December 6, 1973

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The International Magazine of Electronics Technology

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Highlights

The cover: A workaday digital VOM, 99
A digital volt-ohm-milliammeter, by using a liquid-crystal display that runs off a 6-volt power supply, achieves year-long battery life. Built around a C-MOS logic chip and a bipolar analog chip, the instrument also rivals analog VOMs in price and reliability. Cover is by Art Director Fred Sklenar.

IEEE reports on the job situation, 75
An engineering-style analysis of the engineer's changing job status provides new and concrete information on industry requirements, the manpower picture, careers, and personality factors.

How to keep power semiconductors cool, 103
The right choice of heat sink and mounting technique for a power semiconductor requires a systematic thermal analysis but pays off in reduced failure rates. This is the third in *Electronics'* series on thermal design.

Computer easily models NAND gate's function, 121
Computer models that treat digital ICs as black boxes instead of complex collections of components greatly simplify the computer-aided analysis of a system. NAND gates are covered first in this five-part series entitled "Digital-IC models for computer-aided design."

And in the next issue . . .
Electronics' annual survey of the European market . . . a computer model for flip-flops

Electron Devices meeting coverage

Reports on the International Electron Devices Meeting can be found on pages 40–41, 62–63, and 78–80.

Electronics

Publisher's letter

A technical editor's dream—that's what executive editor Sam Weber calls the two big annual leading-edge-of-technology meetings: the current International Electron Devices Meeting and the International Solid State Circuits Conference held early in the year.

"When these two meetings are on," says Weber, "we can concentrate our energies, going to where the innovators are gathered and where the technological trends stand out in bold relief. Besides, so many of the steps in the advancement of electronics show up at these meetings. For example, for the past two or three years the meetings have been heavy with CCD and MOS developments that are now turning up in products."

We've prepared wide-ranging coverage of the Electron Devices meeting. In our Probing the News department, we've gathered together a host of the major developments presented at the meeting (see p. 78). You'll also find items from the meeting in the Electronics Review section, starting on page 39, and in the Electronics International section, starting on page 62.

As usual, we sent a team of reporters and editors to the meeting. Their coverage will show up in future issues as we bring you further up-to-minute news stories, in-depth trend analyses, and detailed technical articles.

When Sony Corp's president Akio Morita (at right in photo above) arrived in Washington last month to deliver an invited lecture on industrial creativity at the Smithsonian Institution, the event provided bureau manager Ray Connolly (left)

an opportunity for useful conversation with the industrialist (see p. 42).

As part of the on-going story of Japan's expansion in the world's electronics markets, and of Sony's success in particular, Morita put heavy stress on the importance of marketing—as did Sony co-founder and chairman Masaru Ibuka before the IEEE of Canada in Toronto recently [*Electronics*, Nov. 22, p. 50].

In one of his lighter moments, Morita told Connolly about how Sony became the company's name. "The story," says Connolly, "sounds too funny to be true. First, the name had to sound the same in most languages. Second, it had to be short and easy to remember. Three initials were ruled out because there were already too many used.

" 'Going to four letters was the next logical step,' according to Morita, who told of reading many dictionaries before finding words like 'sound' and 'sonic.' Then, he discovered the song title 'Sonny Boy.' That led him to the name Sony because 'we were the sonny boys of our industry.' "

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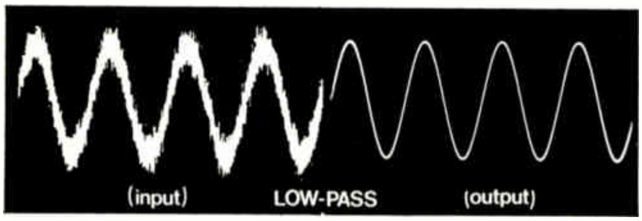

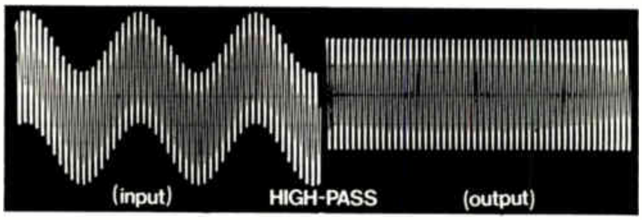

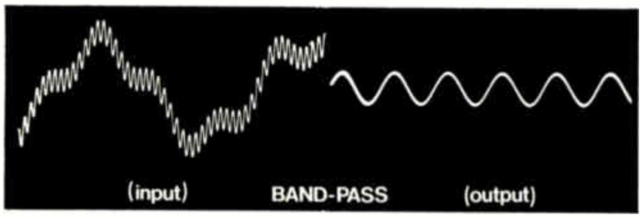

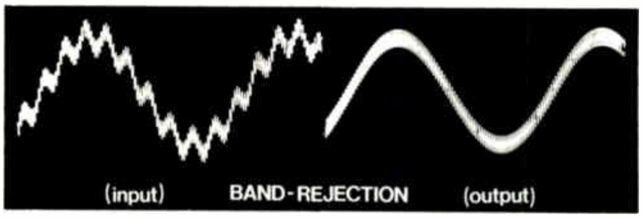

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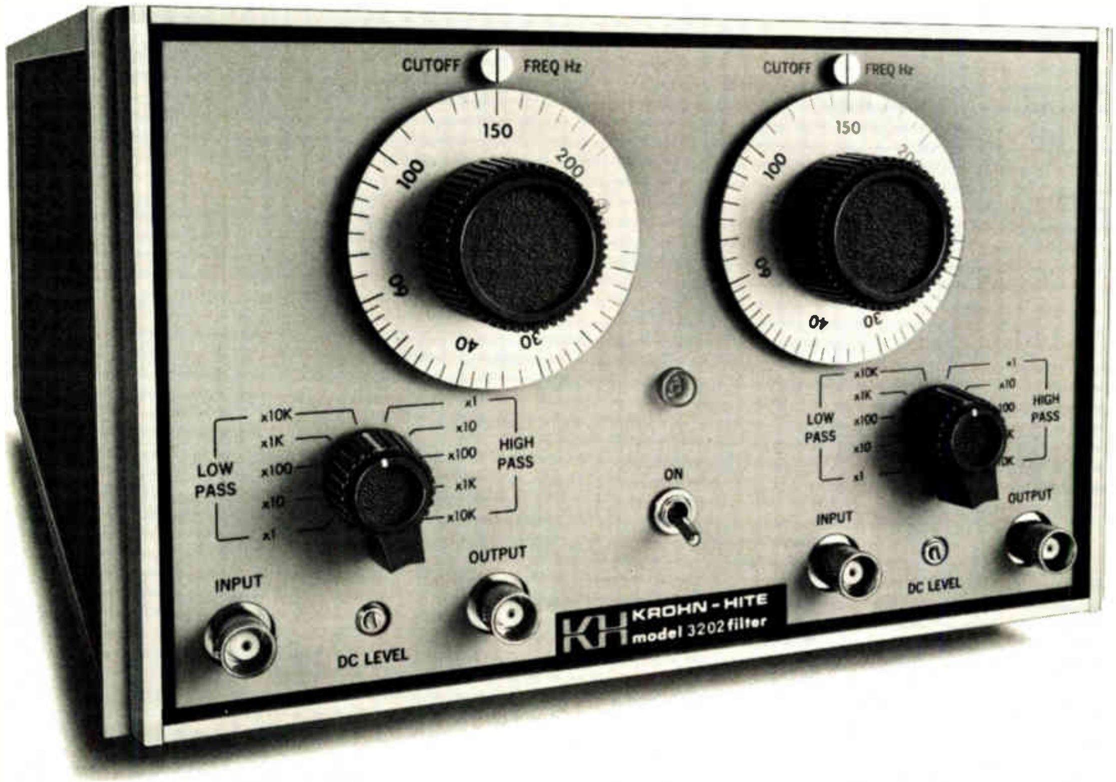

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Readers comment

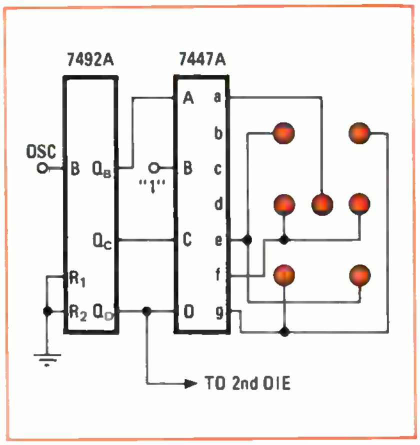
Achieving statistical veracity

To the Editor: The dice in "Electronic dice ease tough decisions" [*Electronics,* Aug. 16, p.118] will not give statistically correct results. Isolated, each die will show the numbers from 1 to 6 with correct probability. The combination, however, should have 36 equally probable outcomes, but the suggested circuit gives only 12.

The second die should be clocked from the carry output of the first counter. To secure "maximum randomness," the oscillator frequency should also be as high as possible. Besides, the circuit may be considerably simplified by using a seven-segment decoder/driver to drive LEDs directly.

Counts	Decoder input	Active segments	Dice outcome
0	2	a,e,g,(b,d)	5
1	3	a,g,(b,c,d)	3
2	6	e,f,g,(c,d)	6
3	7	a,(b,c)	1
4	10	e,g,(d)	4
5	11	g,(c,d)	2
0	2	a,e,g,(b,d)	5

Per J. Johnson
Institute of Physics
Oslo, Norway



Profilemeter price pinpointed

To the Editor: Your "Zenith tests acousto-optic surface profilemeter" [Oct. 11, p.36] overestimated the price. We intend to sell in the area of $12,000, including the laser.

Albert Hollander
Zenith Radio Corp.

When Frank Riccobono, DDC's Instruments Product Manager, makes an offer to introduce you to our fine family of synchro instruments, who can refuse?

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Programmable standards—as well as programmable computer interfaced angle indicators—are also present and accounted for in the SR-400, SR-102, and the custom-designed instruments immediately to Frank's left.

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40 years ago

From the pages of Electronics, December, 1933

NBC's new studios

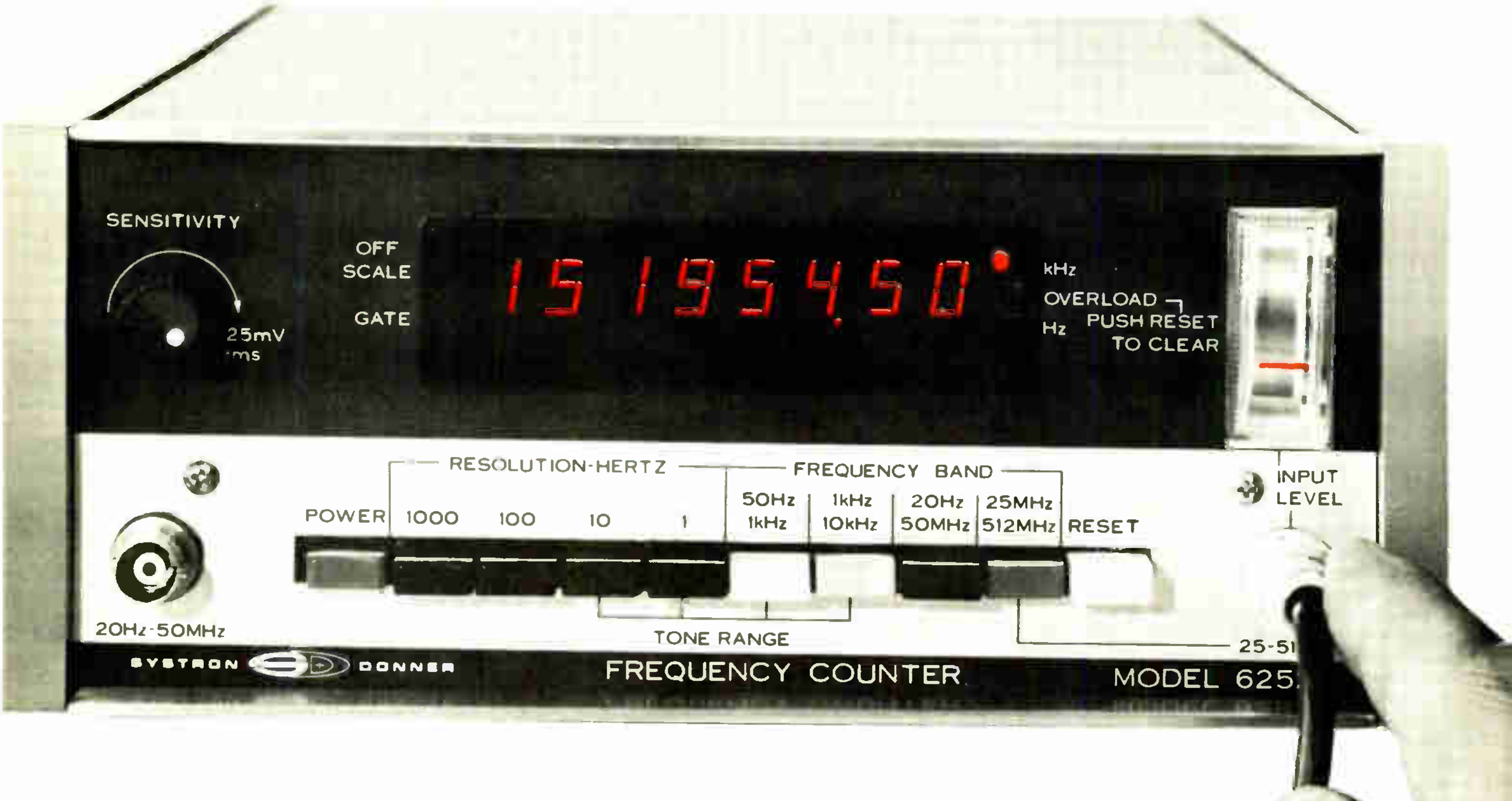
The world's largest and finest radio-broadcasting studios are now in operation at Radio City, New York. Built by the National Broadcasting Company at an outlay of five million dollars, they incorporate many novel features . . .

Thirty-five studios of various sizes are provided, of which sixteen went into operation in November; eleven others are yet to be electrically equipped, and eight more will be installed in the unfinished floors. The mammoth three-story auditorium studio measures 78 by 132 feet and seats 1600 people. Another large theater studio is equipped with opera chairs, stage, and a sound-insulating glass curtain which slides in from the wings, in sections. A unique four-unit "clover-leaf" studio group provides four studios served by a central operating room glassed in on all sides. Suitable for eventual television productions, this studio group has immediate application for carrying out the English practice of setting up a broadcast with the vocalist, orchestra, speakers, etc., in different sound-proof quarters, and combining them at different levels to produce the desired ensemble effect. Several of the studios also have controllable acoustics in the form of motor-operated panels and curtains, which can be manipulated from the corresponding studio control-rooms to produce any degree of sound reflection in any part of the room.

Provision for future television broadcasting in the NBC studios is seen in the use of special direct-current circuits for all studio lighting, although all the rest of the Radio City group is served with the usual 60-cycle alternating current.

The electrical and audio equipment for the new Radio City studios is estimated to have cost about two million dollars. For the sound-insulated and acoustic treatment, air conditioning, etc., another two millions were expended. Thus with a million dollars for the eleven-story steel structure the total investment comes to about five millions.

Will your next frequency counter have all these features?



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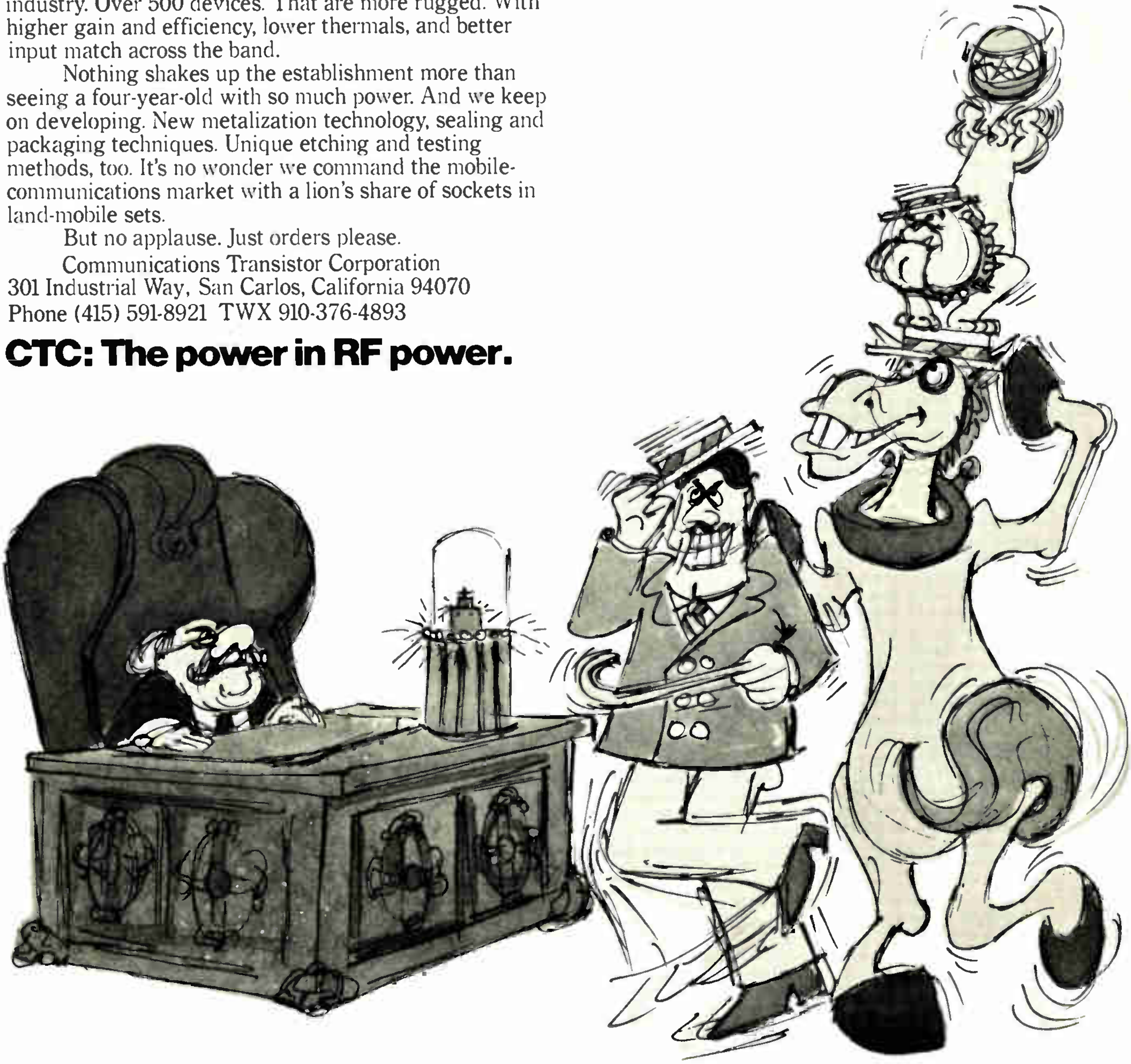


Apollo and the Arabs

For the moment the energy crisis presents the electronics industries with more problems than opportunities. And that is no surprise, for crises by their very nature focus everyone's attention on immediate problems, leaving little time for long-range planning.

Manufacturers of most things electronic talk today of keeping factories warm for the winter and semiconductor furnaces at even temperatures. Some are weighing the option of a four-day work week as a means of conserving energy while filling those order backlogs they have on hand. If they have thought about it, few are saying anything about what may happen to that order backlog if, for example, a significant slump in sales of Detroit's 1974-model gas guzzlers or a cutback in commercial and general aviation aircraft deliveries results in cancellation of subcontracts for seatbelt semiconductors and avionics.

The immediate answer to the energy problem supplied by President Nixon to the nation is a patchwork of conservation measures that have been hastily sewn together with very thin thread. And Nixon's many critics contend the patch cannot cover the energy hole.

But what about Project Independence? Advanced by President Nixon as the silver lining behind the energy cloud that hangs over the nation, he likens it to earlier American efforts to land men on the moon under the Apollo program and to develop nuclear weapons during World War II's Manhattan Project. The lessons of those two programs are in Nixon's view "the same lessons that are taught by the whole of American history: whenever the American people are faced with a clear goal and they are challenged to meet it, we can do extraordinary things."

The leaders of the Arab world know the lessons of Apollo well, of course. They know that a nation that put men on the moon probably could evolve alternatives to petroleum for energy. "That is why they are cutting back on petroleum deliveries, not cutting them off," explains one Washington oil industry man. "They want us to hurt enough to get them a settlement" with Israel. "But they don't want us to become independent" of their resources.

Arab actions thus far have been well calculated. They know that Project Independence, as described by President Nixon, is nothing more than new frosting on stale cake. Certainly it is not a well-defined, funded, and coordinated national goal, as was Apollo.

Manned space flight costs came to more than $26 billion in less than a decade. Project Independence funding, on the other hand, is virtually nonexistent. After you cut through the White House flimflammery that lumps together all existing Federal agency energy outlays and calls them a national program, all that is left is the Nixon proposal asking Congress for a five-year, $10 billion package to create an energy R&D agency. The legislation—long delayed in its delivery to the Congress since its White House announcement on June 29—has gone nowhere to date. But should it pass, it can hardly be called a program of the proportions of the Apollo or Manhattan projects.

No one doubts that there are opportunities possible for electronics technology in alleviating the national energy shortage and making America independent of foreign resources. But technology—particularly electronics technology—costs money. Someone must pay for it. The Nixon Administration, for all of its apparent concerns with energy, is not yet willing to put the country's money where its mouth is when it comes to funding new energy research and development. And just as many industry managers know this, so it must be assumed that the oil sheikhs know it too.

In future editorials, we'll discuss some concrete ideas we have on how electronics ought to be tapped in helping solve this crucial problem. Meanwhile, we'd welcome your ideas and suggestions.

People

Ancker-Johnson: a scientist at Commerce

Is it shortsighted for the U.S. to export its electronics manufacturing techniques to potential competitors? Or is it wiser to protect our technological expertise and limit exports to the products of that know-how? The Commerce Department's assistant secretary for Science and Technology, Betsy Ancker-Johnson, says candidly, "I don't know, and I don't think anybody else knows yet either" [*Electronics*, Oct. 25, p. 200].

At Commerce. Betsy Ancker-Johnson promotes licensing Government patents.

The question is one of the most divisive within the electronics industries [*Electronics*, Oct. 11, p. 41]. The fact that the diminutive 44-year-old physicist, mother of four and former Boeing Co. executive, has no pat answer therefore reflects more her background in science and engineering than any unwillingness to align herself with conservative or liberal trade policies.

Positives. Now in the eighth month of her Federal assignment, Ancker-Johnson is heavily involved in developing ways to improve America's use of electronics to domestic and world markets. For example, the Patent Office recently adopted her plan to speed up the processing of patent applications relating to energy.

She is also disturbed that the Federal Government is laying out about $17 billion this year for R&D but receiving only about 5% of the 70,000 patents awarded annually. Consequently, she has urged the National Technical Information Service to promote the licensing to industry of Government-patented technology that has been judged to have commercial potential.

Also, the Committee on Government Patent Policy, which she chairs, has drafted and had issued through the General Services Administration new regulations permitting exclusive licensing of Federally-owned inventions for limited periods in order to encourage their commercial exploitation. "We have in mind initiatives to vastly increase the amount of Government-discovered technology that gets patented and transferred to public use," she says.

In addition to presiding over the Patent Office and NTIS, her job as assistant secretary gives her jurisdiction over the department's offices of Telecommunications, Environmental Affairs, Product Standards, as well as the huge National Bureau of Standards. The NBS alone accounts for $62 million, or close to half of the fiscal 1974 budget request of $130 million for her bailiwick.

To back her decisions in these areas, Ancker-Johnson has an unusually useful set of qualifications: a doctorate *magna cum laude* from Tuebingen University in Germany, followed by positions at the University of California in Berkeley, Sylvania Applied Physics Laboratory, RCA, Boeing, Bell Laboratories, and Washington University.

Malco's Meyer plans new products

It's hard to keep a long-range view in a time of critical shortages, but that is the principal task of Harry H. Meyer Jr., new vice president and general manager of Malco Manu-

facturing Co., the Chicago-based maker of connectors and terminals. By agile footwork, Malco has avoided severe shortages. "A shaky, even keel," is how Meyer characterizes Malco's present position with its suppliers, but he admits he's wary of next year.

Nonetheless, Meyer emphasizes planned growth, including stepped-up new product development and increased acquisitions—a change from Malco's recent past and one he hopes to encourage by his separation of Malco's R&D arm from its engineering organization. As a result, Malco is studying higher-density connectors, and connectors for use in the automotive industry. Meyer believes that this and other new markets are going to be particularly important in the connector business because of the different interconnection technologies they involve.

This month the firm will introduce a simple transistor socket—the first of a family of transistor and integrated-circuit interconnect devices, and a new market for Malco. "You can either acknowledge or ignore the impact of the semiconductor business," Meyer says, "and we've decided to do something about it."

Meyer got his first look at planning with a BS in business and engineering administration from Massachusetts Institute of Technology in 1948. He joined the Maytag Co. as an industrial engineer and moved to Honeywell in 1951, where he most recently was director of engineering at Honeywell Microswitch, Rockford, Ill.

Long-range view. Harry H. Meyer emphasizes new-product development at Malco.

MEASUREMENT COMPUTATION NEWS
innovations from Hewlett-Packard

DECEMBER, 1973

in this issue

New desktop business calculator

Take along our portable strip-chart recorder

A digital thermometer for hot projects

New battery-powered dmm improves field service

Measure resistance, ac and dc voltage with a new autoranging digital multimeter that fits the palm of your hand.

HP's pocket-sized 970A digital multimeter is one of the most significant user-oriented instruments of the seventies. It operates on rechargeable batteries; automatically ranges ac, dc, volts and ohms through five ranges; displays measurements on a 3½ digit LED readout; yet weighs just 7 ounces (200 grams). This new probe is so small, so convenient that you can carry it on your belt or in your pocket—it's ideal for field service, as well as bench and lab use.

With thin film and MOS IC technologies, HP packed the electronic equivalent of 3000 transistors into this handheld probe. You can measure:

- dc voltage from 100 mV full scale

(continued on page 3)

A few ways to use HP storage displays

In this simulated radar exercise, an HP storage display helps train pilots.

Storage and variable persistence displays offer many advantages where information must be gathered over a relatively long period of time, then processed and presented for display. The bright stored information provides easy viewing in high ambient light, and highly burn-resistant CRTs ensure long life with no special operating precautions.

A unique medical application for HP storage displays is in conjunction with an ultrasonic diagnostic system that provides a "picture" of internal organs or tissues in selected areas of the body. Storage allows build-up of the display by using as many scans as needed for the desired image detail.

Another application is in a simulated radar acquisition system which provides pilots with a realistic training environment. By adjusting the variable persistence in an HP 1331 storage display to match the scan rate, the pilot can see relative position trends that are not possible to view with long fixed-persistence phosphors.

A new brochure describes other storage scope and display applications. For your copy, check E on the HP Reply Card.

Now, run FORTRAN faster with new HP software

Good news for 2100A and 2100S computer users: HP's new fast FORTRAN processor (FFP) dramatically speeds execution of FORTRAN programs and subroutines. Typical applications demonstrate that FEP generally causes programs to execute 10 times faster.

FFP contains microcoded library subroutines including double-precision floating-point operations, single-to double-precision conversions, as well as address and control transfer routines. And you can call the FFP subroutines with ALGOL and assembly language, as well as FORTRAN.

The processor is available in Read Only Memory (ROM) chips or in binary tape with two Writeable Control Store cards; and it can be either factory or field installed.

To learn more about fast FORTRAN, check R on the HP Reply Card.

FORTRAN Double Precision Programs	Software Execution Time (Sec)	FFP Execution Time (Sec)	Improvement Factor
Conversion Process of Mathematical Equation	319	16	19.9
Analysis of Variance	1800	210	8.57
Data Conversion	3780	425	8.89

New mass memories expand calculator storage

With this new mass memory, you can store or read a complete 250-line calculator program in about 2 seconds.

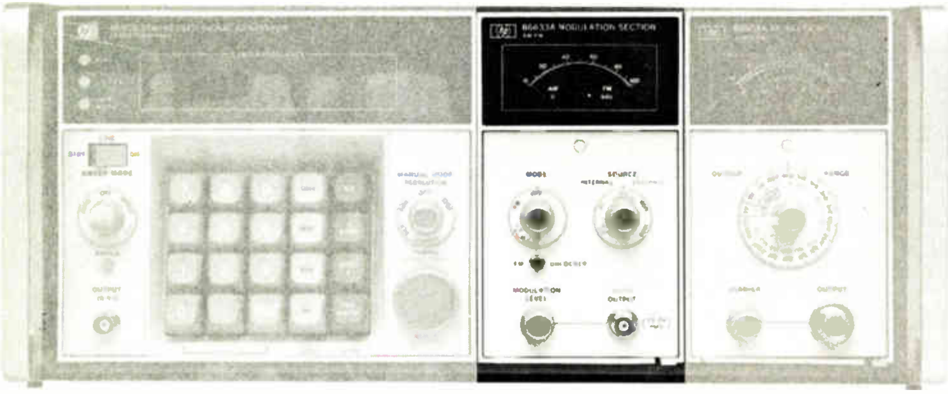
For calculator users who need lots of storage, there are two new mass memories for HP's powerful 9830A programmable calculator. Now, you can have large data storage for such varied applications as general ledgers, accounts payable, personnel records, patient data, laboratory tests, real estate listings, structural design, and statistical analysis

The 9880A is a single disc memory subsystem that stores 2.4 megabytes; the dual-disc 9880B has capacity for 4.8 megabytes. Both have a photoelectric mechanism for fast, accurate read/write head positioning. It takes just 50 ms (average) to access and transfer a data item from the memory to the calculator.

The subsystem is versatile, too. You can connect up to 4 memory discs, in any combination (A or B), to one HP 9830A calculator through a controller—or connect up to 4 calculators to one mass memory subsystem. However, only one calculator can access the memory at a time.

For more on calculator memories, check P on the HP Reply Card.

New options expand RF synthesizer capabilities



New modulation section for HP 8660 signal generators permits FM with phase-locked center frequency.

With the new 86633A modulation plug-in for HP 8660A/B synthesized signal generators, the center frequency is phase-locked while operating in the FM mode. This brings highest stability when you're making narrowband FM measurements—for example, in mobile radio receiver tests.

The 8660A/B signal generators provide fully-calibrated AM, FM and CW signals with synthesizer accuracy and spectral purity—from 10kHz to 1300 MHz. Some key performance characteristics are: 3×10^{-8}/day frequency stability, −80 dB spurious, <1.5 Hz residual FM, and calibrated output levels from +10 to −146 dBm. Now, the 8660 signal generators can be supplied with an optional ASCII interface which means they can be controlled from a 9820A calculator.

For more information, check O on the HP Reply Card.

(continued from page 1)

to 500 V with worst case accuracy of ±0.9% at full scale.

- ac voltage from 100 μV to 500 V rms, from 45 Hz to 1 kHz, with an accuracy of ±(2% of reading + 0.5% of range).
- resistance from 1 Ω to 11 MΩ, at an accuracy of ±(1.5% of reading +0.2% of range).

Yet the 970A is fast and easy to use—no confusing inputs or manual adjustments need be selected. You set only one function control, and there are just two input terminals, instead of the usual three to eight.

Select one of three probe tips, depending on your application: one for normal use; a longer tip for reaching otherwise inaccessible circuit test points; and a concave tip to cup wire-wrapped terminals and test pins. For other applications, the tip socket will accept a standard banana plug.

Simply touch the probe tip to the test point, push a button, and the LED readout displays the correct polarity and reading. Should the display be upside down when you hold the probe, a front panel switch electronically inverts the display. Thus, you won't mistake 6's for 9's.

There's more. For all the details, check D on the HP Reply Card.

New bipolar power supply doubles as an amplifier

HP's new bipolar power supply/amplifier is really three instruments in one package:

- A fast 50W bipolar power supply with continuous through-zero output.
- A fixed-gain power amplifier with dc—40 kHz bandwidth.
- A dc—15 kHz power amplifier with programmable gain.

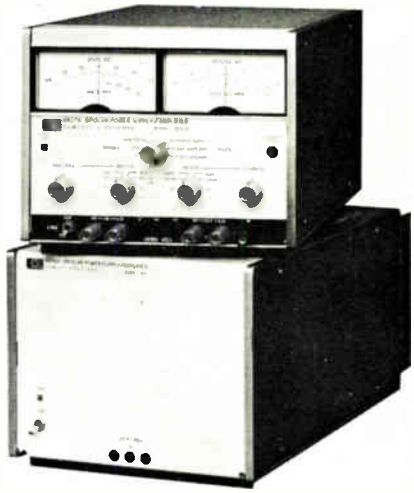
As a power amplifier, the supply teams up with many lab-type function generators to produce signals at voltage and current levels high enough to test deflection yokes, zener diodes, transistors, power relays, resolvers, motors, and many other devices. Individual units can supply outputs up to 40V p-p at 2A pk, 100V p-p at 1A pk, or 200V p-p at 0.5A pk. Auto-series or auto-parallel connections of multiple units further extend the range of possible outputs. Input/output impedance of 10 kΩ/0.5 mΩ means minimum loading of the signal source and plenty of output drive.

When operated as a bipolar power supply, output ratings are:

6825A/6830A: ±20V at 0—2A
6826A/6831A: ±50V at 0—1A
6827A/6832A: ±100V at 0—0.5A

The voltage output of all models can be programmed remotely (0.1% accuracy).

For specifications, check K on the HP Reply Card.



Choose between the laboratory versions with meters and front panel controls (models 6825A-6827A) or the system versions with blank panels (6830A-6832A).

Now, interface HP automatic measurement systems with an IBM 360/370

A new software/hardware package enables communication between an HP Real-Time Executive (RTE) system and an IBM 360/370 system. This gives you three-level distributed systems capability, with HP 9600 series measurement systems (first level) operating as satellites to an HP 9600C/E RTE system (second level), which in turn communicates with the IBM 360/370 batch computer (third level).

With RDTS, your measurement systems double as remote job entry terminals.

The new HP 91780 Remote Data Transmission Subsystem lets the satellite systems and RTE system operate independently, yet communicate with the IBM batch computer when desired. This gives each system access to the batch computer for large-scale computations and for storing measurement data in the IBM data base. Essentially, with RDTS the RTE system emulates an IBM 2780 Data Transmission Terminal, allowing it to operate as a remote job entry terminal.

Some major application areas are:

- **Manufacturing**
- **Military/aerospace**
- **Colleges, universities**
- **Health services**

Full information is available; just check Q on the HP Reply Card.

New business calculator challenges a computer

Now, there's an HP desktop business calculator especially for accountants, bankers, financial and tax analysts, investors, real estate agents, stockbrokers, and bond dealers. Like the popular pocket-sized HP-80, the HP-81 business calculator can perform 40 financial functions...plus interest per period, depreciation schedules, discounted rate of return for uneven cash flow, coupon equivalent yield, amortized loan schedules, bond and note calculations.

For statistical analysis, use the HP-81 to calculate mean and standard deviation, correlation coefficient, percent and % difference. You can also compute a two-variable trend line, and/or multiply and divide by any constant. Enter both x and y values of a data point; the correlation coefficients are calculated automatically when the trend line is calculated.

Answers are printed on a tape so you have a permanent record. Negative numbers are printed in red. If you make an operational error, such as dividing by zero, the calculator immediately prints an error message.

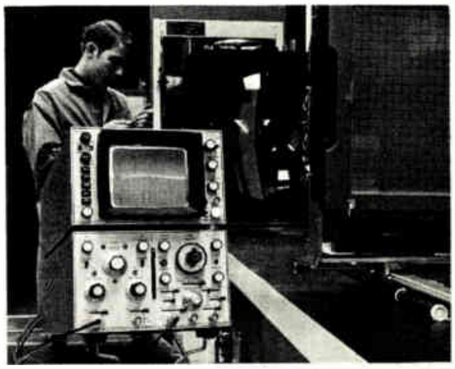
With the time and money you'll save, the HP-81 pays for itself within weeks.

For more information, check C on the HP Reply Card.

The streamlined, compact HP-81 weighs just 13.5 lbs (6.12 kg).

HP storage oscilloscopes for a variety of uses

At the U.S. Air Force Academy, an HP 181A storage scope is used in a research project on how cracks develop in such critical structures as aircraft wings.



HP storage oscilloscopes enable you to capture nanosecond transients or low rep-rate signals in bright, flicker-free displays. Very high speed signals, single-shot events, or low frequency applications are easily resolved with storage writing speeds of 0.5 cm/μs. to 400 cm/μs. These stored displays are bright up to 100 foot-lamberts and are highly burn-resistant so that they require relatively little care. Improved storage CRTs make it possible to capture and view high-speed phenomena that previously you could document only by difficult photographic techniques. Multi-mode capability means that our storage CRTs also satisfy general purpose applications.

For high-speed data, the 184A storage scope with fast writing speed (up to 400 cm/μs) captures infrequent events and retains them long enough for visual waveform analysis.

For low duty-cycle traces that can't be seen on a conventional CRT or are barely discernible under a viewing hood, the storage scope with variable persistence integrates low rep-rate signals to a bright display without annoying flicker. Also, with variable persistence you can retain a signal until a second signal is captured, allowing you to readily compare differences in time, amplitude and shape.

For the complete storage scope story, check F on the HP Reply Card.

Two scientific calculators fit your computation needs, your pocket and your budget

HP-35

Which HP scientific pocket calculator should you choose? That's a difficult decision. Both the HP-35 and HP-45 weigh just 9 ounces each, operate on batteries, perform trigonometric and logarithmic functions, are accurate up to 10 significant digits, and feature LED display and solid-state memories. Both are designed for a variety of applications in science, engineering, surveying, navigation, statistics, and mathematics.

The HP-35 has an operational stack of four registers, plus a data storage register for constants. The stack holds intermediate answers and, at the appropriate time, brings them back for further use. With the HP-35, you can perform addition, subtraction, multiplication, division, exponentiation, square roots, reciprocals, trigonometric and logarithmic functions in a fraction of a second... in the palm of your hand.

HP-45

The HP-45 advanced scientific pocket calculator has nine addressable memory registers and, like the HP-35, a four-register stack that holds intermediate answers for future calculations. There are three trigonometric operating modes—degrees, radians or grads—and you can easily convert from any mode to degrees/minutes/seconds and vice versa. Other additional capabilities include polar/rectangular coordinate conversions, percent and % difference, metric/U.S. unit conversions, n factorial (for permutations and combinations), mean and standard deviation. A special storage register, "last x," lets you correct an error without having to start over in the midst of a long calculation.

To learn more, check A or B on the HP Reply Card.

New battery-powered strip-chart recorder goes anywhere

Now, there's a lab quality, portable strip-chart recorder that operates up to 9 hours on internal rechargeable batteries or on an external ac or dc power from 48 to 440 kHz. Compact size (5-inch or 12.7 cm writing width) and rugged durability means the new 7155 recorder works well in trucks, field stations, airplanes, or any remote location.

Seven chart speeds range from 20 sec/in. to 60 minutes/in. Accuracy is 0.5% of full scale with overshoot <0.05 in. (.13 cm). Disposable pens and coated paper give you a sharp, clean trace that dries instantly. The writing system is so trouble-free you can even run the recorder upside down. It's ideal for recording at locations where ac line power is not available—for example, monitoring air and water pollution in the wilderness. And a see-through front cover protects the recorder from dirt and moisture.

Metric scaling is available.

For more information, check L on the HP Reply Card.

Take our new strip-chart recorder into the wilderness—it weighs less than 30 lbs (13.6 kg).

HP's new digital thermometer: a hot buy at a cool price

HP's new 2802A universal digital thermometer is a medium-priced unit that contains several features usually found only in expensive thermometers—features like two measurement ranges, linear analog output, high resolution, 4½ digital readout, and battery operation.

One temperature range extends from −200° to +600°C with 0.1°C resolution. Push a button to switch to the −100° to +200°C range with 0.01°C resolution. On both ranges, accuracy is always ±0.25% of reading ±0.5°C.

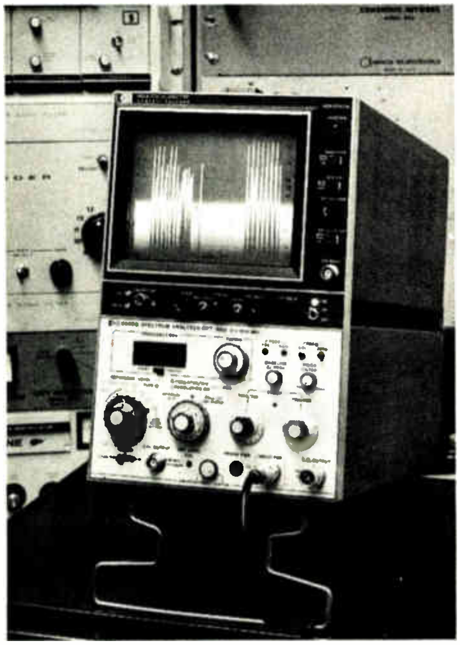
Linear analog output means you can connect the 2802A to any recorder for temperature charts and graphs. Snap in a 6-hour battery module, and the thermometer becomes completely portable, ready for field use. An optional BCD module for buffered output lets you send your digital temperature readings across the country. Various probes and sensors with standard or armored cable adapt the thermometer to a variety of needs. There are other optional snap-on modules that convert your thermometer to make voltage, current, and resistance measurements.

This new digital thermometer leaves expensive units out in the cold. To learn more, check G on the HP Reply Card.

Cryogenic measurements are easy with the new 2802A thermometer. Here, it measures the temperature of a device being cooled with liquid nitrogen.

New 75-ohm spectrum analyzer for communications and CATV

Spectrum analysis of CATV system signals is accurate and convenient with the HP 8558B spectrum analyzer.



For measurements in 75-ohm systems, two versions of the low-cost 8558B spectrum analyzer are now offered: one is calibrated in dBm for 75-ohm communications systems, and the other is calibrated in dBmV especially for CATV and television broadcasting. Major features of the 8558B are precision performance and ease of operation. Most measurements are made using only three controls.

Both versions offer a 0.1 to 1500 MHz frequency range and a 70 dB spurious-free amplitude display range. Resolution bandwidths are from 1 kHz to 3 MHz, and frequency response is <±1 dB. The analyzer has digital LED readout to show either center or "start-of-sweep" frequency.

For details, check M on the HP Reply Card.

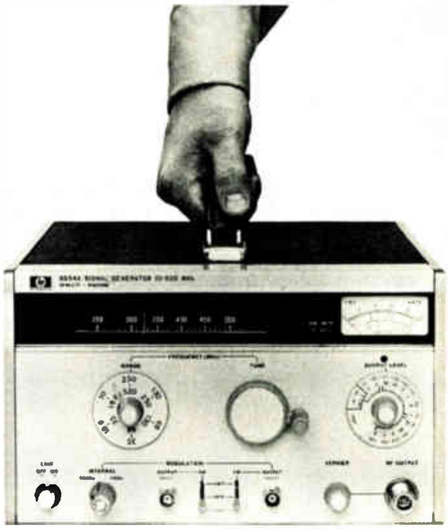
New low-cost RF signal generator is portable

The HP 8654A VHF signal generator—solid-state, portable, and low cost—provides calibrated output and versatile AM and FM modulation from 10 to 520 MHz. Compact and small in size, this precision instrument fits easily into production, mobile, airborne, and shipboard test locations.

The 8654A produces stable RF signals for testing receivers, amplifiers, antennas, and filter networks. Calibrated output range is +10 to −130 dBm. An auxiliary RF output is also available at the rear panel to use with a counter or other external equipment. Stability is 0.002% per 5-minute operating period, after two-hour warmup.

Portability, stability, and versatility make this a high-value VHF signal source for economy-minded users.

For specifications, check N on the HP Reply Card.



Carry it with you—the versatile 8654A AM/FM signal generator weighs just 16.5 lbs (7.5 kg).

HP offers "how to" newsletter for service technicians

Bench Briefs, a bimonthly publication, is your private line to HP Customer Service. It is offered to personnel servicing HP instruments and to service managers—and is particularly useful to anyone doing repair, calibration, incoming inspection, and system configuration of HP electronic instruments.

This attractive 8-page bulletin contains service tips, instrument modifications, new methods of testing, and new tools that simplify service and troubleshooting. *Bench Briefs* are full of practical information, such as the effects of IC tarnish or how to remove solder flux. There are tutorial articles to upgrade your technical knowledge in areas such as digital techniques or Boolean equations. Also included periodically are listings and order forms for Service Notes, as well as factory recommendations for updating or modifying HP products.

For two sample issues and a subscription qualification form, check T on the HP Reply Card.

Bench Briefs: an HP service that improves your service.

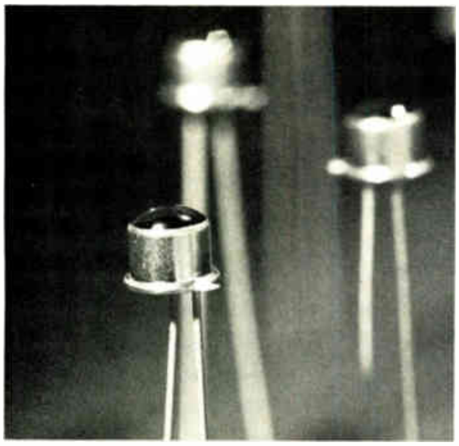
HEWLETT-PACKARD COMPONENT NEWS

New hermetic LED meets military specs

A new hermetically-sealed gallium arsenide phosphide LED lamp has been formally approved for use in military systems as a JAN/JANTX component. The JAN 1N5765 and JANTX 1N5765 alleviate the need for users to generate a special military specification and apply for non-standard parts approval.

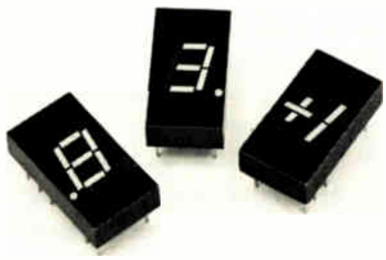
This hermetically-sealed solid-state lamp offers a minimum luminous intensity of 0.5 mcd at 20 mA and an operating temperature range of −65°C to +100°C. The HP commercial part number is 5082-4420.

For specifications and reliability data, check I on the HP Reply Card.



LED lamp for high reliability applications

New LED over-range digit expands display family



The new plus/minus one digit LED for HP 5082-7700 series LED displays.

A new plus/minus one digit is now available for applications requiring polarity designation or over-range capability. The 5082-7732 LED display is ideal for instrumentation such as digital voltmeters and digital multimeters. The unique feature of this display is the decimal point to the left of the "1" which allows the designer to show an additional range on the meter without the cost of an extra digit.

Designed for use with HP's 5082-7700 series of 0.3 inch (0.8 cm) LED displays, the 5082-7732 offers uniformly lit segments with wide viewing angle. They are available from stock or from any HP franchised distributor.

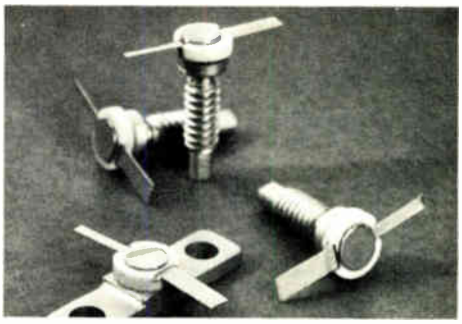
For details, check J on the HP Reply Card.

Use new medium-power microwave transistors

Our new 35850 series microwave transistors deliver ½ watt power output to 3 GHz with documented high reliability. They're ideal for applications requiring linear, broadband power and for Class C saturated power.

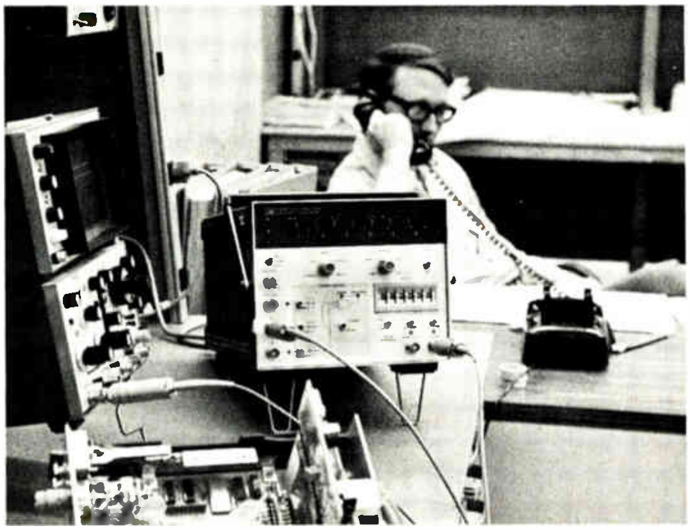
Available as chips or in rugged, hermetic metal/ceramic packages, these NPN silicon bipolar transistors fill both common emitter and common base design needs. The common emitter versions provide linear power up to +26 dBm at 2 GHz for broadband amplifiers. The common base versions fit Class C saturated power amplifiers.

For specifications and reliability data, check H on the HP Reply Card.



HP's high-reliability linear microwave power transistors come in two packages plus chip form.

New logic analyzer book tells how to troubleshoot digital circuits easily



The 5000A logic analyzer solves a broad spectrum of problems that range from determining the logic state of a circuit node to locating a spike that occurs 850,000 clock periods after a trigger.

When is that short reset pulse really occurring? Or is it? What causes this flip-flop to end in the wrong state at the end of each machine cycle? Are these two lines ever HIGH at the same time? If these problems sound familiar, send for "The Logic Analyzer—A Step to Easier Digital Troubleshooting" and learn how HP's 5000A logic analyzer can help you solve such digital problems.

This new application note (167-1) describes the easy-to-use logic analyzer as a practical problem-solver. To display the sequence of HIGHs and LOWs occurring at several points in a digital circuit, simply connect the circuit clock to the analyzer, then freely probe through the circuit. The analyzer displays these HIGHs and LOWs as "bits" on two rows of LEDs. At a glance, you can determine if a flip-flop is toggling, if the output of a shift register is following its input, or if a decade counter is really dividing the clock by ten. Even single-shot or very slow data is captured and stored for easy viewing.

