EDN

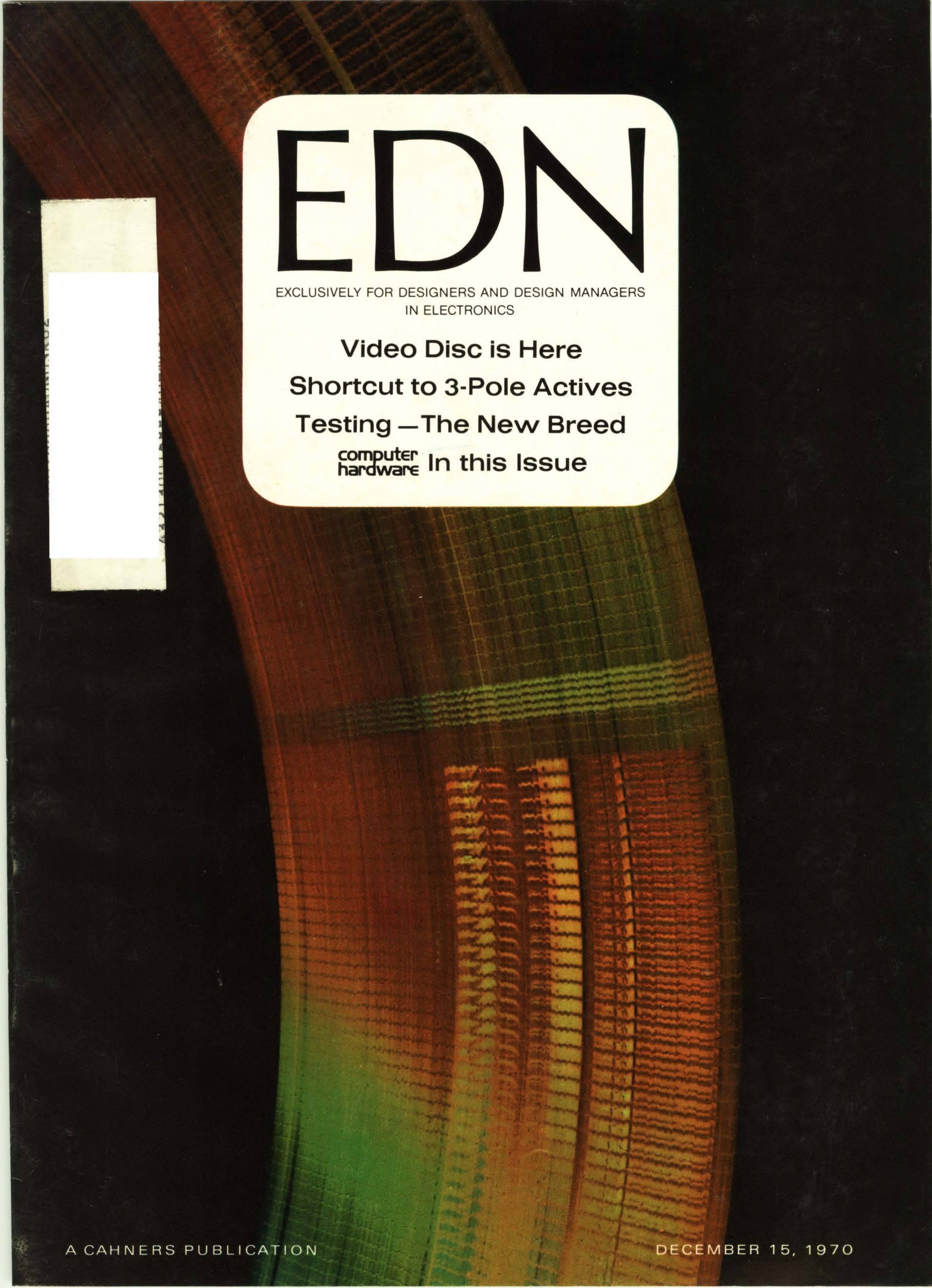
EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

Video Disc is Here

Shortcut to 3-Pole Actives

Testing —The New Breed

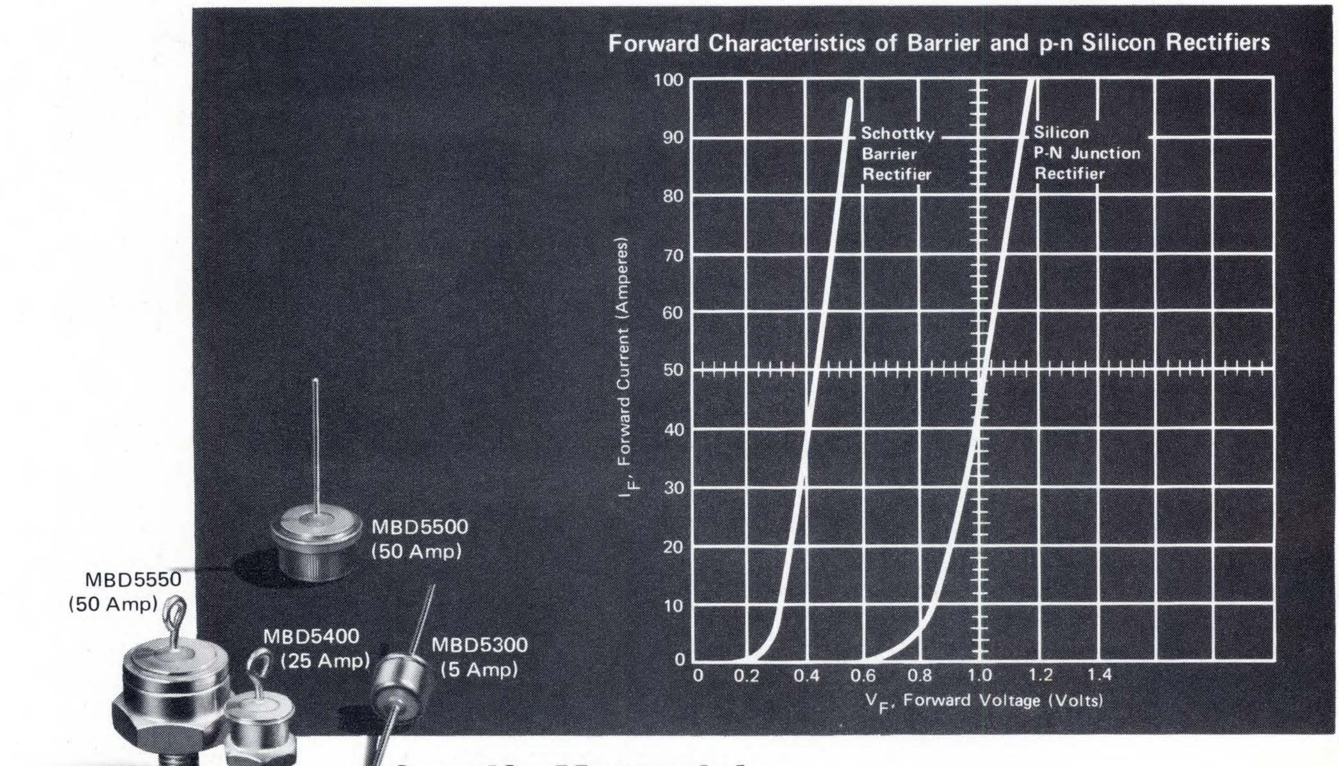
computer hardware In this Issue



A CAHNERS PUBLICATION

DECEMBER 15, 1970

Reduce power loss, improve the efficiency of low-voltage, high-current rectification.



Specify Motorola's 5, 25 or 50A hot-carrier power rectifiers.

All four 20-volt devices employ the Schottky barrier low resistivity, metal-over-oxide junction techniques to offer a forward voltage drop *less than half* that of conventional silicon rectifiers. They also provide extremely low stored charge and high surge current capacity.

These features translate into major benefits in your circuitry:

- The low V_F extends over the entire forward current range, affording 50% less power loss than alloy or diffused devices — a real breakthrough for low-voltage power supplies or anywhere power loss hurts.
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- High surge current capacity (up to 800 amps) allows you extra design latitude in capacitive-loaded circuits as well as providing extra protection.

Combine these advantages with top efficiency, low thermal resistance and passivated junctions and you have an ideal rectifier for low-voltage, high-current applications.

Production quantities are in the warehouse now — awaiting your evaluation and your order. 100-up prices are: MBD5550 (Case 222) — \$9.10; MBD5500 (DO-21) — \$8.50; MBD5400 (DO-4) — \$6.00 and MBD5300 (axial-lead case 60) — \$3.60. For complete details call your nearest Motorola representative or write Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, Arizona 85036.

MOTOROLA POWER
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CIRCLE NO. 1

7 problem-solving accessories you get free with every HP scope

When you own an HP 180 System scope, you're not stuck with an "orphan." That's because, at HP, we care about you and your problems—not just when you're looking for a new scope, but afterwards, as well.

Hardware is only half the story in scope selection; after all, what you're really looking for is a solution to your measurement problems. So, when we give you state-of-the-art performance, plug-in versatility, and an unequalled value for your money—that's just the beginning. In addition, you get the back-up necessary to let you get the most out of your scope—to get what you paid for.

Specifically, with every HP 180 System scope, you get seven problem-solving accessories money can't buy.

- A field engineer—"your man at HP," always available to give you personal counseling on measurement problems, drawing both on his own knowledge and that of other HP experts.
- A field-office staff engineer—the first of these experts, whose broad knowledge of measurement instruments is available to help you choose those best for your needs.
- An order co-ordinator, who makes sure that your order is taken care of smoothly and efficiently.
- A training consultant, who works with your field engineer to provide your people with the know-how to operate, calibrate, and repair your scope—via live demonstrations, seminars, video tapes, and literature.
- Repair/calibration technicians, who will perform any service you need, at local, regional, or factory calibration-and-repair centers.
- A factory applications engineer, to provide economical solutions to "impossible" measurement problems.
- And a field-office secretary, to co-ordinate communications between you, your field engineer, and the other "problem-solvers."

Things are changing in the world of oscilloscopes... and if your ability to do your job depends on your scope, you have to change, too. Call your local HP field engineer, and ask him about HP's seven problem-solving accessories. Have him show you HP's new video training tapes on the 180 System. Or write to Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

Scopes are changing. Are you?

081/1

HEWLETT hp PACKARD

CIRCLE NO. 2

DECEMBER 15, 1970
VOLUME 15, NUMBER 24

EDN

EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

Cover

No rainbow, cover close-up examines tracks from plastic video recording, playable on new Telefunken TV playback system. For full story, see p. 10.

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Performance evaluation test equipment hasn't kept pace with digital equipment sophistication. Technique is the problem, entangled with cost-effectiveness, versatility and over-capability.

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EDN's DESIGN ACTIVITY FILING SYSTEM is used to classify all Design Feature and Design Idea articles. The first word indicates the *activity* discussed in the article. The second word denotes the principal product being used in the activity. The third word modifies the second word. Finally, a number is used to specify frequency, where applicable. This number is the $\log_{10}$ of the frequency in hertz.

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ibpa International Business Press Associates
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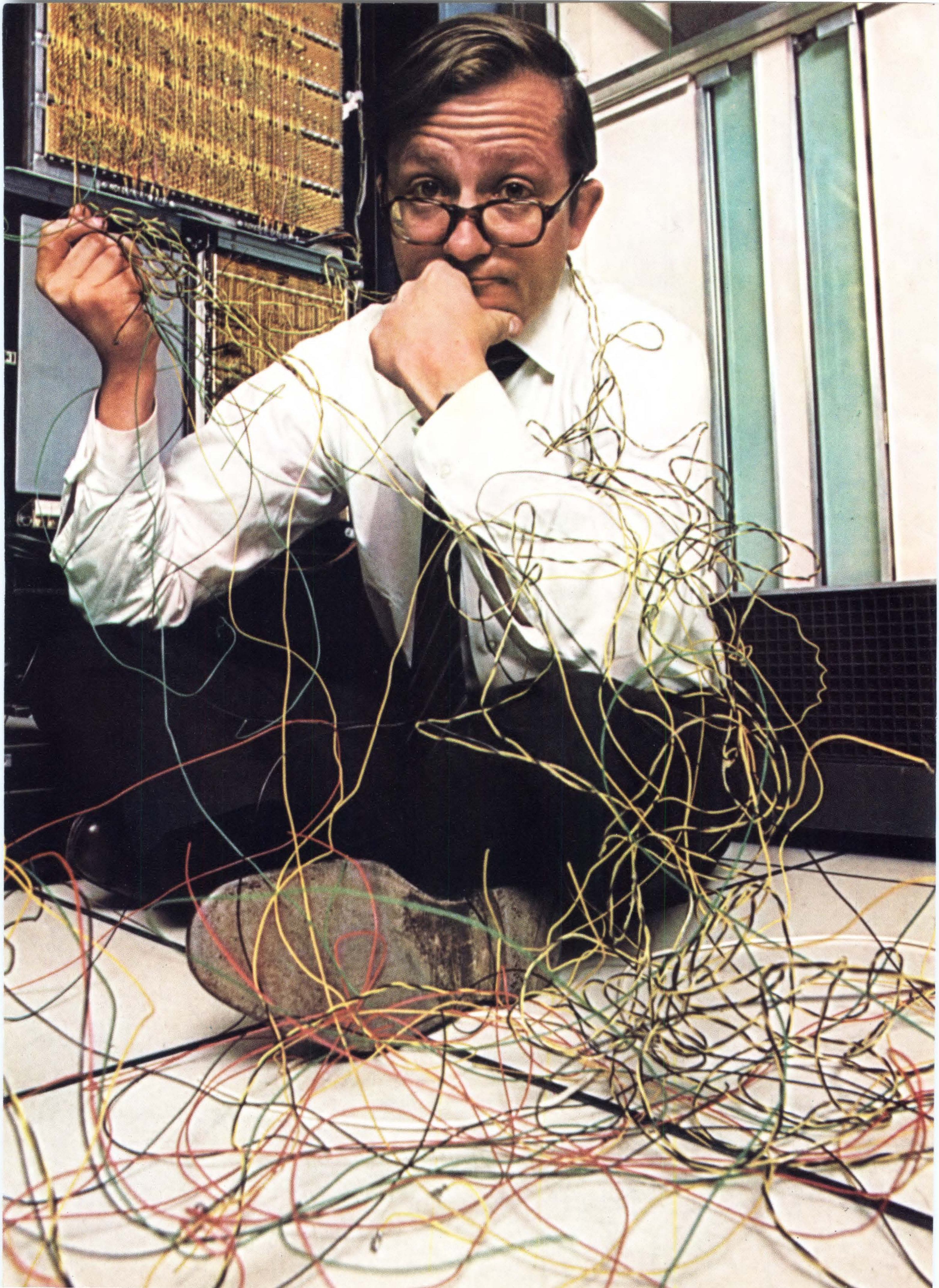

We make components for guys who can't stand failures.

Even the coolest and calmest of us somehow comes unglued when there's a "little" electronics systems failure. Because before it's done, that little systems failure often becomes a big, big systems failure. One that takes a long, long time to forget.

But that's where we come in. We make resistors and capacitors for guys who can't stand failures. Guys like your most important customers, guys like you.

We build an extra measure of reliability into all our components to help you build extra reliability into all your systems.

To be specific, we make tin oxide resistors—now including both miniature RLR05's and flame proofs—and glass and Glass-K™ capacitors. They're the best you can get, though they'll cost you no more.

Resistors for guys who can't stand failures—

Take our tin oxide resistors—no other resistors can deliver the same stability and reliability over life. They offer guaranteed moisture resistance across all ohmic values, for reliability that can't be matched by metal film, wirewounds, carbon comps or metal glaze resistors.

This kind of extra performance comes in miniature size, too. Our new RLR05 (commercial style C3), developed for dense packaging applications, competes costwise with carbon comps.

Including Flame Proof Resistors—

And we lead the field with flame proof resistors. Ours will withstand overloads in excess of 100 times rated power without any trace of flame. And because they open rather than short under severe overload, they provide protection for the rest of the system—a vital consideration in critical and expensive EDP, telecommunications, and instrumentation gear.

Capacitors for guys who can't stand failures—

Or take our glass capacitors. The Air Force has confirmed they have much better stability and much higher insulation resistance than the ceramic, mica, and other capacitor types tested. That's why our glass capacitors have been designed into so many major aerospace, EDP and instrument applications.

Or our Glass-K™ capacitors—we developed them to give you the volumetric efficiency and economy of monolithic ceramic capacitors, but with the much improved stability and reliability that only a glass dielectric can add. Our Glass-K™ capacitors are now being used in pacemaker heart units and in several major EDP systems. And these Glass-K™ capacitors can now be used in BX characteristic applications.

As you might expect, both our resistors and capacitors meet Established and High Reliability standards, such as MIL-R-39017, MIL-R-55182, and Minuteman.

And they'll cost you no more—

And even though you might expect to pay a lot more for these features, you don't. Because as the largest manufacturer of these type components, our production volume affords us economies that enable us to be competitive in price.

So the next time you're designing a system, design-in an extra measure of performance. Reach for your CORNING® resistor and capacitor catalogs or look us up in EEM. Or write us at: Corning Glass Works, Electronic Products Division, Corning, New York 14830.

Then call your local CORNING authorized distributor for fast off-the-shelf delivery. He not only stocks components for guys who are demanding, but he offers service to match, too.

CORNING ELECTRONICS

CIRCLE NO. 4

Editorial

Have You Finished Your Christmas Shopping?

If you're like most of us, you haven't. About now, you're getting that panicky feeling, riding with the shopping-day countdown to Christmas.

We have a gift suggestion. How about April in Paris for both you and your wife? Last issue we announced an EDN group journey to the Paris Components Show (tour dates, March 30 through April 8). In addition to the show, we'll be taking a first-hand look at the European electronics industry via plant tours and seminars. As we pointed out, there are many good reasons why you should be there.

In addition to a solid technical program, we are planning a dazzling ladies' schedule. And, aside from becoming the household hero, there are many good reasons for you to bring your wife. For a two-page rundown on those reasons, dig out your Sept. 15 issue and read the article, "Wives Are A Convention 'Plus'". It's in our "Executive Life" section, page 64E.

We have an information kit, yours for the asking, that explains the details of both the ladies' and men's programs. Simply clip, complete and mail the coupon below. Do it today and forget about that last-minute shopping hassle. Think April in Paris.

Editor

PS

$$\left\{EY\left[M(X-A)(X+A)+A^2M\right]\right\}\left\{\frac{\frac{R+X}{X}+\frac{X}{R-X}}{\frac{X}{R-X}}-\left[\frac{4AS}{3Y\{(X+E)^2-(X-E)^2\}}+\frac{4AS}{3E\{(X+Y)^2-(X-Y)^2\}}+\frac{4AS}{3X\{(E+Y)^2-(E-Y)^2\}}\right]\right\}$$

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Bench or System – the HP 3450A gives you maximum performance in a minimum space.

A quick look at the unfolding dodecahedron shows each of the 12 functions the Incredible Dodecameter performs. What it doesn't show is just how well this 5-digit multifunction meter performs each function.

For instance, you not only get true rms capability—you also get value-plus features like true 4-terminal ac ratio testing and 4-terminal ohms measurements.

And, accurate, fast measurements in each of these twelve categories is only the start. You can add digital output and directly control external equipment like a printer. Or, add remote control and get full programmability for system use.

No matter what the application, you get more for your money with the HP 3450A.

This Incredible Dodecameter lets you start with the basic dc meter and add the capability that best fits your requirements. If your needs change, any of the options (except the rear input terminals) can be easily installed in the field.

For more information on this outstanding 12 in 1 bargain, just call your local HP field engineer. Or, write Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

Price Basic HP 3450A, $3300; AC Option 001, $1250; Ohms Option 002, $425; Limit Test Option 003 $375; Digital Output Option 004, $225; Remote Control Option 005, $260; Rear Input Terminal Option 006, $70.

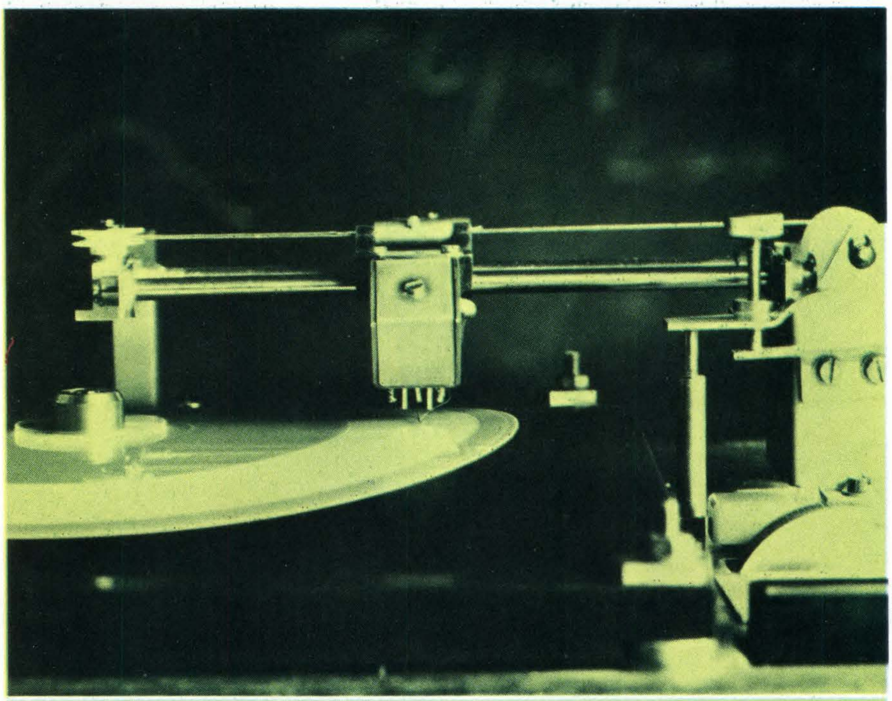
090/8B

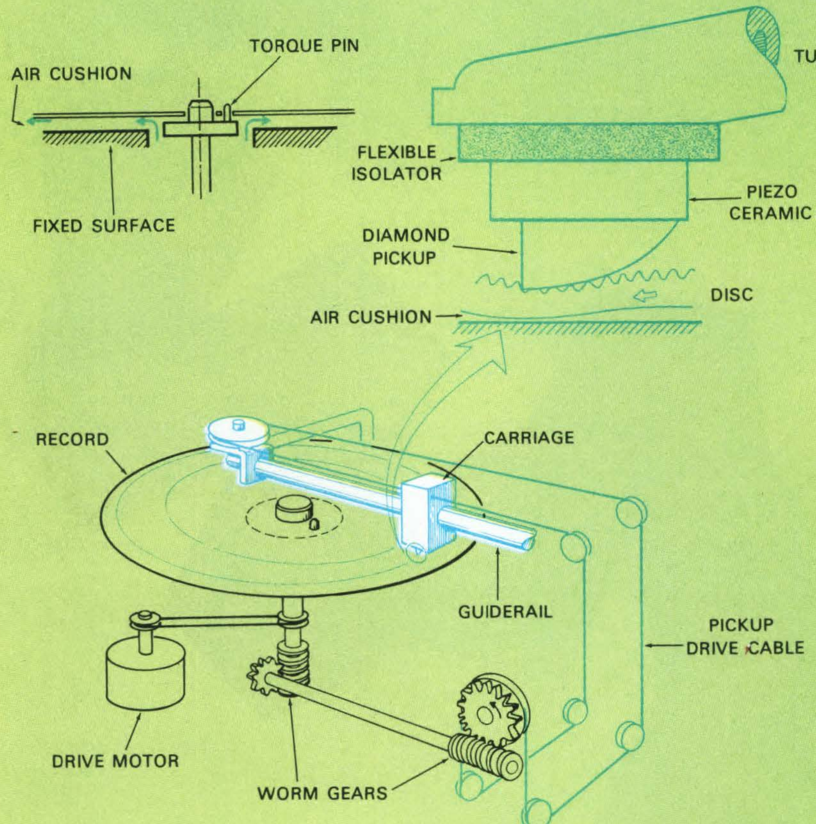
The Incredible Dodecameter– A 12-in-1 way to better measurements!

HEWLETT hp PACKARD

DIGITAL VOLTMETERS

CIRCLE NO. 7





Player mechanism for Teldec system looks more complicated than it really is. The thin flexible plastic records revolve around central spindle. They ride "fluidically" on air cushion formed between the whirling disc and slightly curved top of the player. Tiny sled-shaped pickup "needle" is driven across record by a rail-and-pulley arrangement.

Record-Player

1970's most technically surprising development may well be Teldec's technique of video recording on phonograph discs. Picking off signals above 18 to 30 kHz mechanically seemed an improbable achievement for any kind of record system, let alone mass-produced, inexpensive plastic platters.

But AEG-Telefunken engineers did it, and Teldec demonstrated it at the Audio Engineering Show in New York. This first U.S. demonstration indicates that the new system has adequate quality for black-and-white programming. In addition, Teldec should have no difficulty extending their system to color video.

The inventors put down extremely fine patterns on the disc, then use a "pressure-principle" stylus to play them back. With grooves spaced only 0.3 mil apart (an order of magnitude tighter than most LPs), the vertical (rather than lateral) modulations are spaced just 0.08 mil apart for the maximum 3 MHz bandwidth. These dimensions, combined with 1500 rpm record speed, yield the video bandwidth capability.

Given the capability to press a disc with these accuracies, two problems remained – how to make any cutting head move fast enough to cut such a record, and how to pick up the 3 MHz "hills and dales" for playback.

The Germans at the show were very tight-mouthed about how they apparently had achieved a cutting-head speed in the video bandwidth, but an informed source said that masters are cut at 1/50th speed from original magnetic-taped material run at 1/50th speed. This enables the cutting head to move vertically at a more reasonable 60-kHz rate.

Once the master is cut, Teldec officials say, records can be stamped rapidly from 8-mil PVC with essentially the same high-volume, high-production techniques used for ordinary audio records. With projected cost as

TV Promises Low-Cost Sight/Sound

low as $0.20 apiece, hardly more than the $0.06 to 0.07 cost of audio discs sometimes inserted in magazines, it would be possible to send a video record of news and sports events along with a newspaper or other publication.

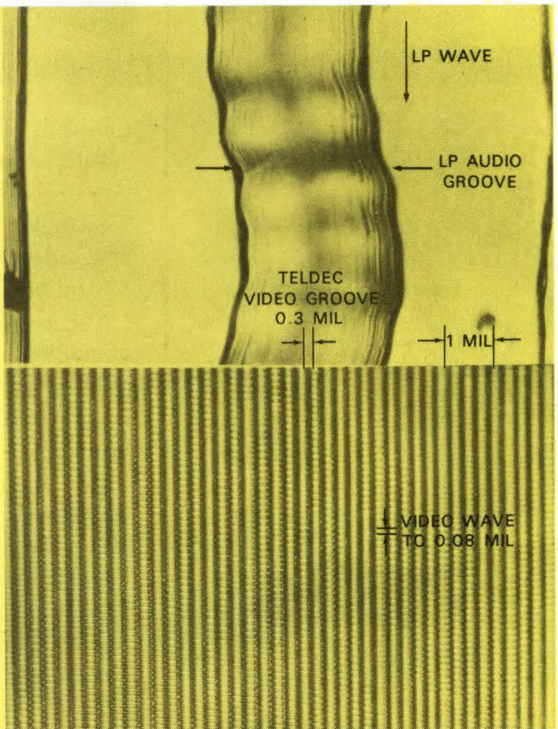
The pickup itself is the basis of the invention, and furnishes the solution to the second problem. The Germans found they could "pressure sense" the groove modulations. Since no conventional stylus could follow "hills and dales" at 3 MHz, Teldec uses a sled-shaped pickup that flattens the tops of the "hills" as it passes. The signal is generated as a shock wave when the tiny "hill" in the resilient plastic pops back up at the vertical trailing edge of the sled. A tiny ceramic element cemented on top of the diamond pickup sled transduces these pressure shocks into millivolt electrical signals.

The resulting video signal is conventional and can be played directly into the antenna terminals of a TV set. The audio signal is inserted in sampled-data form in the gaps that the horizontal retrace leaves in the video signal.

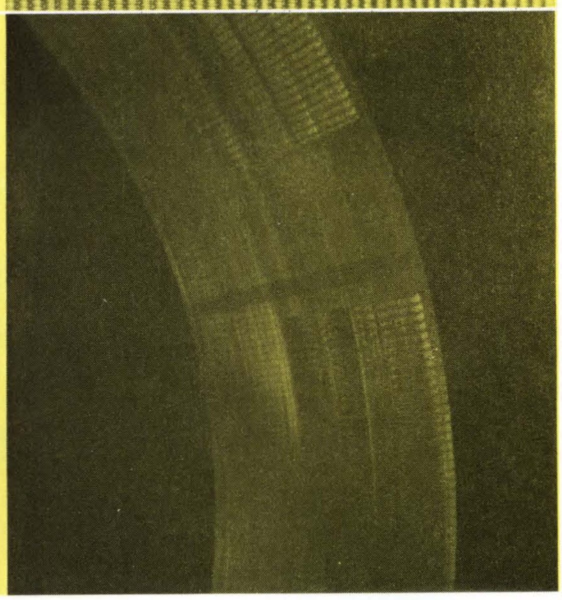
The playback system spins the flexible polyvinyl chloride (PVC) discs at 1500 rpm (for European 50 Hz systems), with an air cushion keeping the discs flat much as in some digital computer disc drives. An overhead "monorail" guides the pickup carriage radially across the record, the rate of advance being programmed by a cable-and-pulley arrangement. This is apparently enough to keep the "needle" securely in the minute grooves, for during the demonstration, one of the engineers turned the unit upside down in the air while it played, and there was no discernable disturbance to the video picture.

Teldec expects to have inexpensive playback units for consumers by 1972. Price for the black-and-white playback unit is anticipated to be $150, and 5- to 12-min playing time records will cost about the same as present stereo LPs. Color units will also be introduced in 1972 at about $300, and both black-and-white and color units with changer will cost $75 extra.

Teldec is a joint AEG-Telefunken (Berlin) and Decca (London) company, formed to exploit the invention by manufacturing and licensing.



Groove pattern for video record provides 100 times the signal density of an LP audio record. The grooves are spaced approximately 10 times closer and carry approximately ten times as many modulations per unit length.



Video signal pattern can be seen easily on the records. Each revolution contains the two complete scans of an interlaced frame. Synch signals in the vertical retrace are visible between the frames, as are the individual horizontal line scans for the picture. Audio is pulse-position coded in the horizontal retrace gaps. These occur at roughly 15 KHz, so an audio bandwidth of about 5 KHz is possible.

Design Briefs

Aircraft Power Management Decentralizes

Evolution has hit electrical power systems in aircraft. The same evolution that led the larger dinosaurs to develop widely-separated control centers in their nervous systems has led Westinghouse's Aerospace Electrical Div. to propose remote and automatic control of electrical loads.

The result of this new method of managing electrical power should be reduced complexity, flight crew work load, over-all cost plus improved performance.

Instead of the present system, in which heavy feeders lead from generators to cockpit controls and thence to loads, Westinghouse engineers propose a system in which the feeders run directly to load centers. Actual switching of power would be handled remotely at the load center.

They call their system ACES (for "automatically controlled electrical system"), and a demonstration model is scheduled for completion by January 1971. In it, tiny remote power controllers will perform switching functions under the guidance of a computer-like control center (memory board held by engineer). Remote input/output units multiplex and demultiplex control signals, and a data entry and display panel provides manual control and system status.

To prevent electrical source overloads, ACES will shed loads automatically in accordance with a preprogrammed load priority schedule. The system will accept up to four such schedules, selectable according to the flight mode.

Sets Ceiling Prices

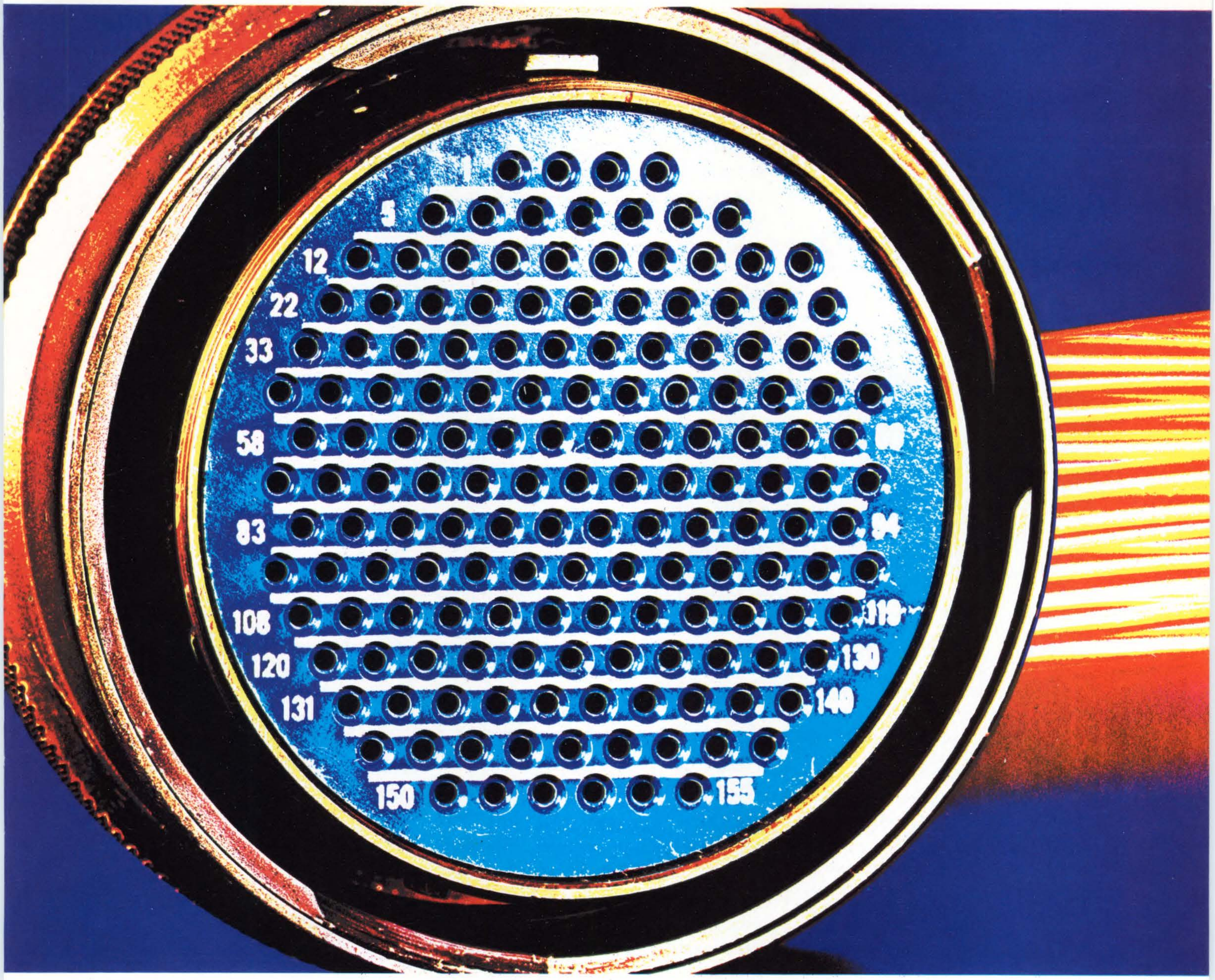
Top prices ranging from \$9500 to \$12,500 have been set by Collins Radio Co. for its new MOS/LSI design/build service plan. All company services from automated design and phototooling through assembly and final test are included. Designer-customers are required to complete a design implementation engineering course, after which computer design run time is limited to 2 hours, and numerically-controlled artwork generator run time limit is 8 hours.

Modulates Light with Sound

A miniature modulator that may find use in a tri-color laser TV projection system uses ultrasound to modulate a laser beam and is said to be highly efficient, requires only low power and is cheaper to build than conventional electro-optical modulators, because it uses inexpensive glass rather than exotic crystals.

Developed by a Zenith Radio Corp. group and hailed as the first of a group of acousto-optic diffraction devices, the system includes a modulator cell with a glass block and 40 MHz ultrasound source. The sound waves traveling through the glass cause Bragg angle light diffraction of the laser beam at 85% optical efficiency. Since the modulator is not temperature-sensitive, it achieves a high degree of operating stability.

Count your savings.



15¢ a hole.

ASTRO/348® Our MIL-C-81511 tri-service connector, the Astro/348®, saves you 15¢ a hole because you get 20% more circuit contacts per square inch. For example, on our #23-22 high-density connector we have 155 circuit contacts instead of the usual 128.

So, with the Astro/348 connector you can engineer circuit cost reduction while demanding aerospace construction.

For computers, for television cameras and for portable communications; solid-state modular electronics are perfect applications for the low-voltage Astro/348. We know you can add more.

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CIRCLE NO. 9

Design Briefs

Probe Your Vortex

Laser light that doesn't interfere with air flow is the latest technique developed to measure and analyze vortex flow fields. In case it sounds highly theoretical, remember that vortex flow fields are those swirling (and sometimes capricious) currents that spin off airborne surfaces. Controversy still rages in aeronautical circles about the minimum safe distance to follow a jet aircraft after take-off.

Lockheed-Georgia researchers believe they have found a way to track such patterns electro-optically. They beam laser light into a smoke-seeded wind tunnel containing an aerodynamically-configured model and measure resultant patterns with new electronic detection devices. Thus nothing disturbs the flow field, as in the case of traditional mechanical probes — which set up their own vortex fields.

Help for Dumped Engineers

NASA's Employment Assistance Center has alerted prospective employers that a large pool of skilled professional personnel is available, as a result of recent budget cutback force reductions. About 200 NASA headquarters employees were idled, with engineers, as usual, taking the brunt. Employers can pursue the matter further by calling James R. Miles at the Center, 202/962-8696.

