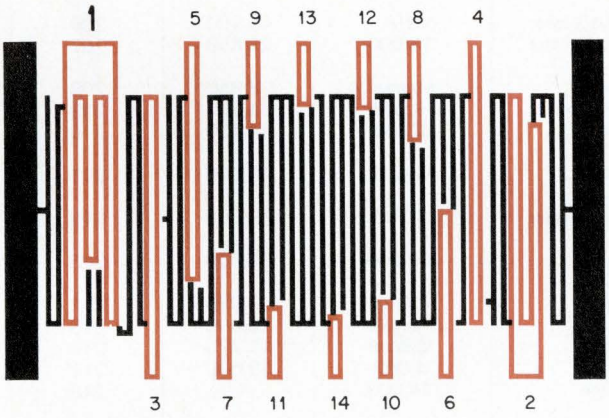


Fig. 1. A 1,300-square thin-film resistor pattern with parallel adjustment loops. A portion of each loop is common to the main conducting path. Opening the loop removes a shunt according to the following values:

Loop No.	Increase (%)	Loop No.	Increase (%)	Loop No.	Increase (%)
1	8.192	6	0.256	11	0.008
2	4.096	7	0.128	12	0.004
3	2.048	8	0.064	13	0.002
4	1.024	9	0.032	14	0.001
5	0.512	10	0.016		

Line widths are 1½-2 mils. Widths down to 0.4 mils have been used; patterns ranging from 5 to 200,000 squares have been made; and resistance ratios as high as 10,000:1 (0.0001%) have been produced. Courtesy of Allen-Bradley Co.[2]

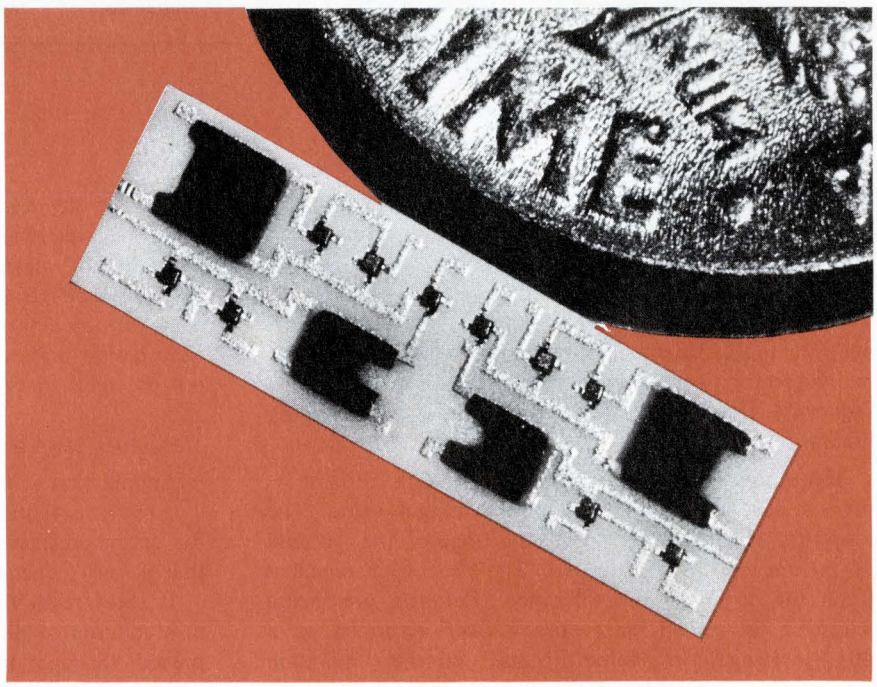


Fig. 2. Can you spot a good trimming technique and one that could be improved? Ten beam-leaded transistors and four resistors are attached to this 0.15-in. x 0.5-in. substrate from Texas Instruments. The ratio of the large to small resistor on each side is trimmed to ±1% by air abrasive trimming. Using a wide nozzle to trim the large resistors preserved maximum width and minimized the possibility of hot spots during high power dissipation. Orientation of the trimming direction on the large resistors is such that the body of the second one trimmed protects the first one from being altered by overspray. This is not the case for the smaller resistors, though a protective overglaze could be applied to the first one trimmed.

TABLE I RESISTOR TRIMMING EQUIPMENT

Manufacturer	Model	Type	Throughout (trims/hr)	Base price ($)	Inquiry card no.
Apollo Lasers Inc.	Lasertrim Y	CO_2 laser	Manual	7,100	201
Apollo Lasers Inc.	Lasertrim YAG	YAG laser	Manual	18,375	202
Arvin Systems Inc.	ART	CO_2 or YAG laser	3-6,000	50,000	203
Axion Corp.	RA-650	Air Abrasive	Manual	6,500	204
Axion Corp.	RU-2	Ultrasonic Scribe	Manual	4,650	205
Electro Scientific Inst.**	16	CO_2 or YAG laser	N/A	45,200	206
Electro Scientific Inst.**	20	CO_2 or YAG laser	18,000	91,850	207
Hughes Aircraft Co.	5550H	Argon laser	Manual	9,950	208
Hughes Aircraft Co.	5560H	YAG laser (split)	6,000	24,950*	209
Hughes Aircraft Co.	5561H	YAG laser	3,000	14,450	210
Korad Laser Systems	KRT	YAG laser	Manual	19,000	211
Micronetics Inc.	70	CO_2 or YAG laser	7,200	69,500	212
Spacerays Inc.	YT60C	YAG laser	3-7,000	85,000	213
S. S. White	LAT 100	Air Abrasive	Manual	5,950	214
S. S. White	AT-701A	Air Abrasive	Manual	13,800	215
S. S. White	AT-701AR	Air Abrasive	Manual	17,775	216
S. S. White	AT-704	Air Abrasive	4,000	39,500	217
S. S. White	AT-707	Air Abrasive	24,000	N/A	218
Teradyne Applied Systems**	W102	CO_2 or YAG laser	24,000	89,100	219
TRW Instruments	110A	Xenon laser	Manual	8,980	220

* Price includes two stations. This unit can operate up to four stations from a single laser.

** This company also markets resistance bridges for trimming systems. The names of two other manufacturers of resistance bridges for trimming systems came up over and over again. They are:

Boonton Electronics Corp. Inq. No. 221 James G. Biddle Co. Inq. No. 222

Mind over technique

Allen-Bradley in Milwaukee, Wisconsin, uses a sophisticated version of the bonding pad technique to trim chromium/cobalt thin films over a range from 50Ω to 70 MΩ.[2] The resistors are constructed, as in Fig. 1, such that many paths exist in parallel with a main serpentine path. Each parallel path loops outside the main conductor pattern for easy access. The lengths (squares) are chosen so that they form an overlapping binary sequence.

Trimming is an iterative process. The resistor is probed and R is matched against a target value. The loop that will produce the largest change on the low side of the target value is opened. The process is repeated until the R is within tolerance. Patterns are being trimmed to ±0.001% accuracy over as much as a 40% change in value. Some circuits maintain ±0.005% accuracy over the −55 to 125°C temperature range. Using the technique, Allen-Bradley has A/D converters and voltage divider standards in production.

This method has several advantages. The main portion of the resistor is untouched, minimizing uneven power dissipation due to trimming, and eliminating thermally or mechanically induced stresses. The area between loops is large enough to accommodate ultrasonic or laser trimming. The important consideration is to design patterns and calculate which loop to open, not the method of opening the loop.

Resistors take a bath

Anodization is another thin-film trimming technique. Typically, a tantalum or tantalum-nitride film covers the entire substrate, except for a high-value test resistor that is very dependent on sheet resistivity.

If sheet resistivity is low, the substrate is immersed in a solution of dilute oxalic acid and a low current is passed through the film and the solution, causing tantalum pentoxide to form at the film-solution interface. This action reduces the film's cross-section and increases resistance. Tolerances of ±5-10% are considered good in this batch process.

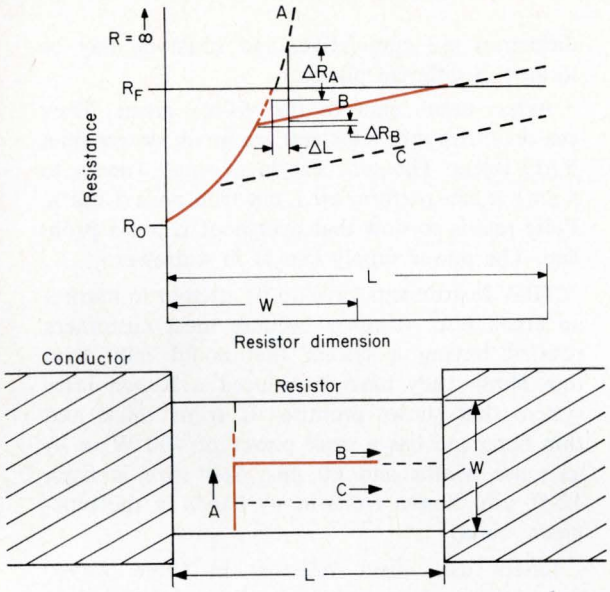


Fig. 3. Benefits of the laser "L-cut" technique. If the resistor shown is trimmed to its final value, R_f, by cutting straight across along line A, two undesirable effects are noted. The resistance change, △ R, per length of cut is relatively large, making accurate adjustment difficult. The hottest spot will occur at the narrowest remaining portion of the resistor. By approaching R_f along A, then completing the trim along B, a slope of much smaller △ R/unit length is followed. This aids accurate adjustment, and retains a greater minimum width, minimizing chances of a hot spot. If the combination A-C is chosen, such that the end of the resistor arrives before R_f is reached, the resistor must be rejected.

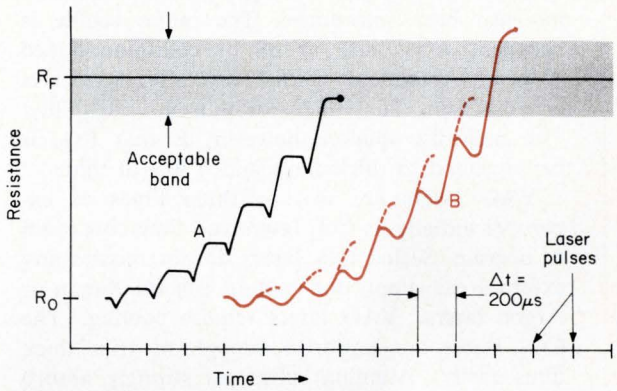


Fig. 4. Effect of plasma plume on laser-trimming measurements. Ionized gas, formed when the laser vaporizes the resistors, provides a conducting path that effectively lowers resistance at the start of each measurement cycle. If the duration of the effect is about 100 μs and the laser pulse rate is 5 kHz, curve A might result. This assumes a cut similar to line A in Fig. 3, and that measuring circuitry could shut the laser off 50 μs before the next pulse is due if R measures in the acceptable band. If the effect does not clear for about 250 μs, solid line B might result. The dashed portions show where the reading would have been if a 300 μs pulse interval were used. Because R never stabilized, the laser kept pulsing, and the acceptable band was missed. This type of effect may limit realistic measurement intervals and laser trimming speeds.

Trimming to a given stability

The pulsed voltage method, used also for trimming thin-film resistors, has not found wide acceptance. Nichrome resistors are oxidized and R increases when rf pulses heat them to the proper temperatures. The advantages are that this technique can be used on very small resistors, without foreign material being introduced. The disadvantage is that it is a very time consuming method and if the circuit is exposed to voltages exceeding the original voltage, the resistance may change still more.

Trial by light or sand

Air abrasive trimming (AAT) is the tried and proven workhorse of resistor trimming. Basically, it is sand blasting in its finest form. Typically, an air jet carries alumina particles of 10 to 50 microns to the resistor where they abrade the film, causing R to increase. Very precise accuracies can be achieved rapidly, reproducibly, and automatically.

Laser trimming (LT) is the challenger. Chemical or mechanical changes are made in the resistor by heating or vaporizing the resistor, respectively. The laser beam is switched on and off rapidly, producing discrete changes in R with each pulse. It is faster, at least as accurate, and at least as reproducible as ATT.

Speed and accuracy

Neither side has established an accuracy advantage in this classic trade-off. Both claim 0.01% as average with a possibility of 0.001%, if desired. Almost nobody needs that high an accuracy and there is reasonable doubt that many resistors trimmed to better than 0.1% remain there for long. Most users are satisfied with the 1-5% range.

However, there are exceptions. Texas Instruments has found that to match ratios of two resistances to within 1%, an overall accuracy of 0.5% is required. One goal at Varadyne, in Santa Monica, Calif., is a 12-bit ladder network with ±½-bit significant bit ac-

Lasers come in many colors

Four types of lasers are in use today. Of these, Argon has not gained wide popularity and Xenon has just been introduced. The major scuffle is between CO_2 and YAG (neodimium-doped Yttrium Aluminum Garnet crystal). Advocates of each type claim thick- or thin-film capability. The majority opinion, however, is that CO_2 is better suited to thick films and YAG to thin.

YAG lasers are two or three times as expensive initially as CO_2 lasers and they cost more to operate. Sealed CO_2 lasers do not require any external gas supply for cooling, nor do Xenon or Argon lasers. YAG lasers require cooling. The CO_2 lasers are powerful enough to trim thick films easily. Alumina substrates strongly absorb their 10.6-μm wavelength, but the effects are minimal. These CO_2 lasers have also been in development longer, so many consider them more reliable.

YAG lasers are preferred for thin-film work because of smaller spot sizes and because the metal films tend to reflect the CO_2 wavelength and absorb the YAG's 1.06-μm wavelength. This suggests that YAGs may be better suited to thin-film trimming than air abrasive trimmers (AAT).

YAG lasers can trim thick films, but their lower power makes them slower. They pulse faster and have smaller spot sizes, so there is speculation that they may be inherently more accurate. There is a tendency for users to accept YAG lasers as the universal trimmer, even though each laser will probably be dedicated to a single type of production line.

The YAG laser is more sensitive to the vertical location of the resistor. Delco reports that the active focal length of a YAG can only compensate for a deviation of 4 mils, while a CO_2 laser can cover 20 mils. Across large substrates, where camber can easily be ±8 mils, a YAG could have trouble. Abrasive systems are relatively indifferent to camber. This could make them a good choice for trimming multilayered structures, where variations in print thicknesses of resistors and dielectrics are cumulative, and resistors may be located in different planes.

Argon lasers emit in the visible green. They can only trim thin films and are much slower than YAG lasers. The spot size is so small (down to 5 μm) it can perform an L-cut trim on a 1-mil R. Pulse rate is so slow that overshoot is not a problem. The power supply can fit in a drawer.

TRW Instruments gave up its attempt to market an argon laser trimmer because most customers resisted buying a system that could only trim thin films. They have introduced a Xenon laser system that shows promise. It trims thick and thin films and has a peak power of 400 W at ½ μs pulse widths and 60 pps. Spot size is from 12-50 μm. Xenon emits in six bands in the blue-green band.

Lasers can affect resistors in three ways: Vaporizing, melting, or annealing. Melting has been discarded as impractical. Most trimmers are set to vaporize a small portion of the material, thus raising R. At TRW Systems, an argon laser trims cermet thin-film resistors through a glass-topped package and anneals the resistor in place. You could not do this with CO_2. This technique allows functional trimming of the finished package without adding or removing any material. The annealing adjusts resistance downward. An overshoot can be reversed, within limits, by increasing the energy content of the beam and eroding a small portion of the resistor inside the package. Ten-micron spot sizes are possible and adjustments of 0.1% are routine, with 0.01% reported. After visual inspection, the package is made opaque to protect the light-sensitive circuitry.

There are also three techniques, all of which are successful, for relative motion of the beam and the work. Most trimmers move the X-Y table. Korad will move either the laser head or the table because the mass is about equal. Coherent Radiation inserts mirrors between the head and the work, using them to control beam motion.

curacy. This means having resistances matched to 0.01%, with a temperature coefficient of resistance (TCR) tracking of 1 ppm. Varadyne, which is now close to the 1 ppm goal, feels that the pulse-and-read capability of the laser is needed for this accuracy.

Users agree that LT is inherently faster at achieving a given tolerance than AAT. Obviously, if you are dealing with many resistors, the speed is important. At low volume, trimming time approaches zero compared to handling and positioning time, regardless of method. Trimming time does become significant at high volume. The laser is capable of stopping within a pulse or two permitting high trimming speed. The interval from the "stop" command to end-of-trim is relatively long in AAT because particles continue to arrive at the resistor for several milliseconds. This causes an overshoot which

must be anticipated. Mechanical techniques of blocking the nozzle with a gate or reversing the direction of the table during shut-off are not as responsive as the laser, so reduced table speed is the practical solution to the AAT overshoot problem.

The most successful way to increase AAT throughput is to use a separate nozzle for each resistor on a substrate, trimming them simultaneously. An S.S. White AT707 at Delco Radio in Kokomo, Indiana, has seven heads and trims on a 2-s cycle, or 12,600 trims/hr, which includes wafer changing.

Delco uses both AAT and LT to turn out 20,000 thick-film voltage regulator and audio circuits daily. Since circuit performance is independent of technique, they are interchangeable. Although Delco's AAT systems are faster than almost anyone else could use, they are converting to LT largely because of the speed advantage. Delco finds that in AAT the shut-off and read time is about 25 ms. Lasers reduce this to about 3.5 ms. Laser trimming is considered a minimum of three to five times faster than AAT.

S.S. White systems trim to within $\pm 0.1\%$ at speeds of 0.15-1.5 in/min. At 6 in/min., accuracy drops to $\pm 0.3\%$. Production systems trim to 0.5% in 0.5s, and speed increases rapidly above 0.5%. Delco easily maintains $\pm 1\%$ at laser speeds of 2-3 in/s.

Functional trimming is next to cleanliness

As an electronic industry process, sand blasting is a messy source of contamination. The AAT equipment is often kept in a separate area, interrupting the production flow. Though the abrading spot may be only 3 mils in diameter, sand flies in all directions. This overspray coats and abrades nearby circuit elements, including other resistors just trimmed. Particles follow the substrate surface unless deflected by something, so shielding against them is very difficult. Minute particles enter nearby rotating machinery where they can cause accelerated wear.

Laser contamination is restricted to redeposition of the vaporized resistor. Some laser manufacturers ignore the vapor; others blow it away with a fine jet of inert gas, mainly to keep it off the focusing lens.

Overspray virtually eliminates AAT from consideration for functional trimming. "Active circuit" or "dynamic" trimming are synonyms for this increasingly popular technique, where an operating circuit is probed and resistors are trimmed to bring a circuit response, such as output voltage regulation, into spec. Functional trimming permits a manufacturer to adjust the spec he is really concerned with.

A cost analysis at Du Pont in Wilmington, Deleware, showed that an audio amplifier circuit cost $3.00 in materials and labor at a volume of 25,000 per day. Eight cents of this was in thick-film paste and $1.00 was in add-on components such as chip resistors and

"As fired" resistors are getting much better

During the firing process of the older PdAg type of thick-film inks (pastes), the conductor material preferentially precipitated, resulting in a glassified resistor with an incipient hermeticity. Non-Pd, noble-metal inks, such as DuPont's ruthenium-based Birox[T], were developed to overcome deficiencies in PdAg inks. These deficiencies include process sensitivity, highly positive noise figures, any TCR greater than 100 ppm/°C, and sensitivity to reducing ambients.[5] In the new inks, the conductive phase is chemically preformed during manufacturing. No additional reactions take place during the printing, drying, and firing cycles. Sheet resistivity depends only on firing temperature, not firing time, and the final product is virtually chemically inert.

Though Birox was not invented to aid trimming, it has done so, probably because the resistive element is homogeneously distributed in the vitreous matrix. Birox resistors have better characteristics than PdAg resistors after both are trimmed by either AAT or LT. Some indications are that LT Birox resistors are almost as good as untrimmed ones.

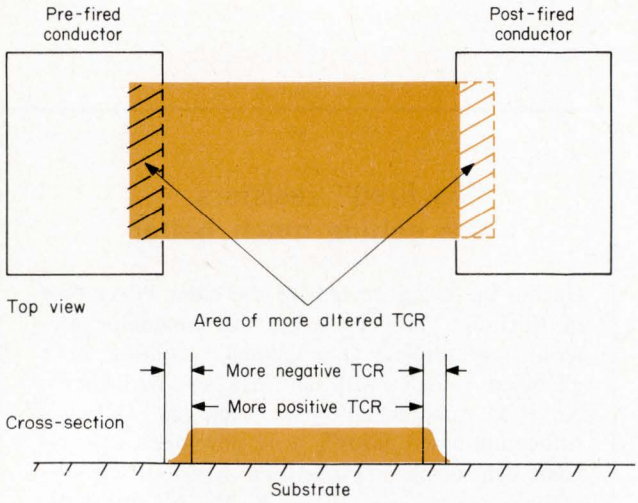
Many users did not want to convert from firing PdAg near 760° to firing Birox at 850°C. Du Pont introduced a low temperature Birox to upgrade PdAg users. This is their 100 series which fires at 760°C. The three main types of inks compare as follows:

SCREENING ACCURACY

Type	Lot-to-lot	Day-to-day	TCR	Cost/oz
PdAg	±30%	±30%	250 ppm/°C	$25
1100	±30%	±4-20%	250 ppm/°C	$50
Birox	±10%	±10%	100 ppm/°C	$100

If manufacturers keep improving the inks, it is possible that some circuits will not need to be trimmed. Several non-Pd ink producers are:

Company	Trade name of ink	Major[4] base metal(s)	Inquiry card number
Electro Materials Corp. of America	Firon	Ru, Ir, Rh	230
Du Pont	Birox		231
Electro Science Labs.	3800 Series	Pt, Au, Ir	232
Methode Development Co.	Blend-Ohm	Pb, Ru	233
Alloys Unlimited	Series A	Ru, Ag	234



Boundary effects. The TCR of a thick-film resistor can be considered to be a composite of the contributions of the four edges plus the central portion. Conductor material diffuses into the resistor at the conductor-resistor interface, causing large upward shifts in TCR. In short resistors, contact area becomes a large percentage of the total area, so contact resistance and TCR effects become more pronounced. Use of high performance pastes and post-fired conductors gives the best control of R and TCR[6] because of minimal interface diffusion. The thin tapered edge region of the fired cross-section is more negative in TCR than the bulk, because negative TCR constituents concentrate there during firing. Removing large portions of the center of a small R during trimming can shift TCR negative by tens of ppm/°C.[7]

capacitors, and active devices. The best way to cut costs was to functionally trim the circuit, allowing relaxed specs on the add-ons, eliminating separate testing of components, and increasing the module yield simultaneously.

After the trim is over

Trimming a resistor can affect its long term stability, TCR, and noise figure. Extensive information describes abraded resistors. No such data base has been established for laser-trimmed resistors as yet, though Hughes Aircraft reports that load-life characteristics for argon-trimmed thin films are well established and meet Mil-5400 series tests quite well.

Physically, AAT erodes the protective glass layer formed when thick-film resistors are fired, exposes the aggregate material underneath, and destroys the hermeticity. Sometimes overglazes are applied to reseal the surface, but these can also alter R values.

The laser eliminates any need for an overglaze because it vaporizes the material leaving a resealed or reglazed resistor.

Unanimity is not found among users. Centralab holds that laser trimming does not seem to affect the TCR; however, they say it does affect the current noise, but no more than other methods. Fairchild engineers think the older palladium-silver (PdAg) inks were incompatible with LT, while the new noble metal-based one will be compatible. Their engineers do not like the noise the AAT introduces into resistors. Varadyne finds that noise, stability, and TCR are equivalent with either method when they trim noble metal inks. Delco, which uses PdAg inks, does not overglaze the trims. Their engineers find that laser-trimmed resistors are twice as stable as abraded ones.

Manufacturers' inputs are what one might expect. Korad Lasers Systems claims that they cannot tell laser-trimmed resistors from untrimmed ones. S. S. White says that with equipment specifically designed for tight tolerance trimming there is no appreciable change in noise level after AAT. Axion adds that there is no problem with the stability of abrasively trimmed resistors.

The largest paste manufacturer, Du Pont, believes that their PdAg resistors undergo significant changes when trimmed, adversely affecting drift. Samples of their noble-metal composition, Birox™, trimmed by laser and abrasive techniques show no significant differences over the time span that they have been able to test them. They feel that the laser-trimmed resistors may be as good as untrimmed ones. Electro-Science Labs notes that AAT overspray introduces pits in the surface causing noise. They see no TCR change with LT of their 3800 series noble-metal pastes, and could not tell untrimmed resistors from resistors trimmed by Apollo Lasers.

Pay now or later

Laser systems are more expensive than AAT systems. (See Table I). The more complex and automated the system, the less the difference, because much of the expense is tied up in software and handling equipment common to either system. As systems increase in size, they become custom and several have been assembled in-house. Bourns estimates that their own tape controlled CO_2 laser trimmer cost between $60,000-$70,000.

Maintenance is another story. Users universally bemoan the fact that AATs are mechanical and subject to wear. Bourns found that for high volume production, nozzles were replaced once a week and after 6 months the whole system started to wear. Fairchild looked to lasers because the abrasive equipment broke down a lot. Abrasive systems consume sand, nitrogen, and nozzles regularly while LTs use up light sources and lesser quantities of nitrogen.

Laser users report that their systems are on-line most of the time. Replacing light sources is as easy as replacing nozzles and occurs less frequently. Nozzles cost $8.00-9.00 each. Korad's YAG (neodimium-doped Yttrium Aluminum Garnet) laser typically needs $13.00 sources every 200 hours. Hughes changes their

two YAG sources every 400 hours at a cost of $24.00.

No personnel changes were required in places that converted to laser trimming. Safety is no problem either. The CO_2 lasers emit light in the infrared that is strongly absorbed by outer layers of the skin or eyes. It is totally absorbed by glass or plexiglass, so most operations shield the working area with plexiglass and insist that operators wear safety glasses. YAG lasers also emit in the infrared, but at a wavelength that can pass through the aqueous solutions of the eye and be focused on the retina. Tinted shields that absorb the dangerous wavelengths are used and TV substrate monitors are common.

One area where AAT systems are way ahead is capacitor trimming. Doing it with lasers is difficult because the dielectric tends to form a semiconductor and the laser fuses layers of ceramic and metal at the edges of the trim. Metal layers tend to reflect CO_2 beams. We have found no capacitor trimming by laser on a production basis.

Measurement limitations

Laser manufacturers are fond of blaming the accuracy and speed limitations on instrumentation. Resistance bridges or DVMs do not settle fast enough to take advantage of the laser's speed, they say.