The particular 32 bits displayed on each channel are selected by a combination of the versatile triggering controls and the digital delay. The trigger controls permit selection of any single input or any combination of up to three inputs for triggering. Digital delay lets you display information anywhere from 64 clock periods before the trigger event to 999,999 clock periods after the trigger event.

AN 167-1 also explains how to do more complex tasks such as investigating the output sequence generated by a ROM-controlled state machine, determining the content of Teletype data transmitted to a computer interface, or displaying jitter-free data from a moving-head disc as it is transmitted to the computer.

For your free copy, check S on the HP Reply Card.

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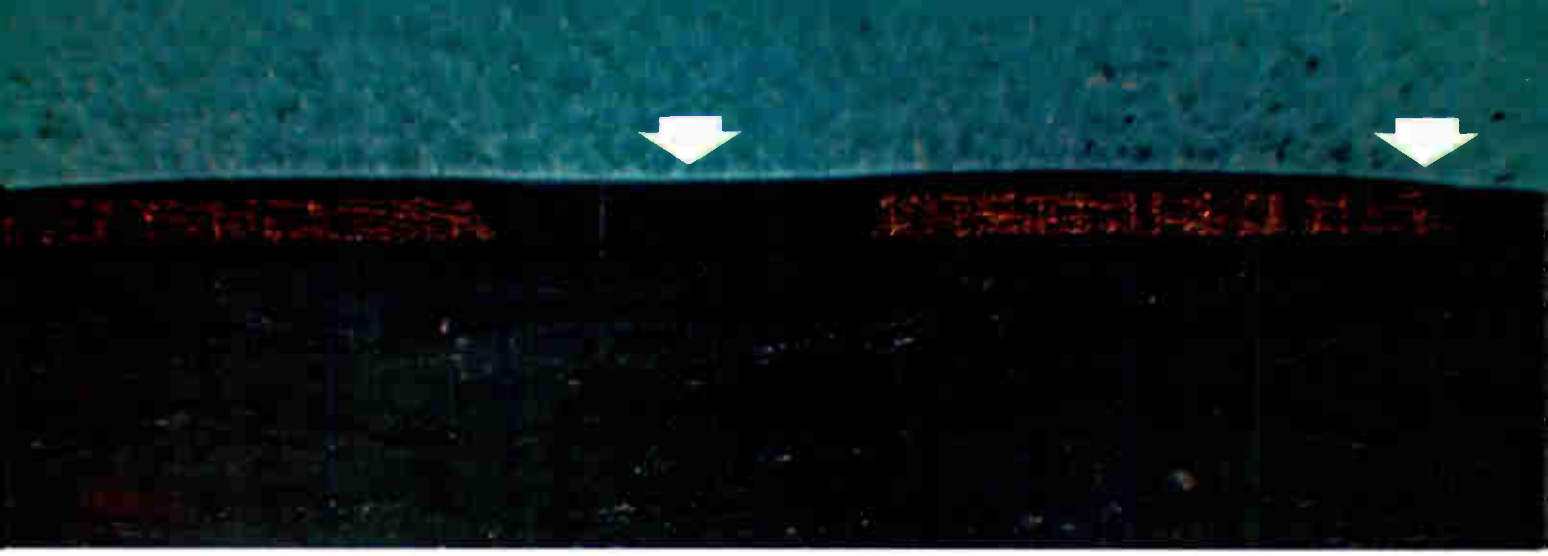

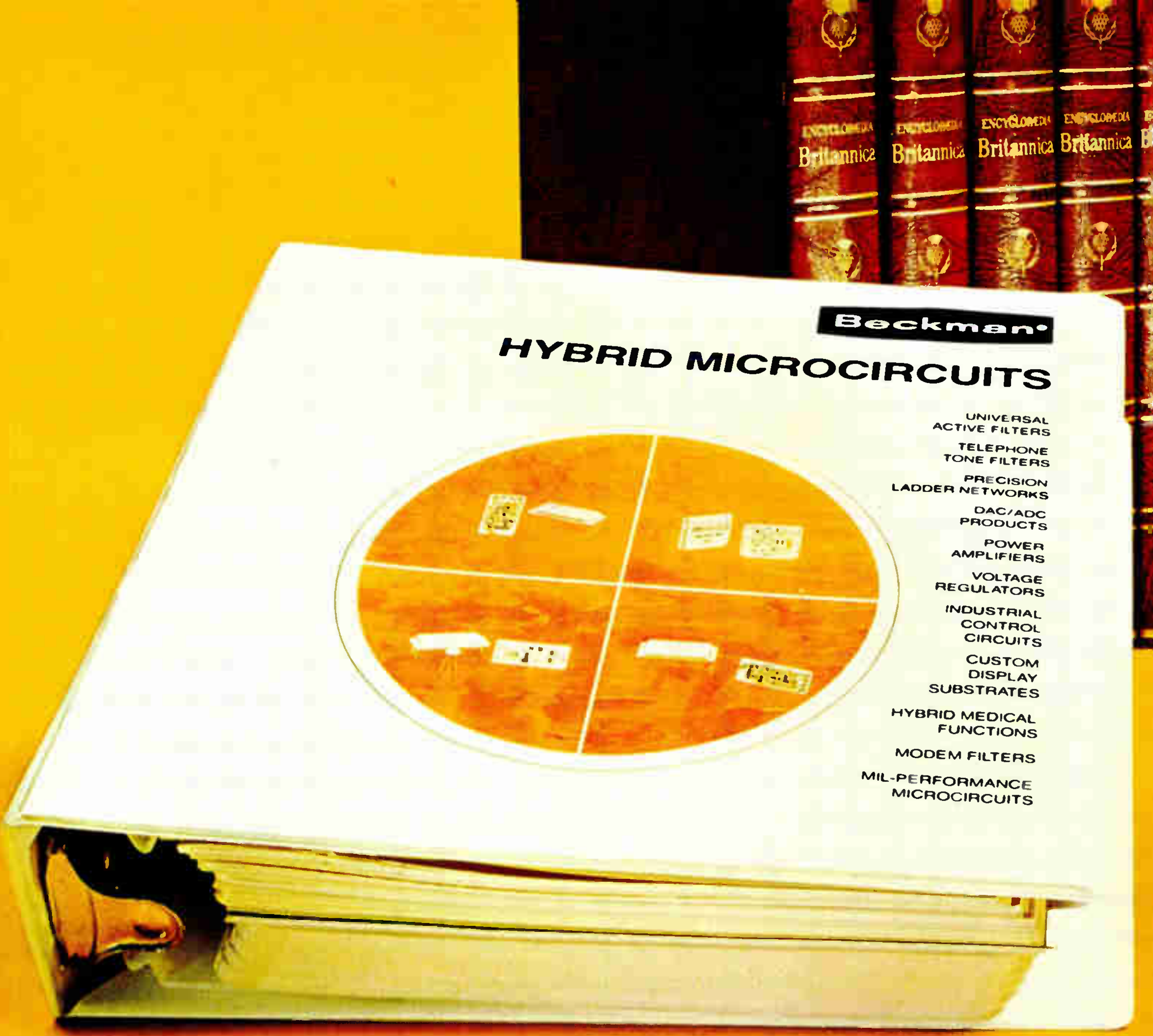
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For breadth of line in microcircuits or in information, hit the right books.

Reliable, at-hand sources are some of the good things in life. Like the encyclopedia, for compact information. And, to more and more electronic designers, Beckman for our broad line of high-quality hybrid microcircuits at competitive prices.

Our distributors are a main reason. All around the country, they're stockpiled with the full line of standard hybrids, as well as with our industry-leading DIP resistor networks, trimmers, dials and pots. So they can offer delivery as fast as any in the industry, and usually faster.

Typical Beckman standards include universal active filters, for example. And telephone tone frequency filters. Precision ladder networks. Four-quadrant multiplying DACs. Successive approximation ADCs. High-power, high-slew FET input Op Amps. High-reliability MIL voltage regulators. And dual-tracking voltage regulators.

Our custom hybrid service is also something to turn to. Because we produce custom alterations or new products in infinite variety. To time schedules few others can meet. We either build to customer design and specs or supply the design help when needed.

Typical custom units are modem and tone frequency filters. Entertainment system hybrid DACs and equalization filters. Custom display substrates (calculators, watches). Medical diagnostic timing and control functions. MIL-performance log amps, regulators, DACs, ADCs, and many others.

The point is, as a hybrid source, the Beckman line and distributor system are front-runners. For high quality and fast delivery. For competitive price and thorough service—including even a toll-free telephone express system to get literature to customers in just days. (Call toll-free 800-437-4677.)

It's no wonder thousands of designers think of the Beckman catalog as a "most-valued reference work."

Beckman®
HELIPOT DIVISION

Circle 29 on reader service card

Meetings

Joint Conference on Sensing of Environmental Pollutants: ISA, IEEE *et al.*, Sheraton Park, Washington, D.C., Dec. 10-12.

Winter Consumer Electronics Show: EIA Consumer Electronics Group, Conrad Hilton Hotel, Chicago, Ill., Jan. 10-13, 1974.

Reliability and Maintainability Symposium: IEEE, Biltmore, Los Angeles, Calif., Jan. 29-31.

International Solid State Circuits Conference: IEEE, University of Pennsylvania, Marriott Hotel, Philadelphia, Feb. 13-15.

Computer Conference (Compcon): IEEE, Jack Tarr Hotel, San Francisco, Feb. 26-28.

Aerospace and Electronics Systems Winter Convention (Wincon): IEEE, Marriott Hotel, Los Angeles, March 12-14.

Zurich Digital Communications International Seminar: IEEE, Swiss Federal Institute of Technology, Zurich, Switzerland, March 12-15.

International Convention (Intercon): IEEE, Coliseum and Statler Hilton Hotel, New York, N. Y. March 25-29.

Carnahan Conference on Electronic Crime Countermeasures: IEEE, Univ. of Kentucky, Lexington, April.

International Reliability Physics Symposium: IEEE, MGM Grand Hotel, Las Vegas, Nev., April 2-4.

International Optical Computing Conference. IEEE Computer Society, Zurich, Switzerland, April 9-11.

Optical and Acoustical Micro-Electronics: IEEE, Commodore Hotel, New York, N.Y., April 16-18.

International Circuits and Systems Symposium: IEEE, Sir Francis Drake Hotel, San Francisco, April 21-24.

Communications Satellite Systems Conference: IEEE, International Hotel, Los Angeles, Calif., April 22-24.

CAUTION: 50,000 VOLTS

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When you talk about designing and packaging miniature, low current High Voltage Power Supplies and Voltage Multipliers, the name ERIE should come to mind first. Why? *No other manufacturer of these sophisticated devices has its own capacitor and rectifier technology in-house*. Only ERIE does it all. Our many years experience in producing State of the Art high voltage capacitors and high voltage silicon rectifiers — plus an unsurpassed technology in circuit designing, packaging and encapsulation, makes ERIE an ideal source for your high voltage component needs. From very low input voltages, ERIE can produce output voltages up to 50,000 volts. Application for these compact, high reliability devices includes night-vision image intensification systems. Apollo TV cameras. CRT displays. Avionics systems exposed to rugged environments. Industrial, commercial and military equipments . . . an almost infinite variety of applications. So bring ERIE in early. Let us design and build *your* High Voltage Power Supplies and Voltage Multipliers. We're equipped to handle large or small volume orders . . . in-house.

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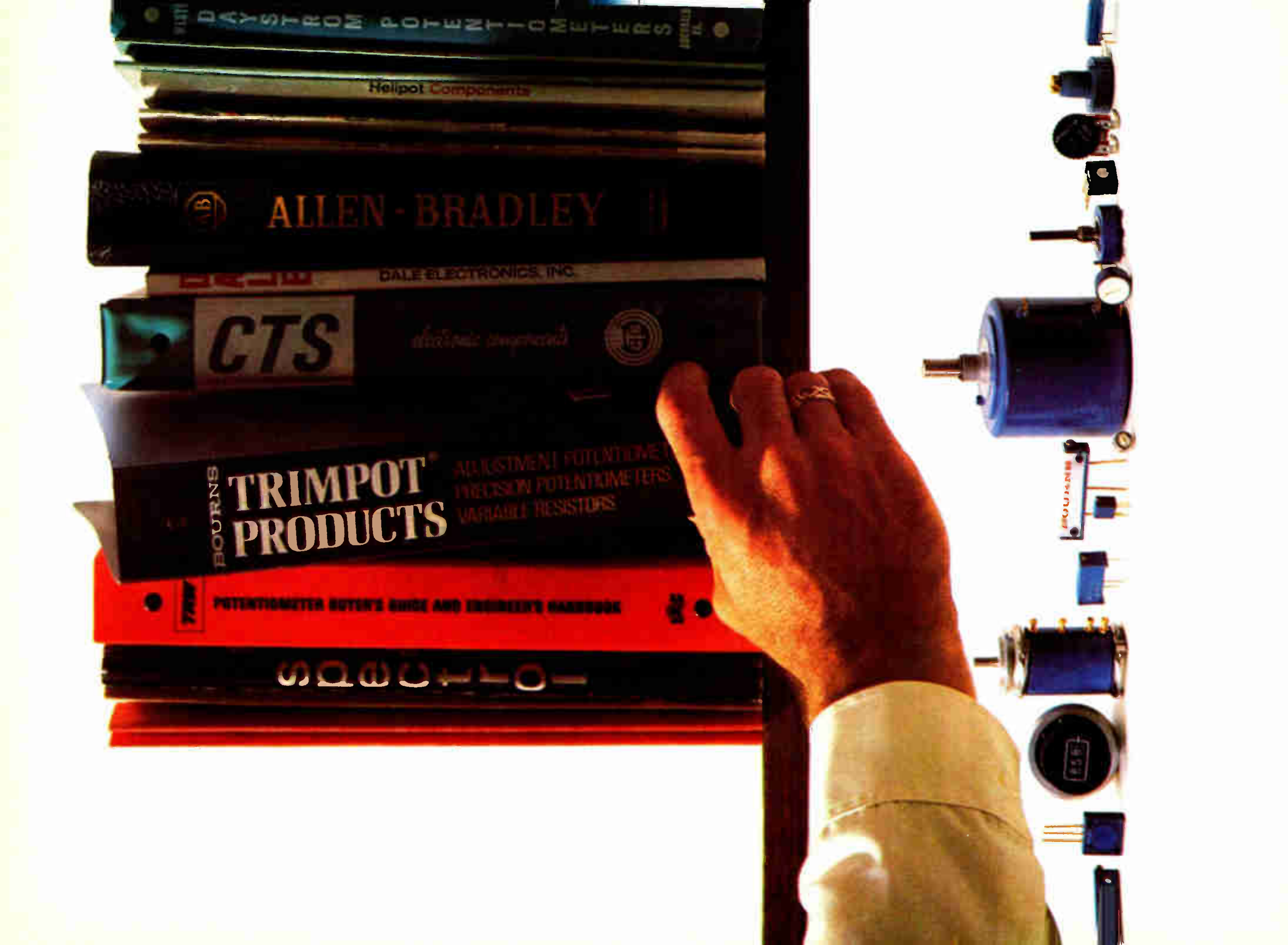
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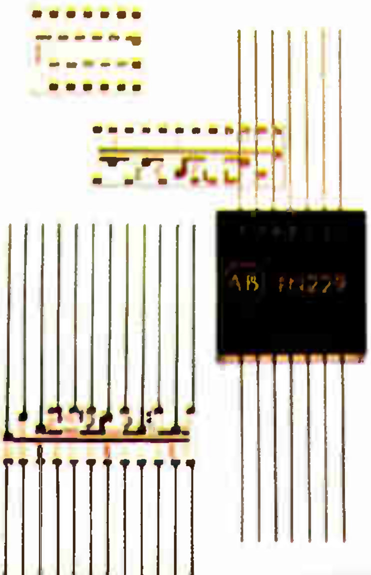
Repeatability in thin film networks is a matter of experience.

If you're really serious about cost, be serious about quality.



Our chrome-cobalt technology, for example, has been proven in dozens of applications ranging from D/A and A/D conversion, voltage division in digital multimeters and telemetry equipment, to communications paging devices.

In seventeen years of film resistor production, we've solved many problems that others are yet to encounter. This hard earned experience allows us to respond quickly to your custom needs. We regularly duplicate prototype performance in virtually any quantity. You get excellent delivery along with greater assurance of part-to-part quality.

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Performance specifications

TCR: 10 to 25 ppm/°C
Absolute tolerance: as low as .01%
Interconnections: metal film (no soldered or welded joints)
Stability: 50 ppm/year
Packaging: chip, conformal coated, encapsulated

ALLEN-BRADLEY
Milwaukee Wisconsin 53204

EC65

Circle 34 on reader service card

Field-effect crystal promises lower threshold, drive needs

A new field-effect liquid-crystal display, now being tested by a California company, promises to operate at very low threshold and drive voltages. **The company, Antex Inc. of Mountain View, Calif., says that its material has a threshold of 2.85 volts peak to peak, and can be driven at about 3 V.** This compares with a 10-V threshold and drive voltage of 15 to 20 V for dynamic-scattering liquid-crystal displays; conventional field-effect displays must be driven at 5 to 6 V. Thus, the new material has the advantage of single-battery operation.

Equally important, it has a relatively high switching speed— **nowhere near as fast as light-emitting diodes, but fast enough to multiplex eight to 10 digits.** And Antex's founder and chief executive, Ken T. Chow, says the speed permits strobing of the digits and use of a seven-line drive for all the segments.

Data system eliminates need to change software

Without requiring any time-consuming or expensive change in host-computer software, a data-communications system developed by Computer Transmission Corp., El Segundo, Calif., **connects a high-speed line printer in one city and a data-processing computer in another city. This link is transparent in that the computer acts as if the printer were in the same room.**

The MultiTran 4000 has been installed by Time Inc. to connect its data-processing centers in Chicago and New York City. At Time, says Jon Woolley, the company's New York data-processing manager, the M-4000 operates at 7,200 bits per second in a full-duplex mode over a conditioned private line. Including some peripherals, system cost was about $100,000, says Woolley.

10-bit DAC needs but 30 mW

Several advances in monolithic digital-to-analog converter design are claimed for a new 10-bit C-MOS multiplication DAC by Analog Devices. **The firm says this is the first microelectronic DAC—either monolithic or hybrid—to operate monotonically over the full military temperature range, the first truly low-power DAC, and the first C-MOS DAC.**

The normal range of monotonicity—about 10°C—no longer applies, since the C-MOS chip's low power dissipation (30 milliwatts maximum) and stability of the silicon-chromium R-2R resistor network cuts self-heating and temperature drift of linearity and gain. **One operational amplifier is added to the device for two-quadrant multiplication and two for four-quadrant multiplication** (unipolar and bipolar binary operation). The C-MOS chip measures only 74 by 96 mils—small enough the company says, to price the DAC competitively with hybrid converters assembled from bipolar devices.

Fairchild to offer first Isoplanar MOS RAM

The first MOS random-access memory to be fabricated with Isoplanar dielectric isolation is under development at Fairchild Semiconductor. C. Lester Hogan, president of the parent Fairchild Camera & Instrument Corp., says **the RAM will be plug-compatible with Intel Corp.'s 1103, but will operate at higher speeds.** Fairchild is aiming the new RAM at the 1103 market, Hogan says, because more than half the RAMs now sold are 1103s, a design that "will live for a long time." **The RAM is**

scheduled for introduction in the first quarter of 1974.

Previous Isoplanar products have been bipolar [*Electronics*, March 1, p. 26], except for a 1,024-bit shift register that came out this fall.

Data communications via cable TV to be tested

Experiments will begin next year on a method of transmitting business data over urban cable-television lines in the uhf spectrum. Developed by Joseph Garodnick, a staff consultant for Goldmark Communications, Stamford, Conn., **the cable system operates at 2,400 to 1 million bits per second and can handle all data information equipment** ordinarily used on telephone lines.

Black box turns TV into automatic intrusion detector

A black box that attaches to a closed-circuit-TV camera and detects changes in the video image is going on the market as a security and industrial sensor. **It will trigger an alarm if an intruder moves past the camera, turns on a light, or causes any other marked change in the video image.** It can also be used to convert a camera to a conveyor-line counting and control sensor, says Robert Simmons, general manager of Information Processing Systems of Belmont, Calif.

Circuits in the box sample the video images, integrating energy levels in the video signal and detecting changes in the energy content of the samples. The detector's output then triggers an alarm or alerts a guard to watch a TV monitor. **Many cameras may be coupled to a single monitor through bridge switches,** Simmons says, making it unnecessary for a guard to stare continuously at rows of monitors.

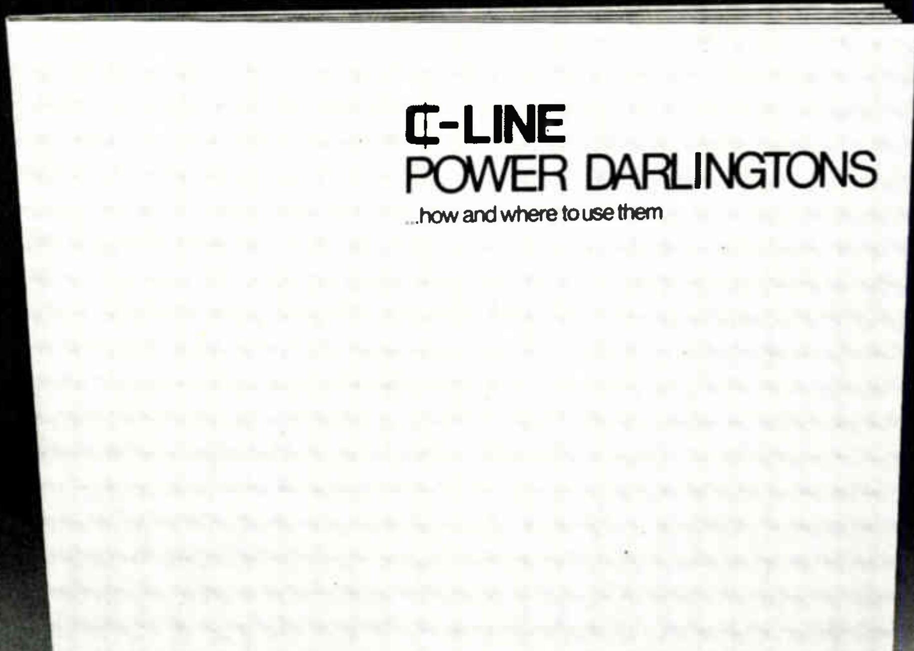
Hughes, Rockwell add production lines

Two major Southern California aerospace firms aggressively pursuing commercial microelectronics markets are setting up lines to produce advanced semiconductor parts such as charge-coupled devices. **Rockwell Microelectronics in Anaheim is putting together a 15,000-square-foot line,** to go onstream next year, for CCDs, silicon-on-sapphire MOS, and nonvolatile MNOS memories. In fact, Rockwell will introduce in January a 1,024-bit nonvolatile MNOS RAM compatible with its conventional 1,024-bit MOS RAM.

Meanwhile, the Industrial Products division of Hughes Aircraft **is setting up a line in Oceanside to make CCD imaging devices.** The new facility will be headed by Hans Dill, former head of Hughes' microelectronics research activity.

Addenda

A semiconductor house and a TV set maker have collaborated on a design that may go a long way toward making remote electronic TV tuning a reality while satisfying FCC rules that uhf tuning be as easy as vhf. What the two, Fairchild and Admiral, have done is **compromise by using TTL MSI circuits instead of LSI.** . . . Speculation is growing that the Justice Department is **readying an antitrust suit against AT&T** alleging, among other things, monopolization of, and unfair restraint of trade in, devices designed to protect the phone network against damage from customer-provided equipment. The Justice Department declines comment.

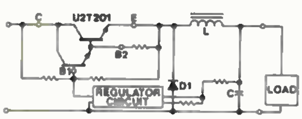


new application notes contain more than 15 Power Darlington circuits

Here in one place is everything you've always wanted to know about Darlingtons ... how to design for higher speed, lower saturation voltage and high gain in less space. Major applications include pulse and switching circuits, power supplies and linear amplifiers. Four typical applications are illustrated below.

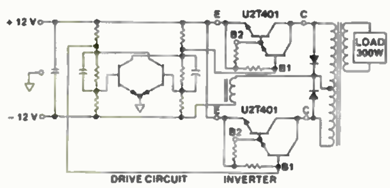
SWITCHING VOLTAGE REGULATOR

Unitrode Power Darlingtons are optimized for switching-regulator service with very fast switching, very low $V_{CE\ (sat)}$ and high current gain. In this circuit, the full load efficiency can be better than 95%.



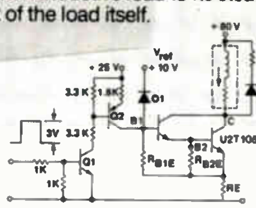
PUSH-PULL INVERTER

The high current gain of the Unitrode Darlington allows it to be driven directly from a logic-level multivibrator. The low $V_{CE\ (sat)}$ not only raises efficiency, but indirectly reduces the magnetizing inductance requirement of the transformer. At 10KHz and full load, the circuit attains an inversion efficiency of approximately 90%.



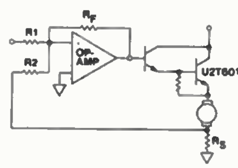
HIGH SPEED SWITCH FOR INDUCTIVE LOADS

Used with loads such as solenoids, phase shifters and small DC motors, this circuit is not only a switch, but (in the ON state)a constant current source which can drive an inductive load to its steady-state current in less than the time constant of the load itself.



MOTOR CONTROLLER

Unitrode Power Darlingtons are most suited for applications where high-speed jogging, fast dynamic braking or high slew rates are required, and conventional power transistors will not satisfy the highest speed requirements.



In all applications presented, the circuits have been proven with Unitrode's U2T Series Power Darlingtons in both NPN and PNP types – from 2 to 20 amps, 60 to 150 volts in TO-33, 3 pin TO-66 and 3 pin TO-3 packages. 100 quantity prices for the series range from $1.25 for 5A, 60V devices to $5.40 for 20A, 150V types.
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SOS technology boosts performance in microcomputer

General Automation uses 160-mil-square SOS chip as the microprocessor for its LSI-12/16

While semiconductor makers are producing 8- and 16-bit n-channel microprocessors [*Electronics*, Sept. 27, p. 33], a minicomputer company, General Automation Inc., has leapfrogged them and that technology with the first known n-channel silicon-on-sapphire microcomputer.

General Automation officials believe they have jumped ahead one product evolution by offering TTL performance at MOS prices, rather than slightly reducing the cost of a TTL-type minicomputer or drastically reducing the cost of a lower-performance MOS machine, the two courses that have characterized minicomputer evolution.

With an eye to replacing low-end minicomputers and opening up new control applications, General Automation designed—using rules supplied by Rockwell International Corp.'s Microelectronics Device division—an SOS computer. Rockwell is General Automation's prime source for the chip. Both companies are in Anaheim, Calif.

The 2,000-gate-equivalent SOS processor, heart of the new LSI-12/16 computer, is one of the most complex SOS parts made for production. It is on a 160-mil-square chip and is contained in a 28-pin package. The LSI-12/16—including 2,048 bytes of random-access memory—is on a board smaller than a standard sheet of typing paper. A small piggyback board provides up to two times more random-access memory or 8,192 bytes of read-only memory. An additional small board holds up to 32,000 bytes of memory. A battery is used for memory protection.

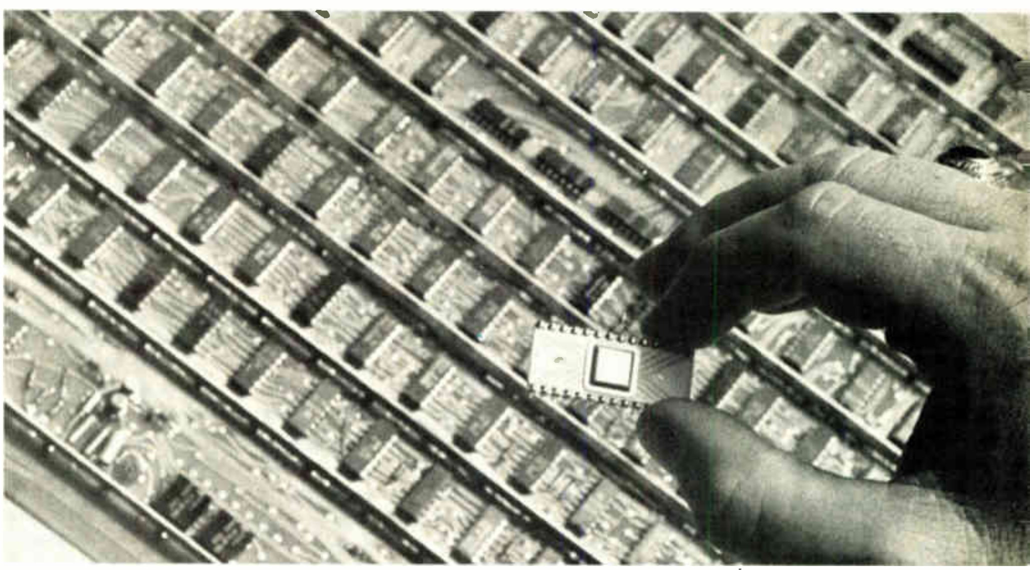
The LSI-12/16 is priced at about $1,000, which includes 4,096 bytes of memory. The microcomputer is self-contained, except for its power supply, and includes a simplified control console and light-emitting-diode indicators for troubleshooting. Aside from the SOS processor and memory, the board includes system alarms, plus fail-safe and interface circuits. Deliveries are expected to start early in 1974.

The LSI-12/16's closest competitor is Computer Automation's Naked Mini LSI [*Electronics*, April 12, p. 36], although General Automation claims its machine is two to three times faster. The Naked Mini LSI fits on a board measuring about 15 by 16 in., including a 4,096-word MOS memory and is also priced at about $1,000 in OEM quantities.

According to Lawrence Goshorn, president of General Automation, the LSI-12/16 is equivalent to a standard 2-microsecond, 8-bit minicomputer in performance. It is slightly faster than the SPC-12 it replaces. Goshorn feels that the board microcomputer—he saves the word microprocessor for individual chips—is a new business, fitting between LSI and present minicomputers and offering the same relation to the semiconductor component business that present minicomputer systems have to basic minicomputer boxes.

Goshorn expects the SOS computer to be in full production by next summer and suggests that General Automation has other SOS

All in one. The SOS processor chip used in the LSI-12/16 contains all the functions previously housed on its predecessor SPC-12's large CPU board (background).



SOS sets fast pace

Silicon-on-sapphire technology is not new, but it has been of little practical use so far, despite its numerous advantages over present popular bipolar and MOS technology.

The SOS process involves making conventional MOS circuitry in a thin layer of silicon that is grown epitaxially on the surface of an insulating wafer of sapphire. The insulating substrate permits much denser spacing and far lower capacitance than conventional MOS, so that p-channel MOS on sapphire is about as fast as present high-speed n-channel MOS. General Automation and Rockwell are using n-channel MOS on sapphire, permitting speeds now possible only with bipolar TTL circuitry.

These speeds, moreover, are possible with the very low power consumption typical of MOS. Thus, complex circuitry impossible with bipolar circuits due to heat problems are expected to become commonplace in SOS. And, future complementary-MOS on sapphire offers even lower power requirements, plus speeds that may equal emitter-coupled logic. Semiconductor memories are prime candidates for SOS, and major semiconductor and computer firms are known to be working hard to bring them into use.

developments in the works. "We've been shipping minicomputers with Schottky TTL for over a year now, and where is there to go from there? ECL would require a big jump, and the SOS route gives us opportunities for much speed improvement."

General Automation doesn't yet have firm orders, but the new unit is being designed into four or five major programs, each in the 1,000- to 5,000-unit range, Goshorn says. The prospective users are present General Automation customers in the automotive, machine control, and communications businesses. □

Solid state

CAD IC trimmer is fast, precise, cheap

A unique application of the "blown fuse" technique to the pretrimming of monolithic operational amplifiers may shake up the analog-module and hybrid-IC markets. Developed by Intersil Inc., the technique will be used to trim other types of ICs in the future.

The op-amp chips are trimmed automatically during wafer-probe tests, making it practical to mass-produce monolithic equivalents of best-selling types of modules and hybrids, reports Jack Gifford, director of analog products at the Cupertino, Calif., firm.

Intersil has applied for patents on the amplifier-trimming method and design, which are adaptations of a technique the company uses to field-program read-only memories. In the ROMs, diodes diffused into the bulk silicon are "blown" with current pulses to store data in the memory array. In the amplifiers, similar diodes allow thin-film resistors to be interconnected as a parallel network that adjusts both offset voltage and the temperature drift of the offset voltage.

Six nichrome thin-film resistors, which have values of 200 ohms to 12 kilohms, are deposited on the chip along with diodes that, until blown, block the resistors out of the circuit. When blown, each diode shorts, and one resistor is added in parallel to a network that nulls the amplifier, as though a technician were adjusting the circuit with a potentiometer.

However, the trimming method is more sophisticated than one based on a potentiometer. Gifford explains that "we program toward a network with a close-to-zero temperature coefficient." As each chip on the wafer is probed to determine its basic characteristics, a computer-aided-design routine worked into the test program computes the best combination of resistors for that chip's nulling network. In effect, the CAD routine individually designs a network for each chip.

Fine tuning. One such operation generally reduces the offset voltages of an amplifier to less than 10 millivolts. Offsets as low as 1 mv can be obtained by alternately testing the chip and blowing diodes to "fine tune" the network. Gifford says the method costs 30% to 50% less than laser-trimming a resistor network on a hybrid IC substrate. "Besides, if the system overtrims a chip, we throw away just the chip— not a relatively expensive hybrid assembly," he says.

Gifford says Intersil engineers tried the pulse-programing method "in desperation" more than a year ago when they learned that an automatic laser-trimming system would cost $200,000 to $500,000 and still not provide trimming rates consistent with wafer-production rates. "If we could trim only at onesy-twosy rates, we couldn't get under module and hybrid costs," Gifford says.

Experiments started with 741-type op amps, then were shifted to a new version of Intersil's 8007 op amp, which has input field-effect transistors fabricated on the same chip as a bipolar op amp.

Since the trimming network is on the bipolar stage, it does not affect the FET characteristics. Input bias currents remain the same as in the 8007—chips with input bias currents from 1 to 50 picoamperes can be sorted from a production run.

However, offset voltages of the trimmed 8007 units range from about 1–15 mv, compared with 10–50 mv for untrimmed chips, and offset drifts of 10 or 15 microvolts. Exceptionally well-trimmed amplifiers will be offered as "specials." Prices have not been set, but Intersil plans to shave the price for modules and hybrids somewhat. □

GaAs MIS FET made in Japan

Searching for devices that can operate at higher frequencies than those made with n-channel silicon, researchers at Hitachi Ltd. have reported success at making n-channel gallium-arsenide, metal-insulator semiconductor (MIS) field-effect transistors. Higher frequencies are possible with MIS FETs because the mobility of the electrons in gallium arsenide is at least five times greater than it is in silicon.

Hitachi's experimental devices, however, only operate to about 140 MHz because of the geometrical effects of the relatively long—50-micrometer—channel length, which was chosen for ease in making the initial devices. Details were presented at the International Electron Device Meeting [see p. 78] by Takao Miyazaki. Coauthors were Nobuo Nakamura and Takashi Tokuyama.

Other goals of the Hitachi Central Research Laboratory project include the development of practical surface-passivation techniques, which give low densities of surface states, and the development of practical planar-device techniques. Passivation is necessary in making MIS devices because the gate-insulator interface must have a relatively low number of surface states. Planar technology is necessary because the surfaces of the source and drain regions are coplanar with the channel and because it permits multidevice interconnection.

Hitachi researchers say that a basic problem in fabricating devices of this type is difficulty in obtaining high-quality gallium-arsenide single-crystal materials. The usual p-type pulled crystal has a carrier concentration of 10^{17} per cubic centimeter or greater, and bulk characteristics tend to change during the thermal processing steps. Thus, the Hitachi researchers grow, from liquid, a p-type epitaxial layer at about 700°C with a carrier concentration of 10^{15} per cubic centimeter on the wafer surface.

The next important fabrication step is formation of the n^+ source and drain at low temperatures. Two techniques have been used. In the first, two silicon-dioxide films are used—one for defining the junctions and another, doped with tin, overlaying the first. The temperature of the wafer is raised to 900°C, and tin from the doped oxide diffuses through windows in the undoped layer to form n^+ regions.

In the other method, the p-type gallium arsenide is implanted with silicon ions at a temperature of 240°C at energies up to 175,000 electron volts. Then the implanted area is covered by a film of silicon dioxide or polycrystaline silicon and annealed for 1 hour at 850°C in a nitrogen atmosphere.

So far, engineers have deposited silicon-dioxide films on gallium arsenide with surface-state densities of $10^{11}/cm^2$ and achieved field-effect mobilities at 1,480 cm^2/volt-second—a value below the theoretical maximum, but still higher than that achieved in silicon.

The gate insulator can be silicon dioxide deposited by chemical-vapor deposition in an oxygen-free atmosphere, such as nitrogen.

Until now, practical gallium-arsenide FET devices have been Schottky-barrier depletion-type devices. Carrier flow is in an epitaxial layer deposited on a nonconducting substrate. During operation, current is pinched into the interface between insulating and epitaxial layers. In general, since crystal defects are numerous in this interface, practical transistors will probably continue to achieve far less than the theoretical characteristics that are based on calculations of a low-defect crystal structure.

A gallium arsenide MIS FET was built previously by Hans Becke, Joseph White, and Robert Dawson of RCA. However, their device had a rather high concentration of surface states at the interface of semiconductor and gate insulator, and there was no inversion layer. FET operation was obtained by doping the channel. □

Components

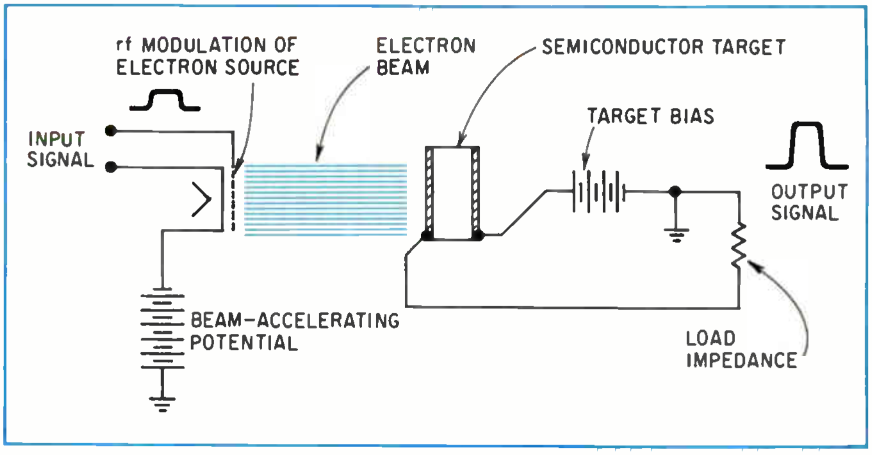
New tube is half solid state

Just when it seemed that transistors might make tubes obsolete in medium-power radio transmitters, along came a new class of tubes that could reverse the trend. These electron-bombarded semiconductor (EBS) devices were first conceived at Watkins-Johnson Co., Palo Alto, Calif. with support contracts from the Army and Navy in the late 1960s. Now the devices are almost ready for production.

An EBS device is a marriage of vacuum-tube and semiconductor technologies, but it provides capabilities not found in either. What's more, it has gain-bandwidth and voltage-rise-time capabilities 10^3 to 10^5 times greater than existing competitive devices.

In an EBS tube, the rf signal is amplified by using it to control a high-voltage electron beam that bombards a semiconductor diode, which produces the output signal. The electron beam, generated by an oxide-cathode electron gun, is controlled in one type of EBS by a grid

Hitter. An rf modulated pulled-electron beam strikes the back-biased diode target at 10 to 15 keV. Amplification is achieved through charge multiplication in the depletion region.



and in another by a beam-deflection structure similar to the meander lines used in some traveling-wave tubes. The beam may be deflected back and forth between two diode targets for class B amplifier operation.

Highly reliable tubes with power outputs ranging from up to 100 watts at frequencies around 300 megahertz and several watts at 1-2 gigahertz appear practical, according to D.J. Bates, the Watkins-Johnson engineer who presented an EBS-device paper at the International Electron Devices Meeting [see p. 78]. The paper is coauthored by Aris Silzars, also of Watkins-Johnson; Aaron Ballonoff, who has been developing diode targets at Signetics Corp. Sunnyvale, Calif.; and George Taylor, of Army Electronics Command's Evans Laboratory, Fort Monmouth, N.J.

Shielded. According to Bates, Watkins-Johnson is the first company to produce EBS devices. Several experimental types were used this year at military labs in R&D on new system designs. These had uncertain reliability due to diode target degradation at high voltage. Bates says that hurdle appears to be overcome with a radiation-hardened diode design from Signetics—a planar diode with beam shields deposited on passivated silicon. A layer of phosphorus-doped glass covered by metal films—like those used to form the beam of beam-lead chips—lies over the oxide coating on the junction periphery. The shield keeps diode avalanche-breakdown voltage well above the peak output voltage of the tube. Without a shield, surface charges induced by the electron beam would cause the avalanche level to drop too low.

Ten tubes have already accumulated a total of nearly 60,000 diode hours of high-voltage, high-power operation without any failures in tests conducted at Watkins-Johnson and Evans Laboratory.

"We've more or less passed the military mean-time-between-failure requirement of 7,500 hours and are now hoping for much longer MTBF and operating lifetimes of 20,000 to 30,000 hours," Bates says.

He thinks that both types of amplifiers being tested—grid-controlled pulse amplifiers and deflected-beam cw amplifiers—will be ready to go into production within a year. The pulse amplifiers can drive a 100-ohm load at 400 volts with a 4% duty cycle, while the cw amplifiers put out more than 100 w in class B service from dc to 300 MHz. Bates says that variations of the latter give power levels to 6 w at 1-2.5 GHz.

The tubes, which cost about $1,000 in quantity, are ceramic and glass-metal devices 9 or 10 inches long and 2 in. in diameter. Their bandwidths are orders of magnitude larger than rf power transistors,

Sony Corp. considers expanding its North American operations

Sony Corp. is contemplating—but has yet to decide on—expansion of its North American manufacturing operations. Sony president Akio Morita says the company, which is in the process of expanding its television manufacturing operation in San Diego, Calif., with the addition of a picture-tube plant has "not yet" made a decision to open a second plant in the United States. Asked about reports that Sony also is considering a Canadian manufacturing operation, Morita said "no decision has been reached" on that prospect.

The disclosure by the Sony executive came during a late November visit to Washington, where he delivered an invited lecture on "Creativity in Modern Industry" at the Smithsonian Institution. In conversations before and after the lecture, the 52-year-old Sony cofounder asserted that:

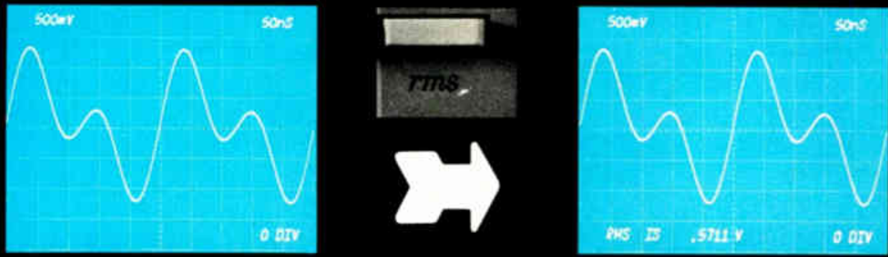
- Sony, whose approach to technological innovation has made it "a leading follower," expects to sell 1.5 million Trinitron color-TV receivers this year.
- Productivity of U.S. workers at the company's San Diego plant is approximately 80% of that of Japanese workers in the company's domestic plants. He attributed the higher Japanese productivity in part to the generally higher degree of education of Japanese workers.

Morita declined, however, to elaborate on the observation of Masaru Ibuka, Sony chairman and cofounder, in October at Toronto that the San Diego operation has encountered "minor" problems with U. S. managerial personnel.

Sen Nishiyama of Sony's international affairs staff, who accompanied Morita on his U. S. visit, confirmed that the company was disappointed by many of the more than 1,500 U. S. product applications it had received following Sony's advertisements offering to act as distributor of American goods in Japan. Many of the U. S. electronics and appliance makers Nishiyama said, apparently are unaware that Japan's electrical system operates at 100 volts, rather than the 110–115-v standard of the U. S.

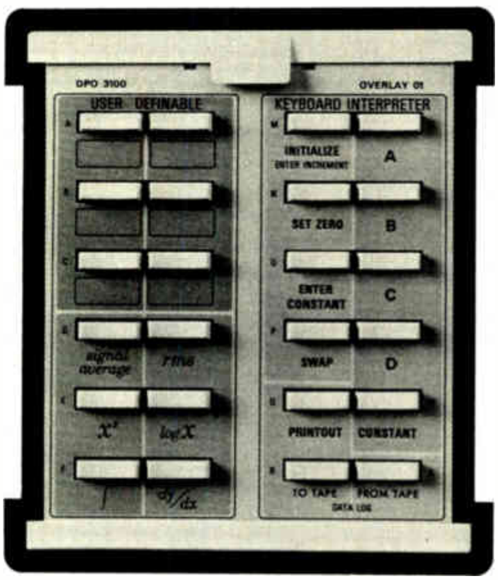
Orientation. Host S. Dillon Ripley shows landmarks to Akio Morita and his wife.

Easy Solutions to Difficult Measurements



at the Press of a Key!

When a difficult and time consuming measurement is required like determining the RMS value of the above waveform, the new TEKTRONIX DPO3100-Series really performs. At the press of a single key the answer is displayed on the same CRT which displays the signal! Best of all, many types of measurements are possible. You can add, subtract, multiply, divide, log x, integrate, differentiate, signal average to name but a few. When you need more, simply program your own special functions and routines with the "User Definable" keys.



So what is the DPO3100-Series? It is a system combining a TEKTRONIX Digital Processing Oscilloscope with our Type 31 Programmable Calculator.

The key to the system lies in a processor unit that digitizes waveforms displayed on the CRT. The digitized waveform is available to the calculator which is programmed to perform the desired calculations.

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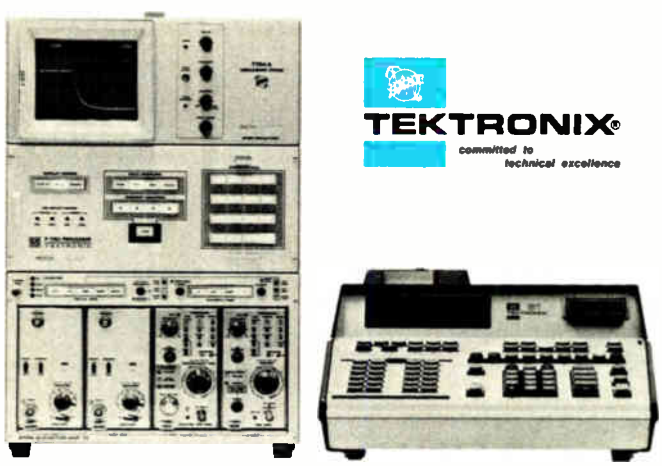
Price depends on options and plug-ins chosen. A complete operating DPO3101 can be as low as $10,650.00. Let us tell you all the details on this versatile package, use the reader service card, contact your field engineer or write Box 500A, Beaverton, Ore. 97005. In Europe: TEKTRONIX LTD., Guernsey, C.I., U.K.



TEKTRONIX®
committed to technical excellence

For a demonstration circle 42 on reader service card

Circle 43 on reader service card

Bates says, so they have much greater gain-bandwidth and power-bandwidth products. Since each tube is really a complete amplifier, one can replace roughly 20 transistors in a transmitter, he adds.

Bates says that EBS devices should also make good instrument amplifiers—because of their dc capability he recommends them, for example, as oscilloscope amplifiers. □

Trade

Hogan presses for sales to East Bloc

They are true—those reports on the semiconductor industry grapevine that Fairchild Camera & Instrument Corp. has tentative agreements to sell semiconductor-production technology to the Soviet Union, as well as to Poland. "If I can get the Polish contract approved, I'll be back with a Russian deal," confirms C. Lester Hogan, Fairchild president.

The Polish contract has been submitted to the U.S. Office of Export Control. Hogan says he is hopeful that contract will be approved, but it must run a gauntlet of several agencies, including the Munitions Control Board. And there is an embargo on sales of semiconductor technology to Eastern Europe [*Electronics*, Sept. 27, p. 42; Oct. 11, p. 41].

Hogan says the embargo should be lifted because the Poles are already being taught how to make semiconductor devices by the French firm, Sescosem, and they are also being supplied with production equipment and materials by the French and Japanese. Hogan claims that the bipolar-device plant built by Sescosem in Poland is "as modern as any in the U.S." He also says he saw at the plant items on the American embargo list, such as American-made photo-resist and Japanese step-and-repeat cameras.

Details of contract. Under terms of the contract, Fairchild would teach the Poles how to make MOS LSI circuits and provide mask sets for such consumer products as calculators, Hogan says. In return, the Poles would pay for licenses and know-how, promise not to sublicense other countries, and guarantee Fairchild a "substantial share" of the Polish semiconductor market.

Hogan stresses that the prohibition against Poland sublicensing other countries is strict. It allows Fairchild to audit Polish operations with Fairchild people in Poland.

The contract, Hogan says, prohibits him from disclosing the dollar value or the volume of American-made devices the Poles have agreed to buy. However, he indicates that sales would be greater than those being made in Poland by Sescosem. Sescosem sales, according to Hogan, have jumped from $20 million a year to $36 million because of its Polish deal.

Hogan argues that it is "foolish" to forbid technology sales to Eastern Europe because of fears that American technology would allow Eastern Europe to catch up with America in military microelectronics or become competitive in civilian semiconductor markets—two often-cited arguments against such sales.

Technology sales must be made if American firms are to crack Eastern Europe, which has a semiconductor-device market that Hogan estimates will total $5 billion between now and 1980. "If we don't get that market, the Japanese, British, and French will. The Japanese have been hurt by American price cuts, but they will be able to get up off the mat if they win that market," Hogan argues. "This would cost the U.S. complete dominance of the world semiconductor market."