Russ to Help

A joint study of the structure and form of auroral "substorms" will involve both American and Russian scientists, says the National Science Foundation. NSF announced a University of Alaska grant to study the magnetic storms that occur in the earth's outer atmosphere and cause radio blackout, clutter on radar and the familiar "Northern Lights". Cooperation will take the form of U.S. equipment supply, in exchange for data from an auroral infrasonic observatory the Russians will set up. All data gathered will be available to both nations.

Help for Physicists

Hard hit among those casualties of budget cutbacks, physicists facing unemployment are being aided by the American Institute of Physics and The American Physical Society. Jointly, they have appointed Raymond W. Sears, recently retired director of University Relations and Employment at Bell Labs., as special placement consultant. He'll seek out jobs for physicists and counsel them on possible job opportunities. At the same time, AIP has launched two studies: the first will scrutinize present enrollments in physics, and the second will analyze employment status of recent physics graduates.

Low-Noise Substrate

"Perfect Crystal Technology" is what Toshiba calls its new process for growing dislocation-free epitaxial layers on dislocation-free silicon substrates. Company spokesmen claim that the new process insures low-noise ICs and can be applied to production of low-noise transistors. A highly concentrated diffused layer results from simultaneous introduction of phosphorus and arsenic. Toshiba uses its PCT ICs in TV sets, stereo and tape recorders for audio amplification stages.

These are reference standards.

This is the new Fluke working standard.

The new Fluke 730A DC Transfer Standard, a rugged 20 pound, battery powered instrument, takes the fuss out of calibration.

Of course you'll continue to use your standard cell bank as a basic reference. But you'll be time and money ahead if you use the Fluke 730A as your "working standard" and avoid standard cell problems such as temperature sensitivity, length of settling time, and overload. The truly portable Fluke 730A features low temperature coefficient, full accuracy in minutes, overload protection, and quick and easy calibration to your reference standard.

The Fluke 730A consists of four identical independent reference supplies. Output terminals provide individual outputs, the mean output of up to four references and the series output of up to four references. Specific reference voltage outputs available are 1.000, (1.018 + ΔV), (1.019 + ΔV), 10.000 and ΔV Volts. The Model 730A may be used as a 1 volt or 10 volt standard, or as an "electronic standard cell."

Transfer accuracy is 2 ppm. Stability is 10 ppm/month for individual references. Only 3½" high, the 730A can be used on the bench or in a rack. Guarded outputs give you freedom from noise in high accuracy floating measurements.

Price is $1995.

For the full story, see your Fluke sales engineer or contact us directly.

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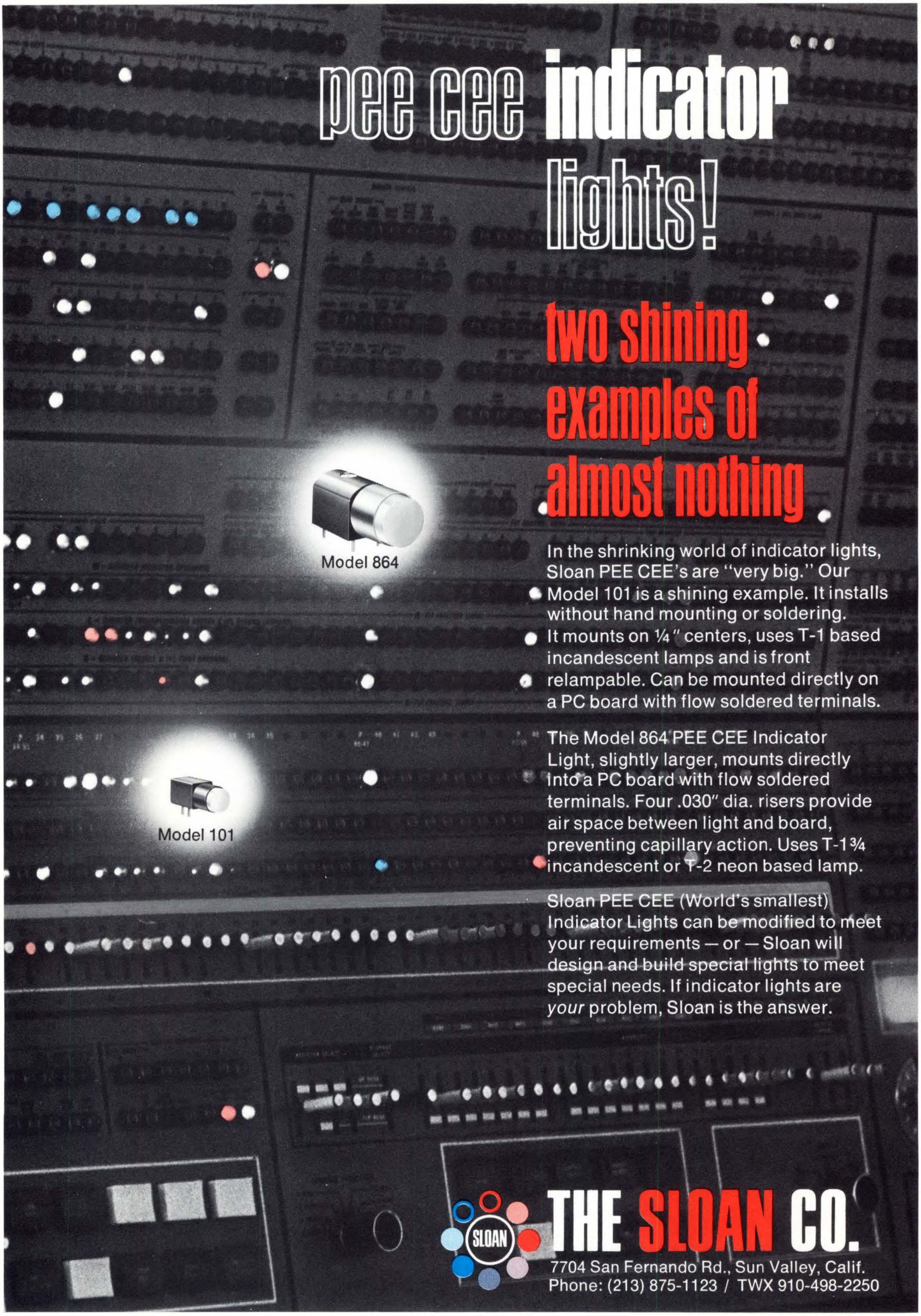
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two shining examples of almost nothing
Model 864
Model 101
In the shrinking world of indicator lights, Sloan PEE CEE's are "very big." Our Model 101 is a shining example. It installs without hand mounting or soldering. It mounts on ¼" centers, uses T-1 based incandescent lamps and is front relampable. Can be mounted directly on a PC board with flow soldered terminals.
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CIRCLE NO. 12

Teleprogram Center

In a move calculated to protect its flanks in the coming cartridge TV war, Motorola has announced establishment of a "program center" to convert existing program material to the CBS-EVR format and originate new programs for EVR. The new group operates under Motorola's Education and Training Products unit, charged with marketing the company's "Teleplayer" that plays CBS-developed EVR cartridges. On its left flank, Motorola and its Canadian outlet, Bellvue Pathe Ltd., have agreed with the National Film Board of Canada to convert and distribute its films in the EVR format.

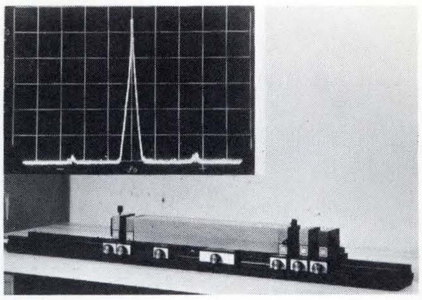
Big Shrink

New machine from Xerox Corp. takes engineering drawings as large as 24 by 36 in and shrinks them as small as 8 by 10 in. Potential boon to firms that must handle and store volumes of drawings, the Xerox 840 reduces either 65% or 50% and cranks out 40 copies/min. Process is electrostatic.

Junction Output

Workers at NBS Institute for Basic Standards have very accurately measured the voltage output of a Josephson junction when its input is in the form of known-frequency microwaves. The work has large significance in measurement of standard cells, establishment of standard voltages and more accurate determination of fundamental constants such as the electron charge, Planck's constant and the electron rest mass.

Mode-Locked Laser

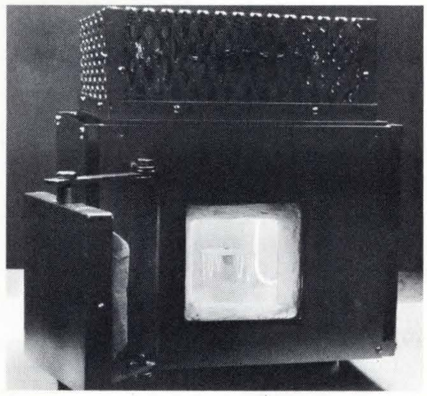


Long touted as an optical communications medium, lasers may at last be entering the practical era with the development of a 40 to 60W Nd:YAG CW device. Holobeam's system is closed-loop for high stability, and fully automatic, mode-locked for output pulses whose center frequencies can range from 75 to 300 MHz at a nominal pulse width of 200 ps. Output power ranges from 2 to 5W, primarily because phases "bunch" into a series of ultra-short pulses.

Multiplex the Pilot

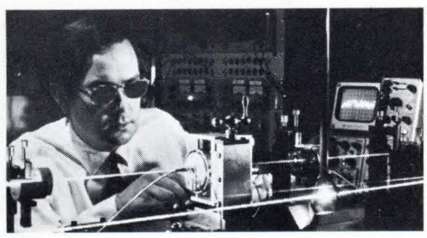
Pilots of tactical aircraft whose eyes and hands are fully occupied still have one channel of information input open—their ears. Now RCA is developing a system for the Army that will allow a pilot to get a spoken message if trouble develops in any of 35 different aircraft functions. The system consists of sensors to monitor components, RCA's signal adapter and an AN/ASH-19 voice playback unit.

1700°C in 5 Minutes



With a molybdenum disilicide heating element, 0.75 in of fibrous zirconia insulation and weighing only 15 lb, Union Carbide's new "bench" furnace can provide temperatures as high as 1700°C in 5 min. Platinum crucible in photo reflects "Kanthal Super 33" heating elements with heating speed limited only by power supply capability; MoSi elements also have no watt-loading limit. Experimental furnace shown is equivalent to a 48-in conventional cube that would weigh 900 lb and take 8 hr heat-up.

Gigabit Modulator



Workers have long known of lasers' large message-carrying capacity, but relatively "slow" electronic circuits have limited the modulation frequency. Now, Bell Labs. has developed low-voltage, high-speed circuits, comprised of four transistorized gates fabricated in microstrips on thin film, and capable of transmitting 250 megabits each, for a total of 1 megabit/s. This multiplexed stream modulates an optically-pure laser beam. Single frequency beam can be modulated with about 5V, rather than the 30V previously required.

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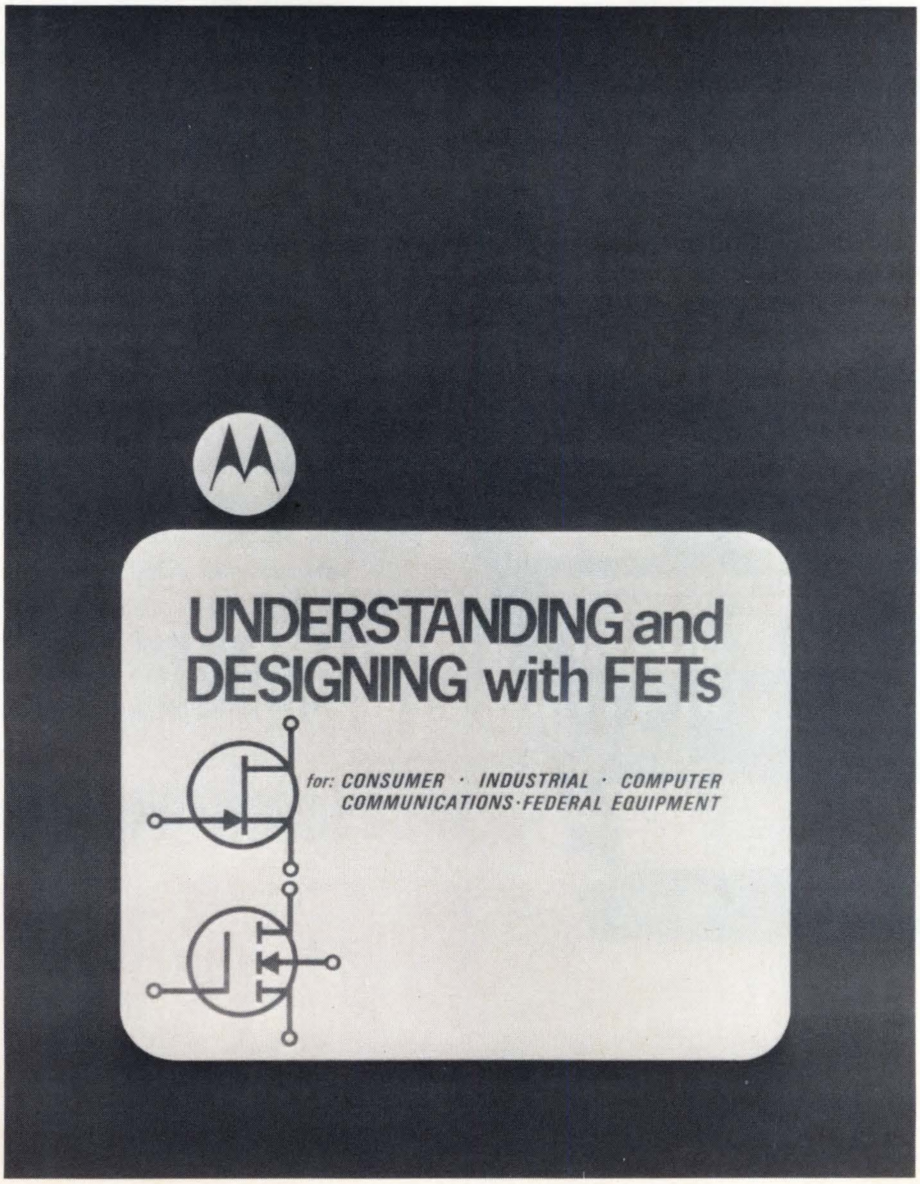
Classes of FETs are clarified: enhancement, depletion (Types A & B) and how they fit into switching, chopper, amplifier, voltage-variable resistor, current/limiter/source and microwatt logic designs.

Specific FET applications are also treated, such as: FETs in Chopper and Analog Switching, Low Frequency FET Applications, The FET In Digital Designs and A Unified Approach to Optimum FET Mixers are 4 of the many.

Your personal request on your company letterhead will bring you a copy of this valuable instruction — Box 20912, Phoenix, Arizona 85036. Find out what you need to know about FETs . . . write now!



CIRCLE NO. 13

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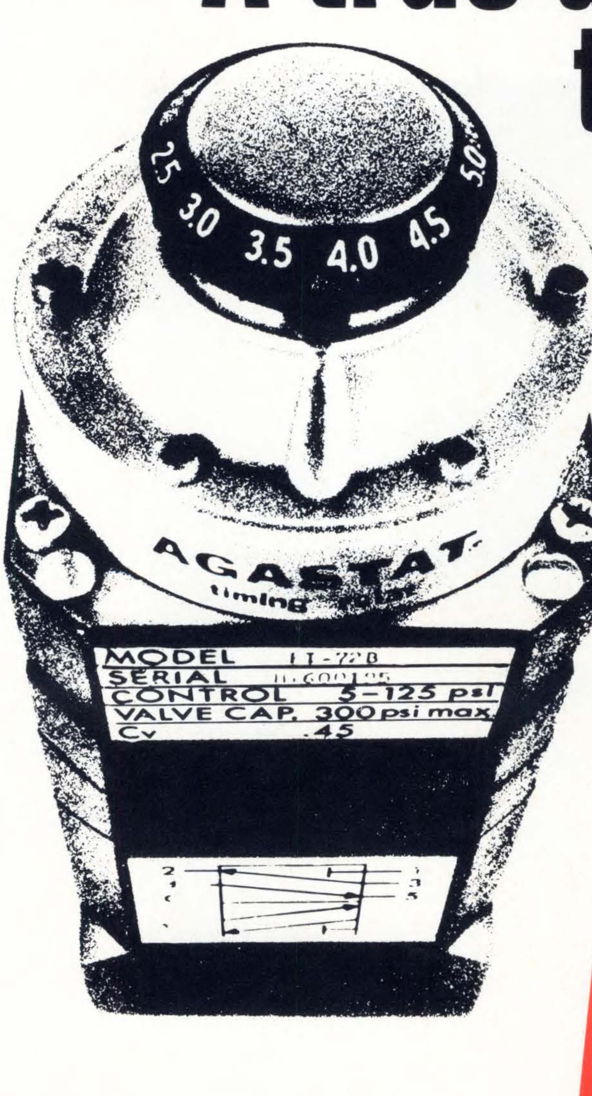

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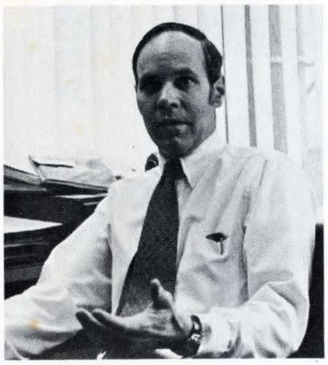
CIRCLE NO. 14

EMPHASIS ON POLLUTION WILL BOOST POWER CIRCUITS

As the programs to monitor and control pollution on this planet gather momentum, we will see a rise in the popularity of micropower circuits. These are circuits that are optimized to use as little power as possible in performing their functions.



ROBERT CUSHMAN
EDN Regional Editor

This trend will be encouraged by a growing public outcry against any technology they feel does more harm than good. The electronics industry will use its established micropower capability as a powerful tool to gain public good will.

By "micropower circuit", I mean those linear op amps that make extensive use of complementary bipolar stages to idle at microamperes and those logic circuits that make extensive use of complementary MOS stages to idle at nanoamperes. These circuits, by the law of "speed-power," tend to be slow—at least when they are delivering micropower performance. But the world of man and nature that they will be monitoring is even slower, so these micropower circuits will be more than adequate for primary pollution sensing, just as they have been adequate for similar uses in NASA space probes.

I foresee large numbers of micropower sensing stations being spotted about this planet to monitor air, water, noise, etc. Many will also serve as weather monitors.

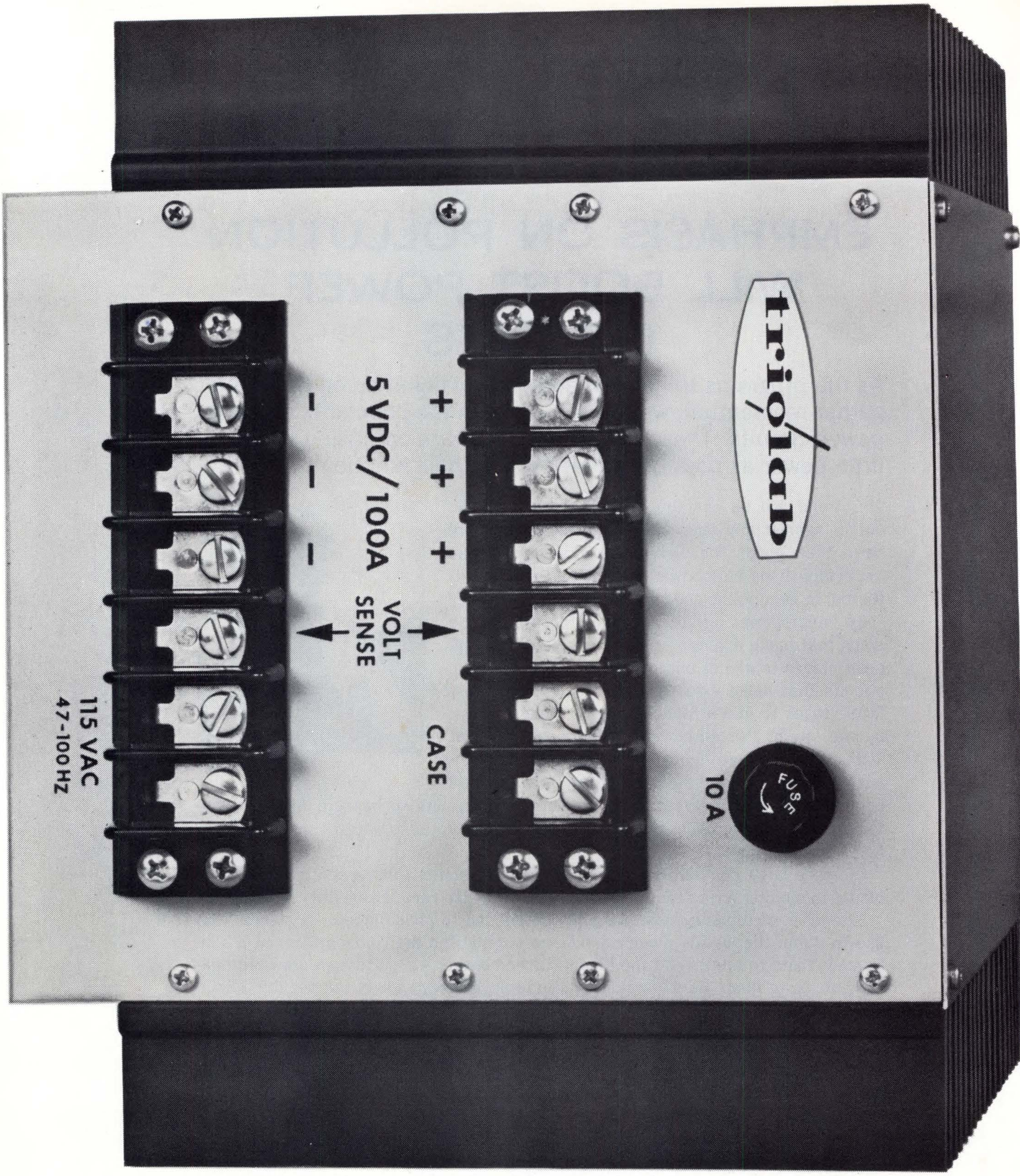
Extensive, continuous monitoring will be needed to police industrial plants "who like to dump the week's chemical residue quietly into the Hudson River at 3 a.m. Sunday," and to apprehend the "mammoth oil tanker whose foreign crew unthinkingly starts to flush the sludge out of the tanks as they slide out under the Golden Gate Bridge in the fog." They will also be needed to catch the EE who drives to work in a second car that never gets a tune-up.

All of us—industrialists, shipowners, you and I—are going to have to pay for a clean environment. And we are not going to pay unless we are being watched. It will be the electronic micropower policeman who'll be doing the watching.

At first, these stations will be micropower just because so many will be remote and battery operated. Some will be micropower because only miniature, unobtrusive micropower units will get past the scrutiny of the "nature lovers" who are already "anti" any technology, just on principle.

Eventually, they will have to be micropower because the proliferation of sensing and preliminary computation and temporary data storage in future systems will make micropower mandatory at all levels.

Meanwhile, our industry's micropower capability will make us the one "noble" technology to the ecologists. They'll think of us as the industry with answers, not problems. We do the vital job of watching the polluters without being polluters ourselves.



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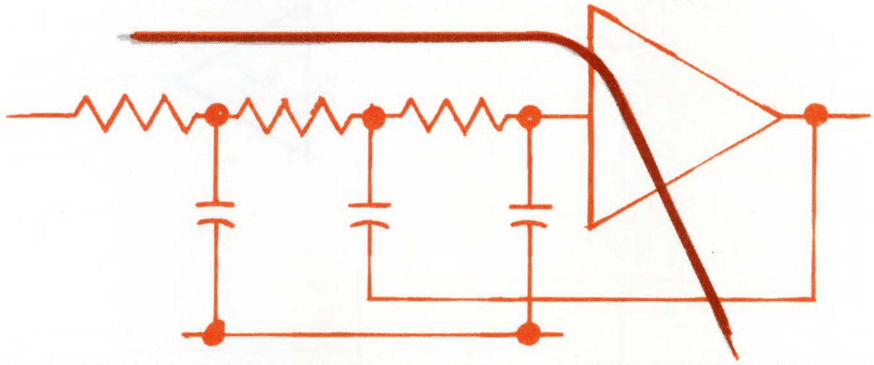
CIRCLE NO. 11

SIMPLIFY 3-POLE ACTIVE FILTER DESIGN

Synthesis of odd-order active filters is no longer burdensome, thanks to a simple, low-cost circuit, and an easy-to-use table. If your preference is a computer program, try the one given here.

A. PAUL BROKAW, Communications Technology, Inc.



The increasingly frequent appearance of better, cheaper operational amplifiers makes them more and more attractive for use in active filters. In such applications, they eliminate the need for inductors in transfer function synthesis. However, calculations for RC component values are tiresome without the computer program or table derived here. This direct method for synthesizing third-order filters, which may be used separately or in cascade with second-order sections, results in a filter using a theoretical minimum number of RC components and fewer amplifiers to produce a given filter performance.

In principle, a single amplifier can be included in an RC network to yield any physically realizable transfer function. In practice, however, synthesis of the RC network is often difficult if the desired transfer function is of a high order. Many published algorithms synthesize component values for circuits producing a single complex pole-pair per amplifier, and these circuits may be cascaded to give any even order, all-pole transfer function wanted. But 3-pole response generally yields a "better" filter (sharper cutoff, flatter passband, etc.), and a 3-pole circuit may be cascaded with 2-pole networks to give even higher odd-order transfer functions. Several filter types which are degenerate in 2-pole forms, are separately distinguishable only as 3-pole or higher order realizations.

An Active Realization

The circuit based on the model in **Fig. 1**, using only resistors and capacitors, can be made to exhibit any 3-pole response including: Butterworth, Chebyshev, Legendre or Optimal, Bessel or Paynter. When arranged as in **Fig. 2**, the circuit yields a 3-pole low-pass response which can be used directly or in cascade with additional networks to produce a higher odd-order response. Several unity gain (k=1), noninverting op amps are available as complete modules that closely approximate the active element used as the voltage controlled voltage source in **Fig. 1**. (An ideal voltage amplifier with infinite input impedance, zero output impedance, and an output voltage which is equal to the input voltage multiplied by some positive or negative constant.)

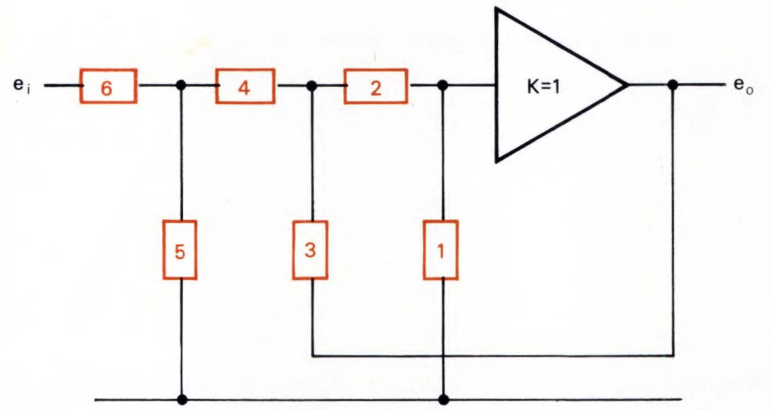
The minimum number of components required to produce this active filter combines economy with convenience, and its low dynamic output impedance makes it easy to use in cascade or to drive other circuits directly. The algorithm presented also yields component values for a 2-pole response if elements 5 and 6 are omitted. This 2-pole circuit has the same features as the 3-pole version, i.e., minimum complexity and low dynamic output impedance.

Because of the ease with which a filter design may be scaled in both frequency and impedance levels, it is convenient to synthesize various filter types in normalized form. Normalized element values can be tabulated and then modified by multiplication to provide rapid solutions to design problems. The algorithm derived has been used to generate an easily usable table (**Table 1**) which contains element values for the selected five low pass filter types. Capacitor values are

(Continued)

Filter Design *(Cont'd)*

given for a filter normalized to 1 Hz and resistors are all set equal to 1Ω. Values given can be conveniently scaled to give convenient resistance level and corner frequency. The filter will retain its desired response when resistors are increased by factor **R**, as long as resistor values are kept equal (or in the same ratio), and calculated capacitor values are reduced by the same factor. Frequency scaling may be done by scaling capacitor values, with the frequency scale being inversely proportional to the capacitor values. If a filter is designed with a predetermined band-edge, the band-edge frequency will be raised by factor **f**, when each



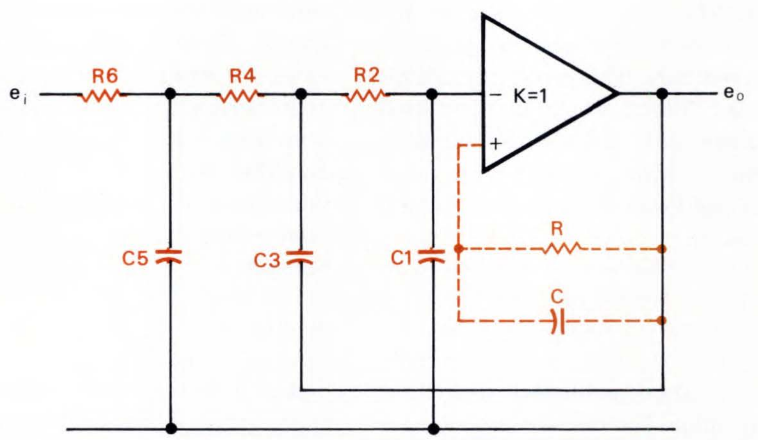


Fig. 2—**Active Filter Arrangement** for 3-pole low-pass response. If amplifier gain is greater than k=1, an RC feedback circuit (shown as dashed lines) must be added to convert the op amp to a unity-gain follower. R should be equal to R2+R4+R6 to cancel input current offset voltage.

Component Value Synthesis. Fig. 2 shows the arrangement of resistors and capacitors that will result in an all-pole low-pass response. Substituting resistances and capacitances into **Eq. 1** yields:

$$\frac{e_0}{e_i} = \frac{A_0}{A_3S^3 + A_2S^2 + A_1S + A_0} \qquad \textbf{(Eq. 3)}$$

where

$$A_3 = R6R4R2C5C3C1 \qquad \textbf{(Eq. 4)}$$

$$A_2 = (1-k)R6R4C5C3 + R6(R2+R4)C1C5 + R2(R6+R4)C1C3 \qquad \textbf{(Eq. 5)}$$

$$A_1 = (1-k)(R6+R4)C3 + R6C5 + (R2+R4+R6)C1 \qquad \textbf{(Eq. 6)}$$

$$A_0 = 1 \qquad \textbf{(Eq. 7)}$$

Assuming the A_i are preselected to produce the desired response, **Eq. 4, 5** and **6** can be solved to yield component values. Note that **Eq. 7** expresses a requirement on the term A_0, which can always be satisfied by dividing numerator and denominator of **Eq. 3** by the constant term if it is different from unity.

For k=+1, the solution of these equations is greatly simplified. By setting k=+1, **Eq. 5, 6** and **7** are solved by substitution:

$$C3 = \frac{A_2/C1 - R6(R2+R4)C5}{R2(R6+R4)} \qquad \textbf{(Eq. 8)}$$

derived capacitor value is divided by **f**.

Computer Program

The most tedious portion of this synthesis is finding a value for C5 by means of **Eq. 10**. This involves finding a real root of a cubic equation. It can be done in closed form by use of Cardan's formulas, and once C5 is evaluated the other values are easily found.

Since the entire process is straightforward, it is readily transformed into a simple computer program. A program listed in **Fig. 3** has been written for the Telcomp system to perform the synthesis. Telcomp is a

Fig. 1 — **Circuit Analysis.** Each of the six elements of **Fig. 1** will be referred to as Yn or Zn indicating whether the admittance or impedance of the element is used in calculations. The network voltage transfer ratio can be shown as:

$$\frac{e_0}{e_i} = \frac{1}{Z6Y5Z4Y3Z2Y1+(1-k)(Z6Y5Z4Y3)+Z6Y1(Y5Z2+Y5Z4+Y3Z2)+Z4Y3Z2Y1+(1-k)Y3(Z4+Z6)+Z6(Y1+Y5)+Y1(Z2+Z4)+1} \quad \textbf{(Eq. 1)}$$

This form is convenient for the synthesis of an all-pole low-pass function. Multiplying both numerator and denominator of **Eq. 1** by Y6Z5Y4Z3Y2Z1 yields:

$$\frac{e_0}{e_i} = \frac{Y6Z5Y4Z3Y2Z1}{1+(1-k)Y2Z1+Y4Z3+Z3Y2+Z5Y4+Y6Z5+(1-k)Z5Y2Z1(Y6+Y4)+Y4Z3Y2(Z5+Z1)+Y6Z5Z3(Y4+Y2)+Y6Z5Y4Z3Y2Z1} \quad \textbf{(Eq. 2)}$$

This form is convenient for the synthesis of a 3-pole high-pass network.

$$C1 = \frac{A_1 - R6C5}{(R2+R4+R6)} \quad \textbf{(Eq. 9)}$$

By means of multiple substitution, C5 can be found implicitly:

$$\frac{C5^3-C5^2A_1}{R6} + \frac{C5\,A_2(R2+R4+R6)}{R6^2(R2+R4)} - \frac{A_3(R2+R4+R6)(R6+R4)}{R6^3R4(R2+R4)} = 0 \quad \textbf{(Eq. 10)}$$

Since six parameters are to be determined, and there are only three constraints, **Eqs. 4, 5** and **6**, three of the parameters can be pre-selected. If the three resistors are pre-selected, **Eqs. 10, 9** and **8** can be solved in that order for C5, C1 and C3. For a purely arbitrary selection of resistor values, the calculated capacitor values may not all be positive. In this sense the synthesis is not completely determined. Nevertheless, it produces useful results in practice. A simplification of the equations results if the resistors are all set equal to 1Ω. In this case, the capacitor values may be calculated from the following:

$$C5^3-C5^2A1+C5\ 3/2\ A_2-3A_3 = 0 \quad \textbf{(Eq. 11)}$$

$$C1 = \frac{A_1-C5}{3} \quad \textbf{(Eq. 12)}$$

$$C3 = \frac{A_2/C_1-2C5}{2} \quad \textbf{(Eq. 13)}$$

where the units are farads, farad^2 and farad^3 for A_1, A_2 and A_3 respectively.

If a two pole response is desired, it is only necessary to set C5 and R6 both equal to zero. The two remaining capacitor values are found from **Eqs. 7** and **8**:

$$C1 = \frac{A_1}{R2+R4} \quad \textbf{(Eq. 14)}$$

and

$$C3 = \frac{A_2}{C1R2R4} \quad \textbf{(Eq. 15)}$$

In this case **Eqs. 12** and **13** reduce to:

$$C1 = \frac{A_1}{2} \quad \textbf{(Eq. 16)}$$

and

$$C3 = \frac{A_2}{C1} \quad \textbf{(Eq. 17)}$$

if R2 = R4 = 1Ω.

Once the values of the capacitors are calculated, the resistor values may all be increased to a convenient level. So long as the resistor values are kept equal (or in the same ratio, if they were not all selected to be 1Ω) they may be increased by a factor **R**. If the calculated capacitor values are reduced by the same factor, the filter will have the desired response. Frequency scaling may be done by scaling the capacitor values. The frequency scale of the filter will be inversely proportional to the capacitor values. If a filter is designed with a predetermined band edge, the band edge frequency may be raised by a factor **f**, by dividing each of the derived capacitor values by **f**.

Because of the ease with which a filter design may be scaled in both frequency and impedance level, it is convenient to synthesize various filter types in normalized form. The normalized element values can be tabulated and then modified by multiplication to provide rapid solutions to design problems. **Table 1** contains element values for the selected five low-pass filter types. The capacitor values are given for a filter normalized to 1 Hz (not 1 radian which is more convenient in derivation but frequently less so in use of the results) with the resistors all set equal to 1Ω.

(Continued)

remote terminal time-shared service convenient for short programs of this type. The program may be easily converted for use with other systems, since its steps are largely self-explanatory to anyone familiar with simple programming, even though Telcomp may not be available to him.

The program is not well suited to computation of the values of a 2-pole response. Since the value of R6 appears as a denominator factor, it may not be set equal to zero. **Equations 14** and **15** make the 2-pole case a trivial computation, so the program was not arranged to accommodate this case.

A. Paul Brokaw, a senior staff engineer for Communications Technology, Inc., is a graduate of Oklahoma State University with a B.S. degree is physics. Prior to his present position he was a group leader and consulting circuit designer for 6 years at Arthur D. Little, Inc. He has been granted six patents.

FILTER TYPE		FEATURES	DENOMINATOR	CORNER ATTENUATION	C_1*	C_3*	C_5*
Butterworth		Maximally flat passband	s^3+2s^2+2s+1	3 dB	0.032221	0.56449	0.22165
Chebyshev	1 dB Ripple	Equal 1 dB passband ripples and rapid cut-off	$s^3+0.98834s^2+1.23845s+0.49131$	1 dB	9.3456 x10⁻³	2.3531	0.37314
	3 dB Ripple	Equal 3 dB passband ripples and very rapid cut-off	$s^3+0.59724s^2+0.92835s+0.25059$	3 dB	4.0312 x10⁻³	6.9102	0.57751
Optimal		Rapid cut-off and monotonic in passband	$s^3+1.31s^2+1.359s+0.577$	3 dB	0.020572	1.0846	0.31314
Bessel		Approximates Gaussian response. Minimizes phase delay distortion	$s^3+6s^2+15s+15$	0.84 dB	0.023094	0.12949	0.08987
Paynter		Excellent time domain response	$3.2s^3+4s^2+3.2s+1$	10.4 dB	0.043743	0.78006	0.37807

* *Note: All capacitances in farads.*

Table 1 — **Normalized data for synthesis of a 3-pole active filter.** To use the above table, first locate filter type in left-hand column. If the type of filter has not been previously selected, the second column gives a brief listing of the characteristic features of the five types. The third column lists denominator polynomials of the Laplace transforms. The numerator is equal to the denominator constant term. These numbers would be used in the computer program for A0, A1, A2, A3.