Electro Scientific Industries (ESI) of Portland, Oregon, disputes that. A laser pulsing at 5 kHz causes a step change in R every 200 μs. If this represents a 0.1% bite out of the R, the bridge will settle in 100 μs. If the bite is larger, settling will take longer. ESI thinks it would be as easy to speed up the laser shutdown circuitry as it would be to provide a 10 μs bridge. An alternative is to slow down the cutting rate by changing direction (L-cut) as the resistor approaches its final value. For accuracies better than 0.1%, a measure-and-predict mode is definitely needed.

ESI questions the meaning of measurements at 10 μs intervals, if they were available. They think that thermal time constants as high as 1 ms can exist. These could be caused by substrate relaxation, paste interactions, etc. Both ESI and Coherent Radiation Inc. agree that there is a plasma created when the resistor is vaporized which must be allowed to clear before accurate measurements are possible. The ionized gas persists for 50-300 μs and provides a shunt that effectively lowers the measured R as shown in Fig. 4.

S. S. White claims minimal thermal effects in AAT. ESI and McDonnell Douglas[3] report that static charges can build up on the substrate and be imparted to the abrasive. The charged abrasive introduces all sorts of pick-up into the resistor which make trimming very difficult. McDonnell Douglas solved this problem by raising the moisture content of the nitrogen from 25 ppm to 600-700 ppm.

ESI thinks that a basic instrumentation advantage of laser systems is the minimum coupling with the resistor being trimmed plus the high speed turn-on/turn-off capability.

What's ahead?

While AAT appears to be under siege, it has some powerful things going for it. For one, it is cheaper. Despite all the problems with AAT, users have learned to live with them and circumvent them one way or another. Laser trimmers will make inroads in very high speed and functional trimming applications. However, in the large majority of everday applications where AAT does an economical, adequate job, the advantages of lasers may not be so important.

Are AAT manufacturers hedging their bets? Axion offers ultrasonic trimming in addition to AAT and is looking at the laser technology for new product development. Hal Skurnick of S. S. White states, "We will continue to give the industry the best equipment that will do the job for them. This may be either by the air abrasive trimming technique or laser technique. We, of course, have been investigating lasers but have yet to find a system that we can firmly stand behind and guarantee unquestionably to our customers."

Acknowledgments

The author would like to credit the following individuals for their many hours of personal interviews, phone calls, and correspondence: Wayne Moritz, Allen-Bradley; Dr. F. Burns & Tony Johnson, Apollo Lasers; Tom Garmhausen, Arvin Systems; Wilbur Hardison, Bourns; L. Palmer, D. Auda, and E. Callander, Centralab Semiconductor; Mark Dowhley, Coherent Radiation; Dwight Callaway and Gary Wagner, Delco Radio; Don DeCoursey and Ted Reissing, Du Pont; Richard Ringer, Electro-Science Labs; Ed Swenson, Electro Scientific Ind.; Dick Bader, Fairchild Semiconductors; M. Dixon Browder, Hewlett-Packard; Gene Peifer, Hughes Aircraft Co.; Mike Weiner, Korad Laser Systems; Hal Skurnick, S. S. White; R. Sullivan, C. Shaffer, and G. Fritz, Texas Instruments; David Breuer, TRW Systems; Max Jacobs, TRW Instruments; and Rene Cote, Varadyne.

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2. Moritz, W. and Wood, F., "Chromium/Cobalt—An Extremely Versatile Thin Film Technology," *Proceedings of the 1970 20th Electronic Components Conference*, McGregor & Werner, Inc., Washington, D.C., May, 1970.
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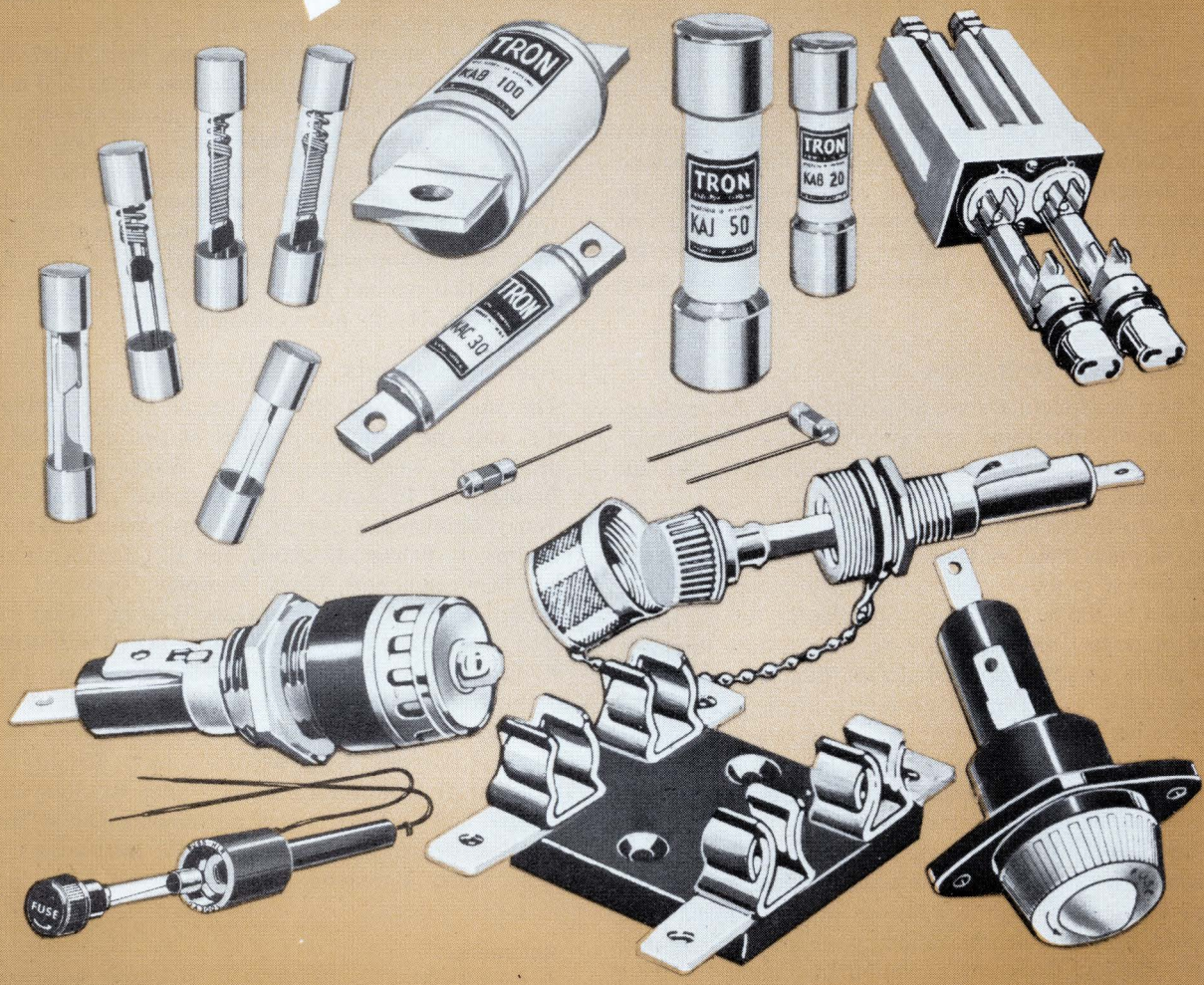
5. Hoffman, L. and Popowich, M., "Some Important Process and Performance Characteristics of 'Birox' Thick Film Resistor Compositions," Ibid.
6. Garvin, J. and Stein, S., "The Influence of Geometry and Conductive Terminations on Thick Fi m Resistors," Ibid.
7. Stein, S., Garvin, J., and Vail M., "Thick Film Resistor Pastes for High Performance Use," presented at the 1969 Hybrid Microelectronics Symposium, Dallas, Tex.

NAME YOUR REQUIREMENT



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THE WHAT, WHY, WHEN, HOW AND WHOM OF COORS MICROCERAMICS

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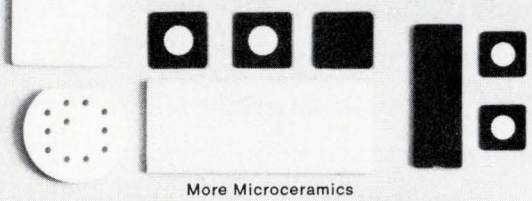
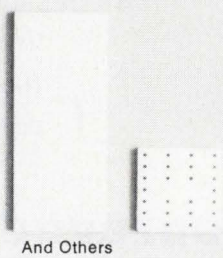


Q. WHY SHOULD I USE COORS MICROCERAMICS?

A. (1) Because you can be sure they will be manufactured exactly to your specifications and not modified to suit our production capabilities; (2) Because you can be sure they will be of uniformly high quality; (3) Because of (1) and (2) your yields will improve and your unit costs will be lower.

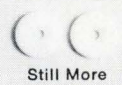


Q. WHEN SHOULD I USE COORS MICROCERAMICS?

A. When you want ceramic components of highest quality and reliability. Also when you need a ceramic producer with dependable, high-volume production capacity—or one that can turn out prototype and small-run quantities economically. We're geared to do both.

Q. HOW CAN I GET MORE INFORMATION ON COORS MICROCERAMICS?

A. Simply by asking. We'll be glad to counsel with you anytime by letter or phone. Or have our sales engineer in your area contact you for personal assistance. Or send you an informative data pack. Or all three.



Q. WHOM SHOULD I ASK?

A. Who else?

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CP-137

APPLICATION IDEAS

Here is your chance to apply the basic knowledge gained in the earlier parts of this course

By Jack Hickey, Managing Editor

Congratulations! You've made it this far in the course, and you're approaching the end. While the most difficult part of any course is to apply what you've learned, it is also the most interesting. Generally, courses quit after you have learned the basics of a subject. Here we're going to go beyond that point and cover many application ideas for you. Because there are so many ideas to work from, this portion of the course is split into parts A & B.

Originally, we had intended to take these application ideas and divide them into various categories. We looked at the possibilities of dividing the applications into groups such as digital and linear, commercial, military and industrial, or dividing them into emitter, sensor, and combinations, etc. But looking at the applications for optoelectronic devices we realized that an idea listed under one category could, in many cases, be applied in another area. By looking in only one category, then, you might have missed a good idea, so we simply selected those ideas we thought would be most useful to you.

Because optoelectronics is a relatively new field, it's very likely that you're not aware of all that can be done with a light source and detector. With this thought in mind, we selected at random many applications of optoelectronic devices. Hopefully, you will examine these application ideas one-by-one and, from them, get ideas of your own that will be useful to your designs.

By no means will we be showing all of the applications of optoelectronic devices, but rather, different ideas that will trigger your imagination. And to make it easier for you to grasp the basic ideas quickly, we have deliberately avoided using complete circuits with component values. We don't want you to miss the basic concept by getting lost in circuit details.

As you go through these applications you will notice that some of the ideas are very simple applications, while others are very complex. At present, however, the major applications of optoelectronic devices, whether simple or complex, are primarily "sensing" applications. Sensing ranges all the way from a simple counting application to a sophisticated character recognition application.

Another broad application area growing rapidly is the use of these devices for isolation, with isolators being sold as complete packages.

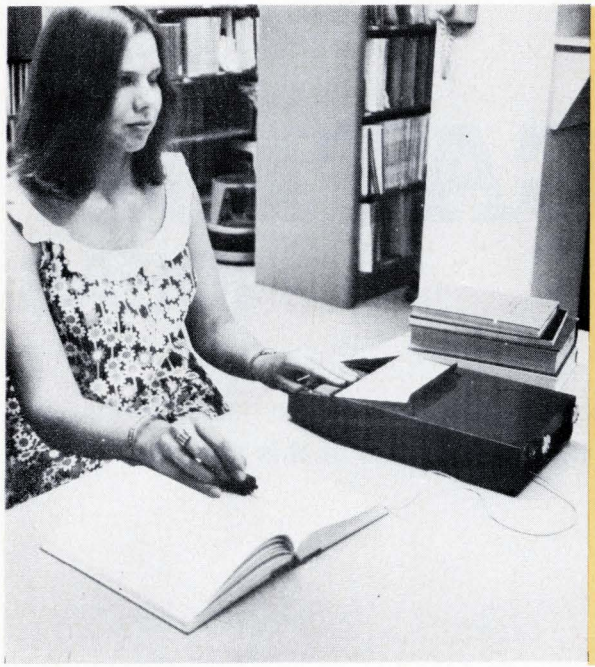
While the concepts developed in this part of the course may appear to be simple, remember that many will require sophisticated designs to function. For instance, in an industrial application line transients caused by switching machinery on and off may result in many problems. Don't forget to consider such "environmental" problems as this in your applications.

In each application or group of applications we give the name of the company that provided the idea. If one or more of these application ideas are of interest to you, then you can contact that company's applications department for more detailed design information. The companies will be glad to supply any information or assistance that you would like to have.

Earn your certificate

As with all good courses, at the end of this one there will be an exam. To all readers who take this exam and pass it, we will send a certificate indicating successful completion of the course. It is suitable for framing, so study hard. . . .

OPTOELECTRONICS Part 3A

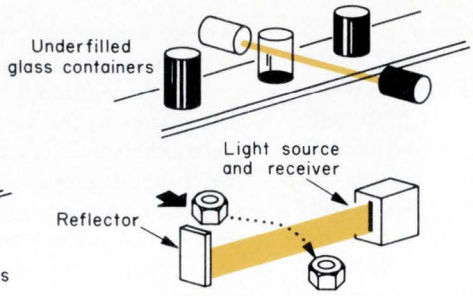


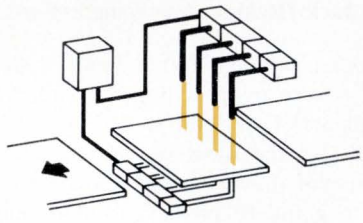
Candy Linville is using an optoelectronic device to convert printed matter into Braille for reading by the blind. The experimental device was developed by her father, Professor John Linville of Stanford.

Ideas supplied by Centralab

INSPECTION

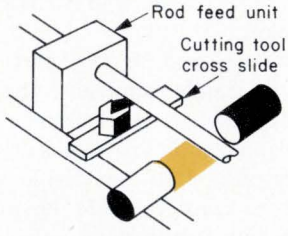
Missing bottle cap liners





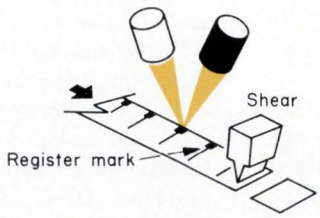
Scanning for material imperfections

MEASURING LENGTH



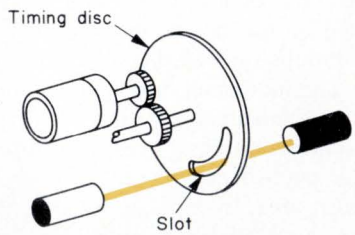
Cutting rods to length

REGISTER MARK



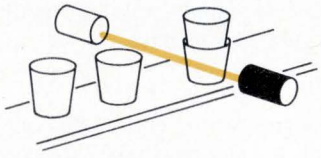
Cutting labels

TIMING CONTROL

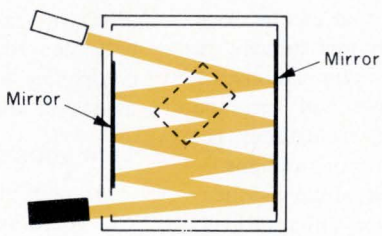


Timing impulses

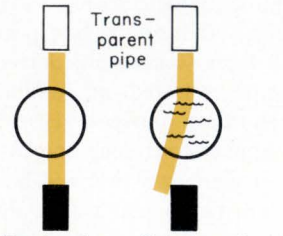
FLOW CONTROL



Doubled-stacked parts

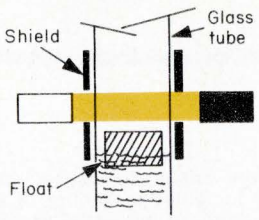


Small objects in large chute

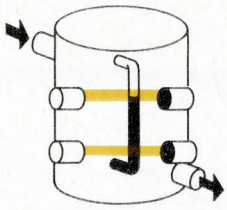


Liquid presence

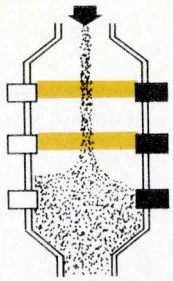
LEVEL CONTROL



Level with float

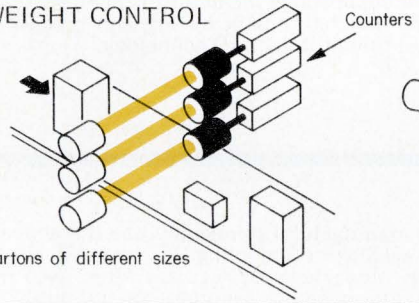


Level by opaqueness of liquid

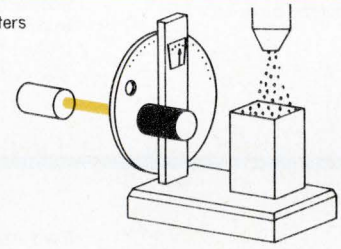


Level within bins

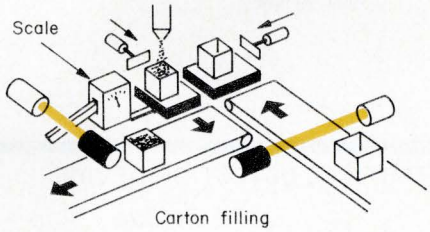
WEIGHT CONTROL



Cartons of different sizes

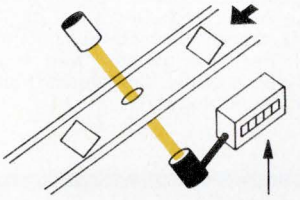


Controlling package weight

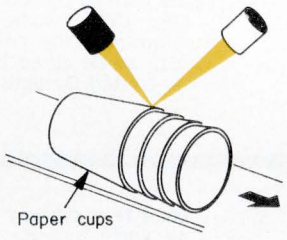


Carton filling

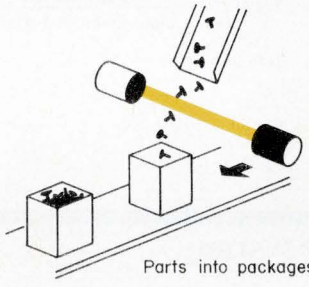
COUNTING



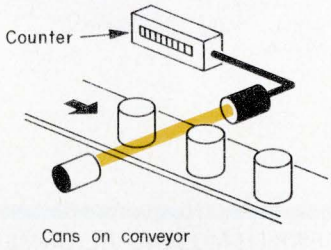
Parts in a chute



Paper cups

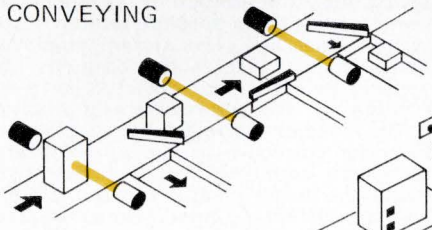


Parts into packages

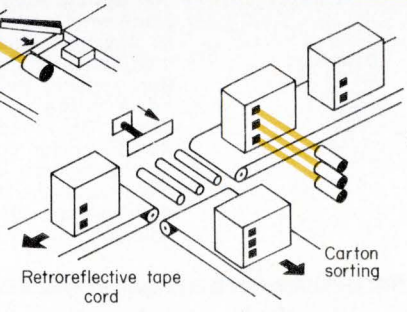


Cans on conveyor

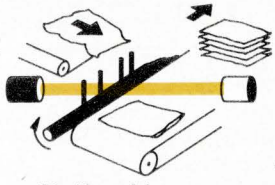
CONVEYING



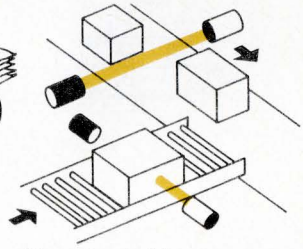
Sorting packages by height



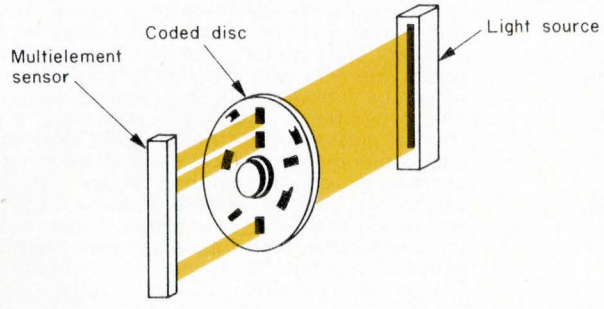
Retroreflective tape cord



Stacking of bags



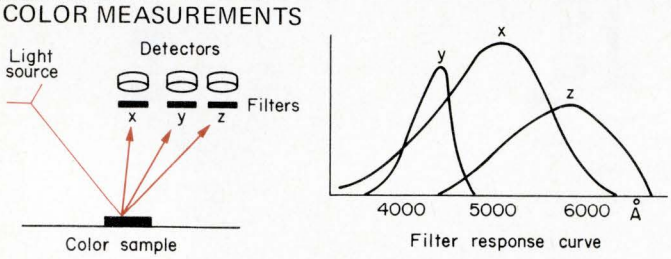
Flow of materials



Shaft encoders use multiple unit optoelectronic light sensors. A shaft position encoder, also referred to as a "converter" or "coder", is a device which transduces mechanical analog shaft rotation into digital representation. It will give a separate distinct digital indication for each position of the shaft, and the rotation can be divided into as high a number of segments as necessary.—Centralab.

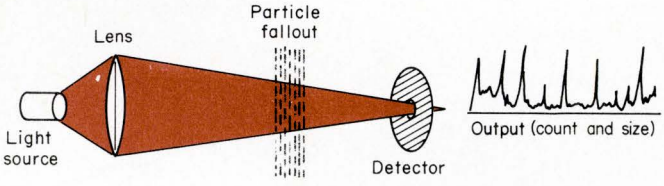
OPTOELECTRONICS Part 3A

COLOR MEASUREMENTS



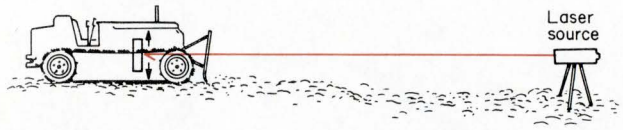
The need often arises to make quantitative measurements for color matching or color control in a wide variety of industrial and laboratory applications. This is done by using photocells and filters for color synthesis, color process control, color matching and color identification. Some applications include fruit ripeness testing, textile matching, paint mixing and process control.—United Detector Technology.

PARTICLE DETECTION DEVICE



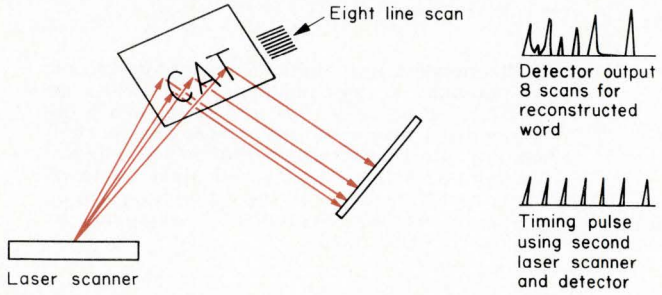
Two manufacturers presently use the scheme in the sketch for detecting the particle count in "dirty air." These devices are often used inside computer cabinets, laboratories and outdoor environment. The illuminated beam going through the center hole does not illuminate the active surface. If there is any back scattering as would be caused by loose particles falling through the air, this transient condition would partially illuminate the cell. Particles of less than 1 μm can be detected by a carefully designed system. —United Detector Technology.

EARTH MOVING ALIGNMENT SYSTEM

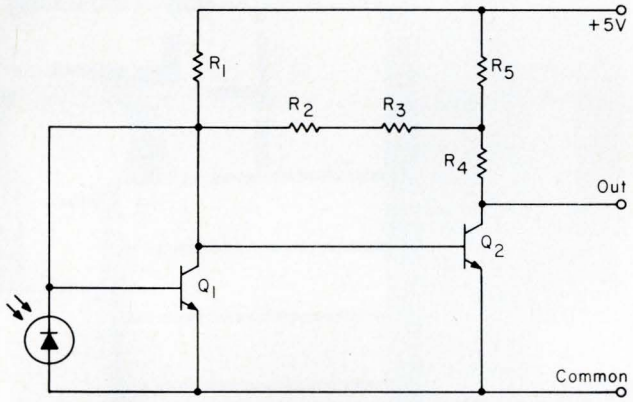


Here is a system that indicates to the driver of an earth moving machine (ditch digger—grading, paving, etc.) the attitude of his vehicle and blade with respect to an absolute reference such as a visible laser line. The system employs a modulated (visible) laser and continuous position sensing detector. The detector is free to move on the "y" axis and is driven to a null position. The position correction is displayed to the driver for corrective action. A modification to the system connects the corrective signal directly to the blade control through a heavy duty servo system.—United Detector Technology.

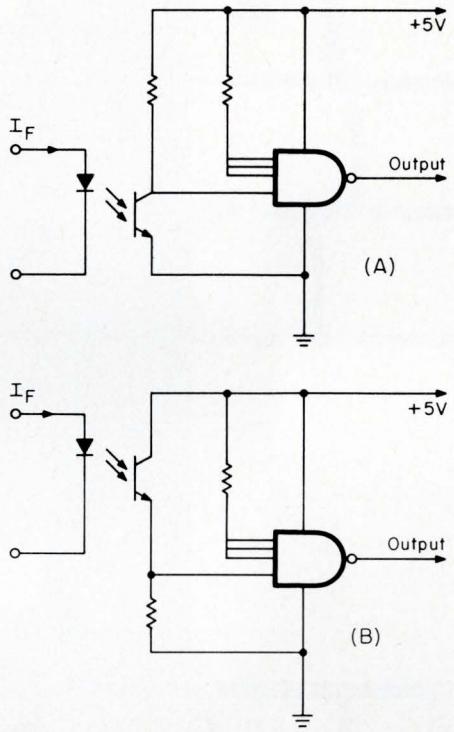
REMOTE OPTICAL CHARACTER READER



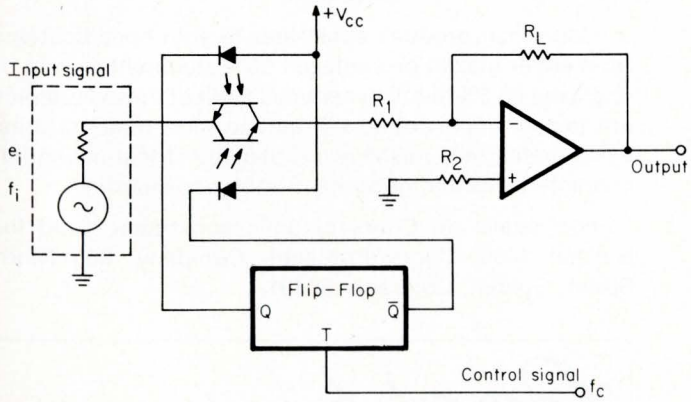
This system was designed for remote character reading applications. There is a timing channel and each line of written characteristics is scanned eight times. The light to dark ratio pulses are sent with the timing pulses through wires or microwave link to a remote computer. The computer analyzes the data and timing channel pulses and restructures the information into computer compatible (digital information) or reconstructs the printing at the computer site or at another remote station. Both the timing channel and data channel use a continuous surface, high frequency response photodetector selected for a very high surface uniformity.—United Detector Technology.