MOS LSI sales won't have much effect on military technology since other forms of semiconductors are generally required, he adds. What's more, it will not be possible for Eastern Europeans to undercut American prices for civilian products. "We are billions of devices further along the experience curve, and we will always stay ahead." □

Communications

Packet switching starts to move

Now that the Federal Communications Commission has approved Packet Communications Inc.'s application for its value-added network (VAN) [*Electronics*, Nov. 22, p. 26], company president Lee R. Talbert's next move is to secure financ-

On VAN and packets

The value-added carrier leases dedicated lines from the phone company, installs modems and communications processors in major cities to be served, and then, in turn, leases time slots for packet switching on this network to customers. The advantage of a VAN is that it provides customers with the economy-of-scale savings of large networks plus the value-added services of code and speed conversion and error detection and correction. By contrast, circuit switching for data transmission dedicates an entire circuit to one customer, whether he uses it or not.

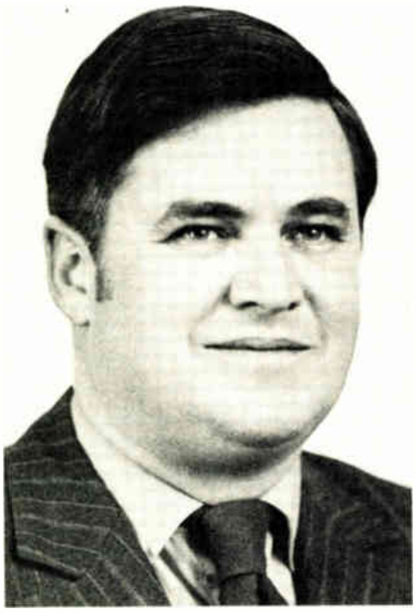
PCI and Telenet will implement their networks using packet-switching technology. For example, if the message to be sent contains 10,000 bits, it will be divided into 10 packets, each 1,000 bits long. Each packet will be routed independently of others, depending on instantaneous traffic and queuing delays between network nodes—the communications processors. Packet switching loads the lines more efficiently than circuit switching. Thus for a given volume of data traffic, the network can be made up of fewer lines and thus reduce monthly operating cost of the VAN.

The user's computer or terminal will interface with the Bell System channels via a processor rented from a value-added-network company. The processor will convert the user's transmission to a standard character set and protocol; similar processors will interface with network computers. Thus any terminal in the network can talk to any computer the network supports.

ing and to start buying equipment.

Assuming capital equipment is financed through third-party sources, Talbert says his Waltham, Mass., company will need equity of perhaps $17 million over the next three to four years. The company's first stage, which may last from one to two years depending on the rate funds come in, will see the actual implementation of packet-switching technology, which is based on the Department of Defense's Arpanet [*Electronics*, Feb. 15, p. 32]. This initial venture could cost $5-6 million, he says.

The second stage, lasting another one to two years, will see 18 cities in the PCI network, connected by 26 intercity lines, brought on line. Another $10-12 million could be needed for this stage. The 18 cities, which range in size from Seattle to Boston and Chicago, were chosen on the basis of the company's projections as to where the largest markets are. By 1978 or 1979, Talbert expects 60 cities will be on the network. (See "On VAN and packets.")



PCI chief. Lee R. Talbert's firm is the first to get FCC OK for a value-added network.

Contender. Meanwhile, Lawrence G. Roberts, president of Telenet Communications Corp., a Washington-based company that has also applied for VAN certification, sees the FCC's decision as establishing the validity of the value-added-network concept and setting a policy of liberal entry of other VAN carriers into the market.

Telenet, which received most of its original capital from Bolt, Beranek, and Newman, the Boston area operator of Arpanet, filed its application with the FCC on Oct. 9 and expects to receive authorization in early January. Telenet officials are discussing additional financing now, and the company will start procuring equipment when it gets approval from the FCC.

Stuart L. Mathison, a vice president of Telenet, says that a complete system covering eight major cities–running from Boston and New York to Los Angeles and San Francisco–will be ready by the fall of 1974 for acceptance tests.

PCI's timetable is based on "realistic guesses on growth," according to Talbert. "It is hard to tell just how it will work out. There is a great deal of latency in the marketplace. People are sending a lot of data, and they surely will send it via a network, but we don't know how explosive it will be."

But he feels that "the beauty of the technology is its ability to grow to meet traffic." Large fixed assets are not needed since each terminal-access processor will handle up to 60 low-speed terminals. Therefore, the network can grow in increments of capacity to meet market needs.

Network centers will use standard, off-the-shelf minicomputers, and Packet Communications has already made a vendor selection. General Automation Inc., Anaheim, Calif., recently signed a contract, which could total $7-10 million over the next four years.

Packet Communications is planning on a network speed of 50 kilobits per second. The entire network will be supervised by two network operations centers–one in the Boston area and one in the Western U. S. Installation rates for full-time terminal interfaces will run from $100 to $300, while monthly rentals will run from $150 to $450. Talbert says, "We will look at any [transmission] channel which can compete on a cost basis; if satellite becomes available we will use it"– or for that matter, laser transmission or coaxial waveguide technology. □

Instruments

H-P takes aim at a universal tester

Minicomputers have taken on another new role: simulating groups of measuring instruments while performing the more familiar chores of controlling tests and processing test results.

This month, Hewlett-Packard Co. plans to announce a $60,000 minicomputer system that analyzes the transmission parameters of voice-grade telephone lines. The same system can also serve as a general-purpose tester, suggests Roger Rauskolb, engineering section manager for electronic applications at H-P's Santa Clara, Calif., division.

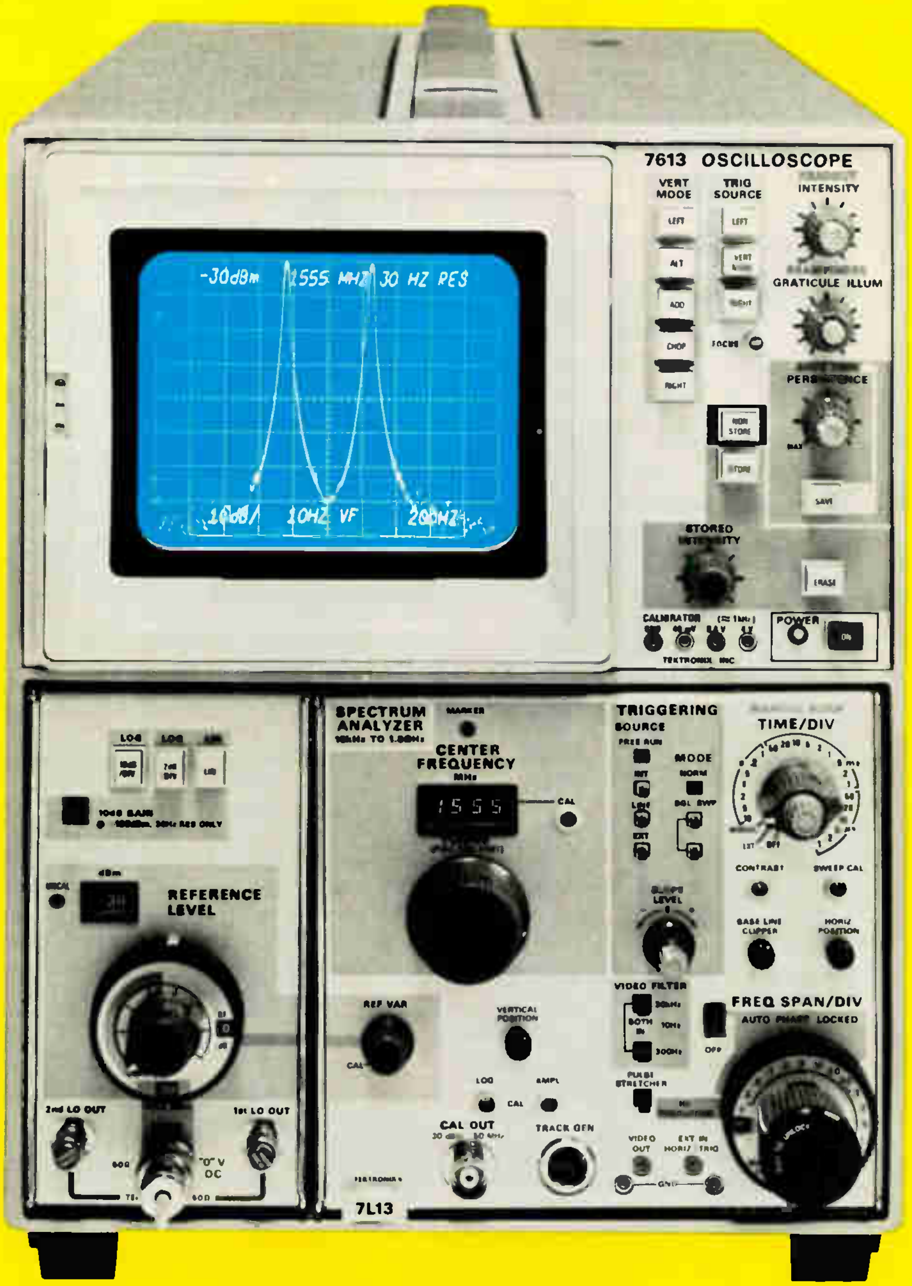
Although it generates and processes analog signals, the new HP-5453A analyzer contains no oscillators, mixers, limiters, tracking filters, or meters. It is simply an HP-2100S microprogramable minicomputer with analog-to-digital and digital-to-analog converters and the usual peripherals–disk memory, display terminal, and printer. With the aid of the converters, the computer simulates the battery of instruments that telephone-company technicians usually lug around.

To make nine standard tests for transmission-line distortion–noise, loss, interference, phase jitter, and the like–a telephone technician need only enter the word "all" on a test list displayed by the computer. He can type in requests for such tests as special frequencies, readouts of peaks, averages, and other analyses.

The computer will also compare measurements with line standards, store the results of periodic tests, and print out trend-line analyses as a guide to preventive maintenance. The standard tests are completed in about 2 minutes, compared with the one to three hours that technicians

the 30Hz Resolution Revolution

Spectrum Analysis in the 0-to-1800 MHz region



The TEKTRONIX 7L13 adds revolutionary measurement power to spectrum analysis: 30 Hertz Resolution that is useful all the way to 1800 MHz.

There is no smearing from drift or FM in this 200 Hz/div display, even though the total sweep time is 20 seconds. Signals are resolved to 70 dB down even though they are only 500 Hz apart. Center frequency is 1555 MHz.

It is generally understood that High resolution means the ability to distinguish between signals differing little in frequency. Actually, the design that makes 30 Hz resolution possible results in more than just the ability to distinguish between close together signals. The design of the 7L13 means better sensitivity, −128 dBm; less drift, under 2kHz per hour; less FM, under 10 Hz phase locked; it means less noise . . . it means the revolutionary analyzer performance that is available from Tektronix, Inc. in the 7L13.

Because of the resolution revolution, the performance of your edge-of-the-art circuitry and devices can now be quantified, not guessed at. A discussion or demonstration of TEKTRONIX Spectrum Analyzer performance can be arranged by any Tektronix Field Engineer. Call him or use one of the two reader service numbers below.

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normally spend testing a line.

The minicomputer acts as a collection of analog and digital instruments because part of its software converts it to a fast-Fourier-transform processor—one that converts test signals from time domain to frequency domain and vice versa. Digitized signals and the software—which includes an interpretive compiler—are swapped between the core and disk memories as they are needed to set up, control, and process tests. Test signals are specified in frequencies on the display, but the computer generates them in the time domain.

Fast conversion. The computer generates sequences of digital words which are fed through a d-a converter to convert them to various tones needed to perform tests. For digital processing, line responses come back via the a-d converter. Transformations are completed in 100 milliseconds, which, Rauskolb points out, makes the computer extraordinarily fast at some tasks. A digital frequency counter, for instance, would have to gather samples for 100 seconds to resolve 0.01-Hz. The H-P minicomputer does it in 100 milliseconds.

Almost any kind of analysis can be made because the analyzer is not hardware limited. In contrast, conventional test sets with groups of locked receivers, for example, are tied to standard voice-line test frequencies, which generally go to only 3,200 Hz. The minicomputer can test to the frequency limit of the a-d converter itself: 100 kHz. Also, limiters are used in conventional testers so that the amplitude modulation can be killed while phase modulation is measured. The analyzer can check amplitude and pulse modulation simultaneously.

One possible commercial contender is a system developed by Honeywell Information Systems for the Defense Communications Agency [*Electronics*, July 5, p.26]. That system, however, is a large computer-controlled instrument system rather than a fast-Fourier-transform analyzer.

While H-P's system cannot test microwave performance directly,

News briefs

Postal Service plans electronic-mail system

The Postal Service is planning to sink up to $100 million into a six-city experimental electronic-mail system to be completed by 1980. At the recent National Telecommunications Conference in Atlanta, assistant postmaster general for research and engineering Alan Schneider outlined the system as a hard-copy operation using inter-post-office facsimile equipment able to handle color-picture transmissions, as well as offering satellite transmission and teleprinter service in the home.

Oxide alignment gives high-speed, low-power chips

An oxide-aligned transistor, developed by TRW Systems Group, Redondo Beach, Calif., not only allows the fabrication of bipolar chips having a rise time of less than 1 nanosecond with low power dissipation per function, but also provides a device gain of up to 3 gigahertz.

Similar to earlier developments by Fairchild, Philips, and Bell Laboratories, the OAT uses denser layouts and reduced capacitance to overcome problems previously encountered in marrying high speed with low power in bipolar chips. The process also provides a 1-GHz divide-by-two circuit requiring 40 milliwatts of power and has an expandable four-by-four multilayer ECL multiplier with a 13.5-ns multiply time, dissipating only 1 watt.

EIA seeks semiconductor Phase 4 exemption

Exemption from Phase 4 controls for semiconductors is being sought by the Electronic Industries Association, through its Solid State Products division. A 20-page petition submitted to the Cost of Living Council, covering items falling into Government classification 3674, points out that the semiconductor industry is characterized by declining prices, consistent technological advancements, and increased productivity, which result in self-regulating noninflationary behavior.

Four TWTs are linked in parallel

A travelling-wave tube, designed by Teledyne MEC, Palo Alto, Calif., is combinable, through the use of Magic Tees, a type of 180° connector, with other devices of its kind. The company has paralleled a total of four tubes to produce up to 1 kilowatt of cw power from 10–20 gigahertz. Since random difference in noise and distortion tend to cancel each other, the four-tube combination can give noise and linearity performances equal to or better than single-tube amplifiers.

IBM investigating signature dynamics

Signature dynamics—the way a person signs his name—is being investigated at IBM's Thomas J. Watson Research Center, Yorktown Heights, N.Y., as a means of identification for access to a computer. IBM plans next to develop a device for transmitting signature information by telephone.

Common-carrier takeovers continue

Moving with a trend toward consolidation of specialized common carriers competing with AT&T's Long Lines department private-line service, United Video was acquired late last month by Southern Pacific Communications Corp. Also, Nebraska Consolidated Communications Corp. will be acquired by MCI Telecommunications Corp., New York City, pending FCC approval [*Electronics*, Nov. 22, p. 71].

Wafer standards may be near

A seminar that may produce semiconductor wafer standards will be held during the International Microelectronics/Semiconductor Conference, Feb. 26 at the Anaheim, Calif., Convention Center. Sponsored by the Wafer Standardization Committee of the Semiconductor Equipment and Materials Institute, Mountain View, Calif., the committee hopes to establish characteristics that could lead to standardization of wafer-production equipment.

SCIENCE/SCOPE

A polyurethane foam retainer to lubricate ball bearings for spacecraft was described by Hughes engineers at a recent symposium. The circular ring device serves as a lubricant reservoir as well as a retainer and separator for the bearing balls. The tough polyurethane material is chemically inert to hydrocarbons, stores 60 times more oil than the commercially produced cotton phenolic now widely used for bearing retainers, and shows virtually no wear after a year's operation. The new retainer may have applications in the aircraft, automobile, and machinery equipment industries.

Only the information an aircraft pilot requires at the moment is presented on the cockpit TV screen of a computer-controlled electronic map display developed by Hughes in a company-funded project. It stores data digitally, eliminating printed and microfilmed graphics. The map shows aircraft position and course and is updated every two seconds. It can be oriented "north up" or "heading up". The pilot has a choice of five scales, from one to 40 nautical miles to the inch. The EMD's magnetic tape unit can store up to 15 million bits of data (enough to cover the continental U.S.). A civilian version has been delivered to the FAA for testing; a military version has been developed for Air Force and Navy flight test programs.

Greater flight dependability for America's burgeoning air traffic is the goal of a 27-month project by Hughes engineers to develop specifications and a handbook for the Federal Aviation Administration's National Airspace System (NAS). Handbook will detail how the FAA can identify, handle, and strengthen any weak links in the system or equipment elements. The project is aimed at existing as well as future air traffic control systems, whose operations are expected to more than double in volume in the next 10 years.

High-speed functional testing and troubleshooting of printed circuit boards is the function of a new computer-controlled digital logic test system developed by Hughes. The Hughes 1024 is a diagnostic system with advanced disk software and dynamic response measurement at programmable rates to 10 MHz. Its software-controlled probe rapidly isolates manufacturing failures. The solid-state system provides up to 1024 bi-directional input/output lines and is expandable to three independently operated test stations using a common minicomputer.

Hughes needs a Senior Communications Project Engineer to take charge of a communication satellite subsystem. Technical responsibilities: direction of circuit design, packaging, testing. Administrative responsibilities: project direction and coordination of fabrication and assembly, date of requirements, contractual matters. Requirements: 5-15 years experience in project engineering hardware development, U.S. citizenship. Please send resume to: Mr. D.D. Rossier, Hughes Aircraft Company, P.O. Box 92919, Los Angeles, CA 90009. An equal opportunity M/F employer.

A twin radome-covered antenna test range to measure radiation patterns of communication satellite antennas during development and manufacturing is now in operation on the roof of the 12-story Hughes Space & Communications Group building in El Segundo, Calif. The 30-foot-diameter radomes enable space engineers to test antennas on a daily basis despite high winds or adverse weather. The new test facility includes a penthouse laboratory housing data-recording electronics and remote control equipment.

Circle 50 on reader service card

Rauskolb notes, it can do so "by inference"—the link is checked by transmission of voice-frequency test signals. If the link doesn't degrade those signals, it can be considered satisfactory.

Some production-test applications are also expected. For example, Rauskolb says, audio amplifiers of many different designs could be automatically tested for such characteristics as frequency response and harmonic distortion.

Direct tests of radio-frequency systems will have to wait until higher frequency a-d converters are developed. However, Rauskolb indicates that it may be possible to design suitable frequency converters and mixers that would bring the test signals down to the converter frequency ranges. "If this could be done, we'd have an almost universal test system, capable of simulating network analyzers and even microwave-spectrum analyzers," says Rauskolb. □

Consumer electronics

An IC replaces a TV power transistor

The horizontal-deflection systems in color-TV sets now use one power transistor for horizontal deflection and another as a power-supply regulator—to stabilize the dc voltage supplying the horizontal output stage and to nullify the effects of ac line and loading variations. But Texas Instruments Ltd.'s Advanced Technology Center, Bedford, England, has designed a circuit that does away with the second power device, cutting the cost of the horizontal deflection stage by about $5 and reducing its power requirements as well.

"The concept of a self-stabilizing system is to integrate stabilization and deflection functions in a single circuit, using one power transistor, operating from the directly rectified ac line," says Mick Maytum, designer of the circuit and TI Ltd.'s home entertainments manager. The TI Ltd. system taps the power transistor while it is not sweeping horizontally and uses it as a switched mode regulator, varying the time at which the transistor is turned on to control the voltage path across the inductance.

At the heart of the system is an integrated circuit placed between the horizontal oscillator and horizontal driver. This replaces the series stabilizer, which now comprises a power transistor and associated discrete components. An error amplifier within the IC compares the deflection voltage with a reference, and the amplifier's output adjusts the switching time of the transistor to control the power supply. Additional circuits monitor the power device's operation, and will shut the circuit off temporarily if an overload occurs.

The IC will first appear in a product to be announced next year by a major color-TV manufacturer, and it will be available from TI Ltd. in the second quarter for about $1 in quantities. Power transistors to give the system maximum cost advantage will also be introduced. □

Displays

Multicolor display uses laser beams

A laser writes the data in an unusual multicolor display system, which is adaptable to large- or small-screen displays, can provide variable-persistence images, and can generate large permanent records of displayed material.

The Librascope division of Singer Co., Glendale, Calif., has already delivered one real-time system, which produces record copies of data from radar or infrared sensors, to Rome Air Development Center. A second, a large-screen tactical-mission-simulator plotter for the S-3A aircraft, has gone to Singer's Link division in Silver Spring, Md. Another version that has already been delivered provides display plus hard copies for use with a battlefield command and briefing display.

The Singer family differs from most laser displays that have been proposed in that the laser beam itself does not strike the display screen, except in some applications where the beam is used as a cursor or to display in real time a few dynamic symbols. Instead, the beam writes on a small— generally 35-mm—film. As the image is built up on the nonprocess film, it is projected onto a screen by a conventional xenon projection lamp. An argon ion laser is used for colors from ultraviolet to blue-green, a helium-neon gas laser for red, and a neodynium YAG laser for infrared.

The film can be a red or blue variable-persistence photochromic layer for erasable displays. It can be a dry-process or metal film if a permanent record is needed. Since a projection system is used, other material—such as sector maps and grids—can be superimposed on the screen. Both red and blue can be projected from the xenon and the laser-beam optical systems. Similarly, additional lasers or projection filters could provide other colors.

Higher intensity. Singer went to lasers after working with CRTs as light sources. But even with very-high-power CRTs, such as those with fiber-optic face plates, the light intensity is marginal for creating a satisfactory image on the relatively insensitive photochromic materials, says Robert C. Dartnell, manager of electro-optics. The laser gives high intensity, an easily controlled beam, wide-modulation capability, and a spot as small as 0.8 mil.

For large, permanent copies, the dry silver film on Mylar is exposed to the image, producing in about 10 seconds an overlay that can be used with charts and maps. No processing is required, and no waste materials are produced. Singer feels that certain versions of the display system—such as the metal-film permanent-record model—are about ready for production now, and the company expects to shortly start delivering one every two months. The complete line of displays, however, is not expected to be in production for two to three years. □

Interchangeable CPUs. That's modularity.

SUE's basic CPU gives you a minicomputer that's high in flexibility yet low in cost. Other CPU models provide additional arithmetic or math capability to satisfy specific application needs.

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The component computer. And you're not limited to one CPU at a time. SUE's multiprocessor capability lets you hook up as many as four on a single Infibus. Just choose the combination of processors that suits the system best.

That's because SUE (the System User Engineered minicomputer) is the first of its kind: a component computer for systems. Its modular processors, memories and controllers all plug together in almost any combination to solve your application problems.

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Built for systems builders. SUE's built-in flexibility makes it fit your systems now, makes it easily changeable later on.

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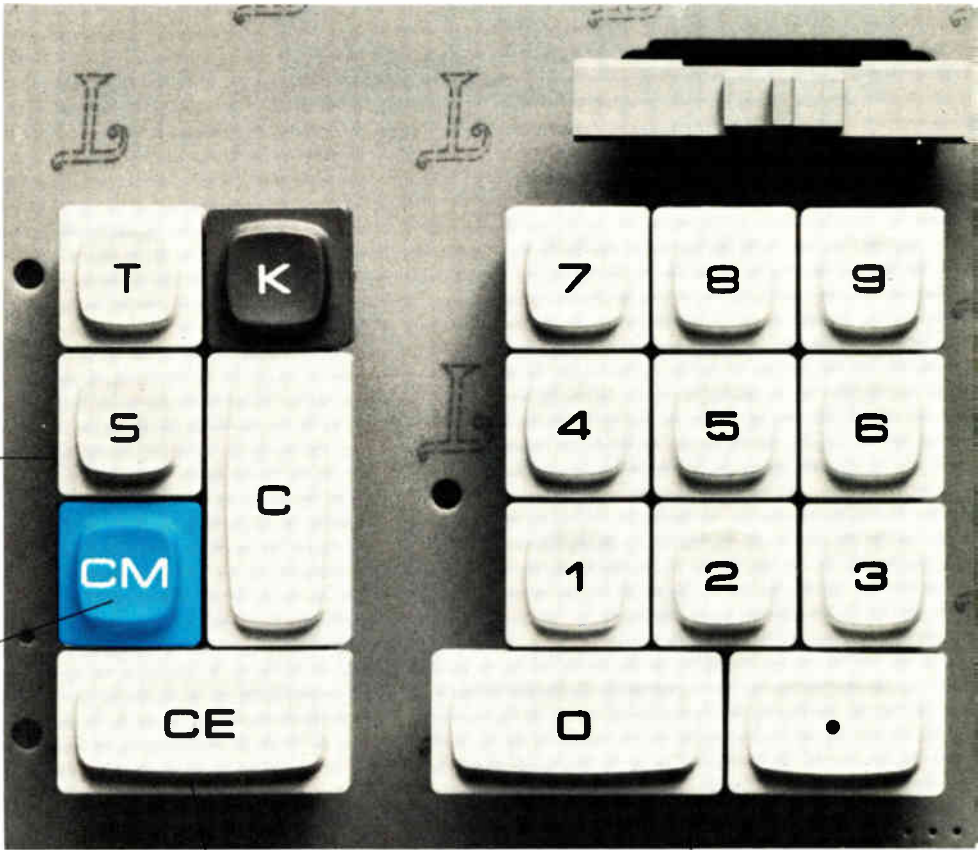

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Keyswitch materials and a high length-over-diameter ratio provide the smooth, quality feel necessary for professional users.

Fully assembled on a circuit board to reduce your assembly costs.

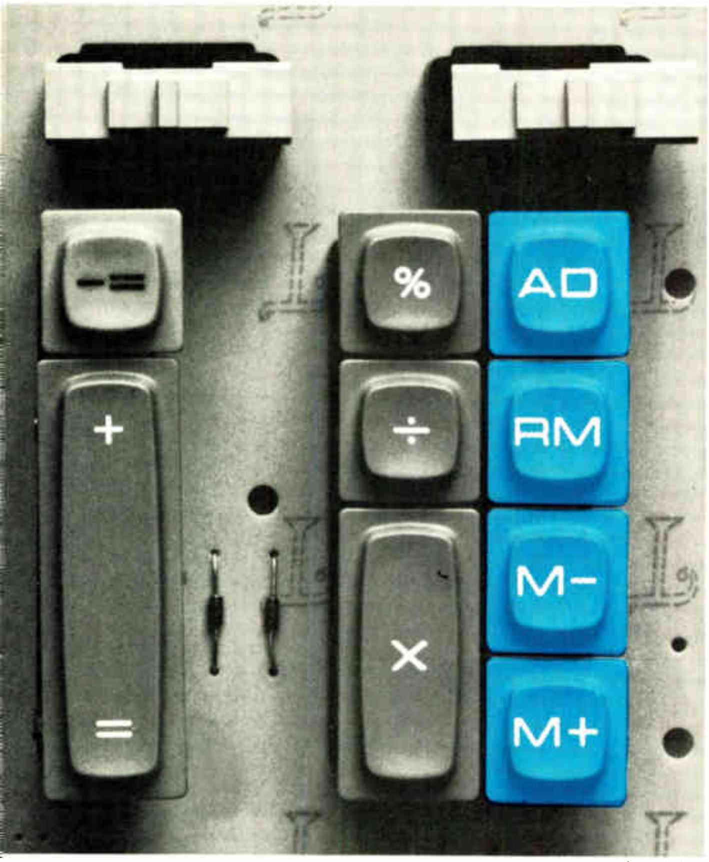
The new 5KS desktop keyboard from Texas Instruments, the world's leading supplier of pocket calculator keyboards. A new money-saving modular keyboard system provides the design flexibility desktop calculator manufacturers need for quick and inexpensive model changes.

Before Texas Instruments modular keyboard systems, you could get keyboards for desktop calculators two ways. First you could buy individual keyswitches or keyswitch rows and assemble them yourself. (This assembly, which includes mounting on PC boards, soldering and testing, adds at least 25% to the price of the keyswitch alone.) Secondly, you could buy a custom molded assembly which requires a high tooling charge.

Now the people who brought you the pocket calculator keyboard bring you the best of two worlds. The first complete travel keyboard that gives you economy and flexibility using a unique modular keyboard system.

The keyswitches consist of only four parts for simple trouble-free operation and low cost. The keyboard assembly is a series of keyswitch clusters that can be arranged on a printed circuit board in any desired layout. Using TI's established library of available cluster modules, calculator manufacturers can change models with only a low cost circuit board revision.

This is the new 5KS from TI, a dependable low cost keyboard for desktop calculators, credit card verifiers, point-of-sale terminals, and other equipment where a keyboard is required. For more information, fill in the coupon.



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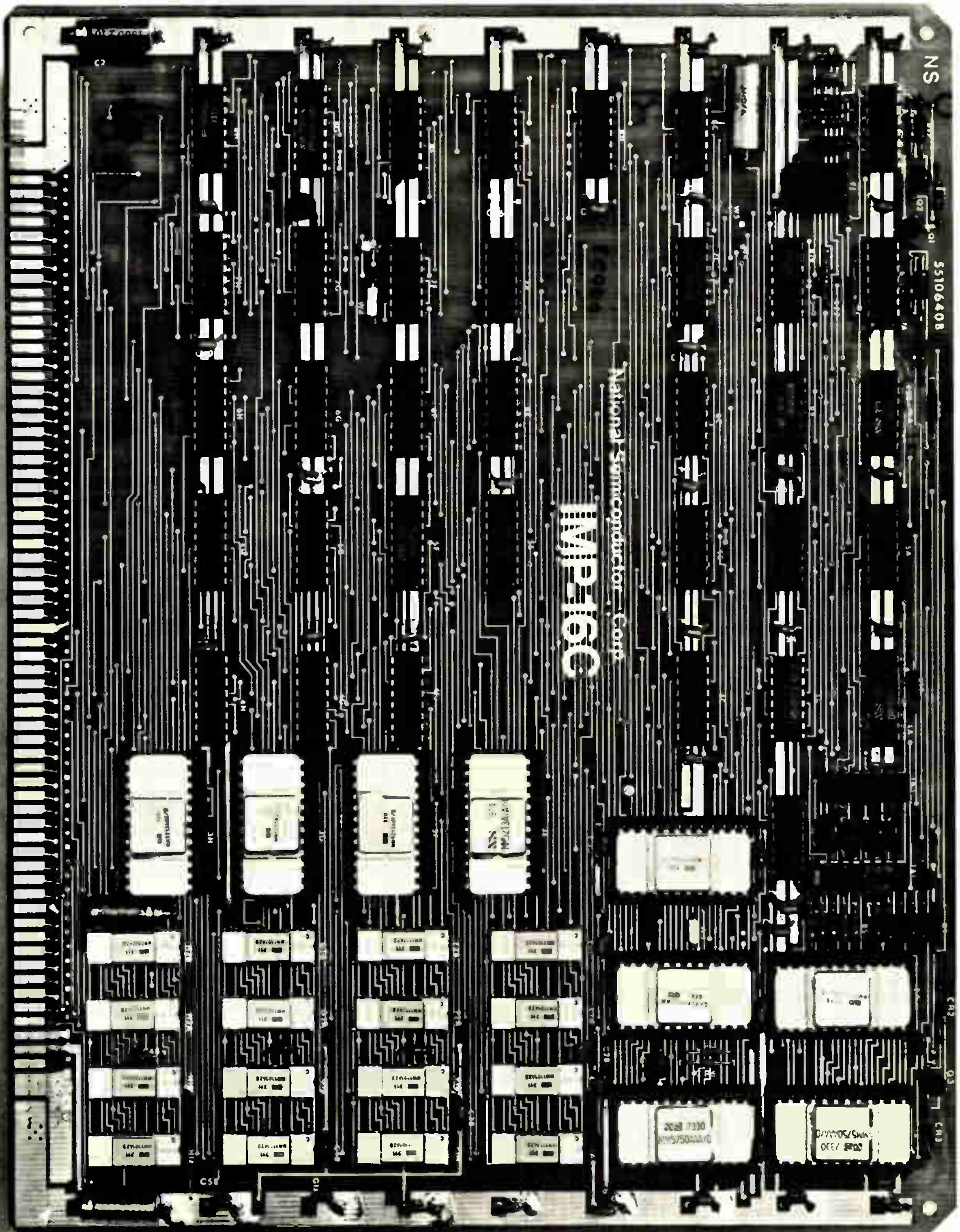
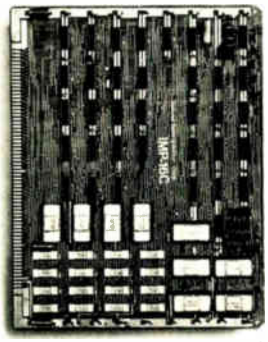


Our IMP-16C microprocessor on a card has just multiplied into a family of microprocessors.

A full line of flexible building blocks you buy off the shelf and program to your needs. And a self-assembler to help you do it fast. It's so much better than hardwiring your own stuff that microprocessors have become the hottest thing to hit electronics since the IC.



Our first was the IMP-16C, shown on the left.

Clock system, memory and I/O ports with bus drivers (upper half of photo). 16-bit microprocessor (lower right-hand corner). 256 words of read/write random access memory (lower left). And provision for 512 words of ROM/pROM memory (left below center).

With its standard set of 43 instructions, IMP-16C is dandy for the control of equipment such as data terminals, test systems, communications equipment, machine tools, process control systems, and peripheral device control systems.

Now meet the rest of our family.

IMP-16P

Marvelous as our 16C is, you really need something to help debug your program.

The 16P.

It's a debugging tool. A prototyping tool for the IMP-16C.

The IMP-16P is an IMP-16C card with 4k memory, self assembler, programmer's panel, self-contained power supply, optional card reader interface and a lot of other goodies.

You can program the unit, then trap through your program on a step-by-step basis while you debug.

You can assemble on your in-house 360/370 or on Tymshare's network, worldwide. And you can add 4k memory blocks as you need them for more powerful programs up to 65k.

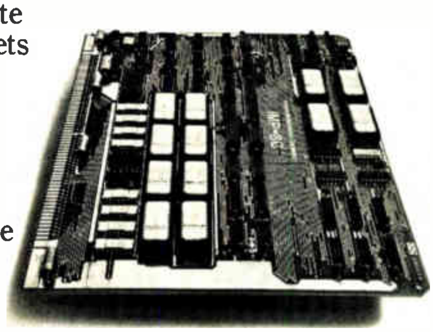
IMP-16L

The 16L, like the P, is a 16-bit microprocessor card in a box with stuff like a programmer's panel, 4k memory and self-contained power supply.

The difference is that the L offers Direct Memory Access (DMA) architecture for applications that need high throughput. It's configured around a 1MH$_z$ asynchronous data bus which allows both programmed data transfers and direct memory access, independent of CPU operation. The system data bus also provides a means for multiprocessor systems to share a common memory.

IMP-8's

For 8-bit oriented applications we offer the IMP-8C card which contains an 8-bit CPU. 256 word words of read/write memory and sockets for up to 2k of ROM/pROM storage.



There is also an 8P prototyping system (like the 16P) to help you work out your program.

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Microprocessors are going to have one helluva big impact on your business, putting relays and gears and cams in mothballs, and hardwired logic into the back seat.

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Trident budget priority seen killing Sanguine

Navy efforts to restore the $240 million cut from the Trident missile submarine budget for fiscal 1974 are being given preference by the Pentagon over other efforts on behalf of the Sanguine extremely-low-frequency submarine communications system. **The House Appropriations Committee has eliminated all fiscal 1974 Sanguine funds—$16.7 million—and ordered that the program be terminated,** making its outlook "very grim," says one Pentagon budget official.

While the Sanguine cancellation is unlikely to be reversed by the vote on the House floor, **the project could be retained in the counterpart Senate appropriation.** If so, resolution of the issue will be left to the House-Senate conference committee that will settle any differences between the two bills. **Nevertheless, Naval Electronic Systems Command officials are not optimistic about Sanguine's chances now.** The two funding cutbacks were part of a $2.8 billion cut in the Pentagon appropriation by the House Appropriations Committee, leaving a total of $74.5 billion.

OTP proposes national emergency medical network

The Federal Communications Commission is likely to speed up its **plans to allocate frequencies for a national Emergency Medical Services network—which could create an estimated $50 million to $100 million market in new and retrofitted communications gear**—after the White House Office of Telecommunications Policy publicly unveiled its proposal to set aside 38 frequencies for the network. Backed by the Departments of Transportation and of Health, Education, and Welfare, **the OTP plan would reassign frequencies in the 150-megahertz and 450–470-MHz bands** for mobile emergency communications to be used on a regional basis.

However, the network would face additional hurdles after FCC concurrence: financing the projected $680 million network, and getting local governments to agree on operations. A system to serve two million persons in the Baltimore, Md., area would cost $2 million for communications equipment alone. DOT and HEW this year have $40 million in grants and equipment funds for emergency medical services in general.

Major weapons costs rise in six months

Costs of 45 major weapons systems now in procurement rose $2.7 billion to more than $125 billion in the first six months of the year, according to the General Accounting Office. **Largest single increase was $2 billion for the Air Force B-1 bomber being developed by Rockwell International Inc.,** raising the program's current cost to $13.3 billion. The gain is attributed to the plane's increased weight and new Pentagon inflation estimates.

Grumman's F-14A, being built for the Navy, rose nearly $692 million, pushing the total to just under $6 billion because of a two-year program stretchout that will boost costs of airframes, engines, and electronics, said GAO. **The Army's biggest increase of $104 million for the Raytheon SAM-D air defense missile system** put the project's total at $4.4 billion, with the increases attributed to "refinement of the launcher group estimate and other vehicle costs." The over-all DOD net increase would have been greater if some programs had not reported declines in estimates, due mainly to equipment cutbacks.

Washington commentary

Public servant Strassburg

Words like bureaucrat and politician are most often used in the United States as terms of opprobrium, particularly today when public confidence in the Federal Government and the people charged with running it is at one of its lowest points in the nation's history. The time, therefore, seems appropriate to make the point that there are some outstanding public servants still around—and the Federal Communications Commission's Bernard Strassburg stands high among them.

Such eulogies are traditionally reserved for the dead in contemporary Western societies. Happily, this is an exception. Bernie Strassburg, who will retire at year's end as chief of the Common Carrier Bureau, is anything but dead—as AT&T and everyone else affiliated with the communications industry will quickly attest. Of his 31 years at the FCC, Strassburg has served the last 10 in his present assignment. And in that decade, he has been responsible for more landmark decisions in the communications common-carrier field than anyone can remember. His service represents a remarkable achievement. Many have disagreed vigorously with Strassburg's judgments, but even his opponents acknowledge his ability and integrity.

Landmarks

Year after year, when FCC chairmen have gone before the Congress to report on the state of the commission and justify their budget requests, they have put into the record a list of accomplishments that, more often than not, had their beginnings in Strassburg's bureau. Among them have been the opening of the domestic communications business to companies other than those of the Bell System—a judgment that led to the creation of a whole new class of specialized common carriers such as the MCI companies and Datran.

In addition, there have been such issues as the computer-communications inquiry and such decisions as the extension of competition to domestic satellite systems and the interconnection to the telephone network of customer-provided hardware. Moreover, Strassburg initiated and has vigorously pursued the continuing investigation of the American Telephone & Telegraph Co., its rates, and its ratemaking policies.

Thus, it seems most unlikely that public servant Strassburg will disappear from the communications scene when he becomes no more than a private citizen. Now 55, he will not lack job opportunities for his special talents.

Perhaps the only negative aspect of Bernie Strassburg's retirement is its untimeliness. The timing is poor because a number of crucial issues—interconnection in particular— are not yet fully resolved, and AT&T has mounted only recently a strong counterattack.

No one recognizes the nature of the Bell System assault better than Strassburg, who countered it sharply last month with his own critique of AT&T's views on interconnection. "Considering the size and inner momentum in the growth of its natural monopoly services," declared Strassburg before the National Association of Manufacturers' telecommunications committee, "I am at a loss to understand the policy of the Bell System, as recently articulated by its current chairman John deButts, to extend rather than contain its monopoly. For interconnection does not have the attributes that warrant treatment of the terminal market as a natural monopoly. . . . Mr. deButts makes the typical argument of the monopolist. He says that if we, the Bell System, are able to control all sources of supply in basic and ancillary services, the public will benefit in the form of higher-quality services at lower cost. No unregulated monopolist could make such an argument without risking antitrust action. Mr. deButts seeks to avoid this consequence by cloaking himself in the armor of a regulated monopoly. But a facility or service is not transformed into a natural or economic monopoly simply by either the desires of corporate management or regulatory fiat."

Taking on Goliath

Strassburg has never evidenced fear at challenging the communications giant. After noting that deButts "expressly invites more regulation, rather than less, as a tradeoff to more monopoly and not less," Strassburg posed the question once more: "Is the Bell System prepared to open procurement of all equipment by the operating companies and Western Electric to public competitive bidding so as to remove any question as to the extent of the influence or power the Bell System retains with respect to the fortunes of its suppliers?"

Such questions need to be asked and then asked again until they are answered. In the public interest, they need to be asked by the public servants of the FCC. Whether the Nixon-oriented FCC under Chairman Dean Burch wants to find another such public servant with Strassburg's courage and integrity who can and will continue to ask such hard questions is much on the minds of those in the communications industry these days. **—Ray Connolly**

The Rise and Fall*

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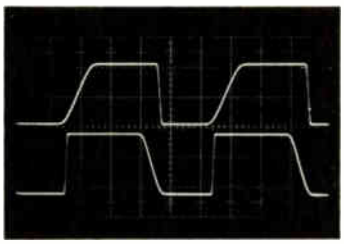

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Electronics international

Significant developments in technology and business

Sony gas-discharge TV prototype has 32 brightness levels

The dream of hanging a television screen on the wall like a picture is approaching reality with the introduction by Sony Corp. of a new type of flat gas-discharge panel. In fact, company engineers have also built a prototype that lays flat on a desk with its tuner. But the display differs greatly from the world's first flat-panel TV with matrix scan that Sony developed five and a half years ago [*Electronics*, Electronics International, April 15, 1968].

The new panel has a diagonal of not quite 7 inches, and together with its drivers, consumes a scant 10 watts. Another 80 W are required for other circuits, including tuner, brightness control, and memory and scan circuits. The earlier eight-foot diagonal model consumed about 10 kW of power.

Because the technique provides an easy way to illuminate the brightness scale, the new panel has a direct-current glow discharge, rather than the alternating-current plasma discharge used for many of the latest alphanumeric displays. In a second innovation, brightness is controlled by using the best features of the conventional method of varying current through the tube plus selection of the various combinations of the outputs of four monostable multivibrators for each driver.

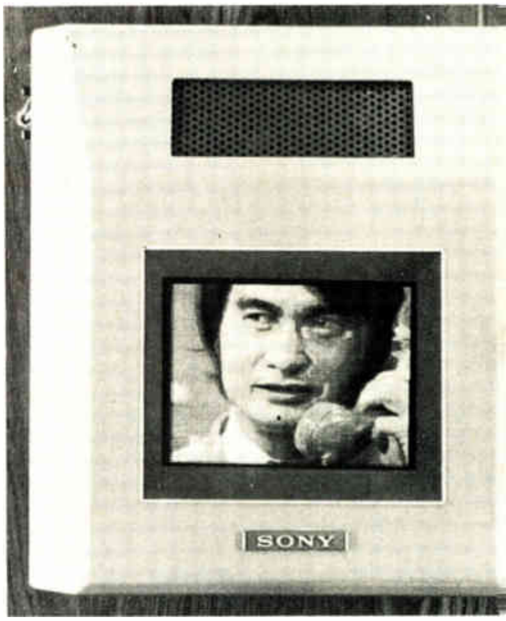
This new system provides 32 discrete brightness levels of neon-orange. Maximum brightness of the new tube is 30 foot-lamberts with a contrast ratio of 40:1. The panel was described by researcher Yoshifumi Amano at the International Electron Devices meeting.

Sony engineers have fitted the panel, the tuner, and all circuitry into a housing measuring only 300 by 350 by 80 millimeters. Since the gas-discharge panel itself is only 6 mm deep, most of the space is occupied by circuitry. However, the panel requires further development, while the circuits can be readily integrated. Future objectives include incorporation of phosphor to provide tones of black and white, increasing the number of electrodes to increase detail, and using three sets of electrodes for color pictures.

Adaptation. The panel is fabricated by an extension of the thick-film printed-circuit techniques developed earlier by Sony for its simplified Planitron numerical-indicator tube [*Electronics*, Electronics International, May 24, 1971]. The prototype panel has a matrix of 210 by 280 lines with 0.5-mm spacing to give a 105-by-140-mm picture.

The TV picture is formed by the cathode glow of nearly 60,000 crosspoints under the anodes. The anode conductors are printed vertically on the front glass plate, while cathodes are wider conductors printed horizontally on the rear glass plate. To separate the glows of the individual picture elements, glass frit barriers are printed perpendicularly across the cathodes so that they are located midway between the anode lines in the finished panel.

To avoid the necessity for forming gas-tight seals between adjacent sections of cathode lines to prevent the migration of ions, which would cause crosstalk, barrier electrodes were placed parallel to and midway between the anodes and the front panel. The 20 barrier electrodes, which Sony engineers consider a significant advance in panel technology, are controlled by a suitable dc potential. □



Flattened. Sony's prototype flat TV uses new gas-discharge panel that has 32 brightness levels and consumes 10 W.

West Germany

Transistor chips attain uhf levels

Hybrid techniques have been used to fabricate ultrahigh-frequency circuits because, compared with monolithic methods, they offer far better performance at high frequency levels. But recent advances in semiconductor technology, which have, for example, produced discrete silicon transistors with cutoff frequencies of 10 gigahertz and more, have now made monolithic uhf circuits possible.

By optimizing conventional techniques and incorporating a few new processes, engineers at West Germany's AEG-Telefunken have come up with monolithic integrated transistors with cutoff frequencies of 4 GHz and beyond. Developed by Klaus Woerner and Arno Kostka, of the company's Heilbronn semiconductor facilities, these new transistors were discussed in a paper at the International Electron Devices meeting.

As Kostka notes, the high-frequency performance of the monolithic transistor structure is enhanced basically by keeping the horizontal and vertical dimensions as small as possible to minimize the parasitic capacitance, the transit times, and the base resistance. Furthermore, high doping densities are used in those regions that would otherwise contribute to the total base and collector resistance and thus tend to reduce the quality of high-frequency operation.

For reasons of yield, however, the AEG-Telefunken designers had to make certain compromises in the design of a transistor structure that can meet uhf requirements. They found, for example, that a 2.5-micrometer emitter-stripe width would give reasonable yield when using chromium contact-masking techniques and molybdenum-aluminum emitter metalization. But reducing the emitter width to 1.5 μm caused problems and did not decrease the noise figure enough to make such a reduction pay off.

A similar technique was developed for the diffusion and epitaxial steps. Although high doping levels in the buried layer reduces the collector resistance, these levels lead to degradation of the epitaxial layer above the buried layer. A narrow base width, combined with moderately high doping inside the base, is achieved by positioning the emitter and base junctions near the crystal surface.

On to 4 GHz. Through these design compromises and by using phosphorus diffusion techniques, sample monolithic transistor ICs have cutoff frequencies of about 3 GHz when operated at a collector current of 20 milliamperes and collector voltage of 2 volts. This frequency value was achieved with devices having two emitter stripes, each 2.5 by 50 μm in area, a 0.5-μm emitter-junction depth, and a 0.5-μm base width.

Even better results were obtained by using arsenic diffusion for the emitter and ion implantation for the base. These techniques enabled the Heilbronn designers to push the maximum cutoff frequency for the monolithic transistor to 4 GHz and more.

Arsenic emitter diffusion offers the advantage of a steeper emitter profile, the absence of emitter dips, and less crystal damage in the highly doped regions. The improvements realized through ion implantation result from changes in the active and inactive base profile and in better control of the process parameters.

AEG-Telefunken has thus far produced such uhf ICs as frequency mixers and dc-coupled broadband amplifiers consisting of two double stages. A capacitor connected externally to this circuit increases the voltage gain at high frequencies and also compensates for any irregularities. A high load at the output is achieved by integrating two emitter followers on the same chip.

With supply voltages of +4.2 V and -2.8 V, the total power dissipation of the amplifier is only 130 milliwatts. It is 380 mW when the emitter followers are used. The voltage gain is 23 dB at a 3-dB-down bandwidth of 750 MHz. □

The Netherlands

CCD hits megahertz speeds

A new type of charge-transfer integrated circuit that operates efficiently at speeds in the megahertz range has been developed by Philips Gloeilampenfabrieken. Philips claims that its so-called peristaltic charge-coupled device—PCCD for short—is the fastest charge-transfer IC thus far to be developed. It was named for the way in which the charges, particularly the final fractions of each charge, move. The transfer is similar to the alternate peristaltic contractions and dilations of the digestive system.

The PCCD has a charge-transfer efficiency of better than 99.99% at a rate of more than 100 megahertz. Leonard J. M. Esser, the researcher credited with its design, says that it should be possible for the PCCD to attain speeds as fast as 1 gigahertz.

Useful. Like all such devices, the PCCD can be used in such applications as imaging, delay lines, filters, and memories—to name only a few. But its high speed, coupled with its high efficiency, make feasible an increased sophistication in these applications, Esser asserts, and it also makes possible processing of large-bandwidth signals.

Although a similar transfer efficiency can be achieved by other types of charge-transfer devices, such as the Philips-invented bucket-brigade device and the U. S.-developed charge-coupled device, Esser points out that their values are obtained at a transfer rate of only a few megahertz.

As in any charge-transfer IC, the PCCD transports a well-defined quantity of charge temporarily stored in one capacitor to the next one. The speed at which the charge is transferred is determined primarily by the transport time of the last fraction of the charge that is to be moved down the line of capacitors. It is in driving this last vestige of charge along that the PCCD differs from its predecessors.

Fractions. In the PCCD, this last fraction of charge is kept at some distance from the capacitors' electrodes—that is, deep inside the semiconductor. As in the other charge-transfer ICs, the larger part of the capacitors' charge in the PCCD is still near the electrodes so that a low switching voltage will suffice for the charge transfer.