Select a convenient resistance level for the filter. This will generally be a compromise constrained by the amplifier input current offset and drift on one hand, and the desire for small capacitor values on the other. Set R2, R4 and R6 of **Fig. 2** equal to the selected resistance value **R** in ohms.

Operating frequency must be determined by the filter requirement. The fourth column indicates the attenuation of the selected filter characteristic at the "corner" frequency (where $s = -j$). If **f** is the desired corner frequency in Hz, find product **fR**. Take the value for C1 in farads from the fifth column and divide it by **fR**. Use the resulting value for C1 in **Fig. 2**. Similarly, divide normalized values of C3 and C5 by **fR**, and use the results in the circuit in **Fig. 2**.

Examples: (**1**) Assume it is desired to produce a 1-dB ripple Chebyshev filter, with 1-kHz corner frequency and total resistance at the filter input must be limited to 30 kΩ.
Set each resistor (R2, R4 and R6) equal to 10 kΩ ($R = 10^4$). If the corner frequency is 1 kHz, filter amplitude response will ripple below 1 kHz; but maximum pk-pk ripple will be 1 dB. At 1-kHz response will be down 1 dB and above 1 kHz attenuation will increase monotonically. Note that $f = 10^3$, therefore $fR = 10^7$. C1 from the table is 9.3456×10^{-3}F, and when divided by **fR**, becomes 9.3456×10^{-10}F or 935 pF, which is the value assigned to C1 in **Fig. 2**. Similarly, values of C3 and C5 are calculated to be 0.23532 and 0.37314 μF respectively.
(**2**) Assume that a second filter is required with cut-off frequency of 300 Hz, a rapid cut-off is desired, but passband ripples cannot be tolerated. Select the Optimal characteristic as the best compromise. Suppose also that current drift is a less severe problem, so that 60 kΩ total is an acceptable resistance level. Set R2 = R4 = R6 = 20 kΩ ($R = 2 \times 10^4$). Since cut-off frequency is 300 Hz ($f = 300$), then $fR = 6 \times 10^6$. From the table, the normalized value of C1 is 0.020572F and the denormalized value is 0.0034286 μF. Denormalized values for C3 and C5 are 0.18076 and 0.05219 μF respectively.

```
TRIPOL

Ø1.Ø1 TYPE #, "TYPE IN THE DENOMINATOR COEFFICIENTS STARTING WITH THE"
Ø1.Ø2 TYPE "CONSTANT TERM , THE RESISTOR VALUES IN OHMS,"
Ø1.Ø3 TYPE "AND THE FREQUENCY IN HZ."
Ø1.Ø5 DEMAND AØ, A1, A2, A3, R2, R4, R6, FREQ
Ø1.Ø8 A1=A1/AØ, A2=A2/AØ, A3=A3/AØ
Ø1.11 D1=R2+R4, E1=D1+R6, F1=R4+R6, P=1
Ø1.14 TO STEP Ø1.38 IF A3=Ø
Ø1.17 Q=-A1/R6,R=A2*E1/(R6*R6*D1),S=-A3*E1*F1/(R6*R6*R6*R4*D1)
Ø1.20 TO PART 98.21
Ø1.23 TO PART Ø1.32 IF X[1]>Ø
Ø1.26 TYPE "TOUGH LUCK, CARE TO TRY AGAIN?",#
Ø1.29 TO STEP Ø1.Ø5
Ø1.32 C5=X[1]
Ø1.35 TO STEP Ø1.41
Ø1.38 C5=Ø
Ø1.41 C1=(A1-R6*C5)/E1
Ø1.44 C3=(A2-R6*D1*C1*C5)/(R2*F1*C1)
Ø1.47 FR=1/(FREQ *2*$PI)
Ø1.50 C5=FR*C5, C3=FR*C3, C1=FR*C1
Ø1.51 TYPE C5, C3, C1
Ø1.53 DONE

98.21 K=Q/(3*P), F=(R-Q*K)/P, G=2*K↑3+(S-K*R)/P
98.24 SET DIS=(G/2)↑2+(F/3)↑3
98.4 TO STEP 98.71 IF DIS>Ø
98.41 TO STEP 98.81 IF DIS=Ø
98.51 L=SQRT(-4*F/3), C=(3*G)/(F*L), M=ATN(SQRT(1-C↑2)/ C)
98.54 X[J]=L*COS(M/3+(J-1)*2*$PI/3)-K FOR J=1,2,3
98.55 TO PART Ø1.23
98.71 U=SGN(-G/2+SQ)*'(-G/2+SQ)'↑(1/3) FOR SQ=SQRT(DIS)
98.72 T=SGN(-G/2-SQ)*'(-G/2-SQ)'↑(1/3) IF(G/2+SQ)<>Ø
98.725 T=Ø IF (G/2+SQ)=Ø
98.73 X[1]=U+T-K, A=-((U+T)/2+K),B=SQRT(3)*(U-T)/2
98.76 TO PART 01.23
98.81 H=Ø IF G=Ø
98.82 H=SGN(G)*'(G/2)'↑(1/3) IF G<>Ø
98.83 X[1]=-2*H-K, X[2]=H-K, X[3]=H-K
98.85 TO PART Ø1.23
```

Fig. 3 – **Computer Program.** To use the program titled TRIPOL, it is necessary only to load it on the Telcomp system and give instructions, "Do PART 1". The terminal will print out the instructions listed in the fourth step. The variables A_0, A_1, A_2 and A_3 are coefficients from **Eq. 3** and column 3, **Table 1**. R2, R4 and R6 are resistance values from **Fig. 1**, which should be entered in ohms. FREQ is the desired corner frequency for the finished filter in hertz.

Once this data has been entered by the user, the program will formulate **Eq. 10**, find a real root (by means of the 98.xx steps which are part of a standard Telcomp cubic root routine) and use this result to find values for C1 and C3 by **Eqs. 9** and **8**. Resulting capacitances will be denormalized (dividing by $2\pi \times$ FREQ), and printed out.

```
←DO PART 1

TYPE IN THE DENOMINATOR COEFFICIENTS STARTING WITH THE
CONSTANT TERM , THE RESISTOR VALUES IN OHMS,
AND THE FREQUENCY IN HZ.
           AØ=.2505943
           A1=.92834805
           A2=.5972404
           A3=1
           R2=1
           R4=1
           R6=1
         FREQ=1
           C5=      .577509459
           C3=     6.91024748
           C1=     4.03122017*10↑ -3
```

Fig. 4 – **Printout of executed TRIPOL program.** This sequence illustrates use of the program. The printout was made after loading the program, and shows results for a 3-dB Chebyshev filter. The terminal typed entire printout with exception of the command "Do PART 1", and input data numbers following the first eight equal signs. The resistor values and frequency were all normalized to 1. Note that values for A0, A1, and A3 were taken from column 3 of the table for a Chebyshev filter with 3-dB ripple.

Filter Design (Cont'd)

Databank

The author recommends the following references:
1. "Handbook of Operational Amplifier ACTIVE RC NETWORKS", First Edition Copyright 1966 by Burr-Brown Research Corp. (This is a valuable source of 2-pole synthesis procedures.)
2. "Network Analysis and Synthesis", Franklin F. Kuo, Second Edition, John Wiley, 1966. (Kuo discusses several filter types including "Optimal" response.)
3. "Network Analysis and Synthesis", Louis Weinberg, McGraw-Hill, 1962. (This text is a good general reference including discussion of asymptotes for Chebyshev and other filter types.)
4. "The Lightning Empiricist", Vol. 13, No. 1 and 2, Jan.-July 1965, Published by Philbrick/Nexus, formerly Philbrick Researches, Inc. (This publication contains practical designs and a comparison of Paynter, Bessel and Butterworth responses.)

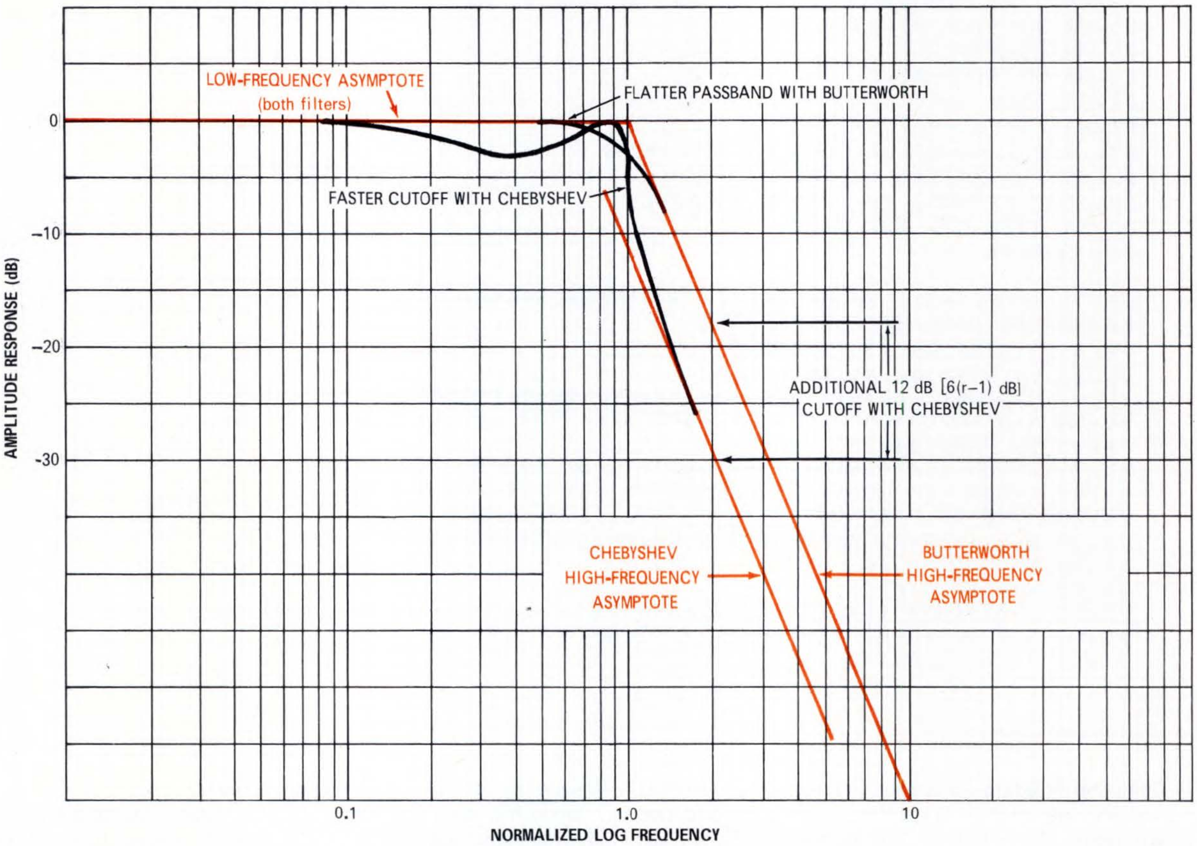


Fig. 5—**Comparison of 3-dB Chebyshev and Butterworth responses.** The Chebyshev asymptote is displaced, usually toward greater attenuation, and can yield an attenuation of as much as 6 (n−1) dB, (12 dB in this case) more than the Butterworth filter of the same order (Chebyshev filter with 3-dB passband ripple).

Selected Low Pass Filter Types

The Butterworth filter is possibly the best known of the exact function filters. It is characterized by closely approximating the ideal low pass below the cut-off frequency (i.e., minimum attenuation) and is "maximally flat" at zero frequency. It has a high frequency asymptote of 6n dB/octave (n = number of poles), which intersects zero attenuation at the cut-off frequency.

The Chebyshev filter is also well-known. Its outstanding property is that it has the sharpest cut-off of any all-pole filter of a given order with a given passband error. Its amplitude response has a number of equal amplitude ripples between zero frequency and cut-off frequency, and response has a high frequency asymptote of 6n dB/octave.

The Legendre or Optimal filter offers a compromise in some applications where passband ripple is unacceptable, while a sharp cut-off is still required. It is monotonic in the passband (although not maximally flat) and has the sharpest cut-off rate possible for an all-pole filter without passband ripples.

The Bessel filter is a low pass filter with a maximally flat time delay. This characteristic is a minimum phase approximation to the Gaussian response, which minimizes delay distortion and dispersion. It is used where the phase relationship of the passed signals must be preserved and, as a result of the approximately Gaussian response, this filter has "good" (i.e., small overshoot) transient response.

The Paynter filter also has "good" transient response, optimized in the time domain. In the passband it is a poor approximation to the ideal low pass characteristic (when compared to the Butterworth response) but has a high frequency asymptote of 6n dB/octave. It has a delay which "ripples" as a function of frequency so that passband delay distortion is not minimized, but it has an excellent step response with little overshoot. It is useful as a delay line as well as a filter in systems primarily based on time domain phenomena. ▭

FOR A FREE REPRINT OF THIS ARTICLE, **CIRCLE NO. L61**

DIGITAL SYSTEMS
NEED DIGITAL MEASUREMENT

Those Siamese twins, digital systems and digital test instruments, are in trouble. Systems have evolved much more rapidly than test instruments. Here's a building-block test approach that may let the weaker twin catch up.

EARL N. POWERS, Data Display Systems, Inc.

Our digital equipment industry is in a measurement bind. As increasingly sophisticated digital equipment evolved, test equipment to evaluate its performance could not keep pace. Although the problem is one of technique, it is inextricably entangled with questions of cost-effectiveness, versatility and overcapability.

In "the olden days", before IC technology matured, digital systems were made up of discrete devices. It was easy for designers to control and vary, from circuit to circuit, a number of signal parameters—amplitude, rise time, fall time and delay were some of the most common. Now, digital ICs have pre-empted most of this control. Once the particular class of IC has been chosen, rise time, fall time, delay and noise cannot be varied. For all practical purposes, the designer's control is limited to the signal logic level and the transitions from one logic level to the other.

Despite this shift, the major efforts of the instrument industry have been to refine the basic, and essentially analog instruments of that earlier day, rather than to evolve the new generation of digital instruments that will be needed in the future. As a result, many present-day instruments are very complicated and cumbersome to use, and they require much training, experience and sophistication to deduce the important variables.

Instrument Value

A measuring instrument's value depends on how accurately it can present those quantities that are important to the observer, meanwhile suppressing extraneous influences. Obviously, the IC quantities that are most important to the designer are those that he can control—the direction and position, either spatial or temporal, of signal transitions from one logic level to another.

Older measuring techniques present such quantities amid a welter of other information, and it takes a good deal of training, experience and sophistication on the operator's part to deduce the important variables with any degree of assurance. This situation is only aggravated by the refinement of these basic instruments. Any real solution to this problem must begin with a fresh approach that will bridge the operating gap between the essentially analog instruments of the past and a new generation of digital instruments that will be needed for the future.

Whole New Way to Go

One such new approach is based on the premise of manipulating and displaying selected attributes of a signal, rather than the signal itself. Signals to be measured are processed and reduced so that the important characteristics, or attributes, are derived and retained, while the redundant portions are discarded or ignored.

Fig. 1 shows the basic block diagram of a digital analyzer based on this principle. The signal attribute measuring portion is a device that detects the desired property of the waveform and converts it into data to be processed and later displayed. Display provides some visual or electronic indication that the attribute (or the processed version of the attribute) is or is not present.

Generally speaking, the more sophisticated the attribute detector is, the simpler the display. Conversely, the simpler the attribute detector, the more complex the display. Take the oscilloscope as an example of one end of the spectrum. It performs no attribute detection or signal processing, so the display is

(Continued)

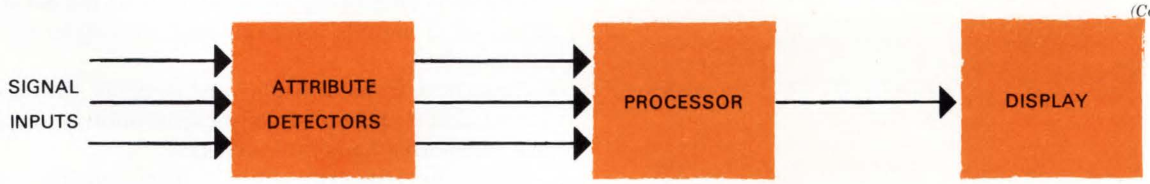


Fig. 1—**Digital Analyzer Structure**

quite sophisticated and shows all the fine structure of the signal. In other words, the measurement is simple, but the display is complex.

At the other end of the spectrum is a fully-automated, computer-controlled analyzer that examines a digital signal and makes one judgment—that the signal has exhibited all of the attributes that constitute a satisfactory digital signal. It then supplies the observer with a simple yes or no decision as to the quality of the digital signal. In this case, the processing and attribute detectors are complex, but the display is simple.

A Look at Attributes

Particular attributes that are adequate to describe a digital signal depend upon the application. **Table 1** lists some typical attributes. Attribute selection to describe a digital signal for a particular application depends upon a number of conditions, since there is a variety of possible tradeoffs. For example, the first two simple attributes listed in **Table 1** are adequate to completely describe the logic signal generated by an IC. In this case, the display required is reasonably complicated since it essentially must display an amplitude-quantized version of the original digital signal, plus rise-time limit conditions. If, on the other hand, attribute 4 is used (i.e., if the signal's logic values are sampled only at the times of clock transitions), the required display can be much simpler—now only a finite number of values need be displayed.

Once the attribute decisions have been made, the signal is characterized by a relatively small, easily manipulated set of data. Operations such as storage, correlation, comparison and other complicated functions become simpler to implement. Also, the linearity and bandwidth limitations imposed on most measuring instruments are eliminated and the full power of digital computational techniques can be brought to bear upon the signal attribute data.

Simple Attributes

1. Instantaneous logic value
2. Rise/fall time limits
3. Temporal positions of logic level transitions
4. Sampled logic values
5. Spike or noise properties

Multi-Signal and/or Higher Order Attributes

1. Relative temporal positions of transitions
2. Relative periodicity of signals
3. Race conditions
4. Signal structure attributes, e.g. does measured signal contain the sequence 1,0,1,1?

Table 1—**Typical Digital Signal Attributes**

Production Test

Equipment designed to put these ideas into practical use includes an analyzer designed primarily for use in production test and maintenance of digital systems. In these applications, the structure of a digital system is known. Wave forms to be analyzed are sufficiently well specified that the observer does not need full knowledge of the digital signal. Consequently, the digital analyzer is based upon the simple attributes 4 and 5 in **Table 1**. This means the analyzer will show the observer a quantized version of the signal by sampling it at the transition of the sample waveform. It also can respond to certain types of noise or spike signals.

Fig. 2 shows a typical example of the waveform that has been quantized in this fashion. The processing portion of the digital analyzer is tailored to make the machine particularly suitable for production test.

Production testing often requires comparison of data or timing signals that are almost exactly alike. The important parts of the signal may occur only during a very small percentage of the time over which the signals are active. Such applications require an extremely accurate and highly calibrated time base and triggering system—a unit that can be precisely set to examine a portion of a waveform that occurs way out in time.

Internal or External Clock

In these systems, the display time base is obtained by counting down a basic source clock, derived either from the system under measurement or the system's internal oscillator. When locked to an external clock, the display rate is as stable as the timing used to generate the waveform to be viewed, and the display is jitterfree, regardless of display duration or trigger delay. Also, clock signals need not be periodic in order to provide a stable display. As shown in **Fig. 3**, the front panel controls of the machine are calibrated essentially in terms of clock cycle duration, i.e., the duration of a graticule division of the display screen is expressed in multiples of a clock cycle period. Clock cycle duration is a more meaningful measure of time to the digital user who is employing a master clock, so the period and duration of signals are expressed directly in terms of clock cycles.

Therefore, in both display and controls, the observer is provided with immediately useful information about the waveforms he is measuring.

Since the triggering unit is level sensitive rather than slope sensitive, it responds to any external clock waveform up to the maximum specified clock frequency of 20 MHz. Thus, the display rate, if expressed in absolute time rather than clock cycles, can be varied from a minimum of 50 ns/graticule division to a maximum of (10^5-1) times the external clock period. If the internal clock is used, the display rate in absolute time can be varied over a range from 50 ns to 5 ms/graticule division.

The display delay, like the display rate, is calibrated in terms of clock cycles, so that a fixed delay corresponding to an integral number of clock cycles can be introduced between the triggering instant and time of display. It is very easy to view portions of a long period waveform. The display delay is so arranged that it can be set to any value of delay over a range from 0 to 10^5 times the number of clock cycles indicated by the display rate.

Display Parallel Data

Parallel data display is another mode of operation for this analyzer. Data can be accepted in a parallel rather than serial form. Such a mode is useful in production test, since the signals to be compared often arrive in the form of bytes (parallel bit streams). In this case, the process is so arranged that the display delay control which formerly controlled the interval of time between the triggering instant and the time of display now functions as a delay control to permit scanning through sequential parallel words. By simply advancing the display delay control in the parallel mode, sequences of words of 16 bits or less can be displayed one after another on the analyzer's screen.

Spike Display

The final mode of operation of the processing unit is the spike display mode. In this mode, the system examines an input signal for pulses that are shorter in duration than intervals defined by the display rate. The system detects spikes or impulses wider than a minimum of 10 ns and narrower than the reciprocal of the display rate chosen. A front panel indicator indicates the presence of a detected spike. When the system is switched into the spike mode, the position of this impulse is displayed on the analyzer's screen.

Attribute choice strongly influences the structure of the analyzer's display portion. Since the waveforms are sampled only at finite intervals of time, and since only the logic levels of these times are indicated, the display can be quantized. In particular, each of the traces is represented by a graph-like display consisting of 16 divisions that show either an upper level, representing a logic 1, or a lower level, representing a logic 0.

Memory and Comparison

Overall, the Data Display System's family represents a new approach to the measurement of digital signals. The entire philosophy is perhaps reflected in the newest analyzer—the 201 SPN. It, like others in the family, is based on showing only the important characteristics of the signal and not the signal itself. Multiple signals can be stored in the 201 for indefinite amounts of time, freeing the display area for presenting other data. Combining internal memories and comparison circuits provides an instrument with the capability to perform camparison testing to a degree that is unavailable with other than specially built equipment. This comparison testing mode becomes significant in the case of random or sporadic changes in signals. When used with the memory and comparison modes, a means of monitoring the operation of digital systems to permit the detection of totally random signal changes is provided.

A trap trigger mode that permits placing the time origin of the display in the center of the viewing area also is included in the 201. Thus, it is possible to view not only the signal changes after the trigger instant point, but also the signal changes immediately prior to the trigger point. This can be done not only with periodic triggers, but also with random one-time sporadic triggers. □

Earl N. Powers is president of Data Display Systems, Inc. He received his B.E.E. in 1956 from the Univ. of Pennsylvania and his M.S.E.E. in 1958 from the Univ. of Delaware. Powers has several patents pending in digital instrumentation and has authored several papers.

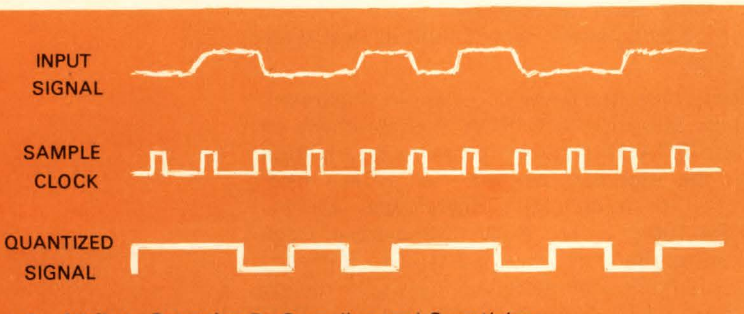
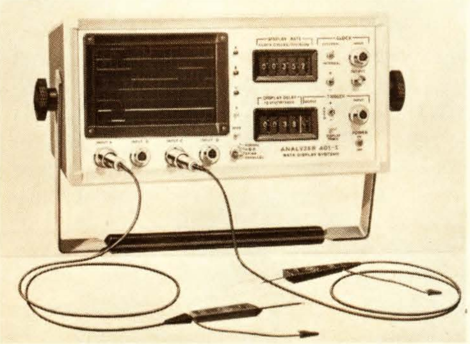
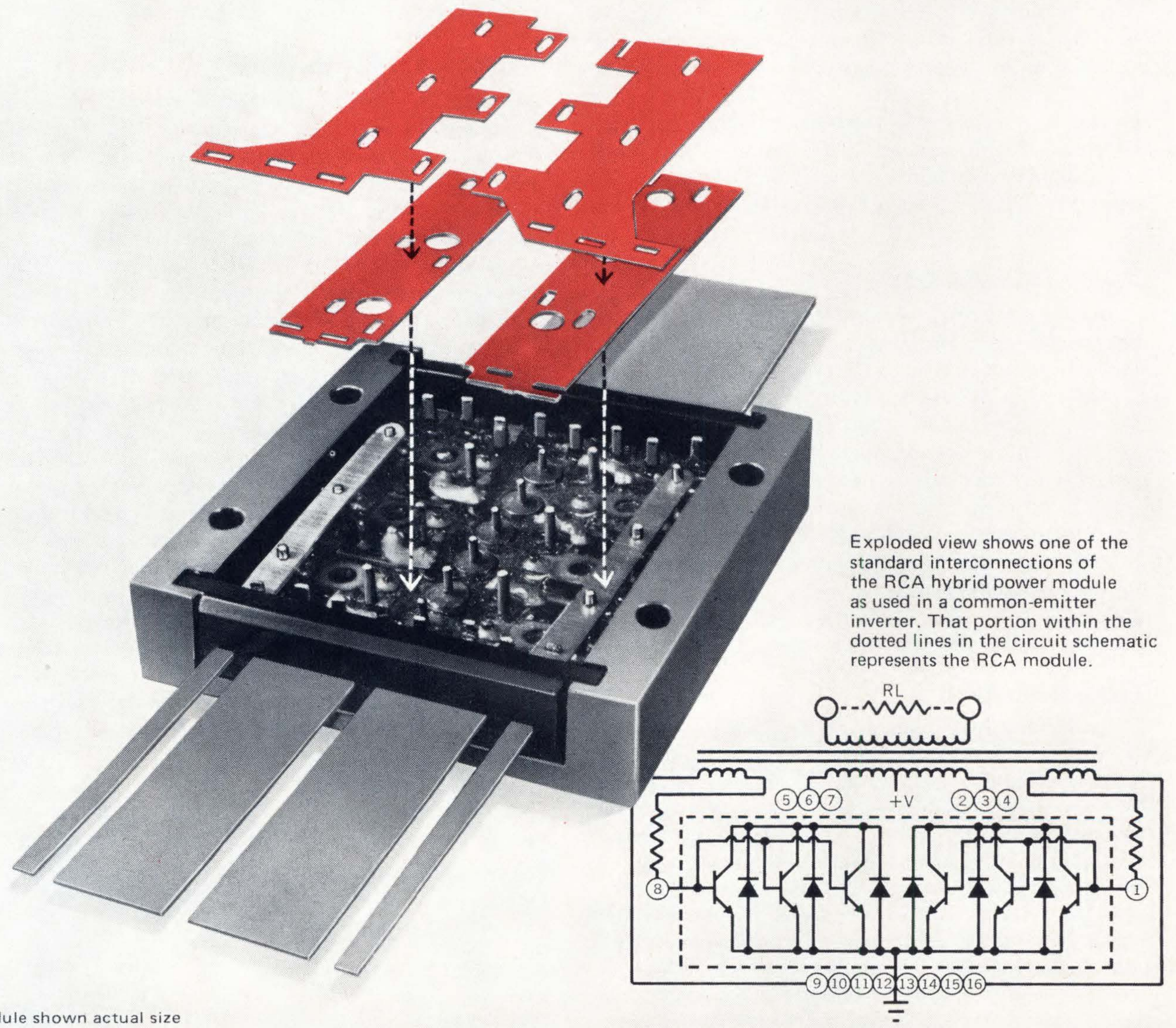


Fig. 2—**Attribute Detection** By Sampling and Quantizing



FOR A FREE REPRINT OF THIS ARTICLE, **CIRCLE NO. L62**

Introducing... A New Modular Concept in RCA Hybrid Power Circuits



Exploded view shows one of the standard interconnections of the RCA hybrid power module as used in a common-emitter inverter. That portion within the dotted lines in the circuit schematic represents the RCA module.

Module shown actual size

Take RCA transistor chips with current capabilities up to 80 A, rectifiers with peak currents to 80 A, and resistors to 10 watts. Interconnect them – in any number of ways. What do you get? A power capability up to 800 W, current capability up to 300 A!

Right now, RCA is mass-assembling a variety of thick-film hybrid high-power arrays that are ideal for switching and amplifier applications in military and industrial equipment. Modules are also available in unconnected versions, if you prefer to create your own design.

These hybrid power circuits offer obvious power circuit advantages, including: compactness, light weight, fewer parts, minimum assembly costs, factory-selected and matched components, and efficient built-in heat dissipation.

Look over the inverter example illustrated. Then call your local RCA Representative or your RCA Distributor for more information on the modular concept. For RCA's new, detailed brochure, "High-Power Arrays" (HPA-100), write: RCA, Commercial Engineering, Section 50L-15 / UC2R, Harrison, N.J. 07029. International, RCA, 2-4 rue du Liévre, 1227 Geneva, Switzerland, or P.O. Box 112, Hong Kong.

RCA

CIRCLE NO. 16

Diode Provides Low-Distortion Amplitude Modulation

One of the oldest ways of modulating a carrier—simple diode modulation—delivers excellent results when used for high-percentage modulation at low signal levels.

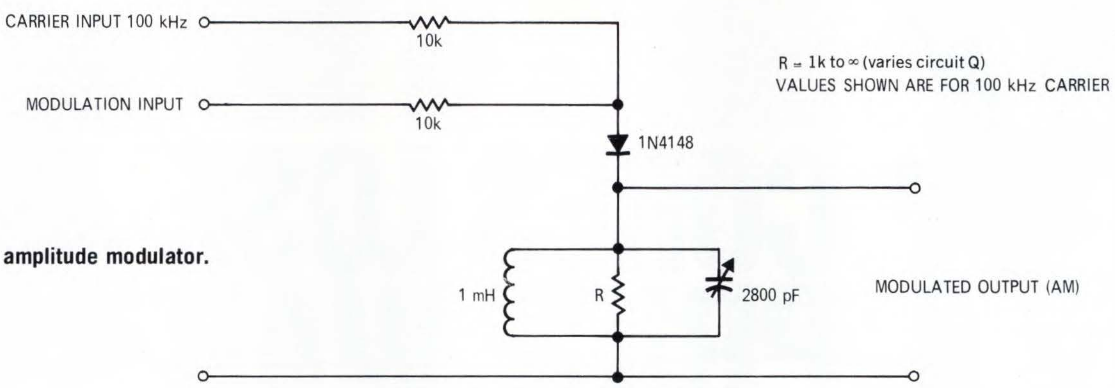
DAROLD K. SMITH, General Dynamics

A simple, inexpensive modulator was required that would yield low-distortion at up to 95% modulation by a triangular wave. On all counts the circuit shown performed well.

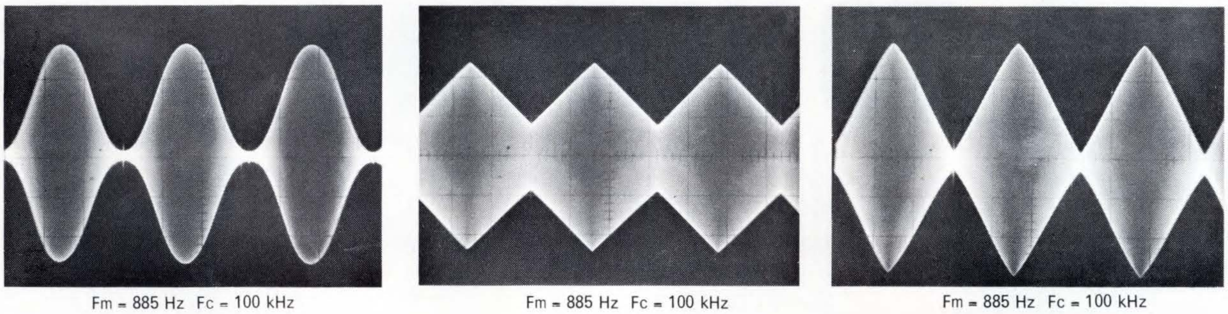
Constants are for a carrier frequency of 100 kHz, but with a suitable tank the circuit will give good results at any frequency at which the diode approximates a good switch. To extend frequency above that for which the IN4148 is suited, a hot-carrier diode can be substituted.

Shunt resistor (R) reduces the tank circuit Q enough to permit it to handle the triangular-modulated wave without appreciable distortion. Measured carrier harmonic distortion was found to be less than 3% with practical circuit Q. ▭

Darold K. Smith, a senior engineer engaged in circuit design at General Dynamics (Electronics Div.), has been with the company 14 years. He holds a B.S. (Physics) from San Diego State and is a member of IEEE and National Management Assn.



Low-level amplitude modulator.



Modulation envelopes obtained with sine and triangular modulation. Carrier frequency was 100 kHz, modulation frequency 885 Hz.

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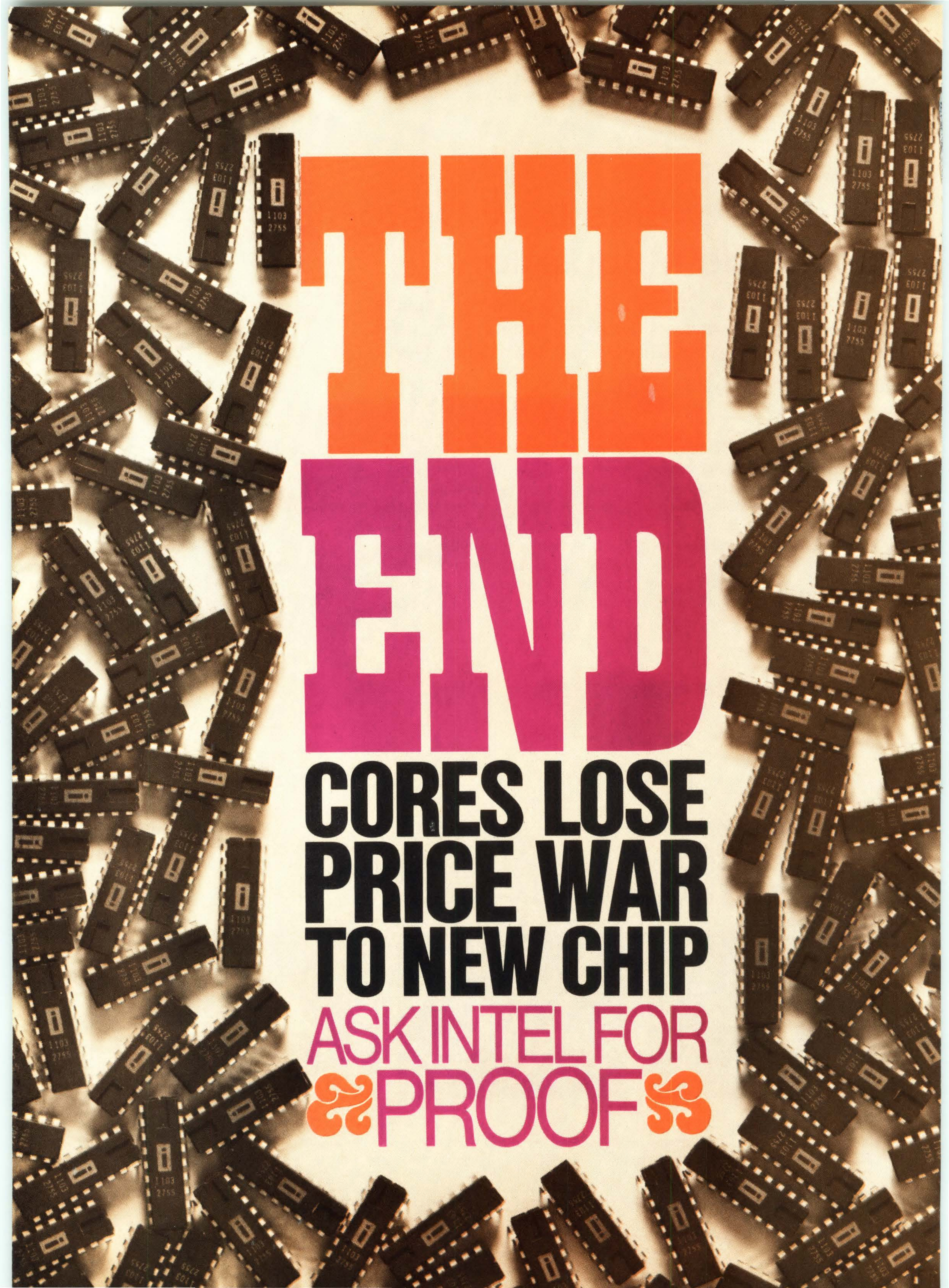
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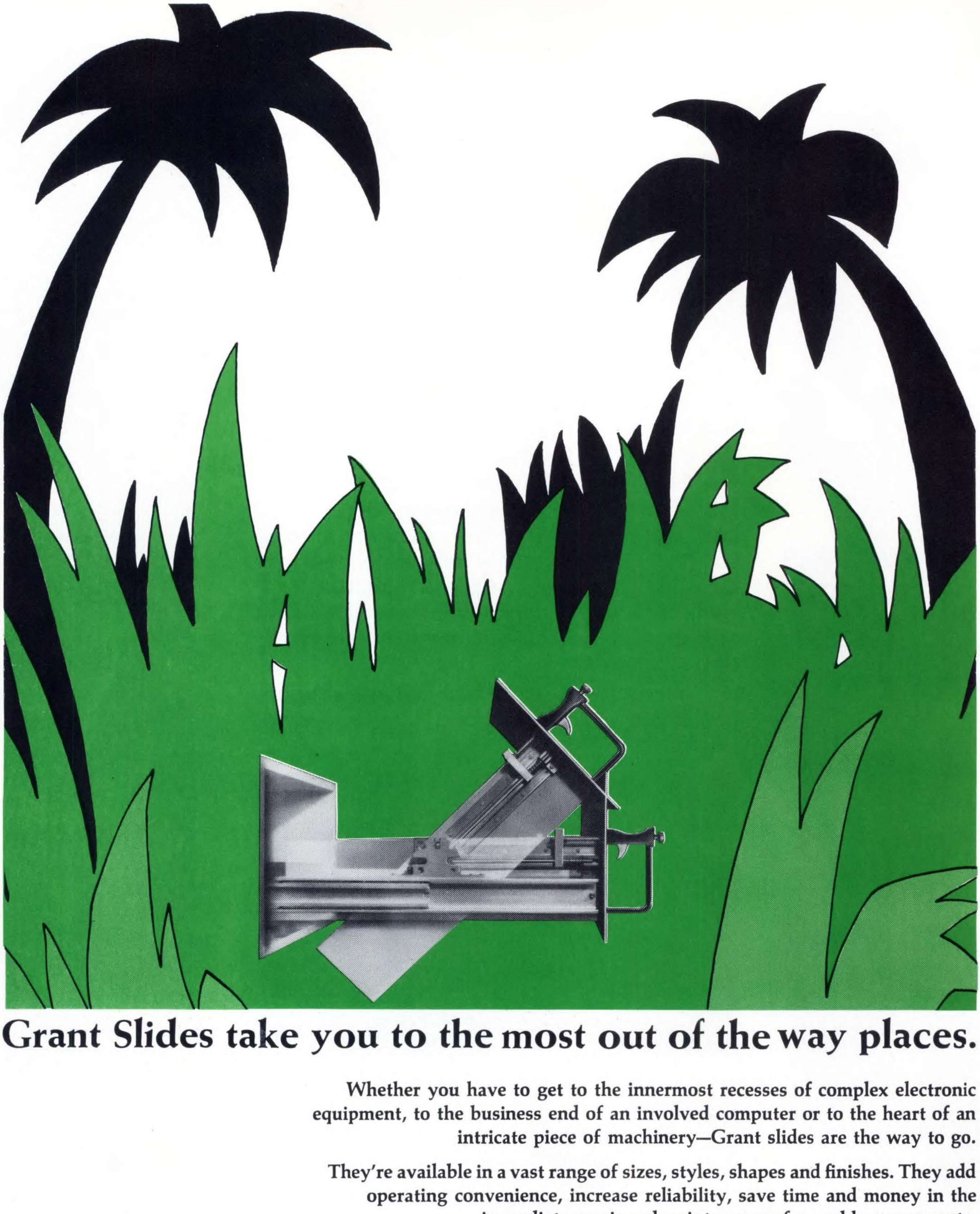

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CIRCLE NO. 18

Bidirectional Crowbar Protects Logic

Low-cost life insurance for your expensive logic.