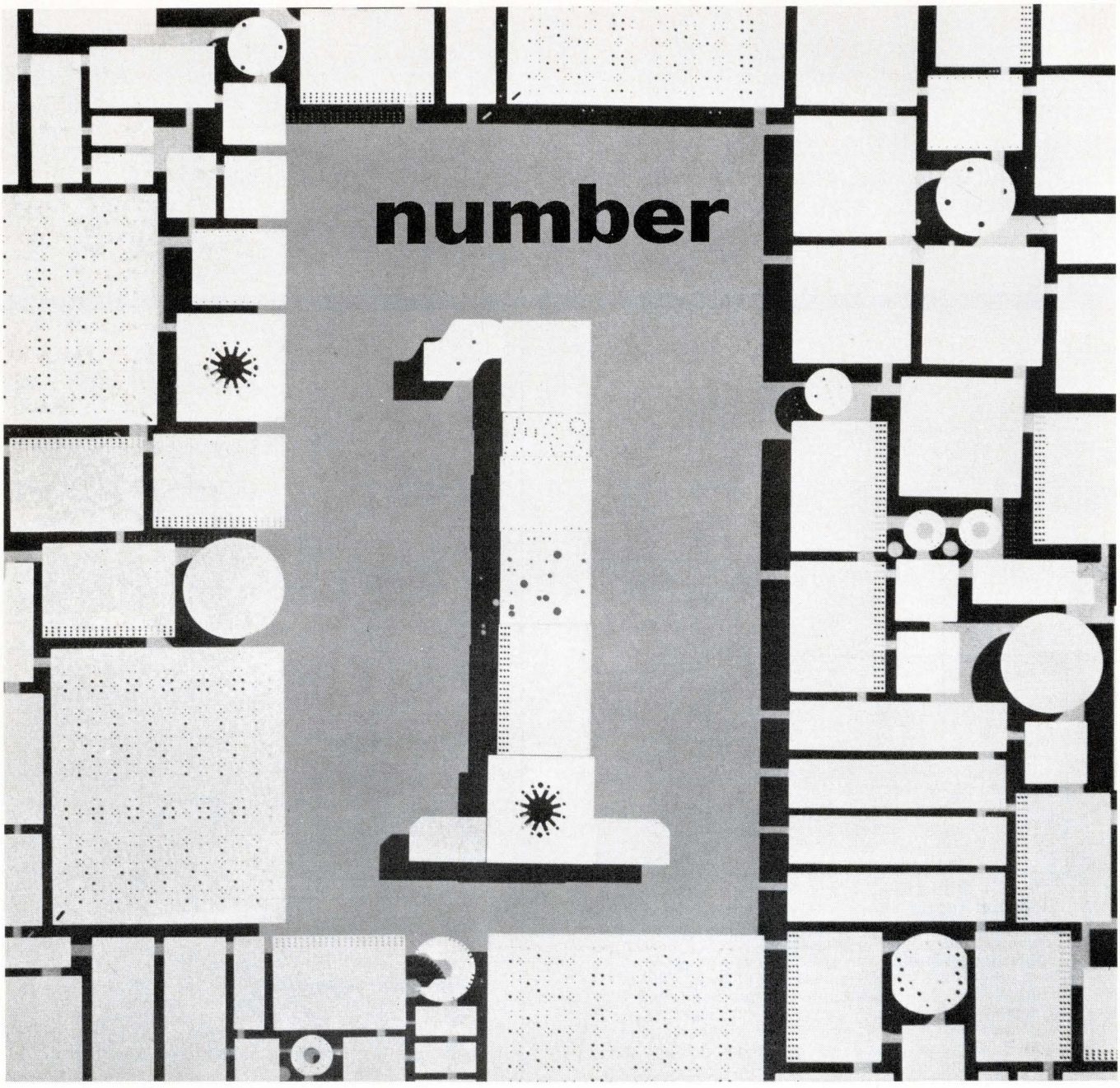
Schmitt trigger circuit permits card reader output to be compatible with TTL or DTL logic functions. In the hybrid circuit, R_1, R_2, R_3, can be internally shunted to shift the switch point to correspond to the desired light level. Photovoltaic cell is operated in diode mode. Light incident on photocell causes Q_1 to switch OFF, in turn switching Q_2 ON. Q_2 ON lowers voltage at R_5, R_4 junction, changing bias on Q_1 through R_3, R_3, and R_2.—Sensor Technology.



A Schmitt trigger circuit using an optical couple to interface with TTL offering fast rise and fall times with an isolated signal input. Figure A provides a non-inverting function, while Fig. B provides an inverting function.—Texas Instruments.



Chopper circuits which use mechanical relays suffer from a speed problem as well as switching transients at the load. By using bipolar transistors or FETs as series and shunt switching elements, the speed will be improved but capacitive coupling to the switching circuitry may still produce transient "spikes" on the output signal. By using OCIs to switch the input signal as shown, the switching circuitry can be isolated from the output and thereby reduce output "spikes." The use of two couplers in the configuration shown will allow chopping of either positive or negative input signals with a frequency of one-half that of the input to the flip-flop.—Texas Instruments.



Coors Porcelain Company is the Number 1 producer of high-alumina ceramics and a major producer of alumina-ceramic substrates for thick- and thin-film circuits. This produces a number of benefits for you. Namely:

LOW COST—Whether your substrate order is large or small, you'll always find fair, competitive prices at Coors.

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HIGHEST QUALITY—Coors has long been known as *the quality* manufacturer of technical ceramics. This means you can be sure Coors substrates will have uniform surfaces, precise dimensions, maximum strength, maximum flatness, minimum camber, minimum waviness.

Coors can produce substrates to your specifications from either glazed or unglazed 96% alumina ceramic or unglazed 99.5% alumina ceramic. Both of these ceramics are dense, impervious, resistant to high temperatures, easily metallized, and have excellent electrical-insulation characteristics and good heat-transfer properties.

For details on Coors ceramic substrates, send for Bulletin 1400. Coors Porcelain Company, 600 Ninth Street, Golden, Colorado 80401.

Coors/CERAMICS

Circle 25 on Inquiry Card

IC IDEAS

This month's Ideas

Vote **for the one you like best.**

Write the number of the Idea you like best in the box on the Inquiry Card, and send to us.

Send us practical, reproducible ideas that are original with you and have been implemented with linear or digital ICs.

- If we publish your idea you win a check for $25.00.
- If our readers vote yours the best of the issue in which it appears, you have your choice of a Simpson 270 or a Triplett 600 multitester.
- After 12 issues our readers will vote on the best idea for all 12 issues. The winner gets his choice of either a Hewlett-Packard 1206A or a Tektronix 310A oscilloscope.

Submit your IC Ideas to:
Alberto Socolovsky
Editor
THE ELECTRONIC ENGINEER
Chestnut & 56th Sts.
Philadelphia, Pa. 19139

Here's how you voted

The winning Idea for the May 1970 issue is, "Digital frequency doubling."

David Sporre, our prize-winning author, is a computer systems engineer with The Reflectone Division of Otis Elevator Co. Mr. Sporre has chosen the Triplett Model 600 TVO as his prize.

930 How to gain access to a synchronous device anytime

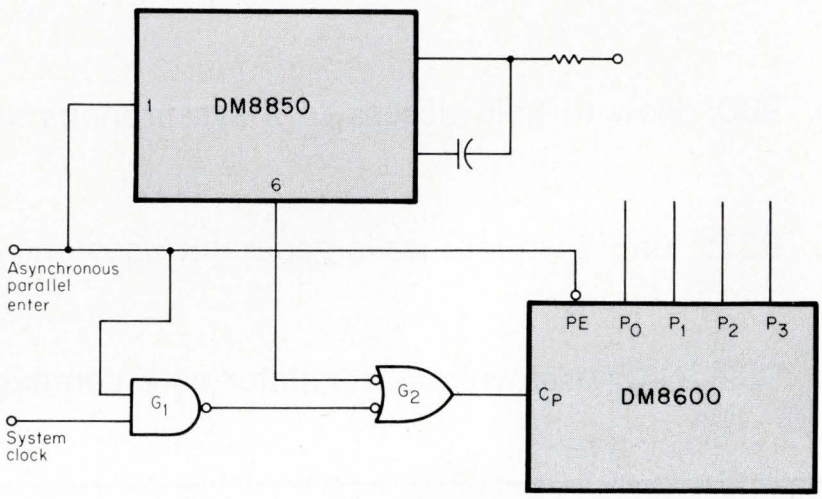
Don Femling

National Semiconductor, Santa Clara, Calif.

Some MSI devices are designed for synchronous operation only. National's DM8860 and Fairchild's 9300 4-bit registers are good examples of this type of device.

To enter parallel data into these registers, the PE terminal is brought low and then when the clock goes true, the data on P_0, P_1, P_2 and P_3 is set into the internal flip-flops of the device.

When no system clock is available, parallel entry into these devices is difficult. With the circuit shown, however, you can do it with one command.



When the asynchronous parallel enter signal is applied, it performs three separate functions. First of all, it enables the register to receive parallel inputs upon receipt of a clock pulse. Secondly, it prevents any stray system clock pulses or noise from interfering with the stable entry of data. The third function is the initiation of the one-shot which provides the clock pulse for the parallel entry.

Gate G_2 allows operation of the clock line from either the one-shot or from the system clock. It also provides the delay needed to allow the PE terminal to go low before the clock pulse.

931 Simple square wave generator uses one IC

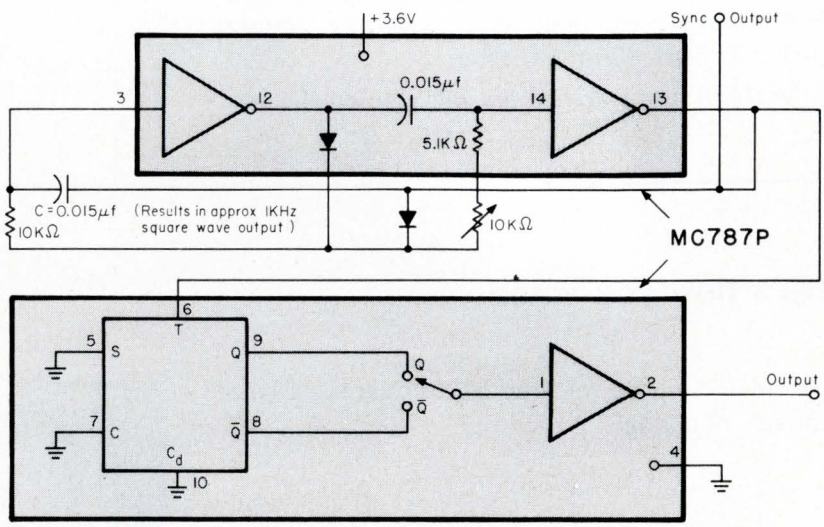
Henry D. Olson

Stanford Research Institute, Menlo Park, Calif.

The MC787P in Motorola's RTL series can easily be made to function as a square wave generator. The output is a square wave with a large (80) RTL fanout and will even sink sufficient current to drive TTL or DTL gates.

The MC787P is a combination J-K flip-flop, inverter and two buffers. The circuit uses the inverter and one buffer as an astable multivibrator, divides the rectangular waveform by two with the J-K, and uses the remaining buffer as the output stage. Since the on and off periods are not determined by separate RC time constants, but by a toggling J-K, you get a near perfect square wave.

The circuit is useful from at least 1 Hz to 2 MHz which an output frequency of about 1 kHz for the RC values shown. A variable frequency control, sync output and Q or $\overline{Q}$ selector have been added to make a complete generator. The output is 3 V with no load.



932 CCO uses voltage regulator as a comparator

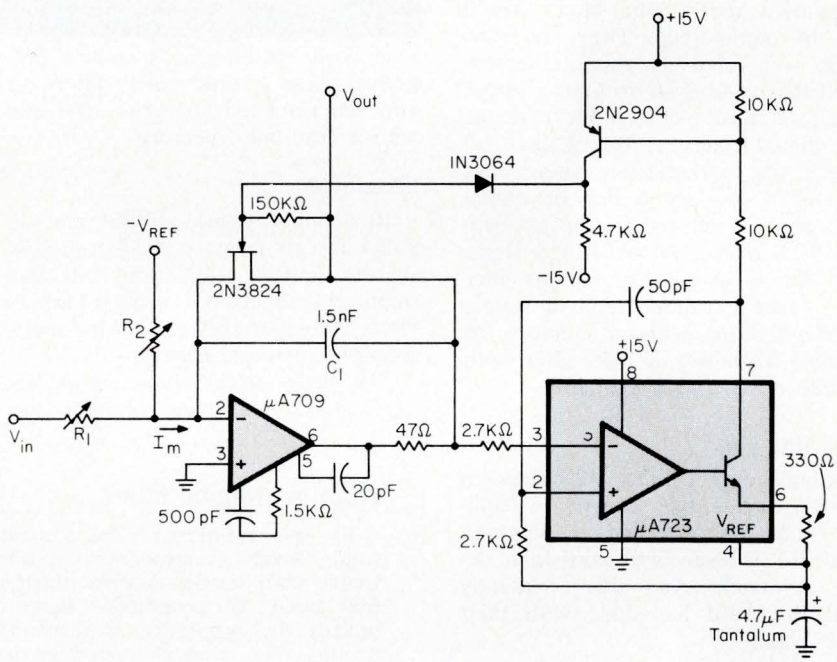
Sam Ben-Yaakov

UCLA, Los Angeles, Calif.

The μA723 voltage regulator has both a reference voltage source and a differential, high gain amplifier. This current-controlled oscillator uses these units as a comparator to produce a short pulse whenever the input exceeds the reference voltage level.

You get the comparator operation by connecting the negative input of the diff. amp to the reference point. The emitter of the internal transistor is also connected to the reference point through a 300 Ω resistor while the collector is driving a 10-kΩ resistor. The 50-pF capacitor between the collector and the negative input of the amplifier provides positive feedback. The transistor is in the cutoff condition as long the voltage to the positive input is below the reference value. If the input momentarily exceeds the reference value, however, the amplifier gives you a positive-going pulse that drives the transistor into conduction. The positive feedback produces an 8-μs pulse even if the input voltage is a short spike.

The CCO uses a μA709 op amp to feed the comparator. The current to the negative input of the op amp is integrated by the feedback capacitor. Wherever the output of the integrator reaches the triggering voltage of the comparator, it fires and produces a positive pulse at the gate of the normally cutoff FET. The FET will conduct and discharge the capacitor to ground, allowing a new cycle to begin. The output waveform of the CCO is thus a positive going sawtooth with a maximum amplitude equal to the reference voltage.



You can calculate the CCO frequency by assuming a constant negative input current to the device (I_{in}) and deriving the period of each cycle. The output voltage (V_o) of the integrator is a linear function of the capacitor's charge;

$$V_o = t_1 I_{in} / C_1$$

where t_1 is the time (per cycle) until the firing level is reached. When the firing level is reached, $V_o = V_{ref}$ so that

$$t_1 = V_{ref}\, C_1 / I_{in}$$

The period of oscillation (T) is the integration time plus the pulse length of the comparator (t_2).

$$T = V_{ref}\, C_1 /_{in} + t_2$$

The maximum operating frequency for this CCO was found to be 75 kHz with an input current of about −2 mA. The linearity of the circuit is better than 1% from 0-10 kHz. Above this range, the linearity deteriorates since the pulse length of the comparator is no longer negligibly short when compared to the period.

The CCO can be operated as a linear analog-to-frequency converter or as an fm carrier modulator. In the second case you should choose R_2 to provide a constant bias corresponding to the desired carried frequency. The input impedance of the unit is near zero and by providing an input resistor (R_1) the CCO frequency can be controlled by a voltage input.

NEW PRODUCTS

Digital filters become commercial

Have you ever heard of a filter that has infinite Q, can be dc coupled and has a variable center frequency? If you have, you can bet it was a digital filter.

Lowering price and the increasing complexity of digital ICs have made it apparent that digital filters would soon be commercial. They are now, thanks to a relatively young company called Rockland Systems Corp., whose principals have picked up experience with digital filters at Bell Labs.

Since the market is so young, it is difficult to produce a line of digital filters that is tailored to the applications. Therefore, Rockland Systems Corp. has developed a modular filter that can be expanded from a simple signal processor without memory, to a highly variable, all-pass filter with variable delay and phase shift.

Flexibility plus

Because digital filters are composed of components like adders, multipliers, shift registers and a memory, they lead themselves to a modular design approach. And this is exactly what Rockland has done with their Series 4000

Depending on your application, you can select recursive (poles and zeros) or non-recursive (zeros only) structures. With the recursive structure, you get very sharp frequency-domain cutoffs while the non-recursive structure is useful for realizing finite impulse response, precise linear phase and other special characteristics.

The basic component in the Series 4000 is a second order building blocks (two poles and/or two zeroes). Rockland then combines these building blocks to achieve any number of filters of any order.

The basic line in the Series 4000 has sampling rates of up to 500 kHz at 16 bits which you can modify in 4-bit increments. The units also include a built-in, timesharing capability that lets you use, for example, one filter for as many as 50 channels at a 10-kHz sampling rate, or 500 channels at a 1-kHz sampling rate. A

read/write coefficient memory programs these multichannel filters or you can get fixed filter characteristics with a read-only memory.

Six groups

Rockland's digital filters are divided into six primary product groups. In the Series 4100, you will find standard and custom general-purpose filters for laboratory-scale data analysis, simulation and testing.

The Series 4300 filters are primarily suited for narrow band-pass (or band-reject) applications such as wave and distortion analysis.

Rockland's Series 4400 are programmable comb filters for spectral analysis and will find their way into data analysis, vibration testing and radar applications.

A series of special purpose filters, the 4500, produces natural sounding speech in real time and are suitable for computer voice response systems.

The Series 4600 includes variable low-pass, high-pass, band-pass and band-reject filters while the Series 4900 are designed for phase equalization and variable delay approximations.

Prices for these digital filters range from $5000 to $20,000 depending on the options you need. Rockland Systems Corp., 131 Erie St. East, Blauvelt, N.Y. 10913. (914) 359-1818.

Circle 235 on Inquiry Card

What is a digital filter?

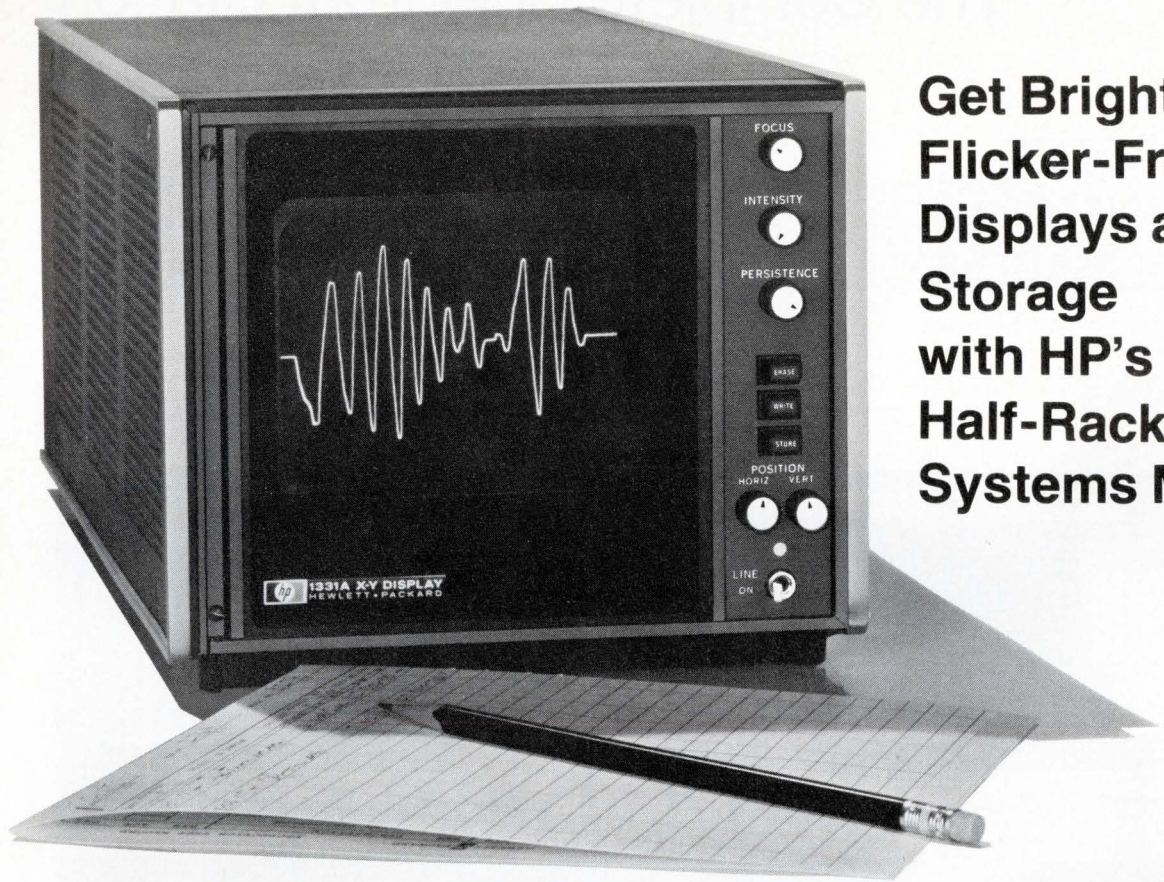
An analog filter provides a band within which its attenuation is different than its attenuation outside that band. To accomplish this, it utilizes the properties of resonant circuits. The principles involved in the design of these filters have been known for some time. It is also known that since it is more difficult to miniaturize inductors than capacitors, the size of an analog filter increases extraordinarily at lower frequencies.

A digital filter, on the other hand, is a signal processor that operates on a digitized signal. The availability of inexpensive digital integrated circuits have made these units increasingly attractive—particularly for low frequency applications.

The most common digital filter is the sampled-data filter. Such a filter accepts analog signals at the input, and digitizes them with an analog-to-digital converter. The signals are processed through a digital filter which is nothing else than a digital calculator that operates on the digits, and then are converted back to analog form with a digital-to-analog converter. The output from such a filter is the desired frequency but it is full of high frequency spikes which must be smoothed out with a simple analog filter.

One big advantage of digital filters is that as long as the input bit rate (sampling rate multiplied by the number of bits per sample) is well below the operating speed of the digital circuits, you can multiplex the filter in one or both of two ways. You can, for example, use one filter to operate on a number of input signals by interleaving the inputs. This approach amounts to time-sharing of the filter and results in more efficient usage.

The second type of multiplexing lets you process an input signal with a number of different filters. In this application, the filter coefficients are stored in a memory and read out as required by the multiplexed filter. This capability also allows the construction of higher order filters out of a number of second-order filter sections. Here, the second-order sections are identical and differ only in the values of the coefficients.



Get Bright, Flicker-Free Displays and Storage with HP's New, Half-Rack Systems Monitor

"Freeze" your displays, vary their fade rate. Here, is the first systems monitor using HP's mesh-storage CRT – that eliminates low rep-rate flickering, and eye-fatiguing erase-flashes... the HP 1331A.

Storage Capability – Waveforms can be stored for up to 15 minutes, just by pressing a button. An important advantage of the HP mesh-type storage tube is that writing rate and trace brightness do not deteriorate. Also, with mesh storage, stored traces "dissolve" off the screen, rather than being "flashed" off.

Variable Persistence—Trace persistence can be varied from 0.2 seconds to more than a minute. This enables you to quickly and accurately compare traces, analyze trends, determine the effects of input variables, eliminate flicker of low rep-rate information.

High-Intensity Display—For systems operators, traces can be observed in high ambient light, without having to sit "glued to the screen," because traces are displayed at a brightness of 100 ft-lamberts. This is many times the intensity of displays on other storage monitors.

Wide Bandwidth – Utilizing electrostatic deflection, the HP 1331A is capable of handling signals ranging from dc to 1 MHz. This provides fast, 1 μs settling time, which reduces computer waiting time when generating rasters, alpha numeric, X-Y or other fast-changing displays.

Z-Axis Gray Scale—The exclusive ability of the CRT to display varying trace intensities, gives the HP 1331A a capability to show "shades of gray" —for added realism in 3-D displays, and added clarity in two-dimensional displays or photos.

Compactness – Measuring only 7¾" wide by 6½" high by 16" deep, the HP 1331A takes up only half of a standard systems rack width.

Choice of Standard or Programmable Models – Model 1331A has front panel operating controls, to allow easy manual control. Model 1331C is designed for remote programming operation in system applications of computer displays—alpha numeric or graphic. It has the operating controls and programming input connector mounted on its rear panel.

For the complete story on the 1331A or 1331C, contact your HP field engineer. Or, write to Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland. Price: $1575; OEM discounts available.