But, because the last fractions of the charges are farther from the electrodes, they can be subjected to external drive, or fringing, fields. These external fields ensure a fast transfer of these vestiges of charges from one capacitor to the next. The input signal generates a negatively polarized charge cloud at the input, and clock voltages are applied in successive inputs that are rotated in 90° increments so that the charge is alternately pulled and pushed along, thereby kicking the final fraction of the charge abruptly from each capacitor.

In addition, the mobility of charge carriers inside the semiconductor is greater than it would be if the carriers were near the surface, which contributes to the high transfer rate. The device was described at the International Electron Devices meeting. □

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Circle 64 on reader service card

International newsletter

Telefunken video disk runs into problem

A last-minute technical problem is postponing the long-awaited market debut of the Telefunken-Teldec video disk, which was originally slated to hit retail stores on Jan. 7. What's holding back the introduction of the socalled TED—for Television Disk—system is, according to Telefunken, **the improper design of the disk-protecting paper jacket that is inserted, with the disk inside it, into the playback unit.** That jacket, as the company explains it, affects the paper-thin plastic disk during shipment and storage in such a way that small surface changes occur. These, in turn, lead to picture distortion during playback. Telefunken says that by modifying the jacket this shortcoming can be straightened out, **but it concedes that such a jacket modification may call for a design change in the playback unit as well.**

Just when the new date for TED introduction will be depends on how long the tests with redesigned jackets and with possibly revamped playback units will take. Company officials speak of "only a short-term delay," which they say means the TED market debut will still be sometime in 1974. The delayed introduction, independent observers feel, is a decided **setback for the Telefunken system because it cuts down the lead the German company has over the competing Philips-developed Video-Long-Play system,** which is scheduled for a mid-1975 market debut. Thus far, Telefunken has considered that lead one of the big plus points for its system.

Common Market looks to strengthen computer industry

The Common Market Commission is recommending a strong Community-wide program of financial aids, joint development efforts, and intercompany cooperation **aimed at making the European computer industry competitive with U.S. companies.** In a report on the industry adopted last week, the commission places priority on an all-European grouping of computer firms. While the document mentions the Unidata linkup between CCI, Philips, and Siemens, it implies that the approach does not go far enough in putting the European industry on a strong basis.

The commission envisages the regrouping of European companies in two phases: **the first starting with cooperation between firms, the second terminating in fusion of production facilities.** The document also calls for measures to aid European computer companies in selling to various national government markets. **It wants parallel efforts to strengthen the European peripheral, software, and components industries.**

Japan plans to up TV exports to Britain . . .

Japan will be able to export 25% to 30% more color-TV sets and about 10% more black-and-white sets next year, according to Noboru Yoshii, managing director of Sony Corp., leader of a Japanese team that just returned from a bilateral meeting of industry executives in London. **That will make a total of about 350,000 color and 240,000 black-and-white sets to be exported next year under Japan's self-imposed export restrictions.** The Ministry of International Trade and Industry is expected to set the actual numbers early in December. Representatives of the electronics industry in the two countries will sit down again in May in Tokyo.

Although England's domestic economy, international balance of payments, and oil situation are unclear, industry representatives at the recent meeting agreed that **next year's market for color will probably**

exceed this year's total estimated market of 2.74 million sets by at least 25%, and the market for black-and-white sets will probably exceed this year's estimated market of about 500,000 by 10%. The percentage of the market allocated to Japanese sets for next year is to be kept the same as this year.

. . . where makers continue to worry over Japanese gains

In Britain, the statement by officials of Japanese industry that it expects to raise color-TV exports to Britain to 350,000 sets next year, compared with 275,000 this year, has had mixed response among domestic set makers. The majority view is that **if the total home market increases next year so that imports from Japan make up about 10% of it, as they are this year, the imports won't harm the home industry.** However, if the market soon levels off—as is quite possible, though it's expanding now—the increased imports will start to cut into home production. Then will come the **test of Japanese protestations that they will not let their exports harm the British industry.**

Overall, British set makers are less worried than they were a year ago, mainly because Japanese set prices have been rising steadily and are now—tube size for tube size—equal to or more than British set prices. Because of this, a few industry leaders **believe the main threat from Japan has passed, and when the market slumps the imports will be the first to feel the pinch.**

In West Germany, Sunday driving, no; color-TV, yes

As much as West Germany's ban on Sunday driving is hurting some branches of the economy —innkeepers, for example, are complaining about lack of business **it is proving to be a boon to the entertainment-electronics makers.** Radio and television dealers, industry people say, are reporting sharply rising sales of their products in recent weeks, with color-TV sets doing especially well. Retailers attribute the increase not so much to the usual pre-Christmas buying spree, but rather to the no-driving-on-Sundays edict.

Several Frankfurt dealers say they are chalking up sales from 20% to 30% higher than those during the same period last year. "Just by how much the driving ban will boost nationwide color-set sales this year is hard to pin down at this time," a marketing expert at Stuttgart-based Standard Electrik Lorenz AG says. "There's no doubt, however, that people's immobility on Sundays is intensifying color-TV business and proving to be a market factor of sorts." The ban on all non-essential Sunday driving, already in force in several Western European countries, is, of course, one result of the energy crisis currently gripping many of the world's industrial nations. **In West Germany, the ban went into effect on Nov. 25 and will continue to be enforced on all Sundays at least through mid December.**

Russia snaps up automatic-test equipment at show

Booming demand in the West for automatic-test equipment apparently has reached Russia. At an exhibition of British instruments in Moscow last month, **the Russian state buying agency Mashpriborintorg paid Marconi Instruments Ltd. $50,000 cash for the stock demonstrator Marconi had on its stand.** It's a tape-controlled system and will be used to check component values and do functional tests on computer boards in a plant in Kiev. Marconi men say the Russians seemed not have seen a full automatic-test system before.

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Circle 67 on reader service card

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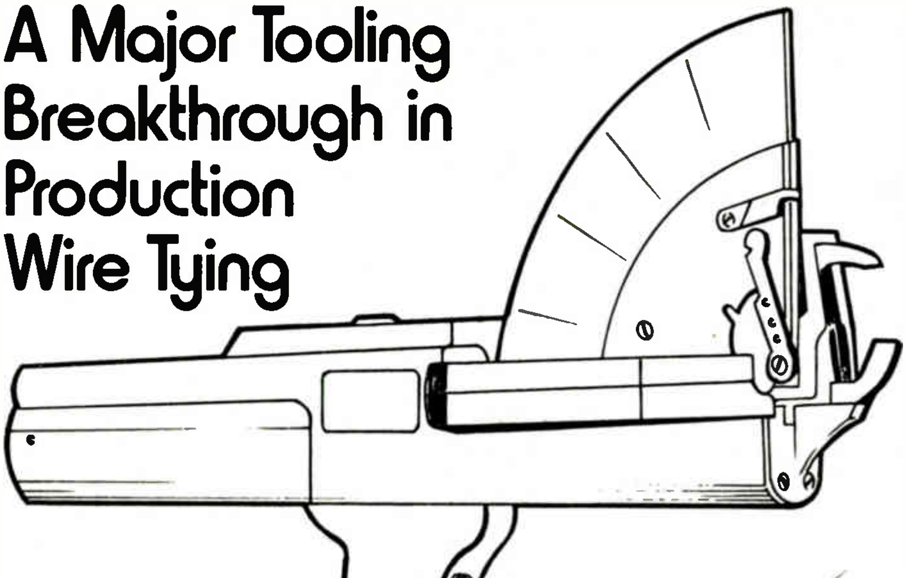

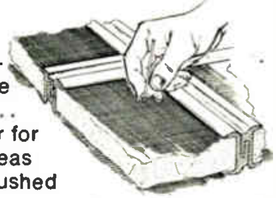

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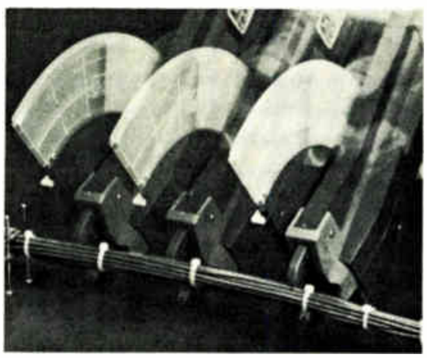

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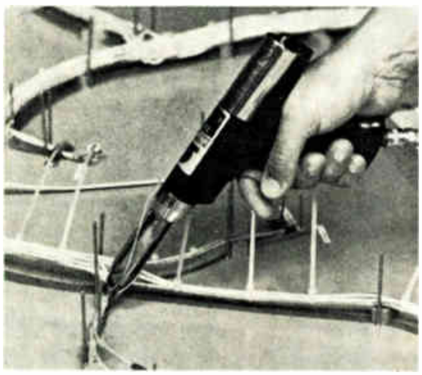
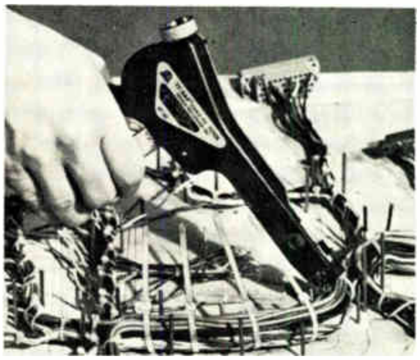


rugged design yet light weight and human engineered for both men and women operators. It was built to provide reliable performance day after day in a production environment . . . (has been test cycled 1,000,000 times per month without a failure). The tool accommodates most TY-RAP tie sizes . . . 16 in all . . . ranging from $\frac{1}{16}''$ to 4″ bundle diameters. A further convenience is the long narrow nose that works easily at breakouts or in tight areas. If your production volume is such that it does not require the exclusive use of the TR-225, perhaps the new WT-193 hand tool would supplement your operation.



The WT-193 tool accommodates the same bundle range as the TR-225. With a similar narrow nose and long barrel, it is also well suited for tough to reach places. This particular design gives the operator the convenience of a long tying stroke with one squeeze of the trigger . . . the tie is cinched to a preset tension and trimmed flush with the head. The speed of tying is good for smaller volume tying as compared to the pneumatic TR-225.

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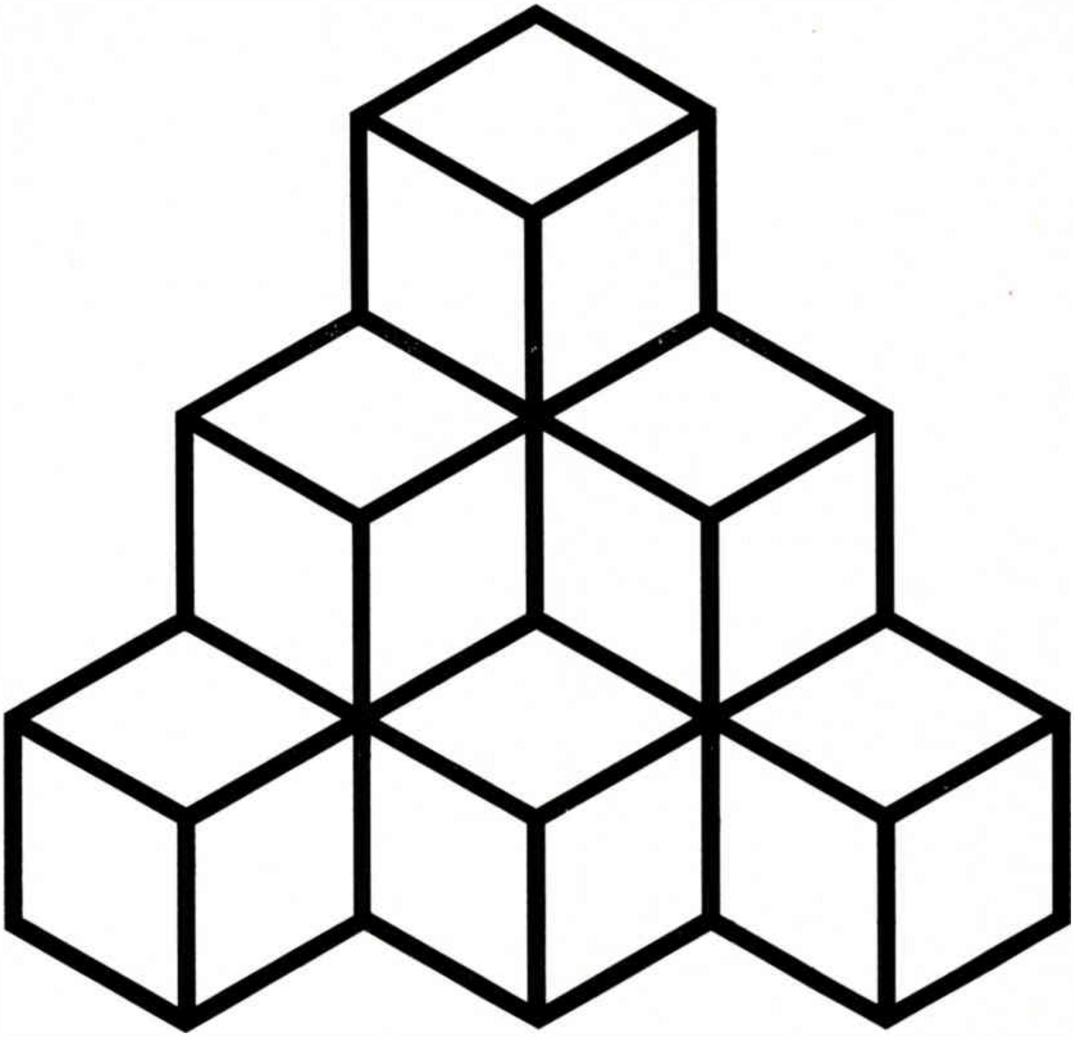

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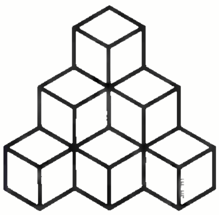

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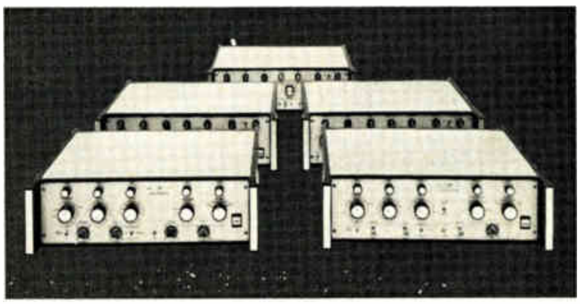

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An engineering analysis of EE jobs

IEEE's latest report examines factors in picking a job, but the decision is still up to each EE—as usual

by Gerald M. Walker, Associate Editor

Back in the depths of the 1969–71 recession, when many engineers were on the beach, the common complaint among those attempting to remedy the situation was that there were not enough statistics—no numerical handle on how bad the situation was, who was hit hardest, and the like.

Now, at the crest of an economic boom in which there appears to be a shortage of some types of EEs, comes the IEEE's "Career Outlook in Engineering—I," the result of an arduous study to correct the lack of a good analysis of the EE job situation. Prepared by the institute's manpower committee, the report goes a long way toward providing engineers and students with a tool to help figure out the ups and downs of employment in the electronics industries and to plan some sort of strategy to cope with employers' hiring needs.

The decision-making, however, is still in the hands of the individual. This report, running some 225 pages, is not a secret potion to magically get every EE into the best of all possible jobs at just the right time. In fact, there is a certain amount of conflict within the report about whether or not there actually is or will be a job shortage, but this adds to its believability because the same conflict exists within industry, academia, and Government agencies.

Overall, the publication, which is due to be released as soon as the IEEE decides how much to charge for it, is about as thorough and exhaustive a summary of careers as an engineering paper is of a technical subject. It's indeed an engineer's view of the engineering career.

Says committee chairman Frank Astorini Jr. in the preface: "As a preliminary report in this area, it is hoped that the historical picture portrayed, along with current statistical data available, will provide a source document from which the engineer (or potential engineer) may obtain a real sense of personal perspective with regard to his professional status, as well as its changing and changeable character.

"The overriding objective of this report is to provide IEEE members with information affecting their professional status and with which they can form individual judgments about such broad areas of concern as 'How am I doing? Where do I stand? What should I do?' and provide the means to make good decisions on the future."

Oscillation. Plainly, this collection of 14 chapters is an attempt to explain the apparent oscillation in the supply and demand of engineers and how the individual EE can ride the hills and valleys. Actually, taking the long view of employment, the rise and fall in demand has occurred along a steadily increasing total-employment curve. Never-

The audience: they're encouraged

Gary Rago and Chris Ross have read the report, and they are encouraged. And that's important because these 20-year-olds, junior EE majors at Manhattan College in New York, are typical of the young men and women the IEEE is trying to reach with its "Career Outlook in Engineering—I."

Rago and Ross agree that, until they had read the study, they had had some misconceptions about what an EE is and what he or she does. "I thought all of them did research. It turns out that only 2% do," says Ross. Rago likes the comprehensiveness and detail of the IEEE's effort, saying that it's good to have numbers backing up his feelings that EEs are doing vital work. He also points out that he had been leaning toward working with power devices after graduate school "mostly because of what some seniors and an engineer with GE told me." But the report has opened the world of sales and management to him, and now he's less sure about power. "I really would like to go into business for myself," he says. Ross, whose inclination is toward bioengineering, likes the report's view of management qualities. "I had the impression that EEs work alone."

But both students agree that they dislike one part of the report. "We don't like the part classifying EEs as people who aren't well-rounded, who aren't able to talk with other people."

Reader. Report pleases Gary Rago.

theless, as the summary of general conclusions points out, "Even though the long-term trend will be upwards, with demand outpacing available graduates, the fluctuations of the market itself will result in the need to make an increasing number of shifts in the years ahead."

If the economists are correct, the U.S. economy—and possibly the electronics industries along with it—is due for a growth slowdown in the coming year, thus making a careful study of this report uncomfortably necessary. It's organized under four main headings: the industry picture, the manpower picture, careers in engineering, and the engineering challenge. These sections are not uniformly appealing; the writing ranges all the way from pompous to dry to intriguing. But on the whole, the report is a good career review for just about every EE. It's crammed with tables and charts covering engineering-school enrollment, job demand, business conditions, salaries, and distribution of engineers—to name just a few. And it's refreshingly free of what might loosely be labeled "the IEEE party line"—that is, the view that everything is all right out there in the working world if you will just be a good fellow, work hard, and always listen to what your boss tells you.

Balance. To be sure, there is some of that kind of thinking in the report, but it's balanced by some tough-minded advice on the characteristics of engineers, of engineering jobs, of the electronics industries, and of the cruel race known as continuing education. So it's not exactly a travelogue through the glories of engineering. Rather, it's a trip that details the fears, uncertainties, and just plain absurdities of the EE career, along with the satisfactions, excitement, and challenges.

The section on manpower begins with a study of employment trends provided by Deutsch, Shea, & Evans Inc. On the whole, it shows an encouraging picture for the EE—a notable decline in engineering enrollments, an upward-moving economy, and a technology-oriented socioeconomic structure. This spells plenty of jobs. However, DS&E warns that companies have learned to get along with fewer engineers, and—not so good for the EE—the cost of recruiting is increasing. Thus, the individual engineer must take a conservative view of job planning and look for pensions and employment contracts that protect him from summary dismissal.

Another chapter on manpower hits a sore point these days—employment statistics: "The most serious deficiencies in the various series of national data are inconsistency in definitions, lack of coordination in collection, excessive delay in publication, lack of essential detail, and lack of coverage. Taken together, these deficiencies reveal the absence of a coordinated manpower policy, so that what exists is a collection of loosely related statistics of uneven quality and completeness."

The last three chapters in the manpower section merit the engineer's closest attention, for they reveal through a maze of charts and formulas an excellent picture of today's employment that's worth the struggle to absorb all the statistics. Significantly, conclusions in these chapters are not in complete agreement. For instance, contradicting other chapters indicating a shortage of engineers, Robert A. Rivers, chairman of the manpower committee's subcommittee on the assessment of supply and demand, concludes, "There is a large 'stored supply' of qualified engineers available." And he adds that even with a "normal" demand for more engineers, the surplus of displaced engineers may grow, while "decreasing or static demand can only result in further dislocation."

The chapters on careers in engineering touch yet another sore point among EEs: the conflict between becoming a specialist or a generalist. In one spot, the report states, "When the cards are down, it is the fact of life that industry, education, business, etc., put specific parameters on every job. Yes, there is the generalist to a fair degree, but the generalist has evolved from having gained experience in a number of specialties. For the most part, the openings from which choices can be made fall into a surprising variety of quite specialized categories."

Three pages later, this appears: "From this analysis it is obvious that specialty experience in engineering and design, application engineering, and management aspects is in high demand." And four pages later, it says, "Overspecialization and professional inactivity have contributed the greatest barriers to enjoyment of a stable and improving job picture." Thus, the general conclusion seems to be that the EE has to be a specialist in a range of disciplines.

Character. Chapter 10, "Personal Attributes and Career Goals in the Electronics Industry," by Michael Maccoby of Harvard, gets off to a terrible start with this line: "The EE's future depends as much on his character as on his technical ability and training." But EEs should grimace only once at this one and read on, for this turns out to be an interesting chapter.

In it Maccoby describes four basic character types found among an analysis of engineers in a sample of electronics companies. They are:

- The craftsman. This engineer, who prefers to work alone and is stimulated by the task, is satisfied by seeing a design work.
- The company man. He, on the other hand, derives his security from knowing that he fits into a company structure. He is driven by a fear of failure—that is, falling from favor in the company.
- The gamesman. He plays the game of the business world. He thrives on competition and often uses football jargon like "the big play," or "the game plan." "He lacks patience and commitment to people, principles, and goals, beyond winning. His hunger for excitement and glory may distract him from realities beyond the game he is currently playing. Indeed, he can be looked upon as creating a secondary reality for himself. If life is not interesting enough for him, he makes it a game and enters a semi-fantasy world," comments Maccoby. In a striking understatement, he points out, "The gamesman and the craftsman often feel frustrated trying to communicate with one another."
- The jungle character. This type of engineer may get the job of cleaning house in an organization and probably likes knocking off others in his path. □

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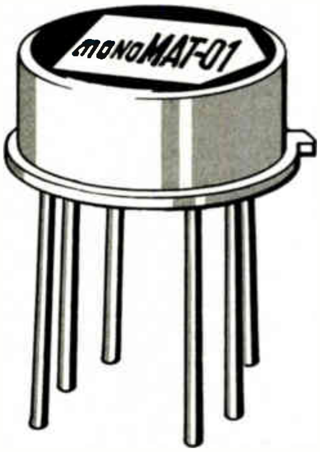

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Solid state

Technologies prophesy products

International Electron Devices Meeting hears of innovations due in 1974 in areas ranging from CCDs to power tubes

The move from laboratory to production line is so swift nowadays that a forum on the latest technology becomes a reliable indicator of upcoming new products. For 1974, the past week's International Electron Devices Meeting in Washington promises dramatic advances in the state of the art of many products.

The list ranges from microwave power tubes to the most sophisticated kinds of memory, logic, and linear solid-state devices:

- Charge-coupled devices, already emerging as imagers and fast memories, are also reaching final development as delay lines and signal processors with efficiencies up to 99.9999%.
- The latest MOS memories achieve record bit densities on record small chips with the help of electron-beam, ion-implantation techniques, and novel isolation structures.
- MOS and bipolar technologies are being combined on the same linear integrated-circuit chip to extract high operational-amplifier performance—minimal bias-current input voltage and maximum gain from a single power supply.
- In the microwave technologies, low-noise FETs now rival bipolar devices in the 4–7-GHz range, and higher-power klystrons achieve greater efficiency (in Japan), wider bandwidth (in France), or both (in America).
- Finally, in optics, gallium-phosphide displays are brighter, gas-discharge displays are more versatile, and tunable lasers may at last make holography a reality.

Charge-coupled-device memories, already built into hardware by scores of semiconductor manufacturers, are destined for use in fast-access swapping memories, cathode-ray-tube-refresh memories, and sequential-access buffers, besides replacing delay lines and drum memories. CCD shift registers range from a 4,096-bit silicon-gate structure being developed at Bell Northern in Ottawa, Canada, to operate at 2 megahertz—30 times faster than ordinary disk files—to a 500-bit surface-channel CCD linear register being fabricated by Texas Instruments with double-anodized aluminum. And a 1-MHz, 8,096-bit CCD register [*Electronics*, Nov. 22, p. 25] soon will be in production.

Delay lines. CCD delay lines and signal processors for radar and telecommunications systems are in the final development stage at many laboratories. One program at Westinghouse's Defense and Space Center, Baltimore, Md., pairs a CCD analog delay line with a nonvolatile MOS nitride memory to form an electrically programable transversal filter. At General Electric Co., Schenectady, N.Y., the serial charge-transfer efficiency of CCD shift registers and variable delay lines has been recorded at an astonishing 99.9999% by virtue of a structure that allows some charge to remain in each storage site and that residue mixes with subsequent transfers.

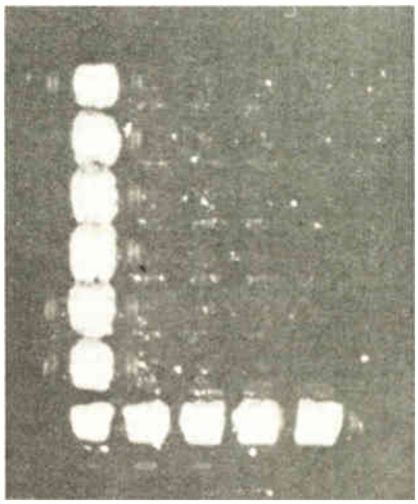
Three ways to shrink MOS memories

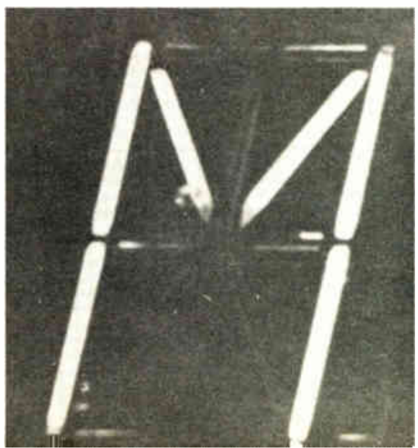
Figuring prominently in MOS-memory development are Bell Laboratories in the U.S., Mullard in England, and Hitachi in Japan.

At Bell, a 1,024-bit p-channel random-access memory [*Electronics*, Dec. 18, 1972, p. 29] was refabricated with an electron-beam technique so that the entire memory circuit—address, decode and sense amplifier—fits on a chip only 47 by 71 mils on a side. That's four times smaller than today's MOS RAMS.

The single-transistor-per-cell RAM, which must be built with alignment accuracy to 1 micrometer that may also be a record for a MOS RAM—45 nanoseconds.

Some of the cell dimensions are impressive. Gate lengths of the RAM are 4 μm contact holes are 2 μm square. As in the other chip, the new





one uses ion-implanted source, drain, and channel stops, and double-level tungsten metal gates, beam leads, and silicon-nitride sealing.

Prototypes are being made available to switching-system-design groups within the laboratories for evaluation, according to R. C. Henderson of Bell's technical staff. However, the electron-beam-fabrication work is being applied to still finer designs—as much as two or three times smaller.

Bell also makes use of ion implantation for device isolation and depletion-mode operation in n-channel memories. But Mullard is unique in using ion implantation to build high-value resistors for extremely small low-power static-MOS memories that, like Bell's, promise to be faster than today's dynamic memories.

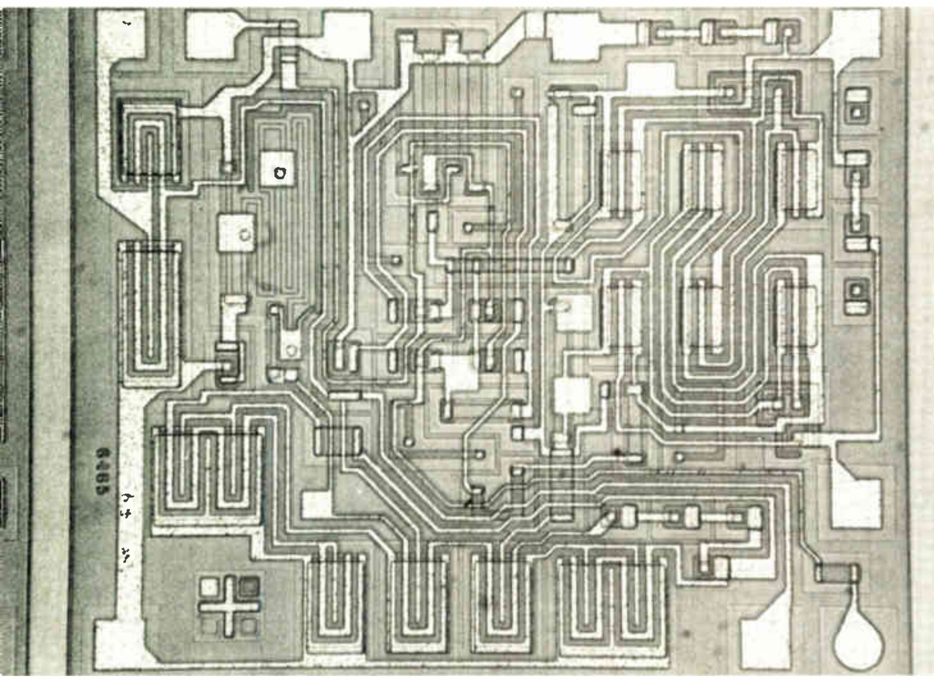
By deliberately damaging the structure of resistors in MOS and bipolar integrated circuits by ion implantation, researchers K.H. Nicholas and R.A. Ford of Mullard Research Laboratories in Surrey, England, have enhanced the properties of such resistors in a way that may lead to very small static MOS random-access memories and low-drift bipolar linear circuits.

The technique consists of adding a second boron implant to the original doping implant and annealing the resistor at elevated temperatures. Although not fully understood, the resulting improvement appears to be related to the reduction in mobility produced by the procedure. With this technique, the researchers have built experimental static RAMs that operate with an access time of 80 ns and very low power consumption—150 microwatts per bit. This is almost five times faster than conventional static RAMS.

To increase C-MOS packing density, researchers at Japan's Hitachi Ltd. developed a new isolation structure for high-density LSI circuits that also features high switching speed and reduction in parasitic effects. An oxide-isolated 16-stage binary C-MOS counter of the type used in quartz-crystal watches has already been fabricated with a cell size of only 130 by 125 micrometers, or only about half the cell area of conventional C-MOS circuits.

Useful process. Significantly, the process can be used for other types of MOS and also bipolar structures. In the C-MOS circuits, the process has the additional virtue of eliminating the space-wasteful channel stops normally required. Moreover, the structure can provide an extra layer of wiring, making a total of four in silicon-gate MOS, three in bipolar and others.

Capital devices. Bell's monolithic GaP displays can use either domed matrix array (top left) or a mesa bar format (bottom left). The new RCA op amp (below) mixes p-MOS inputs, C-MOS outputs, and bipolar gain stage for sought-after low-input parameters and high gain.



New linear technique: mixed processing

In the linear area, designers are now combining linear and digital processes on the same chip.

The researchers at Harris Semiconductor of Melbourne, Fla., have developed a mixed linear process using complementary MOS-complementary bipolar, structures that are dielectrically isolated. This technique allows logic and linear capabilities on the same chip. Op amps, comparators and monolithic analog-to-digital conversion devices are all possible with this process.

An essential feature of the process is double-diffused high-performance npn and also pnp transistors. The npn is an 800-megahertz unit, and the pnp transistor operates up to 600 MHz.

An operational amplifier built at RCA combines a complementary MOS output structure, a p-MOSFET structure, and a bipolar gain stage and does it with conventional processing to boot. The result: an op amp needing only one power supply with input bias current of only 100 picoamperes (at 25°C), input offset of only 20 millivolts maxmimum, and a slew rate as high as 10 V/μs—all achievable in a device built with standard junction isolation.

According to Murray Polinsky, one of the developers of the mixed linear process at RCA, the ability to combine different processes on the same linear chip allows designers to use the device best suited for a given circuit function, independent of the process needed to build it. For example, p-channel MOS devices were used in the op amp for input structures because of their inherent low-input bias requirements. C-MOS is ideal for outputs because the combination of n- and p-channel devices means that the amplifier can track both positive and negative outputs from a single supply. Using bipolar gain stages is the most effective method of getting the required signal amplification with low noise.

Considerable process innovation was required to ensure that the presence of C-MOS and bipolar devices on the same linear chip would not degrade the performance of either.

The FET story: faster and smaller

Besides using such small-geometry fabricating techniques as electron-beam lithography to build MOS memories that are super-dense, researchers are making considerable progress in applying it to field-effect transistors to decrease their size. At TI, electron-beam lithography is being used to build FETS with 0.5-micrometer dimensions. The devices, which are being delivered in 100-quantities to the U.S. Army Electronics Command, operate at 6 megahertz with gains of 8.5 decibels and noise of only 4.5 dB, greatly advancing the state of the art of FET microwave production devices.

"For small-signal applications between 8 and 12 gigahertz, we felt the field-effect device is best," says John M. Pankratz, manager of TI's Advanced Microwave Transistor branch. "But in the 4-to-7-GHz range, it's a tradeoff. FETS, because of the impedance-matching problem, lose some of their apparent noise advantage. And below 4 GHz, the bipolar device will pretty much hold its own, and the noise figures are fairly close."

The tale of the tube is happily not ended

While microwave semiconductors are making inroads on several fronts, new tube designs, especially for high-power communications and electronics applications, seem to be attracting renewed interest. Dual-mode tubes now under development are typically capable of about 1 to 2 kilowatts pulsed power and 500 watts continuous power, a pulsed-power-to-cw-power ratio of about 3 dB. Such tubes would operate over octave bandwidths and are being developed for electronic-countermeasure systems from 2 to 28 GHz.

Engineers at Nippon Electric Co. have used computer-aided design to greatly increase the efficiency of a 10-kw klystron for use in the output stage of uhf television transmitters. The design allows optimum positioning of five external cavities along the direction of the electron beam, and also optimization of the stagger tuning pattern used to achieve the 6-to-7-MHz bandwidth needed in TV transmitters. Efficiency of the new tubes is about 60%, compared with efficiencies of about 40% for conventional tubes of this type.

Working on a klystron at higher frequencies, engineers at Thomson-CSF in France have developed an S-band tube capable of delivering 200 kilowatts peak output over an unusually large bandwidth of 10% of operating frequency. The tube has been developed under a French-government contract, and according to Thomson-CSF, the technique developed to achieve the large bandwidth is applicable to other frequencies and power ranges.

Displays growing brighter and bigger

Display technology is also scoring major breakthroughs. Red and green monolithic gallium-phosphide displays with improved brightness and efficiency have been built at Bell Laboratories, Murray Hill, N.J. These mesa structures show an external surface brightness of approximately 130 foot–lamberts per ampere per square centimeter, significantly higher than previously GaP displays. In liquid crystals, Hughes has made CRT graphic displays that contain 10,000 LCD cells [*Electronics*, Nov. 22, p. 34].

Burroughs Corp.'s new 140-by-350-dot matrix gas-discharge display was built with an eye on the flat "picture-frame" type of TV that researchers have long been promising [for recent Sony work, see p. 62]. This is an extension of the company's self-scan panels that are sold commercially in alphanumeric displays. Perhaps more important than the number of dots in the newest display is its ability to discriminate the variations a 16-step gray-scale. This variation is a measure of the display's ability to produce a sharply defined image. The discrete shades are produced by using a combination of amplitude- and pulse-length modulation applied to each dot, according to Thomas E. Maloney, manager of Burroughs' display-device development. The modulation produces a dynamic luminance range of 200:1; previously, using amplitude modulation alone, a range of only 40:1 could be produced. Burroughs is also at work developing gas-discharge displays that will glow in other colors beside the orange output produced by the neon gas generally used.

Tunable laser takes on holography

The benefits that the wideband tunability of dye lasers offer holography have been demonstrated by Peter Shajenko of the Naval Underwater Systems Center in New London, Conn.—namely, the application of holography to working media other than air. The light source can be tuned for maximum transmissivity through sea water or any other medium.

Furthermore, Shajenko points out, double-exposure holograms at two different wavelengths can display contour fringes of surfaces, so that sizes and shapes of objects can be determined. Such interferometric techniques may have applications in biology and medicine, where selective interaction of the laser light with living cells could permit measurement of minute changes in organisms and tissues.

Until now, dye lasers haven't been used in holography because there have been none with sufficient coherence and output power. But Shajenko has designed and built one with output in a single transverse electromagnetic mode, tunable over a wide spectrum. □

Reporting for this roundup—related stories are on p. 40, 41 and 62—were Laurence Altman, Samuel Weber, Lyman Hardeman, Joel DuBow, Paul Franson, Larry Armstrong, George Sideris, Charles L. Cohen, and John Gosch.

Commercial electronics

'Tis the season for shoplifting prevention

Stores turn to electronic measures to halt practice that costs them some $3 billion a year

by Marilyn Offenheiser, Assistant Editor

Shoplifting is the fastest-growing larceny in the nation, says the FBI. There was an 84% increase from 1966 through 1971. And this is the season, with its crowded stores and harassed sales personnel, when shoppers a bit short of Christmas cash may succumb to the temptation to beat the system—a system that in an increasing number of stores includes electronic theft prevention.

The National Retail Merchants Association, which keeps statistics on what the retail industry euphemistically refers to as "shrink," estimates that one in every 12 persons is or has been a shoplifter. This multitude—plus larcenous store employees—managed to make away with $3 billion worth of merchandise in 1972, says the NRMA. The antidote, many retailers believe, ranges from sophisticated closed-circuit-television arrangements to the ubiquitous microwave tags.

The tag system is simple and relatively inexpensive, a big plus for smaller stores. It includes a deactivating unit, alarm ports set up on either side of all store exits, and the tags themselves. To deactivate, the microwave diode on the tag is interrogated by a microwave deactivator tuned to the same frequency. After a sale, the tag is reused.

The Knogo Corp. of Westbury, N.Y., which says it developed the tag, aims its sales efforts at the smaller specialty shop. Some, says executive vice president Mickey Perlmuth, have reported that the system has cut pilferage by as much as 95%. Knogo's major competitor, Sensormatic Electronics Corp. of Hollywood, Fla., claims to have 350 customers, or 80% of the big-department-store market, including Macy's of New York.

Just looking. Shoppers are unaware of the two-way mirror over their heads.

Drawbacks. Yet not all retailers are sold on the efficacy of electronic tags, nor is the NRMA. A spokesman says, "Stores are beginning to question the devices. After all, retailers used the tags because they were desperate."

The biggest drawback of the tags is accidental triggering when a clerk fails to remove one from an article. Albert Seedman, security director of Alexander's Inc. stores in the New York metropolitan area, estimates that, of 1,937 alarms set off in his stores last year, 1,328 were accidental.

Some companies—Knogo among them—are working on a tag that does not have to be removed. A

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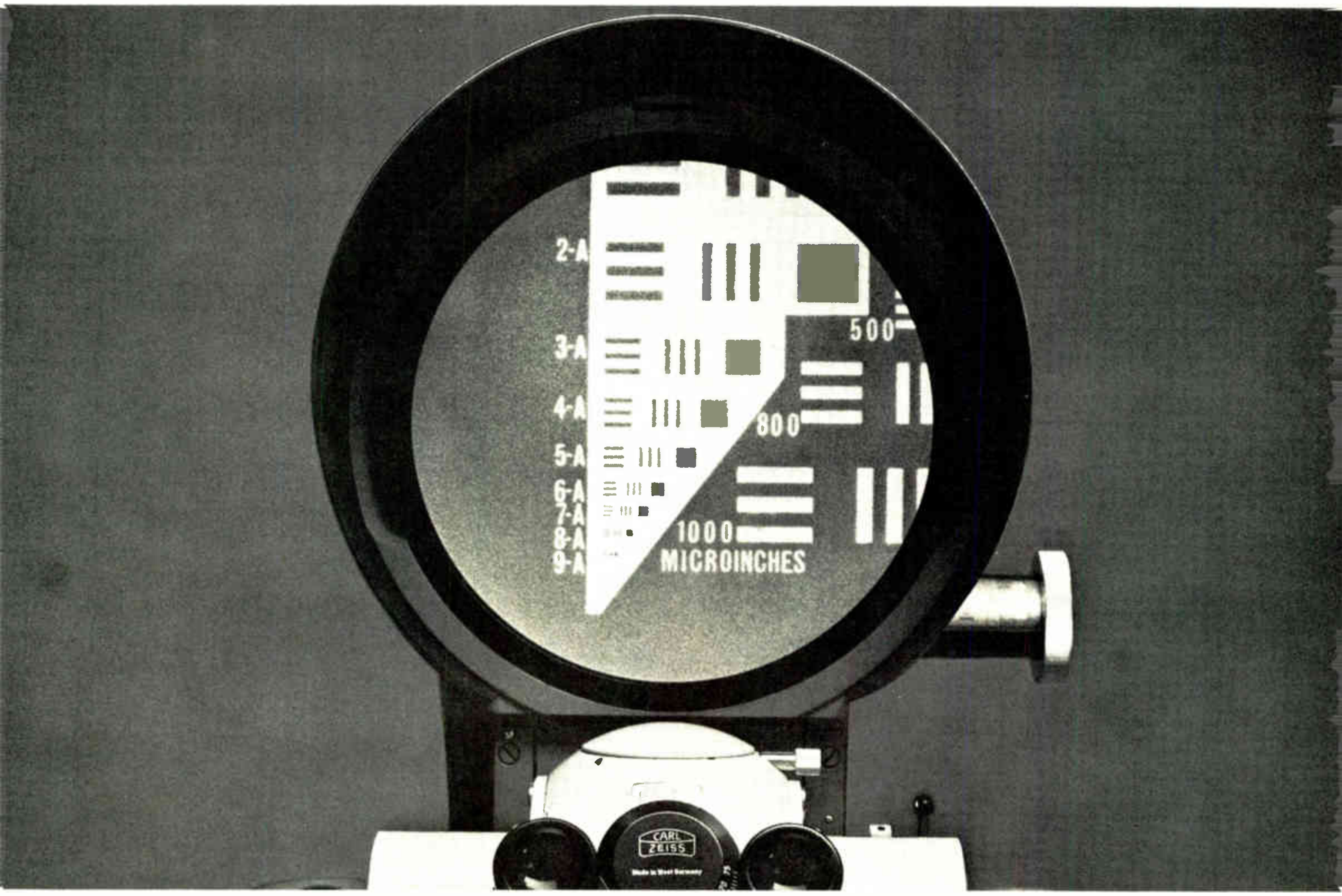

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spokesman for ADT Corp. of New York, a major supplier of closed-circuit TV to retail stores, says the company is anxious to enter the tag market and that "deactivatable tags are the only way to go. It's a market we'd like to get into." But Sensormatic and even Knogo aren't totally sold on the approach.

Says Knogo's Perlmuth: "Tags are intended to deter. Deactivatable tags have to be hidden. This is contrary to the deterrence principle and often challenges people to steal." Sensormatic, a three-year-old company, also is test-marketing a system called Compuvision, in which a computer monitors the CCTV. The computer triggers an alarm if it detects certain variations from the normal in the picture. Other company projects include a system to eliminate fitting-room personnel and use of microwave tags with point-of-sale devices.

The market. Industry insiders are vague about the size of the market, but they agree that it's potentially a large one. Perlmuth points out that it's difficult to stay solvent because equipment is leased. Timothy Smith, Sensormatic's manager of marketing services, says the market can't even be estimated. He says more and more skeptics are coming around as they realize that elimination of security personnel more than pays for the system—for Sensormatic's, $95 a month plus a penny a tag.

However, two of the nation's largest chains, Allied Stores of New York and Federated Department Stores of Cincinnati, are less than enchanted with electronics. Sam Rieger, director of operations at Allied (Boston's Jordan Marsh and New Jersey's Stern Bros.) says the number of false alarms—and insulted customers—isn't worth the security of the tags. Until something better comes along, possibly deactivatable tags, well-trained personnel and store detectives are the answer, he says. However, Harry Strimell, director of security for Montgomery Ward & Co., Chicago, says that tags are an interim measure—and Ward's lost $4 million in pilferage last year. □

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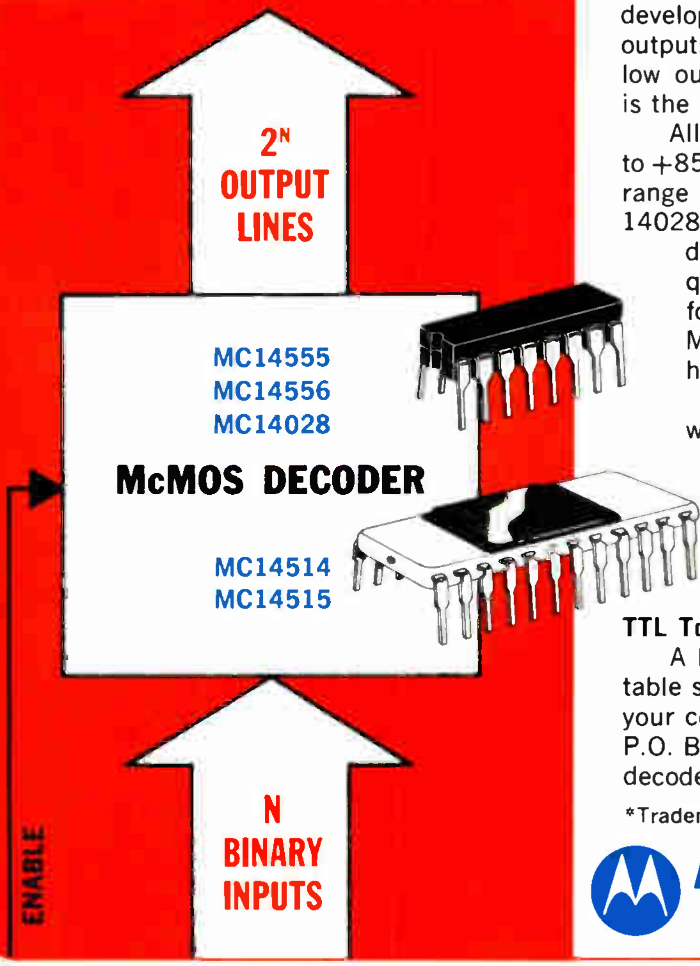

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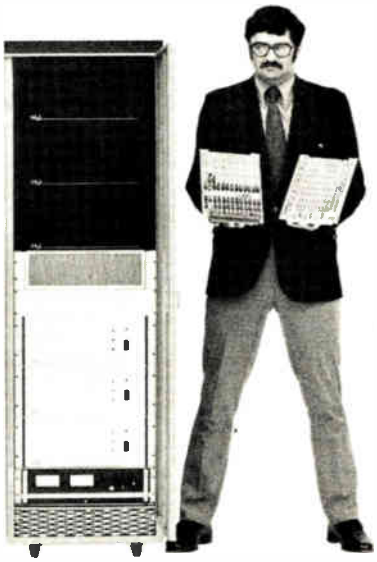


Displays

Electrochromics glow on horizon

Technology promises wristwatch and calculator displays with storage capability—but skeptics say they're still years away

by Howard Wolff, Associate Editor

"In the next 10 or 20 years, the study of electrochromics will open one of the least explored areas of electronics—insulating physics. What we are starting to see now is the analog to what happened 25 years ago when the study of semiconductors led to the whole field of solid-state electronics."

The speaker is that eternal enthusiast, Zoltan J. Kiss, founder and chief executive of Optel Corp. And the object of his lavish enthusiasm is a display technology that, because it has inherent memory, is generating a good deal of hot debate between those who consider it a true electronic answer to the printed page and those who suspect that it will not get much beyond the stage of the wristwatch display—if it ever gets that far. But even many of those who tend to discount Kiss's statements, along with his ebullient charm, concede that what isn't being said about electrochromics is almost as interesting as what is being said.

The companies that should logically be most involved in electrochromics research seem to be the least willing to talk about their work. One is the American Cyanamid Co., which did the original work and which holds the basic patents on electrochromic materials. All that the company will say from its Wayne, N.J., headquarters is that it does, indeed, have five patents in the technology; it also will explain briefly the basic mechanism of electrochromics.

And RCA Laboratories, pointing out that it was first to demonstrate liquid-crystal displays, will concede only that it has "had projects for several years in electrochromics and similar effects that might have potential use in displays." Comments a scientist at a competing company: "We know that they're working hard on electrochromics. If they're not talking, it must mean that they think the work is important and significant."

And, even though insiders say that Philips Gloeilampenfabrieken in the Netherlands is Europe's leading electrochromics house, company spokesmen, like most of their American counterparts, simply are not saying much. But they do admit that the Philips display consumes very little power—for one write-erase cycle, typical consumption is 1 millijoule for a seven-segment numeral 10 millimeters high. The display is compatible with transistor-transistor logic and injection logic.

Just what is electrochromics? Basically, the materials are organic or inorganic insulating solids that change color when injected with positive or negative charges. They are based on such transition-metal compounds as tungsten oxide or strontium titanate, and are doped with such materials as molybdenum and iron. In most electrochromic displays, the image goes from colorless to dark blue.

Familiar look. Electrochromic displays closely resemble liquid-crystal presentations—in fact, at first glance, they appear to be identical. But there are significant differences. First and most important, of course,

An innovator from Bangladesh

Satyen K. Deb is a modest man who is interested in reincarnation, the transmigration of souls, and electrochromic displays. Born 41 years ago in what is now Bangladesh, Deb received his doctorate in physics in 1959 from Cambridge University in England. "I wanted to go to America," he recalls, "because there was more money there for research—and researchers." So Deb took a job with the National Research Council of Canada, then moved south to the American Cyanamid Corp. research facility in Stamford, Conn.

Initially, he worked on photochromics, but saw difficulties and switched to electrochromics in 1965. His work led to the first display patent in the field, granted to him and Robert F. Shaw in July 1970 and assigned to Cyanamid. But Deb became disappointed with the company's decisions not to press ahead quickly in the new technology—"although I understand their reasons. After all, they are a chemical company used to selling materials by the carload."

He left and went to work this year as visiting scientist with the French national research council at Grenoble. Then, in July, Optel Corp.'s Zoltan Kiss, on one of his trips to Europe, induced the scientist to return to America, and Deb, by this time a U.S. citizen, moved his electrochromics work to Optel's crowded building on Route 1 in Princeton, N.J.

is the storage capability, which inspires comparison with a printed page. Satyen K. Deb, Optel's research director, says the material stores data until it's erased or altered—reduction of power or total interruption has no effect.