DAVID L. SPORRE, Singer-General Precision

While simple, this bidirectional triac crowbar promises digital logic a long, zap-free life. It can handle a 5A constant load and is suitable for use with almost any logic system. Operating time is <1 μs.

Most TTL and DTL logic uses +5V as V_{cc}. Also, most logic can withstand, without damage, +6V or even more for fairly extended periods of time. This crowbar can readily be set to insure that positive voltages greater than 6V and negative excursions greater than 1.5V will not get to the logic. Its major component, the triac, sells for about $5, so the total component cost is very reasonable.

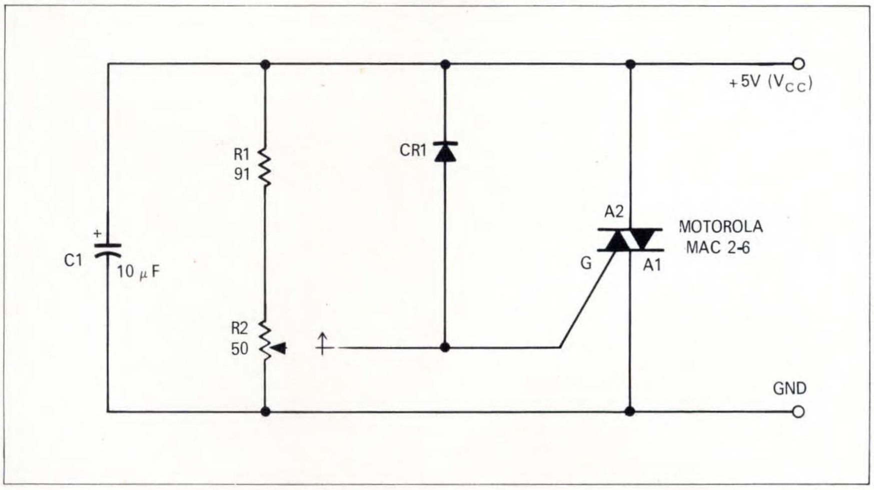
Operation. The gate trigger voltage of most triacs is between 0.6 and 1.5V. The circuit shown, when connected across a +5V V_{cc} logic supply, applies an adjustable portion of the supply voltage as the gate trigger for its triac. When this portion equals the gate threshold voltage, the triac fires and pulls V_{cc} down to less than +1.5 V. The triac also acts to limit negative excursions, for any negative transient that exceeds the triac's firing voltage will pass through diode CR1, firing the triac.

Adjusting Operating Point. To adjust the circuit for any one particular triac, first turn R2 fully counterclockwise, set V_{cc} at +5V and connect a suitable voltmeter between the triac gate lead and ground. Then, while observing the voltmeter, slowly turn R2 clockwise until the triac fires. Note the voltmeter reading at which this occurs. Immediately turn off the V_{cc} supply and reset R2 fully counterclockwise. The reading you noted should lie somewhere between 0.6 and 1.5V. If it is near 0.6V, turn V_{cc} back on and adjust R2 for a reading of 100 mV less than the noted reading. The circuit is now ready to protect your logic. (For firing voltages much above 0.6V, the voltage margin should be increased to compensate for the sensitivity increase that occurs when R2 is set more clockwise. The arm position for 0.6V applies about 12% of any changes in V_{cc} to the triac gate. This percentage increases to about 20% for 1.0V firing and to about 28% for 1.5V firing.)

Precautions. Aside from noting that the gate trigger voltage of individual triacs may fall between 0.6 and 1.5V, decreasing with increasing temperature, there is the matter of power supply protection. Crowbarring should not be applied without first making sure that the logic supply is designed with the ability to withstand a prolonged short circuit.

Another, perhaps familiar caution is to locate the crowbar circuit as close as possible to the logic to be protected. ▭

When this article was written, **David L. Sporre** was an EE at Singer-General Precision, working on the design of semiautomatic digital test equipment and simulators for the A7D/FB-111 Aircraft. Mr. Sporre is now a computer systems engineer affiliated with the Otis Elevator Co., Reflectone Div.



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It's our gold-doped IM5001. Packaged in a 14-pin DIP, it handles 120 mA per channel with a 20-ns propagation delay. Get it now for $6.50 (100 pcs).

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CIRCLE NO. 19

CUSTOMER ENGINEERING CLINIC

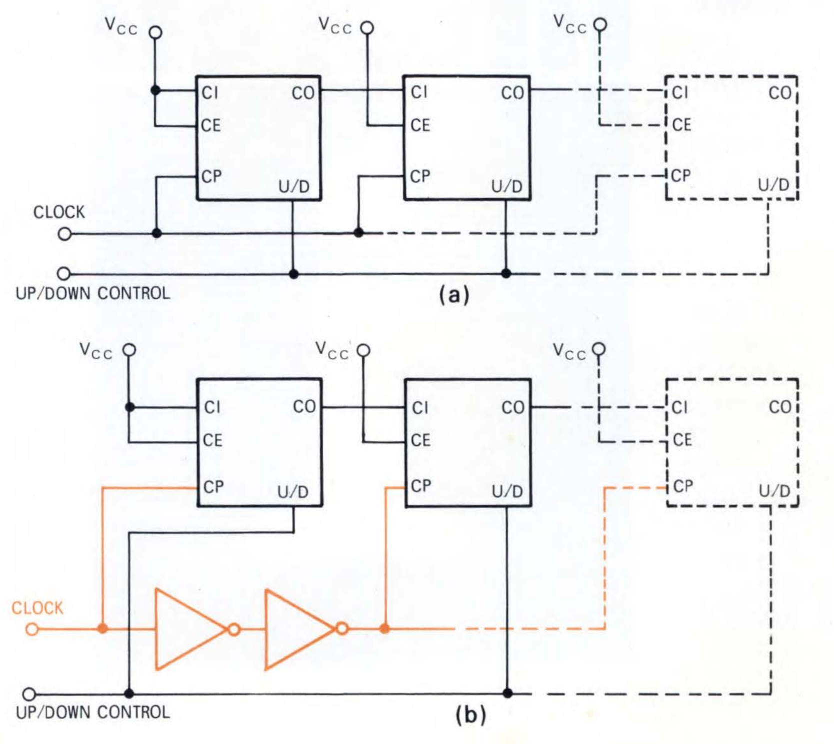
30-MHz Synchronous Counter Is Erratic at 20 MHz

AARON MALL and CHARLES H. DOELLER, III, Bendix Communications Div.

Problem: A chain of 30-MHz up/down MSI counters fails at 20 MHz. The first stage operates normally, but it triggers the second stage erratically.

Discussion: After it had been verified that all power and signal lines were noiseless and all components functioned properly, the carry-out signal from the first stage was identified as the culprit. This is the signal that allows the next clock pulse to advance the second counter. Careful investigation showed that this pulse was delayed 40 ns from the active edge of the clock, 5 ns more than nominal. This left just 10 ns setup time for the second counter, 5 ns less than the specified setup time.

Solution: Delaying the clock input to the second counter with a pair of logic gates, circuit (**b**), allows the counter to operate properly. Specifications indicate that these counters operate at a minimum frequency of 20 to 30 MHz typically. In practice however, the clock input to all elements beyond the first may have to be delayed. ▭



Synchronous up/down counter (**a**) fails at 20 MHz. Addition of two gate delays, as in (**b**), allows clock to occur after carry out (CO) from preceding stage has set up.

EDN will pay $50 for any problem-solution article accepted for publication.

NEXT ISSUE'S PROBLEM

'Don't Forget Magnetic Blowout'

Switching inductive loads can be hard on relay contacts. If pitted relay contacts plague you—then maybe it's time to "magnetically blow out" those switching transients.

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computer hardware

FOR DESIGNERS OF COMPUTER MAINFRAMES, PERIPHERALS AND SYSTEMS

A CAHNERS PUBLICATION / DECEMBER 15, 1970

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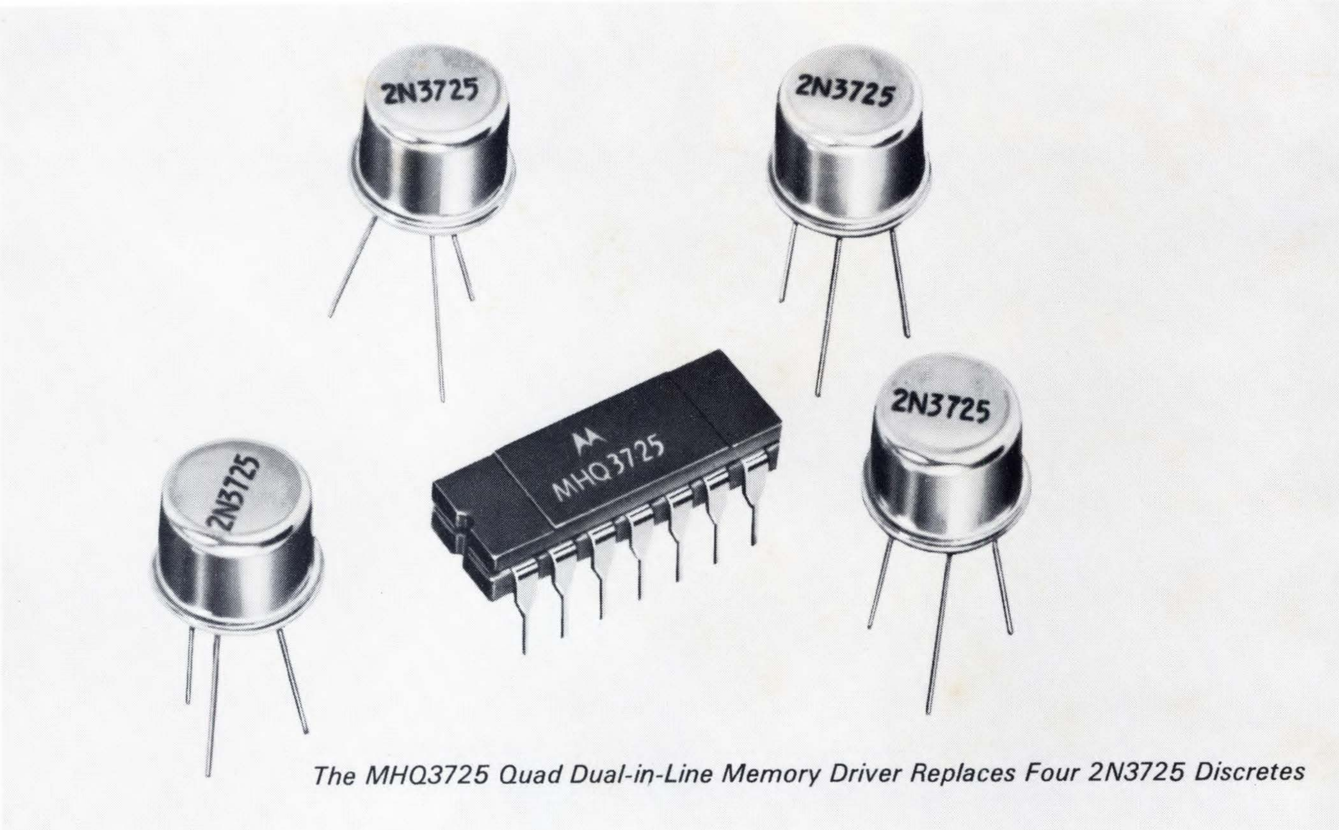

The MHQ3725 Quad Dual-in-Line Memory Driver Replaces Four 2N3725 Discretes

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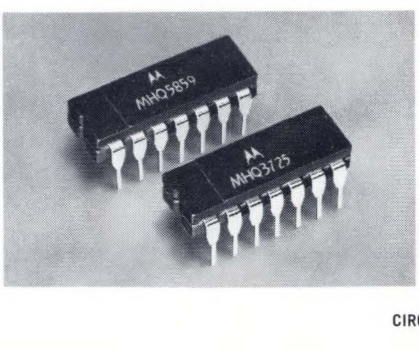
CERAMIC TO-116 PACKAGE (CASE 632)



SPECIFICATION HIGHLIGHTS and PRICES*

Characteristic	MHQ3725	MHQ5859
BV_{CEO} @ 10 mA	50 V (min)	40 V (min)
h_{FE} @ 500 mA/1 V	35 (min)	35 (min)
h_{FE} @ 1 amp/5 V	25 (min)	25 (min)
$V_{CE(S)}$ @ 500 mA/50 mA	.52 V (max)	.52 V (max)
t_{on}	35 ns (max)	35 ns (max)
t_{off}	60 ns (max)	65 ns (max)
P_D @ $T_C = 25°C$	4 W	4 W
Price Quantities	**Prices per Unit**	
1 — 99	$6.85	$5.50
100 — 999	5.95	4.75

The foregoing is only a part of the Quad Memory Driver, bargain-driving story. Get all the fascinating facts from your nearest Motorola representative. Or, write us direct: Motorola Semiconductor Products Inc., Box 20912, Phoenix, Arizona 85036.

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CIRCLE NO. 407

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EXCLUSIVELY FOR DESIGNERS OF COMPUTER MAINFRAMES, PERIPHERALS AND SYSTEMS

cover

Cover photo by EDN's Art Director Ray Lewis represents keyboard design article by Chris Clare, HP Palo Alto, on p. 001011.

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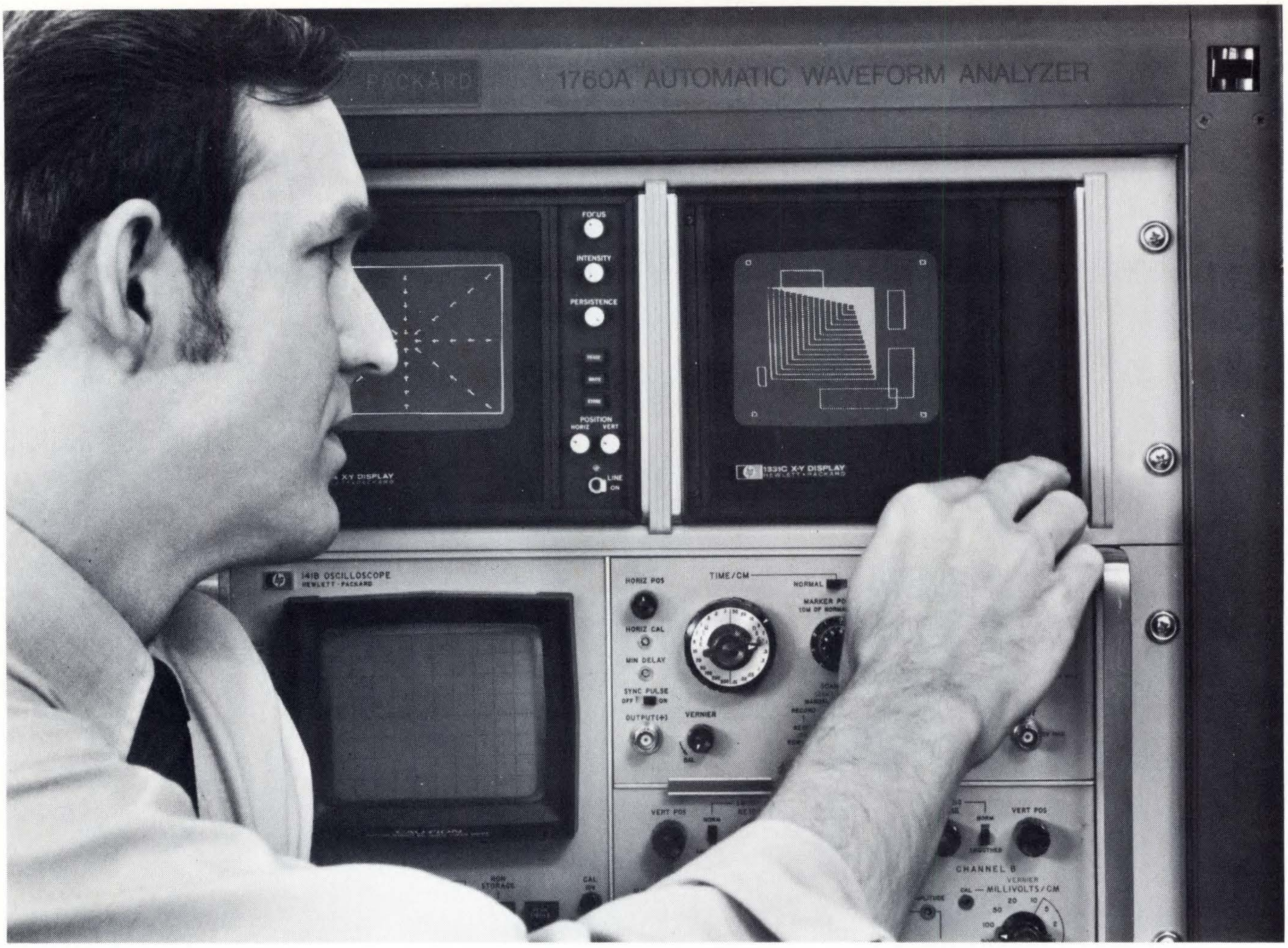


Improve your image — put The Bright Ones in your system

Easy-to-read displays enhance any system, because nobody likes to squint and strain to keep track of what's going on. HP X-Y displays are easy to read. They're brighter than the others, by more than a full order of magnitude. That's why we call them "The Bright Ones."

Our 1331, for instance, displays information at 100 ft-lamberts (as compared to the competition's 3 ft-lamberts), and gives you 1 MHz bandwidth, variable persistence, and flicker-free storage. This latter feature eliminates the need for display refresh in computer-controlled systems, saving valuable processing time.

Display brightness lets you observe data even under the brightest lighting conditions; you don't have to turn your work area into a "darkroom." And the 1331's storage-mesh CRT lets you show information with Z-axis shades of gray—an HP exclusive.

The 1331 takes up only one half of a standard-width systems rack, and is available in two versions. The 1331A has front-panel controls; the 1331C, a programmable version, has the controls and programming input connector in the rear.

Price of the 1331A or 1331C is only $1575, with OEM discounts available. For applications where variable persistence and storage capability are not required, we offer the 1330A. It costs only $800, with OEM discounts also available.

Whether your system will be used for electronic testing, communications work, chemical or nuclear analysis, spectrum analysis, military, aerospace, commercial, medical or educational applications, one of HP's "Bright Ones" can help solve your display problems.

For further information on these and other HP X-Y displays, contact your local HP field engineer, or write to Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

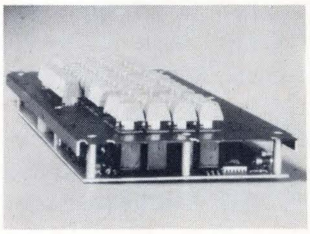
CIRCLE NO. 401

081/2

HEWLETT hp PACKARD

OSCILLOSCOPE SYSTEMS

reduce development cost; borrow a keyboard—



At times, the cost of a keyboard can be prohibitive to users who are in R&D or want a prototype model to check interface. This cost for a one-time effort includes breadboarding, packaging, tooling and engineering. Consequently, the user either pays the price or has to settle for a standard unit that may not meet his requirements.

To help reduce development cost, Cherry Electrical Products Corp. of Highland Park, Ill. offers electronic keyboards to designers who have the option of having the factory do the encoding to their specifications or performing their own. Nonvariables are hard wired and variables have wire-wrapped or termi-point contacts to allow for encoding selection.

computers no bigger than a telephone—

Now there is a computer smaller than a telephone, so rugged that it can be tossed from a building and still run. Using a proprietary packaging technique called PLANAR COAX, Bunker-Ramo Corp., Electronic Systems Div., has reduced an entire computer mainframe, with thousands of interconnections, into what is believed to be the smallest space yet. And the company pointed out that the computer, despite its tiny size, has capability equivalent to many of today's computers that are larger than file cabinets.

This computer, the BR-1018, consists of modules the size of a bar of soap and it weighs less than 10 lb. A random-code generator with 12 IC flatpacks is packaged into less than 1 in^3 and weighs about 2 oz. Twenty flat packs make up a programmable counter in less than 1 in^3. Plated wire and semiconductor memories also are being developed, with the latter permitting a 300 kilobit memory in a cube about 2 in on a side. "We're not far from seeing this kind of computer in machine shops and other industrial plants, in automobiles, airplanes and other general applications," says Ralph S. LaMontagne, vice president and group executive of Bunker-Ramo's Government Systems Group.

memories on loan—

Memory systems designers can now borrow memories from Corning Glass Works to study their memory requirements. The move is designed to overcome a "low-cost-per-bit syndrome" in memory purchase.

"Memory selection," says Charles A. Bashore, sales manager for Corning memory products, "is usually made by determining the memory's technical requirements and then buying the unit with the lowest cost per bit, which generally ranges from one to three cents." Bashore noted that, although other memory technologies offer components with more attractive per-bit costs, additional engineering, assembly and testing are needed for these components to become functional memories.

Because glass memory modules are fully assembled and tested, their purchase price in small quantities is proportionately high—often high enough to discourage the purchase of prototype models in the design stage. To overcome this initial purchasing hurdle, Corning will loan memory modules for up to 2 months to selected design engineers with memory requirements.

walk-in design—

Mt. View, Calif., and Burlington, Mass., will be the first two locations to offer Applicon's computer-aided IC design system to companies on a pay-as-used basis. The Applicon system, called "Design Assistant" (see EDN, Sept. 1, 1970 p. 18), enables MSI/LSI circuit designers to shorten their design cycle from months to hours.

Photomask artwork for up to 16 drawings of a composite is made directly from data provided by the system. The centers are being staffed to allow both major suppliers and small companies or OEMs with limited needs to take advantage of the design system.

conductive elastomers improve keyboards—

Two new similar but dissimilar approaches to keyboard design have not only reduced total height to as little as 1/8", but also provide long-life low-cost switches. These approaches are similar in that they both use conductive elastomers as the contact closure device, but there the similarities end.

Flex Key Corp., Waltham, Mass., makes the lowest profile and simplest keyboard. It is simply a series of N.O. switches. Physical switch contacts are plated conductors on a PC board as shown in **Fig. 1**. Contact closure is made by pressing conductive elastomer against the conductor area, thus shorting adjacent fingers. Flex-Key uses a carbon filled elastomer whose resulting contact resistance varies with pressure, from 200Ω max at 2.5 oz pressure to 30Ω at 10 oz. The contracting membrane is self-wiping by means of stretching in a hemispherical shape, thereby breaking any oxide film each time a button is pressed. Typical key travel is .020 in, open resistance is infinite, and power capabilities are 200 mW at 150V. It is directly compatible with DTL, TTL, and MOS logic interfaces, has an operating temp. range of −10° to +125°F, and a claimed life of over 50 million operations. Keyboards can be made in any pattern and shape desired and the one-piece silicone keyboard surface makes the entire keyboard virtually waterproof to any type of liquid "spills".

Chomerics, Inc., Woburn, Mass., takes a completely different approach. Its keyboard height is just under 1 in with half this height above the mounting surface. Chomerics provides direct BCD coded outputs of up to 16 bits per key in a snap-action switch. They believe the latter is necessary, especially

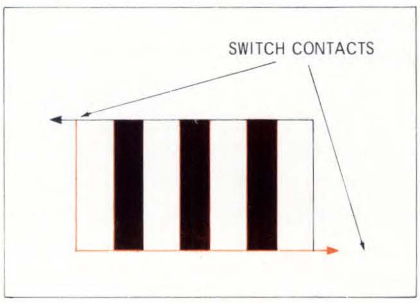


Fig. 1—**Switch contacts** are closed as conductive membrane contacts and thus shorts adjacent conductors.

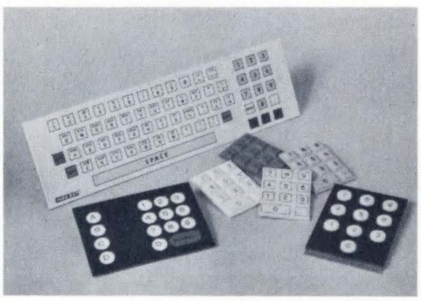


Fig. 2—**Variety of keyboard** configurations include raised, depressed, and continuous flush surface.

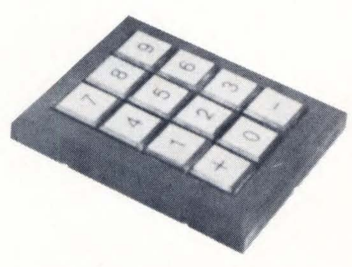


Fig. 4—**Basic keyboard shape.** Plug-in modules in vertical groups of 4 buttons will be available soon.

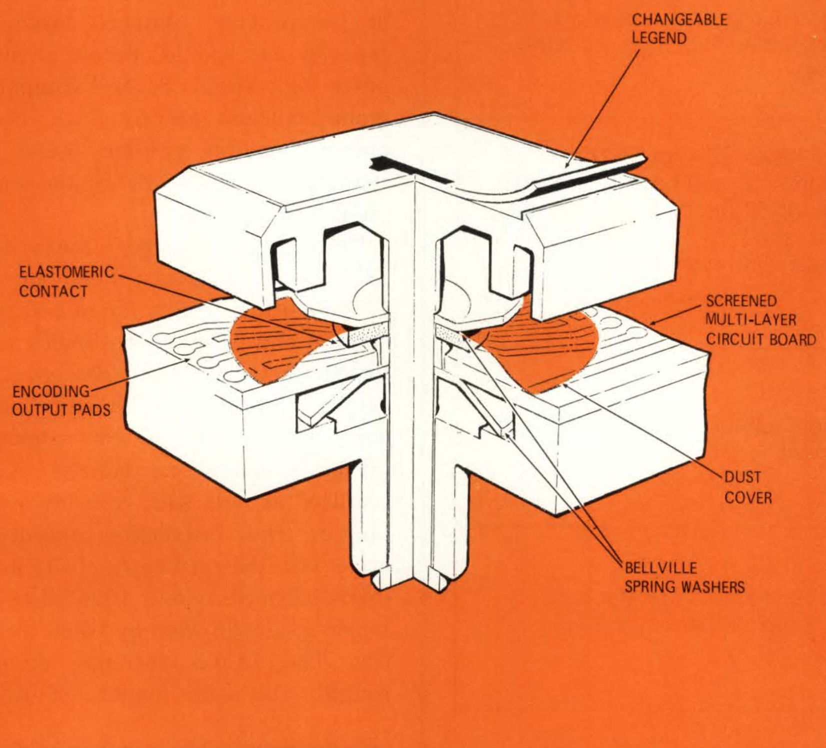


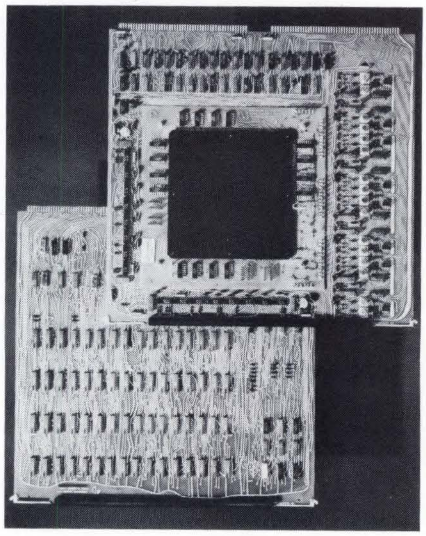
Fig. 3—**Encoded switch construction.** All parts are non-metallic including spring washers and multi-layer circuit board. Breaks in conductors show coding scheme for binary '0'.

for applications where tactile feedback is the only indication that switch contact has actually been made. Switch construction diagram in **Fig. 3** shows basic switch operation and is all plastic. Even the circuit board is screened with a silver-filled acrylic in lieu of a more expensive copper-clad PC board. When a key is depressed, the elastomeric contact essentially closes a 16 pole N.O. switch simply by shorting conductors. Binary '0' is obtained by leaving a gap in the particular screened conductor so that switch closure will have no effect on this individual output. Since Chomerics uses silver-plated copper particles in their elastomer, contact resistance is a constant 50Ω at 2 oz pressure. These switches are also self-wiping by means of silver-plated particles breaking through any oxide film as the key is depressed. Key travel is .080 in (including .050 overtravel). Contact rating is 40 mA at 30V max, and operating temp. range is −55° to +125°C. Switches have been tested to over 5 million bounceless, noiseless operations, and keyboards can be supplied in various physical and electrical configurations, including custom coding.

SEMICONDUCTORS: safe bet for

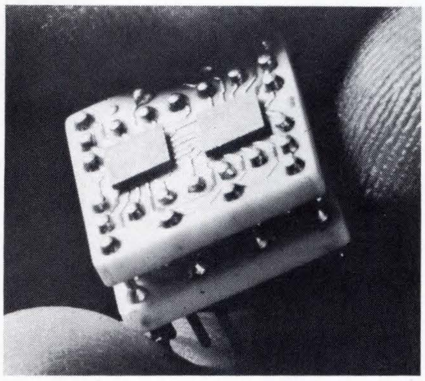
Ideally, a mainframe memory should be inexpensive, compact, large in capacity and should operate at computer logic speed. Several computer manufacturers recently have introduced computer systems based on the latest technology in LSI and semiconductor memories.

Data General Corp.'s "Supernova SC" computer takes full advantage of monolithic devices for mainframe storage and executes arithmetic and logical instructions in 300 ns. The central processor uses the non-destructive nature of the semiconductor memory (no rewrite cycle required as it is with core) by overlapping the instruction execution cycle with the read cycle of the next instruction. Sixty-four 1024-bit chips make up a 4096-word by 16-bit memory. The 18-pin packages occupy roughly the same amount of board



"Supernova SC" semiconductor memory (bottom board) uses sixty-four 1024-bit chips (Intel's 1103) with associated circuitry. A complete 4096-word by 16-bit 300-ns memory is mounted on a 15- by 15-in board. Top board is 4K by 16-bit core memory for "Nova" 1200 and 800.

mainframe storage —



Main memory of IBM System/370 Model 145 uses two chips mounted back-to-back per memory module. Each 1/8-in^2 chip has 174 complete memory circuits. Double layer modules house four chips. Complete memory system offers users more than a half-million bytes of main storage.

space occupied by a core mat of the same capacity.

At the Fall Joint Computer Conference, Four-Phase Systems unveiled a computer and terminal display system that uses semiconductor memories exclusively. Called System IV/70, it comprises a CPU, semiconductor memory expandable up to 96K bytes, and up to 32 keyboards and CRT terminals. Cycle time for this memory is 1.9μs.

To store data and instructions, the new IBM System/370 Model 145 uses a silicon chip $<1/8$ in^2 with 1434 components in 174 complete circuits including 128 storage cells and 46 support circuits. The 113- by 122-mil chips, fabricated 208 at a time, are on a 2.25-in wafer. Each storage cell is 6.2 by 6.2 mils. Four memory chips are mounted two each on two stacked substrates in an 18-pin module. Each module has a storage capacity of 512-bits.

Memory array modules and support modules are packaged on multilayer pluggable cards in two capacities. One contains 24 memory modules and eight support modules for a capacity of 12,000 bits. The other contains 16 memory modules and eight support modules for a capacity of 8000 bits. Lower capacity memories use the smaller card.

A basic memory unit contains up to six boards each with 36 memory cards and two support cards that provide line termination and additional buffering. A seventh board contains error correction circuits that automatically correct any single-bit errors and detect any double-bit error. Two basic units comprise the maximum capacity of 512,000 bytes.

In Burrough's B7700 system introduced in October, a 16 MHz central processor incorporates an IC memory with a speed of 62.5 ns whose "look ahead" ability virtually eliminates fetch time overhead for program strings. The B7700 accommodates up to eight memory subsystems. Memory modules within a subsystem have a capacity of 786,432 bytes and a speed of 1.5 μs for 24 bytes with four-way phased interleaving.

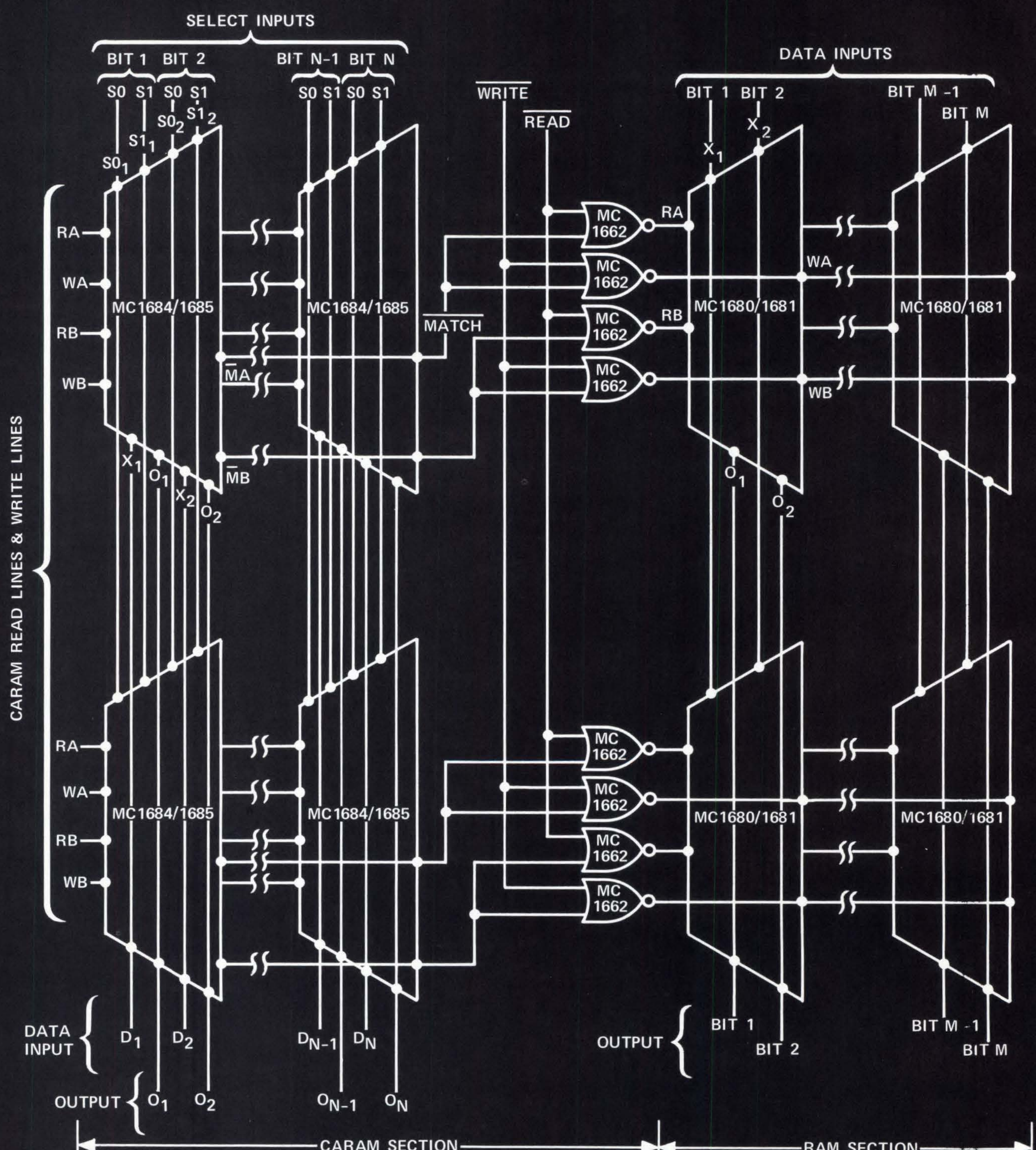
Using semiconductor memories, manufacturers are realizing improved system performance with cost reduction; efficient usage of hardware and simplified software design; and greater capability for transmitting data between main-frame and intermediate storage, thus reducing cost in time-share systems.

standardized memory modules save time and money

In a departure from most other computer manufacturers, RCA, Marlboro, Mass. announced the use of standard memory modules in its new line of computers, RCA 2, 3, 6, 7. Thus the main memories in four different sized computers are identical in design and manufacture and are expandable, switchable and shareable. This leads to lower overall costs and improved performance.