080/13

HEWLETT hp PACKARD

OSCILLOSCOPE SYSTEMS

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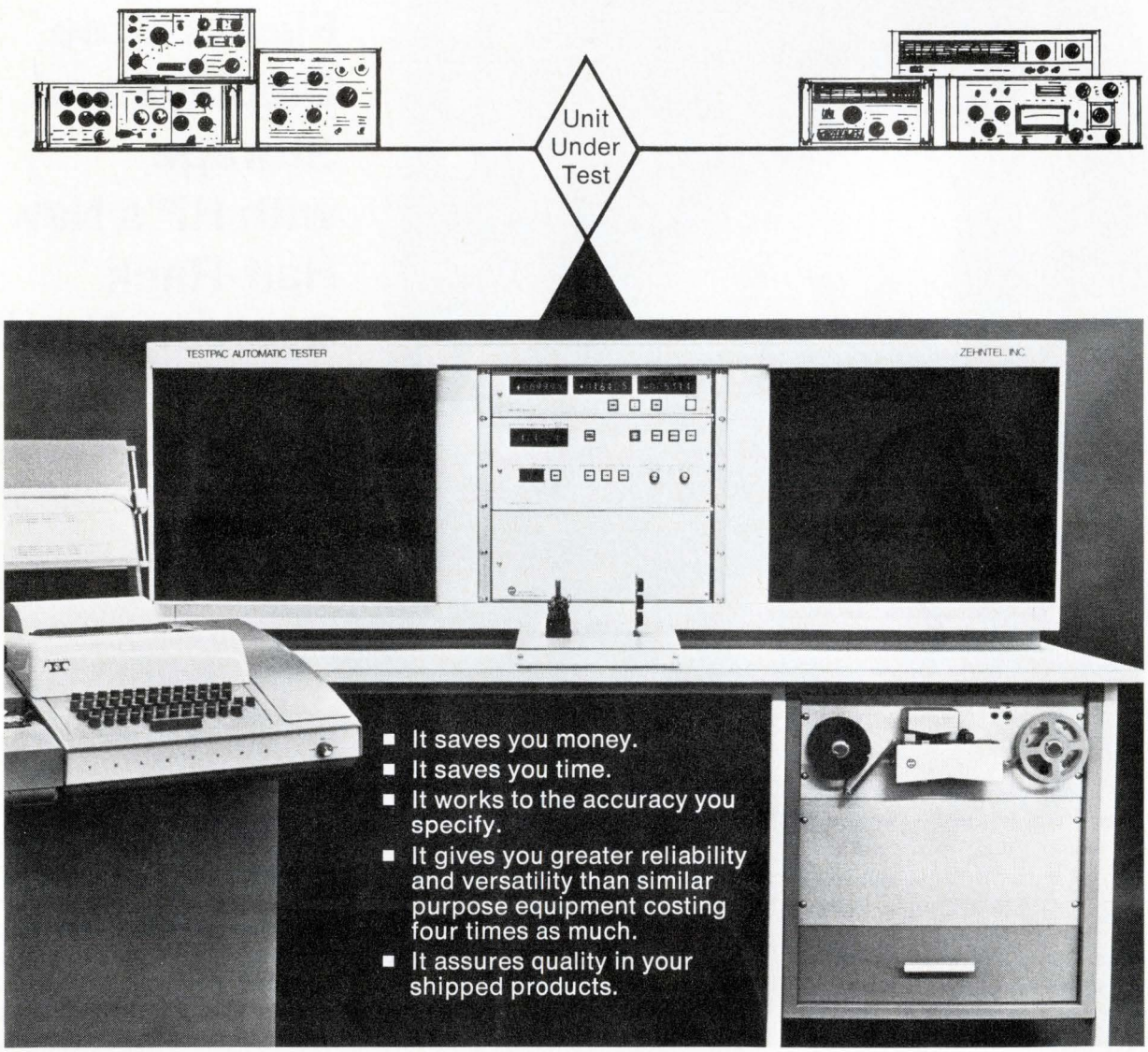
Zehntel's Testpac™

The Complete Checkout Station



It is simple in the sense that it permits you to select the best balance of programmable stimulation and measuring instrumentation using TESTPAC's interface and control equipment.

Zehntel's TESTPAC is designed to accept simple instructions, while it is capable of precise and detailed readout. Ideally suited as a production checkout station, it is also capable of giving you a means of speedy calibration and detailed diagnostic readouts.

TESTPAC is simple enough to be operated by unskilled personnel, yet it is sophisticated enough to let you undertake the most complex, exacting test procedures.

And, while it costs a fraction of comparable equipment it gives you the versatility to eliminate the costly obsolescence of dedicated checkout stations.

For further information contact: Marketing Manager, Zehntel, Inc., 1450 Sixth Street, Berkeley, Ca. 94710 Telephone: (415) 527-5440 TWX 910-366-7047

An affiliate of Electronic Memories & Magnetics Corporation

Multi-octave rf amplifiers in TO-8 cans

Broadband rf amplifier design has never been an easy task. It sometimes involves so much tweaking that you wish you had a trained octopus to make the circuit adjustments. And too, assuring production repeatability can be quite a battle.

But all of this could turn out to be a thing of the past. A new line of sapphire substrate, thin-film amplifiers may well do for rf equipment design what packaged op amps have already done for lower-frequency circuit design.

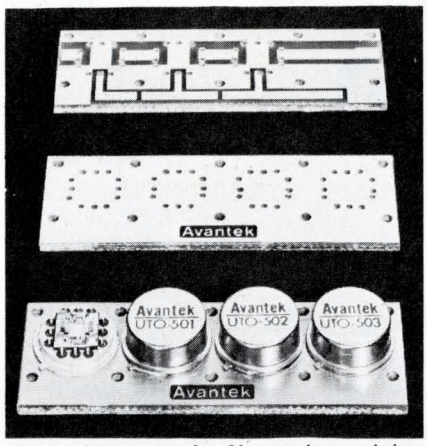
Each of Avantek's Series 500 amplifiers uses a proprietary microwave transistor chip (at the low end of its f_T curve) to produce a 5-500 MHz, cascadeable unit of gain, with guaranteed specifications.

These gain modules—called MIC•amps[tm]—are patented. Included in the patent is coverage for the module's input/output VSWR matching and gain flatness techniques.

Each MIC•amp is complete and ready to use without trimming of any kind. In fact, even though the TO-8 can has 12 leads, only five are used: rf in, rf out, dc bias, and two grounds. (Presumably, later versions will use other pins for agc, detection, and so forth.) Solder the package into your PC board, and you're ready to go.

Three versions of the MIC•amp are currently available. The UTO-502 is the middle-of-the-line, general purpose amplifier, so here are its specs:

- Gain (min.), 14 dB
- Gain flatness (max.), ±1 dB
- Noise figure (max.), 5.5 dB
- Power output at 1-dB gain compression point (min.), +7 dBm
- In/Out VSWR (max.), 50 Ω, 2.00:1



Just solder them in. New gain modules take the work out of broadband circuit design. Stable, repeatable, and cascadeable, each TO-8 can has 14 dB of gain and a 5-500 MHz, ±1 db response. (Extra flatness is available to order.) Shown here is an optional 4-socket PC board; 1-, 2-, and 3-socket boards are also available. You can order assembled cascades and shielded cases as well.

- Reverse isolation (typ.), 20 dB
- dc bias, +15 V.

The UTO-501, meant for low-noise applications, differs in noise figure (4 dB max.), and power output (−2 dBm). And the UTO-503, for power output stages, differs in noise figure (7 dB max.), gain (9 dB min.), reverse isolation (16 dB typ.), power output (+13 dBm min.), and dc bias (+24 V).

Temperatures between −54 and +125°C has very little effect on any specified parameters. This is probably because the transistor chips are bonded directly to the sapphire substrate, which provides excellent heat sinking.

The MIC•amps are unconditionally stable, which means that you can run them between impedances other than 50 Ω. But don't expect to retain I/O matching, of course.

There is no bandwidth shrinkage when you cascade the modules, because the quoted response is conservative; the true bandwidth is more like 2-700 MHz. Furthermore, the worst-case cascaded flatness is half the sum of the unit flatness specs (±1 db max.), because the response curves of all modules track each other within ±½ dB. Similarly, phase response is uniform within 2°. The input/output VSWRs in a cascade do not degrade; they stay at 2.00:1 max. And the minimum cascaded gain is simply the sum of the unit gains.

Because the MIC•amps are stable and repeatable, they eliminate almost all the dog-work of broadband design. For narrowband use (as in equipment i-f stages), simply use pre- or post-filtering, a common—and often preferred—technique in high-gain selective amplifiers.

The MIC•amps pass both Mil and NASA specs, which make them usable in an enormous variety of equipments. The price range makes them suitable for a wide range of industrial gear as well. Their cost is less than that of designing an amplifier and readying it for production. Small-quantity pricing of the Series 500 MIC•amps starts at $165 each. Large-volume prices will be less than $100. And delivery is within 10 days ARO. Avantek, Inc., 2981 Copper Rd., Santa Clara, Calif. 95051. (408) 739-6170.

Circle 236 on Inquiry Card

STACKING PLUGS

New plugs are for custom patchcord assembly and the replacement of damaged molded patchcord plugs. They permit quick, easy assembly of patchcords to any length using std. 0.144 in. dia. insulated wire. The polyamide housing comes in red, green, black, white, yellow, blue. The std. banana plug is rated at 15 A; the std. 0.080 in. tip plug at 10 A. E. F. Johnson Co., Weseca, Minn. 56093. (507) 835-2050.

Circle 237 on Inquiry Card

HV CHIP CAPACITORS

This line of chip capacitors is made from a new hv dielectric that provides over three times the working voltage previously possible. Development of this new line makes possible the use of chip capacitors in hv power supplies and other applications in which their use was previously impossible or impractical. Tech-Trans, Inc., 7596 Eads Ave., La Jolla, Calif. 92037. (714) 459-5885.

Circle 238 on Inquiry Card

ISOLATION TRANSFORMERS

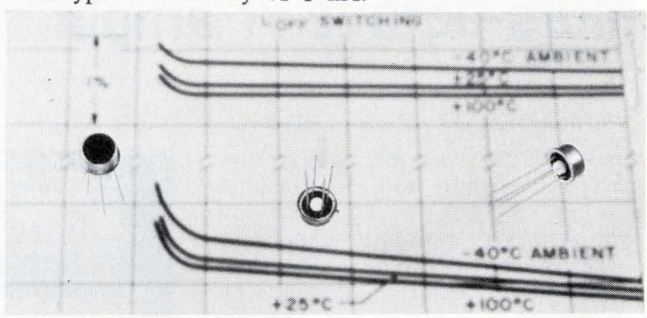
Model 150 has a broad BW and high CMR. Its min. BW for a 3-dB insertion loss is 300 Hz to 100 MHz. (Typ. BW is 150 Hz to 150 MHz. Corresponding pulse capability is 1 ns risetime and 0.1 ms duration. The CMR ratio exceeds 100 dB below 1 kHz and diminishes to 40 dB at 150 MHz. Model 150I has a phase inversion, while 150 does not. $65.00. Deerfield Laboratory, Box 1300, Los Altos, Calif. 94022. (415) 948-4535.

Circle 239 on Inquiry Card

NEW MICROWORLD PRODUCTS

MONOLITHIC THRESHOLD DETECTOR

With typical sensitivity of 1 nA.



The PA-494 is intended for applications requiring the logic function of a Schmitt trigger but offers superior voltage and temperature stability. The trigger threshold is 0.6 of the supply voltage and has 10% hysteresis. Operating voltage is 2.3 to 9 V and the output current drive capability is 250 mA maximum. This range of voltage and current capability makes the circuit compatible with many types of linear and digital circuits. Available in a hermetically sealed TO-5 package, the suggested price in quantities of 100 to 999 is $7.50 ea. General Electric Co., Northern Concourse Office Bldg., North Syracuse, N.Y. 13212. (315) 456-2396.

Circle 314 on Inquiry Card

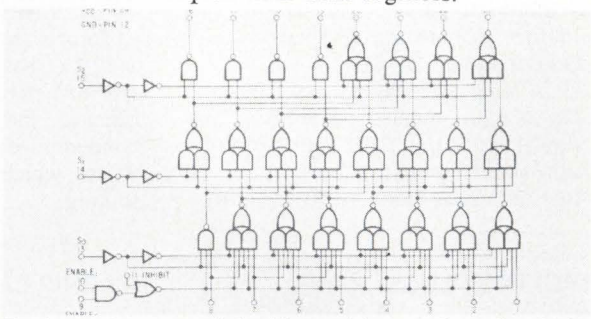
SWITCH AND RESISTANCE ELEMENTS

The μDAC AD555 is a monolithic quad voltage switch, while its companion, the AD555 is a thin film R-2R resistor ladder. The voltage switch includes four, logic operated, single pole, double throw high performance switches. These npn transistor switches can conduct current in either direction, with very low offset and series resistance. A novel feature of the μDAC AD555 is that it includes two independently variable analog references which allow it to perform complete 4 quadrant multiplication. For a 12-bit kit (3 AD555's and 1 AD855), the price is $151.00 ea. Analog Devices Inc., 221 Fifth St., Cambridge, Mass. 02142. (617) 492-6000.

Circle 315 on Inquiry Card

POSITION SCALER

Faster and less complex than shift registers.



Designated as an eight bit position scaler, the 8243 is an IC array of approx. 70-gate complexity. It accepts eight data inputs and, upon command of a 3-bit binary selector code, can transfer the data through to the output or can shift positions right or left before transfer takes place. Typical propagation delays to the outputs of the position scaler are 20 ns for Data In, 30 ns for Select Sn, 25 ns for Inhibit, and 30 ns for Enable 1 and 2. Data input logic zero loading is reduced to less than −100 μA when the unit is disabled. Price is $12.60 ea. in a silicone DIP (100-999 pcs). Signetics Corp., 811 E. Arques Ave., Sunnyvale, Calif. 94086. (408) 739-7700.

Circle 316 on Inquiry Card

Circle 28 on Inquiry Card→

10 microvolt sensitivity with a lot of numbers.

40,000 to be precise.

Our latest bi-polar Model 1294 packs more numbers than any other into industry's smallest package! And it reads them with a sensitivity of *10 microvolts!* The 1294 is a true bi-polar 4½-digit instrument with a display capability of 19999 and out-of-range indication. Its state-of-the-art electronics utilizes T^2L logic and unique time-sharing circuitry that cuts power consumption to less than six watts. BCD output is optional.

Input impedance is high: 10 megohms on the 100 millivolt range. Reading rate is 5 per second. Response time is well under one second. Accuracy is .05% of reading, ±1 digit.

Housed in the same 7 sq. in. front-panel-mountable case as our five other DPM's, the 1294 offers all the features that have distinguished this line . . . Weston's patented dual slope* integration, plug-in Nixie** tubes, repairable (non-potted) circuit boards, and ten standard voltage and current ranges.

If you're sensitive about your numbers, Weston Model 1294 provides the ultimate at a reasonable price. See how the 1294 complements industry's broadest DPM line. Write for details from the DPM originators.

WESTON INSTRUMENTS DIVISION, Weston Instruments, Inc., Newark, N.J. 07114

a Schlumberger company

WESTON®

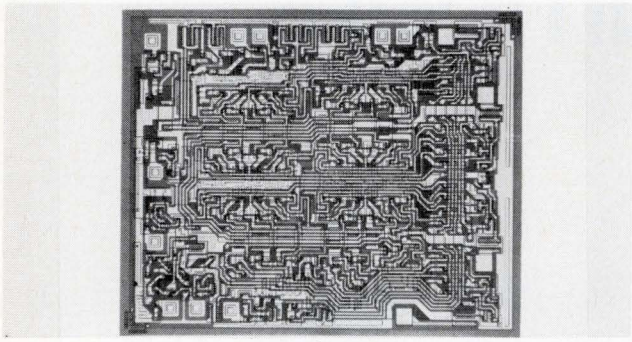
*U.S. Pat. #3,051,939

**Registered trademark, Burroughs Corp.

NEW MICROWORLD PRODUCTS

SIMULTANEOUS READ/WRITE MEMORY

Improves memory utilization up to 100%.

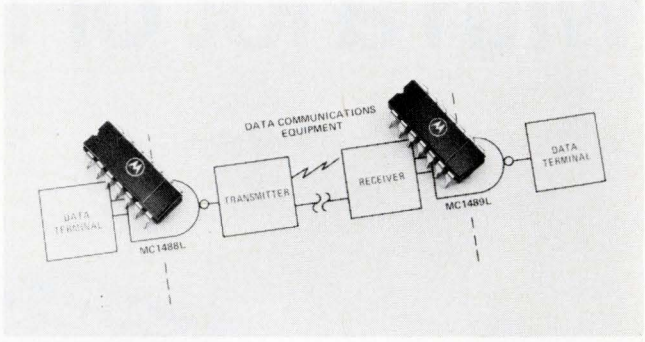


The SN54/74170 is a high-speed, 4 x 4 register file on a 90 x 110 mil chip. The register file provides separate on-chip decoding for addressing the four word locations to either write-in or retrieve data. This permits simultaneous writing into one location and reading from another. The memory is particularly suited for use as a scratch pad or buffer. It has a 45 ns maximum cycle time and when used as a buffer, it can acquire data from the main memory while operating with the CPU. Available from stock, the SN7417ON is $5.94 ea. for 100 to 999 pc lots. The SN5417OJ, also available from stock, is $20.29 ea. for the same quantities. Texas Instruments Incorporated, Inquiry Answering Service, Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741.

Circle 312 on Inquiry Card

MODEM ICs

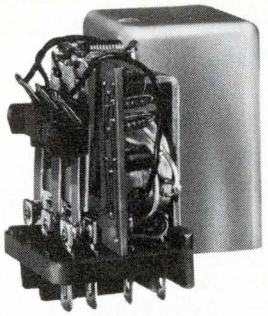
Supplied to EIA RS-323-C standard.



The MC1488L quad line driver and the MC1489L quad line receiver are DTL/TTL compatible and provide systems interfacing between communication networks and data terminal equipment. The line driver is comprised of four NAND gates: three two-input gates and a single-input gate. The output current is limited to 10 mA (max.) which easily complies with the RS-232-2 spec. An external capacitor is required to limit the output slew rate to <30 V/μs. The four special two-input NAND gates in the MC1489L quad line receiver enable it to satisfy the RS-232-C requirements without external components. Prices (100-up lots) are: MC1488L, $7.00; MC1489L, $6.00. Technical Information Ctr., Motorola Semiconductor Products Inc., Box 20924, Phoenix, Ariz. 85036.

Circle 313 on Inquiry Card

New Potter & Brumfield
magnetic latching/solid state
IMPULSE RELAY
has permanent memory



This hybrid impulse relay is unique.

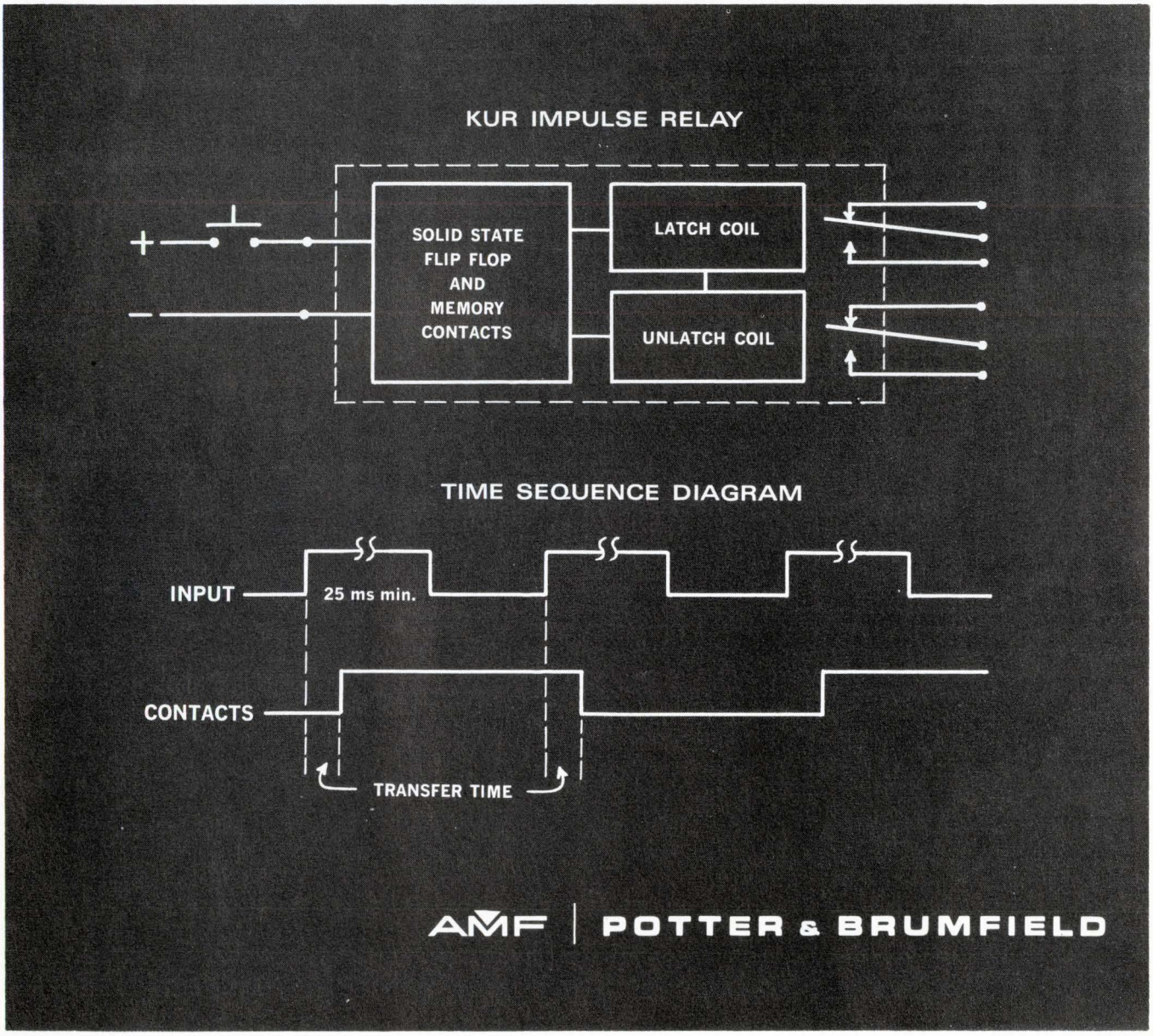
Its basic structure is our KUL, a single coil latching relay employing a shunting-type magnetic circuit. To that we have added a solid state flip-flop circuit to obtain a truly modern, alternate-action, impulse relay.

Consider the many features of this extraordinary device:

- A pulse width of 25 milliseconds (min.) effects transfer of the DPDT contacts to switch 5 or 10 ampere loads.
- Contacts will hold in their last position without power. This memory is obtained through the magnetic latching ability of the relay.
- There are no mechanical linkages as found in ordinary impulse relays, to wear out or malfunction.
- The assembly is neatly packaged in a popular-size case which provides a wide choice of mountings, terminations and readily available sockets. Mounted height is only 2.126″.
- An ordinary SPST switch will operate the KUR impulse relay. As coils are rated for continuous duty, there is no limit (except minimum) to the pulse length.

The price? A modest $15.00 in single lots. Quantity discounts apply. Today, call your local P&B sales representative for complete information.

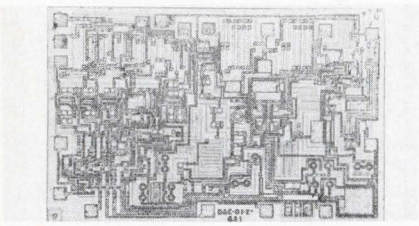
Potter & Brumfield Division of American Machine & Foundry Company, Princeton, Indiana 47570. (812) 385-5251.



Circle 59 on Inquiry Card

D/A CONVERTER

On a single chip

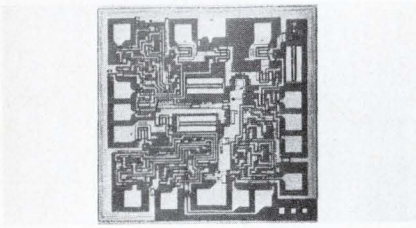


The monoDAC-01 converter is a 6-bit current steering converter. It consists of an internal voltage reference, six precision current sources, six current steering logic switches, a diffused resistor network, and an internally compensated output op-amp. $40 ea. in quantities of 100. Precision Monolithics Inc., 1500 Space Park Dr., Santa Clara, Calif. 95050.

Circle 323 on Inquiry Card

DRIVER AND RECEIVER

For 50- or 75-Ω lines.



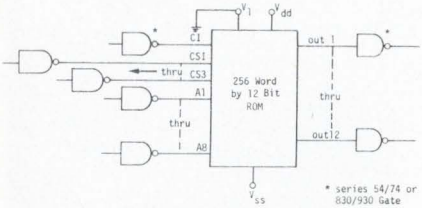
The 8T13 dual line driver transmits high-speed data over low impedance coaxial lines. The new 8T14 triple line receiver uses hysteresis for noise immunity. In 100-999 quan., the driver is $2.88 ea. and the receiver is $5.33. Signetics Corp., 811 E. Arques Ave., Sunnyvale, Calif. 94086. (408) 739-7700.

Circle 324 on Inquiry Card

STATIC MOS ROM

Stores 3072 bits.

BIPOLAR TO MOS TO BIPOLAR DIAGRAM



The UA2572/UA3572 has a typical access time of 750 ns. Both input and output are directly bipolar compatible, and you need no external pull-up resistors. The ROM also offers programmable chip select for easy expansion. Operating temperature range for the US2572 is -55 to 125°C, and for US3572 from -25 to 70°C. UNISEM, Trevose, Pa. 19047.

Circle 325 on Inquiry Card

BIPOLAR RAM

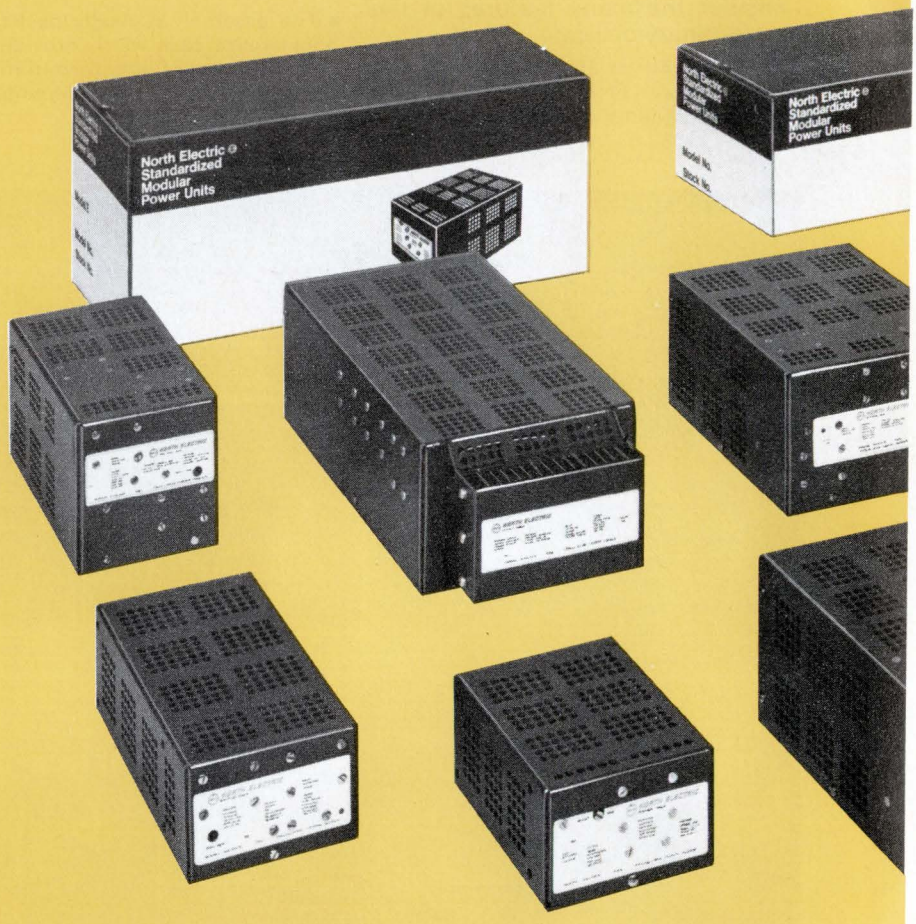
The IM5501 is a fully decoded TTL memory with a 16 x 4 organization. It has on-chip address decoding, chip select, write enable and uncommitted collector outputs. Specs include a 40 ns access time and a 6 mW/bit power dissipation. The 100-up price is $26.50 ea. (commercial) and $33.50 ea. (military). Intersil Inc. 10900 N. Tantau Ave., Cupertino, Calif. 95014.