Deb did the original work at Cyanamid; he and his electrochromic knowledge came to Optel last summer (see "An innovator from Bangladesh"). Also, he says, electrochromic displays absorb light, while liquid crystals scatter light. Thus, electrochromic displays have no angular dependence—there is no distortion—and they offer better contrast.

Deb also says that electrochromics have a wider range of working temperature than liquid crystals: -50°C to 100°C vs -15°C to 75°C. The big disadvantage at this point in electrochromics' development cycle is speed. Although the displays are potentially fast—ranging from milliseconds to a second—liquid crystals are faster.

Other potential advantages are pointed out by Thomas D. Hinkelman, president of Electronic Time Industries Inc. of Los Altos, Calif. Hinkelman, whose company plans early next year to introduce watches using light-emitting-diode displays, says the electrochromics memory function would give it significant advantages in cost and size over other displays. That's because it's possible to multiplex an electrochromic display with one drive line per digit and one shared drive line per segment.

Thus, a watch display could be driven with 11 lines (seven for segments, four for the three full digits and the 1) while a liquid-crystal display requires 24 lines. What's more, says Hinkelman, a liquid-crystal display requires a purely ac drive and 15-volt drive level, but an electrochromic display can be driven without the power needed by crystals. The key is that electrochromic displays need only be driven intermittently. Sums up Hinkelman: "Electrochromic displays are quite clearly the display of the future. The question is when."

Prototype coming. And that, as they say in bad novels, is the burning question. Most estimates of the state of the electrochromic art place it at approximately where liquid crystals were four or five years ago. ("However," points out one wag, "liquid crystals are where liquid crystals were four or five years ago.") Optel's Kiss says he will have a prototype wristwatch display next year. His research director, Deb, ever the cautious scientist, says only that much work still must be done in the materials area.

A more sanguine view is taken by the watchmakers at Ebauches SA of Neuchatel, Switzerland's biggest watch company. After three years of work, Ebauches showed a quartz-crystal watch with an electrochromic display at the 1973 Basel Fair. Ebauches' American partner in this work is believed to be Cyanamid, but neither company will discuss it.

For every supporter electrochromic technology has managed to inspire, there is a skeptic to point out that not enough is known about the material and that displays will have to compete with the pricing of LEDs, expected to drop to around 50 cents a digit, and liquid crystals, at about $1 a digit. At the moment, no

From Switzerland. Ebauches' liquid-crystal watch is shown at left, with the electrochromic version at right. The firm says it will have an electrochromic prototype next year.

From New Jersey. This is electrochromic display produced by the Optel Corp.

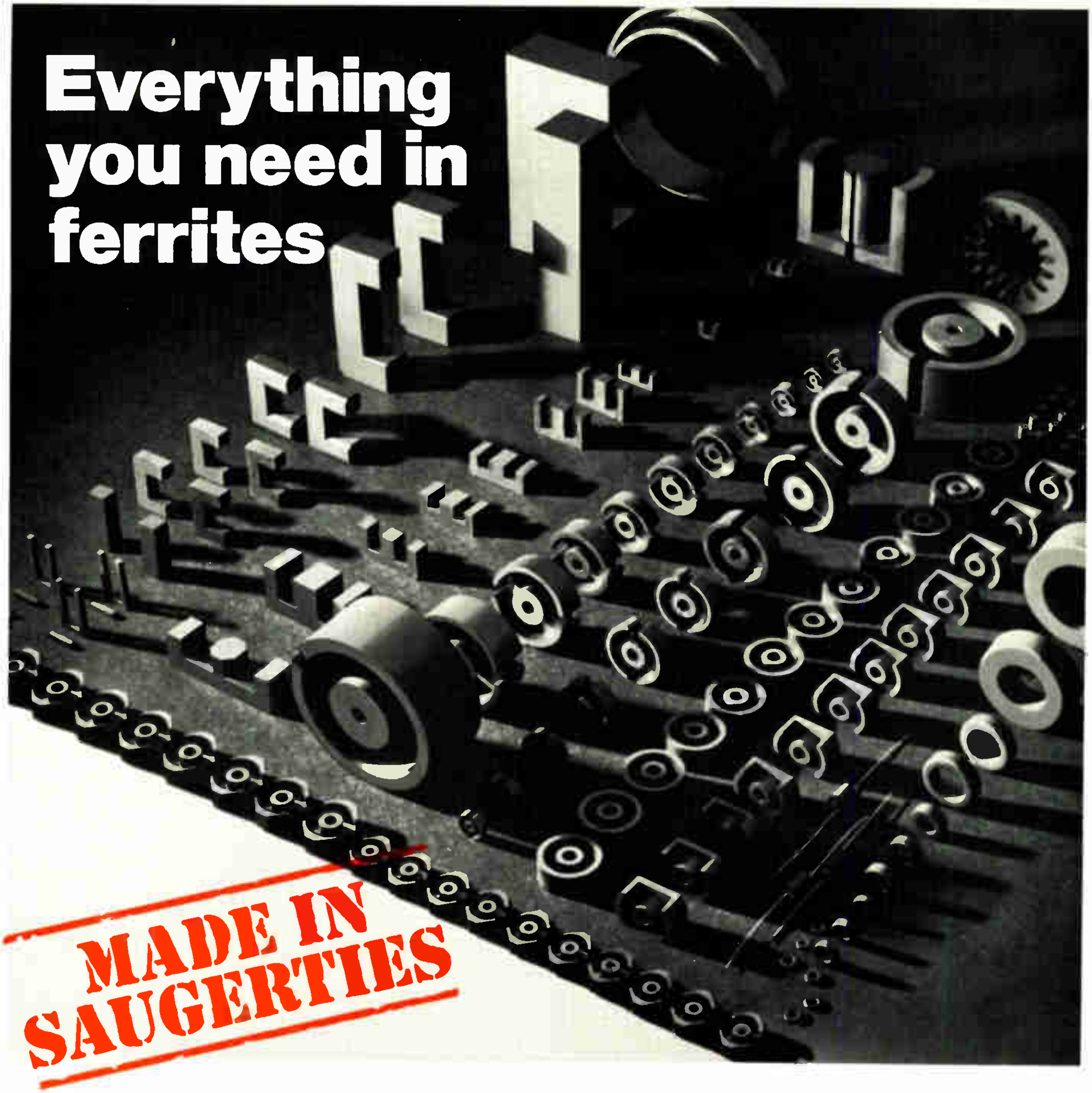
one is willing to hazard a guess about what electrochromic displays will cost when they hit the market.

Another disadvantage is mentioned by James Fergason, president of International Liquid Crystal of Cleveland. He points out that electrochromic displays require hermetic seals to keep out oxygen. Technology is not advanced enough, he adds, to keep the materials pure.

Opportunities? As for the commercial possibilities of electrochromic displays, Kiss of Optel predicts immediate opportunities in alphanumeric displays; timepiece applications, where display with storage is so desirable; and auto dashboard readouts—a natural use for reflective displays that thrive on bright sunlight. Then, after a decade or so, says Kiss, such areas as reversible optical storage will be opened—electrochromics could be used in optical versions of magnetic tape and magnetic disks.

But there is another big question: can liquid crystal and electrochromic displays coexist commercially? Some companies, feeling they have to select one or the other, have put their money on crystals because they have lived with the technology, know it well, and it is here for sale now! However, another school of thought believes the two can live side by side—with electrochromics going on to more exotic applications—such as the tablet envisioned by Kiss as the electronic analog of the printed page.

But whatever lies ahead for the still-gestating technology, chances are that electrochromics will force some shifting and change the thinking of many display makers. ☐



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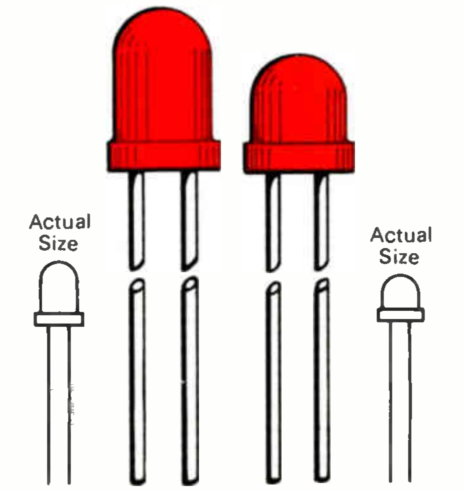

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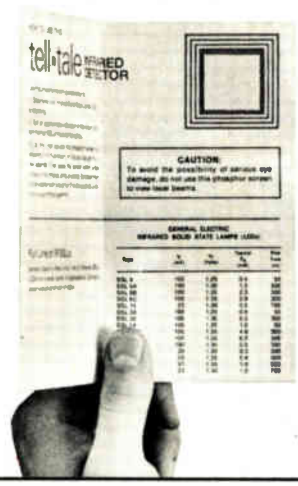

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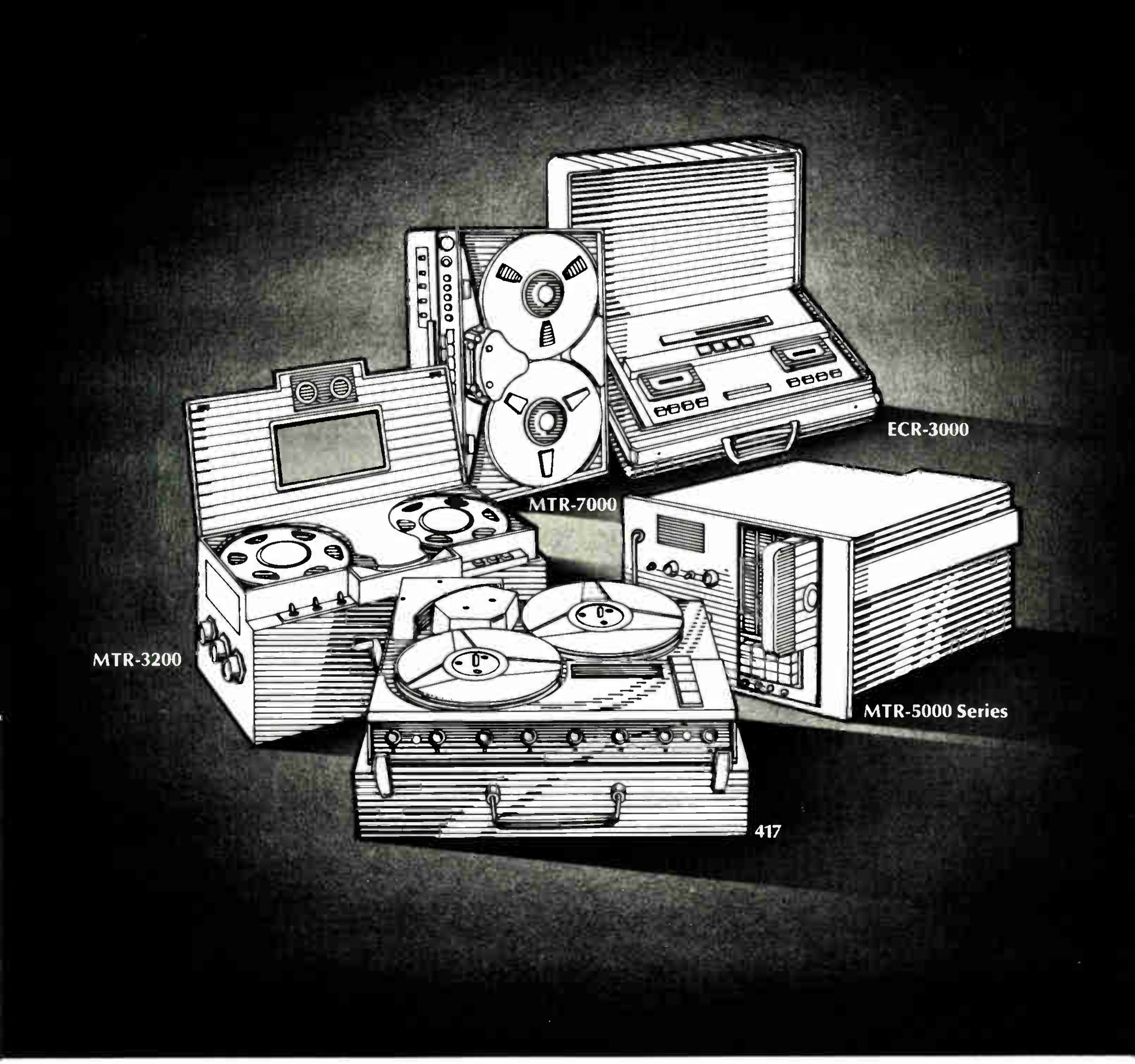

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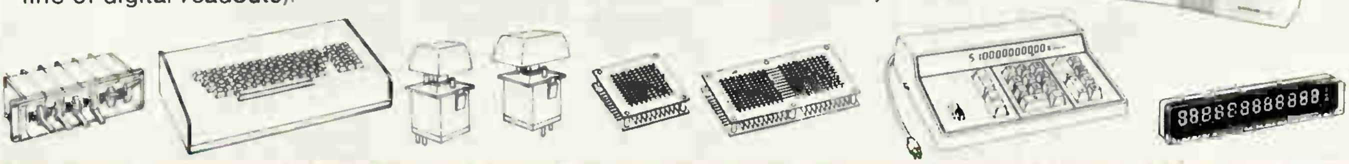

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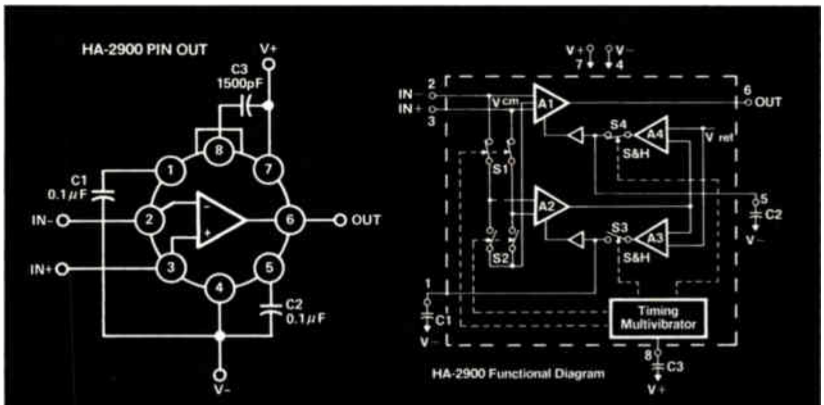

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C-MOS teams with liquid crystals to make a reliable digital VOM

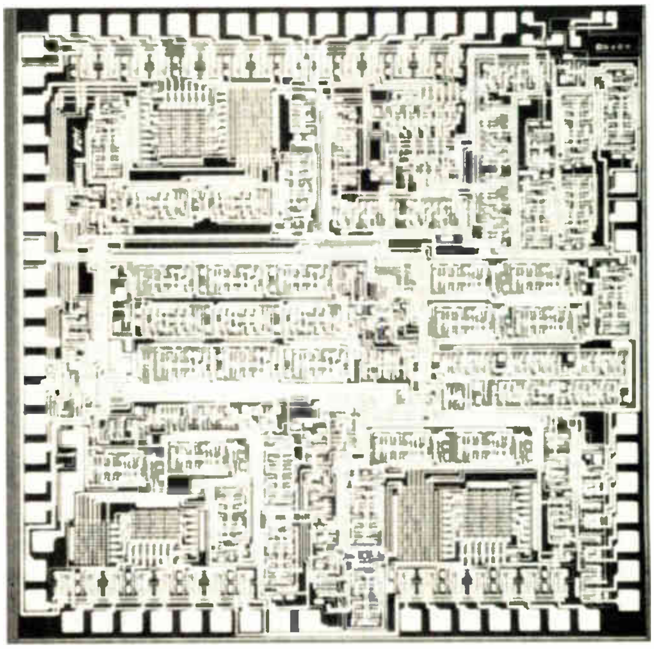
Low-power bipolar LSI is combined with an unloaded mercury cell as a voltage reference to keep power consumption below 1 milliwatt; because the two-layer, high-density ICs are small, costs are kept low

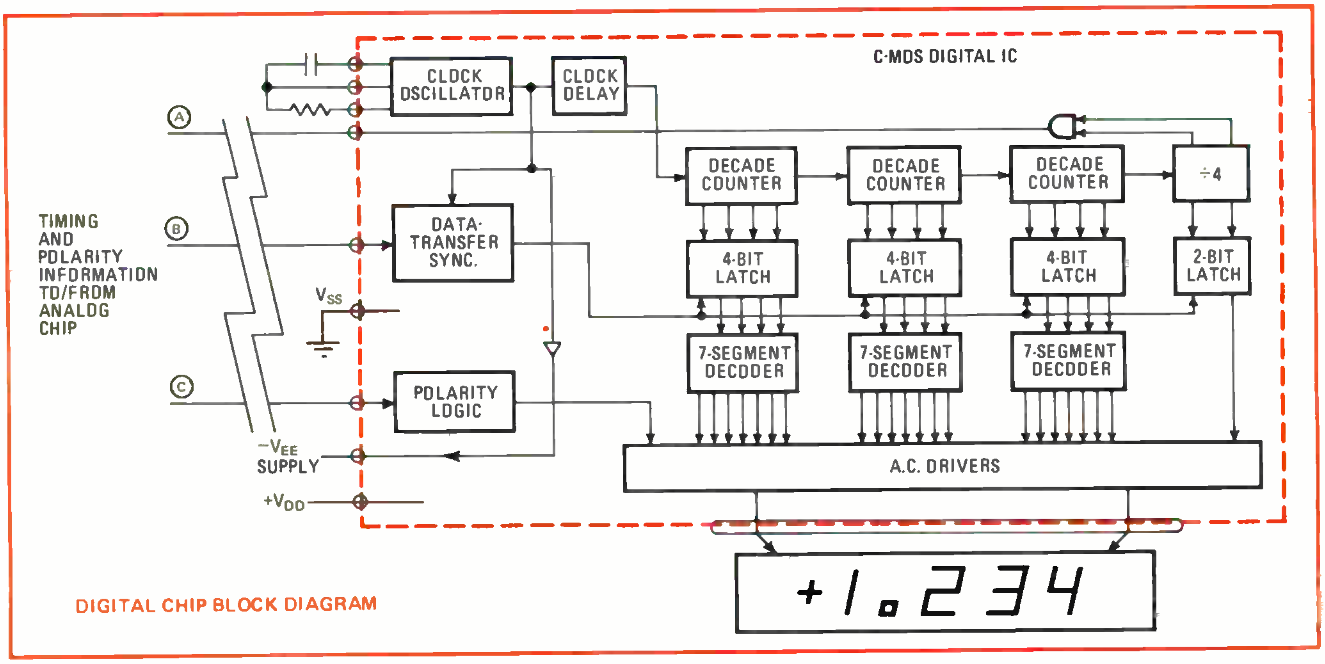
by Garry C. Gillette and John Crosby, *Dana Laboratories, Inc., Irvine, Calif.*

☐ Any digital replacement for an analog volt-ohm-milliammeter should not only have the unambiguous display of a digital multimeter, it should also have the portability, year-long battery life, and versatility of the performance-proved analog instruments it is designed to replace. If digital meters are ever to gain the broad acceptance that has been enjoyed by analog VOMs for several decades, they must match or exceed the analog's extremely high reliability, interval of at least a year between calibrations, and low price.

The most important factor in the design of a digital VOM is its display. Unless the power demands of the display can be kept far below those of earlier digital instruments, it would be impossible to meet the goal of year-long battery life. This consideration makes the liquid-crystal display the only readout device that could be seriously considered for this application.

When the field-effect LCD had been developed to the point where lifetime was no longer a problem, the engineers at Dana Laboratories decided that the display could make their Danameter digital VOM a reality. The final design used International Liquid Crystal Corp.'s





1. The digital chip. High-density C-MOS allows the integration of all digital logic functions and the clock oscillator on a single chip. Micro-Power Systems' two-layer process was used in the above chip's fabrication.

nematic birefringent display. This readout, which costs only a dollar a digit in large quantities, can be driven by a 6-volt complementary-MOS power supply. Weighing only a pound, the VOM is priced at $195.

Dynamic-scattering-mode LCDs were rejected for the instrument largely because their appearance was regarded as unacceptable under typical conditions of use. In addition, they needed excessively high peak-drive voltages, and some units even required backlighting, which raised the display's total power consumption to an unacceptable figure.

Designing the meter

After selecting a display whose power requirements, lifetime, and cost made the digital VOM possible, the designers focused on the design of the rest of the instrument. To keep the cost down, they had to use as high a level of circuit integration as possible. At the same time, mixing too many technologies on the chip could have reduced yields, and hence, increased costs. The tradeoff between these two conflicting considerations led to the use of two IC chips—one for the digital circuitry, and the other for the analog.

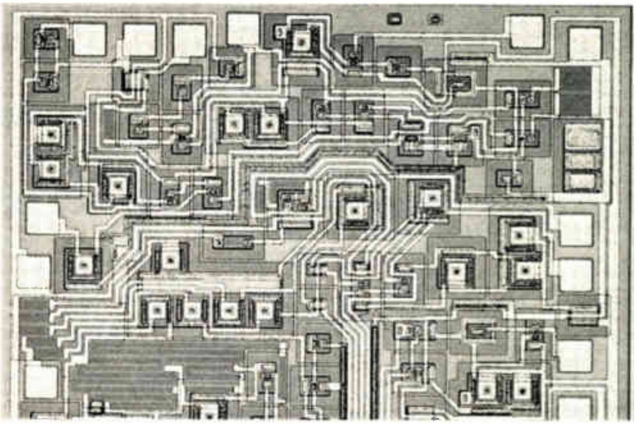
The digital chip

The digital chip (Fig. 1) utilizes high-density C-MOS circuitry having a threshold of only 1 to 2 V for both the 8-kilohertz system-clock oscillator and the digital logic. Normal up-counting decade dividers are driven without interruption by the internal clock to ensure that timing signals for the dual-slope analog-to-digital integrator on the analog chip are available continuously from the previous decade divider.

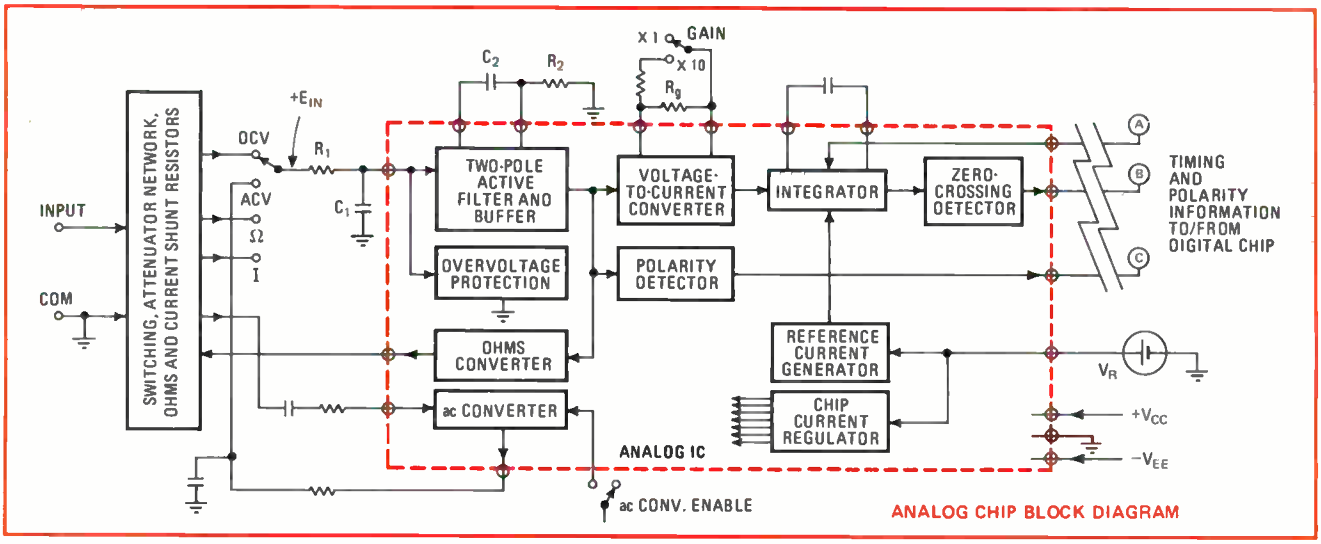
Since the dividers never stop counting, some means had to be provided to extract data from them "on the fly." An array of latches was designed to perform this function by accepting data upon strobe command from the control circuitry on the analog chip. The data stored in the latches is sent to an array of seven-segment decoders and subsequently to circuitry that provides the ac drive for the liquid-crystal display.

To ensure battery life in excess of one year when operating from a small 9-V transistor-radio battery, it was necessary to limit the total current drain of the analog chip to less than 100 μA. Despite this power limitation, the chip had to exhibit:

- High resolution and sensitivity: resolution must be better than one part in 2,000 (3½ digits). And input sensitivity must be 100 μV per digit to meet the desired specification of 200 mV maximum voltage drop on the current ranges.
- Auto polarity: the chip must accept inputs of either polarity, determine what the polarity is, and generate a signal for display on the LCD readout.
- High input impedance and low bias current: a basic chip input impedance in excess of 1,000 megohms and a bias current error of less than 100 pA were specified to eliminate loading errors on the 10-megohm input divider.
- Noise and overload immunity: the chip design must incorporate an active filter to reduce input noise without significantly affecting reading speed. It also must include protective circuitry to prevent damage from overloads, to detect overload conditions, and to display them.
- Capability of accurate ac measurements: the chip must include an active ac rectifier circuit to overcome the nonlinearity problems that plague passive rectifiers at low voltage levels.



2. The analog chip. Design of this chip was based on Micro-Power Systems' ability to integrate low-current npn and pnp transistors, Schottky diodes, and thin-film resistors on the same chip.



To meet the above requirements while keeping the chip size small enough to guarantee high yields and low costs, design of the analog chip was based on the integration of low-current npn and pnp transistors, Schottky diodes, and thin-film resistors. Because the thin-film resistors are deposited on top of the active circuitry (Fig. 2a), their inclusion does not affect the circuit yield. The closely matched resistors, having a value of 75 kilohms per square, reduce circuit complexity by replacing equivalent active devices; hence, they might be said to increase the yield of the analog chip.

In the fabrication of the analog chip, the processing of the vertical npn and lateral pnp transistors was adjusted to maximize the beta at low collector currents.

Close base-emitter voltage matching provides excellent thermal stability. The chip's positive supply of 6 to 10 V is obtained directly from a 9-V transistor battery. A capacitive voltage doubler driven from a C-MOS inverter on the digital chip generates the -5- to -9-V substrate bias that the analog chip requires. The two diodes and two capacitors in the voltage doubler are among the handful of components that are not integrated. A current regulator internal to the analog chip eliminates the possibility of drift problems caused by the varying supply voltages.

Analog chip has separate blocks

The block diagram of the analog chip (Fig. 2b) shows separate blocks for the two-pole active filter and buffer, as well as the voltage-to-current converter. These circuit functions are all performed by the circuit shown in Fig. 3. In that circuit, transistors Q_1 and Q_2 can be thought of as the voltage-to-current converter, operational amplifier U_3 can be thought of as the buffer, and operational amplifiers U_1, U_2, and U_3, together with the various capacitors and resistors in the circuit, act as a two-pole filter. Resistor R_1 and capacitor C_1, which are labeled on both the block diagram of Fig. 2b and the detailed circuit diagram of Fig. 3, make clear where Fig. 3 fits into Fig. 2b.

Referring to Fig. 3, negative feedback around U_1 (via Q_1 or D_1) forces voltage e_a to follow E_{in}. At the same time, feedback around U_2 (via Q_2 or D_2) causes voltage e_b to remain at a zero dc potential.

For positive input voltages, Q_1 and D_2 conduct, causing a current nearly equal to E_{in}/R_G to flow in the collector of Q_1. No current flows through D_1 or Q_2 because they are reversed-biased. In similar fashion, negative inputs cause Q_1 and D_2 to turn off when collector current of E_{in}/R_G flows through Q_2 and D_1.

With only R_G controlling the voltage-to-current transfer (transconductance) of the circuit, the need for the usual separate positive- and negative-input gain adjustments is eliminated. The cumulative voltage offsets of both op amps may be compensated for with only a single adjustment.

The floating differential-input configuration leads itself well to active filtering. Resistor-capacitor pairs R_1 with C_1 and R_2 with C_2 determine the cutoff frequency of the two-pole low-pass filter that the over-all circuit represents. The components were chosen to provide 50 dB of rej c tion at 60 Hz, increasing at 12 dB per octave.

Ohms-conversion is performed by passing a constant current through, and measuring the voltage across, the unknown resistance. The measured voltage then becomes a direct function of the resistance. To establish the constant current, the patented Dana Ratiometric ohms-converter block (Fig. 4) is used. With this circuit, accuracy is limited only by the scaling resistors (R_2 through R_6) and is independent of the reference voltage. Although the resistance-measuring current is constant over each of the meter's resistance ranges, it is not the same on all ranges. The measurement of large resistances obviously needs less current than the measurement of small values of resistance.

Generating the constant currents

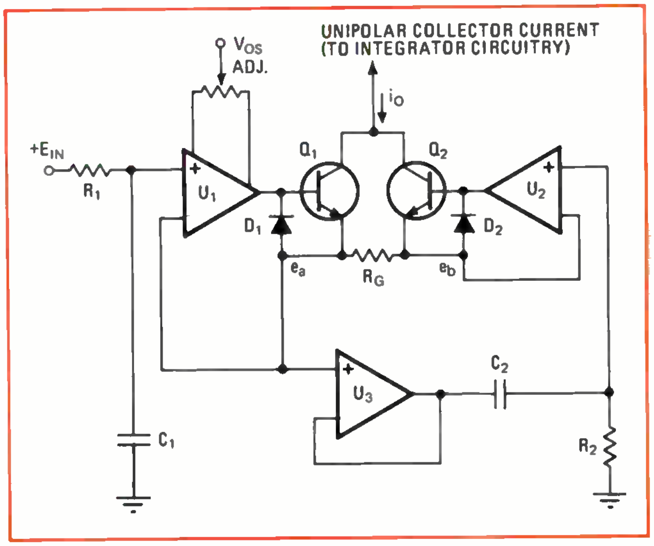
With the Ratiometric technique, the measuring current is generated by maintaining a constant voltage across the multiplier resistor associated with each range. This gives the advantage over other methods of working well throughout the very broad range of constant currents needed by an ohmmeter that has ranges from 200 ohms full-scale to 200 megohms full-scale. An on-chip, precise 1-μA constant-current source is buffered by an op amp and then flows through adjustable resistor R_6, across which it develops the 1-V drop for multiplier resistors R_2 through R_5. R_1 provides overvoltage protection and also serves as part of the input noise-rejecting filters.

Note that capacitor C_1 of Fig. 2b is actually made up of two capacitors—0.03-μF and 0.001-μF in parallel. The two capacitors are connected in parallel for all measurements, except when the meter is switched to its 200-megohm range. Then the 0.03-μF capacitor is switched out of the circuit to maintain an acceptable response speed for the meter.

The ac converter

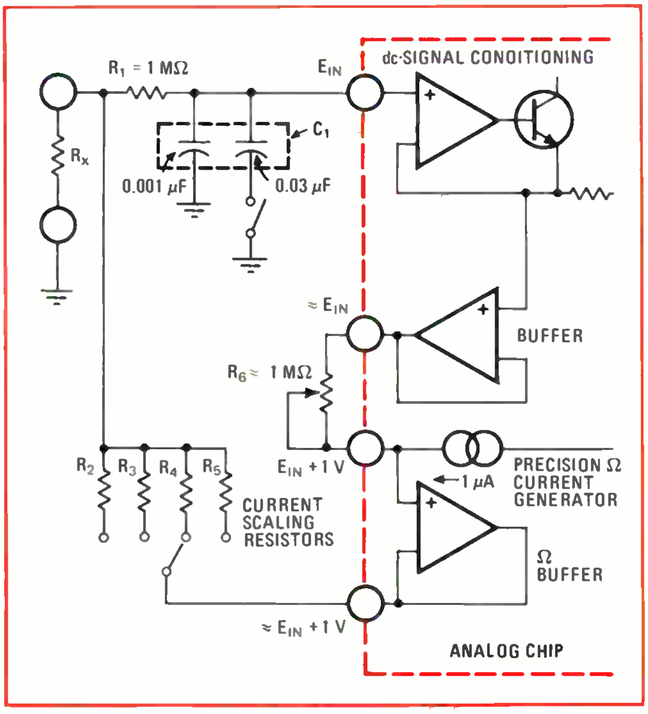
Ac input signals are routed to the switchable decade attenuator via an input-coupling capacitor (Fig. 5). The attenuator, which is also used for dc functions, is a

3. Signal conditioner. The two-pole active filter, buffer, and voltage-to-current converter of the block diagram of Fig. 2b are contained in this circuit. All of the circuitry shown here is on the analog chip except resistors R_1 and R_2, and capacitors C_1 and C_2.

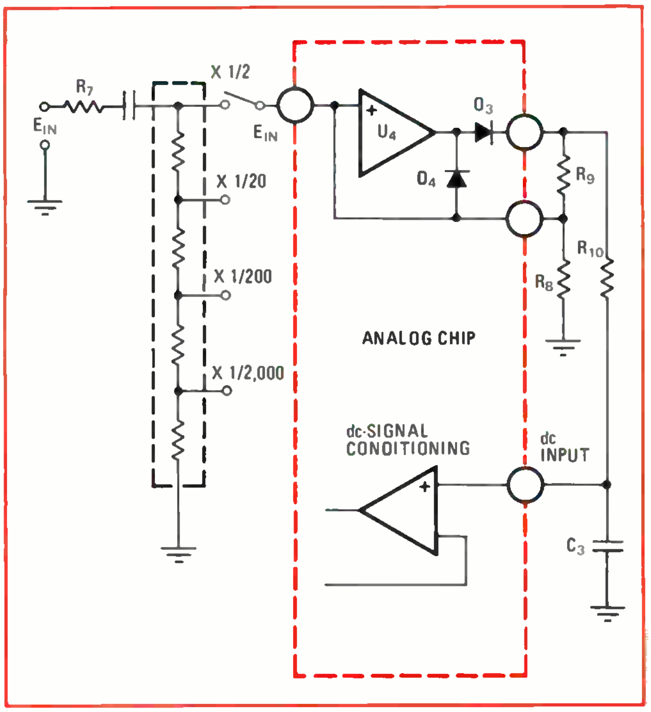


thick-film network that provides attenuation factors of 2, 20, 200, and 2,000.

Resistor R_7 serves primarily as a current-limiting resistor to protect the meter when large overloads are applied to it when it is on the 2-V ac range. Op amp U_4, is combined with diodes D_3 and D_4 resistors R_8 through R_{10}, and capacitor C3 to comprise the active rectifier circuit. R_8 and R_{10} form a simple filter, extracting the average dc value from the waveform at the output of the active rectifier. Additional filtering is provided by the active filter at the input to the dc signal-conditioning circuitry.



4. The ohms converter. By maintaining a constant voltage of 1 V across the current-scaling resistors, this circuit is able to push a wide range of constant currents through the unknown resistance, R_x.



5. Ac converter. Passive rectifiers become very inaccurate at low voltage levels because of nonlinearities in the diodes. For that reason, this ac converter uses an op amp in an active rectifier configuration to keep D_3 and D_4 operating in well defined on and off states.

Mercury cell sets reference voltage

Most good dual-slope integrators use a zener diode to establish the stable reference voltage needed by these converters. But, although zeners provide excellent voltage stability, they have two drawbacks for the present application:

- The current needed to bias the zener into its constant-voltage region can significantly raise the power consumption of such a low-power instrument.
- Integrating a voltage reference onto the analog chip would significantly reduce the chip's yield, and hence, would raise the cost of the instrument.

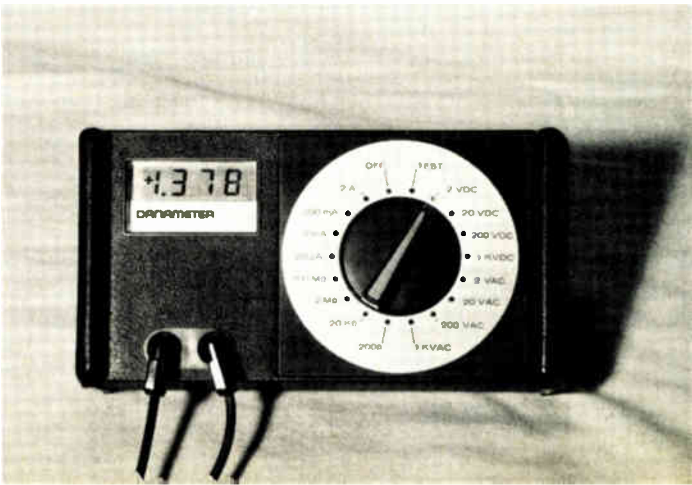
For these two reasons, the designers finally selected the common mercury cell used to power wristwatches. Back in the 1950s, mercury cells used as voltage references developed a somewhat shaky reputation because of their relatively poor stability. Modern units, however, are extremely stable over both temperature and time, and they perform their function admirably.

Most engineers are probably aware of the voltage-versus-time characteristic of the loaded mercury cell: the voltage remains almost perfectly constant until the battery's life is over, when it drops precipitously. Such behavior, if it occurs in a meter might lead to unexpected inaccuracies. Fortunately, however, when a mercury cell is very lightly loaded, this phenomenon does not occur. Instead, when the constant-voltage part of its life is over, the cell voltage very slowly drops with the passage of time.

In the Danameter, the loading of the mercury cell is sufficiently light—about 1/1,000 of a wristwatch load—that the voltage drop at the end of the cell's life is slow enough to allow recalibration of the meter at only one-year intervals without losing rated accuracy. Eventually, after three to five years, the mercury cell would have to be replaced.

By combining a high level of integration, a mercury-cell reference that saves power and money, and a field-effect liquid-crystal display, the designers of the Danameter are confident that their digital instrument can compete effectively with conventional analog meters. □

6. The result. Unretouched photo of Danameter demonstrates visual appeal of field-effect LCD. Meter weighs one pound, costs $195.



Analysis can take the heat off power semiconductors

Designing for thermal requirements with good electrical isolation ensures stability and reliable performance of these devices

by Forest B. Golden, *General Electric Co., Auburn, N. Y.*

☐ Cost-conscious design engineers, well aware that a 1% component-failure rate during the warranty period can easily add 50 cents to a product's cost, are eager to reduce device temperatures. To put it simply, the cooler a device operates, the more reliable it is. Generally, if an engineer can lower its temperature by 20%, he will reduce the device's failure rate by a factor of three. This concept applies to such discrete devices as the power transistor, diode power rectifier, and thyristor family, which includes the silicon-controlled rectifier and the triac.

Thus, keeping semiconductors cool, while often thought of as a necessary evil and a chore to the design engineer, is really an intimate part of the design process. It is not enough for the designer merely to select a device that meets circuit requirements. He must follow up with a systematic thermal analysis to enable him to select a heat sink and mounting technique that will hold device temperature low and thereby assure reliable operation for a long time.

These factors should be considered in making the thermal analysis:

- Determine power dissipation and temperature limits so that the case-to-ambient thermal resistance can be calculated and the proper heat-transfer techniques selected.
- Evaluate electrical-isolation requirements of the device package.
- Ensure that the thermal resistance of the device interface is minimal.
- Verify the calculations by careful temperature measurements under operating conditions.

The thermal circuit

Semiconductor-design engineers learned early to translate heat-transfer units to understandable circuit units—watts for heat and degrees per watt for thermal resistance. Thermal resistance—the inverse of thermal conductance—is the key to selection of the cooling hardware, such as a heat sink, for a semiconductor device.

A thermal circuit (Fig. 1) includes thermal capacitor elements to account for thermal storage. However, since power dissipation of most device designs can be calculated as rms values, thermal capacitance can usually be ignored.

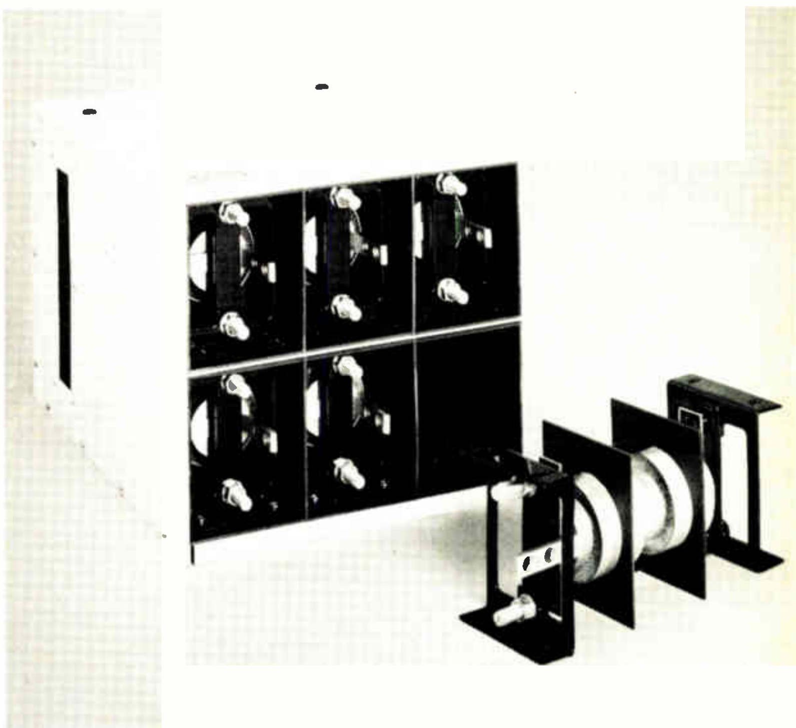
The thermal equation resembles Ohm's law because heat in watts is analogous to electrical current, and temperature difference is comparable to potential difference:

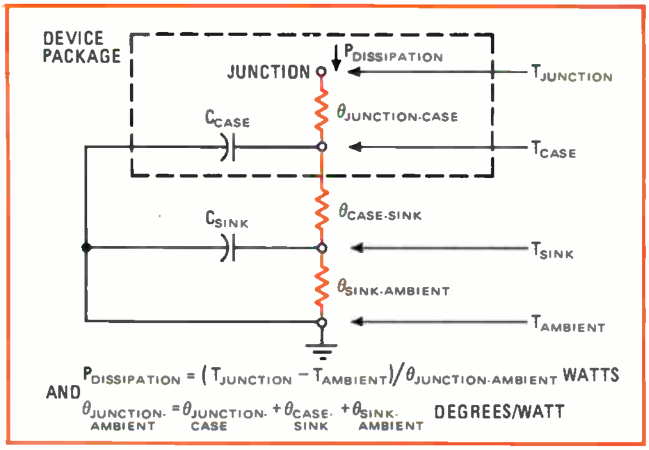
$$\theta_{JA} = (T_J - T_A)/P_D$$

where θ_{JA} is the thermal resistance of the junction in degrees per watt, T_J is the temperature of the semiconductor junction, T_A is the temperature of the ambient, and P_D is the power dissipation in watts.

To calculate the all-important thermal resistance—from junction to ambient—the designer must determine three thermal parameters: the maximum allowable

Kilowatt cooler. This cooling package is typical of some of the highly efficient thermal packages recently developed to cool power-semiconductor rectifiers and SCRs. The enclosure, developed by Thermalloy, is 13 inches high, 14 in. wide and 16 in. deep. It can dissipate approximately 3.5 kilowatts. Devices shown are three-phase full-wave rectifiers that can handle 1,000 amperes. Each of the six modules provides a thermal resistance of 0.07°C/watt from sink to air. Assembly requires 300 cubic feet per minute of air at a pressure drop of 0.9 in. of water to achieve this low thermal resistance.





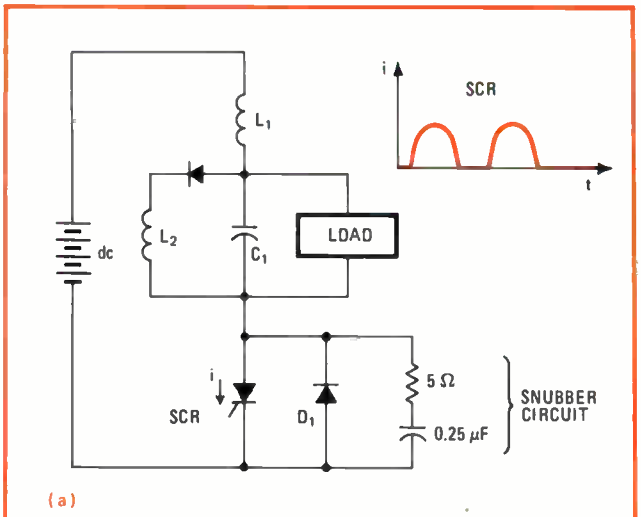
1. Thermal circuit. Circuit analogs enable the designer to analyze the thermal paths. Resistors represent the thermal resistivities of the various components. Capacitors account for storage capabilities, but are usually omitted in steady-state calculations.

temperature of the semiconductor junction, the maximum ambient temperature, and the maximum power that the device will dissipate.

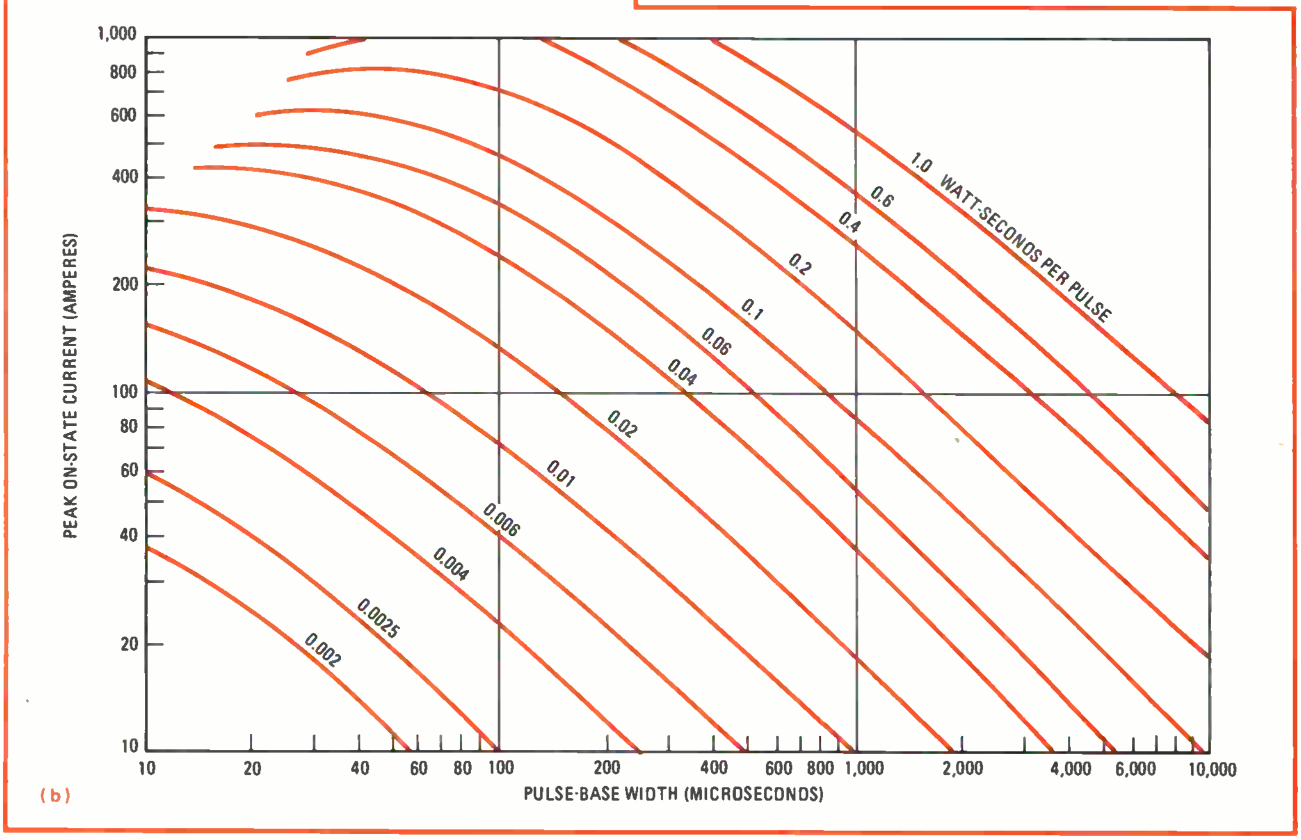
Applying thermal parameters

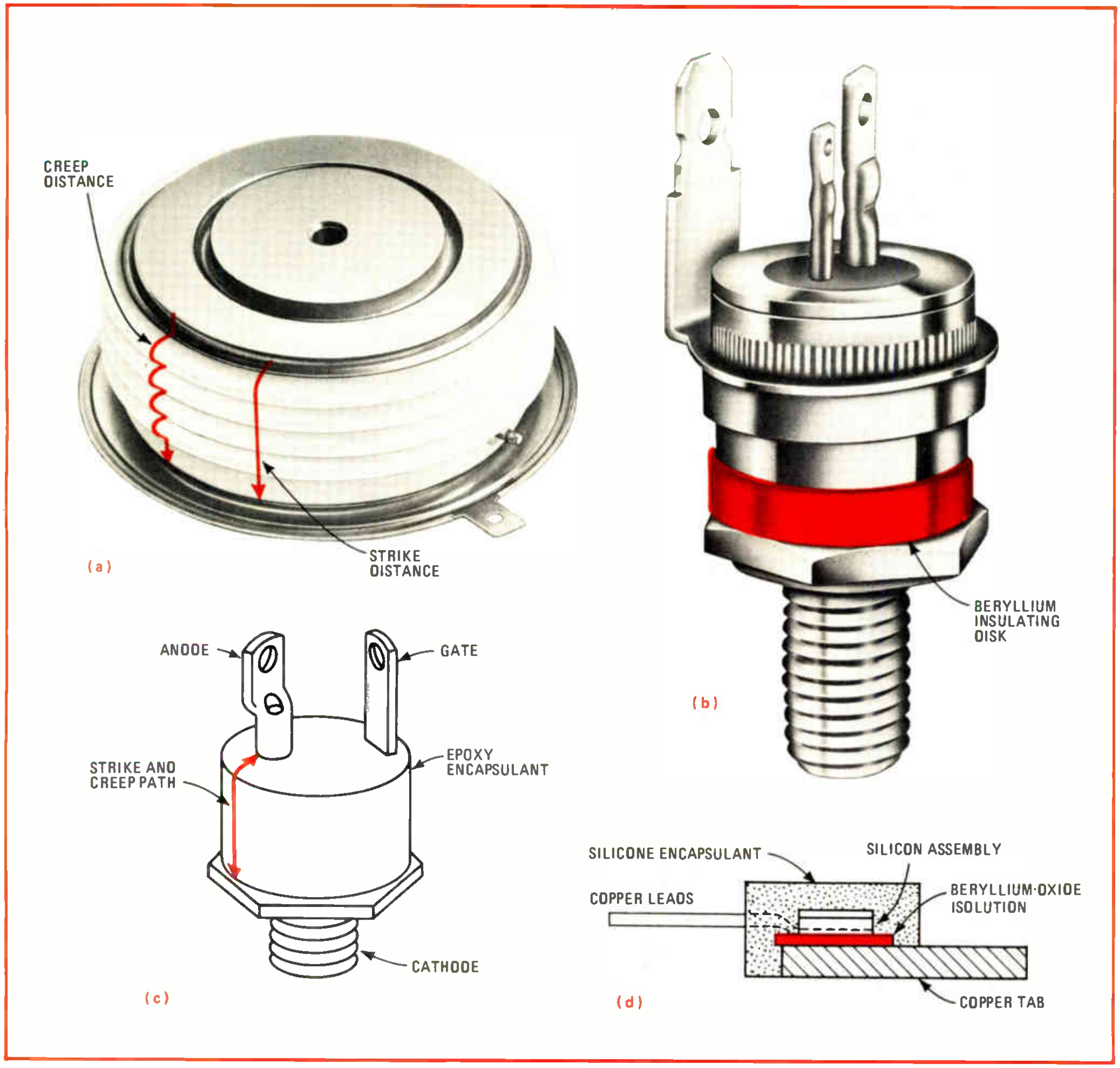
Determining the power dissipation of a thyristor or a semiconductor rectifier is not difficult because worst-case values are specified by manufacturers' data sheets. Application of this data is illustrated by calculation of dissipation for a high-frequency inverter circuit to be used in pulse operation. The term inverter applies to a circuit that converts dc to a periodic waveform. The inverter circuit (Fig. 2a) develops a near-sinusoidal current through the SCR. A typical rating curve for such an SCR (Fig. 2b) provides the maximum watt-second loss per pulse for any sinusoidal pulse the SCR can handle.