RCA standardized memory modules are constructed as banks containing two identical plug-in modules of 131K 8-bit bytes. These banks can be linked together to expand a main memory to over two million bytes. They can also be manually switched among processors of the same or different models. Since the main memories are switchable, they are also shareable, thereby allowing primary and back-up systems to be different models. The overall result is a more efficient utilization of equipment.

FOR A FLEETING MEMORY . . .



CAM/RAM BUFFER MEMORY

. . . MECL III OFFERS THE FASTEST

Picture a computer with limitless storage capacity and instantaneous retrieval. Impossible? Today, yes — but new technologies are providing more rapid access to data, and performance of high-speed memory functions outside the main storage memory are paving the way to the ideal computer. MECL III now introduces three basic memories to meet state-of-art requirements for high-speed buffers and applications requiring rapid storage and transfer of data.

The MC1684 (High Z)/MC1685 (Low Z) Content Addressable Random Access Memory performs the read-write (scratch-pad) function *plus* the content addressable (interrogate-match) function. In other words, information may be written-in, read-out and the memory may be interrogated to check its contents. Typical read, write and search delays are 2.5-3 ns, 4 ns and 2.5-3 ns, respectively.

The MC1680 (High Z)/MC1681 (Low Z) Random Access Memory is sometimes called a decoded scratch-pad memory. Data can be entered or read out of the memory from either of two words simultaneously. Recommended for ultra-high performance applications, the MC1680/1681 features typical 2.5 ns access times and a write delay of 3 ns. Computer interrogation is speeded through application of the MC1682 (High Z)/MC1683 (Low Z) Content Addressable Memory. Sometimes called an associative memory, the MC1682/1683 features a search (interrogate) delay of 2.5-3 ns and a write delay of 4 ns, both typical values.

As illustrated, the MC1684/1685 CARAM and MC1680/81 combine to form a very high speed buffer memory. When a word is required from the mass storage memory, it is placed in the RAM portion of the buffer for future access. The word's address in mass storage is placed in a content addressable memory tied to the random access section thereby allowing words to be addressed by their mass storage location in one cycle time of the buffer memory.

As the address of the desired word is presented to the content addressable section, the CAM will indicate (in one cycle time) if the address is in the CAM and if the desired word is available in the buffer. If the word is present, the desired read and/or write function can be performed at buffer RAM speeds. If the word is not present it must be brought from the slow mass storage through 'push-down pop-up" techniques. Through the use of the CAM/RAM Buffer Memory, the effective access time is a function of the memory access sequencing and not the mass storage access time.

For further details on these high-speed memories write to Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, Arizona 85036. Evaluation devices are available at your nearby Motorola distributor. MECL III provides the fastest memory functions available today. Design in and THINK FAST!

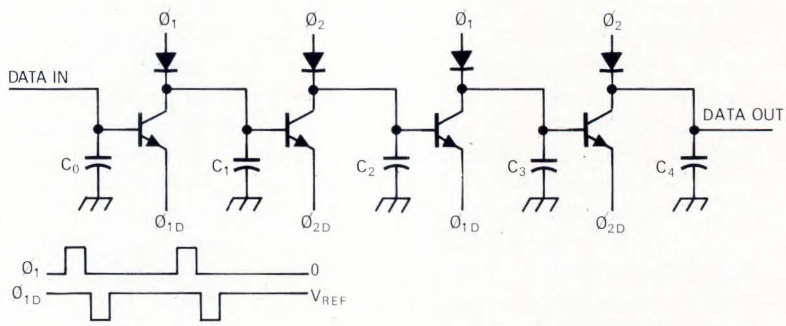
MOTOROLA MECL
the only way to go . . . FASTER

CIRCLE NO. 404

bipolars fight back

Although MOSFET technology dominates the dynamic logic or storage field because of its low cost and great function packing density, a novel bipolar dynamic shift register storage with simplified circuitry, described at NEREM '70 by IBM Components Div., Hopewell Junction, N.Y., is making a strong challenge. Excluding peripheral circuitry, this bipolar shift register consumes an order of magnitude less power per bit per each MHz clockrate ($3\mu W$) and runs at 10 times higher clockrate (10 MHz). Its simplified bipolar technology such as collector-diffusion-isolation (CDI) structure gives the bipolar shift register cell a packing density comparable to MOSFETs, although the individual bipolar transistor is much larger. The CDI structure requires more processing steps than MOS but overall cost of finished devices should be comparable if all testing and packaging costs are considered, says IBM. While the bipolar dynamic shift register operates at higher clock rates and lower power, its signal swing is smaller than FET's.

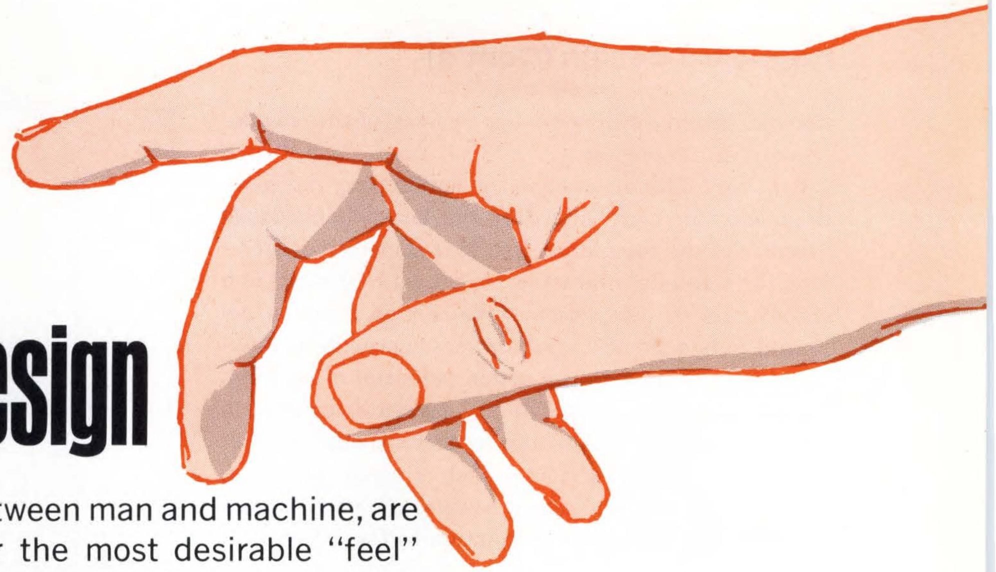
The principle of operation of these bipolar dynamic shift registers is to utilize the state of "with or without" stored charge at the stray or parasitic capacitor (collector-substrate capacitor) to transfer data toward the next cell. By using the bipolar transistor's unilateral characteristics, each logical AND function can be performed by one bipolar transistor as opposed to the two bilateral MOSFETs needed with MOS technology Therefore a single diode-transistor combination can be used as an element or half cell of a bipolar shift register.



Bipolar dynamic shift register. Clocks $\phi 1$ and $\phi 2$ charge capacitors C1, C3, . . . Cn-1, and C2, C4, . . . Cn respectively while clocks $\phi 1D$ and the input data perform an AND function to discharge or not discharge C1. Similarly, clock $\phi 2D$ with appropriate timing and the stored charge at C1 performs an AND function to charge or not discharge C2. Thus, data at CO is transferred one cell toward C2 in one cycle of four clocks. $\phi 1$ and $\phi 2$ clock amplitudes are controlled so there will be sufficient transient current to charge the parasitic capacitors within a reasonable pulse width, but with effectively no dc current passing through any path. Amplitudes of $\phi 1D$ and $\phi 2D$ are controlled so that they cannot turn on the transistor of any element by themselves unless its base is up representing logical "1".

CHRISTOPHER R. CLARE, Hewlett-Packard Co.

human factors in keyboard design



Keyboards, the interface between man and machine, are subject to controversy over the most desirable "feel" and the resulting design. For the first time, some first-order approximations have been made on the interplay of touch and kinesthetic sense. These yield some interesting results, verified by actual measurements.

Designing a keyboard calls for solutions in two separate areas: 1) the mechanical set of motions, pressures and general "feel" that constitute a selection of one particular key, and 2) the electrical array that detects, converts or generates a distinct code for each key selected.

The technology that can applied to the latter is quite sophisticated. Little or nothing has been done to analyze the former, however. This may be because the subject is highly complex, subjective and almost infinitely variable. Acknowledging this, there are still several basic conditions that we can use to standardize many of these human factors.

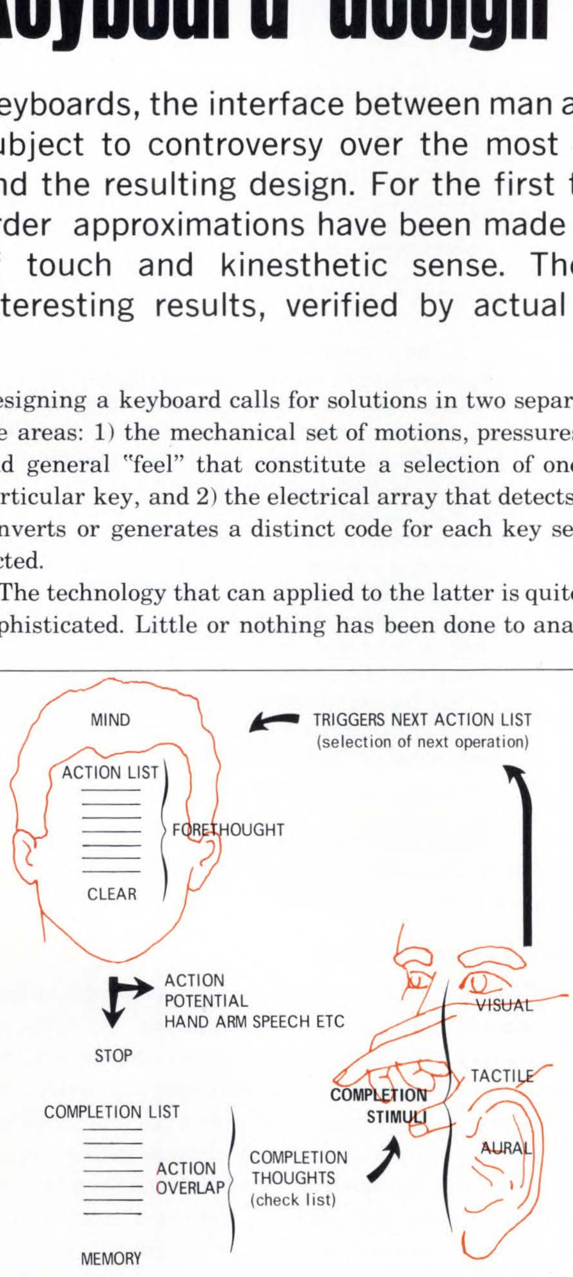


Fig. 1—**The Interactive Process of Sequential Selection.**

From the user's viewpoint, the "best" keyboard allows him to select the next operation from some number of possibilities and gives him some positive, yet natural signal that his selection has been made. Man, an adaptive being, learns to associate a wide variety of stimuli with a particular signal. While any stimulus can be recognized as the completion of an operation, practical bounds are set by the requirement that the interactive process of man and selection be natural.

Lower Bound—The stimulus must be strong enough so that the learning process is rapid and so that stimuli are easily detected (high signal-to-noise).

Upper Bound—The stimulus must not be so strong that it causes discomfort or distraction, or that it overpowers the action potential of the selection.

Thus, a switch or key should have tactile feedback that can be felt but not so strong as to pound on the end of the finger. Although these two bounds are based on human reaction, they are nevertheless measurable. In general, the learning process is helped by a stronger signal. Therefore, the most desirable completion stimulus is one that is as strong as comfortable.

Process of Sequential Selection

Figure 1 sketches the order in which the process of key selection takes place. Note that once an action has been initiated, the *action potential* for the next selec-

(Continued)

Keyboard design (Cont'd)

tion exists and awaits only one or more of the completion stimuli to trigger it.

It is very difficult to have the action potential more than one full cycle ahead of the last acknowledged member of the completion list. It is imperative, therefore, for a speedy interaction, to provide a distinct and closely related completion signal for each action potential. When pushed, a button should provide a stimulus closely related to the action potential of pushing, such as a sudden change in the pressure required to move the button. This tactile feedback should be reinforced by a sound such as a click, ringing, or knock. Some sounds are inadequate because they are not sufficiently time-definitive in relation to the action that initiated them.

Visual completion signals (lights, CRT displays, etc.) are generally unsatisfactory for a number of reasons, but primarily because they are not natural consequences of the tactile action potential of pushing. Man can adapt himself to this kind of stimulus, but it does not seem natural to him.

In summary, the natural or expected consequence of a push is a tactile response, and the most acceptable tactile responses are sudden, well-defined changes in pressure accompanied by an audible signal that is related to the pressure change.

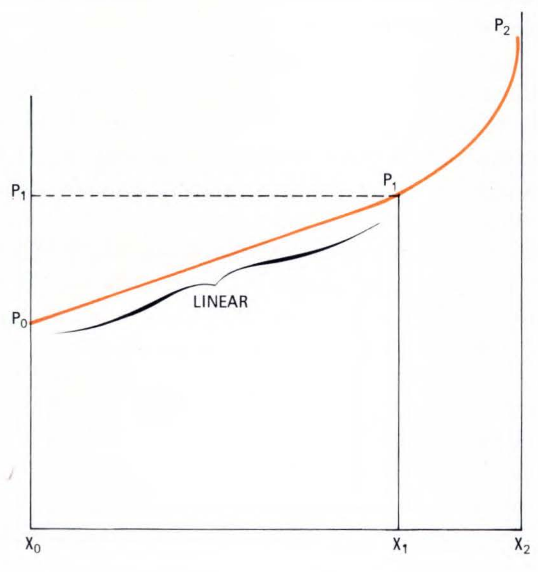


Fig. 2 — **Key Pressure with No Tactile Completion.** P_0 at X_0 is what most people would consider an easy-to-maintain light touch not requiring great care. P_1 at X_1 is what most people would consider a push easy to achieve on all fingers quickly. X_1 to X_0 spacing is determined by the quiver or variation in P_0 such that there is no doubt that point P_1X_1 has been reached. P_2X_2 is simply some high pressure achieved smoothly after P_1X_1.

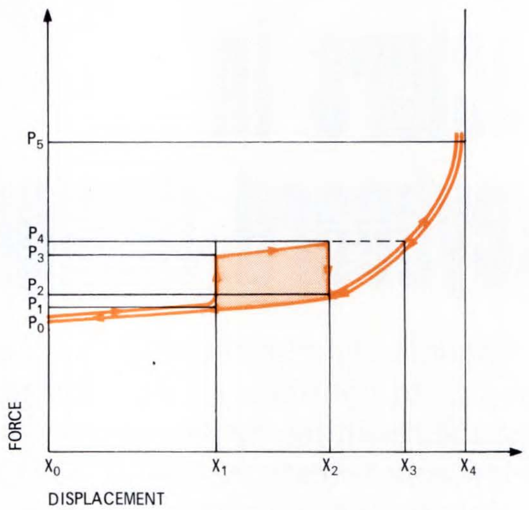


Fig. 3 — **Key Pressure with Complete Tactile Clubs.** P_0X_0 (easy-touch) — point at which the key begins to move. P_1X_1 (pre-travel) — distance of relatively easy force required to develop a good touch without any actuation. P_3X_1, (set) — point of pressure increase indicating that the actuation is approaching. P_4X_2 (actuation) — sudden drop in force indicating completion. P_4X_3 (overshoot) — point beyond actuation at the same pressure as actuation where the finger tends to fall after actuation. P_5X_4 (over travel) — distance beyond X_3 where the pressure smoothly increases to a positive stop at X_4. P_2X_2 (hysteresis) — from point of actuation upon return key travels smoothly to P_0X_0 forming a hysteresis loop between X_1 and X_2. The key cannot be actuated again until X_1 is passed.

Motion and Force

Newton's First Law is a formal statement of one of mankind's most natural assumptions. To state that, "for every action, there is an equal and opposite reaction" is to say in terms of human experience that one of two things will happen if you push on something. Either it will resist the applied force increasingly, or it will resist it up to a certain point and then give way. In either case, the "learning" nature of man soon prepares him to anticipate the object's reaction to his applied force. Under this condition, the anticipated reaction becomes the signal to go on to the next set of actions.

This particular aspect of human behavior can be applied advantageously to the design of a set of actuator buttons or keys. At first glance, it would seem that a key that showed a linear increase in resistance with increasing pressure (**Fig. 2**) would prove popular.

Such an action has no tactile feedback at all, however, and, unless some other stimulus is provided, an operator would have no idea how hard or far to push the key to complete the actuation cycle.

The "feel" described in **Fig. 3** is a thousand years old and represents the feel of a mechanically-actuated "tracker" pipe organ or a harpsichord keyboard. The master of a keyboard instrument demands the optimum in keyboard feel for fast, positive response. Experience over these many years has resulted in the "feel", even though each key also produces a note or aural feedback. Many organists contend that a tracker organ is far more pleasing to play than an electrically actuated organ whose keys have a smooth indeterminate action like that in **Fig. 2**.

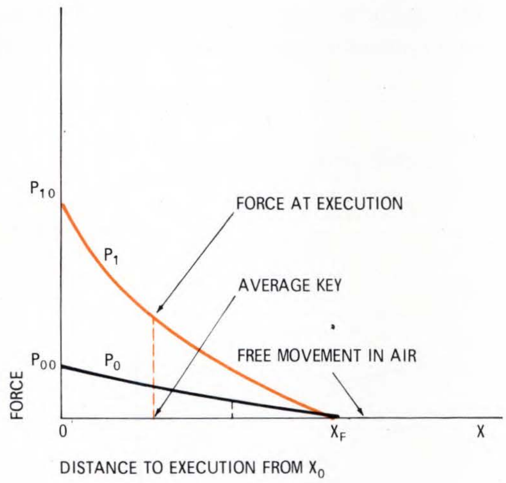


Fig. 4—**Expected Relationship** of force and execution distance for a key with constant level of assurance.

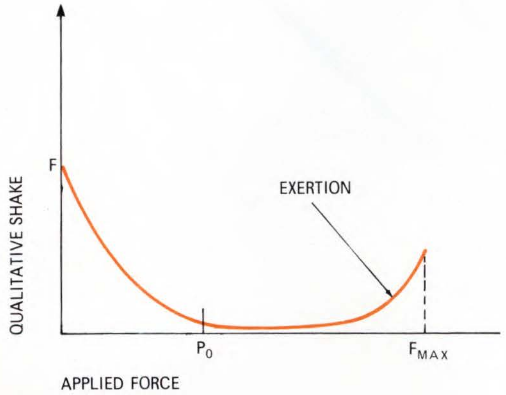


Fig. 5—**Shake and applied force.**

There is little information to determine the relationship between P_4P_0 and the distance X_2. It could be postulated that to achieve the same assurance of operation, P_4P_0 would be less as X_2 increased.

Figure 4 demonstrates the general trend in levels of assurance. To the first order, the pressure P_{00} can be called the "easy touch" sense and P_{10}/P_{00} the static measure of assurance. X_F is the free psychological equivalent of the static measure of assurance, that is, no force, movement only. Further justification of the above curve is seen by looking at the random motion of the hand, quiver, as a function of force on the finger.

In **Fig. 5**, P_0 is represented as the point where qualitative shake decreases to some low value. The amount of shake in the hand and finger depends on the forces on the hand and arm. If the hand and arm extend freely in a horizontal position, then the sources of shake noise, as it could be called, are the shoulder, elbow, wrist and finger. As each of these members is supported, the amount of shake will decrease until it is isolated to the last member, the finger, when the palm of the hand is supported. The amount of force required to move a key that is called an "easy touch" increases as each successive member is supported rigidly. This behavior may seem odd, but, in truth, it is the kinesthetic feedback that explains the action. As each member of the arm is supported, the signal from the finger becomes isolated from joints beyond the point of support, and thus to receive the same total sensation of touch, one of the remaining stimuli must be increased. That stimulus is the force on the finger. This effect may easily be verified by using a simple postal scale to measure finger force. Also note that comfortable touch seems to vary from finger to finger. Closer examination will show that this touch depends more on the force per unit area of contact than on the total force. Even though, by this criterion, keys operated by different fingers should have a different force, P_0, the human can adapt to a slightly greater or slightly less sense of feel, as referred to his index finger.

Area of finger contact to develop the best feel depends on the position of the fingers. For the best kinesthetic feedback, as many joints as possible should be involved in the direction of push. **Figure 6** shows the swing of the fingers, assuming equal angular joint movements. The most comfortable angle for the push

(Continued)

vector is along a line tangent to this curve. This angle is also the angle of strongest push. In any keyboard the operator will adjust the angle of his hand and extension of his fingers to try to push along this curve. To the degree that he cannot readily achieve this correct angle without interference from other keys, table or wrist limitations, he will say that the keyboard is uncomfortable.

Figure 6 is an interesting picture of the motion of the fingers made only from the assumption that kinesthetic feedback is proportional to the angle change of the joints, and that each joint's contribution is independent of the others. Therefore, the maximum kinesthetic feedback will have the maximum effective strength if each angle displacement is the same. Thus, **Fig. 6** which is a plot of equal angular movements of the finger joints, postulates maximum feel for a given motion along the tangent to the curve. **Figure 6** also implies that key motion should be at some particular angle to the plane of the hand for best feel and that for a high-speed operation such as typing, where the fingers move more than the rest of the hand, the keys nearer the operator should move at a different angle than those farther away. If this is not feasible, then different keys should move different distances in the same direction to compensate for the angle disadvantage.

Figure 8 shows some typical angles for a relaxed hand and from **Fig. 6** the angle of most desirable force is shown to be 65° with respect to the arm. Accordingly, if the key action is vertical, the arm should make an angle of 35° with respect to the horizontal plane. However, this angle is more than normally desired. The best compromise for easy location of particular keys is

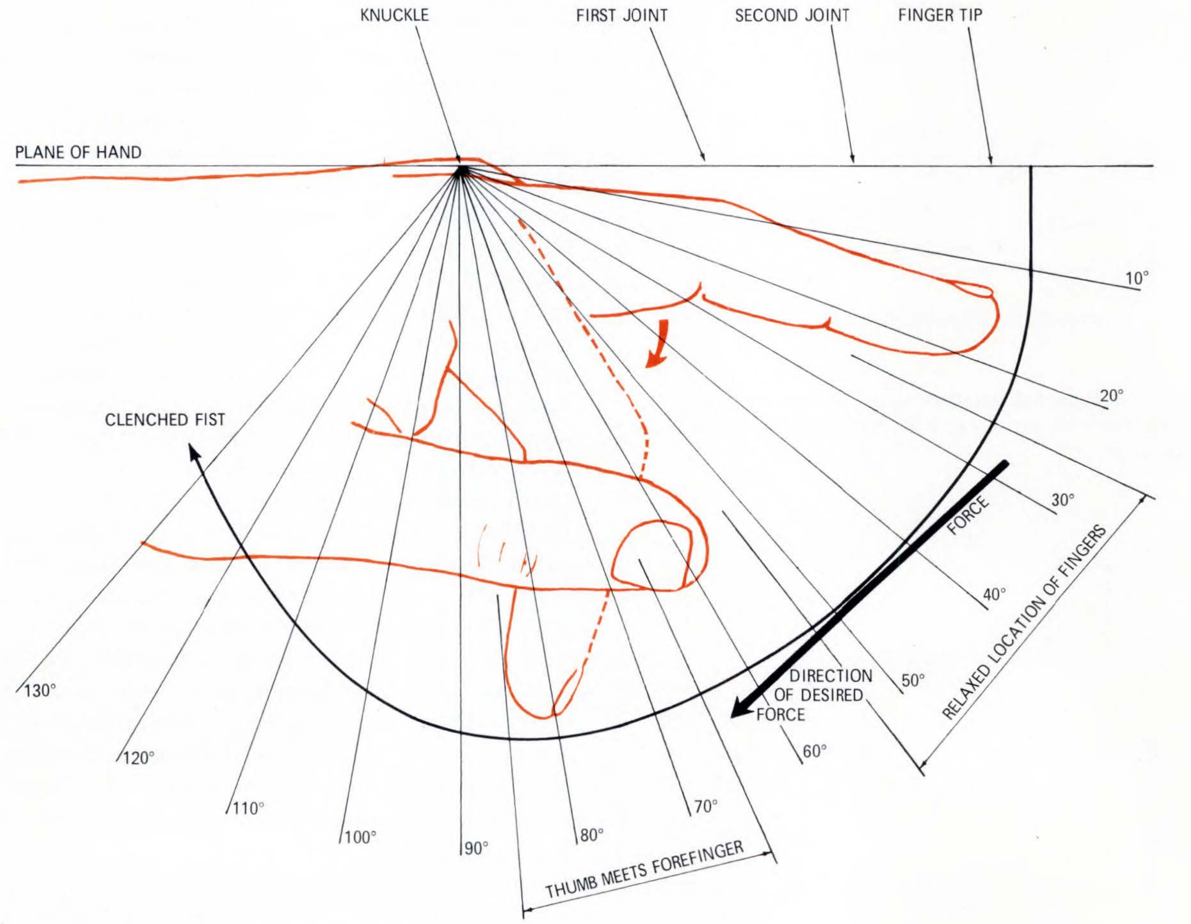


Fig. 6 — **Preferred direction of force** on fingers as a function of finger position relative to knuckle and hand (maximum kinesthetic feedback curve).

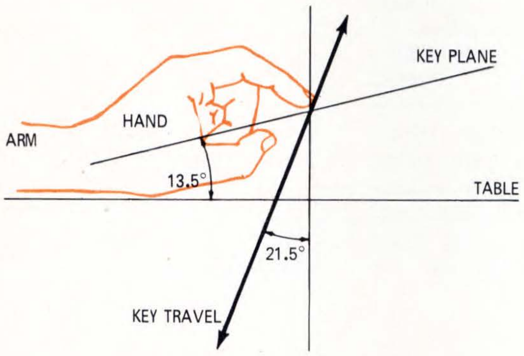


Fig. 7 – **Key travel angle.**

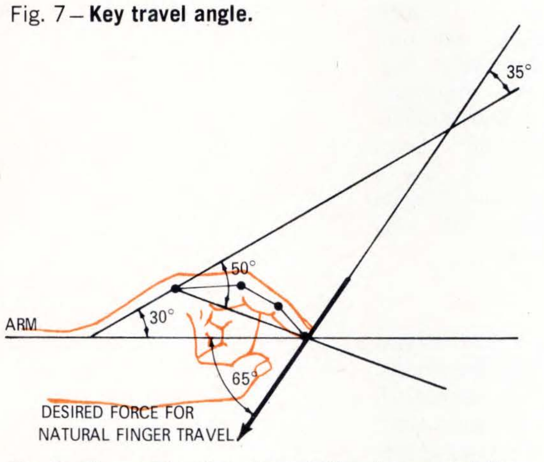


Fig. 8 – **Natural hand angles** relative to arm and the angle of most sensitive force at the hand angles.

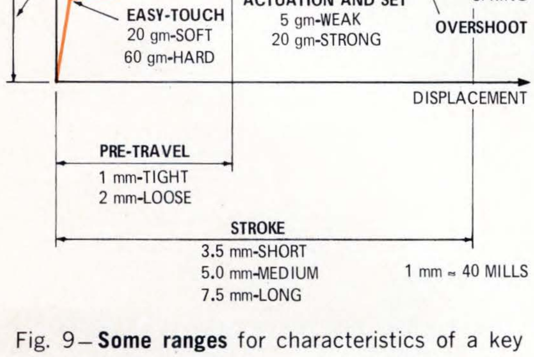


Fig. 9 – **Some ranges** for characteristics of a key with generally good feel.

13.5°. If the arm were parallel to this surface, then the key travel should be 21.5° with respect to the vertical, as in **Fig. 7**.

Correlating Feel With Force-Displacement Curves

A great deal can be learned from a force-displacement curve of a key action. **Figures 10** through **19** are curves taken from real key actions by an accurate measurement system. **Figure 10** is a classic key action depicting all the good qualities of key feel. This key is fairly sensitive and light and is one of the top row keys from the keyboard.

Figure 11 looks like a stretched version of **Fig. 10**. This key was located on the bottom row of keys. The total movement, greater than that of the top-row key, corresponds to the different expected angles of the fingers during their operation. The fingers more likely would be outstretched for the top row keys; and from **Fig. 6** the direction of actuation would probably be almost parallel to the optimum kinesthetic feedback so that a little movement can be felt easily. The bottom key, in contrast, would probably be actuated by the finger tip in a direction almost at right angles to the optimum kinesthetic feedback. Thus, the key has to move farther to give the same apparent feel as the top row keys.

Each of **Figs. 12** through **19** is accompanied by an explanation. From these curves some of the quantities described in **Fig. 3** can be characterized, as shown in **Fig. 9**.

The Keyboard Area

Man is most comfortable in the sitting position with arms and hands supported. He will fatigue most easily with arms outstretched in front or to the sides. He will fatigue less with only forearms outstretched in front. He is also most able to locate controls in this position. Historically, this position has been adopted as optimum for operation of keyboard instruments in general, including piano, organ, typewriter and computer.

Since the angle of the arm is important to the best feel of the keyboard as just shown, the keyboard height with respect to the height of the seat will have to be different for different people. To give the person some reference for this angle, and also to provide a resting place for the hand when not being used, there should be some extension of the keyboard to the side of the array of keys. If movements are made with one hand, the other hand can rest to reduce fatigue. Appropriate rest areas are shown in **Fig. 22**. The plane upon which the hand rests should be slightly lower than the plane of operation, allowing vertical wrist motion.

(Continued)

Keyboard design (Cont'd)

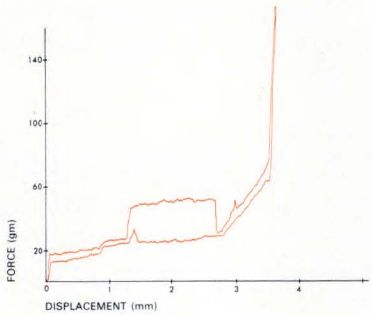


Fig. 10—**A sensitive key** with a light, springy feel and kinesthetic feedback. (IBM Executive Typewriter, △/8 key).

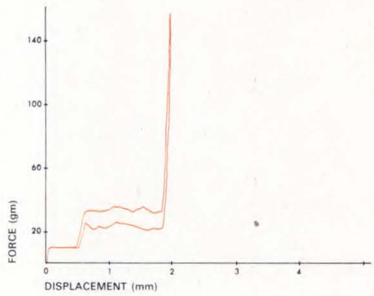


Fig. 15—**Light key,** very sensitive, no tactile feedback, "lumpy". Combination of low force and short stroke makes this touch poor, with insufficient tactile feedback. (NPC Elec. Experimental)

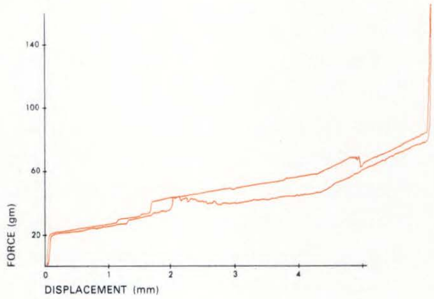


Fig. 11—**Free key** with a light, springy feel and kinesthetic feedback. (IBM Executive Typewriter, =̣ key)

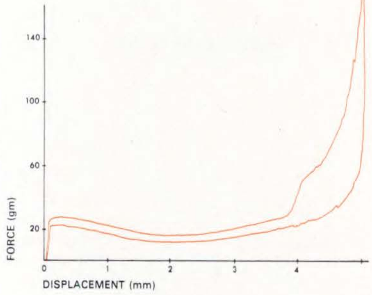


Fig. 16—**"Soggy-feeling" key** with a dead stop. Negative pre-travel slope and no tactile execution clues give this key a soggy feel. (Frieden Model 504 Keyboard)

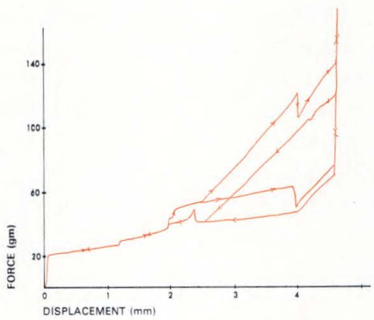


Fig. 12—**Touch variation** for a constant displacement. Does not affect "easy-touch" factor, X_0X_1. (IBM Executive Typewriter)

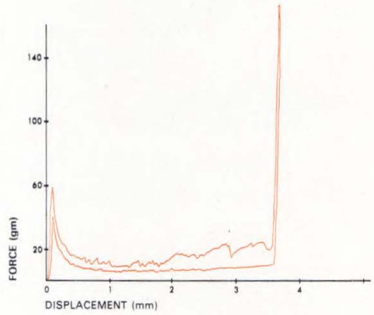


Fig. 17—**"Breakaway" feel,** sloppy. High easy-touch (X_0X_1) and short negative slope pretravel coupled with very low travel force give this key a very sloppy feel. (CRC Experiment—Magnetic Release)

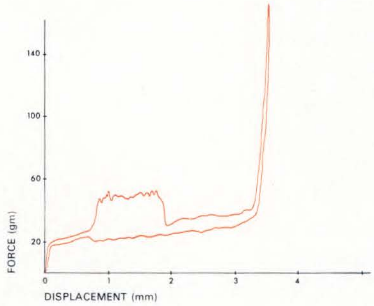


Fig. 13—A relatively "snappy-feeling" key. (IBM Model 29 Keypunch)

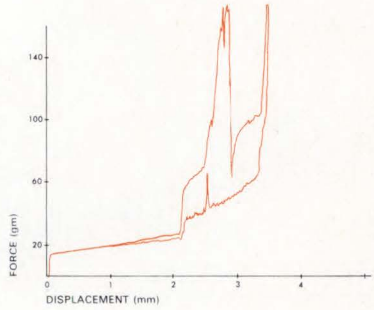


Fig. 18—**"Thumpy" actuation key,** light pre-travel. Actuation force is too high on this key to give a smooth feel. Stroke is long; however, the pre-travel is light and smooth. (ASR 33 Teletype)

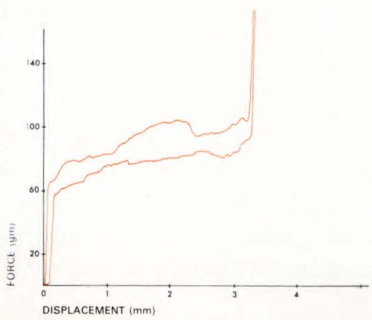


Fig. 14—**Stiff key** with small amount of tactile feedback and friction ending in a hard stop. The high force makes up to some extent for the short stroke. This touch is not particularly good for high speed. (H-P 9100A Calculator)

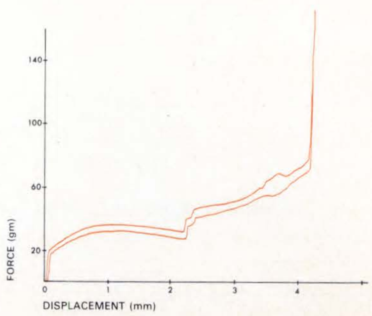


Fig. 19—**Soggy, lumpy,** hard stop touch. This key has many ills as indicated. (Transducer Systems Experimental)

According to **Fig. 21** the keys should be arrayed horizontally as in the standard convention. A possible arrangement for a keyboard is shown in **Fig. 22**. The shape of keys and their relative position is a complex problem intimately which is obviously tied to the following factors:

1. Visual perception of the key label or function.
2. The ability of the finger to locate the key easily, without hitting other keys or fingers.
3. The distribution of pressure on the finger to give feedback about the position of the finger on the key.
4. A distribution of pressure which places the force on the desired portion of the finger.

Bell Laboratories' report "Human Factors Studies of Pushbutton Characteristics and Information Processing in Keyset Operation" by R. L. Deninger supports the view that key tops should be 1/2 inch if the keys are spaced on 3/4 inch centers. Bell Labs. used a square, flat-topped key. Position information had to be relayed by the edges of the key top. However, a 3/8 inch square key top proved less satisfactory than the 1/2 inch, probably because there was more concentration required to maintain finger alignment, tending to cause fatigue and error.

To satisfy key shape factor 4 best, the top of the key should slope away at 21.5° from the horizontal. However, to satisfy key shape factor 1 best, the top of the key should slope forward at a good viewing angle, about 45° to the horizontal. To satisfy key shape factor 2, the finger should be able to feel the side edges of the key, preferably the front edge because this edge is also the most visible. In the suggested configuration in **Fig. 23**, note particularly that there are two distinct raised areas to give positioning feel.