Circle 326 on Inquiry Card

DECODER/DEMULTIPLEXER

The MSI 9321 has two independent decoders, each of which accepts two binary weighted inputs and provides four mutually-exclusive active low outputs. Active low enables, when used as data inputs, give the 9321 a demultiplexing capability. Prices start at $7.90 ea. (1-24 pcs). Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. 94040.

Circle 327 on Inquiry Card



MODEL	10000
HEIGHT	3.19
WIDTH	3.75
DEPTH	6.50
VDC	AMPERES
0–7.5	2.10
0–16	1.25
0–25	0.85
0–33	0.68

MODEL	11000	12000	13000	14000	15000	16000	17000	18000
HEIGHT	3.19	3.19	4.94	4.94	4.94	4.94	3.50	5.25
WIDTH	4.94	4.94	4.94	7.50	7.50	7.50	19.00	19.00
DEPTH	6.50	9.41	9.41	9.41	11.75	16.50	16.50	16.50
VDC	AMPERES							
3.7	4.0	5.6	12.0	14.0	21.0	33.2	50.0	87.0
5.0	3.9	5.3	11.3	13.0	20.0	32.5	49.0	82.0
6.0	3.5	5.0	10.5	12.8	19.0	31.0	47.0	82.0
12.0	2.8	4.2	8.0	10.5	15.0	23.0	36.0	58.0
15.0	2.4	3.7	7.5	9.5	14.0	20.5	27.0	47.0
24.0	1.5	2.8	4.2	7.0	11.0	15.0	21.0	33.0
28.0	1.4	2.4	4.0	6.3	9.0	14.0	20.0	29.0

Note: Specifications subject to change without notice.

MOS SHIFT REGISTER

The TMS 3406LR is a dual, 100-bit register with a 2 MHz guaranteed frequency operation. Power dissipation is typically 0.4 mW/bit at 1 MHz. It comes in an 8-pin TO-100 metal can and is priced at $6.50 in 100-249 piece quantities. Texas Instruments Incorporated. Inquiry Answering Service Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741.

Circle 328 on Inquiry Card

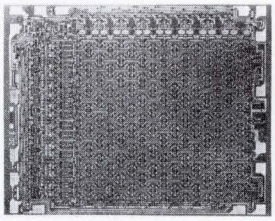
POWER DRIVERS

The FTI-2020/2020H (npn) and FTI-2027H (pnp) are quad Darlington complementary power drivers. The circuits feature dc current gain of 1000 minimum at 500 mA and have typical turn-on/turn-off times of 40/70 ns. They come in both plastic and hermetic packages. Fabri-Tek Micro-Systems, Inc., 1150 N.W. 70th St., Ft. Lauderdale, Fla. 33309.

Circle 329 on Inquiry Card

BIPOLAR 256-BIT RAM

Makes 120 ns main-frame memories.



You can combine the Type 3102 memory unit with Type 3202 decoders, to form fully decoded memories of up to 4096 words of any length. The memory units are addressed by four chip-select inputs on the decoder. Price (1-24 pcs) are $80 for the Type 3102 memory and $20 for Type 3202 decoder. Intel Corp., 365 Middlefield Rd., Mountain View, Calif. 94040.

Circle 330 on Inquiry Card

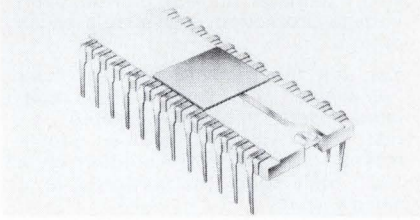
1024-BIT SHIFT REGISTER

The SR-0301 is a four-phase, dynamic shift register. The register has a power dissipation of under 0.15 mW/bit at 1 MHz and a frequency range from 10 kHz to 1 MHz. It's in a low-profile TO-100 (10-lead TO-5) package and has an operating range of 0 to 70°C. North American Rockwell Microelectronics Co., Box 3669, 3430 Miraloma Ave., Anaheim, Calif. 92803. (714) 632-2415.

Circle 331 on Inquiry Card

DATA INTERFACE CIRCUITS

Offer Complete TTY interface.



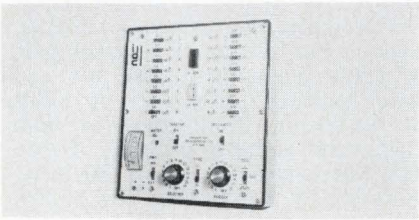
These MOS devices, the AY-5-1008 terminal receiver the AY-5-1010 terminal transmitter, are TTL/DTL compatible. The transmitter accepts inputs up to 9 parallel bits and adds the required start and stop bits. The receiver is a serial-in/10-bit parallel-out shift register with input word length externally selectable for 5, 6, 7 or 8 data bits and can operate in synchronous or asynchronous systems. Price in lots of 100 is $18.70 ea. for the transmitter and $24.15 ea. for the receiver. General Instrument Corp., 600 W. John St., Hicksville, N. Y. 11802. (516) 733-3333.

Circle 332 on Inquiry Card

NEW LAB INSTRUMENTS

IC TESTER

Makes dc and functional tests.

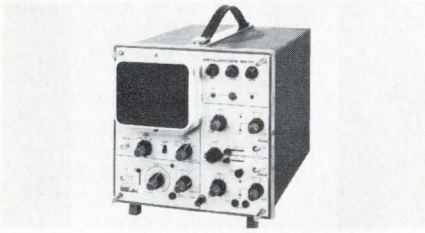


The Model ICT-200 uses individual switches to apply dc voltage levels, a pulse, or a square wave function to any of up to 16 pins. A selectable meter allows rapid verification of the IC's operation and output voltage levels. Unit price, $199. Innovation Development Co., Box 7, Azusa, Calif. 91702.

Circle 317 on Inquiry Card

DUAL CHANNEL OSCILLOSCOPE

With 18 MHz bandwidth.

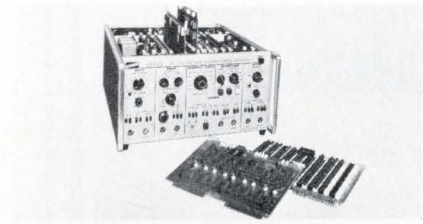


The SM111 has a dc to 18 MHz bandwidth, sensitivity of 2 mV/cm to 50 V/cm, timebase of 200 ns/cm to 1 s/cm, and a 10 cm x 8 cm CRT. The scope is powered by either ac or an optional self-contained battery pack. Available from stock, it costs $1,195. B & F Instruments, Inc., Cornwells Heights, Pa. 19020.

Circle 320 on Inquiry Card

SPECTRUM ANALYZER

For realtime analysis.



Model SAI-54 provides fine line resolution spectral analysis from dc to 1 MHz in 10 selectable bands. This unit processes complex signals for study, evaluation, identification and analysis in vibration testing, medical diagnosis, acoustics, radar and oceanography. $13,000. Signal Analysis Industries Corp., 595 Old Willets Path, Hauppauge, N. Y. 11787.

Circle 318 on Inquiry Card

DIGITAL MULTIMETER

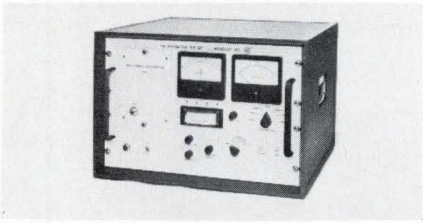
Has 25 ranges.

Model 262A measures dc voltage and current, ac voltage and current and ohms. The multimeter has a basic dc accuracy of 0.1% of reading. All dc ranges feature automatic polarity indication and automatic zero correction circuitry gives you maximum stability. $375. United Systems Corp., 918 Woodley Rd., Dayton, Ohio 45403. (513) 254-6251.

Circle 321 on Inquiry Card

FM TRANSMITTER TEST SET

Measures low level fm.



Model 1216 measures deviations from ±100 Hz to ±2 MHz. It has an accuracy of ±2% of full scale and is internally self-calibrating to within ±0.1%. You can use the test set with telemetry, television and microwave communications. Instrumentation Div. of Microdot Inc., 220 Pasadena Ave., So. Pasadena, Calif. 91030. (213) 682-3351.

Circle 319 on Inquiry Card

SWEEP GENERATOR

With 5 W out in both sweep and cw.

The SS-25 covers from 1-125 MHz and can sweep that entire range in one sweep. Center frequency adjustments aren't necessary as the sweep width is adjusted because the sweep is symmetrical about the center frequency. Price is $3000. with del. in 6 wks. Texscan Corp., 2446 N. Shadeland Ave., Indianapolis, Ind. 46219. (317) 357-8781.

Circle 322 on Inquiry Card

FROM THE WAVE MAKERS:

FUNCTION GENERATORS FOR SQUARES...AND MUCH ELSE

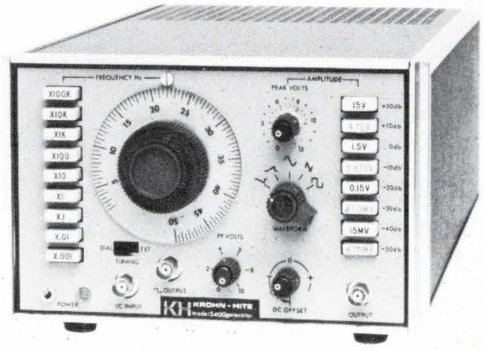
And much less expensive, to boot. Krohn-Hite's new line of function generators give you solid versatility, performance, and operating convenience. Two brand new models covering the frequency range of 0.002 Hz to 5 MHz. Each gives you wavemaking capability for sine, square, triangle, plus and minus ramps, and additional simultaneous square wave outputs. Ultra-fast risetimes. Provision for external V.C. of 1000:1 over the full range. D-C offset control. Adjustable symmetry on square wave for pulse operation. Best of all, we do everything with fewer components.

NEW MODEL 5100 FUNCTION GENERATOR,
0.002 Hz, to 3 MHz

Simultaneous auxiliary square wave
VCO 1000:1 sweep capability
Price: $375.00.

NEW MODEL 5400 FUNCTION GENERATOR,
0.002 to 5 MHz

Symmetry offset provides pulse and sawtooth
VCO 1000:1 sweep capability
Price: $550.00



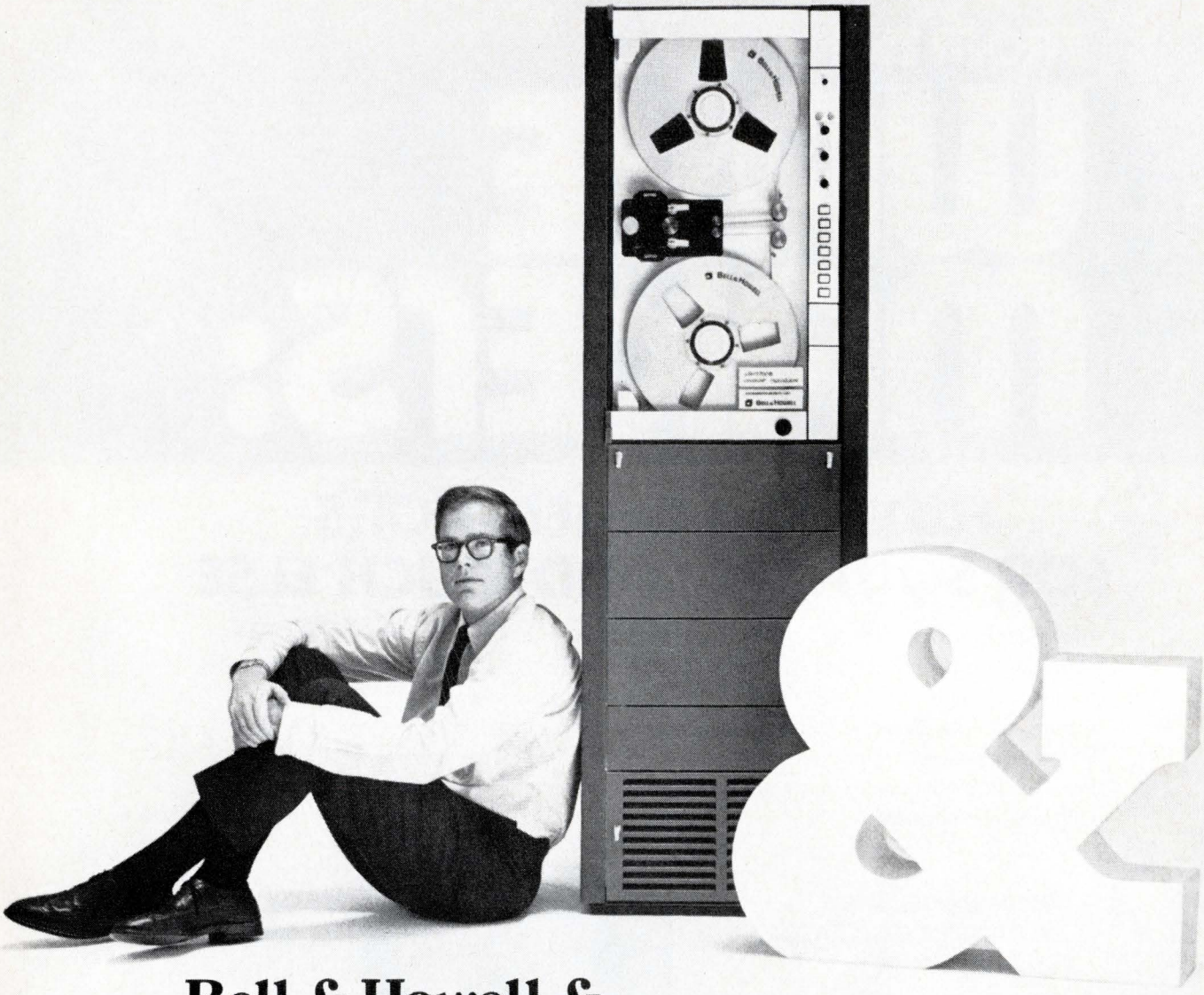
If you would like to know much more about much else, drop us a line: The Wavemakers, Krohn-Hite Corporation, 580 Massachusetts Avenue, Cambridge, Mass. 02139

KROHN-HITE CORPORATION

OSCILLATORS / FILTERS / AC SOURCES / FUNCTION GENERATORS / AMPLIFIERS

OVERSEAS SALES OFFICES: BELGIUM, C. N. Rood s. a.; DENMARK, SC Metric A/S; FRANCE, Antares; GERMANY, Nucletron Vertriebs-GMBH; HOLLAND, C. N. Rood n. v.; ITALY Dott. Ing. Mario Vianello; SWEDEN, Teleinstrument; ISRAEL, R. D. T. Elect. Eng. Ltd.; JAPAN, Shoshin Shoji Kaisha, Ltd.; AUSTRALIA, Sample Electronics (Vic.) Pty., Ltd.; G. B., B & K Inst. Ltd.

Circle 32 on Inquiry Card



Bell & Howell & Jon Wells & The Simple Folk

Some people asked our guys how come we didn't turn out a recorder/reproducer that simple folk could use. At a simple price. Something that was production line oriented for a bunch of industries across the board.

We bounced that problem to Jon Wells who just recently came up with the remarkable, hi-rel VR3700B series.

Back Jon came with a little number called the VR3500. Although it's not as esoteric as the B model, it does have a lot of its features.

He used a modular concept with functions being grouped according to use. Linear IC's to get the bulk down. And large cards so any trouble shooting that needed to be done could be done fast.

Transport and electronics are set up so they can be easily repaired or modified. There's a closed loop tape path so you get real accuracy. Bi-directional speeds for versatility. A fail-safe phase lock DC capstan drive so you won't lose a smidgen of information. And very gentle tape handling.

As far as time base error and dynamic skew and flutter, they're fantastically low.

And so's the price.

Another thing. You don't have to be an engineer to run it. The how-to's are decaled right on the equipment.

That's the VR3500. An industrial recorder/reproducer. Brand new. And ready.

For all the specs, write its father, Jon Wells, Bell & Howell, Instruments Division, 360 Sierra Madre Villa, Pasadena, California 91109.

INSTRUMENTS DIVISION

BELL & HOWELL

Circle 33 on Inquiry Card

NEW LAB INSTRUMENTS

NOISE FIGURE METER

For CATV applications.

Model 792A1 has a 75 Ω, 10 to 250 MHz tuned amplifier input and a 75 Ω, 10 to 1000 MHz full range noise head. The meter provides noise figure readings from 0 to 20 dB for the 6 dB reference and 3 to 30 dB for gas tube and solid state sources. $840. Kay Elemetrics Corp., 12 Maple Ave., Pine Brook, N. J. 07058.

Circle 333 on Inquiry Card

X-Y PLOTTER

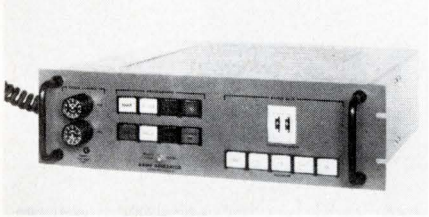
To 100 in./s in both axes.

The Gould 100 produces clear, uniform traces even for discontinuous plots and at crossover points of lines. A disposable plastic ink cartridge has sufficient capacity for 40 miles of trace. Total response time to a full scale step input is 300 ms. maximum. Brush Instruments Div., Gould Inc., 3631 Perkins Ave., Cleveland, Ohio 44114. (216) 361-3315.

Circle 334 on Inquiry Card

DIGITAL RAMP GENERATOR

With variable time range.

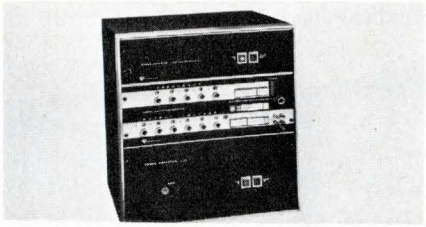


This unit, the Model IDA-6612V provides variable sub-audio, sawtooth voltages over a 10 ms to 168 h time range. It is particularly suited for mechanical stress/strain testing and it has, an optional computer interface. The basic ramp generator is $6,950. with 4 wk delivery. Inter-Computer Electronics, 1213 Walnut St., Lansdale, Pa. 19446. (215) LO 3-2735.

Circle 335 on Inquiry Card

VOLTAGE CALIBRATOR

From 10 Hz to 1 MHz.

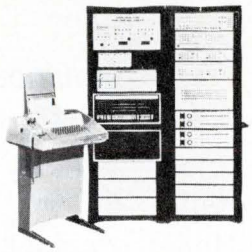


With the AC-110, you can test or calibrate ac instruments with an absolute accuracy of 0.02% +10 μV. Measurement error of the unit being tested is displayed directly in percent. Included is remote programming of all ranges plus freq. and voltage digits. Optimation, Inc., 9421 Telfair Ave., Sun Valley, Calif. 91352.

Circle 336 on Inquiry Card

COMPUTER-OPERATED SYSTEM

For tailoring thick-film circuits.

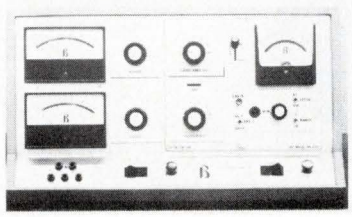


The W102 controls x-y positioning optics and a trimming laser to adjust up to 20 resistors on a single chip while simultaneously checking dc circuit operation. It can process 3000 typical substrates (eight resistor voltage regulator)/h. A basic system is priced at $77,900. Teradyne Applied Systems, 4034 N. Nashville Ave., Chicago, Ill 60634.

Circle 337 on Inquiry Card

RF TEST MODULE

Reads h_{fe} directly.

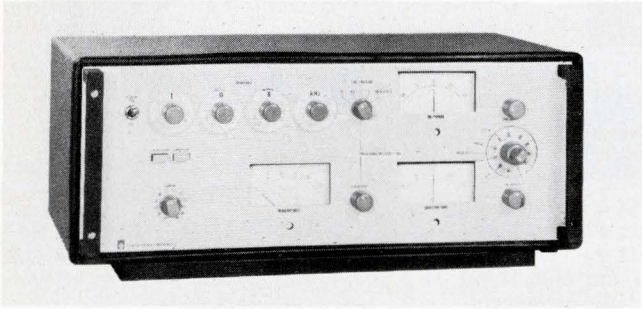


This plug-in module is used with the manufacturer's Model 70 test set to measure transistor high freq. parameters. You can test both pnp and npn transistors from 20 MHz to 100 MHz. The new module is $690 and the Model 70 test set is $945. Birtcher Corp., Instrument Div., 1200 Monterey Pass Rd., Monterey Park, Calif. 91754. (213) 264-6610.

Circle 338 on Inquiry Card

DETECTOR

Has magnitude, in-phase, and quadrature indications.



The 1238 allows the extraction of small signals from noise and resolves signals into in-phase and quadrature components. It features 130-dB gain, and 100 nV full-scale sensitivity. Input impedance is 1 GΩ for minimum loading. The detector has overload protection against signals up to 200 V, and flat or tuned frequency response (with or without line-frequency rejection). Prices are $1260 for the rack model and $1300 for the bench model. General Radio Co., 300 Baker Ave., West Concord, Mass. 01742. (617) 369-4400.

Circle 306 on Inquiry Card

SEVEN-INCH SCOPE

The Model 182A is an all-purpose, plug-in oscilloscope with a CRT display area 85% larger than 8 x 10 cm displays. The CRT graticule has the conventional form (8 x 10 squares) but each square is 1.34 cm on a side. The larger display makes it easier to view waveforms from a distance. One of 13 plug-ins for this instrument gives it 100 MHz response. The new oscilloscope accepts without modification all plug-ins designed for the 180A/181A scopes. The main-frame costs $1100 and plug-ins start at $475. Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304.

Circle 307 on Inquiry Card

AUTOMATIC CAPACITANCE BRIDGE

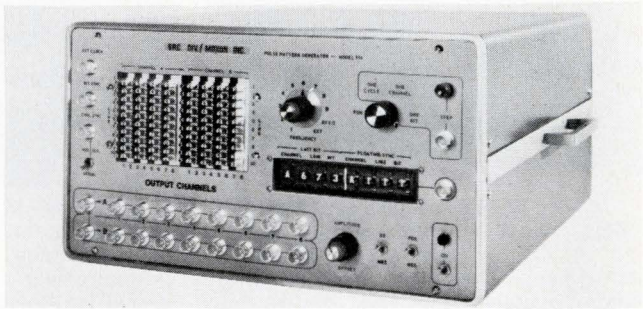
For production applications.

The C403 is a 1 MHz bridge for automatic testing and classification of small-valued capacitors. It has a 25 ms typical balance time and capacitance measurements are displayed in percent deviation from nominal. The bridge can be readily interfaced to automatic handling equipment, and its 5-terminal configuration ensures valid measurements at the end of cables up to 5 ft. long. In addition, an offset adjustment is provided to compensate for fixture capacitance. Measurement range is 1 to 2000 pF. $5850.00, with delivery in about 12 wks. Teradyne, Inc., 183 Essex St., Boston, Mass. 02111. (617) 426-6560.

Circle 308 on Inquiry Card

PULSE PATTERN GENERATOR

Operates up to 10 MHz.



Model 916 gives you an output of 16 parallel channels with 1 to 30 bits each, two parallel channels of 1 to 240 bits ea. or a serial channel of 1 to 480 bits. You can use the generator with either an internal or external clock and its data output is RZ or NRZ with positive or negative logic sense. Amplitude is adjustable from 2 to 7 V and the baseline from −3 to +3 V. Operational modes are 1 bit/step signal, 1 channel/step signal, 1 cycle/step signal, or continuous. $2595. SCR Div., Moxon, Inc., 2222 Michelson Dr., Newport Beach, Calif. 92664. (714) 883-2000.

Circle 309 on Inquiry Card

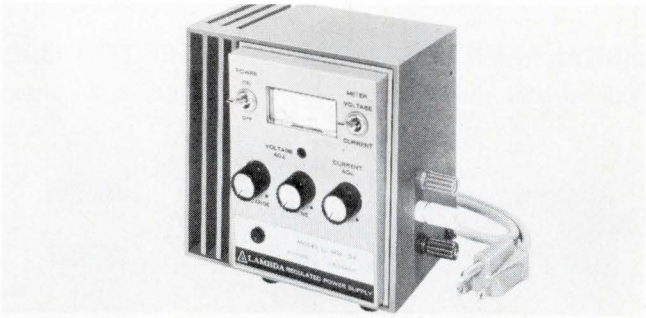
DEVIATION CALCULATOR

Model 520A programmable deviation calculator automatically calculates and displays the signed difference between any measured variable available as a binary-coded decimal input and a reference value. You can set the reference value manually with a 5-digit thumbwheel switch or program it externally. The measured variable is obtained from a measuring instrument with a BCD output. The maximum calculating time of the instrument is 200 μs and it gives you a contact closure at zero deviation. $650. Monsanto Electronic Instruments, 620 Passaic Ave., West Caldwell, N.J. 07006.