The worst-case anode-power dissipation is determined by multiplying the repetition rate by the watt-second loss per pulse. This value will be accurate if the values of the gate drive and snubber circuit are comparable to those specified in the data sheets. (A snubber circuit is a low-pass-filter network that prevents spurious thyristor triggering.)



2. Pulse power. The inverter circuit (a) delivers a near-sinusoidal-shape pulse current through the SCR. Curves in (b) provide the watt-second power loss per pulse. Multiplying this value by the pulse-repetition rate yields the power dissipation.





3. Power-device geometries. Electrical isolation is the principal trade-off hindering low-thermal-resistance mounting and must be weighed against the thermal resistance values in manufacturers' data sheets. The designers of the pressure-mounted disk in (a) assure adequate creep and strike distances by ribbing the surface. Thickness is 26 mm. Device can operate at 480 volts rms, and current-handling ability exceeds 500 amperes. Such devices as the stud-mounted unit shown in (b) pose an electrical-isolation problem because thickening the ceramic or increasing the diameter of the ceramic increases the thermal resistance on one hand and develops an interference with the hex-shaped base on the other. Adding an encapsulant to a stud-mounted device (c) greatly enlarges creep and strike distances required to meet NEMA and U/L requirements. By putting a thin beryllium-oxide insulator within the TO-220 package (d), electrical isolation can be obtained at minimal thermal expense. Designer can then attach the copper tab to a mounting surface with good thermal properties, thus doing away with the added cost of purchasing and mounting an independent heat sink.

However, determining dissipation data for switching transistors is considerably more difficult because the required data is seldom available. As a result, the designer has no choice but to determine the wave shapes and amplitudes of the collector-to-emitter voltages and currents, develop graphic plots of the product, and then integrate over an operating cycle to arrive at the rms power dissipated.

To ensure an accurate evaluation, these guidelines should be followed:

- Assume worst-case parameters—that is, figure on maximum voltage and current, lowest and slowest drive conditions, stiffest snubber networks, and highest frequency of operation.
- Include all power components, notably base power and blocking power.
- Test a number of devices to calculate a worst-case figure.
- To avoid measurement error caused by inductive shunting in high-frequency drive circuits, use a coaxial-

Thermal runaway

It is commonly believed that if the duty cycle of a semiconductor device is low, a heat sink is not required. But this dictum simply isn't true. Because semiconductor blocking characteristics are highly temperature-dependent, thermal runaway can develop. Blocking current is the current that flows during the off portion of the duty cycle, and, despite the fact that it may be no more than microamperes, it can contribute to a runaway condition. Runaway describes the positive-feedback chain reaction in which temperature rise causes a temperature-dependent current to increase. This, in turn, further heats the device to cause a still larger current. If unchecked, the current increases until the device destroys itself.

As an example, the peak off-state current (I_{DRM}) of a thyristor doubles for every 10°C rise in junction temperature. This doubling in current means a doubling of blocking-power loss (P_B). Such an increase under adverse temperature conditions can lead to a runaway that culminates in catastrophic failure.

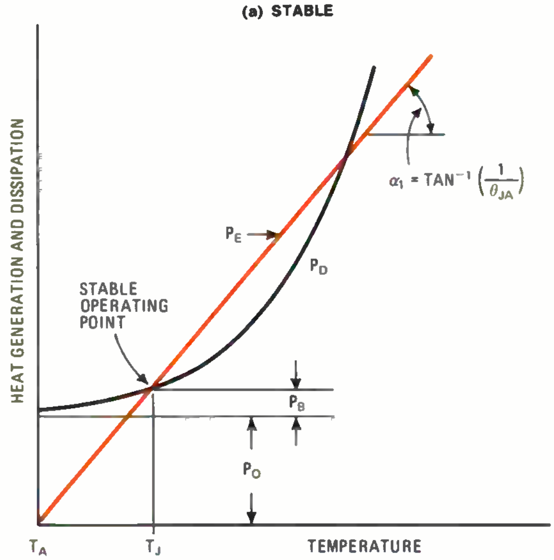
Stability is not solely a function of blocking current; it is also highly dependent on the thermal resistivity of the entire junction-to-ambient path. Thus, a low-resistance heat sink can play a crucial role in assuring stable operation.

The plots below depict both stable and unstable device operation. In each case, the thermal resistivity is superimposed on the power-dissipation curve for the device. In (a), a stable thermal situation is depicted. It is stable because the dissipation capability of the over-all thermal path (P_E)—including the sink and interface—exceeds the power developed (P_D), which is the sum of the on-state conducting losses (P_O) and the off-state blocking losses (P_B). If the ambient temperature were to rise, the (P_E) line would shift slightly to the right, but, since this line would still lie above and to the left of the P_D curve, operation would remain stable. The reason is that the dissipation capability (P_E) still exceeds the power dissipated (P_D). Note that, for stable operation, the blocking losses (P_B) are assumed to be only a small percentage of the total losses (P_O and P_B). However, in such low-duty-cycle operation as a crowbar circuit, the exact opposite may be true. That is, the on-state losses may be negligible, compared to the blocking losses.

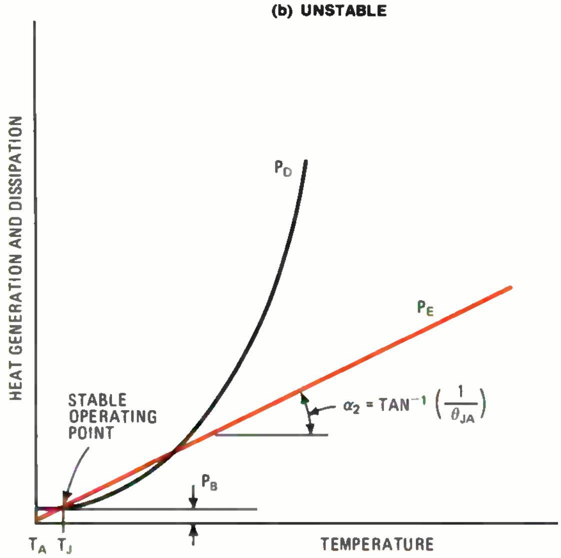
Now, suppose a designer attempts to mount a semiconductor on a bracket that has a high thermal resistance and he makes no attempt to enhance the thermal circuit with a heat sink. This situation is depicted graphically in the unstable plot. Because of the high thermal resistance, the power-dissipation curve has a much lower slope (α_2). The designer might assume that the thermal requirement is ample because the operating temperature is lower. However, a small upward shift in the ambient temperature will shift the entire (P_E) line to the right and beyond the (P_D) plot. If this happens, the device dissipation exceeds the dissipation capability of the system, and runaway develops; that is, temperature and current rise until catastrophic failure occurs.

The prudent design engineer will want to adhere closely to the guidance contained in the data sheets for each device regarding maximum thermal case-to-ambient resistance ($\theta_{C\text{-}A}$), for which maximum blocking ratings apply. If such data is not specified, the designer should consult the device manufacturer.

(a) STABLE



(b) UNSTABLE

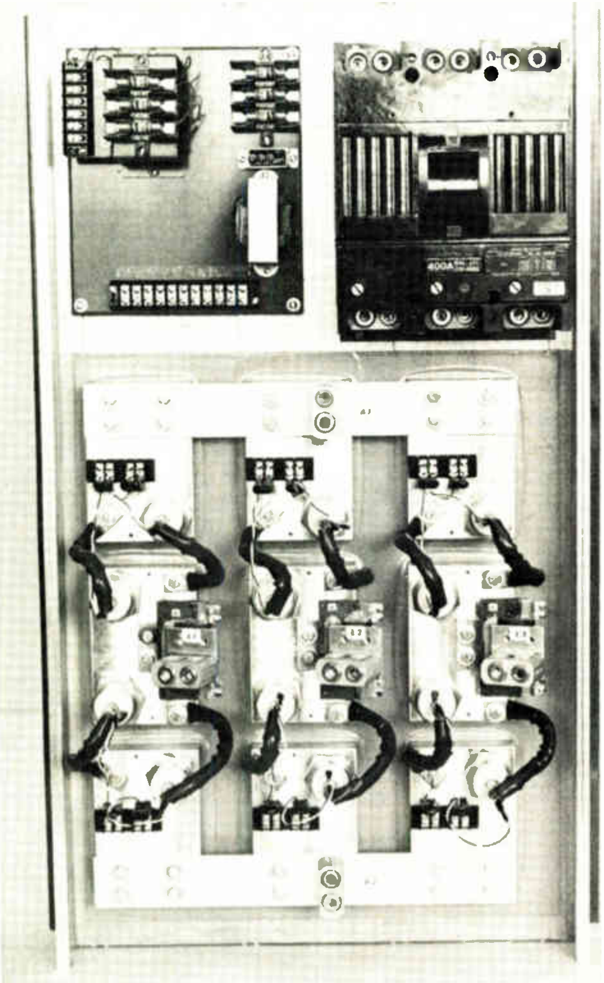


current shunt or a quality current-measuring device that has adequate bandwidth.

Worst-case junction and ambient temperatures should be found. The maximum junction temperature, shown on the device's data sheet, should not be exceeded, except where such other parameters as transistor collector-to-base voltage or thyristor anode-to-cathode voltage can be lowered, thereby raising the limit of the junction temperature.

This method of derating makes possible low-voltage SCRs having a junction temperature of 150°C. The normal maximum is 125°C. To assure optimum reliability, design engineers will usually derate junction temperature according to a derating curve furnished by the manufacturers.

The ambient temperature may be specified in advance, or it may have to be determined. When equipment is enclosed in an unventilated cabinet, the ambient encountered by the semiconductor's heat sink may be considerably higher than the ambient outside of the



4. **Big sink.** Thyristors rated at 480 amperes rms are attached to large heat-spreader blocks, which are attached to the cabinet by an epoxy adhesive. The epoxy provides the required electrical isolation; yet, because of the large heat-transfer surface area, it does not materially hinder the thermal path to the equipment structure.

enclosure, so there is no substitute for careful temperature measurement inside the enclosure. Although papers have been published on the subject of determining ambient temperature inside of enclosures, these design guidelines produce only first-order approximations, rather than final design values.

Evaluating isolation requirements

After power and temperature values have been determined, the designer must examine carefully the system's electrical-isolation requirements. Generally, the shorter the thermal path, the better. However, the requirement for adequate electrical isolation is diametrically opposed—isolation requires a longer path.

The electrical path must be designed to prevent breakdown that might be caused by arc-over or current leakage along the surface between terminals. Sufficient air gap—known as strike distance—must be provided to prevent arcing, and a minimum surface-resistance path, called creep, must be provided between terminals by the intervening insulator surface.

Adequate electrical isolation for a large thyristor with a 500-A rms rating and up with a silicon-pellet diameter from 33 to 40 mm (Fig. 3a) is provided by designing it as a pressure-mounted disk package with a 26-mm height to prevent strike and ribbing the surface as shown to prevent creep. As indicated in Table 1, a package 26 mm thick has more than adequate creep and strike isolation for line voltages as high as 480 V rms.

A tougher problem is posed by stud-mounted semiconductors in the range of 1 A to 50 A (Fig. 3b). Problems develop if the dimensions are altered to improve the strike and creep distances because thickening the beryllium-oxide disk increases the thermal-path length, thereby raising the thermal resistance. And if the diameter of the disk is increased, it interferes with the hexagonal base.

One way to lengthen the creep and isolation distances is to add an epoxy encapsulant (Fig. 3c). The epoxy develops adequate creep and strike distances from both anode to cathode and anode to stud to permit operation at 230 V, which is adequate to qualify the device for approval by Underwriters' Laboratories.

However, electrical isolation inside the TO-220 package shown in Fig. 3 (d) is provided internally by inserting a beryllium-oxide layer between the chip and the copper tab. Thanks to low thermal resistivity, the beryllium-oxide provides a good thermal path for the heat to travel from the chip to the copper tab. Although the chip-insulator interface has a small area that tends to degrade the thermal path, that tendency is offset by making the insulator relatively thin. This is possible because electrical strike and creep requirements are greatly reduced by the protection of the semiconductor package.

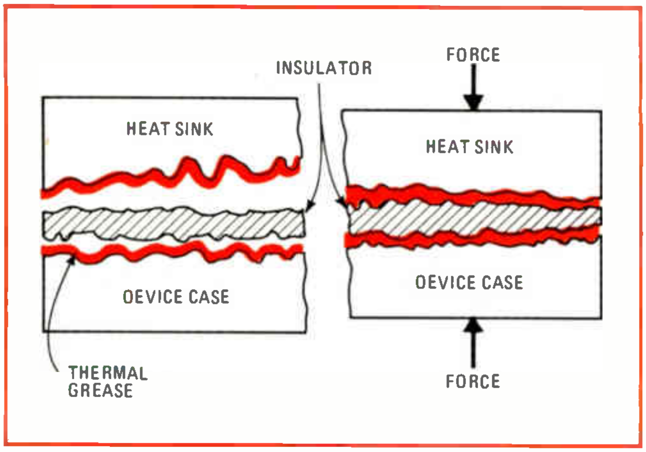
The result is roughly equivalent to the externally isolated package in respect to both electrical isolation and thermal dissipation. Because the copper tab is electrically isolated, the device can be mounted directly on an enclosure wall that can serve as the heat sink. Thus, the additional cost of a discrete heat sink can be eliminated, along with the additional labor required for its assembly.

Spreading heat through a sink is the only effective means that has been developed thus far to cope with the thermal requirements of high-current SCRs. Avtek Corp., Burlingame, Calif., has used this method to advantage (Fig. 4). The large 480-A rms thyristors are mounted on thick heat-spreader blocks that are at-

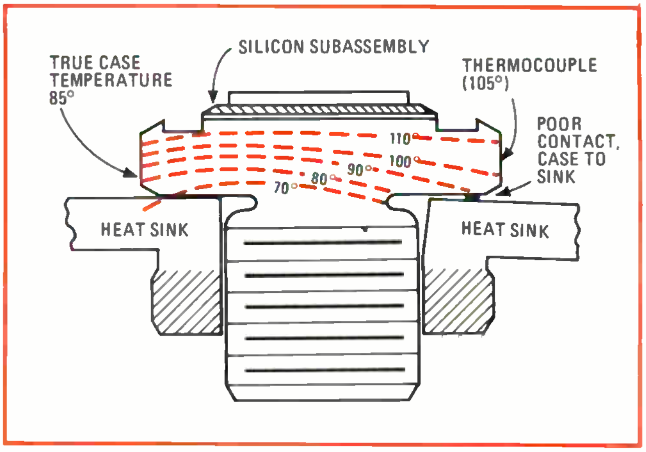
TABLE 1. STRIKE AND CREEP STANDARDS

Voltage (rms)		Distance (mm) U.L.[1]	Distance (mm) NEMA[2]
130	Strike	5.08	3.18
	Creep	6.35	6.35
240	Strike	7.62	6.35
	Creep	10.16	9.53
480	Strike	10.16	9.53
	Creep	12.7	12.7

Notes: 1. Proposed U.L. standard for appliance and consumer equipment – May 1973
2. Standards for semiconductor converters – Nov. 16, 1972



5. Mountainous. Exaggerated profile shows the thermal interfaces between a semiconductor device, an insulator, and the sink before and after engagement. Thermal grease helps to offset poor thermal path between materials that are microscopically rough.



6. Poor contact. If a device's contact heat sink isn't uniform, eccentric temperature profile develops, which cause erroneous temperature measurements. Mating surfaces must be smooth so that the thermal interface will be uniform about the device's circumference.

tached by epoxy to a common convection-cooled heat sink. This sink, in reality the rear portion of the equipment enclosure, also provides a mounting surface for the fuse blocks and circuit-breaker shown. The blocks enlarge the heat-transfer area and thus offset the high thermal resistance of the epoxy.

Knowledge of the thermal-resistance limit and the constraints imposed by electrical isolation equips the designer to select the heat sink and coolant requirements. However, he must also consider carefully the thermal resistance at the interface between the semiconductor device and the heat-exchanger hardware.

The interface

The interface between the semiconductor device and the heat sink is a crucial thermal path. If the interface's thermal resistance is too high, it can render worthless the heat-transfer capability of a good heat sink.

As an example, the thermal-resistance values for the 10-32-thread, stud-mounted device listed in Table 2 range from 0.09°C/W at best to 1.2°C/W at worst—a spread of more than a full order of magnitude. In fact, 1.2°C/W is a far greater thermal resistance than that provided by a good heat-exchanging system (see illustration, p. 106).

Figure 5 illustrates the profile of the mating surfaces making up a typical interface. The roughness of the surface has been exaggerated to dramatize the mechanics of the interface. Applying force to the surfaces brings them into contact, but the net contact area is highly dependent on the ductility of the contacting metals, the surface finish, and the flatness, as well as the amount of force applied. A large void (Fig. 5) can be caused by a non-parallel fit between the device case and the sink. Thermal grease can help fill that void. And, as indicated in Table 2, an insulator would raise thermal resistance.

Although semiconductor manufacturers' guidebooks provide specific instructions, these guidelines can serve for all but the largest pressure-mounted disk packages:

- Mating surfaces should be flat to within 0.001 inch, and surfaces should be finished to a tolerance of 63 microinches or less.
- All paint and other impurities should be removed completely by a treatment with #000 fine steel wool and silicone oil.
- The surfaces should be cleaned and wiped free of foreign matter immediately before assembly.

Measuring temperature

Initial calculations should be confirmed by actual temperature measurements. However, if results are to be meaningful, a number of pitfalls must be avoided. It is crucial to determine the actual power dissipation of the semiconductor because temperature data that overlooks this factor will lead to false calculations of thermal resistance. More is involved than merely inserting a thermocouple and waiting for the device to reach thermal equilibrium before taking a reading.

During the design and prototype stages, the designer should verify his calculations by measurements in the operating environment, according to these guidelines:

- The semiconductor device should be mounted on the heat sink in the actual enclosure intended to contain the manufactured version of the equipment. Merely rotating an air-cooled heat sink 90° can make a vast difference in its thermal properties.
- Follow manufacturer's mounting instructions carefully.
- Limit thermocouple wire diameter to 12 mils to avoid localized cooling.
- Avoid placing high-dissipation elements, such as ballast resistors and transformers, near a semiconductor. If this juxtaposition is unavoidable, make sure that both devices are dissipating their full design-power levels during temperature runs.
- Block off local air currents.
- Prevent direct sunlight from contributing to the heat measurement.
- Make sure that electromagnetic fields do not couple to thermocouple leads and destroy measurement accuracy.

Consider the problem involved in measuring the case temperature of a stud-mounted rectifier or SCR. Assume that the thermal resistance—junction-to-case—is specified at 0.3°C/W maximum and that the ambient temperature is 45°C. Assume further that the device-case

TABLE 2. SOME THERMAL-INTERFACE RESISTANCES

Stud size	Hex size across flats or flat base (diameter)	Thermal resistance-case-to-sink θc-s °C/watt					
		With thermal grease			Dry		
		Minimum	Nominal	Maximum	Minimum	Nominal	Maximum
Stud-mounted devices							
10–32	7/16"	0.09	0.3	0.8	0.2	0.5	1.2
1/4"–28	9/16"	0.07	0.25	0.6	0.15	0.4	0.9
1/4"–28	11/16"	0.05	0.15	0.4	0.10	0.25	0.6
3/8"–24	1-1/16"	0.02	0.06	0.15	0.05	0.1	0.25
1/2"–20	1-1/16"	0.02	0.065	0.2	0.05	0.12	0.3
3/4"–16	1-1/4"	0.025	0.08	0.2	0.06	0.15	0.35
3/4"–16	1-5/8"	0.015	0.04	0.10	0.03	0.07	0.15
Flat Based	1-7/8"	0.01	0.025	0.07			
Stud-mounted devices insulated with 5-mil mica washer							
10–32	7/16"	1.2	2.5	4.5			
1/4"–28	9/16"	0.9	2.0	3.5	—	—	—
1/4"–28	11/16"	0.7	1.5	2.5			

Pressure-mounted disk packages — lubricated

Interface diameter (inches)	Nominal clamp force (lb)	Thermal resistance-case-to-sink θc-s °C/watt		
		Minimum	Nominal	Maximum
3/4	800	0.04	0.06	0.20
1	2300	0.02	0.03	0.10
1-1/4	2300	0.015	0.022	0.08
1-1/3	4000	0.014	0.02	0.07

temperature must not exceed 85°C, in accordance with the manufacturer's data sheet. This amounts to a power dissipation of:

$$P = (85°C - 45°C)/0.3°C/W = 133.4\ W$$

Assume that the case temperature is actually measured to be 80°C. At first glance, the device appears to be below its maximum temperature, and all appears to be well. However, if the true dissipated power during the temperature measurement is less than the 133.4-W value, the actual case-to-ambient temperature is, in fact, too high. To illustrate why, assume that the power actually dissipated during the temperature measurement is 110 W. Then:

$$\theta = (80°C - 45°C)/110\ W = 0.318°C/W$$

Therefore, at full rated power of 133.4 W, the true case temperature would be:

$$\begin{aligned} T_{case} &= (P \times \theta) + T_{ambient} \\ &= (133.4\ W \times 0.318°C/W) + 45°C \\ &= 88°C \end{aligned}$$

or 3°C above the maximum rated case temperature at full power dissipation.

To avoid this pitfall, the designer should make sure that the device is dissipating the maximum power during the temperature measurement. To do this, a direct current is applied to the device, and the junction dissipation is adjusted by controlling the volt-ampere product.

An alternative method is to obtain a limit cell from the device manufacturer. This device, selected for worst-case power dissipation, is suited for thermal evaluation because, under actual circuit-operating conditions, its power dissipation provides a worst-case power-dissipation value.

Another factor can inhibit accurate temperature evaluation. As shown in Fig. 6, a local interface distortion can create a path of high thermal resistance directly under the thermocouple, thereby generating a false reading. If the maximum rated power dissipation and the ambient are the same as in the previous example, but the measured case temperature is 105°C, it does not necessarily mean that the heat sink is defective. It may be the local interface distortion.

To avoid this possible error, it is a prudent technique to use two or three thermocouples and to mate the semiconductor device carefully to the heat-exchanging surface to assure a uniform interface having low thermal resistance. □

DEC, EAT YOUR HEART OUT.

Temperature limiting boosts regulator output current

by Mahendra J. Shah
University of Wisconsin, Space Science & Engineering Center, Madison, Wis.

The efficiency of a precision monolithic voltage regulator can be significantly improved by limiting the junction temperature of the regulator's internal current-limiting transistor.

Conventional current limiting severely restricts the regulator's peak and average output current capability. As an example, consider the 723-type regulator, which can supply an output voltage of 7 to 37 volts. This device has a maximum storage (junction) temperature of 150°, a maximum imput/output voltage differential of 40 V, and a maximum load current of 150 milliamperes.

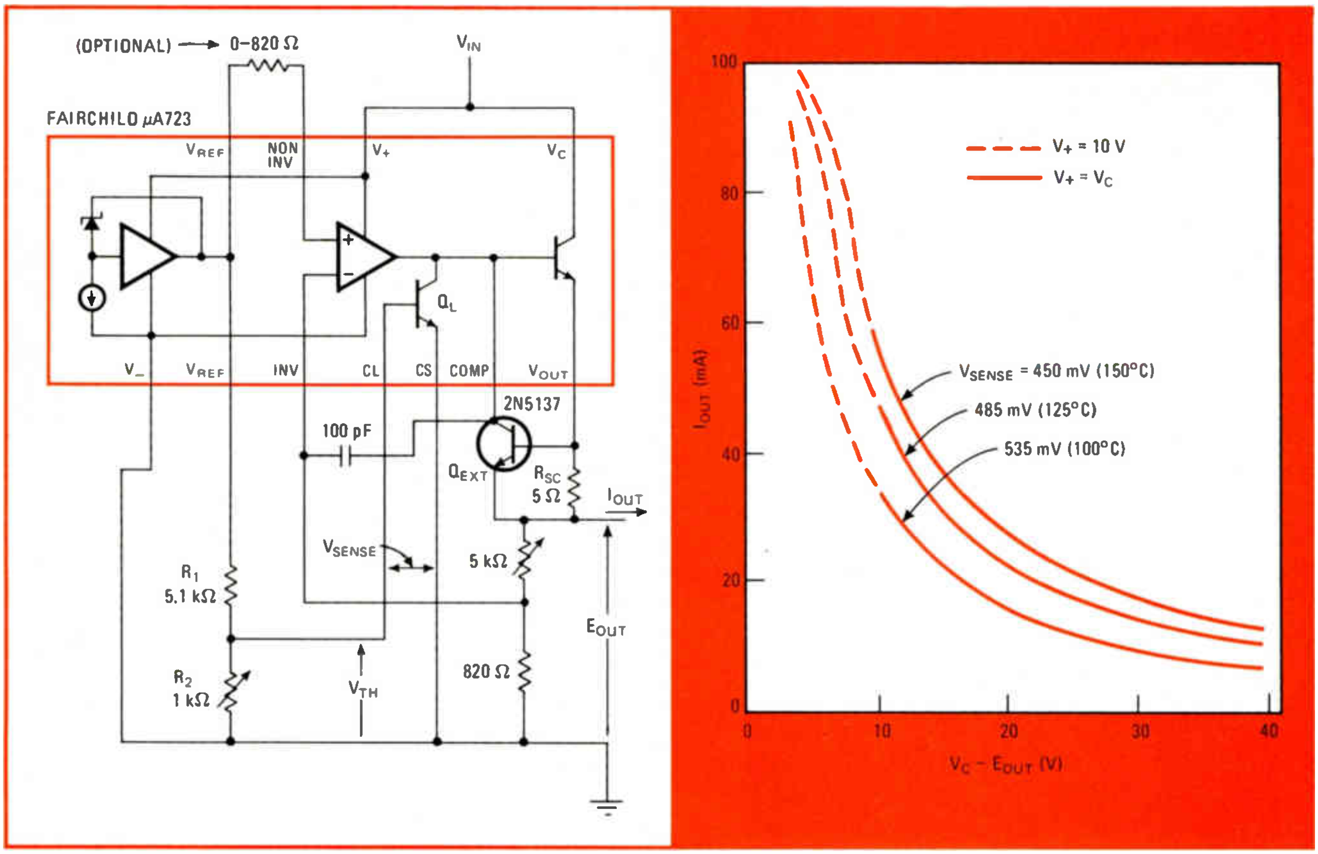
When the regulator's metal-can package is used without a heat sink, its internal power dissipation should be limited to 800 milliwatts at an ambient temperature of 25°C. If the input voltage to the regulator is 40 V, conventional current limiting places the worst-case current limit at 20 mA, or 800 mW/40 V. (The worst-case condition is an output short circuit to ground.) And a foldback-current-limiting approach requires a limit knee setting of 24.2 mA, or 800 mW/(40 – 7) V.

Both of these approaches significantly limit the regulator's output current capability when the regulator must supply a load continously at both intermediate and high output voltage levels, or when it must supply peak currents at any output voltage level. In contrast, temperature limiting protects the regulator from burnout, while allowing it to provide the maximum possible output current (both continuous and pulsed), regardless of output voltage level, ambient temperature, and the amount of heat sinking.

Conveniently, the regulator's own current-limiting transistor, Q_L, can be used to implement this temperature limiting. The transistor's base-emitter junction, which has a temperature sensitivity of −1.8 millivolts/°C, can act as a temperature sensor for the regulator. And the collector terminal of transistor Q_L can be connected to limit the regulator's output current.

A stable voltage source is needed to bias Q_L's base-emitter junction at the threshold voltage (V_{th}) that cor-

Better short-circuit protection. Current-limiting transistor Q_L of monolithic voltage regulator acts as an on-chip thermostat, controlling its own base-emitter junction temperature and, therefore, limiting regulator output current. The threshold bias voltage (V_{th}) of Q_L's base-emitter junction is set to limit this junction's temperature to a value determined by Q_L's sense voltage (V_{sense}).



responds to Q_L's sense voltage (V_{sense}) for a given junction temperature. V_{sense} is the voltage required across Q_L's base-emitter junction to implement output current limiting. Values for sense voltage, limit current, and junction temperature can be obtained from the data-sheet plot of the regulator's current-limiting characteristics as a function of junction temperature.

The threshold bias voltage is easily obtained from the regulator's internal voltage reference source and the voltage divider formed by resistors R_1 and R_2. Some other regulators, like Motorola's MC1460, MC1560, MC1461, MC1561, MC1463, MC1563, MC1469, and MC1569, have a provision for junction-temperature limiting, but they require an external regulated voltage source.

When the actual junction temperature of transistor Q_L is lower than the junction-temperature limit, Q_L's base-emitter voltage is higher than the threshold bias voltage, so that Q_L is off. But when Q_L's actual junction temperature rises to the junction-temperature limit, Q_L's base-emitter voltage drops slightly below the threshold bias voltage, and Q_L turns on, limiting its maximum junction temperature by first limiting the regulator's output current.

The external current-limiting transistor, Q_{XT} and its associated resistor, R_{SC}, are needed to limit regulator output current below the 150-mA secondary breakdown limit of the regulator's internal output transistors. (The optional resistor can be included to minimize output voltage drift.) The graph shows the regulator's output current capability over the full range of input/output differential voltage for three sense-voltage settings. □

All-digital phase shifter handles 5-to-1 bandwidth

by Aleardo Salina
Siai Marchetti, Vergiate, Italy

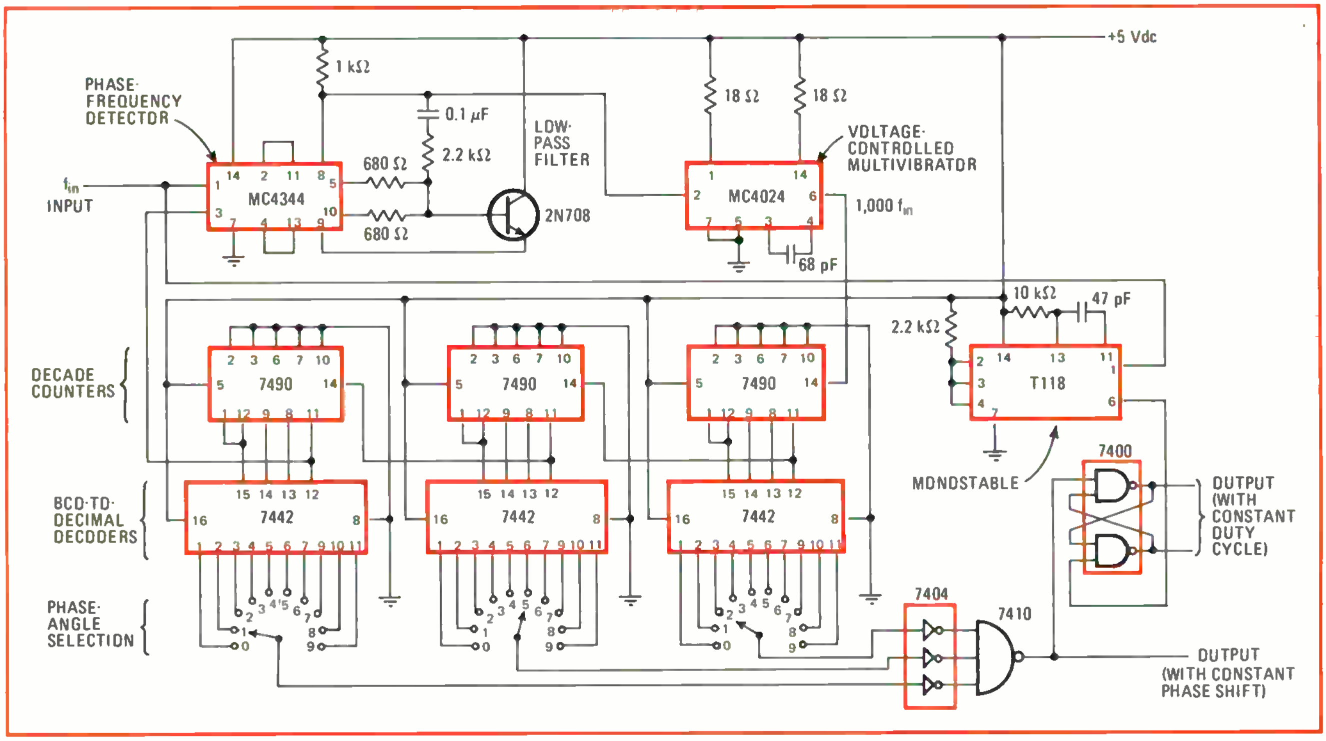
A digitally programable phase-shift network can be made to maintain the phase shift at its output constant, even though the frequency at its input varies by as much as a factor of five. The circuit consists mainly of digital ICs, including its input-detector stage.

The desired phase shift is switch-selectable through a three-stage counter/decoder network. Any phase shift between 0° and 360° can be chosen. Here, the angle selected is divided into 1,000 bits, but a finer resolution can be obtained by increasing the number of decade counters.

For the component values indicated, the circuit's phase angle stays locked for input frequencies from 2 to 10 kilohertz. This operating frequency range can be shifted by changing the values of the low-pass filter components and the value of the timing capacitor for the voltage-controlled multivibrator.

The circuit also produces an output whose duty cycle remains constant. □

Locking phase digitally. Circuit produces the phase shift (between 0° and 360) selected by the three switches. This digitally programed phase angle does not change, although the input-signal frequency may vary from 2 to 10 kilohertz. The circuit's operating frequency can be changed by adjusting the low-pass filter and the timing of the voltage-controlled multivibrator. There is also a constant-duty-cycle output.



Voltage discriminator has 0.1-mV resolution

by Ryszard Bayer
Institute of Nuclear Research, Swierk, Poland

Positive feedback permits a dual IC comparator to perform as a high-resolution voltage discriminator that can detect either positive or negative pulses having amplitudes ranging from a few millivolts to 5 volts. When driven from such low-impedance sources as operational amplifiers, this discriminator has a linearity of better than 0.03% and a voltage resolution of about 0.1 millivolt.

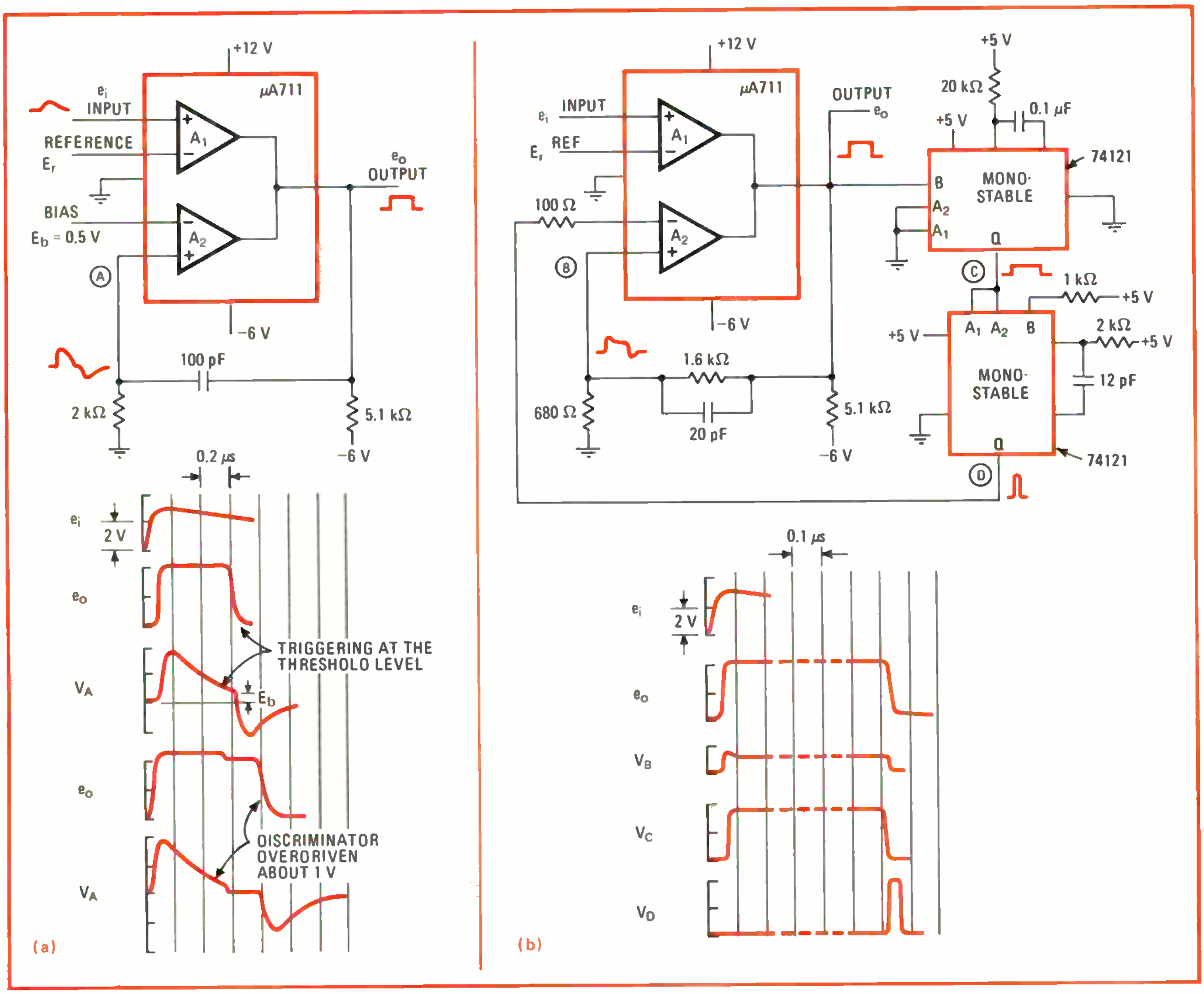
The input signal is compared with the reference voltage by comparator A_1. The signal appearing at the moment of comparison of these two voltages is taken from the common output of both comparators and fed back to the noninverting input of comparator A.

Because of this positive-feedback path, the discriminated signal is amplified considerably, reducing the amplifier's offset voltage and improving voltage resolution. Since the feedback signal is introduced to the noninverting input of comparator A', both inputs of comparator A_1 can be driven from low-impedance sources for better discriminator accuracy.

With capacitive feedback, as in circuit (a), the discriminator has only one stable state. With dc feedback, as in circuit (b), the discriminator becomes bistable. At the moment the input and reference signals are compared, the bistable discriminator is set to its high level. It can be reset by applying a second pulse to the inverting input of comparator A_2. This second pulse can be applied after the first pulse has been terminated for a time that exceeds the duration of the first pulse minus the discrimination-level threshold. □

Designer's casebook is a regular feature in Electronics. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.

Discriminating comparators. Integrated dual comparators can differentiate between input-signal height and the reference-voltage level to within 0.1 millivolt. This high resolution is due to the positive feedback from the output to the noninverting input of comparator A_2. Capacitive feedback (a) produces a unistable discriminator, while dc feedback (b) produces a bistable one that can be reset with a second input pulse.



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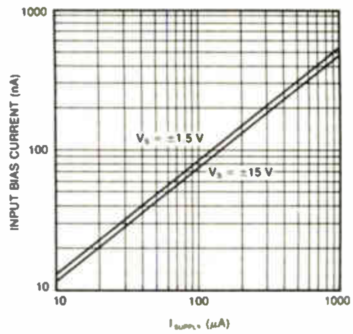
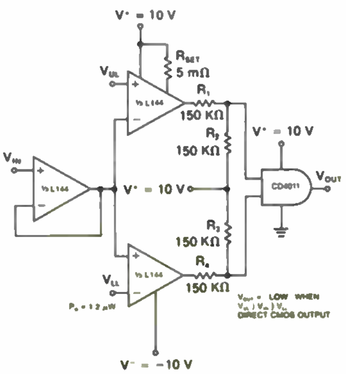


Applications examples:



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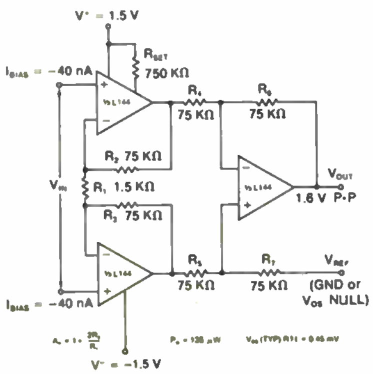

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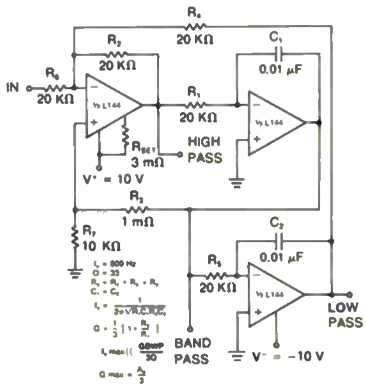

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Norton quad amplifier subtracts from costs, adds to design options

Consisting of four identical linear circuits on one chip, the Norton quad amplifier operates off a single power supply; biasing is simplified, and so too is the design of several waveform-generating circuits

by Thomas M. Frederiksen, *National Semiconductor Corp., Santa Clara, Calif.*

☐ Pressured by the demands of the automobile industry, consumer electronics manufacturers, and other mass-production customers into finding new ways of producing ever cheaper components, semiconductor makers have developed a new family of linear integrated circuits. These linear ICs each contain, in a single package, four identical but independent devices—four comparators, or four conventional inverting-type operational amplifiers, or four of the rather less conventional, so-called Norton amplifiers.

All three types are available from a growing number of manufacturers. Not only do the quads each cost far less than four devices bought separately, but industrial and communications equipment designers are also attracted by their promise of reducing system cost while maintaining high levels of component operation.

The fact is that many linear circuit functions do require more than one of a similar type of comparator or amplifier. Comparators are often used in pairs, in limiting comparator circuits and crystal-controlled oscillators, for instance, while a two-decade high-frequency voltage-controlled oscillator needs three. Similarly, a simple by-pass filter requires two op amps, a phase-locked loop needs three, and a sinewave oscillator or sawtooth generator needs four.

But even if only one component of the quad is required in a given circuit, the others can be used for dozens of auxiliary circuit purposes. Examples are biasing or gain-control networks or simple gain blocks.

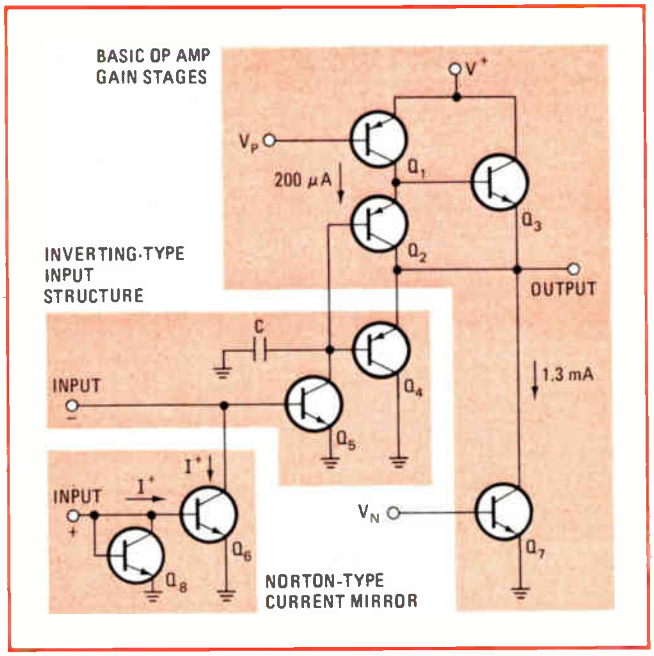
Most important, the new Norton quads need only a single-ended power-supply voltage and operate well over a wide range of power-supply voltages, from 3 volts dc to 32 V dc. Moreover, a typical quad Norton amplifier draws a constant low supply current of 1.3 milliamperes, and both the comparator and the operational amplifier draw a constant 0.2-mA supply current per circuit function.

The Norton quad amplifier

The most radical of all the three quad designs is the Norton amplifier, the LM3900. To obtain noninverting input signals, op-amp designs use a standard transistor differential amplifier—a fairly elaborate circuit that unfortunately requires two (a positive and a negative) supply voltages. In the Norton amplifier, this requirement was eliminated by putting the simplest type of inverting amplifier (that is, a common-emitter stage) at the input (Fig. 1) and then adding a "current mirror" circuit across the inverting input terminal to provide a noninverting input.

Just about all the positive input current is forced into becoming collector current in the diode-connected input transistor, Q_8. At this level of conduction, an "on" biasing voltage (V_{BE}) results across the base-emitter junction of the transistor. The same biasing voltage is applied to a second matched transistor, Q_6, which therefore conducts the same amount of current as in Q_8. Consequently, the current from the output of this stage equals the input current, I_{in}, which has thus been "mirrored" or reflected about ground.

In this scheme all of the voltage gain in the basic amplifier is provided by the gain transistor, Q_5, and the output emitter-follower transistor, Q_3, serves simply to isolate the load impedance from the high impedance that exists at the collector of Q_5. Closed-loop stability is guaranteed by an on-chip 3-picofarad capacitor, C, which provides the single dominant open-loop pole.



1. Inverted inversion. In the Norton amplifier, a current-mirroring circuit has been added to a conventional inverting-type input structure so that a noninverting input signal can be achieved from a single +5-V power supply. Such an input usually requires two supplies.

The output emitter-follower is biased for class A operation by the current source, Q_7.

In the design of the LM3900, two pnp transistor stages have been added. The lateral pnp, Q_2, reduces the input current and provides additional load isolation. The vertical pnp, Q_4, converts the class A output stage to a class B stage for large signal cases. This allows the amplifier to sink larger load currents than the 1.3-mA pull-down current source would provide.

Big gain

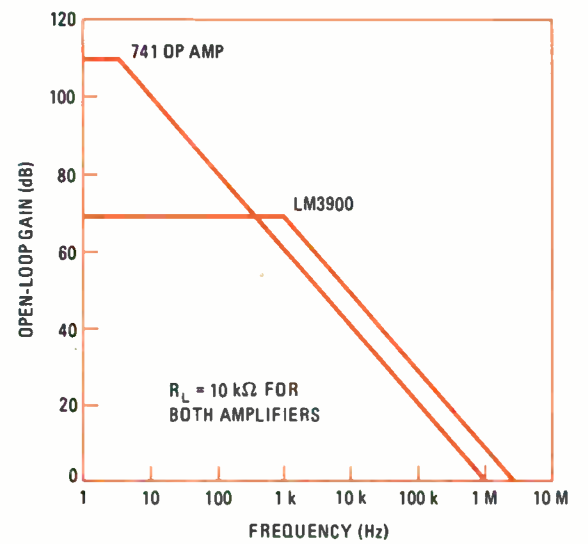
It should be pointed out that the Norton amplifier, by making use of current source loads, achieves a large voltage gain which is constant over a wide range of power-supply voltages. The output voltage has a large dynamic voltage range—essentially from ground to the power supply voltage minus V_{BE}. Power-supply current drain is almost independent of the power-supply voltage, and ripple on the supply line is also rejected. Furthermore, a very small input biasing current allows high-impedance feedback elements to be used.

Besides simplifying the circuit configuration, the use of only a single power supply results in many biasing advantages. Since the bias currents are all derived from diode forward-voltage drops, a bias current changes only slightly in magnitude as the power-supply voltage is varied. The open-loop gain also changes only slightly over the complete power-supply voltage range and is essentially independent of temperature changes.

The open-loop frequency response of the LM3900 is compared with the 741 op amp in Fig. 2. The higher unity gain crossover frequency is seen to provide an additional 10 decibels of gain for all frequencies greater than 1 kilohertz. Also, because currents can be passed between the input terminals, designers can apply this amplifier to jobs that generally are hard for standard op amp configurations to do, like function generators and some phase-locked-loop circuits. Moreover, if external large-valued input resistors are used to convert from input voltages to input currents, most of the standard op-amp applications can be realized as well.