When assembled, the keys using the shape concept in **Fig. 23** would form an unusual-looking, but very legible array of keys with a very pleasing feel. **Figure 24** shows some possible configurations. The proper key

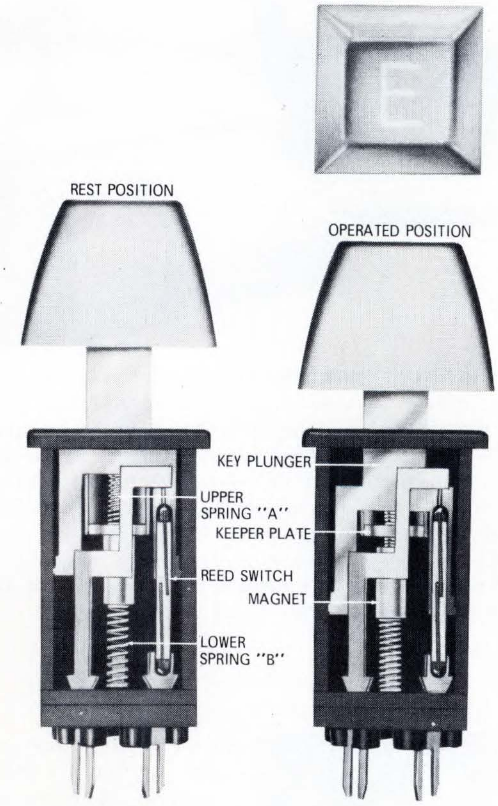


Fig. 20—The first of what may hopefully be many commercial switches to incorporate the tactile cues of breakaway and hysteresis, as described in this article, is this newly designed Cherry-Key Module. Diagram courtesy Cherry Electrical Products Corp.

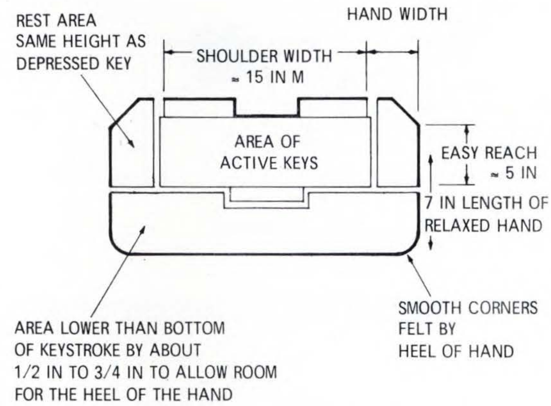


Fig. 22—**Possible arrangement** of keys and rest areas to reduce fatigue and ease operation.

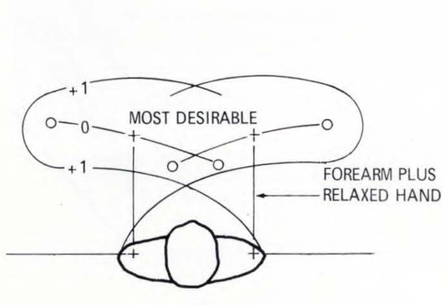


Fig. 21—**Horizontal hand trajectories** of equal comfort from a mean most comfortable.

(Continued)

Keyboard design (Cont'd)

top shape is very important to the success of this approach because the eye must be drawn to the front edge of the key. The curve of the front edge compared to the flat back of the key top should achieve this end. The pivot arm is desirable for low friction.

Designing With Human Factors

This study has attempted to isolate some of the "human factor" constants that affect keyboard design. Since the configuration of machines is easier to change than the configuration of people, it seems reasonable that the designer of a keyboard should take these factors into account. It also seems reasonable to work *with* these factors, rather than *against* them.

Any design involves a series of compromises or tradeoffs. The suggested keyboard and key configurations outlined here involve only one possible set of tradeoffs, and there is surely a wide variety of others that would depend on the requirements of the individual situation. The underlying principles of human physiology presented here will be the determining factor in any case, however, as long as the keyboard remains the commonly-chosen interface between machine and man. □

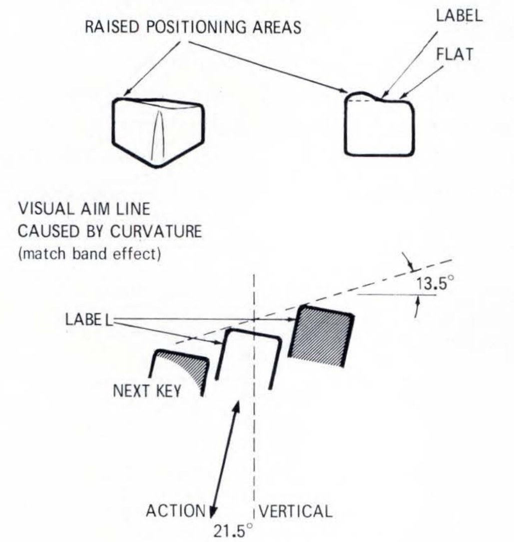


Fig. 23—**Suggested label** and feel compromises.

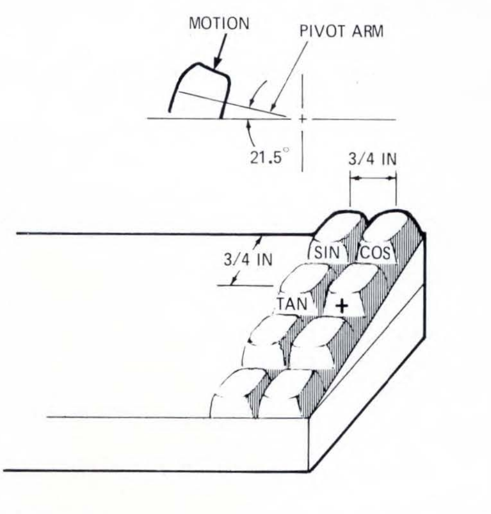
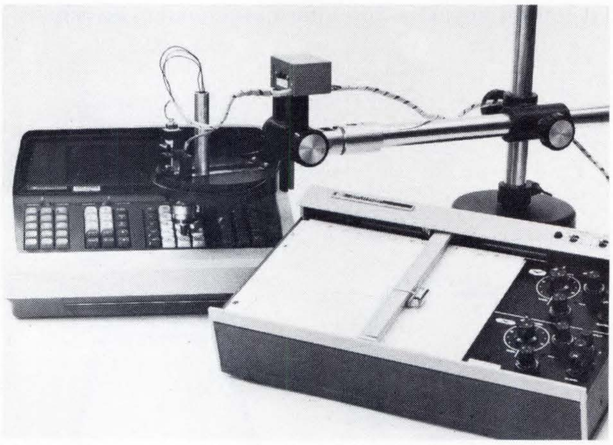
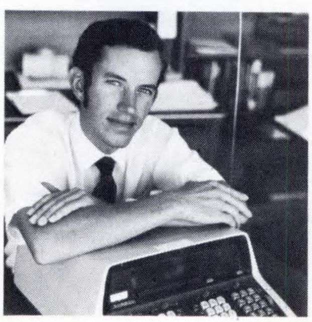


Fig. 24—**Suggested key array** (based on **Fig. 23** key design).



View of instrumentation used to measure the tactile characteristics of keys. Array consists of strain gauge, linear differential transformer, and dc motor all mounted on custom-built fixture. Fixture rotates and tilts so gauges can be placed exactly in line with operating axis of switch or key. DC motor drives screw, slowly depressing key. Gauges are mounted on parallel cantilever springs below fixture, so as to move in straight line. Linear differential transformer indicates position precisely, its output feeding horizontal axis of X-Y recorder. Strain gauge output feeds vertical axis.



Author **Chris Clare** comes closer to "pure" research than most engineers today. Four years ago, with a B.S. from California Polytechnic, he came to Hewlett-Packard Co. Since that time he has been assigned to investigation of logic design principles, and simultaneously has earned his M.S. from Stanford Univ.

GEORGE E. GOODE, Datotek, Inc.

F-I-N logic short cycles counters

A simple technique determines optimum feedback logic for synchronous binary counters of any desired cycle period.

Short cycling a counter means not using the maximum count capability of a counter. Consequently, some sort of feedback logic is needed to achieve the desired counting cycle. One simple approach, referred to as Force-Inhibit-Normal logic or F-I-N, is easily adaptable to synchronous binary counters.

The F-I-N principle is discussed in **Fig. 1**. Using the following steps, the required F-I-N logic for a short-cycle binary counter is easily determined using NAND gates:

1. Write down the last state or count in binary notation.
2. Determine F-I-N designation for each bit using the following rules:
   - Locate the least significant "0" (LSZ) and designate it "I" because it must be inhibited. Designate with "N" any lesser significant "1" because this bit goes to zero on the next clock pulse.
   - Designate by "N" any "0"s of greater significance than the LSZ, since they normally remain zero.
   - Designate by "F" all "1"s of greater significance than the LSZ, because each must be forced to zero.
3. For inputs of the inhibit-force NAND gate, use the Q side of all flip-flops containing "1"s in the last count.
4. Output of the inhibit-force NAND gate is fed to a second-level NAND gate that generates the input of the flip-flop to be inhibited. In other words, the complement of the inhibit function is ANDed with the input logic of the flip-flop to be inhibited. Also, the output of the inhibit-force NAND gate is connected to the first level NAND gate or the force logic is ORed with the input functions of all flip-flops requiring forcing. In case the least-significant-bit flip-flop is either inhibited or forced, an appropriate modification of the rule is required, because normally it does not require two levels of NAND logic.

Notice that the LSZ position is pivotal in the bit designation process and that it alone is inhibited. ▭

George E. Goode received a B.A. from Southwestern at Memphis and an M.A. in mathematics from Duke University. He is currently Vice President of Engineering with Datotek and a visiting associate professor at Southern Methodist University. He has presented papers at several conventions and holds three patents. Material for this article was taken from his forthcoming book.

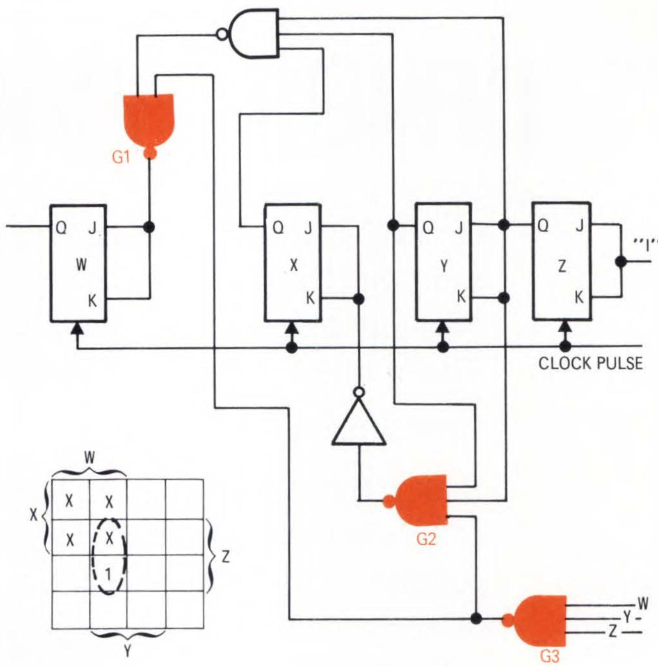


Fig. 1 — **For a modulo-12 binary counter,** counting sequence is 0, 1, 2, . . . 9, 10, 11, 0, 1, . . . etc. Thus, in state 11 (1011), additional steering logic must be incorporated to return the counter to the initial state (0000) at the next clock time. By comparing state 11 with normal next state, 12 (1100), it is seen that "NORMAL" input logic into two least significant flip-flops causes them to reset. However, trigger input to third stage must be "INHIBIT" in state 11 to prevent flip-flop from triggering. Trigger input to last flip-flop must be "FORCED" to 1 in order that all flip-flops are zero (initial state) after next clock pulse.

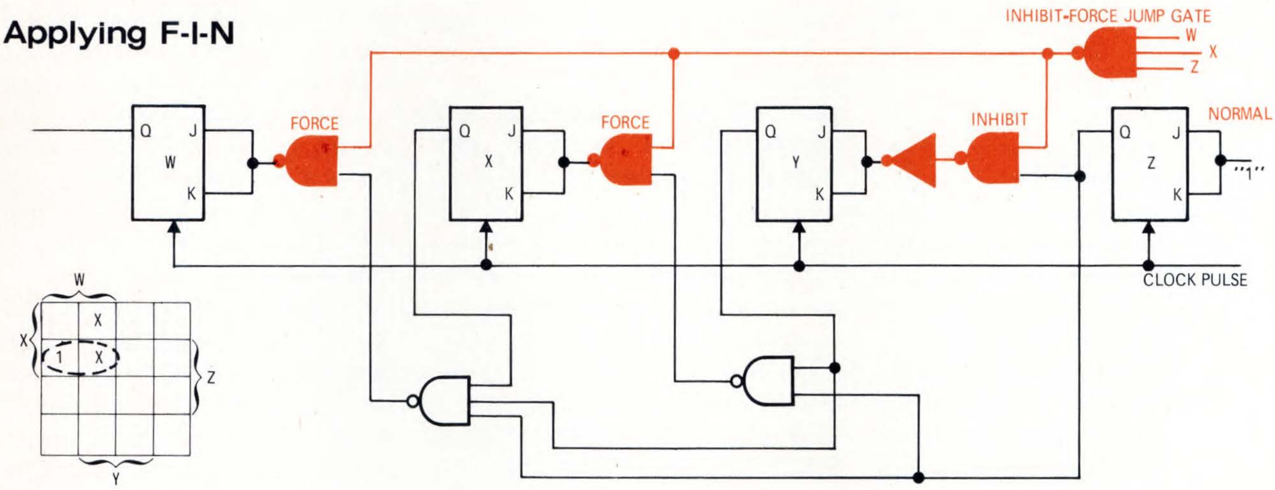
Using NAND logic, inhibit function for third stage is accomplished with third-level gate G3 that feeds gate G2. Gate G3 generates minimized functions for state 11 and four "don't cares" (states 12 to 15) as shown in Karnaugh Map. In state 11, G3 output is 0, thereby inhibiting second-level gate G2 that functions as an AND gate. Similarly, G3 when fed to first level gate G1 of most-significant-bit flip-flop input logic achieves force function. At second level, G3 functions as an AND gate (using normal inputs) with its output OR-ed at first level to provide forced 1 into first stage during state 11. Thus one gate, G3, performs both inhibit and forcing functions.

In summary, during state 11, trigger inputs to W, Y and Z are enabled (W is forced, Y and Z are normal), while the trigger input to X is inhibited. Result at next clock period is depicted below.

```
W X Y Z
1 0 1 1 (STATE 11)
F I N N
↓ ↓ ↓ ↓
0 0 0 0 (STATE 0)
```

If the counter inadvertently gets into one of the invalid states (12 to 15), it will return to valid count within a finite number of clock pulses.

Applying F-I-N



Example 1—Design a modulo-14 straight binary counter using NAND logic and J-K flip-flops. Since a modulo-14 counter counts from zero to 13, the binary representation of the last count is 1101. Therefore, steps 1 and 2 give

1 1 0 1
F F I N

Using designations of W, X, Y and Z (LSB) to represent the J-K flip-flops, F-I-N logic is developed in the following manner:

W X Y Z
1 1 0 1 (Last Count)

F F I N
↓ ↓ ↓ ↓
0 0 0 0 (First Count)

Upon examining the above transition from the last count to the first count of zero, the input logic for each flip-flop is:

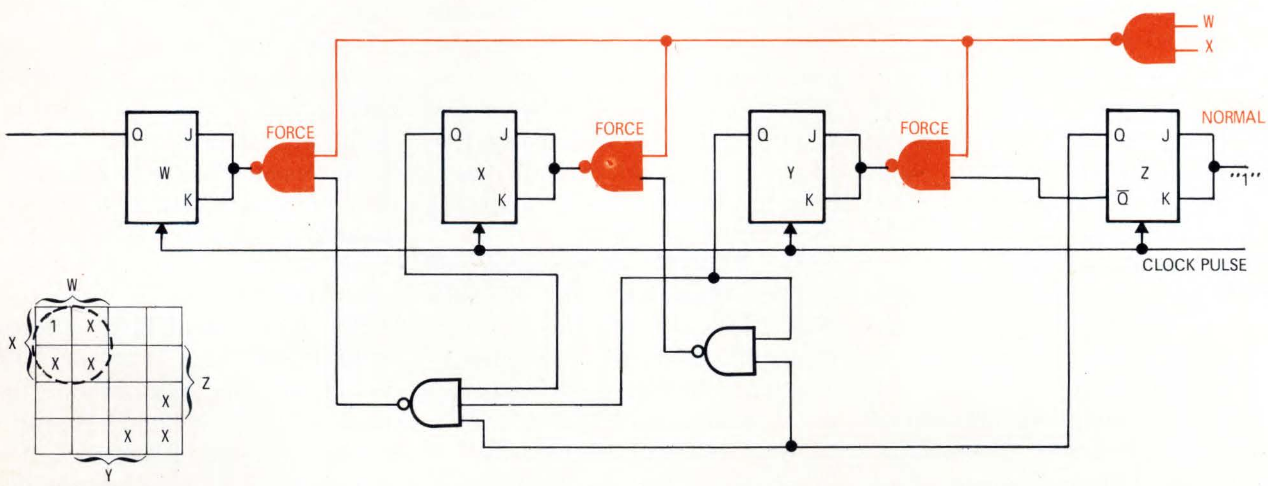
$Z_J = Z_K$ = 1 (normal logic based on J-K complementary properties)

$Y_J = Y_K = Z(\overline{WXZ})$ **(INHIBIT)**

$X_J = X_K = YZ + WXZ$ **(FORCE)**

$W_J = W_K = XYZ + WXZ$ **(FORCE)**

Using NAND logic, the complete design is as shown above:



Example 2—An excess-3 decade counter demonstrates that the F-I-N techniques can be readily adapted to counter design other than those having an initial state of all zeros. Using W, X, Y and Z (LSB) as flip-flop designations, the jump from state 9 (1100) back to state 0 (0011) in excess-3 is shown below with F-I-N designation.

W X Y Z
1 1 0 0 (STATE 9)

F F F N
↓ ↓ ↓ ↓
0 0 1 1 (STATE 0)

From inspection of the ten valid states, it is evident that force function can be implemented by a NAND gate with W and X as inputs. Final logic diagram is shown above.

coming soon...

1971 ANNUAL SYMPOSIUM ON RELIABILITY, Jan. 12-14, The Sheraton Park Hotel, Washington, D. C. *Session 1B* Reliability Assurance—Topics range from procedures for obtaining component reliability to procedures for manufacturing reliability. *Session 2A* Design and Analysis—Design evaluation and analysis are presented for application to the early stages of the system life cycle. *Session 5B* Prediction and Assessment—New methods for predicting and assessing the reliability and related system performance characteristics are presented. *Session 6A* Reliability and Cost—Covers the influence of reliability on total system costs.

1971 MEXICO INTERNATIONAL IEEE CONFERENCE ON SYSTEMS, NETWORKS AND COMPUTERS, Jan. 19-21, Oaxtepec, Mor., Mexico. Sessions will cover: systems engineering, systems science, operations research network theory, ICs, information processing, computer science, automatic control, communication systems, transportation systems and power systems.

COMPUTER AND COMMUNICATION STATISTICAL RELIABILITY, Feb. 1-5, Univ. of Southern Calif. Noncredit course furnishes engineers and practitioners the most up-to-date operations research techniques in areas of computer sciences, reliability engineering and communication sciences. Fee is $300. Contact Noncredit Programs Office, Rm. 355, Adm. Bldg., USC, University Park, Los Angeles, Calif. 90007.

1971 WINTER CONVENTION ON AEROSPACE AND ELECTRONIC SYSTEMS (WINCON), Feb. 9-11, Biltmore Hotel, Los Angeles. Provides a forum for exchanging ideas on current problems and learning about recent advances in system-oriented technology.

call for papers

1971 ANNUAL SOUTHEASTERN SYMPOSIUM ON SYSTEM THEORY, April 5-6, Atlanta, Ga. Papers reporting new results in system theory, novel educational programs in system theory, and new applications to those fields of general interest to the IEEE Groups on Automatic Control, Computers, and Systems Science and Cybernetics are invited. Submit a 50-word abstract, and a 500-word summary prior to Jan. 4, 1971. All manuscripts should be sent to J. R. Rowland, School of Electrical Engineering, Georgia Institute of Technology, Atlanta, GA 30332.

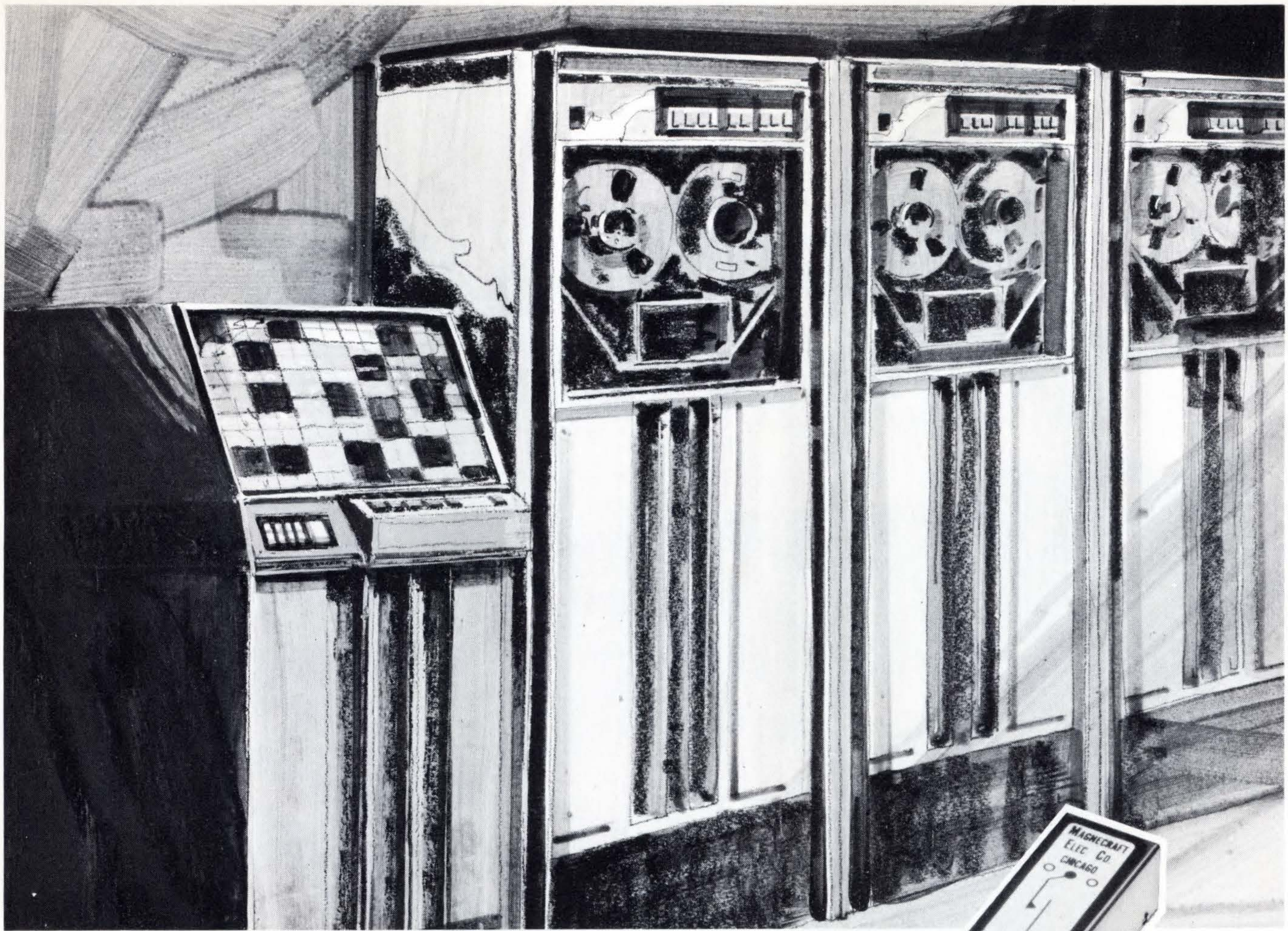
COMPUTER AND SYSTEM SCIENCE, April 26-27, Houston, Tex. Papers are invited in these areas: Computer Organization & Design, Switching Theory and Automata, Information Storage and Retrieval, Aerosystems, Biosystems, Control Systems, Communication Systems, and Environment Systems. Two copies of a one-page, single-spaced abstract must be submitted by March 10, 1971. Mail all abstracts to: Dr. S. C. Lee, Department of Electrical Engineering, Univ. of Houston, Houston, TX 77004.

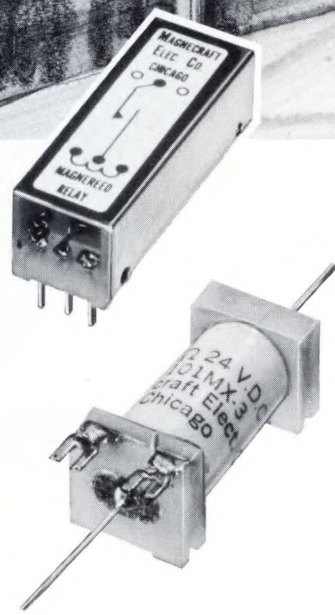
1971 ELECTRICAL & ELECTRONIC MEASUREMENT & TEST INSTRUMENT CONFERENCE, June 1-3, Ottawa, Ontario, Canada. Papers on the rapidly growing fields of automation of measurements, digital and sampling techniques, pulse measurements, and audio-frequency power measurements are particularly sought. Four copies of an abstract (200 words) and summary (500-1000 words) of each contributed paper should be submitted to the chairman of the Technical Program Committee, Mr. F. L. Hermach, Electrical Instruments Section, NBS, Washington, D C 20234.

1971 IEEE/OSA CONFERENCE ON LASER ENGINEERING AND APPLICATIONS, June 2-4, Washington, D. C. Papers are solicited that describe new technical contributions to such areas as: Communication Systems, Techniques and Components; Ranging and Other Active Systems; Beam Steering and Deflection Systems, including Displays; Optical Information Processing, Storage and Retrieval Systems and Techniques, including Holography; Precision Measurement Techniques; Laser Gyroscopes; Interferometers. Submit a 35-word abstract and 500-word summary of paper no later than Jan. 11, 1971 to Mr. Donald R. Herriott, Bell Telephone Labs., Murray Hill, N J 07974.

THE COUNTER-CONFERENCE, Aug. 3-5, Boulder, Colo. Papers describing significant progress in the following areas are solicited: operating systems; computer hardware including I/O and terminals (e.g., graphics); systems organization; theory of computing; numerical analysis; and artificial intelligence. Submit preliminary version of paper by Feb. 1, 1971 (in triplicate) to Program Committee, Counter-Conference, Dept. of Computer Science, Univ. of Calif., Berkeley, CA 94720.

1971 JOINT AUTOMATIC CONTROL CONFERENCE, Aug. 11-13, St. Louis, Mo. Submit five copies of full length paper by Jan. 8, 1971 for presentation at the conference. Abstracts will not be considered. Papers dealing with all aspects of automatic control (theory, design, applications, components, simulation, machine computation, social, economic, biological and ecological systems) are solicited. Send to: Dr. John Lewis, Dept. of Electrical Engineering, The Pennsylvania State Univ., University Park, PA 16802.





MAGNECRAFT
ELEC CO.
CHICAGO
MAGNEREED
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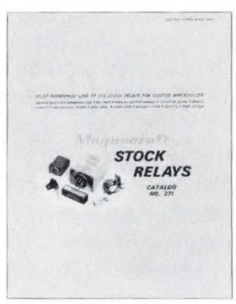
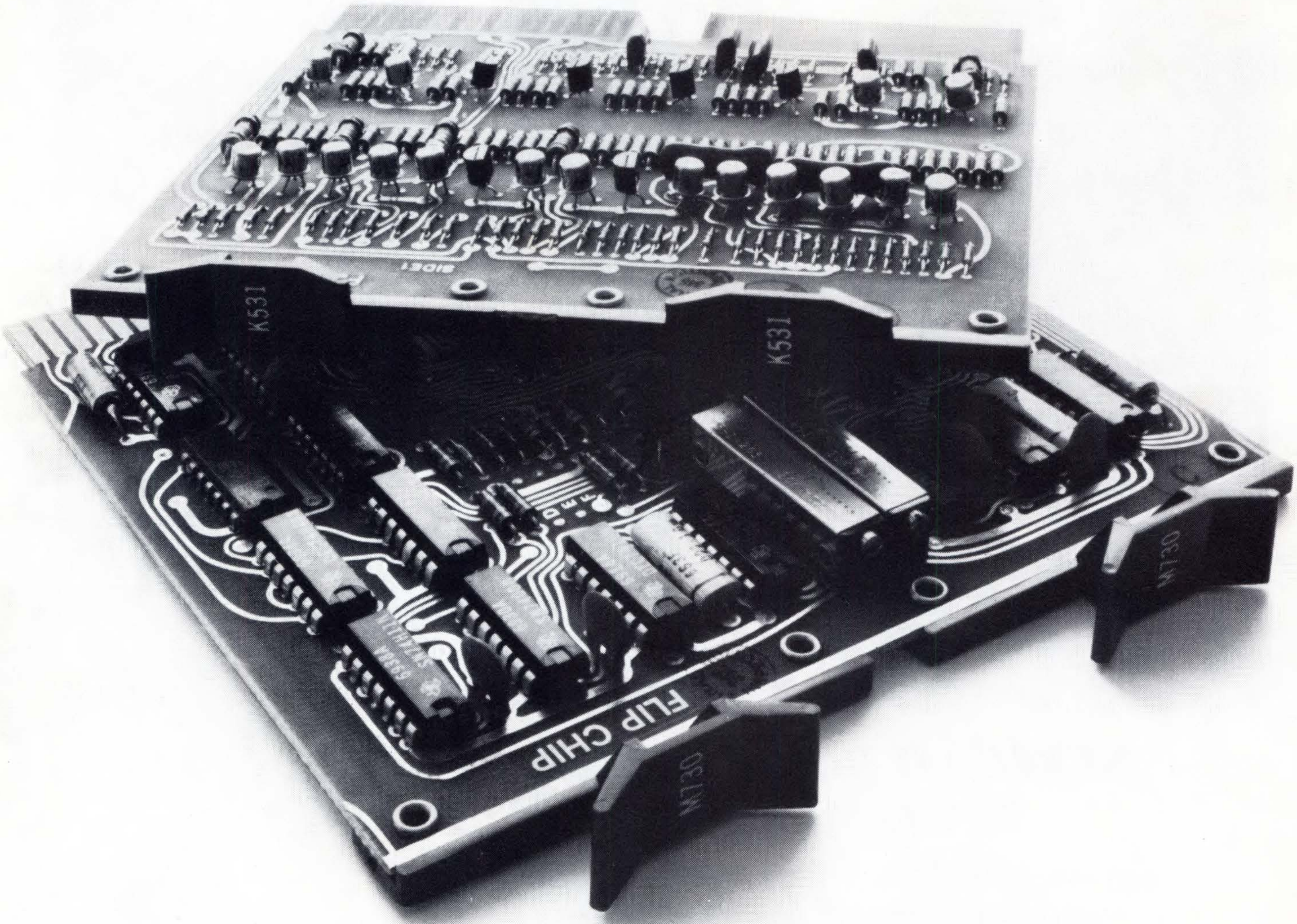


STOCK
RELAYS



The tortoise and the hare

Sometimes, you want all the speed you can get. Interfacing a computer, for instance. Or building an instrument that measures, or tracks, or controls events that require that speed. Digital offers a full line of hare modules . . . M-series, that fly at 10 MHz.

But sometimes, you want something a lot slower. For general laboratory control, or to replace old-fashioned relays, or to control a machine. Designing them slow means that you can also design them immune from electrical noise. Digital has a full line of tortoise modules as well . . . K-series, that crawl at 100 KHz.

Each series is physically, electrically, and logically compatible. 100 modules in M-series. 70 modules in K-series. Each comes with a full line of hardware, power supplies, plug-in boards, cabinets, racks, and so forth. Each comes with Digital's guarantee. Each comes with the knowledge that Digital uses them in their own computers and controllers.

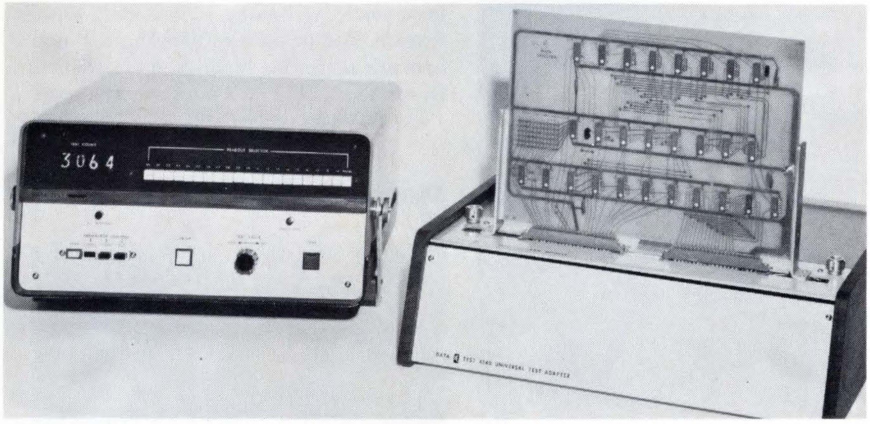
Two free books describe them completely — module by module and function by function. Write.

DIGITAL EQUIPMENT CORPORATION, Maynard, Massachusetts, Telephone: (617) 897-5111 / ALABAMA, Huntsville / CALIFORNIA, Anaheim, Los Angeles, and Palo Alto / COLORADO, Denver / CONNECTICUT, New Haven / DISTRICT OF COLUMBIA, Washington (College Park, Md.) / FLORIDA, Cocoa / GEORGIA, Atlanta / ILLINOIS, Chicago / MASSACHUSETTS, Cambridge and Maynard / MICHIGAN, Ann Arbor / MINNESOTA, Minneapolis / MISSOURI, St. Louis / NEW JERSEY, Parsippany and Princeton / NEW MEXICO, Albuquerque / NEW YORK, Centereach (L.I.), New York City, and Rochester / NORTH CAROLINA, Chapel Hill / OHIO, Cleveland and Dayton / PENNSYLVANIA, Philadelphia and Pittsburgh / TENNESSEE, Knoxville / TEXAS, Dallas and Houston / UTAH, Salt Lake City / WASHINGTON, Seattle / AUSTRALIA, Brisbane, Melbourne, Perth, and Sydney / CANADA, Edmonton, Alberta; Carleton Place, Ottawa; Toronto, Ontario; and Montreal, Quebec / ENGLAND, London, Manchester, and Reading / FRANCE, Paris / GERMANY, Cologne and Munich / HOLLAND, The Hague / ITALY, Milan / JAPAN, Tokyo / SWEDEN, Stockholm / SWITZERLAND, Geneva.

digital
MODULES · COMPUTERS

CIRCLE NO. 408

Low-Cost Logic Tester Generates Gray Code

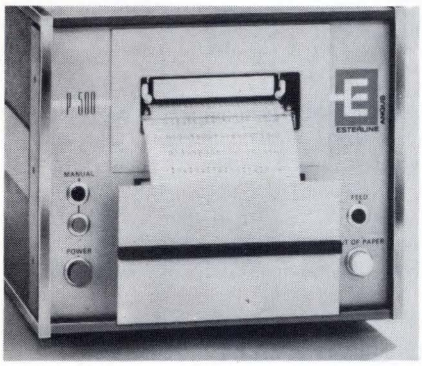


Here's an inexpensive tester for small to medium-sized manufacturers of integrated circuit logic cards, magnetic tape transports or magnetic discs. Whether used for production line testing or field service applications, the **Data Test 4040** fills the need for an economical way to test thoroughly any device that responds to logic inputs.

By generating a Gray-code test signal (series of non-synchronous square waves), the new entry exercises every possible combination of "1" and "0". The output truth table of the device under test is digitally summarized by a method called "Transition Redundancy Check". Comprised of four digits, the TRC summary is handily displayed on the front panel of the unit.