Circle 310 on Inquiry Card

IC REGULATED LAB POWER SUPPLIY

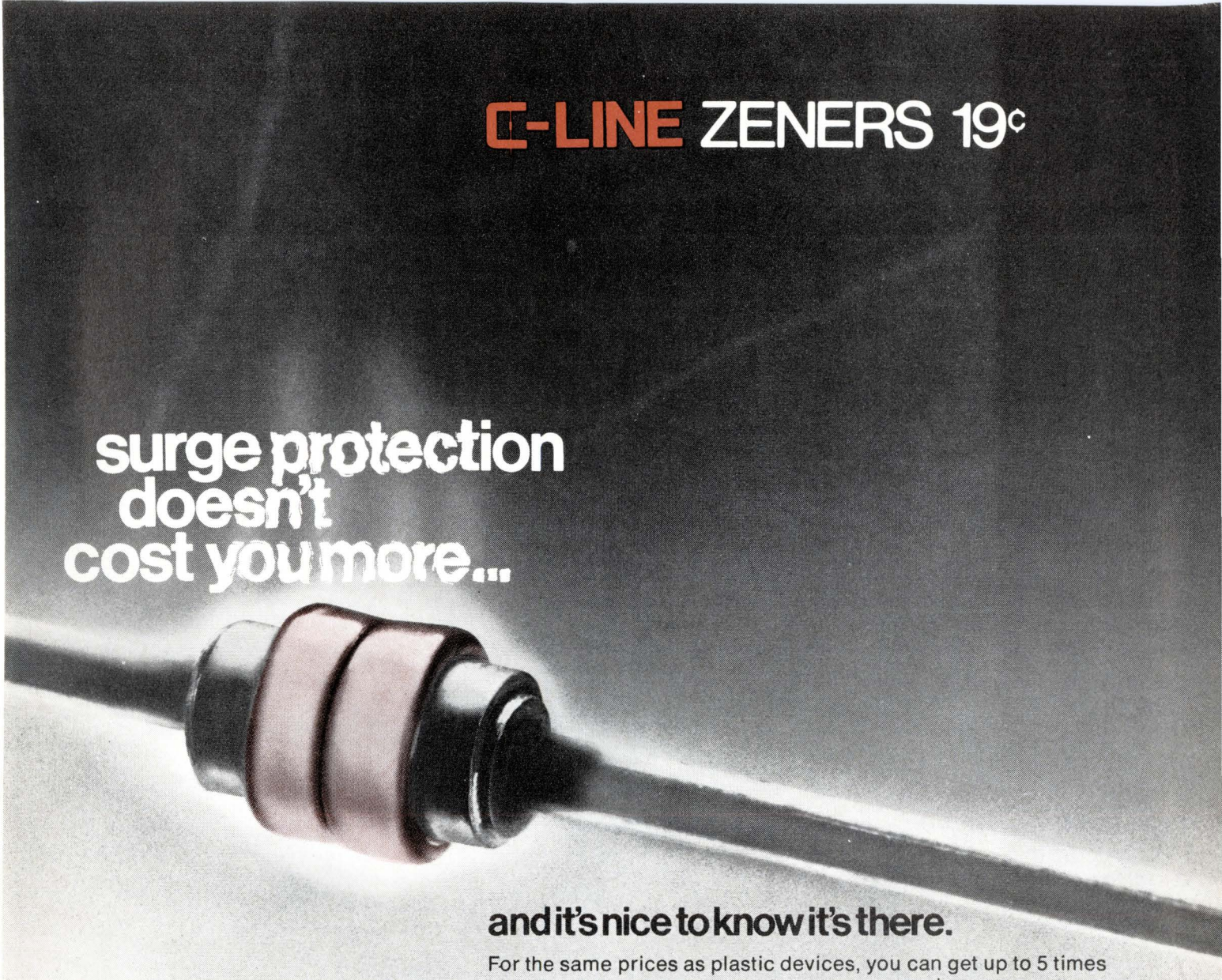
With built-in tracking overvoltage protection.



This series offers three models with adjustable voltage ranges of 0-10 V, 0-20 V, and 0-40 V and current ranges to 1 A. Line regulation is 0.01% +1 mV, and load regulation is 4 mV max. The supplies have a ripple of 250 μV rms, 1 mV pk-pk. The automatic current limiting is adjustable from 0 to 110% of rating. The supplies measure 5⅝″ W by 5½″ H by 3⅞″ D and weigh less than 6 lbs. The LL-901-OV series, 0-10 V, is priced at $90. Models LL-902-OV, 0-20 V, and LL-903-OV, 0-40 V are $99. Lambda Electronics Corp., 515 Broad Hollow Rd., Melville, N.Y. 11746. (516) 694-4200.

Circle 311 on Inquiry Card

¢-LINE ZENERS 19¢



surge protection doesn't cost you more...

and it's nice to know it's there.

For the same prices as plastic devices, you can get up to 5 times greater surge protection. In fact, you can use ¢-line 1 and 5 watt zeners instead of conventional 10 and 50 watt chassis mounted types. And for far less money. Unitrode's unique fused-in-glass construction assures you of monolithic, void-free zener diodes with permanently stable electrical characteristics. And they'll withstand voltage surges high enough to make them hot enough to glow. They're in stock now, ready for immediate delivery. (1 watt ratings as low as 19¢ in 100k lots.) Can you afford not to use them? For fast action, call Sales Engineering collect at (617) 926-0404
Unitrode Corporation,
580 Pleasant St., Watertown, Mass. 02172

UNITRODE quality takes the worry out of paying less.

Circle 35 on Inquiry Card

Unitrode Corporation
Inquiry Processing Dept. 10D, 63 Atlantic Ave., Boston, Mass. 02110

☐ Please send ¢-line zener samples in ☐ 1 watt, ☐ 5 watt rating with complete specifications.

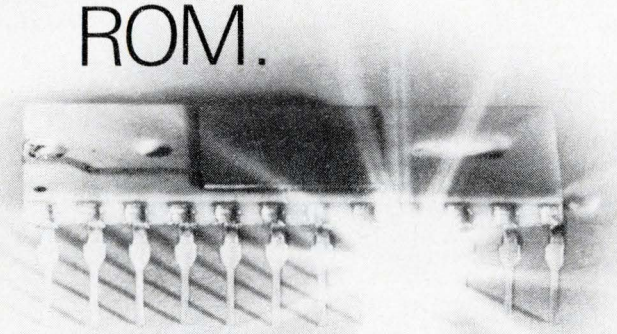
NAME_____ TITLE_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____ ZIP_____

Introducing the first bipolar compatible MOS ROM.



No ifs, ands or external resistors.

A lot of people have said their MOS ROM's were bipolar compatible. For output only. Or just for typical case. Or only if you hung on a resistor.

Solitron's is "worst case" bipolar compatible. Period.

Input can be 0.4v for logic zero. 2.4v for logic one. Any temperature between −55°C and +125°C. Put it with any DTL or T²L and it'll work.

Of course compatibility isn't everything. Which is why we made our MOS ROM fast and versatile. (And static.)

Typical response 500ns. Worst case, 900ns. 1024 bits in four standard word-bit configurations.

Programmable chip select.

We also made it available. Order UC 6525/7525 now and you'll have it in four to six weeks with your bit pattern. Or contact us for details.

Solitron Devices, Inc., P.O. Box 1416,
San Diego, California 92112
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TWX 910-335-1221

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1177 Blue Heron Blvd.
Hi Rel Power Transistors
Si & Ge. Power Transistors
RF & small Signal Transistors
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Bolometer Elements
Ferrite & Ferrite Devices
Microwave Semicond.
Plaxial (R) Cable
Precision RF Coax.

TAPPAN, N.Y.
256 Oak Tree Road
Diodes & Rectifiers
Zeners
High Voltage Assemblies
Power Rectifiers
Thick Film Hybrid Circuits

KENT, ENGLAND
Tubs Hill House
London Road, Sevenoaks
Solidev, Ltd.
Full line of
Solitron devices

BEN BAROO, ISRAEL
51 Hayarkon Street
AEL Israel, Ltd.
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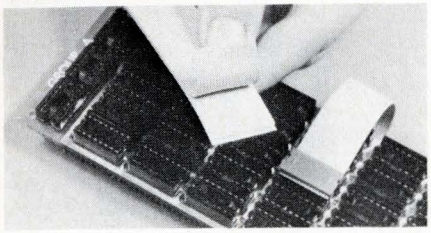
Solitron devices

TOKYO 105, JAPAN
NO. 5, 3-Chome
Shibahamamatsu-cho
Minato-ku
Matsushita Electric Trading
Full line of
Solitron devices

NEW PRODUCTS

DIELECTRIC SPACER



Scotchflex dielectric foam No. 3419, is a low dielectric constant spacer that reduces computer crosstalk. It allows sandwiching of flat cables to give a uniform predictable spacing, and may also be used for shock protection in electronic equipment. 3M Co., 3M Ctr., St. Paul, Minn. 55101. (612) 733-5755.

Circle 240 on Inquiry Card

D/A CONVERTER

Model MDA-10F settles to one LSB of resolution in 60 ns max., 40 ns typ. to ½ LSB, permitting update rates as high as 10 MHz. It operates with its own built-in ref. source, ladder net, and current switches. The converter comes in a PC-mounting module 0.4 h, 2 w and 4 in. l. Analog Devices, Pastoriza Div., 221 Fifth St., Cambridge, Mass. 02142. (617) 492-6000.

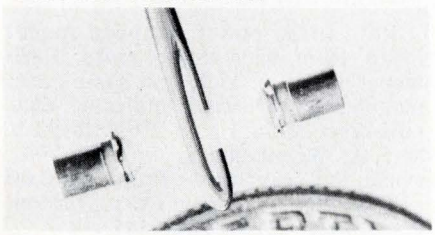
Circle 241 on Inquiry Card

SOLID-STATE AMPLIFIER

Model WJ-5004-13 amplifier provides high dynamic range performance in the 2.0-4.2 GHz freq. range. It exhibits +10 dBm min. power output at 1 dB compression, 30 dB min. to 33 dB max. small signal gain and 10 dB max. NF. It is 1.3 x 3.5 x 3.5 in. and weighs 9 oz. Watkins-Johnson Co., 3333 Hillview Ave., Stanford Indus. Park, Palo Alto, Calif. 94304. (415) 326-8830.

Circle 242 on Inquiry Card

EMITTER-DETECTOR



SE 2450 GaAs emitter and SD 2440 silicon detector are offered as a matched-pair combination of a source and sensor. They are well suited for high-density PCB mounting. Uses include punch card and tape readers, character recognition, shaft encoders, position indicators and warning devices. Spectronics Inc., 541 Sterling Dr., Richardson, Tex. 75080. (214) 231-9381.

Circle 243 on Inquiry Card

PHOTOTRANSISTORS

Three (CLT 2010, 2020 and 2030) new silicon npn planar epitaxial phototransistors cover a light sens. range from 0.2 mA to 3 mA at 5 mW/cm², and max. collector-to-emitter voltages from 15 to 50 V. A narrow 3:1 light sens. tol. range is std. A flat window eliminates the need for critical sensor positioning. Clairex Electronics, 560 S. Third Ave., Mt. Vernon, N.Y. 10550.

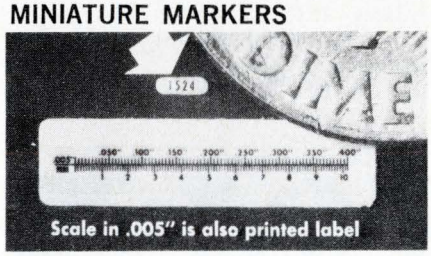
Circle 244 on Inquiry Card

12 BIT LADDER NETWORK

Model HX510 precision network is for use in D/A conversion. It has total output accuracy of ±125 ppm, (±½ LSB) over the range from −55° to +125°C. It comes in a ⅜ x ⅝ in. flat pack. Resistors are vacuum deposited Nichrome thin-film. Halex, Inc., 3500 W. Torrance Blvd., Torrance, Calif. 90509. (213) 370-6175.

Circle 245 on Inquiry Card

MINIATURE MARKERS



Self-sticking micro-miniature marker will fit miniature electronic components and other products. Printed only 0.03 to 0.05 in. high, they make it possible to mark or "brand" product parts on surfaces actually as small as a pinhead. Magnification instantly reveals the message. W. H. Brady Co., 726 W. Glendale Ave., Milwaukee, Wis. 53201. (414) 332-8100.

Circle 246 on Inquiry Card

DIP SOCKETS

A full line of reduced-size DIP sockets is available in 14- and 16-lead configurations, with dip solder leads or solderless wrap pins. The 14-pin receptacles mount on 0.400 x 0.800 in. centers, while the 16-pin type takes only 0.400 x 0.900 in. SAE Advanced Packaging, 1357 E. Edinger Ave., Santa Ana, Calif. 92705. (714) 540-9256.

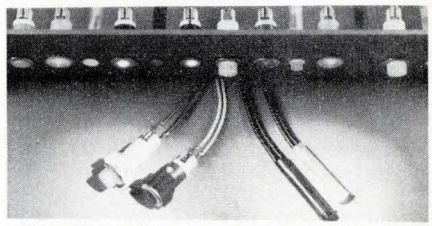
Circle 247 on Inquiry Card

ELECTRODYNAMIC SHAKER

Model PM-250 permanent magnet shaker has a max. output of 250 lbs. force and a recommended freq. range of dc to 5 kHz. Its displacement capability is 1 in. D.A. with an acceleration rating of 92 g and a velocity of 55 in./s. MB Electronics, 781 Whalley Ave., New Haven, Conn. 06508.

Circle 248 on Inquiry Card

SNAP-IN INDICATOR LIGHTS



Pre-assembled nylon encased neon and incandescent Ampillume™ lights are self-mounting in panels 0.032 to 0.062 in. thick. Standard lens styles are "top hat" and "flush." Both types come with natural red, orange, or yellow lenses with 125 or 250 V ratings. Incandescents are also available in blue, green, and purple and 6.3, 12, and 24 V ratings. AMP Inc., Harrisburg, Pa. 17105. (717) 564-0101.

Circle 249 on Inquiry Card

TOROIDAL INDUCTORS

The "low silhouette" toroidal inductor line includes 89 inductors from 0.10 μH to 10 mH. They provide min. distributed capacity, max. Q, and the highest self-resonant freq. possible commensurate with minimum size. Sizes range from 0.200 w x 0.200 l x 0.125 h to 0.550 w x 0.550 l x 0.300 h. They meet environmental requirements of Mil-C-15305. Engineered Components Co., 2134 W. Rosecrans Ave., Gardena, Calif. 90249. (213) 321-6565.

Circle 250 on Inquiry Card

VARIABLE COUPLERS

With Models 100 and 101 the coupling ratio can be continuously varied from about 0 to 30 dB. Directivity is about 40 dB for most conditions, and drops at very high and low freqs. Effective BW (10 kHz to 100 MHz) is taken as the freqs. for which directivity drops to 20 dB when the unit is adjusted for 20 dB coupling. Model 100 ($135.00) has a phase reversal in the coupled port, while 101 ($150.00) does not. Deerfield Laboratory, Box 1300, Los Altos, Calif. 94022. (415) 948-4535.

Circle 251 on Inquiry Card

DC TO DC CONVERTER

C1.0 series miniature power modules convert 28 Vdc to any desired output voltage between 5 and 100 Vdc at full load output current of 1.0 A. They regulate line voltage to ±0.05% or 10 mV (whichever is greater) for input changes of 24 to 30 Vdc at constant load. Load reg. is ±0.05% or 20 mV from no load to full load at constant line. Abbott Transistor Labs., Inc., 5200 W. Jefferson Blvd., Los Angeles, Calif. 90016. (213) 936-8185.

Circle 252 on Inquiry Card

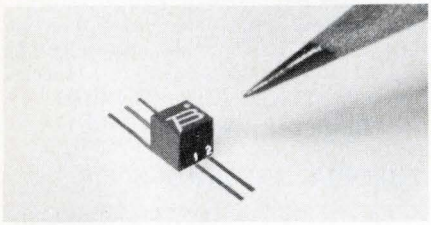
NEW PRODUCTS

SOLID STATE EL DRIVERS

EL20, EL200 series of ss switches are designed and specified as drivers for electroluminescent displays. They have forward and reverse blocking voltages from 200 to 400 V with high reverse gain for min. power consumption, and can be driven directly from low-level ICs. The EL series is available in TO-18, TO-46, and TO-100 packages. Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172. (617) 926-0404.

Circle 253 on Inquiry Card

MINIATURE TRANSFORMER



Model 4211-1007 microminiature audio transformer is a low-profile unit, only 0.125^3. It has a freq. range of 4 kHz to 40 kHz. Power rating is 10 mW at 20 kHz. It meets Mil-T-27, grade 5, and features electrostatic shielding. Bourns Pacific Magnetics Corp., 28151 Highway 74, Romoland, Calif. 92380. (714) 657-5195.

Circle 254 on Inquiry Card

SEALING GLASS

New devitrifying solder sealing glass (Code 7588) for electronics is available as a powder ready for use in a variety of mesh sizes with or without coloring additives. Designed for sealing alumina ceramics, it offers IC manufacturers a means of making a mechanically strong hermetic seal with improved flow characteristics. Electronic Materials Dept., Corning Glass Works, Corning, N.Y. 14830.

Circle 255 on Inquiry Card

WIDEBAND AMPLIFIER

Model WB-23 has a unity gain BW of 150 MHz, a full power output of 12 MHz, and slews at 1000 V/μs. Settling time to 0.1% is 250 ns, and output is ±10 V at 50 mA. It doesn't optimize one parameter at the sacrifice of others. DDC, 100 Tec St., Hicksville, N.Y. 11801. (516) 433-5330.

Circle 256 on Inquiry Card

AC MOTOR BRAKE

Model 291-C AC Motor Brake offers a reliable, inexpensive means of dynamically stopping electric motors thru 16 hp. It controls both single and 3 φ motors, with voltages from 100 thru 600 Vac. $225.00. EMF Corp., 610 Yale Ave. N., Seattle, Wash. 98109. (206) 624-6310.

Circle 257 on Inquiry Card

CERAMIC SUBSTRATE

This alumina ceramic substrate for LSI or hybrid packages is produced by powder pressing which is said to insure a high degree of uniformity. They come in thicknesses >0.035 in. Ceramic components made of aluminum oxide have many properties that make them useful for a wide range of electronic applications. Diamonite Products Mfg. Co., Shreve, Ohio 44676.

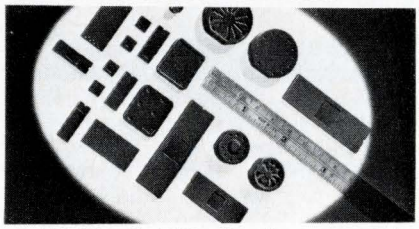
Circle 258 on Inquiry Card

LIGHT EMITTING DIODE

Two new visible LEDS FLV100 and FLV101, feature high brightness (1500 ft. lamberts in the FLV100); wide viewing angle (160° with the FLV101); and low power consumption. They can be driven by std. digital ICs. FLV100 has a transparent lens and the FLV101 a frosted lens. $3.00 (1-99), and $0.99 (10,000). Fairchild Microwave and Optoelectronics, 2513 Charleston Rd., Mountain View, Calif. 94040. (415) 961-9573.

Circle 259 on Inquiry Card

BLACK ALUMINA CERAMIC



AlSiMag® 782 alumina ceramic parts offer a new safeguard for light-sensitive electronic devices. This opaque black material is used for encapsulation and as a substrate. It has a helium leak rate of $< 1 \times 10^{-8}$ cc/s at one atmosphere pressure and can be reheated in an oxygen atmosphere without color change. American Lava Corp., Chattanooga, Tenn. 37405.

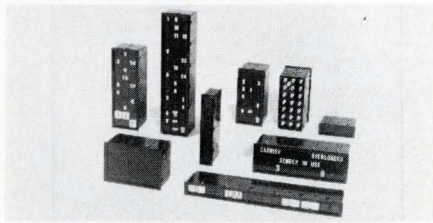
Circle 260 on Inquiry Card

LED PULSER

This compact ss encapsulated unit provides adjustable medium voltage, high-current, fast risetime current pulses for devices such as GaP light emitting diodes. Input is +24 to +32 Vdc, with transients to 80 V for 0.1 s (Mil-Std-704). Output is +1 to +5 A, adj. into fixed loads between 5 and 25Ω (pulse amp. from 20 to 130 V, 650 W pk. max), continuous operation for 1 hr. under max. cond. without ext. heat sinking. Pulse shape: 1μs rise and fall times, pulse flat top adj. from 0.2 to 15 μs. Grafix Inc., Box 3296 Albuquerque, N.M. 87110. (505) 265-6903.

Circle 261 on Inquiry Card

LIGHTED INDICATORS



Series 68011-14 integrated indicator displays come ready to snap into a rectangular panel cutout. Terminal connections are reduced to half of those needed for displays using discrete indicators since a common ground terminal is used for all lamps. $1.50 to $2.50/lamped indicator module. Info-Lite Corp., 2337 Lemoine Ave., Ft. Lee, N.J. 07024. (201) 947-6646.

Circle 262 on Inquiry Card

SWITCH/INDICATOR

These 2-lamp, lighted pushbutton switches and word indicators have an adapter that accepts crimp-type wire terminals. Two lamp reliability is provided by 6, 12, 28 Vdc or 115 Vac lamps. Series 90K 2-pole and 4-pole switches come in either alternate or momentary action as well as holding coil versions. Master Specialties Co., 1640 Monrovia, Costa Mesa, Calif. 92627. (714) 642-2427.

Circle 263 on Inquiry Card

PLASTIC POWER TRANSISTOR

Electrically interchangeable with most similar power transistors on the market, the TIP3055 offers a 15% savings over metal can units. It plugs directly into a TO-3 metal can socket and has a 60 V breakdown voltage (BV_{CEO}) and is rated at 15 A continuous current. $1.00 ea. (100-999). Texas Instruments Incorporated, Box 5012, M/S 308, Dallas, Tex. 75222. (214) 238-3741.

Circle 264 on Inquiry Card

POWER SUPPLY

RM series power supplies mount in std. 19 in. wide RETMA racks. Each model is 3½ in. high, and has a panel mounted power switch/indicator. Outputs range from 3 V at 20 A, to 50 V at 5 A. Regulation is typ. ±0.05%; ripple, 0.5 mV rms. From $280.00 to $330.00 ea. Acopian Corp., Easton, Pa. 18042. (215) 258-5441.

Circle 265 on Inquiry Card

DESOLDER PUMP

Made of lightweight aluminum, this pump has a solid vacuum piston for increased performance. Only 7 in. long overall it may be loaded and discharged with one hand. Replaceable Teflon tips give additional long life. Techni-Tool, Inc., 1216 Arch St., Phila., Pa. 19107. (215) 568-4457.

Circle 266 on Inquiry Card

Unitek Bonders Stack Up Best

Build your bonding line with the source that's proven best in the field . . . take UNITEK

In case after case of tough on-line comparison testing, more leading firms take UNITEK because they've proved that when the chips are down you get the Best Chance for the Best Choice . . . here's why . . . flexibility, repeatability, and service in-depth.

First, you get wider work-choice options. Each UNITEK bonder is built for production-versatility . . . handles all package types by simply interchanging optional accessories. Single units, rack-feed or automatic strip-feed handling of conventional packages . . . hybrids, too, all available on virtually every bonder. Take exactly the options you need now . . . add later when you need to . . . the closest thing yet to custom making your production line.

Pinpoint repeatability is another very big reason. Prototype work or line work, it's guaranteed by exclusive rugged, durable UNITEK construction, perfect process controllability and ultra-simple operation. Training and maintenance stay low . . . rates and yields stay up . . . lot-run after lot-run.

Third . . . service . . . expert guidance you can count on; after you specify as well as before. Your UNITEK man and the entire UNITEK Applications Laboratory team of bonding specialists can make life a lot easier out there on the line.

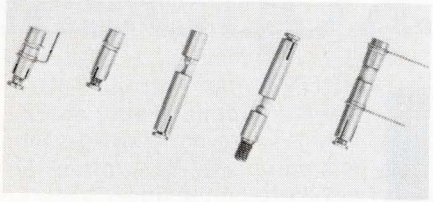
UNITEK stacks-up best . . . has for over twenty years . . . there's bound to be a proven UNITEK bonder for you . . . get more facts by contacting your nearby UNITEK man or UNITEK/ Weldmatic Division, 1820 So. Myrtle Avenue, Monrovia, California 91016. Telephone: (213) 358-0123; TWX: 910 585-3236.

The Best Chance for the Best Choice

UNITEK®

NEW PRODUCTS

MICROCIRCUIT TRIMMERS



The 7200 series trimmer capacitors are for IC, hybrid circuit, microstrip circuit and microwave applications. They have a 10:1 tuning ratio and offer capacitances ranging from 0.1 to 2.0 pF. Made of gold plated brass, they use high K glass and alumina ceramics. Johanson Mfg. Corp., 400 Rockaway Valley Rd., Boonton, N.J. 07005.

Circle 267 on Inquiry Card

5 V, 50 A POWER SUPPLY

New supply has an input of 105 to 130 Vac, 47 to 1000 Hz. Over 85% efficient, it has line reg. of <0.05% and load reg. <0.05%. Ripple and noise are <50 mV pk-pk and response time is <200 μs. Operating temp. is 0° to 50°C. It is 4 x 4 x 6 in. $364.00. Power Devices, Inc., 1240 W. Collins Ave., Orange, Calif. 92656. (714) 532-1621.

Circle 268 on Inquiry Card

RF POWER TRANSISTORS

Four new transistors feature balanced emitter construction for optimum safe operating area, low lead-inductance stripline packaging for increased broadband capabilities, and a choice of four power levels at 12.5 Vdc, 175 MHz. The MM4020 is rated at 3.5 W @ 11.5 dB gain min., MM-4021 at 15 W @ 7.0 dB gain min., MM4022 at 25 W @ 5.5 dB gain min., and MM4023 at 40 W @ 4.5 dB gain min. Prices are $6.20, $15.00, $23.00, and $38.00 respectively (100-999). Motorola Semiconductor Products, Inc., Box 20912, Phoenix, Ariz. 85036. (602) 273-3466.

Circle 269 on Inquiry Card

HEAT DISSIPATOR

Press-on fan top dissipator increases power diss. of transistors and ICs in TO-8 and TO-66 metal cases having a 0.480 to 0.515 in. dia. TXBF2-050-033B needs no additional board space as the 1¼ in. dia. "fan" is positioned above components mounted adjacent to the semiconductor. Below $0.50 in quan. International Electronic Research Corp., 135 W. Magnolia Blvd., Burbank, Calif. 91502. (213) 849-2481.

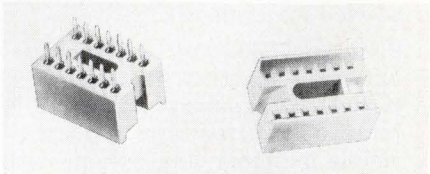
Circle 270 on Inquiry Card

SUB-MINIATURE LAMPS

These T-1 subminiature lamps are for applications requiring illumination from low current sources. They are specified at a max. of 30 mA with the average current ranging from 20-25 mA. They can be driven directly from low output integrated circuitry. Chicago Miniature Lamp Works, 4433 N. Ravenswood Ave., Chicago, Ill. 60640. (312) 784-1020.

Cricle 271 on Inquiry Card

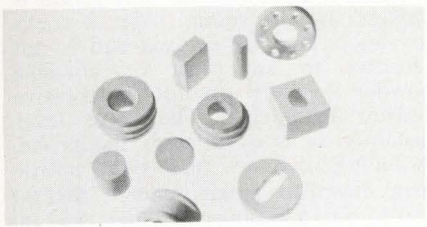
IC SOCKETS



Type 561 socket fits 14-pin DIL ICs on 0.100 in. centers for adjacent terminals. Consistently reliable mating of the IC package is achieved by using a tapered pin entrance design. Solder tail centers of the socket are identical to those of the IC, permitting std. board layouts to be used. About $0.20 ea. Connector Corp., 6025 N. Keystone Ave., Chicago, Ill. 60646. (312) 539-3108.