The LM 3900 Norton amplifier can be biased in several different ways. The circuit in Fig. 3a, a standard inverting ac amplifier, has been biased from the power supply that is also used to operate the amplifier. Note that if ac ripple voltages are present on the V+ power-supply line, they will couple to the output with a gain of ½. To eliminate this, a single source of ripple-filtered voltage can be provided for many amplifiers.

Figure 3b shows both a noninverting ac amplifier and



2. Greater gain. The open-loop gain characteristics of the LM3900, when compared with those of a conventional 741, reveal its advantage at higher frequencies—an extra 10 dB of gain above 10 kHz.

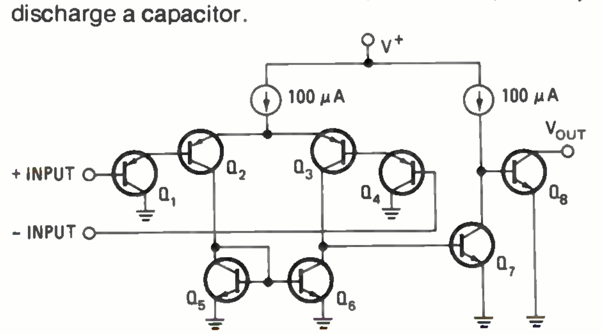
Another quad for comparison

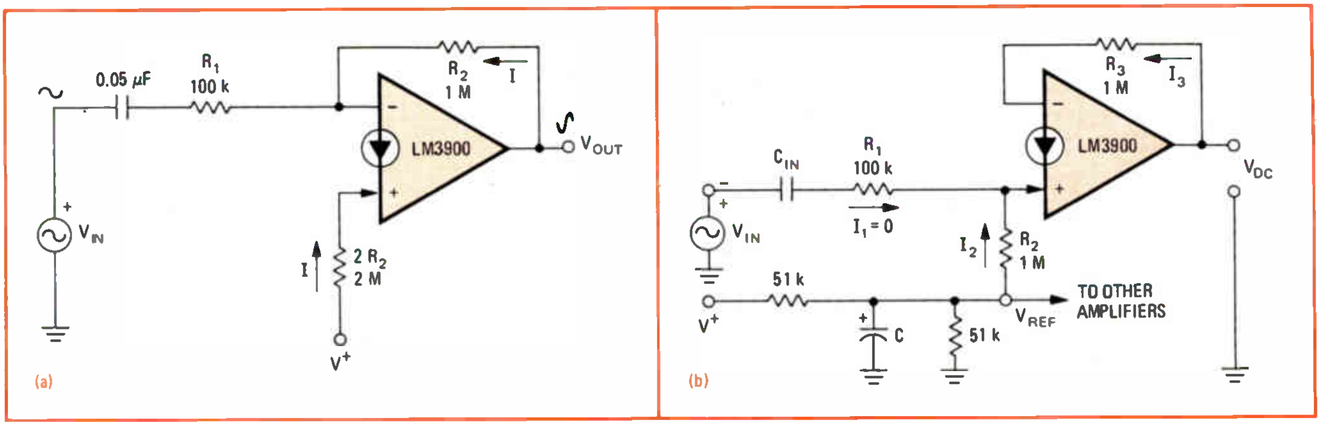
Versatility is also a feature of another member of the quad family—the quad comparator, National's version of which is designated the LM339. The basic circuit, of which there are four per chip, shows high gain and low input current. It comprises a Darlington pnp single-supply differential-input stage, a current source as the load for the second stages, and a grounded-emitter npn output transistor (see figure). Flexibility is achieved by leaving the collector of this output transistor, Q_8, uncommitted. As a result, the voltage to which the external load is returned is independent of the magnitude of the power-supply voltage, and the outputs of more than one comparator can be connected to a common load to provide an output OR-ing function.

The total biasing current for this comparator is only 200 microamperes, yet it achieves a transconductance of 5 mhos (the output will fully switch 1 milliampere of current for a change in the differential input voltage of 0.2 millivolt). The input currents and offset voltage are 35 nanoamperes and 3 mV respectively. Because of their simplicity, four of these comparators are easily fabricated on one die.

These comparators are also unique in that, even though they are operated from a single positive power-supply voltage, the input common-mode voltage range includes ground. Operation is possible over a wide single-supply voltage range (2 to 36 V dc) or from dual supplies (±1 to ±18 V dc), adding to the design's flexibility. Moreover, the supply current drain of 800 microamperes is essentially independent of the magnitude of the power supply voltage, which with a +5-V dc digital supply amounts to 1 milliwatt per comparator.

Large differential input voltages can be accommodated, and a special design for the output transistor provides an offset voltage of 1 mV. This last feature is important when the output of the comparator is used, for example, as a single-pole, single-throw switch to ground in an RC sweep circuit to precisely discharge a capacitor.





3. Straightforward biasing. One way of biasing the LM3900 takes a standard inverting ac amplifier and biases it from the supply that also powers it (a). In the dc biasing method, (b), the amplifier gain is set by the ratio of feedback resistor to input resistor.

a second method for dc biasing. The ac gain of the amplifier is set by the ratio of feedback resistor to input resistor. The small-signal impedance of the diode at the noninverting (+) input should be added to the value of R_1 when calculating gain.

By making $R_2 = R_3$, the dc voltage output will be equal to the reference voltage that is applied to resistor R_2. This filtered $(V^+/2)$ reference voltage can easily be used for other amplifiers.

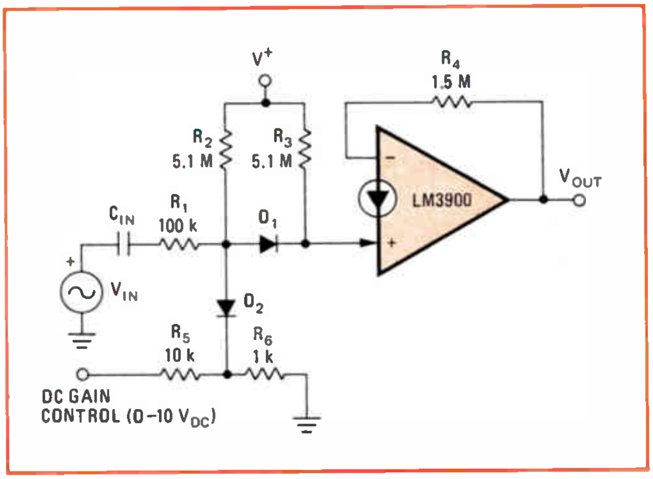
Another interesting feature of this setup is that the input resistor, R_1, is isolated from the inverting (-) input terminal by the output impedance of the transistor of the current mirror. The amplifier is therefore not operating in an input-voltage to output-voltage feedback mode but, instead, along with the feedback resistor, R_3 forms a feedback-stabilized transimpedance amplifier with a gain equal to R_3. As R_1 is isolated from the (-) input, this represents essentially unity voltage feedback, and the resulting bandwidth is the unity gain crossover frequency (2.5 MHz) of the basic amplifier. Consequently, the value of input resistor R_1 can be made small and, by thus increasing the voltage gain without affecting the feedback factor of the basic transimpedance amplifier, can help provide large gain at high frequency.

A gain of over 100 (40 dB) is possible at 1 MHz—and the high frequency limit is now set by the slew rate of the amplifier. This is useful for many applications where gain at signal frequencies above the standard op amp limits is required.

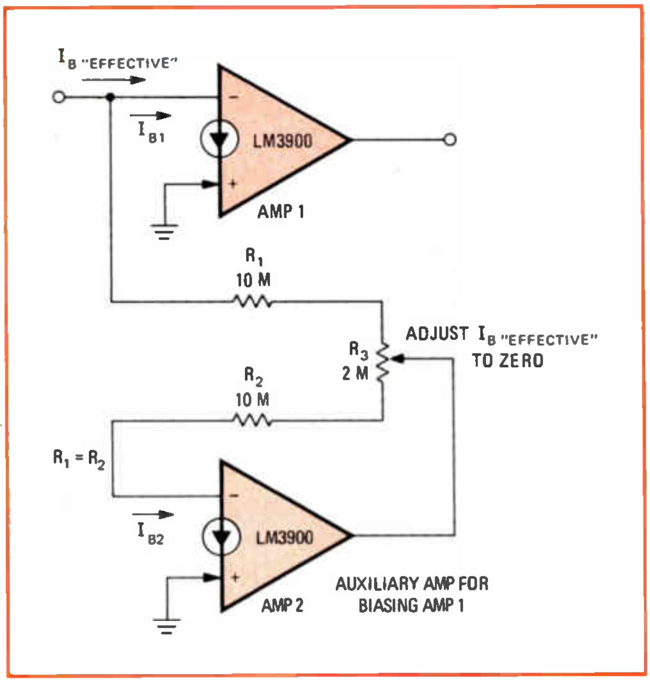
The same effect, incidentally, could be obtained by adding a current mirror to the 741 operational amplifier. But this mirror circuit would have to be made with closely matched discrete transistors, something that is done on the chip with the LM3900.

Adding dc gain control

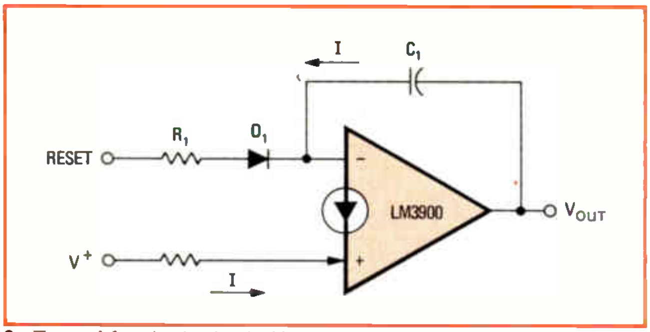
A dc gain control can be added to the noninverting Norton amplifier as shown in Fig. 4. A minimum biasing current passed through R_3 prevents the output of the amplifier from going into saturation as this dc gain control is varied. For maximum gain, the control rectifier D_2 is off, so that the current through R_2 as well as R_3 can enter the (+) input and cause the output of the amplifier to be biased at approximately 6.0 V (with a 10-V supply). For minimum gain, D_2 is on, and only the



4. In control. In this simple dc gain control circuit, input voltages range from 0 V dc for maximum gain, to less than 10 V dc for minimum gain. A biasing current through R_3 prevents saturation.



5. Useful symmetry. Four independent amplifiers available in each LM3900 package make it easy to exploit the symmetry that exists between the individual devices. Here, one amplifier is biasing another.



6. To and fro. In the basic Norton quad sweep circuit, current entering the noninverting (+) input causes the output to sweep linearly in a positive direction. Conversely, current entering the inverting (−) input causes the output to sweep linearly but negatively.

current through R_3 can enter the (+) input to bias the output at approximately +3.0 v. The proper output bias for large output signal accommodation is provided for the maximum gain situation. The dc gain control input ranges from 0 v dc for maximum gain, to less than 10 v dc for minimum gain.

Symmetrical amplifier designs

From these multiple amplifier packages, it is now possible to produce symmetrical designs. Historically, resistors have been the most predictable electronic components, and they gave rise to feedback amplifiers in which closed-loop amplifier performance depended only on resistors. Following this, two matched transistors were placed in a single can to make improved input stages for discrete op amps. Later still, integrated circuits derived performance advantages from their inherent resistor and transistor matching. And now multiple amplifiers in a single monolithic quad package allow designers to exploit the symmetry existing between the individual amplifiers.

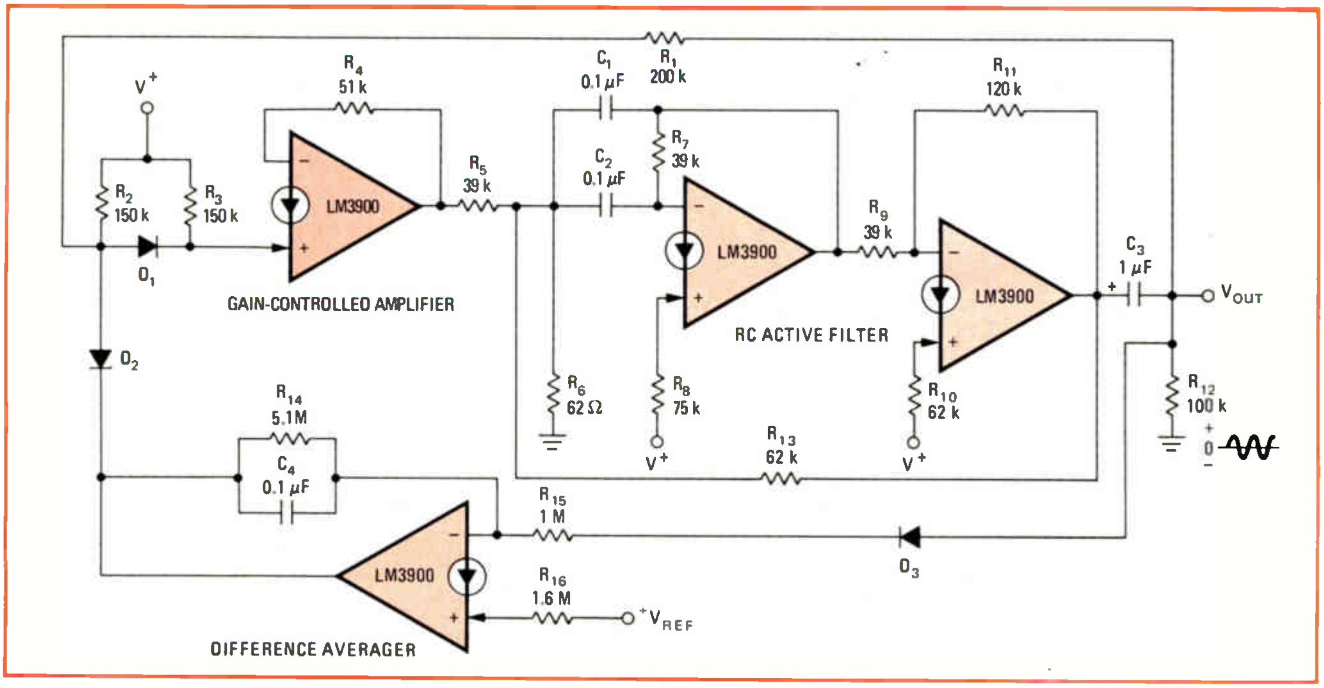
The example of symmetry shown in Fig. 5 has one amplifier biasing one or more additional amplifiers. So long as the dc biasing current, I_B, is accurately supplied via R_1, the input terminal of amplifier 1 needs supply only enough current for the amplifier signal. The adjustment, R_3, allows a zeroing of I_B which is useful in such circuit functions as sample-and-hold, where small values of I_B are desirable. Otherwise, if R_3 were omitted, simply letting $R_1 = R_2$, and relying on amplifier symmetry could cause the effective I_B to be less than $I_B/10$ (3 nanoamperes).

Clean sweeps

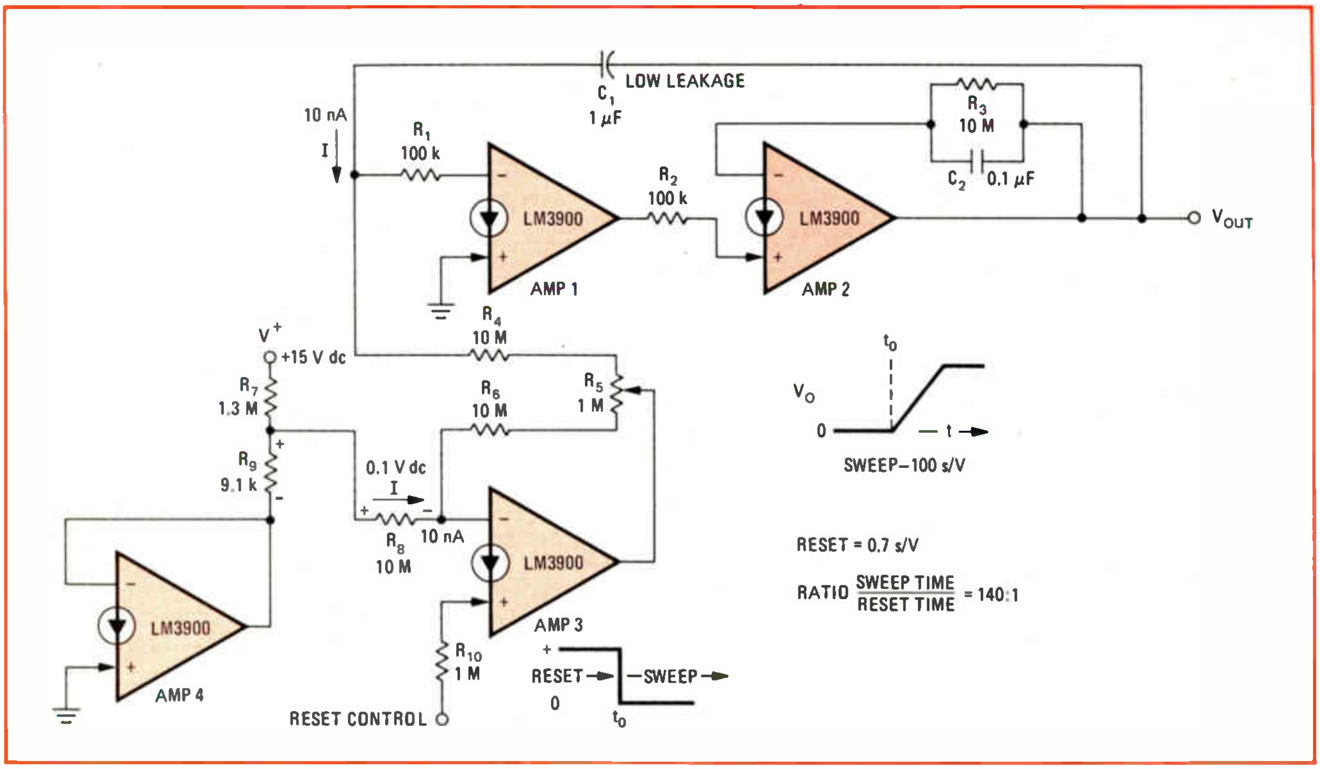
Many waveform-generating circuits can be realized with the Norton quads. The basic sweep circuit is shown in the integrator circuit of Fig. 6. Current entering the noninverting (+) input causes the output voltage to sweep linearly in a positive direction, and current entering the inverting (−) input causes the output to sweep negatively. The diode isolates the inverting input when the input voltage is zero. Either input can be used as a reset control, and the faster negative-going slew rate of the LM3900 generates excellent positive-going sawtooth waveforms with a very short reset time.

A sine-wave oscillator built round the LM3900 is shown in Fig. 7. The two-amplifier RC active filter requires only two capacitors to provide the proper over-all noninverting phase characteristic. If a noninverting gain-controlled amplifier is then added around the filter, the desired oscillator configuration is obtained. Finally, the sine-wave output voltage is sensed and regulated by a differential averaging circuit, so that its average value is compared to a dc reference voltage, V_{REF}.

The averaging circuit also provides a simple way to keep the peak magnitude of the output sine wave equal to twice the value of V_{REF}. This is essentially indepen-



7. Sine-wave oscillator. Four Norton amplifiers can easily be interconnected to make a sine-wave oscillator. A two-amplifier RC filter and a noninverting gain-controlled amplifer are added to a differential averaging circuit for regulation.



8. Slow sawtooths, too. The four amplifiers of the Norton quad work together to generate very slow sawtooth waveforms. To guarantee the required high impedance, the printed-circuit boards used with the packages should be coated with silicon to minimize surface leakage.

dent of both temperature and the magnitude of the power-supply voltage, provided V_{REF} is derived from a stable voltage source.

The LM3900 can also be used to generate a very slow sawtooth waveform, which can in turn be used to generate long time-delay intervals. This is one of the toughest circuit functions to obtain in IC form. The circuit shown in Fig. 8 uses four amplifiers. Amplifiers 1 and 2, which have the desired very slow sawtooth waveform output, are cascaded to increase the gain of the integrator, while amplifier 3 supplies the bias current to amplifier 1. Amplifier 4 provides a bias reference equal to the dc voltage at the (–) input of amplifier 3.

With resistor R_8 opened up and the reset control at zero volts, the potentiometer, R_5 is adjusted to minimize the drift in the output voltage of amplifier 2 (this output must be kept in the linear range to insure that amplifier 2 is not in saturation). The resistor divider, R_7 and R_9, provides a 0.1-v dc reference voltage across R_9 that also appears across R_8. The current that flows through R_8 enters the (–) input of amplifier 3 and causes the current through R_6 to drop by this amount. This causes an imbalance because now the current flow through R_4 is no longer adequate to supply the input current of amplifier 1. The net result is that this same current is drawn from capacitor C_1 and causes the output voltage of amplifier 2 to sweep slowly positive.

To guarantee obtaining the high impedance values needed for the slow sweeps, the printed-circuit board used must be cleaned and then coated with silicone rubber to eliminate the occurrence of leakage currents across the surface. Also, the dc leakage currents of the capacitor C_1 must be kept small compared to the 10-nA charging current. For example, an insulation resistance of 100,000 megohms will leak 0.1 nA with 10 v dc across the capacitor—a leakage that increases rapidly at higher temperatures.

With the basic circuits, other sweep rates can be obtained by scaling resistor R_8 and capacitor C_1. For the values shown in Fig. 9, the 10-nA current and the 1-microfarad capacitor establish a sweep rate of 100 seconds per volt. The reset control pulse at amplifier 3's (+) input causes that amplifier to go into positive output saturation, while the 10 megohms of R_4 provides a reset rate of 0.7 s/v.

The resistor, R_1, prevents C_1 from discharging larger currents and thus from overdriving the (–) input and overloading the input clamp device. For larger charging currents, a resistor divider can be placed from the output of amplifier 4 to ground, and R_8 can tie from this tap point directly to the (–) input of amplifier 1.

Digital and switching circuits

A unique feature of the new Norton quad amplifiers is that they can be overdriven to provide a large number of low-speed digital and switching circuit applications. This is particularly attractive for control systems that operate from single power-supply voltages larger than the standard +5-v dc digital limit. The large voltage swing and slower speeds of the LM3900 are advantages for most industrial control systems. In this context each amplifier can be thought of as a super transistor with a β of 1,000,000 (25-nA input current and 25-mA output current) and with a noninverting input feature. In addition, the active pullups and pulldowns which exist at the output will supply larger currents than the simple resistor pullups used in digital logic gates. □

Part 1: TTL NAND gates

Computer models can be generated for accurate simulation of digital integrated circuits; the ICs are treated as simple individual devices, rather than as a complex collection of transistors and diodes

by John R. Greenbaum, *General Electric Co., Syracuse, N.Y.*

☐ Acceptable computer models for use in analyzing individual transistors and diodes have been available for some time But—until now—more complex device models, such as those needed for digital integrated circuits, simply did not exist.

Wastefully, models for digital ICs usually have followed the same procedures as those for individual transistors. In this extravagant method, each semiconductor junction must be described to the computer in detail. For example, modeling a common type-D flip-flop requires identification of 54 transistor junctions and four diode junctions, which involves nearly 200 complex relationships.

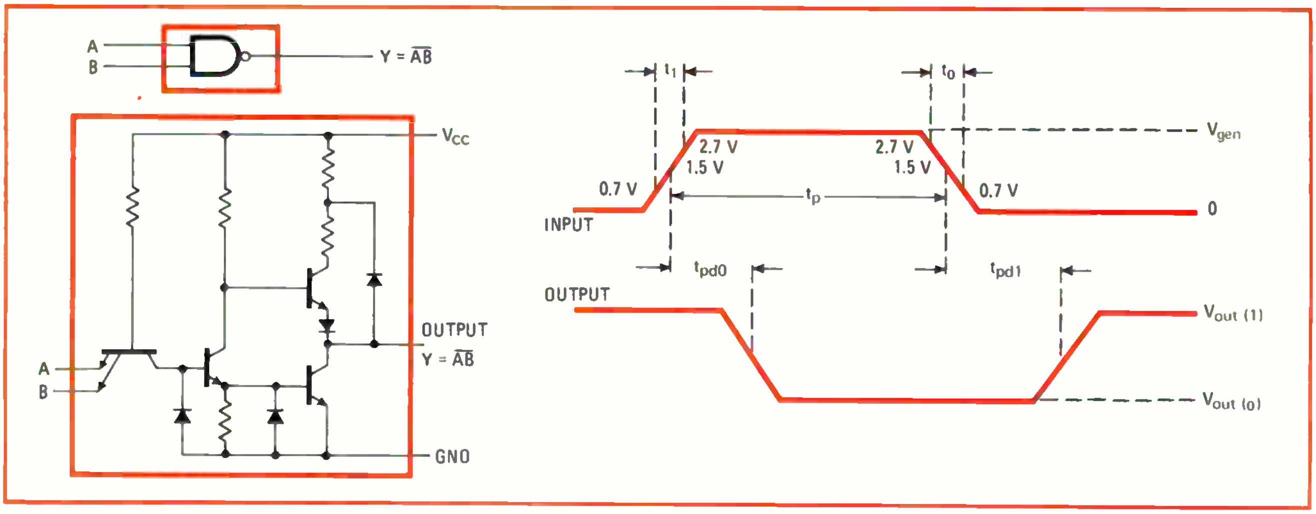
With this cumbersome classical method of device modeling, generally only one IC function can be analyzed at a time because of the size limitations of the computer, the analysis program, or both. Furthermore, complex analyses are uneconomical because they require excessive computer time.

However, a black-box equivalent of a digital IC can be developed so that a practical computer model can simulate the function of that particular device. This series of articles will present models for five different common digital-IC functions: the NAND gate, the flip-flop, the monostable multivibrator, the AND/OR inverter, and the shift register. Although different in function, these models are similar to each other, since they are all developed as black-box equivalent circuits, and although they are simple, they are accurate and can readily be made more sophisticated.

Interestingly, model complexity depends more on the quantity and type of external interface requirements than on the internal complexity of the device itself. Every model described in this series has been validated by comparing the response of simulated test circuits with the response of actual test circuits.

Program listings for the models are given here for the Sceptre (System for Circuit Evaluation and Prediction of Transient Radiation Effects) and Circus-2 (Circuit Simulator) analysis programs. But the models can also be used with such other nonlinear computer programs as Astap (Advanced Statistical Analysis Program) and NET-2 (NETwork analysis program), as well as the French program IMAG-2 (Institut de Mathématique Appliquées de Grenoble).

There are two NAND gate models—one for a two-input device, and the other for a four-input device. Both gates are positive-logic integrated circuits. The two-input device is modeled after the radiation-hardened type-RSN54L00 TLL quad NAND gate, and the four-in-



1. Device characterization. Two-input NAND gate can be adequately represented by its output signal levels and its delay characteristics. With this approach, there is no need for the wasteful classical method of modeling every tansistor and diode junction.

put device is modeled after the type-9704 TTL NAND gate.

Two-input NAND-gate model

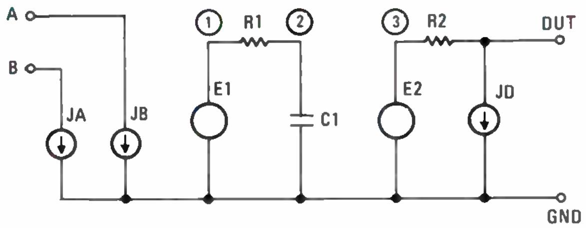
For the two-input NAND gate, the output is logic 0 when both inputs are logic 1; all other signal conditions produce a logic 1 at the output. Figure 1 shows the NAND-gate circuit and its delay characteristics. To develop a simple computer model, the gate's maximum logic 1 output voltage can be considered to be 3.1 v, its maximum logic 0 output voltage to be 0.3 v, its minimum logic 1 input voltage to be 1.9 v, and its maximum logic 0 input voltage to be 0.8 v. Either propagation delay, t_{pd0} (negative-going or t_{pd1} (positive-going), is a maximum of 60 ns.

The computer model for the two-input NAND gate is shown in Fig. 2, together with model descriptions written for Sceptre and Circus-2 and the associated model subprograms. These subprograms can be used with either model description. Subprogram FN2 establishes the gate's output-signal-level characteristics (according to the gate's truth table); the other subprogram, FCAP1, determines the gate's delay characteristics.

Unlike Sceptre, which includes the model's topological description and parameter values in one entry, Circus-2 requires two separate entries under the headings MODELS and DEVICES. MODELS defines the topological description, and DEVICES the parameter values.

The gate's signal-input impedances are represented as the zero-valued current sources JA and JB. In Sceptre and Circus-2, this implies that the impedance of input-signal terminals A and B is infinite, a reasonable first-

MODEL



FOR SCEPTRE: E1 = f(FN2), C1 = f(FCAP1), E2 = f(VC1)
FOR CIRCUS–2: V1 = f(FN2), R1 = f(RR72), V2 = f(V.C1)

SCEPTRE DESCRIPTION

```
MODEL L00 (A–B–OUT–GND)
2 INPUT NAND GATE
A = INPUT A
B = INPUT B
ELEMENTS
JA, A–GND = 0.
JB, B–GND = 0.
JD, OUT–GND = 0.
E1, GND–1 = Q4 (VJA, VJB, 0.8, 3.1, 1.9, 0.3)
R1, 1–2 = 100.
C1, 2–GND = Q2 (E1, E2, 550.E–12, 300.E–12)
E2, GND–3 = X1 (VC1)
R2, 3–OUT = 30.
FUNCTIONS
Q2 (A, B, C, D) = (FCAP1 (A, B, C, D) )
Q4 (A, B, C, D, E, F) = (FN2 (A, B, C, D, E, F) )
OUTPUTS
VJA (A IN), VJB (B IN), VJD (OUTPUT), PLOT
```

CIRCUS–2 DESCRIPTION

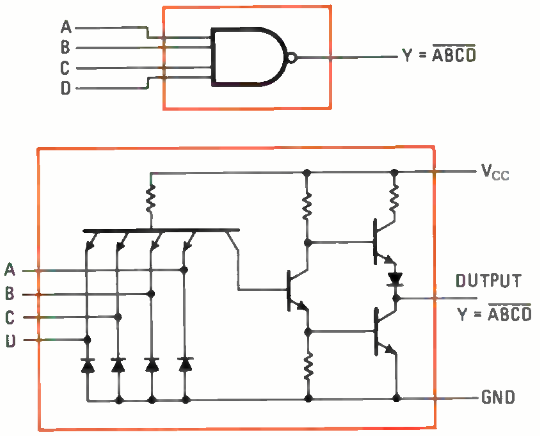
```
MODELS
MODEL NAME = NAND GATE
EXTERNAL NODES = (A, B, OUT, GND)
TOPOLOGY
JA, A, GND
JB, B, GND
JD, OUT, GND
V1, 1, GND
R1, 1, 2
C1, 2, GND
V2, 3, GND
R2, 3, OUT
    EQUATIONS
    A1 = AA1
    A2 = AA2
    R1=RR72(V1,V.C1,A1,A2)
    V2=V.C1
    D(V2,V.C1)=1.
    V1=FN2(V.JA,V.JB,AA3,AA4,AA5,AA6)
    D(V1,T)=1.
    RETURN
    END
END OF INPUT
DEVICES
DEVICE NAME = L00, MODEL NAME = NAND GATE
SINGLE-VALUED PARAMETERS
C1=100E–12,AA1=550,AA2=300,AA3=0.8,AA4=3.1,AA5=1.9,AA6=0.3
JA=0,JB=0,JD=0,R2=30
END OF INPUT
```

MODEL SUBPROGRAMS

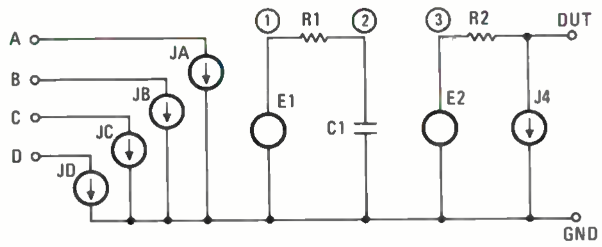
```
CFN2            QUAD 2 INPUT NAND GATE LEVEL SELECT
C           FOR USE WITH 2 INPUT NAND GATE
            FUNCTION FN2(A,B,C,D,E,F)
C           A=VJA  B=VJB  C=0.8
C           D=3.1  E=1.9  F=0.3
            IF(A .LE. C .OR. B .LE. C) GO TO 4
            IF(A .GE. E .AND. B .GE. E) GO TO 5
            FN2=D–AMIN1(A,B)
            RETURN
      4     FN2 = D
            RETURN
      5     FN2 = F
            RETURN
            END
```

```
CFCAP1          DIGITAL IC CAPACITOR SELECT
            FUNCTION FCAP1(A,B,C,D)
CFCAP1      TO ESTABLISH CAPACITOR VALUE OF DIGITAL IC
            FCAP1 = C
            IF(A .GE. B) FCAP1 = D
            RETURN
            END
```

2. Two-input NAND gate. Computer model is based on typical performance of type-RSN54L00 TTL quad NAND gate. Program listings are given for both Sceptre and Circus-2. The model subprograms, which can be used with either model description, determine the gate's output signal level characteristics (function FN2) and its delay characteristics (function FCAP1).



MODEL



FOR SCEPTRE: E1 = f(FN4), E2 = f(VC1), C1 = f(FCAP1)
FOR CIRCUS–2: V1 = f(FN4), V2 = f(V.C1), R1 = f(RR72)

SCEPTRE DESCRIPTION

```
MODEL 9704 (A-B-C-D-OUT-GND)
4 INPUT NAND GATE
A = INPUT A
B = INPUT B
C = INPUT C
D = INPUT D
ELEMENTS
JA, A-GND=0.
JB,B-GND=0.
JC,C-GND=0.
JD,D-GND=0.
E1,GND-1=Q2(VJA,VJB,VJC,VJD,0.8,3.3,2.0,0.4)
R1,1-2=100.
C1,2-GND=Q1(E1,E2,200.E-12,150.E-12)
E2,GND-3=X1(VC1)
R2,3-OUT=25.
J4,OUT-GND=0.
FUNCTIONS
Q1(A,B,C,D)=(FCAP1(A,B,C,D))
Q2(A,B,C,D,E,F,G,H)=(FN4(A,B,C,D,E,F,G,H))
OUTPUTS
VJA,VJB,VJC,VJD
E1,E2,VR2,C1,VC1,PLOT
VJ4,PLOT
```

CIRCUS–2 DESCRIPTION

```
MODELS
MODEL NAME = 4 NAND GATE
EXTERNAL NODES = (A,B,C,D,OUT,GND)
TOPOLOGY
JA,A,GND
JB,B,GND
JC,C,GND
JD,D,GND
JO,OUT,GND
V1,1,GND
R1,1,2
C1,2,GND
V2,3,GND
R2,3,OUT
    EQUATIONS
    A1=AA1
    A2=AA2
    R1=RR72(V1,V.C1,A1,A2)
    V2=V.C1
    D(V2,V.C1)=1.
    V1=FN4(V.JA,V.JB,V.JC,V.JD,AA3,AA4,AA5,AA6)
    D(V1,T) = 1.
    RETURN
    END
END OF INPUT
DEVICES
DEVICE NAME = 9704 MODEL NAME = 4 NAND GATE
SINGLE-VALUED PARAMETERS
C1=100E-12,AA1=200,AA2=150,AA3=0.8,AA4=3.3,AA5=2.0,AA6=0.4
JA=0,JB=0,JC=0,JD=0,JO=0,R2=25
END OF INPUT
```

MODEL SUBPROGRAM

```
 CFN4                 FOR USE WITH 4 INPUT NAND GATE
            FUNCTION FN4(A,B,C,D,E,F,G,H)
 C            FOR USE WITH 4 INPUT NAND GATE
 C          A = VJA  B = VJB  C = VJC  D = VJD
 C          E = 0.8  F = 3.3  G = 2.0  H = 0.4
 C            DATA APPLICABLE TO 9704
            IF(A.LE.E.OR.B.LE.E.OR.C.LE.E.OR.D.LE.E)GO TO 4
            IF(A.GE.G.AND.B.GE.G.AND.C.GE.G.AND.D.GE.G)TO TO 5
            FN4 = F-AMIN1(A,B,C,D)
            RETURN
       4    FN4 = F
            RETURN
       5    FN4 = H
            RETURN
            END
```

3. Four-input NAND gate. This computer model simulates the performance of a type-9704 TTL NAND gate. The subprogram FN4 listed here establishes the gate's output signal logic levels. To adjust the gate's delay, the subprogram FCAP1 in Fig. 2 is used.

order approximation, even though the impedance is measurable and varies with the applied-signal level. For greater accuracy, current sources JA and JB can be modeled in diode-equation format or as tables of functions relating current to applied voltage.

The voltage associated with dependent voltage source E1 is determined by the function FN2, which is set up by the model subprogram by that name. This function establishes the value of voltage E1 to agree with the gate's truth table. If either of the input signals is less than or equal to 0.8 v, then the value of E1 is set to 3.1 v, which represent logic 1. When both input signals are equal to or greater than 1.9 v, the value of E1 becomes 0.3 v, which represents logic 0. If neither of these conditions exists, as for instance, during an input transition, then E1 is computed to be 3.1 v minus the absolute value of the smaller of the two applied signals.

Although the gate's switching-delay times for both positive-going and negative-going output signals are supposed to be no greater than 60 ns, real devices often operate with delays that are not only shorter than this worst-case value but that are also different from each other. Delay times for the model, therefore, can be adjusted by varying the value of capacitor C1 to change the model's R1-C1 time constant.

Subprogram FCAP1 determines the value of capacitor C1, setting it equal to 550 picofarads, except when voltage E1 is less than voltage E2; capacitor C1 then assumes the value of 300 pF. Since output voltage E2 is equal to the voltage across capacitor C1, the relationship between the input-signal levels and the output voltage is established.

Because of the way that Circus-2 computes values, it is considerably more efficient to maintain capacitor C1 as a constant and, instead, vary its associated resistor, R1, to change the gate's time constant. In the Sceptre listing, therefore, C1 is varied while R1 is held constant, but in the Circus-2 listing, the reverse is true. Additionally, the Circus-2 program calls for routine RR72, rather than FCAP1; the two perform identical functions, but in RR72 resistor R1 is varied, and in FCAP1, capacitor C1 is varied.

The gate's output impedance, R2, is fixed at 30 ohms. Although this is not an accurate impedance representation for all voltage and load conditions, it does provide first-order accuracy for the output-signal level. Yet another zero-valued current source, JO, is included at the output as a dummy element to permit monitoring of the gate's output signal under varying conditions.

Four-input NAND-gate model

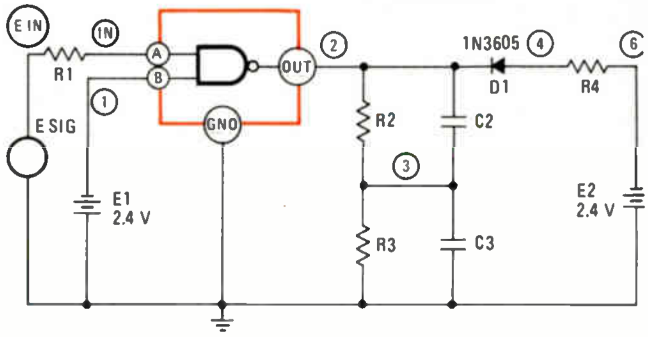
The four-input NAND gate behaves in the same manner as the two-input NAND gate—when all four input signals are logic 1, the gate's output is logic 0; for all other input-signal conditions, the output is logic 1. Figure 3 contains a schematic of this gate, as well as its computer model and Sceptre and Circus-2 program descriptions. (The voltage waveforms illustrating the device's delay characteristics look the same as those shown in Fig. 1 for the two-input gate.)

The electrical characteristics of the four-input gate can be approximated fairly accurately. Its maximum logic 1 output voltage can be regarded as 3.3 v, its maximum logic 0 output voltage as 0.4 v, its minimum logic 1 input voltage as 2.0 v, and its maximum logic 0 input voltage as 0.8 v. Propagation-delay times can also be estimated reasonably well. The negative-going output-transition time is 8 ns typical and 15 ns maximum, while the positive-going output transition time is 12 ns typical and 22 ns maximum.

As was done for the two-input gate, the program description for the four-input gate model includes subprograms to assure that the simulated gate will conform to the desired truth table. Here, the subprogram labeled FN4 establishes the gate's output-signal-level characteristics. The same subprogram, FCAP1 in Fig. 2, used to determine the delay characteristics of the two-input gate is used for the four-input gate.

The signal-input impedances, JA, JB, JC, and JD, are again represented as zero-valued current sources and may be made variable (for greater accuracy), as noted previously. Output impedance R2 is fixed at 25 ohms as a reasonable approximation.

TEST CIRCUIT



TEST CIRCUIT DESCRIPTION

```
TEST CIRCUIT FOR RSN54L00 2 INPUT NAND GATE
ELEMENTS
NA, IN-1-2-GND = MODEL L00
R2, 2-3 = 4300.
C2, 2-3 = 2.6E-12
R3, 3-GND = 750.
C3, 3-GND = 15.E-12
ESIG, GND-EIN = Q1 (.3, 3.,0., 19.E-19, 331.E-9, 19.E-9, 750.E-9, 1., TIME)
R1, EIN-IN = 50.
E1, GND-1 = 2.4
D1, 2-4 = MODEL 1N3605 (PERM)
R4, 4-5 = 800.
R5, 6-5 = 1.
E2, GND-6 = 2.4
RUN CONTROLS
STOP TIME = 999.E-9
 MAXIMUM PRINT POINTS = 100
MINIMUM STEP SIZE = 1.E-18
FUNCTIONS
Q1 (A, B, C, D, E, F, G, H, Y) = (FGEN (A, B, C, D, E, F, G, H, Y) )
OUTPUTS
ESIG, PLOT
END
```

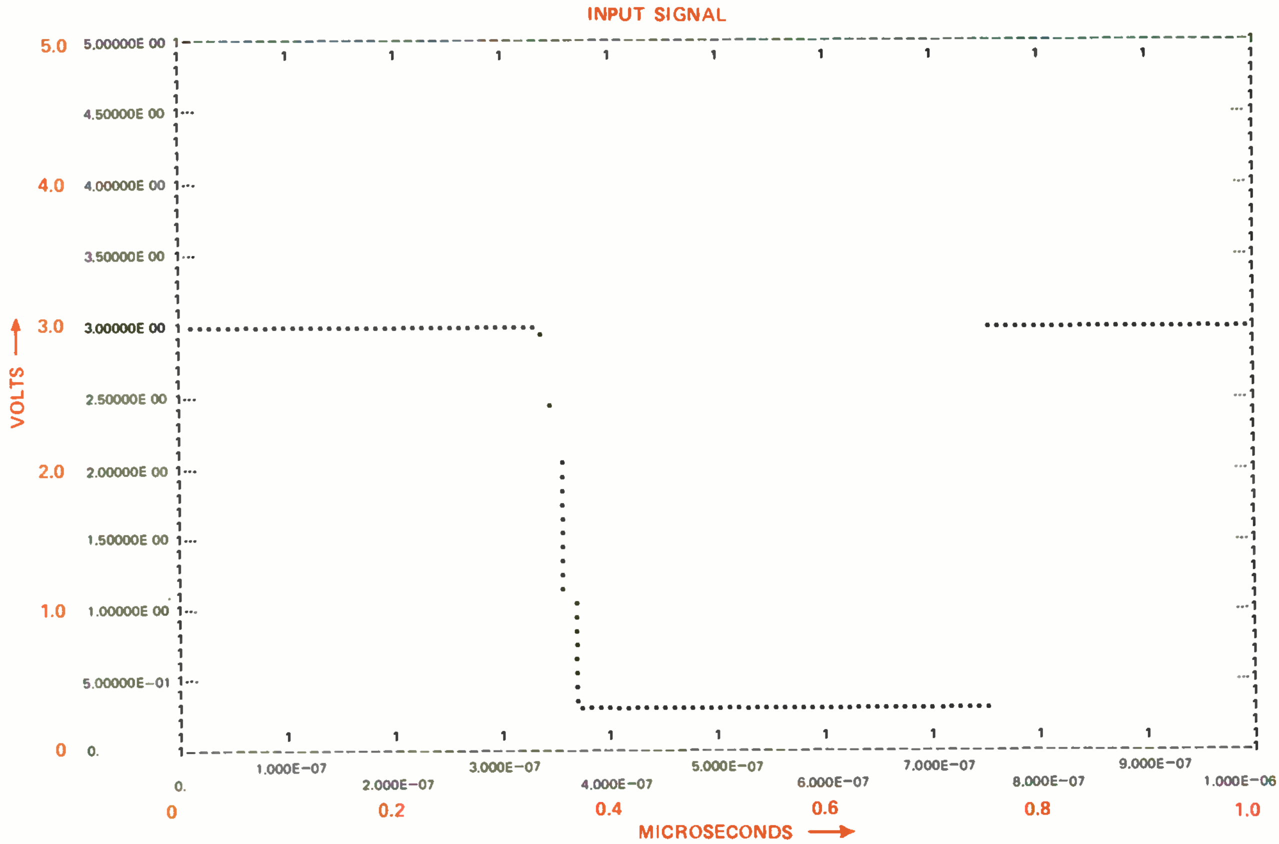
4. Model checkout. Performance of two-input NAND model closely agrees with the response of a real device.

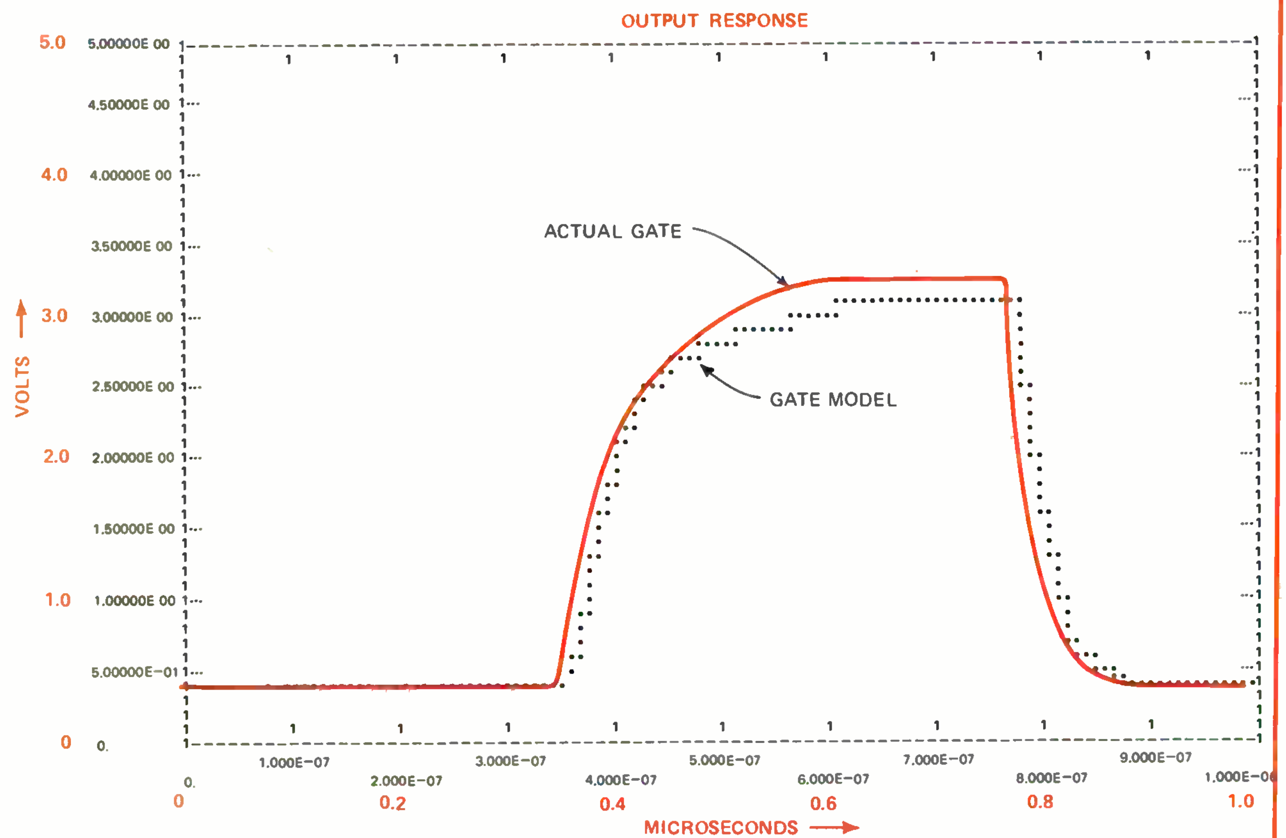
The voltage associated with dependent source E1 is determined by the subprogram function FN4 to agree with the gate's truth table. If any of the input signals is less than or equal to 0.8 v, then voltage E1 is set equal to 3.3 v to represent logic 1. When all of the input signals are equal to or greater than 2.0 v, the value of E1 is set at 0.4 v to represent logic 0. If neither of these conditions exists, then E1 is 3.3 v minus the absolute value of the smallest of the applied signals.

As for the two-input gate, the required delay times, t_{pd0} and t_{pd1}, are established in the model by the R1-C1 time constant. In the program listing, the value of capacitor C1 is set to either 150 or 200 pF, depending upon the voltage relationships between E1 and E2, and whether the output is rising, falling, or constant.