Capable of handling 250,000 tests/s, the versatile tester comes with 40 generator outputs where each output has a fanout of 30. Up to 1200 independent truth tables can be exercised by the **Data Test 4040**, which sells for $2250. The universal test adapter, Model 4540, complete with level-transistor circuit boards is priced at $500; each program board sells for $50. For those wanting very fast go/no-go checks on a card level, **Data Test 4700** features 60 generator outputs, a maximum test time of 5 s/card–and sells for $10,750 (4540 adapter included). Data Test Corp., 822B Challenge Dr., Concord, CA 94520. **225**

Hard Copy



Digital printer, Model P-500, has 20 active columns of data and 2.5 lines/s printing speed. The P-500 employs a simple proven printing mechanism (rotating drum) and solid-state electronics assuring reliability. Esterline Angus, A Div. of Esterline Corp., Box 24000, Indianapolis, IN 46224. **226**

Perforated tape reader, Model 5501, is equipped with 3-1/2 in diam reels that hold 200 ft of tape. Operating speeds are 0 to 150 characters/s asynchronous and 625 characters/s synchronous. Unit price is $1210. Chalco Engineering, 15126 S. Broadway, Gardena, CA 90247. **227**

Hard-copy recorder, ALDEN 600, interfaces with graphic display terminals. Using a "flying spot" recording technique, CRT recordings are generated on Alfax electrosensitive paper at 30 lines/s. Electronic & Impulse Recording Equipment Co., Inc., Alden Research Center, Westboro, MA 01581. **228**

Teletype system allows users of CRT displays to transfer CRT information to a printer. System is made up of a teleprinter and a buffer unit that holds up to 4000 characters of information. Pulse Communications, Inc., Box 1225, Alexandria, VA 22313. **229**

High-speed motorized centerfeed unwinder operates at up to 5800 (UCM-50) and up to 11,200 (UCM-200) codes/min. Measuring 10 by 12 by 8 in, these units list at $200. Robins Industries Corp., 15-58 127th St., College Point, NY 11356. **230**

Digital microfilm plotter, Microplot 1000, has plotting speed of 50,000 points/s. Plotter uses a precision CRT, 16 or 35 mm film camera and forms flash that merges photographic images with computer generated data. Beta Instrument Corp., 20 Ossipee Rd., Newton Upper Falls, MA 02164. **231**

Fiber optic recorder produces records with high resolution, faster writing rates and greater accuracy. It also creates special nonlinear sweeps and presents easily-interpreted graphic displays. Edo Western Corp., 2645 S. 2nd West, Salt Lake City, UT 84115. **232**

Page printer, 123P, is 2-3/4 by 12 by 9 in and weighs 9-3/4 lb. Maximum operating speed is 11 characters/s with a maximum of 80 Gothic-style characters/line. Unit price is from $294 to $414, depending on quantity. MITE Data Equipment Div., MITE Corp., 446 Blake St., New Haven, CT 06515. **233**

Paper-tape reader, Teletype DX, operates at speeds from 0 to 360 characters/s. Unit reads any 5- through 8-level code, including the American Standard Code for Information Interchange (ASCII). Teletype Corp., 5555 Touhy Ave., Skokie, IL 60076. **234**

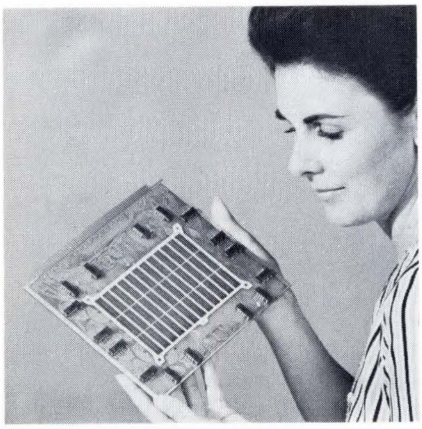
Digital printer Model 511A measures only 4.25 by 7.5 by 15.5 in and prints 21 columns–19 data and two parameter symbols. Maximum printing speed is 3 lines/s. Monsanto Electronic Instruments, 620 Passaic Ave., West Caldwell, N J 07006. **235**

Bi-directional photo reader uses patented bifurcated fiber optic reading technique. Operating speeds are 300 characters/s asynchronously, up to 500 characters/s continuously, with stop on character and 1200 characters/s in search mode. Tally Corp., 8301 S. 180th St., Kent, WA 98031. **236**

Magnetic-card unit is a manual I/O device for any data processing equipment. Unit uses credit-card size cards with >400 byte capacity. File protection prevents accidental erasure. Digital Information Devices, Inc., 210 Welsh Pool Rd., Lionville, PA 19353. **237**

Bar printer BI 1215 differs from the usual rotating drum or guided chain printer in that it has a linear print font on a motor-powered oscillating lateral carrier. The BI 1215 is a medium-speed, 300-lines/min printer. Tracor Data Systems, 4201 Ed Bluestein Blvd., Austin, TX 78721. **238**

Memories



High-density core packaging techniques permit up to 21 different word and bit configurations on an 8- by 7.5- by 0.5-in memory board. This approach offers memory sizes ranging from 1024 to 4096 words of 6 to 18 bits. Ampex Corp., 9937 W. Jefferson Blvd., Culver City, CA 90230. **239**

Memory subsystems, made up of DTL/TTL compatible MOS monolithic memories, are on a PC board and have storage capacity up to 147,456 bits. Access time is 250 ns and cycle time is as low as 300 ns. Cogar Corp., Box 110, Herkimer, NY 13350. **240**

Three additions to the L107 disc memory line are available, each measuring 9 by 9 by 6 in. Capacities, in addition to the present 0.5 megabit model, are 0.75, 1 and 1.5 megabits. Librascope Div., The Singer Co., 1100 Francis Ct., Glendale, CA 91201. **241**

Core-memory stack EM 2220 contains 4096 by 18 bits of storage and measures 3/8 by 6 by 6.5 in. Operating speeds are 700 or 800 ns. Assembly uses two printed circuit boards folded together, each with a 4k by 9, 3D core array. Electronic Memories, 12621 Chadron Ave., Hawthorne, CA 90250. **242**

A 4-megabit bulk memory, DS1, is a fixed-disc, flying-head system for minicomputers that sells for $1770 in OEM quantities. Each removable 14-in oxide disc contains 240 data tracks with 17,000 bits/track. Standard data organization is 1024 bits/block, 16 blocks/track. Genisco Technology Corp., 18435 Susana Rd., Compton, CA 90221. **243**

Drum memory, Model 588, sells for $995 with a capacity of 8k by 16 bits and $855 for a capacity of 4k by 16 bits. Both types feature head-per-track, flying-head design and prices include read/write electronics. Datum, Inc., 1802 N. American, Anaheim, CA 92801. **244**

Magnetic tape

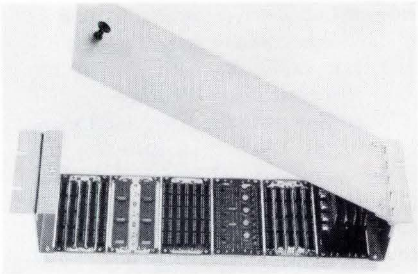
Magnetic tape data communications terminal T-1800 features error control through combined use of character parity, longitudinal redundancy, binary summation and record numbering. The T-1800 records incoming data over standard voice grade telephone lines onto 1/2 in magnetic tape. Tally Corp., 8301 S. 180th St., Kent, WA 98031. **245**

Seven- or nine-channel tape head, 200 ips, operates without a face shield with <4 percent write-to-read crosstalk. This dual-gap, read-after-write head is for use with 1/2-in tape at 1600 bpi (phase encoded). Systematics/Magne-Head Div., General Instrument Corp., 13040 S. Cerise Ave., Hawthorne, CA 90250. **246**

Automatic tape degausser provides 90 dB erasure on all magnetic tape, on reels up to 16 inches in diam and up to 2 inches in width. Automatic cycle takes between 45 and 55s, depending on model used (60 or 50 Hz). Bell & Howell, Electronics & Instruments Group, 360 Sierra Madre Villa, Pasadena, CA 91109. **362**

Precision tape guide, RC 3230, features built-in height adjustment (from 3/16 to 5/16 in as measured from tape edge to deck). Off-the-shelf price can be as little as 30 percent custom price or as low as $3.95 each, depending on quantity. Rotary Components, Inc., 816 E. Edna Pl., Covina, CA 91722. **363**

Systems



With Computer Automated Systems Hardware (C.A.S.H.), the designer can mix 14-, 16- and 24-pin DIP sockets for his system requirements. Typical drawer (Model TD-18) with a 1.75-in front panel houses up to 18 C.A.S.H. cards or 540 14-pin ICs. Standard Logic, Inc., 1630 S. Lyon St., Santa Ana, CA 92705. **364**

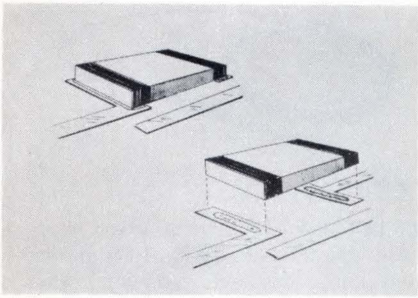
Electronic calculator NCR 18-15 is built with MOS/MSI circuitry and features 12-digit display. It performs basic arithmetic functions and the price is $395. The National Cash Register Co., Dayton, OH 45409. **365**

Data-recording system, 220 Typescribe, records source data on magnetic tape as it is typed on an IBM Selectric typewriter. It can supplement or replace keypunching and key verifying in preparing data for computer input. Data Action, 4445 W. 77th St., Minneapolis, MN 55435. **366**

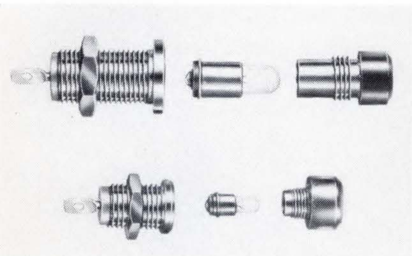
ASCII generator, Model 100, tests and exercises terminals, printers and other peripheral equipment. Model 100 weighs approximately 5 lb and is priced at $690. Sevis Computer Products, Inc., 57 Putnam St., Mt. Vernon, NY 10550. **367**

Multiplex/coupler, Model BAC, converts BCD to ASCII and provides proper interface for Teletype equipment. This solid-state unit features 8-digit data field. Base price is $995. DigiTem Div., Microwave/ Systems, Inc., 1 Adler Dr., East Syracuse, NY 13057. **368**

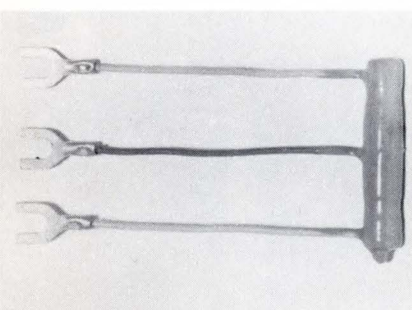
Character generator, Model CG1, finds use with direct-writing, random-scan CRT systems. Features include a 192-symbol character set (ASCII plus 96 common symbols), vertical and horizontal write and four character sizes. Vector General, 8399 Topanga Canyon Blvd., Canoga Park, CA 91304. **369**



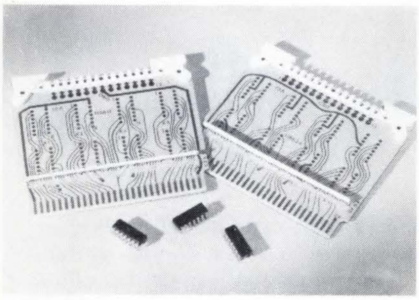
Electrically-conductive silver epoxy, designated Epo-Tek H31, finds use for bonding chips in hybrid circuits. Epo-Tek H31's volume resistivity is 0.0001 to 0.0005 Ω/cm. Curing is accomplished in 15 min at 150°C or 45 min at 120°C. A trial evaluation kit is available for $15. Epoxy Technology, Inc., 65 Grove St., Watertown, MA 02172. **247**



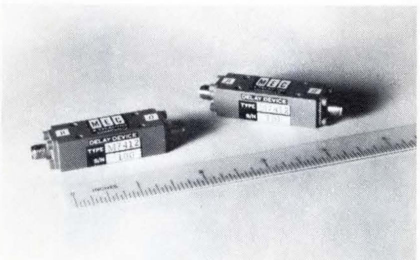
Miniature lamp holders, MCM-100 Series, have 3/8-in diam lenses that unscrew to permit lamp replacement. This series requires 5/16-in diam hole and needs <0.7 in behind panel. Another series, MCM-175, has a similar lens and uses a T-1 3/4 based lamp, mounts in 3/8-in diam hole and requires 1 in behind panel. Prices for both series start at $0.99 each, less lamp. Alco Electronic Products, Inc., Lawrence, MA 01842. **248**



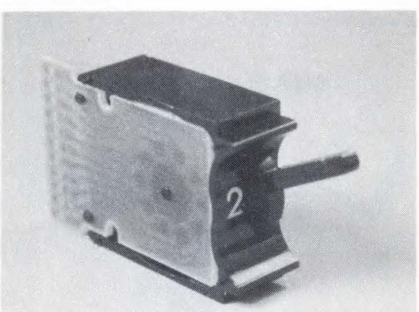
Gas arrester, Model 316, protects against both line-to-ground and line-to-line voltage surges. Surge on one line ionizes rare gas in a common chamber to ground the other lines instantaneously and prevent damage. Model 316 can be easily installed in existing equipment. Telecommunications Industries, Inc., 71 Verdi St., Farmingdale, NY 11735. **249**



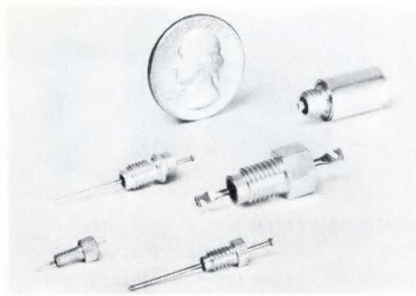
Two accessory cards, H-4720 and H-4721, have been added to the EECoLogIC 2 line of logic cards and hardware. Four 14-pin dual in-line ICs mount on H-4720 with special provision for 12 test points. Ground is prewired to pin 7 and V_{cc} to pin 4. Electronic Engineering Co. of California, 1441 E. Chestnut Ave., Santa Ana, CA 92701. **250**



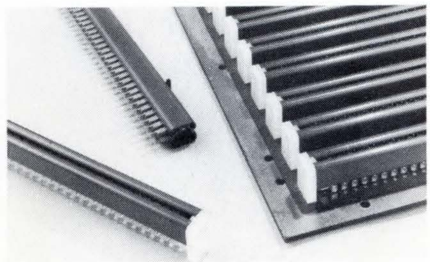
One cubic inch acoustic delay line replaces 750 lb of coaxial cable in an altimeter calibration application. Model M7307C with 30 dB insertion loss over 4.2 to 4.4 GHz radar altimeter band comes in a miniature ultra-rugged package designed for MIL-E-5400 environments. This is one of a series of low loss delay lines available in the frequency range from 200 MHz to 14 GHz. Teledyne MEC, 3165 Porter Dr., Palo Alto, CA 94304. **251**



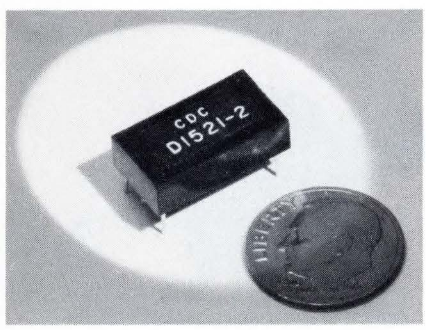
Subminiature leverwheel switch, L-20, features a dial character 0.2 in high. Variety of output codes is available to choose from. Switch characteristics include 0.1Ω max contact resistance, 3A carrying current capability and 7 to 10 oz operating force. Cherry Electrical Products Corp., 3600 Sunset Ave., Waukegan, IL 60085. **252**



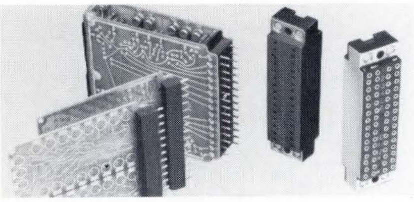
Subminiature 50, 100, 200 and 500V dc feed-through filter/capacitors are available in 10 and 25A current ratings. Designated 9000 Series, capacitance values are from 1000 pF to 1.5 μF for −55 to 125°C. All units are supplied with mounting hardware. Prices start at $1.15. USCC/Centralab, 2151 N. Lincoln St., Burbank, CA 91504. **253**



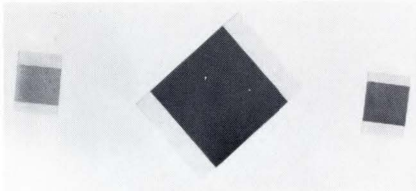
Card-edge connectors with three to 50 contacts on 0.1-, 0.125-, 0.15- or 0.156-in centers accept double-sided 1/16-in thick PC boards over the full range from 0.055 to 0.07 in. Designed specifically for dip or wave soldering to mother boards up to 0.104 in thick, the contact posts are tin plated. Two styles of snap-in card guides are available in lengths from 0.56 to 3 in. AMP, Inc., Harrisburg, PA 17105. **254**



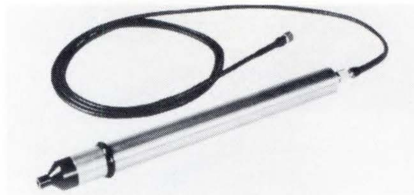
Dual-in-line delay lines, D1521 Series, are available in delays of 5, 10, 25 and 50 ns. Rise time for all models is <30 percent of total delay. Attenuation is held to 1 dB and temperature stability is >60 PPM/°C. Unit price is under $5 in production quantities. Computer Devices Corp., 63 Austin Blvd., Commack, NY 11725. **255**



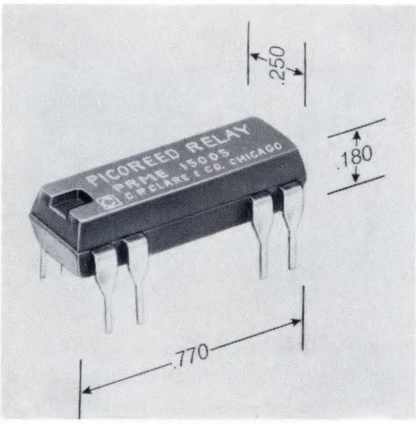
Thirty-contact connector accepts either 30-contact or two 15-contact PC headers. Standard 53 Series taper pins terminate the female connector on the wire side, with seven internal bussing arrangements available. Male headers are terminated to PC boards with standard flow-soldering methods. Control Data Corp., 31829 La Tienda Rd., Westlake, CA 91361. **256**



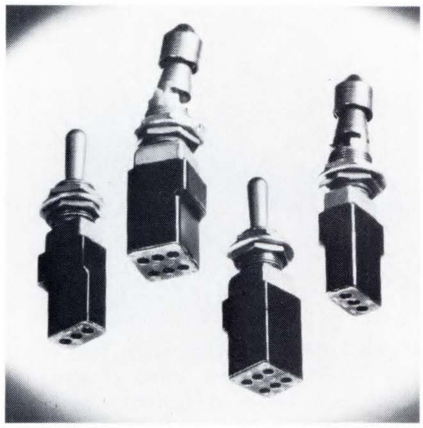
Multilayer chip capacitors for hybrid circuits are available in four proposed standard EIA sizes and capacitance values. Range of the Type MB capacitors is 10 pF to 1 μF. Standard voltage ratings are 50, 100 and 200V dc with no voltage derating over −55 to 125°C. Capacitance tolerances are ±5, ±10 and ±20 percent and GMV. Allen-Bradley Co., 1201 S. Second St., Milwaukee, WI 53204. **259**



Light pen Model LP 200 features 3 μs response time, 2 fL sensitivity, 100 mil resolution and a touch-actuated switch. Processing electronics are on a separate PC board. Hand-held pen unit is 0.5 inch in diam by 6 in long and weighs only 2 oz. Processing electronic package is 2 by 3 by 0.5 in. Price is $795. Information Control Corp., 9610 Bellanca Ave., Los Angeles, CA 90045. **262**



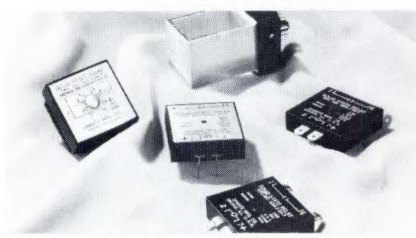
Subminiature 14-pin DIP relay can be driven directly by most DTL/TTL standard gates without power NANDs or external driver/buffers. Operation is within 500 μs, release within 100 μs. Switch rating is 500 mA 100V, 10VA maximum, 2A maximum carrying current. Internal diode and electrostatic shield are options. C. P. Clare & Co., 3101 Pratt Blvd., Chicago, IL 60645. **257**



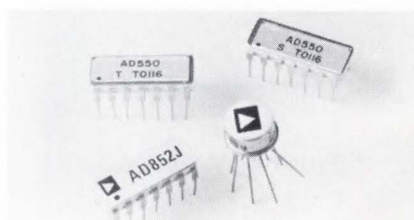
Miniature positive-action toggle switch features an integrated wire termination system (IWTS) that provides for a completely sealed, solderless termination. The IWTS connection is made by inserting a small metal contact crimped onto a wire into a receptacle-like terminal. Prices are from $13 to $24. Specialty Products Div., Cutler-Hammer, Inc., 4201 N. 27th St., Milwaukee, WI 53216. **260**

Laminated flat-ribbon cable can be specified with center-to-center tolerances of better than ±0.003 in. Cable is available with PVC-insulated conductors in 20 to 30 AWG sizes and cables up to 8 in wide can be fabricated. For identification, standard or special 10-color coding in any combination plus striped conductors are available. Spectra-Strip Corp., Box 415, Garden Grove, CA 92642. **263**

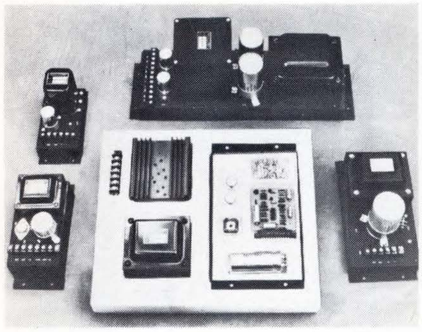
Permanent magnet dc servometer-tachometer, Type MT 3010-02, produces 11 oz-in continuous torque at 4050 rpm at 15V, 4.8A. Pulse torque capability is 190 oz-in, time constant 29.8 ms. Unit weighs 2.35 lb and measures only 3-1/4 inches in diam and 4-3/4 in long. Units are priced below $100 in 100-piece lots. Uriel Corp., 53 Union Ave., Ronkonkoma, NY 11779. **258**



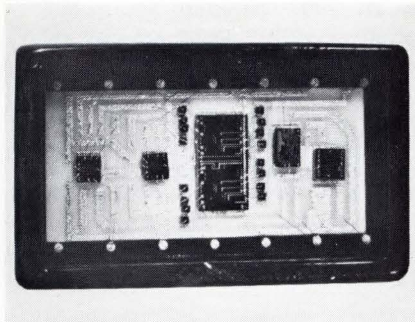
Hybrid solid-state relay—reed-type input and solid-state output—is for applications with driving currents on the order of 10 to 33 mA. Called SSH, three models are available with four mounting configurations. The models feature full isolation between input and output, $<$1 ms pull-in time and 1/2 cycle of load current drop-out time. Ohmite Manufacturing Co., 3601 W. Howard St., Skokie, IL 60076. **261**



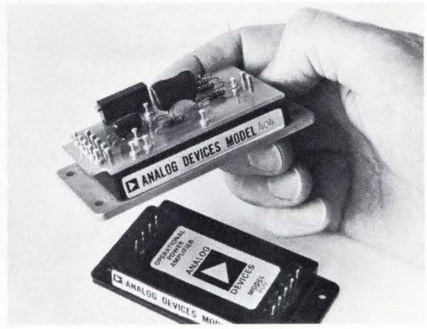
Set of μDAC converter components, two AD550 quad switches and one AD852 thin-film resistor network, is offered for only $65 (100 lot price). These units can be used to develop an 8-bit D/A converter having 0.4 percent accuracy and linearity, 50 PPM/°C. Devices are available in 14-pin DIP or flat-pack. Analog Devices, Inc., Pastoriza Div., 221 Fifth St., Cambridge, MA 02142. **264**



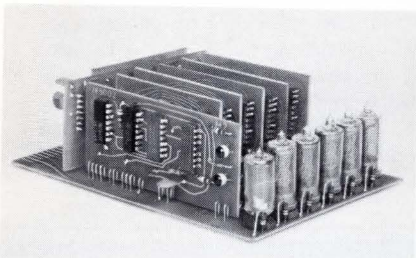
DC power supply kits are available in condenser or choke input, regulated or unregulated versions that deliver voltages from 5 to 120V and currents from 0.25 to 50A. PC boards are prewired and tested. Techni-Kit, Universal Electronics Co., Box 4517, Irvine, CA 92664. **265**



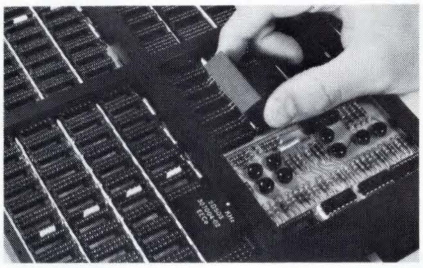
Eight-bit BCD D/A converter in a DIP package, Model MN303, offers slew rate of 0.5V/μs, TC of ±10 PPM/°C and power consumption of 400 mW. Operating temperature range is 0 to 70°C, and price is $79. Micro Networks Corp., 5 Barbara Lane, Worcester, MA 01604. **268**



Power op amps with integral heat sink that develop 60W output are priced from $85 to $98. Models are available that develop either ±20V, 3A or ±12V, 5A. All five modules are rated at 80W internal dissipation. Analog Devices, Inc., 221 Fifth St., Cambridge, MA 02142. **271**

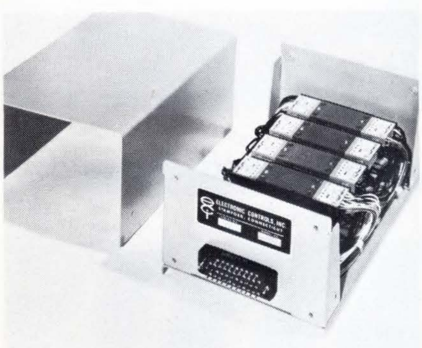


Bi-directional counter for OEM use features plug-in card construction with T²L logic and is available from 2 to 6 decades wide. A buffer card gives high noise immunity, and the standard unit will accept input on two lines—one add and one subtract. Typical price for a five-decade counter with plus/minus sign in quantity of 25 would be $280. Instrument Displays, Inc., 18 Granite St., Haverhill, MA 01830. **266**

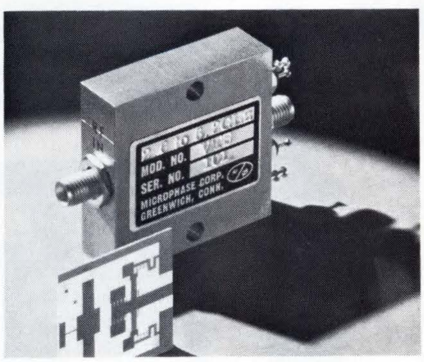


Crystal oscillator plug-ins, Type 2D-TS-1, are available from 12.5 kHz to 16 MHz. These plug-in units have frequency stability of ±0.004% from 0 to 75°C, occupy the space of three or four 14-pin DIPs and include driving circuits and an output amplifier. Prices range from $160 to $195. Electronic Engineering Company of California, Electronic Products Div., 1441 East Chestnut Ave., Santa Ana, CA 92701. **269**

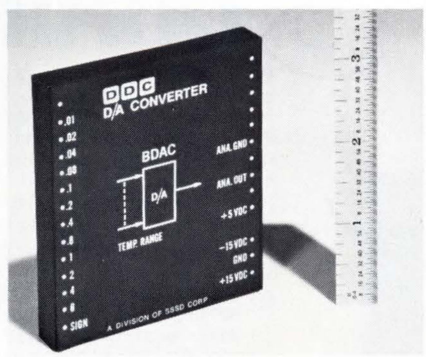
DC to dc power supply Series 3, features 3W of isolated output power in 3 cubic inches. A total of 140 different models are available, including single outputs from 4 to 1600V and dual outputs from ±4 to ±150V. All outputs are adjustable within ±10% by a 25 turn potentiometer. These fully encapsulated units weigh 110g. Price is $273. Mil Electronics, Inc., Dracut Rd., Hudson, NH 03051. **272**



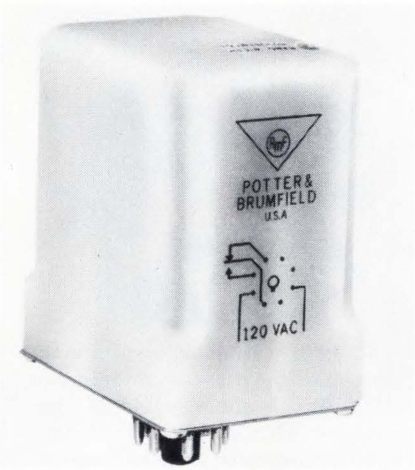
NORScan scanners, Series 809-N, comprise T-Bar® relays connected as a "tree". With them, standard instruments can be easily and economically assembled into an automatic cable, PC card or frame tester. Prices vary from $144.90 for one 16-pole unit to $636.45 for one 128-pole unit. Electronic Controls, Inc., Danbury Rd., Wilton, CT 06897. **267**



Voltage-tunable oscillator series displays reduced size, more consistent unit-to-unit characteristics and improved high-frequency performance. Available are octave and dual-octave frequency ranges from 250 MHz to 5.2 GHz. Quantities from 1 to 5 units are priced at $295 each. Microphase Corp., 35 River Rd., Cos Cob, CT 06807. **270**

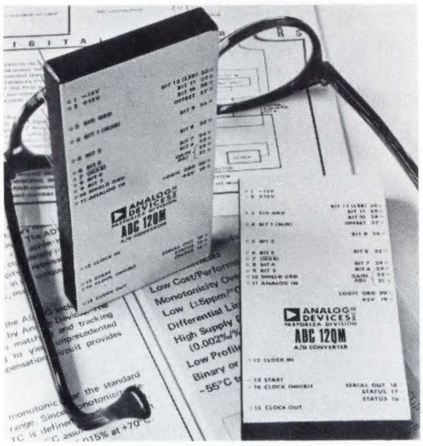


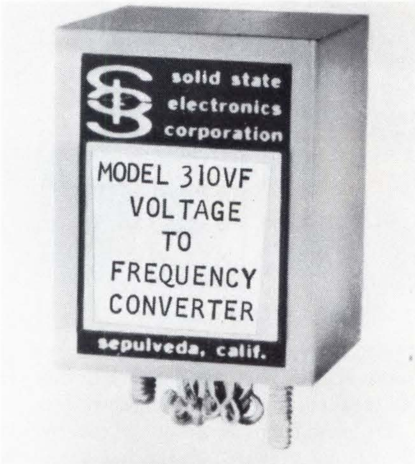
Thirteen-bit D/A converters offer accuracy of ±0.025% of full scale and settling time of 7 μs. The BDAC Series units have bipolar short-circuit-proof output of ±10V at 5 mA. Size is 2.6 by 3.1 by 0.4 inch. Price of units for −55 to +85°C operation is $400, and for 0 to 70°C operation is $250. Data Device Corp., 100 Tec St., Hicksville, NY 11801. **273**



Frequency sensor for 60Hz operation, Model CPF-38, is priced at $82.80. The unit has SPDT contacts rated at 10A at 120V rms, 60Hz resistive and will de-energize a system or energize an alarm when input frequency leaves the established frequency band. Bandpass is adjustable from 56-64 to 59-61Hz. Potter & Brumfield, 1200 E. Broadway, Princeton, IN 47570. **274**

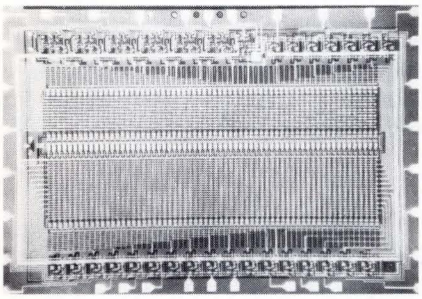
Twelve-bit A/D converters incorporate monolithic IC μDAC components, yet are offered fully encapsulated. Model ADC-QM units feature resolution from 12 through 8 bits. Operating power is $\pm$15V at less than 40 mA and +5V at 250 mA. Prices for 8-, 10- and 12-bit units are $250, $280 and $305 respectively in lots of one. Size is 2 by 4 by 0.4 inches. Analog Devices, Inc., 221 Fifth St., Cambridge, MA 02142. **275**



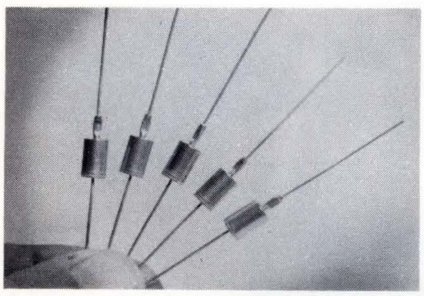


Voltage-to-frequency converters, Series 300VF, convert input signals extending from 0 to +10V to a linearly proportional output frequency extending from 0 to 100 kHz. This provides A/D resolution capability approaching 0.001% on a 1s sampling counter. Four versions, with decade spread, cover from 100 Hz to 100 kHz. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, CA 91343. **476**

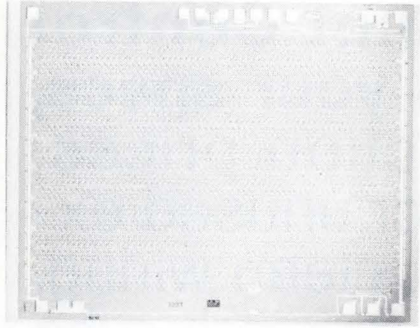
MTNS 16-channel multiplexer is composed of a programmable 4-stage binary counter, a 4 by 16 decode matrix and 16 single-pole double-throw switches. In lots of 100 pieces, price is $32 each. General Instrument Corp., 600 W. John St., Hicksville, NY 11803. **277**



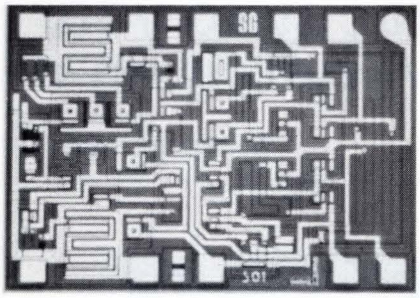
RAMs, ROMs, and decoder/drivers make up a line of products that will have added a 16-bit logic family, a 10-bit parallel access shift register and a 0-to-16-position shifter, with and without end-around. Typical of this family is a 1536-bit (64-word by 24-bit) bipolar read-only memory that is available for approximately $0.04 a bit in 100 piece quantities. Kenics Electronics Corp., 125 Harvard St., Cambridge, MA 02139. **278**



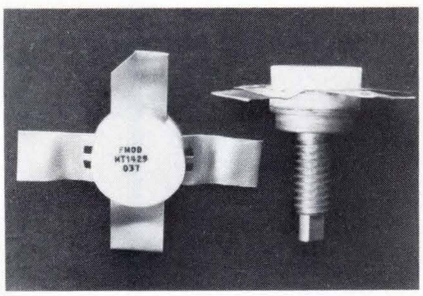
Silicon transient suppressor ICT-5 is a low-voltage unit that protects bipolar and MOS integrated circuits. It is rated for a peak pulse power of 1500W for 1 ms and has a peak clamping time of 1×10^{-12}. Units are priced at $3.50 each in 100 quantities. General Semiconductor Industries, Inc., 230 W. Fifth St., Tempe, AZ 85281. **279**



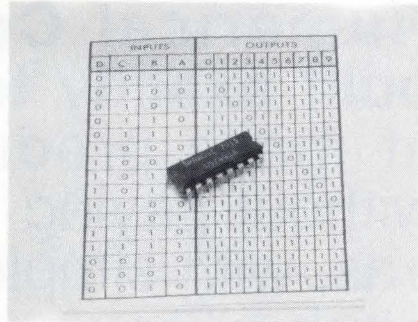
MOS/LSI 1024-bit dynamic shift register operates to 1 MHz with a 25 pF load, and data is shifted through the register by a 4-phase clock. Operating temperature is from −55 to 125°C and price in 100 lots is $20 each. Collins Radio Co., News Bureau, Dallas, TX 75207. **280**



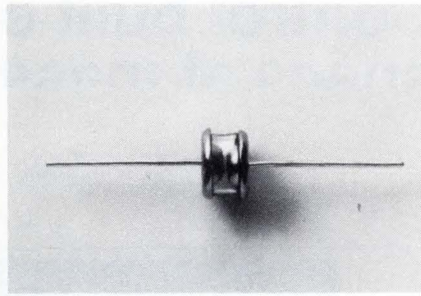
Monolithic dual-polarity tracking regulator SG1501/2501/3501 provides positive and negative outputs which are factory set at ±15V, or are variable from ±8 to ±23V with a single external adjustment. Outputs are balanced to within 1% and typically track one another within 50 mV. Output current rating is 100 mA. Price (100 pieces) ranges from $4.80 to $9.80. Silicon General, Inc., 7382 Bolsa Ave., Westminster, CA 92683. **281**



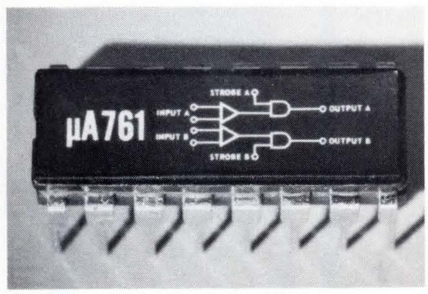
Microwave transistors include two series designed for 400-MHz, 28V and 370-MHz, 12V applications. The 28V units (MT2400 Series) offer power outputs of 1, 3, 12 and 25W. Twelve-volt units (MT1400 Series) offer the same power outputs as the 28V series. Fairchild Microwave & Optoelectronics Div., 2513 Charleston Rd., Mountain View, CA 94040. **282**



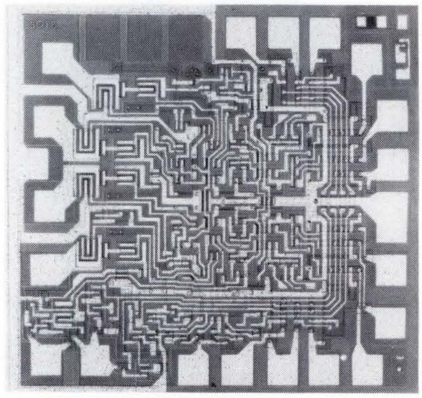
MSI digital decoder US7443A is a 4-line to 10-line unit that features excess-3-to-decimal conversion. The unit has a fan-out of 10 and is available in temperature ranges of 0 to 70°C and −55 to 125°C. Sprague Electric Co., North Adams, MA 01247. **283**



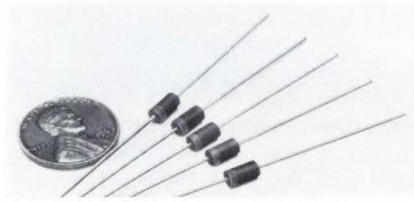
Surge voltage protectors, Types B2-H10 and B2-H25, are only 0.28 and 0.44 in long and provide protection up to 850V and 2000V respectively. The H10 units have a dc striking voltage of 1000V ±15%, and for Type H25 the striking voltage is 2.5 kV ±15%. For both, insulation resistance is $>10^{10}\Omega$ and capacitance is <2 pF. In quantity, price is slightly more than $1 each. Siemens Corp., 186 Wood Ave. S., Iselin, N J 08830. **284**