Circle 272 on Inquiry Card

DESICCANT



This desiccant is strong enough to be a mechanical part, workable enough to be machined into nearly any shape, and weighs only 1.1 g/cc. Natrasorb® 900 will absorb about 18% of its own dry weight in moisture vapor under std. conditions (25°C. 10 mm Hg. water vapor pressure) and can dry atmospheres to a −100°F dew point. Multiform Desiccant Products, Inc., 1418 Niagara St., Buffalo, N.Y. 14213. (716) 881-0100.

Circle 273 on Inquiry Card

RF COAX CONNECTOR

New swivelable design permits 360° rotation about the cable axis without inducing strain to the cable braid. The connection is completely sealed against contamination and moisture. Design is applicable to any rf connector series. Constant positive performance is guaranteed. ITT Gremar, 10 Micro Dr., Woburn, Mass. 01801. (617) 729-8950.

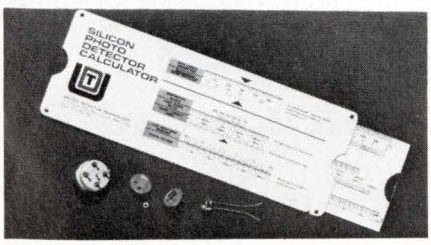
Circle 274 on Inquiry Card

PRECISION INVERTER

New crystal controlled 12 Vdc to 120 V, 60 Hz inverter provides a freq. accuracy of ±0.005% over a temp. range of −40° to +55°C. It will automatically start motors, lamps, and other heavy starting current loads up to its 200 VA rating. $169.00 (1-9). Electronics-Atlanta, Inc., 5300 New Peachtree Rd., Chamblee, Ga. 30341. (404) 458-0096.

Circle 275 on Inquiry Card

CALCULATOR



This silicon photodetector calculator helps you get the best performance out of your photodetectors. Most of the scales are general purpose and can be used for almost all types of photodetectors, including photomultipliers and phototransistors. $1.00 with instruction book. United Detector Technology, 1732 21st St., Santa Monica, Calif. 90404. (213) 393-3785.

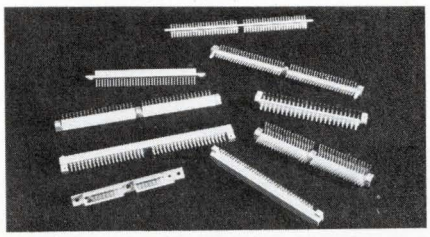
Circle 276 on Inquiry Card

SENSING TRANSISTOR

Heart of this current sensor is a hybrid circuit composed of a Magnistor™ and an op amp which puts out a voltage analog of the current being sensed. Series HM-2000 Magnistor (a magnetically sensitive transistor) sensors come in three ranges to measure ac or dc currents of 0.05 to 2, 2 to 50, and 50 up to 4000 A. All units can operate from voltages of from ±5 Vdc to ±15 Vdc. Power diss. of the device itself is < 700 mW. Hudson Corp., Box 867, Manchester, N.H. 03105. (603) 669-8570.

Circle 302 on Inquiry Card

CARD CONNECTORS



These circuit-card header systems are connectors consisting of extruded or fabricated aluminum bases containing male blade contacts on 0.100 in. (type M1001), 0.125 in. (type M1201), or 0.150 in. (type M1501) centers. The contacts, when used with mating tuning fork contacts, offer low insertion force, typ. < 6 oz./mated pair. Teradyne Components, 900 Lawrence St., Lowell, Mass. 01852. (617) 454-9195.

Circle 303 on Inquiry Card

MINIATURE RESISTOR

Molded precision metal film resistor is only 0.1 x 0.175 x 0.06 in. Style PE-1/20 has a range from 25 Ω to 25 kΩ and is rated 1/20 W at 100°C. Tinned copper leads are 0.015 in. in dia. x 0.5 in. long, spaced 0.075 in. apart. It meets Mil-R-10509, Char. D, C, and E and Mil-R-55182. Tolerances as low as 0.1% and TCs as low as 25 ppm/°C are available. From $0.25 to $2.35. American Components, Inc., Eighth Ave. at Harry St., Conshohocken, Pa. 19428. (215) 828-6240.

Circle 304 on Inquiry Card

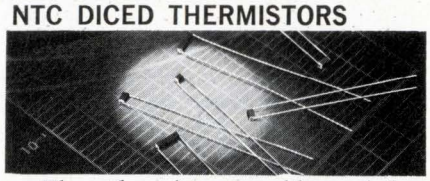
SINGLE-TURN CERMET POT

Model 62 trimming pot is only 0.250 in. in dia. It comes in a nonmetallic housing to guard against dielectric voltage breakdown or shorting. Model 62 side adjust is 0.250 x 0.180 x 0.250 in. allowing closer board stacking, and requires only 0.045 in.^{2} of mounting area. $1.72 ea. (1-9). Spectrol Electronics Corp., City of Industry, Calif. (213) 964-6565.

Circle 305 on Inquiry Card

NEW PRODUCTS

NTC DICED THERMISTORS



These thermistors provide good electrical and physical uniformity and greater lead pull strength than small discs and rods which they replace. Resistance values available are: 50 to 300 Ω with NTC of −3.3%/°C at 25°C, 500 to 3000 Ω with NTC of −3.9/°C at 25°C, and 3 k to 100 kΩ with NTC of 4.4%/°C at 25°C. Total range is from 50 Ω to 100 kΩ. Cal-R, Inc., 1601 Olympic Blvd., Santa Monica, Calif. 90404.

Circle 277 on Inquiry Card

SS POWER CONTROLLERS

These ac and dc ss load controllers were designed to replace both normal EM relays and circuit breakers. They perform the combined functions of a relay and a circuit breaker. The dc units operate on 28 Vdc with ratings of 0.5 through 35 A; ac units on 115/200 Vac, with ratings of 1.0 through 35 A. Leach Corp., Relay Div., 5915 Avalon Blvd., Los Angeles, Calif. 90003.

Circle 278 on Inquiry Card

JUNCTION THERMISTOR

This silicon carbide thermistor can sense temp. changes from cryogenic to the max. operating temp. of 1000°C with extreme accuracy. Almost all other thermistors have a max. temp. of 300°C. The p-n junction of the device has an exponential decrease in impedance as temp. increases. Westinghouse Astronuclear Lab., Box 10864, Pittsburgh, Pa. 15236. (412) 892-5600.

Circle 279 on Inquiry Card

PRECISION CAPACITORS

Wrap and fill construction of these mylar capacitors yields a small lightweight device, yet still affords a secure, moisture resistant seal. MHW Series units feature a capacitance tol. of ±5% std. and high insulation resistance. Constructed of extended foil winding std. units are available from 0.001 to 2.00 μF. Electronic Associates, Inc., West Long Branch, N.J.

Circle 280 on Inquiry Card

INDICATOR LIGHT

The QT, a high brightness microminiature light, now has a retaining clip to ease installation and ensure positive retention. The clip, which fits over the QT base behind the panel, eliminates installation difficulties caused by drilling or stamping oversize mounting holes. Ratings range from 1.5 V to 28 V. Flat and domed lens caps available. Marco-Oak, Box 4011, Anaheim, Calif. 92803.

Circle 281 on Inquiry Card

MINIATURE PROBE

Micro Positioner MP-100 probe is secured thru a vacuum base. It sticks to almost any flat surface and is not sensitive to any dust or abrasive powder (usually present in abrasive resistor trimmers). The valve lever instantly locks or releases the probe. A built-in cylinder moves the needle arm down to make contact. $62.00 ea. (1-5); $58.00 ea. (6-20); $52.00 ea. (21-100). M.P.M. Corp., 9 Harvey St., Cambridge, Mass. 02140. (617) 876-7111.

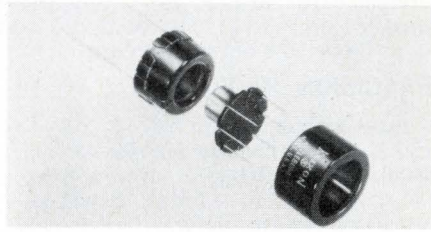
Circle 282 on Inquiry Card

CONNECTOR FAMILY

Nu-Mite 2400 series connectors with two, three or four polarized contacts come in cable mounted plug, chassis mounted receptacle, or thru-bulkhead adapter configurations. The hermetically sealed units can withstand a pressure differential of up to 10,000 psi. All meet environmental resistance requirements of Mil-C-5015. Cinch-Nuline, a div. of TRW Inc., 1015 S. Sixth St., Minneapolis, Minn. 55415.

Circle 283 on Inquiry Card

TEMPERATURE STABILIZER



Operating without thermostatic controls, this ss component stabilizer self-stabilizes itself and contained TO-5 component at 65°C in < 1 min. Drawing < 1 W in its steady state at room temp., it operates over ambients from −55° to 15°C below its control temp. Operating voltage is 24 V ac or dc. Texas Instruments Incorporated, Control Products Div., Attleboro, Mass. 02703. (617) 222-2800.

Circle 284 on Inquiry Card

SILICON TRIACS

These gate-controlled, full-wave Si ac switches, switch from an off- to an on-state for either polarity of applied voltage with + or − gate triggering voltages. They are for operation up to 400 Hz with res. or ind. loads and nom. line voltages of 115 (40773) and 208 (40774) Vrms sine wave, and repetitive peak off-state voltages of 200 V and 400 V. RCA, Solid State Div., Somerville, N.J. 08876.

Circle 285 on Inquiry Card

READOUT

This complete readout (7-segment) and plug-in decoder-driver "display package" can be ganged for multiple use. Model MS-4000B readout uses std. #683 T-1 lamps. Relatively large (0.34 x 0.62 in.) characters displayed are 0-to-9. Model DDM-703 BCD to 7-segment decoder-driver plug-in module with an 80 mA output capability includes a ripple-blanking output of the most significant leading edge zeros, intensity control capability, and independent lamp test input. Alco-Display Div., Alco Electronic Products, Inc., Lawrence, Mass. 01842. (617) 686-3880.

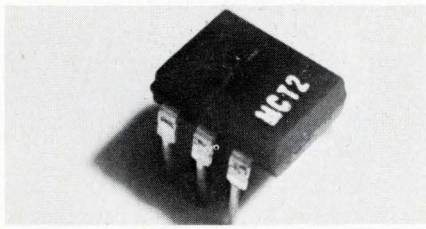
Circle 286 on Inquiry Card

SOLDERABILITY TESTER

Highly automated tester performs all tests needed to accurately evaluate the solderability of component terminations, PC boards and other flat surfaces. The Universal Solderability Tester performs: solder globule test for leads and terminals; edge dip test for PC boards and laminates; dip test for wire leads and terminals; meniscus test (optional) for PC boards. Alpha Metals, Inc., 56 Water St., Jersey City, N.J. 07304. (201) HE 4-6778.

Circle 287 on Inquiry Card

OPTO-ISOLATOR



The MCT2 consists of a diffused planar IR light-emitting diode optically coupled to a silicon planar phototransistor. Voltage isolation exceeds 1500 V and isolation res. is typ. 100 GΩ. It also has a current transfer ratio of 35% and rise and fall times of 2 μs. $5.85 ea. (1-9) and $3.55 ea. (1000). Monsanto Co., 10131 Bubb Rd., Cupertino, Calif. 95014. (408) 257-2140.

Circle 288 on Inquiry Card

ELECTROLYTIC CAPACITORS

Type 502D, low-cost, single-ended miniature aluminum electrolytics are for vertical installation on high-density PC boards. These metal-encased units will withstand an 85°C life test for 1000 h at rated voltage. Sprague Electric Co., 481 Marshall St., North Adams, Mass. 01247. (413) 664-4411.

Circle 289 on Inquiry Card

CURRENT BOOSTER

Model 9693 has two modes of operation: as a current booster inside a feedback loop with an op amp, and as a stand alone voltage follower. Bias current may be adjusted to zero with an ext. pot. Features include (no ext. adj. circuitry): 1 μA bias current, 10 M Ω min. input Z, 20 MHz small signal BW, ±400 V/μs min. slew rate, and ±10 V output at ±100 mA load current. $55.00 (1-2), $50.00 (3-9), $45.00 (10-29). Optical Electronics, Inc., Box 11140, Tucson, Ariz. 85706. (602) 624-8358.

Circle 290 on Inquiry Card

DIGITAL PRINTER

New 2000H series units can print from 4 to 20 columns at 150 lines/min. Options include BCD coded data input, signal compatibility over the range of −30 to +30 V, 24-h clock, floating decimal point, data memory, and special print fonts. Basic 4-col. instrument sells for <$750.00 complete with power supply. Digitron Corp., 2544 W. Main St., Norristown, Pa. 19401. (215) 277-5800.

Circle 291 on Inquiry Card

NEW PRODUCTS

CERAMIC CHIP CAPACITOR

New "BB" size Ceramolithic® capacitor is 0.050 x 0.050 x 0.040 in. and is available in NPO or W dielectrics from 6 pF to 6800 pV in 50 and 100 V sizes. The monolithic chips have silver end terminations (std.), with gold, palladium gold and palladium silver also available. They meet all applicable requirements of Mil-C-11015 and Mil-C-39014. USCC, 2151 No. Lincoln St., Burbank, Calif. 91504. (213) 843-4222.

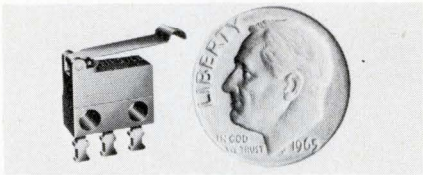
Circle 292 on Inquiry Card

EPOXY PACKAGE

Eccocup packaging scheme saves time and money when you want to prepare only small portions of two part epoxy systems. Used initially with Ecco-bond Solder 56-C, the package consists of 25 wells/4 x 4 in. array. Each is filled with the base material and sealed. To use, the film covering is stripped back to expose the number of wells needed and one drop of catalyst is added to each well using a calibrated squeeze bottle. Emerson & Cuming, Inc., Canton, Mass. 02021. (617) 828-3300.

Circle 293 on Inquiry Card

SNAP-ACTION SWITCH



New Mini-Mite™ has a case that is <0.250 in. high by 0.300 in. wide by 0.100 in thick. Ratings are 2 A, 125-250 Vac; 2 A (res.) and 1 A (ind.), 30 Vdc. The switch, which meets Mil-S-8805 specs, is available with four types of terminals—single and double turret, quick connect spade and solderless wrap. McGill Mfg. Co., Inc., Valparaiso, Ind. 46383.

Circle 294 on Inquiry Card

DIODE OSCILLATORS

Each SYA-3206 tunable X-band coaxial oscillator produces min. outputs of up to 500 mW cw. Each uses an oxide-passivated silicon avalanche diode mounted junction side down for max. thermal efficiency. Power variation is typ. <1 dB over a range of −30°C to +71°C. Semiconductor Div., Sylvania Electric Products Inc., Woburn, Mass. 01801.

Circle 295 on Inquiry Card

COPPER CLAD LAMINATES

Two new laminates, 65M27 Special and 65M28 Special, are measle resistant, warp-free, high impact strength, high insulation resistance glass epoxy copper clads which can be drilled or punched as easy as ordinary G-10 and FR-4 laminates. The 65M28 provides the additional feature of flame-retardance to the easy drilling/punching/shearing and measle resistant characteristics of 65M27. Westinghouse Electric Corp., Industrial Plastics Div., Hampton, S.C. 29924. (803) 943-2311.

Circle 296 on Inquiry Card

FAST PHOTOGRAPHIC PAPER

Linagraph 1930 is designed to record CRT traces, as well as for use with light beam recording instruments. It can be used with P11, P16 and P24 phosphors. Even subtle details are recorded as clean, crisp, black-on-white tracings. Its water-resistant base eliminates swelling, permitting accurate measurement of trace modulation. Eastman Kodak Co., Professional Commercial & Industrial Markets Div., 343 State St., Rochester, N.Y. 14650. (716) 325-2000.

Circle 297 on Inquiry Card

NEW PROGRAMS & SERVICES

DESIGN AND LAYOUT

ICEMAP computer-aided design and layout program starts with the basic design element, i.e., the component which lets you truly design a complete IC. Most of the layout and design programs available today use a standard "cell." With ICEMAP you can design the standard cell and can then repeat the developed cell for high complexity circuits. The program runs in either interactive sharing mode or a batch processing mode. Integrated Circuit Engineering Corp., 4900 E. Indian School Rd., Phoenix, Ariz. 85018. (602) 959-4760.

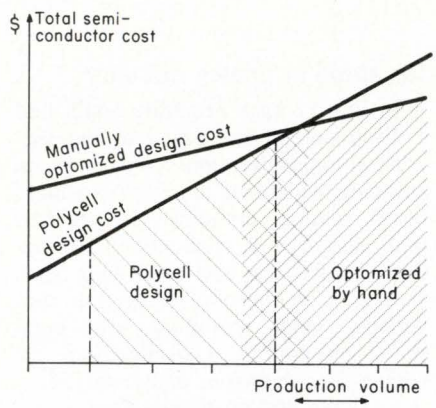
Circle 298 on Inquiry Card

NC/QC PROGRAMS

New efficient NC/QC computer programs for users of the PICOMM computer system feature faster generation of NC tapes and QC reports for electronic and mechanical parts. The NCL computer language program makes NC tapes directly from a keyboard. It eliminates slow and expensive post processors and most slow manual programming activities. Potter Instrument Co., Inc., East Bethpage Rd., Plainview, L. I., N. Y. 11803. (516) 694-9000.

Circle 299 on Inquiry Card

MOS LSI DESIGN



Polycell economics

You can now work together to create custom MOS LSI arrays using the company's design and production system. This service reduces non-recurring circuit costs by 50% or more. The system's design capability includes logic verification, test sequence generation, chip layout, and art work preparation. High threshold, P-channel, static, MOS technology is used.

Basic building blocks are stored in an expanding MOS Polycell library, which now contains 30 cells ranging from inverters, buffers and expanders through multi-input NOR and NAND gates, Exclusive-ORs, latches, and flip-flops.

Short of large production runs, LSI cost tradeoffs favor the Polycell design over a manual design where the circuit size, speed, and cost are optimized at the expense of a larger initial design cost. (See chart) Typically, a Polycell design will cost from $5,000 to $20,000 and prototype parts will be available in 10 to 14 weeks. Motorola expects to be able to sustain a throughput of one design per day. Motorola Semiconductor Products Inc., Box 20912, Phoenix, Ariz. 85036.

Circle 300 on Inquiry Card

MICROWAVE ANALYSIS

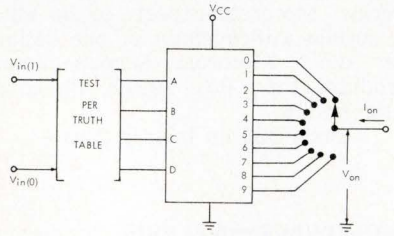
Advanced Microwave Circuit Analysis Computer Program (AMCAP) can analyze the performance of any circuit from a simple filter to the feed system for a phased array antenna. It can be learned in <1 h. $6000, plus travel, installed on most time sharing and batch computers. Environmental Computing Inc., 21 George St., Lowell, Mass. 01852. (617) 453-7745.

Circle 301 on Inquiry Card

LITERATURE

54/74 MSI complex arrays

Another comprehensive catalog from Sprague, this 100-pager covers series 54/74 MSI complex array ICs. It's divided into three sections, the first providing general design characteristics; the second, electrical characteristics (specific test limit and



Dc test circuit—BCD-to-decimal decoder/driver

test condition information for the evaluation of 21 MSI ICs); and the third, parameter measurement information (complete dc and ac measurement methods and procedures). Sprague Electric Co., Marshall St., North Adams, Mass. 01247.

Circle 361 on Inquiry Card

Semiconductor device digest

Each category of semiconductor devices included in this 20-page catalog is presented in compact tables and charts giving ratings, parameters, and specs. Dimensional case drawings supplement the handy reference. Among the products listed you'll find SCRs, power logic triacs, high and low power silicon rectifiers, selenium rectifiers, zener regulators, and light sensitive devices. International Rectifier, Semiconductor Div., 233 Kansas St., El Segundo, Calif. 90245.

Circle 362 on Inquiry Card

Pulse motors

A well-written and very informative reference manual is devoted to high performance digital stepping motors. The motors, which are suggested for applications in computer peripheral equipment, NC machine tool drivers, graphics equipment, and computer-controlled production equipment, range in power from 1/40 to 10 hp and up to 16,000 steps per second in speed. Theory, application and maintenance of both electric and electro-hydraulic versions are provided in the 82-pager as are schematics, and mechanical and electronic design guidelines. ICON Corp., 156 Sixth St., Cambridge, Mass. 02142.

Circle 363 on Inquiry Card

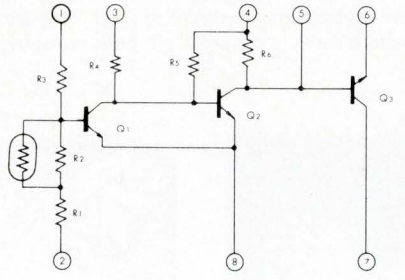
Op amps in analog circuitry

In this 12-page brochure you'll find a discussion of the practical and theoretical considerations necessary in applying wideband amplifiers to high-speed analog circuitry. It provides both design and application information, illustrating and describing such uses as high speed D/A and A/D conversion, video summing, and high-speed integration. Intronics Inc., 57 Chapel St., Newton, Mass. 02158.

Circle 364 on Inquiry Card

Japanese components

Ten catalogs comprise this offer, each detailing a category from the component lines this company has to offer. Types of components include resistors, capacitors, switches, power supplies, and ICs. Especially notable is the catalog of hybrid thick-film ICs. With each circuit described you'll find schematics illustrating the standard



Battery charger

product and a measuring circuit. Also, there's a dimensional diagram for each and charts illustrating ratings and characteristics. There's a quick reference guide at the beginning and a part number code at the end. Matsushita Electric Corp. of America, Pan Am Bldg., 200 Park Ave., New York, N.Y. 10017.

Circle 365 on Inquiry Card

Silicon rectifiers

A wealth of data including performance information, package design, and application data for various types of silicon rectifiers has been gathered together in tabular form. Included in the quick reference source are high voltage, axial, lead silicon rectifier cartridges for peak inverse voltages to 50,000 V with forward current ratings to 1 A, and rectifier packs with PIV to 50 kV at forward currents of 30 A. Electronic Devices Inc., 21 Gray Oaks Ave., Yonkers, N.Y. 10710.

Circle 366 on Inquiry Card

IC analysis

Here's an extremely informative 22-page article telling you what's really on the inside of ICs. The article appears in four sections. The first describes the need for product evaluation, and covers such topics as selecting sample devices, decapsulation, inspection techniques, and electrical and environmental tests. The second part details circuit layout and procuct analysis and the third covers analyzing electrical test results. The last part details circuit layout and processing. Integrated Circuit Engineering Corp., 4900 E. Indian School Rd., Phoenix, Ariz. 85018.

Circle 367 on Inquiry Card

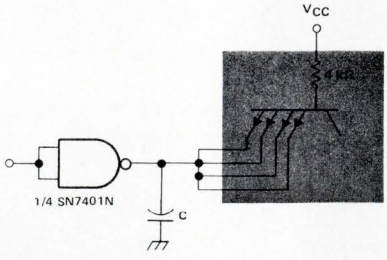
Coaxial connectors

Miniature bayonet locking coaxial connectors for shielded capacitance and pulse type systems are described in a 16-page catalog. They cover a complete range of conductor sizes and locking lug polarities, with either solder pot or crimp type contacts. In addition to just listing and describing its products, the catalog contains handy application information, detailed dimensional drawings, performance characteristics, and installation instructions. Cinch-Nuline, Div. of TRW, 1015 S. 6th St., Minneapolis, Minn. 55415.

Circle 368 on Inquiry Card

TTL Schmitt trigger

The advantages of using the monolithic IC Schmitt trigger over a discrete device wired circuit is the subject of this 7-page application report. Special features of this TTL IC include a built-in temperature to ensure high stability of the threshold levels and the hyster-

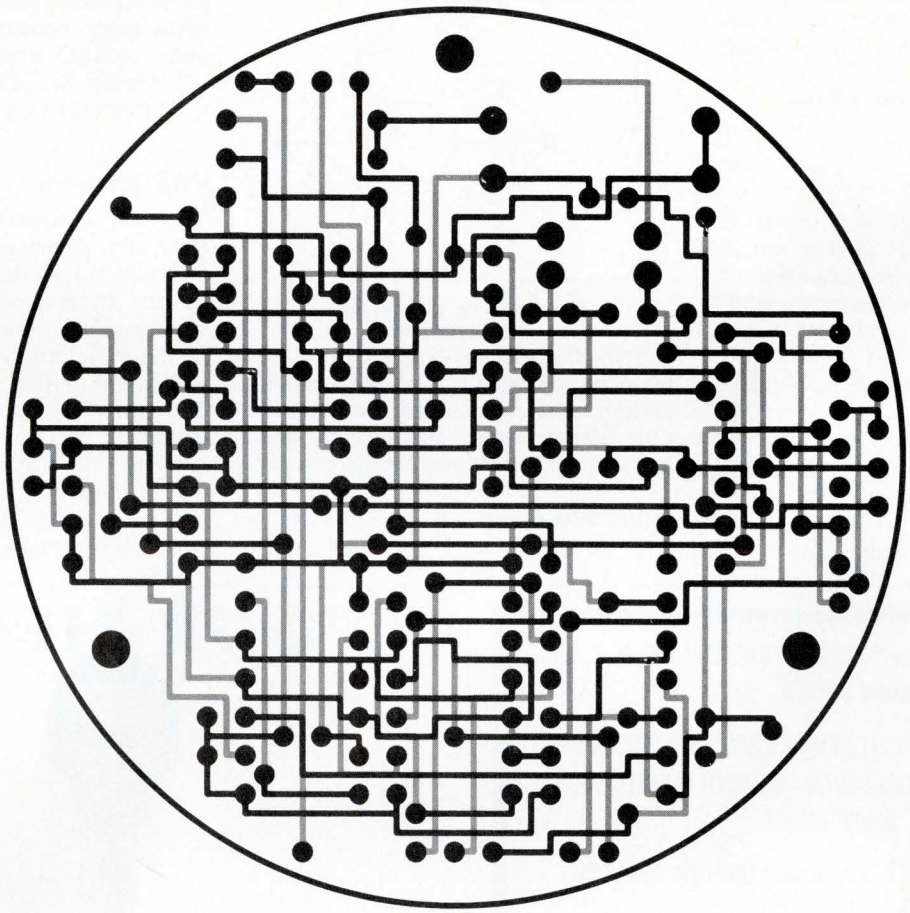


Schmitt trigger in pulse-stretcher circuit

esis over a wide temperature range. Altogether, six applications are given and are supplemented with circuit diagrams and operating waveforms. Texas Instruments Inc., Box 5012, M/S 308, Dallas, Tex. 75222.

Circle 369 on Inquiry Card

Computerized design reduces your printed circuit board cost.



Computerized two-layer printed circuit board interconnection artwork produced by Electronic Graphics, Inc. Shown twice actual size.

Yes, the new Electronic Graphics' computerized photomask system can reduce your circuit board cost in many ways.

REDUCED TURN-AROUND TIME
At Electronic Graphics computerized design of your printed circuit board layout provides in one to four weeks photomasters and documentation that require as much as six months to produce using conventional manual layout techniques. And we can prove it.

INCREASED YIELD
Computerized, precision placement of printed circuit board features in full compliance with your engineering specifications assures error-free artwork, and gives you higher yields on production circuit board runs.

COMPLETE ECONOMICAL TURNKEY SERVICE
Our complete turnkey service gives you precision, production-ready printed circuit board artwork plus associated engineering documentation at a reasonable cost. Numerical control tapes for drills, routers, or insertion machines are also available to reduce your circuit board costs.

Investigate the Electronic Graphics' photomask system today. A letter to the address below will bring you our new Customer Requirements Summary to assist you in analyzing your photomask needs.

electronic graphics, inc.

electronic graphics, inc.
2834 W. Kingsley Road
Garland, Texas 75040 (214) 271-2585

LITERATURE

Transistor cross reference

Here's another pocket-size guide from Fairchild — a cross-reference guide listing the company's complete stock of plastic transistors, the nearest equivalents to over 400 standard industry 2N types. In addition to the transistor listings, it provides the names and addresses of Fairchild stocking distributors and sales offices. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. 94040.

Circle 370 on Inquiry Card

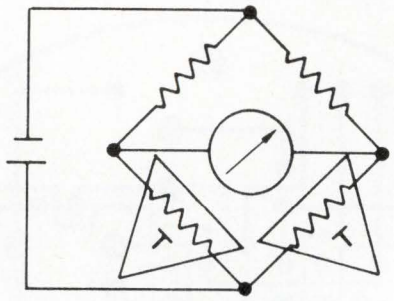
Optical scanning

More than 30 pages of information are included in this catalog which provides scanning terms, examples of bar coding, mark and character reading systems, plus readable OCR fonts. In addition, you'll find a brief explanation and diagrams of an optical scanning system, and examples of "scannable" forms designed for use with present optical scanning equipment. GAF Corp., 40 High School Ave., Shelby, Ohio 44875.

Circle 371 on Inquiry Card

NTC thermistor applications

Here's an 8-page properties and applications brochure on NTC (negative temperature coefficient) thermistors. With a thoughtful description and charts and schematics it discusses such features as resistance temperature characteristic, current time, maximum power rating, and time constant.



Temperature differential measurement

Among the applications it covers are temperature measurement, differential, control, and compensation, as well as time delay, surge suppression, and liquid level detection. Sensitron Inc., 225 Paularino Ave., Costa Mesa, Calif. 92626.

Circle 372 on Inquiry Card

Enclosure designs

Interface 33 is a creative enclosure styling system which gives you the advantages of rack modularization plus design customization. Interchangeable horizontal and vertical extrusions can be styled into 33 different ensembles. Colors allow an even greater variety of appearances. This 12-page booklet gives you the information you need about color, construction, and dimensions. AMCO Engineering Co., 7333 W. Ainslie St., Chicago, Ill. 60656.

Circle 373 on Inquiry Card

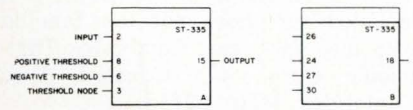
PWR program

Circuit designers can quickly and efficiently determine where to place and how to route conductors on IC boards. In a 7-page application abstract you'll be filled in on the details of the PWR program (placement and wire routing) that make this possible. The program's input and output are described, and a sample problem illustrates PWR's over-all capability. Remote Computing Corp., One Wilshire Bldg., Los Angeles, Calif. 90017.

Circle 374 on Inquiry Card

Modular digital products

A buyer's guide running the gamut from logic modules all the way up to digital controllers is available from Honeywell's Computer Control Division. Containing information on instruments ranging from analog comparators and counters to parity generators and Schmitt triggers, the refer-



ence provides prices, speed, power dissipation, and fan-in and fan-out specs. Individual technical bulletins on each module plus a designer's guide are also available. Robert Mobilia, Honeywell, Computer Control Div., Framingham, Mass. 01701.

Circle 375 on Inquiry Card

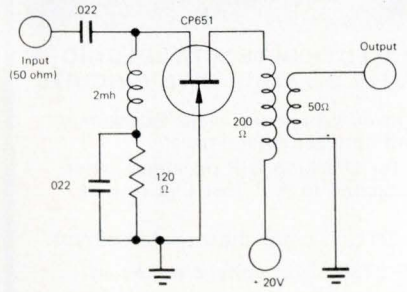
Integrated circuits

A 1970 catalog contains a listing of ICs intended for high-speed, general-purpose digital applications. The 5400 and 7400 series, available in hermetically sealed, dual in-line ceramic packages, offer such advantages as high noise margin, low power dissipation (10 mW/gate at 50% duty cycle) and low output impedance (less than 100 Ω at a logic one output state). Information is also provided on the company's diodes, silicon transistors, MOS arrays, and semiconductor chips and wafers. ITT Semiconductor, 3301 Electronics Way, West Palm Beach, Fla. 33407.

Circle 376 on Inquiry Card

RF and tuning devices

Noteworthy additions to a line of voltage variable capacitance diodes are the subject of a new product brochure. A varactor selection guide



listing operating characteristics of the entire series is included as are schematics and OEM prices. Crystalonics, 147 Sherman St., Cambridge, Mass. 02140.

Circle 377 on Inquiry Card

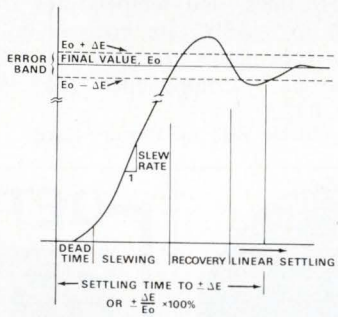
Design guide

This 14-pager offers a rather complete explanation of monolithic Multilox multilayer ceramic wiring structures for packaging electronic devices. A description of what Multilox is, including basic components and applications, is provided along with design principles. Robert E. Hutter, Room 2537, Nemours Bldg., DuPont Co., Wilmington, Del. 19898.

Circle 378 on Inquiry Card

Op-amp settling time

The lead article in Analog Device's Dialogue devotes 11 pages to op-amp settling time, reviewing the need for amp settling performance better than 0.01% in 1 μs. The article also explores linear and non-linear factors that affect settling time and suggests ways to maximize such performance in circuits based on op-amps. Measured curves for some available ampli-



fier types are provided as are measuring techniques. The booklet also includes an article on the treatment of factors affecting differentiator response and stability. The dialogue concludes with a rundown of application notes, data sheets, and short form catalogs available from Analog Devices, 221 Fifth St., Cambridge, Mass. 02142.

Circle 379 on Inquiry Card

Resistor design guide

Corning's complete line of glass, tin-oxide resistors is outlined in a 16-pager, designated RBR 2.00. Qualified to meet the new specs of Mil-R39017 and Mil-R-55182, the resistors' reliability is the result of a continuous manufacturing process. This is emphasized in tables and charts included in the reference which give results of a continuing life test of 600 resistors. Going into its twelfth year, the process indicates less than a 2% change in resistance among all resistors tested. Corning Glass Works, Electronics Div., Corning, N.Y. 14830.

Circle 380 on Inquiry Card

LITERATURE

LSI memory test

A computer-controlled system, which performs functional tests on random access memories, ROMs, shift registers, and random logic, has been designated Doctor 32. A brochure describing the system discusses its unique capabilities, including being able to perform functional tests at actual device speed. Equipped with state-of-the-art equipment, Doctor 32 provides unmatched testing versatility and performance specs. Adar Associates Inc., 85 Bolton St., Cambridge, Mass. 02140.

Circle 381 on Inquiry Card

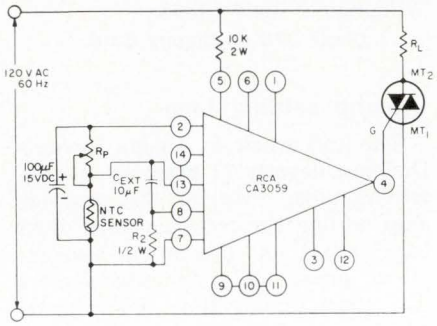
Noise reduction

"Noise Reduction in Core Memories with Pulse Transformers" is the subject of an application note which explains the primary source of noise in core memory systems and how it can be minimized. Pulse transformers for drive and sense line coupling are the key. Schematics help to illustrate the explanation offered in this note. Aries Technology, 3475 Victor St., Santa Clara, Calif. 95050.

Circle 382 on Inquiry Card

Zero voltage switch

Applications and operating characteristics for RCA's IC zero voltage switch (CA3059) are included in application note ICAN6268. The switch has been designed to control a thyristor in a variety of power switching applications. A brief description of the circuit, its functions and configura-



tions, in addition to supplemental data for extending operation to 220 V, 50-60 Hz lines, and temperatures from —40 to +85°C are covered in the note. Schematics are provided. RCA, Electronic Components, Harrison, N.J. 07029.

Circle 383 on Inquiry Card

Specifying filters

Problems encountered in filter specifications and explanations of necessary terms and parameters are covered in a monograph. The 10-pager discusses frequency response, impedance, passband ripple, shape factor, operating temperature range, packaging and environment. A glossary is included for those not too familiar with filter language. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. 02138.

Circle 384 on Inquiry Card

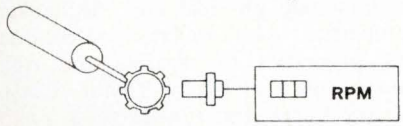
Switch keyboards

Standard, low-profile elastic diaphragm switch keyboards for communications and data entry terminals are the topic of this 16-page catalog. Keyboard layouts, specs, and dimensional diagrams are provided for standard models. An illustrated explanation of the elastic diaphragm switch concept supplements the product information. Datanetics Corp., 2828 Spreckels La., Redondo Beach, Calif. 90278

Circle 385 on Inquiry Card

Digital process monitor

Here's a compact 8-page bulletin giving you all the facts on this Series 76 digital process monitor. There are discussions on applications, lists of specs, a description of the system functions, a selection of options, and



Digital E.P.U.T. monitor

information on instrument types. Schematics, block diagrams, and dimensional drawings supplement each presentation. Airpax, Electronics Controls Div., Box 8488, Fort Lauderdale, Fla. 33310.

Circle 386 on Inquiry Card

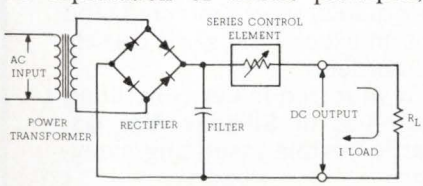
Non-existent product

Because you are as concerned about your special products as you are about off-the-shelf items, this brochure gives you the information you want for your "non-existent product." In other words, you'll read of the company's design and manufacturing facilities and capabilities to find out how they can solve your special circuit or system design requirements. Special products they've already designed include a difference computing counter, a period-average counter, a filter and attenuation system, and a dual channel reversing counter. Itron Corp., 11675 Sorrento Valley Rd., San Diego, Calif. 92121.

Circle 387 on Inquiry Card

Power supply handbook

Detailed specs, descriptions, and illustrations of more than 100 models of dc power supplies are included in this 80-page handbook. You'll find definitions of specs, and a comprehensive application note which gives an explanation of circuit principles,



methods for checking power supply performance, and a special selection guide that helps you choose the right power supply for your particular application. Hewlett-Packard, New Jersey Div., 100 Locust Ave., Berkeley, Heights, N.J. 07922.

Circle 388 on Inquiry Card

Display terminal

Designated the Corning 904, a new display terminal combines interactive graphics with hard copy, large screen capacity, and slide overlay. A complete discussion of the terminal is contained in a 13-page catalog which includes suggested applications. Software support for the 904 is also covered. Corning Data Systems, 3900 Electronics Dr., Raleigh, N.C. 27602.

Circle 389 on Inquiry Card

Spectrum analysis

A series on the practical aspects of audio frequency spectrum analyzers and their application begins with this 8-page application note. After a discussion of the similarities and differences between continuous (noise-like) and line spectra, and the concept of degrees-of-freedom, the first note concludes with a glossary of terms and annotated references. Parallel-filter, swept-filter, time-compression, and digital or numerical methods will be the subjects of future notes in the series. Testronic Development Lab., Drawer H, Las Cruces, N.M. 88001.

Circle 390 on Inquiry Card

Capacitors

Here are two articles which will help you to understand certain characteristics of capacitors. The first, "Capacitance Changes—Why?" explains variation caused by electrical, mechanical, and environmental stress, tells why the capacitance changes, and compares the extent of the variation for the common capacitor dielectrics. The second, "Insulation Resistance Can Be Confusing!" explains the basic principles of insulation resistance, and how it varies with time and temperature, so as to dispel this confusion. Electro Cube Inc., 1710 S. Del Mar Ave., San Gabriel, Calif. 91776.

Circle 391 on Inquiry Card

Monopulse radar system

A general review of a monopulse radar system is contained in bulletin AEB-101. The system's function, along with a detailed description of a monopulse system using a component designated the MIF8394, is included as are block diagrams. Varian, Solid State Div., 1365 Akron St., Copiague, Long Island, N.Y. 11726.

Circle 392 on Inquiry Card

LITERATURE

Communication components

Over 400 stocked parts are illustrated and described in this 16-page catalog. And many of the 3,000 components available are also detailed. Included are such items as miniature plugs, jacks and panels, terminal blocks, and lamp strips and sockets. ADC Products, Communication Components Div., 4900 W. 78th St., Minneapolis, Minn. 55435.

Circle 393 on Inquiry Card

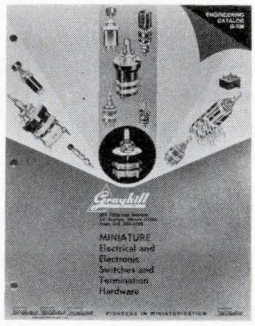
Drafting aids

Pressure sensitive PC artwork drafting aids are the subject of this 20-page catalog. Shapes, patterns, and conductor line tapes for precision layouts are listed. New products include precision patterns of multi-pad configurations for TO cans, 14- and 16-lead dual in-line patterns, and flat-pack patterns. And you'll find such standard features as connector contacts, spaced IC pad sets, and registration marks. By-Buk Co., 4326 W. Pico Blvd., Los Angeles, Calif. 90019.

Circle 394 on Inquiry Card

Switches

Information on push-button and rotary switches fills 88 pages in an expanded product catalog. All the information you need for determining your switch needs is included—an engineering data section explains switch parameters, and selector charts or-



ganize the parameters and data to help you select the proper switch for your needs. Photos, diagrams, and detailed characteristics and ratings are given for each switch described. Grayhill Inc., 543 Hillgrove Ave., La Grange, Ill. 60525.

Circle 395 on Inquiry Card

Circuitry materials

A source guide for metal-clad circuitry materials is in the form of a reference folder. Property values for available materials for flexible circuits, rigid boards, multilayer circuits, and cabling are featured in tabular form and include physical and mechanical properties. Also tabulated are conductor properties for flexible and rigid materials. Synthane-Taylor Corp., Valley Forge, Pa. 19481.

Circle 396 on Inquiry Card

Display driver

A compact presentation of applications is offered to you in this 8-page booklet on the AAT-101 TV display driver featuring a 256 6-bit character refresh memory. System configurations are given for four different applications, and the primary features and suggested uses for each system are listed. Operating information and a price list are included. Ann Arbor Terminals Inc., 918 Greene St., Ann Arbor, Mich. 48104.

Circle 397 on Inquiry Card

EMI filters

Standard ratings, performance curves, and dimensional diagrams accompany each of the bolt-type, high-frequency, industry standard interchangeable, and button-style filters listed in this catalog. The 16-pager also introduces the micro-brute advanced version group in 50, 100, and 115 V. Application information, terminal configurations, and a part numbering system are also included. The Potter Co., 500 W. Florence Ave., Inglewood, Calif. 90301.

Circle 398 on Inquiry Card

Power supplies

A 1970 power supply catalog, organized into product groups for easy access, classifies the groups by major characteristics. A cross reference directs you to other models that share similar characteristics, but are described in other categories. The groups discussed are available with such optional features as calibration controls, over-voltage protectors, and high-speed modifications. A glossary of power supply terms is provided, as are Kepco's application notes, and a nomograph of voltage drop across load supply leads. Kepco Inc., 131-38 Sanford Ave., Flushing, N.Y. 11352.

Circle 399 on Inquiry Card

Transformer catalog

Technical information on transformers, magnetic devices, and power sources is the main feature of this 24-page catalog. The company's technical capabilities are described and include such product areas as rectifier plate supply transformers, inductive elements, high power amps, and power sources. Schematics and graphs supplement the technical information included in each product description. Light Electric Corp., 214 Lackawanna Ave., Newark, N.J. 07103.

Circle 400 on Inquiry Card

Instruments

Complete specs are given in this 72-page catalog for all of the company's sweep generators, rf attenuators, and related rf components. The catalog introduces a new series of solid-state, high-power sweep generators covering the frequency range of 1 to 1000 MHz. Also, an 8-page technical section explains flatness, linearity, and isolation, and how they can affect measurement. Texscan Corp., 2446 N. Shadeland Ave., Indianapolis, Ind. 46219.

Circle 401 on Inquiry Card

LITERATURE

Transmission lines

A comprehensive selection guide offers flexible and semi-flexible rf coaxial cable. Divided into 3 sections, the 44-pager covers parameters for cables, including characteristic impedance, impedance uniformity (VSWR), capacitance, capacitance and impedance stability, cw power ratings, operating voltages, etc. A full listing of the company's products is also provided. Times Wire & Cable Co., Div. of Insilco Corp., 358 Hall Ave., Wallingford, Conn. 06492.

Circle 402 on Inquiry Card

Communications computer

CorCom's encoding and decoding system concept automatically detects and corrects errors occurring in the electronic transmission of data. A 4-page data sheet explains this system and its features. Technical memorandums, supplemented with a table and charts, offer summaries of CorCom's performance calculations. Micro-Design Inc., 1055 First St., Rockville, Md. 20850.

Circle 403 on Inquiry Card

Industrial Controls

More than just a company catalog, this 60-pager provides complete details on a line of solid-state, photoelectric, proximity and timing devices. Included too are schematics, wiring diagrams and dimensioned drawings to aid the designer using industrial controls. Available on company letterhead from: Farmer Electric Products Co., Inc., Tech Circle, Natick, Mass. 01760.

Computer rentals

Are you in the market to rent a computer? Though the agent, Rentronix, doesn't think that short-term rental is a cure-all or a substitute for purchasing or leasing, there are times when renting is the best solution for your needs. Such instances, as emergencies, or when your own instruments fail, are discussed and a full line of instruments that you can rent are outlined. Monthly rental fees, terms, and conditions are also provided. Rentronix, Div. of Inmark Inc., 1150 Huff Court, Kensington, Md. 20795.

Circle 404 on Inquiry Card

Swept impedance measurement

A technique that provides wide dynamic range around any impedance level between 10 and 1000Ω is introduced in this 6-page application note. Display may be either Z-plane or as two traces (magnitude and phase vs frequency) on a single readout. The note details methods, gives set-ups for measurements, and discusses the applicable accuracy considerations. Hewlett-Packard Co., 1601 California Ave., Palo Alto, Calif. 94304.

Circle 405 on Inquiry Card

Products and services

Each major system in this company's product line is discussed in a 36-page short-form catalog. These systems include microwave radio, radio multiplex, trunk carrier, subscriber carrier, data and telegraph, supervisory and control, and auxiliary and test equipment. Operating and applications summaries are provided for each product. Lenkurt Electric Co., Dept. C134, 1105 County Rd., San Carlos, Calif. 94070.

Circle 406 on Inquiry Card

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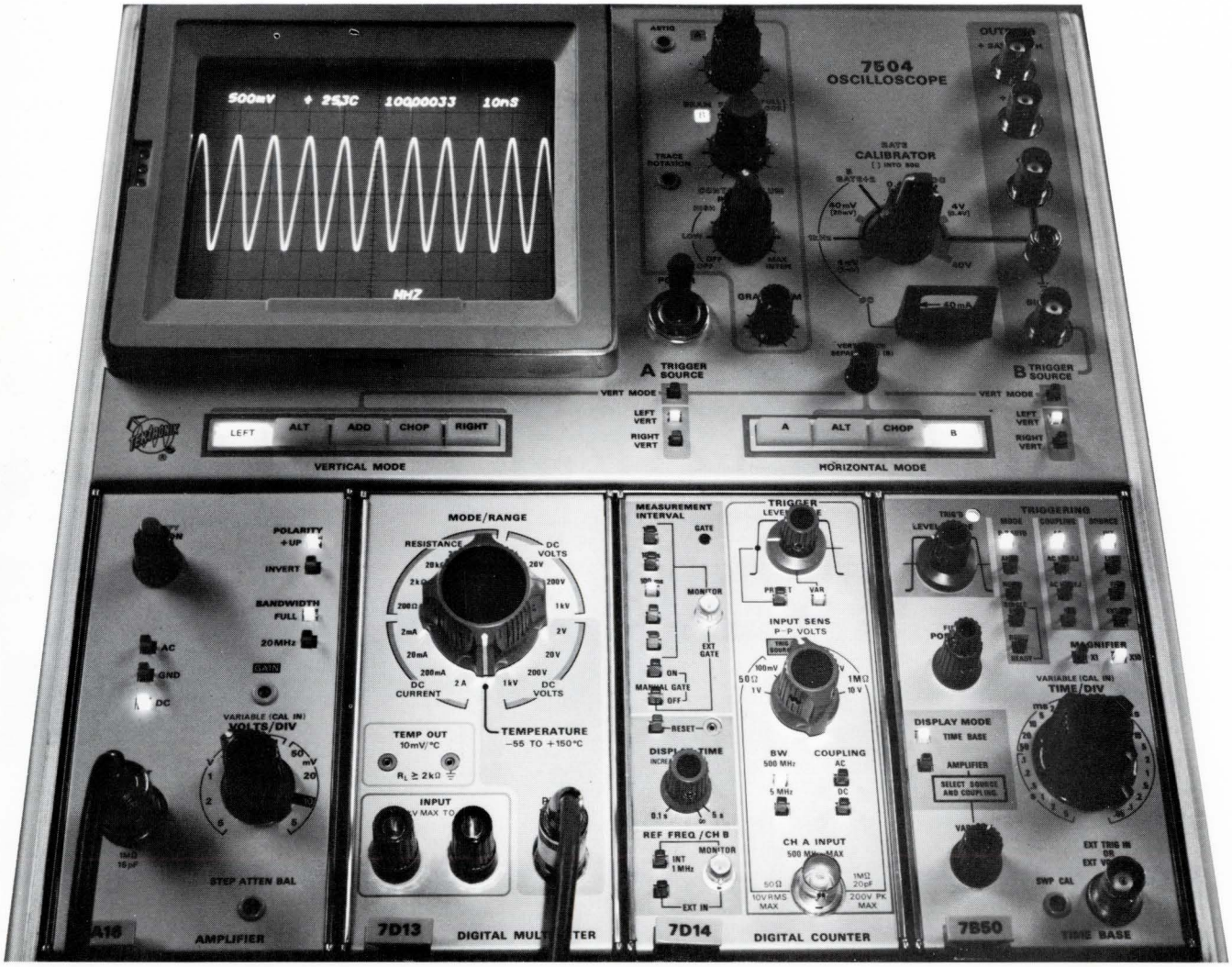
Index to Product Information

Listed below are all products and new literature that appear in this issue, along with the page number they appear on and their Reader Service Numbers (RSN). For more information, see the appropriate page and circle the corresponding number on the reader service card.



introducing the **Integrated Test System**

Measures: • ***Frequency*** • ***Time*** • ***Resistance*** • ***Temperature*** • ***Voltage*** • ***Current***

With the introduction of two new digital plug-ins, a 500-MHz Direct Counter (no prescaling) and a versatile Digital Multimeter, it is even more apparent that the Tektronix 7000 Series was intended to be more than just another oscilloscope . . . ITS much more!

There are already 5 mainframes and 17 plug-ins in the 7000 Series . . . with more to come.

Consult your August Catalog Supplement for complete information. If you do not have a Supplement, check the inquiry card, we will send you one promptly.

TEKTRONIX®
committed to progress
in waveform measurement

Circle 2 on Inquiry Card

RSVP game (U.S. Patent #3427028) used by permission of Selchow and Righter Co., makers of SCRABBLE.

You Win With RCA P-N-P Power... New 2N5954 Family (2N3054 Complement)

This new RCA p-n-p transistor has the qualifications that can make winners of you and your designs. The 2N5954 is a silicon power unit in a hermetically-sealed TO-66 package. Complementing the 2N3054 (already widely known in sockets in military, industrial, and commercial equipment), the 2N5954 features controlled second-breakdown ratings. To be sure, each transistor is individually tested to meet specified parameters before it is shipped.

The new 2N5954 family with its multiple epitaxial structure and emitter ballasting techniques add up to a traditionally rugged RCA power device...giving you the design capability to achieve high performance levels in your equipment. One of three new RCA p-n-p types now offered for switching and amplifier applications, 2N5954 (or its family types, 2N5955 or 2N5956), together with its n-p-n complement, provide bi-directional control and phase inversion advantages.

P-n-p/n-p-n complements are particularly advantageous if you're trying to cascade four or five stages. In a power supply design, for example, the use of complementary types can eliminate voltage build-up that would be encountered if cascaded n-p-n, or cascaded p-n-p types were employed.

Check the chart on these new types. For more information, consult your local RCA Representative or your RCA Distributor. For technical data, write: RCA Electronic Components, Commercial Engineering, Section 59J/UT8, Harrison, N. J. 07029. In Europe: RCA International Marketing S.A., 2-4 rue du Lièvre, 1227 Geneva, Switzerland.

Type No.	V_{CBO} (V)	$V_{CEX(sus)}$ (V)	$V_{CER(sus)}$ (V)	$V_{CEO(sus)}$ (V)	I_C (A)	P_T (W) @ $T_C = 25°C$
2N5954	85	85	80	75	−6	40
2N5955	70	70	65	60	−6	40
2N5956	50	50	45	40	−6	40

RCA

Circle 3 on Inquiry Card