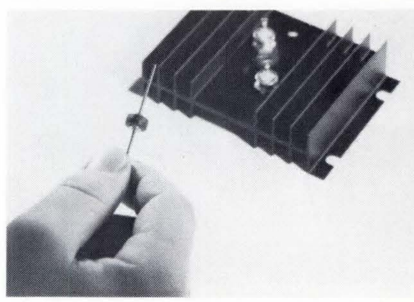
Core memory sense amplifier μA761 features 25 ns response time and ±2 mV threshold accuracy. The design features two independent channels, each of which can sense up to 4000 bits of information. Prices, in quantities of 100 to 999, are $2.50 (±7 mV threshold) and $4.75 (±4 mV threshold). Fairchild Semiconductor, 464 Ellis St., Mountain View, CA 94040. **285**



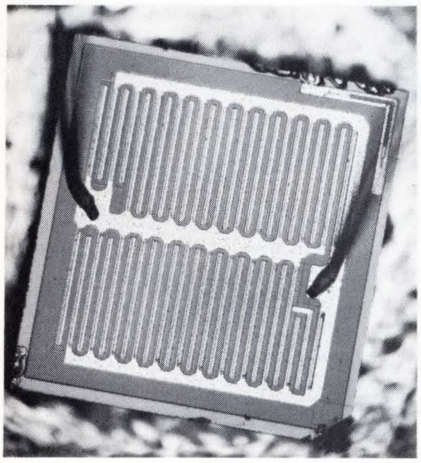
IC digital multiplexers 8263 (active pull-up outputs) and 8264 (bare collector outputs) are analogous to 4-pole, 3-position switches and feature propagation delays of 17 and 25 ns respectively. Power consumption is no more than 475 mW, operating temperature is either −55 to 125°C or 0 to 75°C, and, in lots of 100 to 999, price is $15.95 each (0 to 75°C). Signetics Corp., 811 E. Arques Ave., Sunnyvale, CA 94086. **286**



Silicon rectifiers in the "IMPAC" Series offer PIV from 50 to 600V, average rectified current of 1A at 50°C, dc blocking voltage from 50 to 600V and static forward voltage at 1A of 1V. The "IMPAC" case measures 0.24 in long and 0.128 inch in diam. Semtech Corp., Newbury Park, CA 91320. **287**

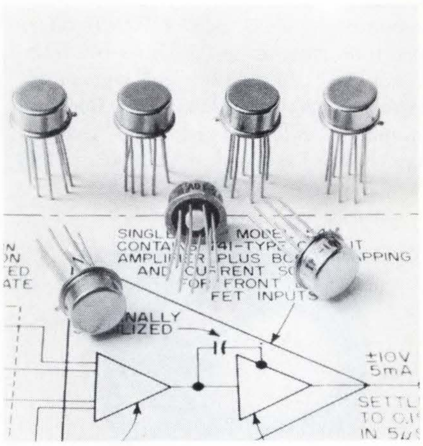


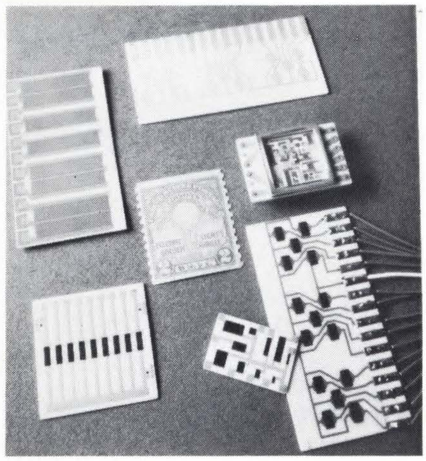
Silicon rectifiers in the MR751 Series are the first 6-ampere units to be packaged in an axial-lead plastic case. Four working peak reverse voltage ratings of 100, 200, 400 and 600V comprise the family. Prices in 100-and-up quantities range from $0.45 to $0.90 each, depending on voltage rating. Technical Information Center, Motorola Semiconductor Products, Inc., Box 20924, Phoenix, AZ 85036. **288**



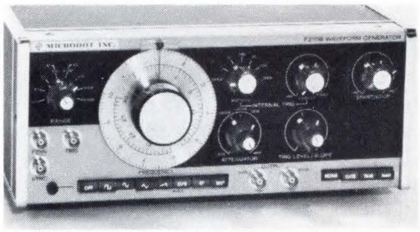
N-channel FETs include the 2N5432, 33 and 34 devices specified at 5, 7 and 10Ω $R_{DS(ON)}$ respectively. Other characteristics include switching time of 6 ns, 0.2 nA leakage current, 25,000 μmhos typical gain, high OFF/ON resistance ratio of 6×10^{10} typical and a temperature range from −65 to 150°C. Intersil, Inc., 10900 N. Tantau Ave., Cupertino, CA 95014. **289**

FET-input IC op amps AD503J and K offer 20 and 8 mV offset voltages, 15 and 5 pA bias currents, 30 and 15 μV/°C voltage drift figures, respectively. Both versions offer 80 dB CMRR, 50,000 open-loop dc gain, 6V/μs slew rate and ±12V, 4 mA outputs. In lots of 100, prices are $15 and $22 each, respectively. Analog Devices, Inc., 221 Fifth St., Cambridge, MA 02142. **305**

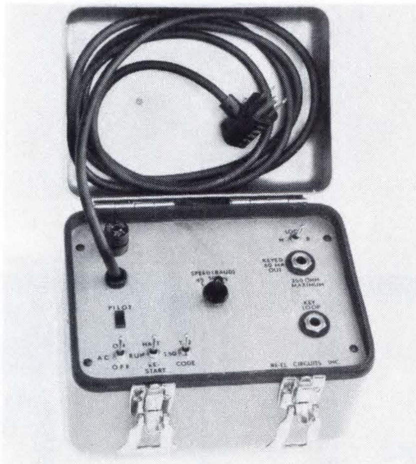




Photoconductive arrays with a dynamic resistance range >500,000 to 1 and peak spectral response in the 500Å to 7100Å range are available in various sizes up to 3 in² with as many as 200 photocells. Typical $0.23/cell cost compares to $0.79 or more for discrete devices. Raytheon Co., Industrial Components Operation, 465 Centre St., Quincy, MA 02169. **306**

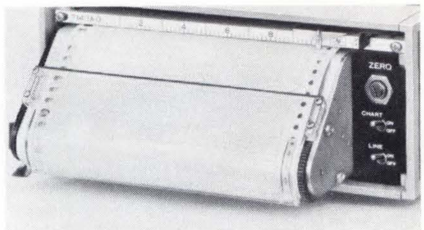


Waveform generator with self-contained trigger, external trigger and gate capability can serve as function generator, pulse generator or VCO. Model F210B offers repetition rates from 0.1 Hz to 100 KHz. A self-check distortion analyzer eliminates the need for additional calibration equipment. Microdot Inc., 220 Pasadena Ave., South Pasadena, CA 91030. **290**



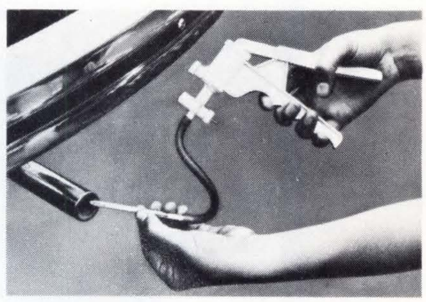
Test message generator for testing Teletype machines, circuits and other data transmission devices is priced at $450 and provides a standard 64-character "Quick Brown Fox ---" message. RE-EL Circuits, Inc., Box 167, Totowa, N J 07511. **291**

Frequency counter with five display digits counts from 1 Hz to over 15 MHz at input levels from <100 mV to >200V. The Model IB-101 kit has both an overrange indicator and a Hz/kHz switch to give the equivalent of an eight-digit readout. Kit assembly takes five hours and the price is $199.95. Heath Co., Benton Harbor, MI 49022. **292**

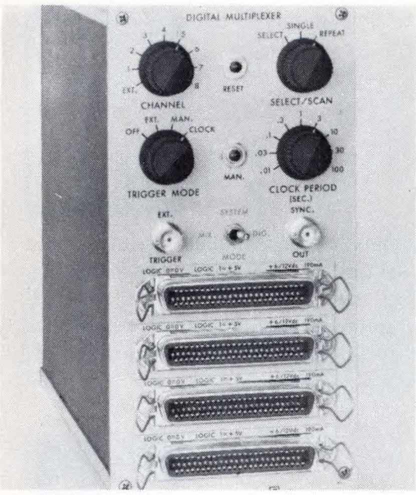


Strip chart recorder, Model 7123A/B, uses a linear servo motor pen drive. Features include a non-wire conductive feedback element, better than 1/3 second for full scale response and printout on 10-in electrosensitive paper. Price is $750. Inquiries Manager, Hewlett-Packard Co., 1601 California Ave., Palo Alto, CA 94304. **293**

Function synthesizer for digital computers permits precise, real-time control of periodic functions with virtually any 12-bit or larger digital computer. Model D800 uses state-of-the-art floating point techniques and provides frequency control of 0.1% at any point in the frequency range of 0.0002 Hz to 16.3 kHz. Selling price is $3450. MB Electronics, New Haven, CT 06515. **294**

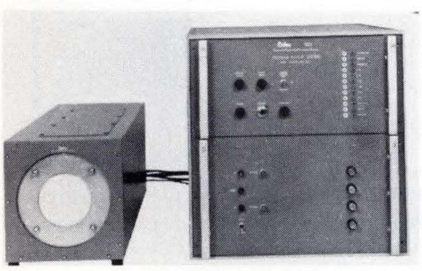


Air pollution tester kit costs only $16.50 postpaid, yet permits quantitative measurement of carbon monoxide, carbon dioxide, hydrogen sulfide, nitrogen dioxide and sulfur dioxide content. Replacement ampoules for testing for each gas are available at $4.75/package of four. Edmund Scientific Co., 380 Edscorp Bldg., Barrington, N J 08007. **295**

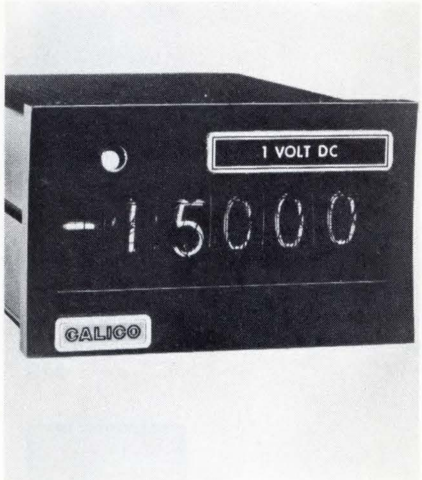


Digital multiplexer provides an interface between the outputs of up to eight digital data sources and a single information handling system. Model 263 is RIM packaged and provides a two-digit BCD output that identifies the channel being sampled. Price is $895, plus $140 for each two-channel plug-in board. Princeton Applied Research Corp., Box 565, Princeton, N J 08540. **296**

Digital counters, Series 2300, use light-emitting diode display and are available with three to six digits of display for both unidirectional and bidirectional operation. Prices start at $216 for the 3-digit unidirectional Model 2303A. Electronic Research Co., 10000 W. 75th St., Overland Park, KS 66204. **297**

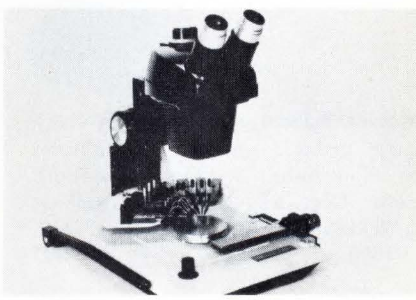


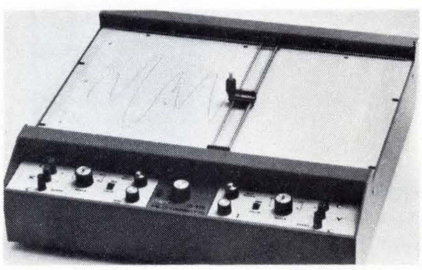
Precision CRT display system, Model DS-2, achieves a spot size of 0.0015 in at center and 0.002 in at the edge of a quality circle. Deflection linearity is 0.5%, bandwidth is 1 MHz. A five-inch CRT is used. CELCO, 70 Constantine Dr., Mahwah, N J 07430. **298**



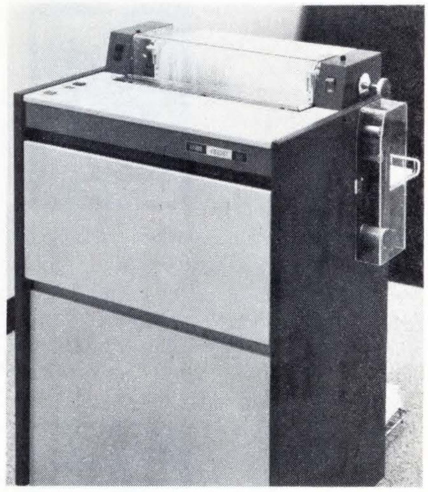
DPM features TTL logic with full-scale count of 15,000. Model 8440 has full-scale ranges of 1.5000, 15.000 and 150.00V. Basic accuracy is 0.001% of reading ±1 digit. Isolated 8-4-2-1 BCD is provided, and overload capability is 100 times full scale with 1000V max. Price is $395. CALICO Div., California Instruments Corp., 3511 Midway Dr., San Diego, CA 92110. **299**

"Mini-Prober", Model MP-0700, permits laboratory or pilot line testing of semiconductor wafers, thin-film circuits and similar devices. Price is $895 complete from stock, plus optics. Wentworth Labs., Inc., Rte. 7, Brookfield, CT 06804. **300**

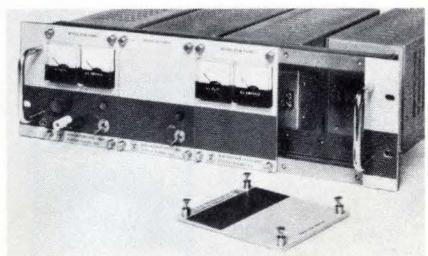




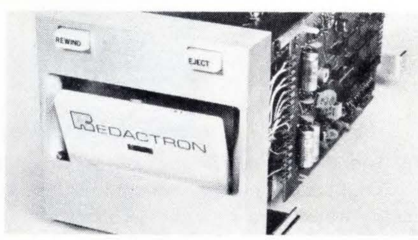
X-Y recorder uses an IC circuit design that eliminates photo or mechanical choppers. The Model 805 covers 11- by 17-in writing area and uses a disposable pen that can be changed in seconds. Price is $850. Bolt Beranek and Newman, Inc., 1762 McGaw Ave., Santa Ana, CA 92705. **301**



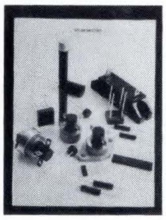
Non-impact printer is now available with a forms-control feature that automatically advances continuous computer forms to predetermined line positions along the vertical length of the form. This simplifies programming when complex forms are being printed on the Videojet printer that sells for less than $7000. A. B. Dick Co., 5700 W. Touhy Ave., Chicago, IL 60648. **302**



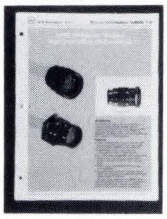
Modular power supplies, available with outputs from 3 to 200V, are series-regulated and provide remote sensing, parallel or series operation and overload protection. Prices for the ABC Series start at $129. Mid-Eastern Industries, A Div. of Eanco, Inc., 660 Jerusalem Rd., Scotch Plains, N J 07076. **303**



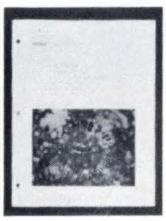
Cassette transport is a read-after-write unit with write gap 10% greater than tape width and read width of 67% of tape width. It operates at 30 ips and the instantaneous transfer rate is 1800 characters/s. Redactron Corp., 100 Parkway Dr. S., Hauppage, L.I., NY 11787. **304**



Silicon rectifier catalog contains 12 pages of information on integrated bridge rectifiers, epoxy bridge rectifiers and high voltage diffused silicon rectifiers. Varo Semiconductor Div., Box 676, Garland, TX 75040. **325**



High density multipin connectors with bayonet coupling are described in Bulletin 7-5. Units are available in contact sizes that include 22, 20, 16 and 12 gauge wires. Microdot, Inc., Connector Div., 220 Pasadena Ave., South Pasadena, CA 91030. **326**

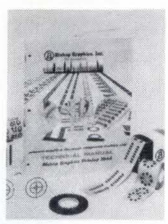


"Design Guide and Short Form Catalog" contains 34 pages on a line of rectifiers, zener diodes, microwave diodes, assemblies, thyristors and transistors. Unitrode Corp., 580 Pleasant St., Watertown, MA 02172. **327**

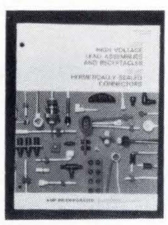
Thumbwheel switches for voltage dividers and resistance decades are covered in this 12-page catalog that provides 12 different configurations along with complete model number and price list section. Digitran Co., A Div. of Becton, Dickinson & Co., 855 S. Arroyo Pkwy., Pasadena, CA 91105. **328**

"Teletype Inktronic Terminals", 16-page brochure, contains information on a line of high-speed electrostatic terminals that operate to speeds of 120 characters/s. Teletype Corp., 5555 Touhy Ave., Skokie, IL 60076. **329**

Pushbutton switches and indicators "Selector Guide" is a six-page foldout that fully describes a line of 4-lamp illuminated pushbutton switches and indicators including holding coil units. Master Specialties Co., 1640 Monrovia Ave., Costa Mesa, CA 92627. **330**



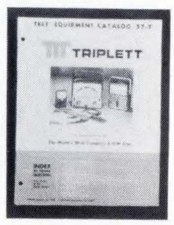
"Technical Manual and Catalog 104A" is a 68-page updated reference on "Circuit Zaps", dual in-line and flatpack artwork patterns. Dept. EDA-1, Bishop Graphics, Inc., 7300 Radford Ave., North Hollywood, CA 91605. **331**



Interconnecting leads and hermetic connectors for high-voltage applications are described in 32-page Catalog No. 723-9. Interconnecting devices are designed for dc and RF currents up to 16A with levels to 50 kV and altitudes to 80,000 ft. CAPITRON Div., AMP Inc., Elizabethtown, PA 17022. **332**

"Automatic Capacitance Bridges and Classifiers" is a 12-page brochure that discusses capacitance measurement including guidelines to choosing capacitance measuring equipment. Teradyne, Inc., 183 Essex St., Boston, MA 02111. **333**

"1970-1971 SCR Power Supply Catalog" features a complete line of power supplies that includes the smallest volume/W output, lowest mV ripple and zero crossover SCR control. Electronic Measurements, Inc., 405 Essex Rd., Neptune, N J 07753. **334**



"Test Equipment Catalog 57-T" features FET and digital VOMs plus a unique VOM comparison chart that designers should find useful. Triplett Corp., Dept. PR, Bluffton, OH 45817. **335**

"Integrated Circuit Sockets, Systems and Accessories" are detailed in this 38-page catalog. Information on IC packages as well as burn-in, breadboard and wire wrapping systems are covered. Catalog No. IC-1070 is available from Robinson-Nugent, Inc., 800 E. Eighth St., New Albany, IN 47150. **336**

Miniature glass tin oxide resistor with 50 PPM temperature coefficient stability and 1 percent tolerance is described in Data Sheet EPD RAD-3. Electronic Products Div., Corning Glass Works, Corning, NY 14830. **337**

Miniature transformers and a transistor transformer substitution box are covered in a two-page data sheet from Solid State Electronics Corp., 15321 Rayen St., Sepulveda, CA 91343. **338**

"UHF Capacitor S-Parameters" (AN102) and a discussion of base emitter tuning and broad-band impedance matching (AN101) are available from American Technical Ceramics, 1 Norden Ln., Huntington Station, NY 11746. **339**

Planar power transistors, JAN 2N2812 and -14 and JAN-TX-2N2812 and -14, are 10A units supplied to meet Mil Spec MIL-S-19500/415. Engineering Bulletin No. 31502 is available from Pirgo Technical Information, c/o Sprague Electric Co., 491 Marshall St., North Adams, MA 01247. **340**

Low temperature coefficient electromagnetic delay lines offering delays from 20 μs to 1 ms and which meet MIL-D-23859 are covered in a technical bulletin from ESC Electronics, 534 Bergen Blvd., Palisades Park, N J 07650. **341**

Insulated strip terminals in wire sizes ranging from 26 to 10 AWG are covered in six-page Catalog KM-4. Kent Corp., A Subs. of Thomas & Betts Corp., 169 Lake St., Mundelein, IL 60060. **342**

Signal power and RF relays including more than 30 types are covered in eight-page Catalog DSC-5. Relay types covered include miniature industrial, general purpose, power, telephone, time delay, microminiature and crystal can units. Hart/ Advance Relay Div., Oak Electro/Netics Corp., Crystal Lake, IL 60014. **343**

Portable FM two-way radios with 2 or 4W four-channel capability and operating in the range of 450 to 512 MHz are described in brochure HC-400. Hallicrafters Co., FM 2-Way Dept. PR, 600 Hicks Rd., Rolling Meadows, IL 60008. **345**

Solid state high threshold logic count/ control is the subject of a new brochure that discusses equipment with prices starting at $180. Durant Digital Instruments, A Cutler-Hammer Co., 622 N. Cass St., Milwaukee, WI 53201. **346**

Components Catalog 747 includes over 1300 new components introduced since Catalog 700 was published. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, MA 02138. **347**

"Custom Thick-Film Hybrid Circuits", eight-page Bulletin No. 2018, describes a company's facilities for manufacturing thick-film hybrid circuits to specification. Electronic Modules Corp., P.O. Box 141, Timonium, MD 21093. **348**

"Puzzled by small computers?" is a six-page brochure that describes SYSTEMS solution-oriented small computer products for OEM and end-user markets. SYSTEMS Engineering Labs, Inc., Communications Dept., 6901 W. Sunrise Blvd., Ft. Lauderdale, FL 33313. **349**

"Communication Antenna Systems" is a 68-page catalog No. 670 that gives complete specifications and performance data on a full line of antenna systems. Phelps Dodge Communications Co., Rte. 79, Marlboro, N J 07746. **350**

"SUHL-Plus" is a 28-page catalog that describes Transitron's answer to the SUHL procurement problem. Transitron Electronic Corp., 168 Albion St., Wakefield, MA 01880. **351**

Miniature aluminum electrolytic capacitors are low-voltage 85°C types featuring both axial leads and upright radial leads. Complete capacitance, voltage and size specifications of both series are covered in a four-page folder from Capacitor Div., International Electronics Corp., Melville, NY 11746. **352**

Solid-state RF switches from 0.3 to 500 MHz and featuring high ON/OFF ratios are covered in this six-page catalog. Relcom, 2329 Charleston Rd., Mountain View, CA 94040. **353**

Miniature, subminiature and microminiature lamps that operate from 1.25 to 48V dc and 120V ac are covered in 16-page catalog from Shigoto Industries Ltd., Empire State Bldg., 350 Fifth Ave., New York, NY 10001. **354**

Digital instruments, including a line of counter timers, DVMs and multiplex/ couplers, are covered in a short form catalog from Eldorado Electrodata Corp., 601 Chalomar Rd., Concord, CA 94520. **355**

Encapsulated reed relays capable of switching dry circuit loads to 10W and 0.5A are covered in this two-page data sheet. Guardian Electric Manufacturing Co. of California, Inc., 5755 Camille Ave., Culver City, CA 90230. **356**

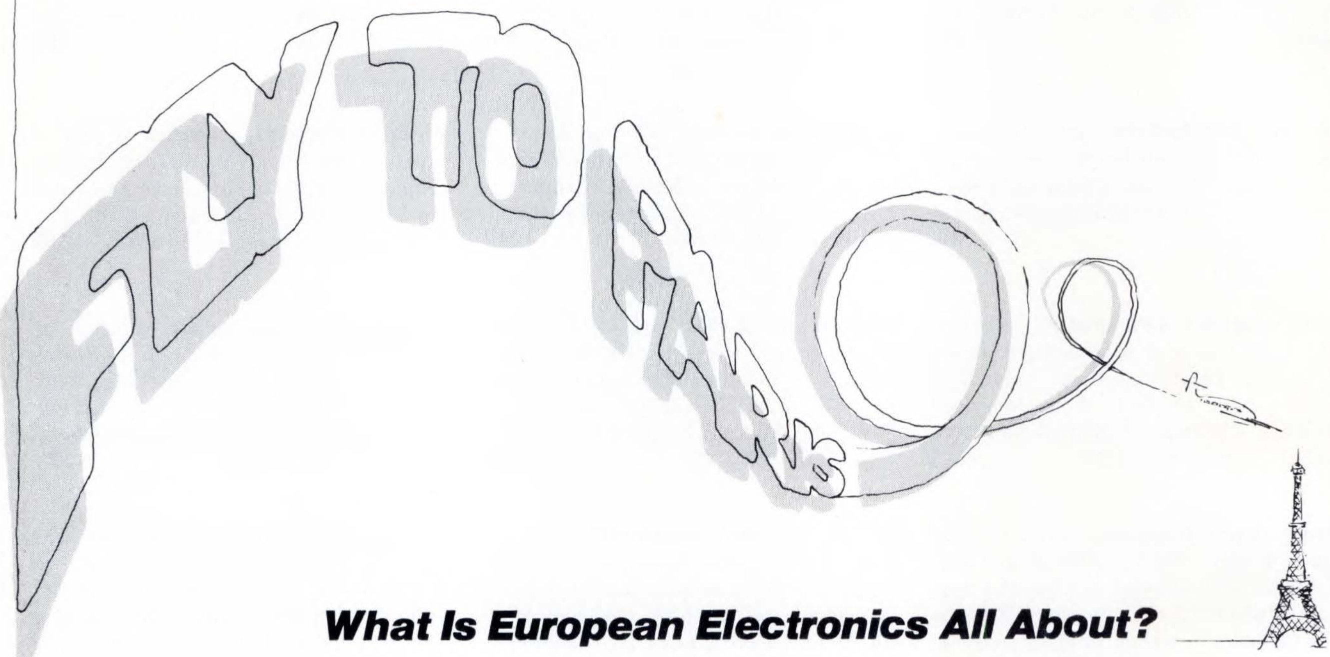
"Slides: What They Are, When They Are Used, Where They Are Used" brochure shows charts, graphs, application photographs and before-and-after illustrations. Grant Pulley & Hardware Co., A Div. of Instrument Systems Corp., West Nyack, NY 10994. **357**

Printers, core and disc memories, remote batch terminals and other compatible peripheral systems are described in a 12-page brochure entitled "Product Profiles". Data Products, 6219 DeSoto Ave., Woodland Hills, CA 91364. **358**

Keyboard Product Sheet 16SW3-1 describes a 16-key solid-state numeric keyboard. Micro Switch, A Div. of Honeywell, Inc., 11 W. Spring St., Freeport, IL 61032. **359**

Solid-state Trace Moisture Analyzer that incorporates a new phosphorus pentoxide detector cell and plug-in circuit boards is the subject of Bulletin 4101. It is available from Technical Information Section, Process Instruments Div., Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, Ca 92634. **360**

"Electrostatic Control Systems Geared to the Future" is a four-page brochure on a company's line that includes static neutralizing, measuring and generating equipment. Testone Electrostatics Corp., Box 50, West Point, PA 19486. **361**



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Application Notes

Ratio system measuring harmonic distortions in noisy environments is the subject of Note T-242. The use of phase-sensitive detectors in a ratiometric system to measure amplifier harmonic distortion is described. Princeton Applied Research Corp., Box 565, Princeton, N J 08540. **375**

Complementary precision hybrid dc voltage regulators from 5 to 30V (either + or −), output voltage TC of 0.01% and output setting tolerance of 0.5% are discussed in 8-page Series 828 and 838 Catalog. Technical Information Section, Helipot Div., Beckman Instruments, Inc., 2500 Harbor Blvd., Fullerton, CA 92634. **376**

"Surface Defects in Silicon Epitaxial Wafers" outlines the various defects that occur during epitaxial growth on silicon and their possible causes. Hacker Instruments, Inc., Box 646, West Caldwell, N J 07006. **377**

"Prevailing-Torque Locknuts—What They Are and Where They Should Be Used" helps users to select the correct locknuts. Part I of the nine-page article describes the functions of locknuts; Part II describes nut materials, plating and lubricants. Copies of Article 70-17 are available from Dept. 017, Precision Nut Products Div., Standard Pressed Steel Co., Jenkintown, PA 19046. **378**

"PRIME" (Programmed Reliability in Micro-Electronics) is a four-page engineering bulletin that contains company's quality assurance and reliability program for semiconductors. Sprague Electric Co., Semiconductor Div., 115 Northeast Cutoff, Worcester, MA 01606. **379**

D/A and A/D converters built from monolithic IC quad switches and thin-film resistor components are the subject of this eight-page note. It illustrates do-it-yourself converters with resolutions from 4 to 16 bits. Analog Devices, Inc., Pastoriza Div., 221 Fifth St., Cambridge, MA 02142. **380**

"Real-Time Spectrum Analysis Condensed Catalog" (Bulletin 620) describes five easy steps to choosing the real-time spectrum analyzer exactly right for you. Federal Scientific Corp., 615 W. 131st St., New York, NY 10027. **381**

"The 9310-9316 Counters", ten-page app note No. 184, describes the 9310 BCD decimal counter and the 9316 binary hexidecimal counter, which are multifunctional TTL/MSI devices with three control inputs for mode selection. Applications include multistage programmable counters and cyclic D/A conversion. Fairchild Semiconductor, 464 Ellis St., Mountain View, CA 94040. **382**

Transient overtesting during vibration tests (Bulletin 424) discusses methods of preventing overtest conditions and a method of employing a peak-reading, peak-holding acceleration meter. Ling Electronics, 1515 S. Manchester Ave., Anaheim, CA 92803. **383**

"TV Video Delay Module" four-page data folder (MCA-5.04) includes circuit block diagrams for three suggested applications of these modules. All circuitry required to interface video signals with ultrasonic glass delay medium is included. Electronic Products Div., Corning Glass Works, Corning, NY 14830. **384**

Testing of rate-integrating gyros is the subject of an eight-page article reprint which begins by identifying and describing 12 sources of error in rate-integrating gyros. Inland Controls, Inc., 250 Alpha Dr., Pittsburgh, PA 15238. **385**

"Parametric Varactor Up-Converters", Form 9370, provides a general discussion of parametric up-converters using varactor pumping for application to low-noise broadband microwave receivers. The paper covers reactance amplifiers, upper-sideband devices with fixed and variable pump frequencies, and lower-sideband devices. Zeta Laboratories, Inc., 616 National Ave., Mountain View, CA 94040. **386**

Reprints Available

in this issue are offered as follows:

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L62	Digital Systems Need Digital Measurement	29
L63	Diode Provides Low-Distortion Amplitude Modulation	33
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L65	Customer Engineering Clinic	40

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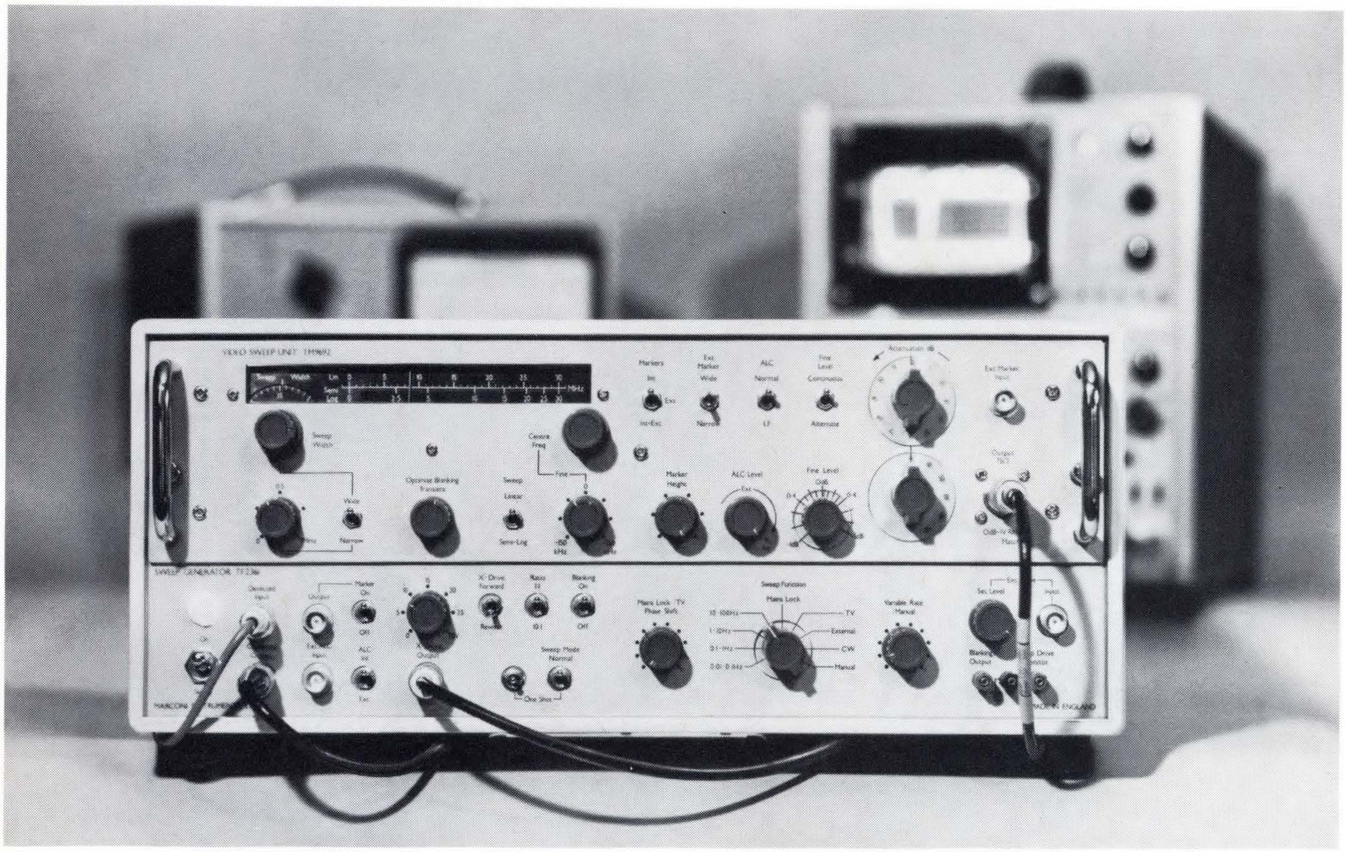

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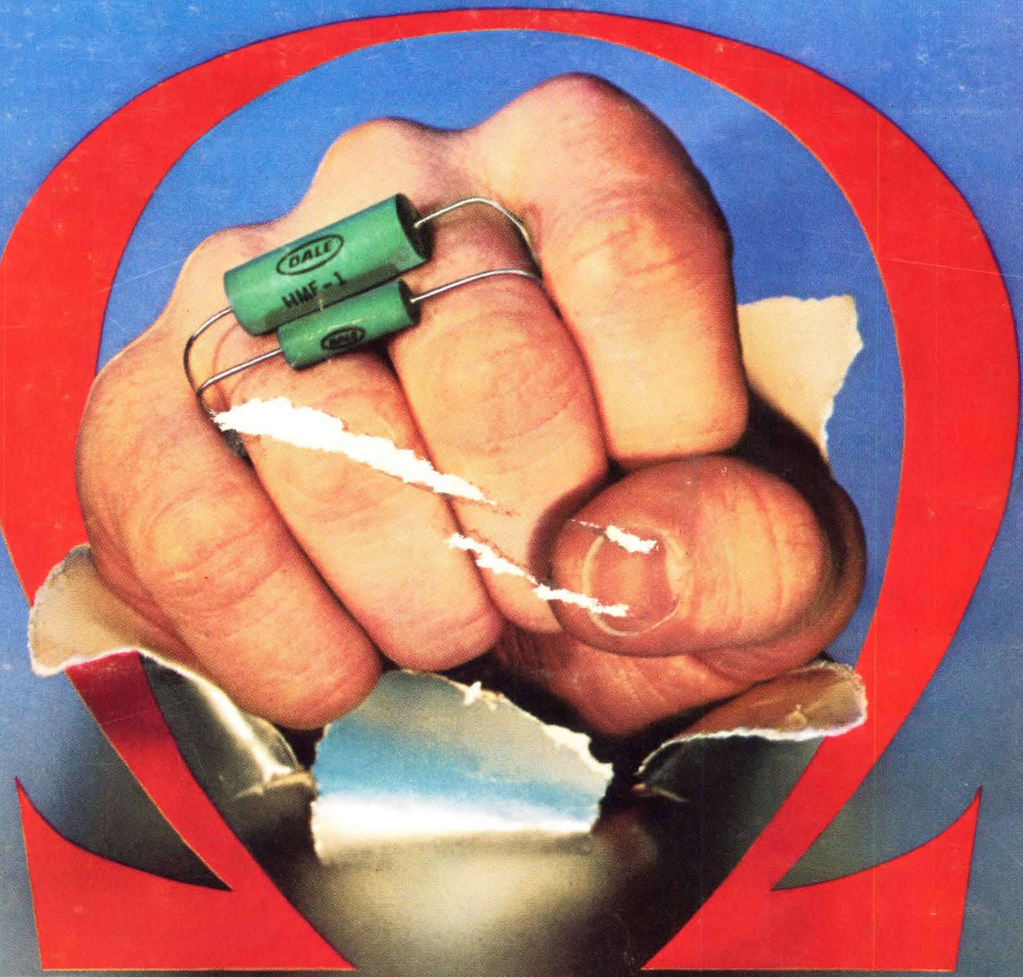

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