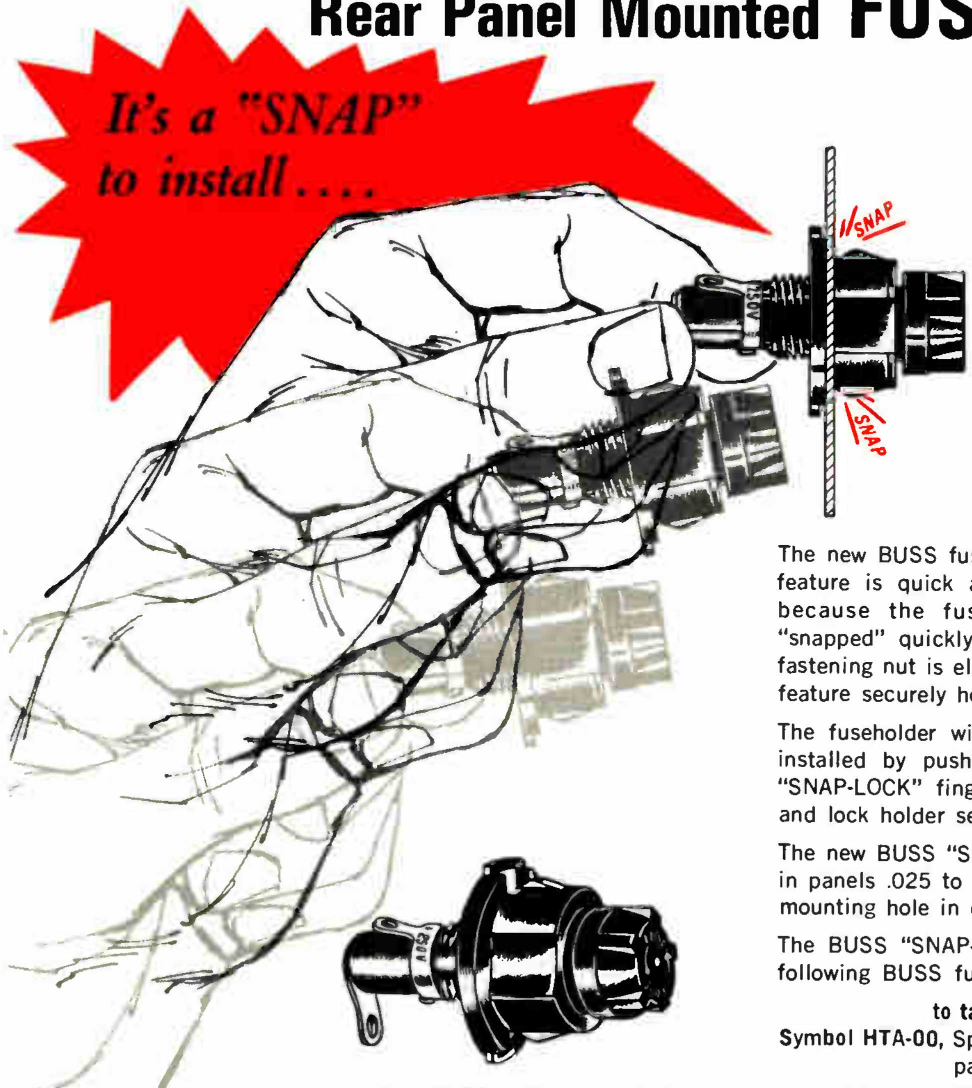
To demonstrate the validity of any computer model, the standard procedure is to compare the response of a computer-simulated test circuit with the response of an actual test circuit. For example, the two-input NAND gate can be tested with the circuit shown in Fig. 4.

A Sceptre topological description of this test circuit, which permits the gate's load (fanout) to be varied readily, is also given in the figure. The test signal shown is applied to one of the gate's inputs, while the other input is held at a logic 1 voltage level (2.4 v). The printout of output response shows how closely the model's behavior simulates that of an actual gate. □


INPUT SIGNAL
5.0
4.0
3.0
2.0
1.0
0
VOLTS
5.00000E 00
4.50000E 00
4.00000E 00
3.50000E 00
3.00000E 00
2.50000E 00
2.00000E 00
1.50000E 00
1.00000E 00
5.00000E-01
0.
0.
1.000E-07
2.000E-07
3.000E-07
4.000E-07
5.000E-07
6.000E-07
7.000E-07
8.000E-07
9.000E-07
1.000E-06
0
0.2
0.4
0.6
0.8
1.0
MICROSECONDS


OUTPUT RESPONSE
ACTUAL GATE
GATE MODEL
5.0
4.0
3.0
2.0
1.0
0
VOLTS
5.00000E 00
4.50000E 00
4.00000E 00
3.50000E 00
3.00000E 00
2.50000E 00
2.00000E 00
1.50000E 00
1.00000E 00
5.00000E-01
0.
0.
1.000E-07
2.000E-07
3.000E-07
4.000E-07
5.000E-07
6.000E-07
7.000E-07
8.000E-07
9.000E-07
0
0.2
0.4
0.6
0.8
1.0
MICROSECONDS

the New BUSS® SNAP-LOCK
Rear Panel Mounted FUSEHOLDERS



Easy...
Quick...
Time Saving...

HTA-00 Fuseholder-actual size

The new BUSS fuseholder with special "SNAP-LOCK" feature is quick and easy to install. It saves time because the fuseholder can be **pre-wired** and "snapped" quickly into place from rear of panel. A fastening nut is eliminated because the "SNAP-LOCK" feature securely holds the fuseholder in place.

The fuseholder with "SNAP-LOCK" feature is simply installed by pushing it into panel from rear side. "SNAP-LOCK" fingers engage edge of hole in panel and lock holder securely in place.

The new BUSS "SNAP-LOCK" fuseholder can be used in panels .025 to .085 inch thick. (See recommended mounting hole in dimensions below).

The BUSS "SNAP-LOCK" feature is available on the following BUSS fuseholders:

to take ¼x1¼ inch fuses:

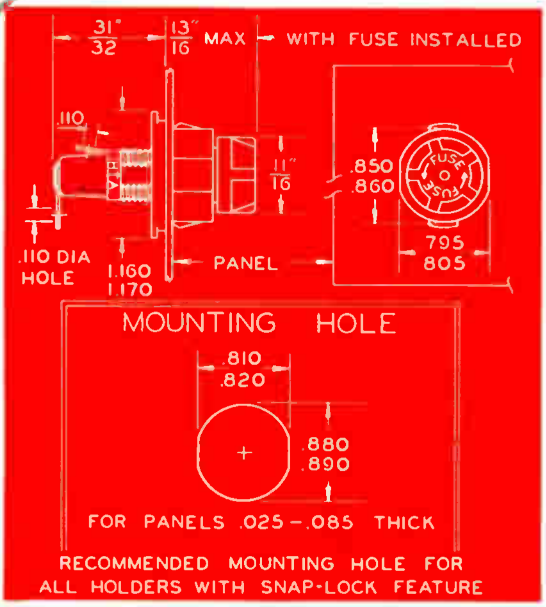
Symbol HTA-00, Space Saver, extends just 1 in. behind panel.

Symbol HLD-00, Visual Indicating Fuseholder.
Symbol HKP-00, Standard Fuseholder.

to take ¼x1 inch fuses:

Symbol HJM-00, Standard Fuseholder.

All are available with quick connect terminals, if so desired.



Dimensions of HTA-00 holder.
When tooling up for mounting get latest blueprint.

Also fits ½ in. knock-out in electrical boxes

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Microstrip matching networks can be designed fast with a Basic program

Parameter values necessary for the design of microstrip impedance-matching transformers are determined in seconds by a simple computer program; the equations solved by the computer are also presented and explained

by James J. Lev, *Autonetics Division, Rockwell International Corp., Anaheim, Calif.*

☐ A simple computer program in the Basic language enables a microstrip matching network to be designed in a fraction of the usual time. All it requires, besides access to a computer, is values for six device and material characteristics, plus two assumptions about the device to be matched.

Upon entry of the required data, the computer will calculate and print out the length, width, and characteristic impedance of the microstrip transmission line required to effect a basic impedance match (i.e., a match accomplished with a single length of constant-width line). If such an impedance transformation cannot be obtained from the given data, the computer will print BASIC MATCH NOT POSSIBLE WITH DATA ENTERED and await new instructions.

Two network conditions must be met before the simplified design can be used. First, the active device to be matched must be unconditionally stable. Second, it must be assumed that the device be unilateral, which, simply stated, means that it must have a high level of output-to-input isolation. In practical applications, however, both conditions are often met.

For a device to be unconditionally stable, it must be capable of being driven and terminated in any impedance without producing oscillations. Consequently, its scattering parameters, S_{11} and S_{22}, must be less than unity. In addition, its stability factor, K, must have a value that is greater than unity and positive. The K factor is computed from:

$$K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2|S_{21}S_{12}|}$$

where $\Delta = S_{11}S_{22} - S_{21}S_{12}$

The second condition, that the device be assumed to be unilateral, is valid where S_{12} is negligibly small in the equation for network gain:[3,4]

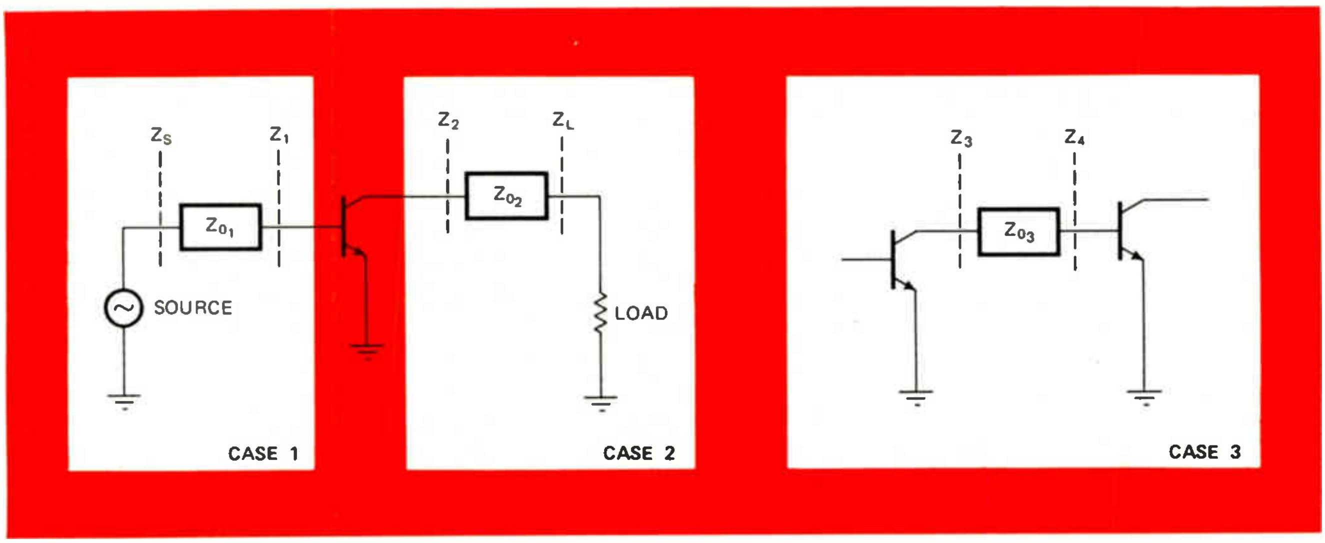
$$G_T = \frac{|S_{21}|^2(1 - |\Gamma_S|^2)(1 - |\Gamma_L|^2)}{|(1 - S_{11}\Gamma_S)(1 - S_{22}\Gamma_L) - S_{21}S_{12}\Gamma_L\Gamma_S|^2}$$

where Γ_S is the source reflection coefficient, and Γ_L is the load-reflection coefficient.

Exactly how small S_{12} must be is difficult to determine. However, the assumption is generally considered valid if the resulting error in device gain is less than 1 decibel.

What the program does

The program computes design data for any of the three fundamental cases of matching networks shown in Fig. 1. Together, these fundamental cases cover all situ-



1. Three matches. These three cases together cover all situations in designing matching networks. In cases 1 and 2, the complex input and output impedances of a transistor stage are matched to the characteristic impedances of transmission lines connecting the source and load, respectively. In case 3, an optimum match is achieved between the complex impedances of two transistor stages.

```
100 REM PRØGRAM FØR MICRØSTRIP MATCHING
110 PRINT"ENTER DATA";
120 INPUT A,B,C,D,E,F,G,H,I
130 IF A<1 THEN 160
140 IF A>3 THEN 160
150 GØ TØ 180
160 PRINT"INPUT DATA NØT IN CØRRECT FØRMAT. RETYPE IT."
170 GØ TØ 110
180 PRINT
190 PRINT
200 PRINT"                              DATA ENTERED"
210 PRINT
220 IF A<>1 THEN 410
230 IF C<>0 THEN 160
240 PRINT"      SØURCE IMPEDANCE        =    ",B,"ØHMS"
250 IF E>=0 THEN 270
260 IF E<0 THEN 290
270 PRINT"      IMPEDANCE NUMBER 1      =    ",D;"+J";ABS(E),"ØHMS"
280 GØ TØ 360
290 PRINT"      IMPEDANCE NUMBER 1      =    ",D;"-J";ABS(E),"ØHMS"
300 GØ TØ 360
310 IF E>=0 THEN 330
320 IF E<0 THEN 350
330 PRINT"      IMPEDANCE NUMBER 2      =    ",D;"+J";ABS(E),"ØHMS"
340 GØ TØ 360
350 PRINT"      IMPEDANCE NUMBER 2      =    ",D;"-J";ABS(E),"ØHMS"
360 PRINT"      FREQUENCY               =    ",F,"GHZ"
370 PRINT"      DIELECTRIC CØNSTANT     =    ",G
380 PRINT"      SUBSTRATE THICKNESS     =    ",H,"IN"
390 PRINT"      CØNDUCTØR THICKNESS     =    ",I,"IN"
400 GØ TØ 530
410 IF A=3 THEN 440
420 PRINT"      LØAD IMPEDANCE          =    ",B,"ØHMS"
430 GØ TØ 310
440 IF E<0 THEN 470
450 PRINT"      IMPEDANCE NUMBER 3      =    ",D;"+J";ABS(E),"ØHMS"
460 GØ TØ 480
470 PRINT"      IMPEDANCE NUMBER 3      =    ",D;"-J";ABS(E),"ØHMS"
480 IF C<0 THEN 510
490 PRINT"      IMPEDANCE NUMBER 4      =    ",B;"+J";ABS(C),"ØHMS"
500 GØ TØ 360
510 PRINT"      IMPEDANCE NUMBER 4      =    ",B;"-J";ABS(C),"ØHMS"
520 GØ TØ 360
530 IF D-B=0 THEN 570
540 LET Y=((C*D+B*E)*(E+(((D-B)*(B*D-C*E))/((C*D)+(B*E)))-C))/(D-B)
550 IF Y<=0 THEN 570
560 GØ TØ 600
570 PRINT
580 PRINT"BASIC MATCH NØT PØSSIBLE WITH DATA ENTERED."
590 GØ TØ 1400
600 LET Z=SQR(Y)
610 PRINT
620 IF A=3 THEN 680
630 IF A=2 THEN 660
640 PRINT"                     INPUT NETWØRK LINE PARAMETERS"
650 GØ TØ 690
660 PRINT"                     ØUTPUT NETWØRK LINE PARAMETERS"
670 GØ TØ 690
680 PRINT"                  INTERSTAGE NETWØRK LINE PARAMETERS"
690 PRINT
700 LET X=Z*(D-B)
710 LET W=C*D+B*E
720 IF X=0 THEN 800
730 IF W=0 THEN 850
740 LET R=ABS(X/W)
750 IF R>2↑24 THEN 850
760 LET Q=(ATN(X/W)*(180/3.14159265))
770 IF W>0 THEN 870
780 LET K=Q+((X/ABS(X))*180)
790 GØ TØ 880
800 IF W=0 THEN 880
810 IF W<0 THEN 830
820 GØ TØ 740
830 LET K=180
840 GØ TØ 880
850 LET K=(X/ABS(X))*90
860 GØ TØ 880
870 LET K=0
880 LET M=K/360
890 IF M<0 THEN 920
900 LET N=M
910 GØ TØ 930
920 LET N=.5+M
930 IF F=0 THEN 570
940 LET Q=2.997925E10/(F*2.54E9)
950 IF G<=0 THEN 570
960 LET L1=(N*Q)/SQR(G)
970 IF H<=0 THEN 570
980 IF I<=0 THEN 570
990 LET P=0
1000 LET E1=(I/3.14159265)*(LØG((2*H)/I)+1)
1010 LET T1=0
1020 LET T2=E1+T1
1030 LET P9=376.819437*H
1040 LET E2=P9/(SQR(G)*T2*(1+1.735*G↑(-.0724)*(T2/H)↑(-.836)))
1050 LET D1=E2-Z
1060 IF P=1 THEN 1150
1070 IF P=2 THEN 1210
1080 IF P=3 THEN 1270
1090 IF D1<0 THEN 1120
1100 LET T1=T1+1E-2
1110 GØ TØ 1020
1120 LET T1=T1-1E-2
1130 LET P=1
1140 GØ TØ 1020
1150 IF D1<0 THEN 1180
1160 LET T1=T1+1E-3
1170 GØ TØ 1020
1180 LET T1=T1-1E-3
1190 LET P=2
1200 GØ TØ 1020
1210 IF D1<0 THEN 1240
1220 LET T1=T1+1E-4
1230 GØ TØ 1020
1240 LET T1=T1-1E-4
1250 LET P=3
1260 GØ TØ 1020
1270 IF D1<0 THEN 1300
1280 LET T1=T1+1E-5
1290 GØ TØ 1020
1300 LET T1=T1-1E-5
1310 LET W2=T1/H
1320 IF W2>=0.6 THEN 1350
1330 LET K1=SQR(G/(1+0.6*(G-1)*((T2/H)↑0.0297)))
1340 GØ TØ 1360
1350 LET K1=SQR(G/(1+0.63*(G-1)*((T2/H)↑0.1255)))
1360 LET L=L1*K1
1370 PRINT"     IMPEDANCE                 =    ",Z,"ØHMS"
1380 PRINT"     LENGTH                    =    ",L,"IN"
1390 PRINT"     WIDTH                     =    ",T1,"IN"
1400 PRINT
1410 PRINT
1420 PRINT
1430 GØ TØ 110
1440 END
```

2. Basic program. Microstrip transformer can be designed quickly with the help of computer listing written in Basic language.

ations encountered in both single- and multi-stage amplifier design.

In case 1, the complex conjugate of the device input impedance, Z_1, is matched to a source impedance, Z_s, via a transmission line of characteristic impedance Z_{o1}. In case 2, the complex conjugate of the device's output impedance, Z_2, is matched to a load impedance, Z_L, via a transmission line of characteristic impedance Z_{o2}. For case 3, the complex conjugate of the output impedance, Z_3, of one device is matched to the complex input impedance, Z_4, of a subsequent stage via a transmission line of characteristic impedance Z_{o3}.

Impedances Z_1 through Z_4 in Fig. 1 are the scattering parameters, or their complex conjugates, for the respective devices. For example, Z_4 would be S_{11} of the driven device in case 3, and Z_3 would be the complex conjugate of S_{22} of the driving device.

The S-parameter values can be measured on a network analyzer or, in many cases, obtained from manufacturers' data sheets.

The computer program is shown in its entirety in Fig. 2. Statement 120 is used to input the nine data variables, as defined in the table on page 129, that are required to find the three transmission-line parameters.

The program is interactive. After it has been loaded onto the machine, the computer prints ENTER DATA? and waits. The numerical data values must then be entered in serial form, each separated by a comma. A 50-ohm source impedance, for instance, would enter as 50,0 while a Z_3 of the 10 – j25 ohms would be entered as 10, -25,.

A few examples will illustrate the method of data entry and the resulting computer printout:

First, consider the design of an input-matching transformer for a special-purpose amplifier operating at 1.25 gigahertz and driven by a 50-ohm source. The device manufacturer specifies an optimum matching impedance for maximum gain of 70 + j20 ohms. The prototype circuit is to use 1/32-inch-thick Teflon material with a relative dielectric constant, ε_r, of 2.37 at the required operating frequency. The conducter is 1.4-mil copper. The data entry and computer printout for this example are shown in Fig. 3a.

Second, given the parameters of the above example, it may be necessary also to match the output of the device to a 50-ohm load. A network analyzer shows that S_{22} for the device is 120 – j80 ohms. Data entry and computer printout for this example are shown in Fig. 3b.

Alternatively, instead of matching the output of the device in the above example to a transmission line, it may be desirable to construct a two-stage amplifier. For this case, suppose the S_{11} of the device in the second stage to be 15 – j11 ohms. Data entry and computer print-out for this example are shown in Fig. 3c.

Equations solved on computer

To make full use of the program, it is helpful to take a closer look at the equations being solved. For a lossless line:[5]

$$Z_S = Z_o \frac{Z_L \cos\beta l + jZ_o \sin\beta l}{Z_o \cos\beta l + jZ_L \sin\beta l} \qquad (1)$$

where Z_o = characteristic impedance of the transmission line, Z_S = input impedance, Z_L = load impedance, l = the length of the matching transformer, and B = $2\pi/\lambda$. Here, λ is the effective wavelength of the signal in the microstrip transmission line. It is calculated to be:

$$\lambda = \frac{k\lambda_o}{\sqrt{\varepsilon_r}}$$

where λ_o = wavelength in free space, ε_r = the relative dielectric constant of the microstrip insulator, and k is a correction factor that is readily determined using equations developed by Sobol.[6] This k factor adjusts for the fact that propagation along the line is in a quasi-TEM mode rather than the strictly TEM mode of a coaxial line.

Replacing Z_L and Z_S with general complex impedances b = jc and d + je, respectively, and then equating real and imaginary parts, equations for Z_o and l are derived to be:

$$Z_o = \left[\frac{(cd+be)\left[e + \dfrac{(d-b)(bd-ce)}{cd+be} - c\right]}{d-b}\right]^{1/2} \qquad (2)$$

$$l = \frac{\lambda}{2\pi}\left[\tan^{-1}\left(\frac{Z_o(d-b)}{cd+be}\right)\right] \qquad (3)$$

Note that if Z_L and Z_S are real, c = e = o, and equations 2 and 3 reduce to:

$$Z_o = \sqrt{bd} \quad \text{and}$$
$$l = \lambda/4$$

which are well-known expressions that define a quarter-wavelength matching transformer.

The width, W, of the transformer section is determined after the section's characteristic impedance, Z_o, is known. This requires an interactive trial-and-error solution of the equation referred to by Sobol as follows:[6]

$$Z_o = \frac{\eta h}{\sqrt{\varepsilon_r}\, W\left[1 + 1.735\varepsilon_r^{-0.0724}\left(\frac{W}{h}\right)^{-0.836}\right]} \qquad (4)$$

Here, η = the free space impedance of the line, and h = the substrate thickness. □

```
ENTER DATA? 1,50,0,70,+20,1.296,2.37,.0282,.0014              (a)

                        DATA ENTERED

    SØURCE IMPEDANCE          =              50             ØHMS
    IMPEDANCE NUMBER 1        =              70    +J 20    ØHMS
    FREQUENCY                 =              1.296          GHZ
    DIELECTRIC CØNSTANT       =              2.37
    SUBSTRATE THICKNESS       =              .0282          IN
    CØNDUCTØR THICKNESS       =              .0014          IN

                INPUT NETWØRK LINE PARAMETERS

    IMPEDANCE                 =              67.082         ØHMS
    LENGTH                    =              .970045        IN
    WIDTH                     =              .04997         IN


ENTER DATA? 2,50,0,120,+80,1.296,2.37,.0282,.0014
                                                              (b)
                        DATA ENTERED

    LØAD IMPEDANCE            =              50             ØHMS
    IMPEDANCE NUMBER 2        =              120   +J 80    ØHMS
    FREQUENCY                 =              1.296          GHZ
    DIELECTRIC CØNSTANT       =              2.37
    SUBSTRATE THICKNESS       =              .0282          IN
    CØNDUCTØR THICKNESS       =              .0014          IN

                ØUTPUT NETWØRK LINE PARAMETERS

    IMPEDANCE                 =              102.817        ØHMS
    LENGTH                    =              1.13637        IN
    WIDTH                     =              .02066         IN


ENTER DATA? 3,15,-11,120,+80,1.296,2.37,.0282,.0014

                        DATA ENTERED                          (c)

    IMPEDANCE NUMBER 3        =              120   +J 80    ØHMS
    IMPEDANCE NUMBER 4        =              15    -J 11    ØHMS
    FREQUENCY                 =              1.296          GHZ
    DIELECTRIC CØNSTANT       =              2.37
    SUBSTRATE THICKNESS       =              .0282          IN
    CØNDUCTØR THICKNESS       =              .0014          IN

              INTERSTAGE NETWØRK LINE PARAMETERS

    IMPEDANCE                 =              50.7543        ØHMS
    LENGTH                    =              1.63884        IN
    WIDTH                     =              .07922         IN
```

3. Sample printouts. From data on device performance and microstrip materials, the computer calculates matching-network line parameters for three application examples.

DEFINITIONS OF DATA INPUT AND OUTPUT

Data Variable	Definition
A	1, 2, or 3 corresponding to case 1, 2, or 3.
B, C	Real and imaginary parts of the Z_S, Z_L, or Z_4 (ohms).
D, E	Real and imaginary parts of Z_1, Z_2, or Z_3 (ohms).
F	Frequency (GHz).
G	Relative dielectric constant of substrate.
H	Substrate thickness (in.).
I	Conductor thickness (in.).

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5. J.L. Potter and S.J. Fich, "Theory of Networks and Lines," Prentice-Hall Inc., Englewood Cliffs, N.J., 1963.
6. H. Sobol, "Extending IC technology to microwave equipment," Electronics, March 10, 1967, pp. 112-124.

Straight talk about today's hi-rel semiconductor shortages. And why it pays military and other hi-rel users to specify Raytheon Semiconductor.

There's no question about it. Semiconductor shortages are really here. Demand is exceeding supply by twenty-five percent. And there's no relief in sight.

Those who feel the pinch most are the military/government and high-reliability commercial users. Who above all cannot accept standard grade semiconductors as substitutes.

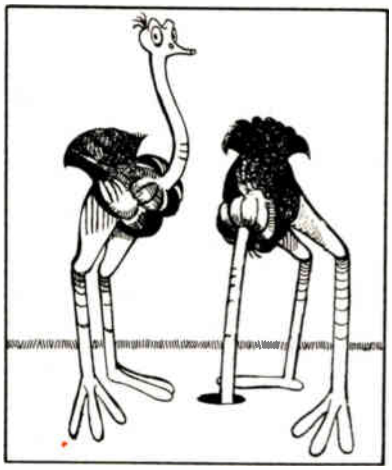
Most other suppliers would prefer to fill orders from the high volume commercial, industrial, and computer markets. And let the military and hi-rel commercial business take what's left. Or simply go without.

Not at Raytheon Semiconductor. We've built our standard commercial business around our basic military and hi-rel nucleus. Instead of the other way around.

Sure. We have a going commercial market. And we are pursuing it vigorously. But not at the expense of our military and hi-rel commercial business.

The other suppliers would rather handle these more "glamorous" burgeoning markets— the calculator, automobile, home electronics — because the volume is great and the design specifications relatively inexpensive on a cost-per-run basis. And because today's commercial contract isn't tomorrow's military cancellation.

We think this attitude is myopic.

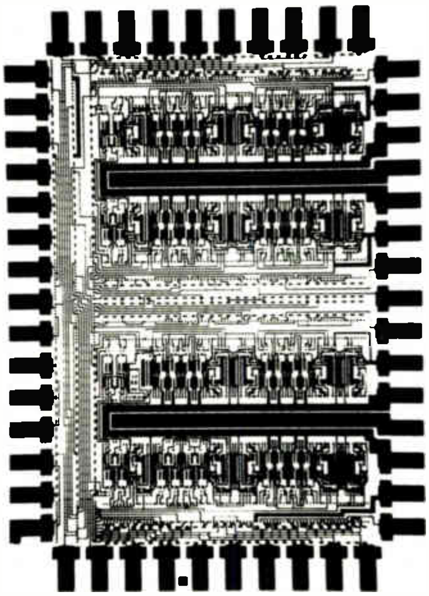


Contrary to the current trend, Raytheon Semiconductor's management is dedicated to continue its pursuit of military and hi-rel business. Not half-heartedly. But with a firm commitment. Just because there's larger volume in more standard commercial designs doesn't mean that it's a more attractive business. Not at Raytheon Semiconductor. Not the way we manage and discipline our military and hi-rel business. Furthermore, this competency becomes well known and establishes a strong loyalty.

Why should there be anything taboo about the military business?

Every day, more and more military requisitioners are asking: "But where am I going to get parts?" And most semiconductor suppliers don't seem to care. Their long-term marketing directions and the military business are at odds. They will tell you a variety of things. To design away from your special packages and custom devices. Or not to use your own unique specifications. But switch to standards. Consolidate your designs into fewer types so that volume will increase. In other words, stick to the industry standard of off-the-shelf components — popular, high volume, standard packages. Or else.

We have always reacted quickly to military and hi-rel needs.



When you need linear or digital IC's, beam-lead chips or JAN TXV transistors for very hi-rel programs of a custom nature, you want them now. Raytheon Semiconductor caters to these very sophisticated requirements. Now. And doesn't ask you to stand in line 12 to 24 months to get them.

We are totally dedicated to the long-term needs of military and other hi-rel customers.

Our track record speaks for itself. We're still delivering a variety of linear and digital IC's and transistors for the Hawk, Sidewinder, Maverick, Sparrow, and Minuteman missile programs. That's why we're not giving up the old just for the sake of the new. We're committed to products such as 930 Series DTL

ROCKWELL INTERNATIONAL SPACE DIV

and SUHL that many suppliers are phasing out. After all, why should we give up a good profit maker.

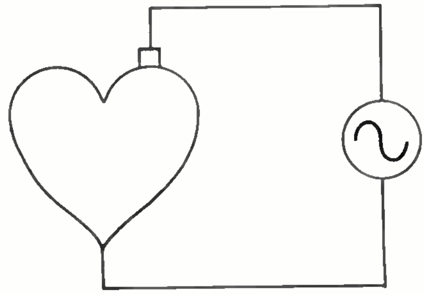
In several space programs we've been a major semiconductor source. Apollo used our 101, 709, and 741 op amps. More than three thousand of our 709's went into Skylab. And we still furnish Agena with transistors and the 930 Series.

The Viking Mars mission scheduled for 1975 will use our transistors, IC op amps, multivibrators and voltage regulators.

And, because of our leadership in beam-lead technology, we're heavily involved with development programs for the SAM-D, Trident C-4, and the B-1.

When it comes to reliability, there's none better than Raytheon Semiconductor.

Let others base their future semiconductor growth on glamorous new products for standard commercial needs. We're building our commercial market around our basic military and hi-rel nucleus. Which explains why Raytheon Semiconductor products are integral to a heart pacer, hearing aids, a solid-state digital watch, and an antiskid



mechanism for the automotive industry. Examples of the hi-rel and advanced beam-lead technology that enhanced the reliability of these exotic new commercial products.

We'll always give you straight answers.

To help solve your military and hi-rel commercial problems contact our Hi-Rel Marketing Manager.

For a copy of Raytheon Semiconductor's hi-rel brochure, called *RayRel*, write us on your company's letterhead. And if you want copies of our Update 1 and 2, we'll be glad to send them along too.

Raytheon Semiconductor, 350 Ellis Street, Mountain View, CA 94042, (415) 968-9211.

RAYTHEON

Digital voltmeters

The usefulness of the ubiquitous digital voltmeter can be extended beyond the traditional applications for which it was designed. For example, in this past year, Engineer's Notebook has included ideas for measuring low-picoampere currents with a regular voltmeter [Feb. 15, p.118], for converting a voltmeter to a linear ohmmeter [March 1, p.102], and for determining the value of any ac waveform with any type of ac voltmeter [Aug. 3, p.104–105]. The ideas in this issue's Engineer's Notebook offer additional ways to extend the applications versatility of your digital voltmeter. And in case you don't have one, there's a Notebook that tells you how to build your own.

—Lucinda Mattera, Circuit Design Editor

Building your own digital voltmeter

by Don Aldridge
Motorola Semiconductor Products, Inc., Phoenix, Ariz.

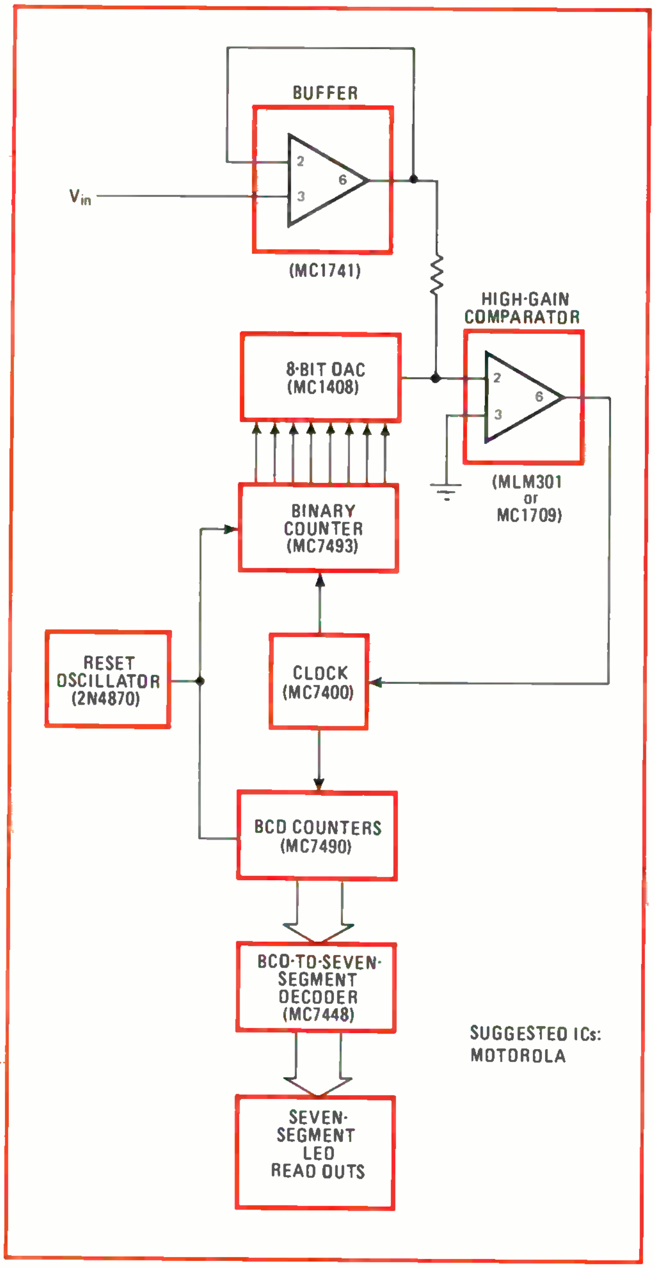
Currently available low-cost digital-to-analog converters are making it possible to design digital voltmeters that are inexpensive and yet that are reasonably accurate. Here's a suggestion for building a 2-2/3-digit (0 to 255 counts) DVM for approximately $35.

The meter is a closed-loop system that uses a clocked binary counter feeding a digital-to-analog converter to produce a staircase ramp function. The output of the converter is compared to the unknown input signal, and the clock pulse is terminated when the input signal level and the staircase function level are equal.

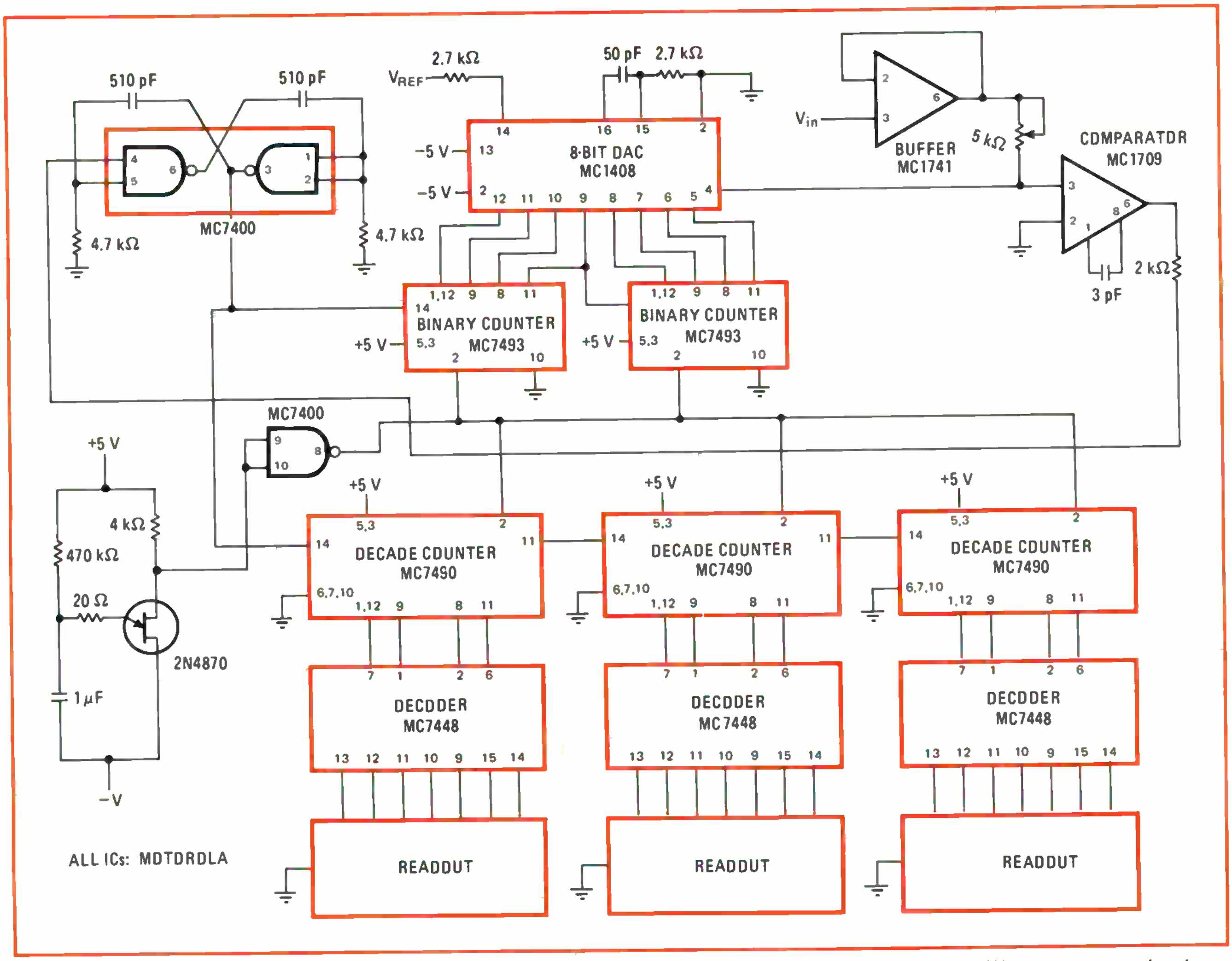
Clock pulses are generated by two cross-coupled TTL NAND gates. The clock frequency is set for 330 kilohertz so that a maximum of 256 counts is provided in less than a millisecond. A high-speed clock like this allows the counting to be done without being detected in the display by the human eye. A fast clock also avoids the need to have latches store the previous total count while the system is sampling and counting. The clock pulses are applied to two sets of counters—a binary counter chain in the feedback loop that controls the converter, and a binary-coded-decimal counter chain that provides an easy interface with the seven-segment digital readouts.

The d-a converter generates an output sink current that is proportional to the value of the applied digital word. The maximum full-scale value of this current, which is typically 2.0 milliamperes is set by a reference voltage and a reference resistor. The converter's output current is compared with the current from an input buffer amplifier. This buffer amplifier provides the meter with a high input impedance while supplying an output current of up to 2.0 mA for comparison with the converter output.

A second amplifier acts as a high-gain comparator to stop the clock when the current ramp from the conver-



DVM outline. Economical but accurate 2-2/3 digit voltmeter takes advantage of today's low-cost digital-to-analog converters.



DVM details. Unknown input signal is compared to the output current from the digital-to-analog converter. When these two signals are equal, the clock is stopped. The same clock is used to drive the converter's binary counters and the display's BCD counters.

ter exceeds the current from the input buffer amplifier. A unijunction-transistor oscillator is used to reset both sets of counters so that the unknown voltage is resampled about every 0.5 seconds. And BCD-to-seven-segment decoders convert the outputs of the BCD counters to the proper format for the seven-segment light-emitting-diode displays.

For the components used here, the meter can measure up to 2.55 v (to within ±5 millivolts) in 10-mv steps. Different full-scale values can be obtained by using suitable input voltage dividers or by providing a fixed-gain, rather than a unity-gain, input buffer. □

Digital voltmeters

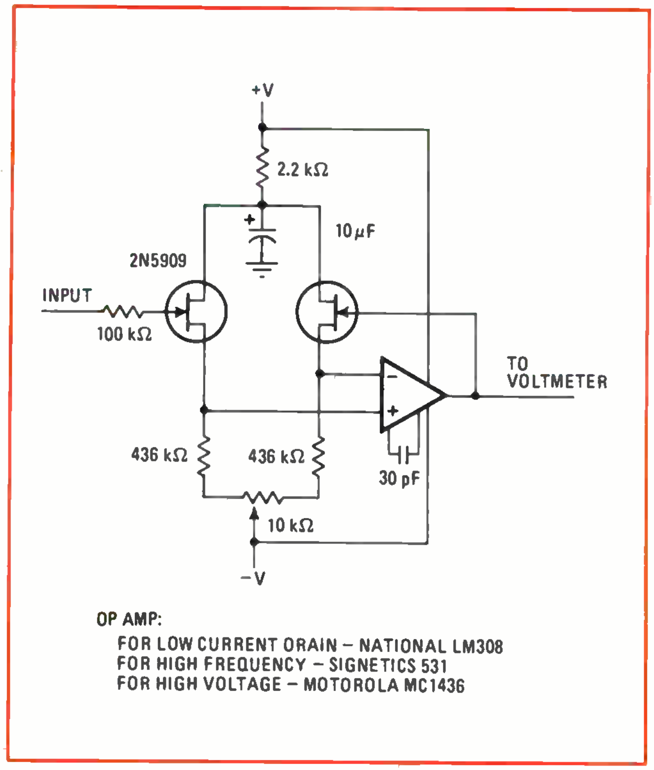
Increasing voltmeter input impedance to 10^{12} ohms

by J.R. Laughlin
San Jacinto College, Pasadena, Texas

Most commercial voltmeters, whether they have analog or digital readouts, provide relatively low input impedances, only on the order of 10 megohms, which makes accurate voltage measurements difficult for many circuits. But, by combining a couple of low-leakage field-effect transistors with an operational amplifier, you can raise the input resistance of your voltmeter to approximately 1,000,000 megohms.

Any dc voltage applied to the gate of the input FET will be reproduced at the circuit's output with sufficient amplitude to drive any type of voltmeter. If Motorola's type MC1436 op amp is used with a 35-volt supply, the circuit can handle input voltages as high as 30 v without an attenuator. If a wide frequency response is desired, Signetics' type 531 op amp can be used with a lower supply voltage. And, because of its low current drain, National's type LM308 op amp is best for battery-operated voltmeters.

A voltage divider to ground at the circuit's input permits higher voltage measurements to be made, but significantly lowers the circuit's input resistance. However,



since FET gate-leakage current is in the low-picoampere range, the resistors used for the voltage divider can have values that are quite large without introducing significant errors. For example, a 1,000-megohm resistor to ground, along with another resistor having the appropriate value to obtain the desired ranging, will still provide an unusually high input resistance of several thousand megohms.

Great care must be taken to prevent extraneous leakage paths to ground. You will invariably degrade the circuit's input resistance considerably by using standard binding posts, or by providing a switching arrangement for the voltage divider, or by terminating the input FET's gate lead on a circuit board.

The circuit will handle ac voltages, although its input impedance will be reduced somewhat by stray capacitance. However, even this lowered input impedance will be much higher than what is usually available from commercial instruments.

The 10-kilohm potentiometer can be used to counteract op-amp offset and drift or to zero whatever offset voltage may result when very high resistance values are used for a voltage divider. □

High-Impedance Input. FET circuit lets you raise the input resistance of any voltmeter to 1,000,000 megohms, a factor of 10^5.

Digital voltmeters

Getting the most out of the digital multimeter

by Louis M. Xuster, Jr.
IBM Korp., Kingston, N.Y.

Your digital multimeter can be used in many more ways than the function switch on the front panel indicates. When it is set to measure resistance, the digital multimeter can be thought of as a precision current source plus a digital voltmeter, a combination that can be used for measurements other than determining resistance values.

To do these other jobs with your multimeter, you must first "calibrate" its ohms range settings. As an example, consider the Fluke model 8000A—its "calibration" table is:

Ohms range setting	Current	Full-scale voltage
200Ω	5 mA	0.2 v
2 kΩ	5 mA	2 v
20 kΩ	0.1 mA	2 v
200 kΩ	1 μA	0.2 v
2 MΩ	1 μA	2 v
20 MΩ	0.1 μA	2 v

The meter's precision current source can now be used to check current meters or to bias a circuit. Also, the forward voltage through a pn junction can be measured at various currents. This is useful for determining whether a device is silicon or germanium, or to match the junction voltages of two or more transistors, or to match diodes, or to compute the effective series resistance of a junction from two readings.

You can even measure capacitance, including very large values. First connect the meter across the capacitor (observe polarity) and then short the capacitor with a jumper. When the meter reading goes to zero, remove the short and time the reading with a stopwatch. Stop the watch when the reading reaches 1,000. For the Fluke 8000A:

Ohms range setting	Each second is equal to:
200 Ω	10,000 μF
2 kΩ	1,000 μF
20 kΩ	100 μF
200 kΩ	10 μF
2 MΩ	1 μF
20 MΩ	0.1 μF

Additionally, you can use your multimeter to determine the internal resistance of a battery, one that supplies under 2 v, by computing the difference between two readings. Simply subtract the battery's no-load voltage from the voltage reading obtained on the 2-kilohm ohms range setting. This yields the battery resistance in kilohms. For instance, suppose the no-load voltage measures 1.533 v and the "2-kilohm" reading is 1.563:

$$1.563 - 1.553 = 0.010 \text{ kilohms} = 10 \text{ ohms}$$

Furthermore, you can take data for plotting a battery's charge/discharge curve. □

Engineer's notebook is a regular feature in Electronics. We invite readers to submit original design shortcuts, calculation aids, measurement and test techniques, and other ideas for saving engineering time or cost. We'll pay $50 for each item published.

Engineer's newsletter

Who said a transfer oscillator can't take 1-MHz modulation?

Here's more on making measurements with microwave frequency counters. An earlier item [*Electronics*, Sept. 27, p. 131] said that transfer oscillators cannot tolerate much modulation on the signals they measure. However, according to Dick Schneider of Hewlett-Packard's Santa Clara division, **a transfer oscillator's deviation tolerance increases by at least 6 decibels per octave,** so that, for sufficiently strong signals, measurements actually can be made even when the modulation bandwidth exceeds 1 megahertz. In fact, Schneider states, **an H-P automatic transfer oscillator can be used to measure communications carriers with modulation rates in excess of 8 MHz.**

An active way around a passive shortage

Beat the shortage of passive components by using active devices instead, like back-biased transistors for resistive loads, diodes for blocking capacitors, and a FET if you need a variable resistance. **For an inductor, an op amp and an appropriate feedback network will make the op amp's gain roll-off simulate an inductive input impedance.** Besides getting around long order delays, the technique extracts fairly high inductance values (several hundred microhenries) out of small op-amp packages. **What's more, even cheap op amps have good temperature-compensation specs, which cheap inductors don't.** Fairchild Semiconductor's application note App 321 describes the technique in detail.

Look into plastic alternatives to glass

Though cheaper than glass lenses, **the new plastic lenses can do many jobs just as well, such as magnifying a panel indicator or a LED display. Magnification is typically 30%.** These little lenses, in fact, more than pay their freight by letting you use smaller, cheaper LEDs, says the "Handbook of Plastic Optics," from Precision Lens, Cincinnati.

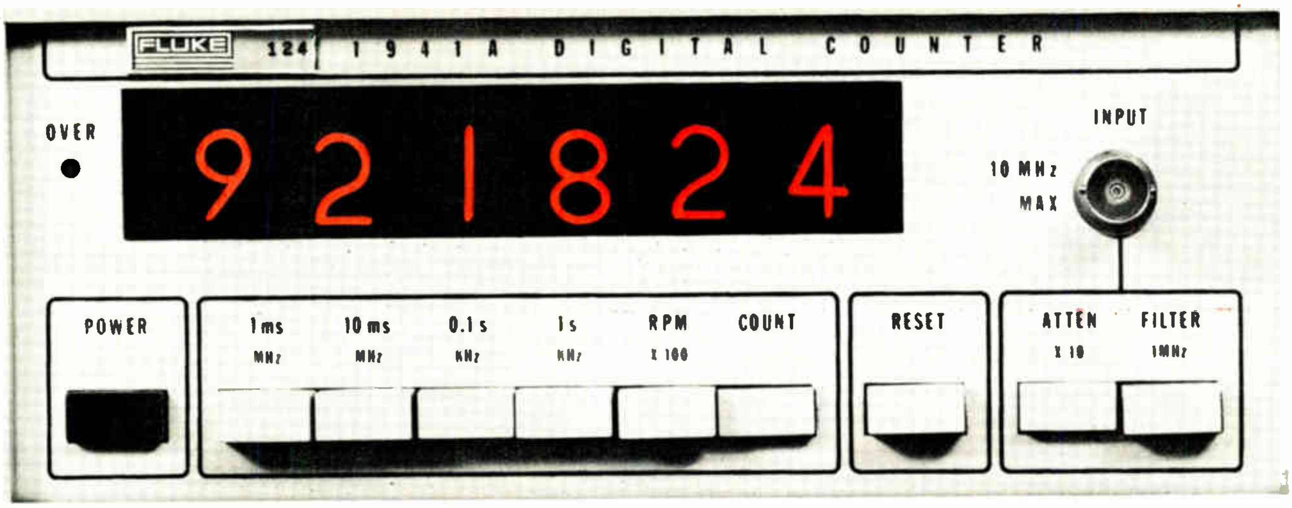
Washing away spacer problems

A clever way of getting uniform component spacing above pc boards is to **put soluble disks between the component and board before soldering.** Available from Bivar, Santa Ana, Calif. 92705, the disks come in assorted sizes and can simply be washed away in hot or cold water.

Inductor speeds up transistor switching

When no negative supply voltage is available but you need to switch a transistor quickly (as in switching regulators where slow on/off transitions cause high dissipation and low efficiency), **connect an inductor and resistor in series between the transistor's base and emitter.** This technique, suggested by Ulf Andersson, ADDO AB, Malmö, Sweden, exploits the fundamental principle that the current through an inductor cannot change instantaneously.

With this configuration, when the drive current is removed from a conducting transistor, inductor current cannot abruptly go to zero, transistor base current is reversed, and the translator turns off quickly. Alternatively, when the drive current is applied, inductor current rises from zero slowly, the transistor receives all the drive current for a short time, and it turns on quickly. **The inductor and the resistor (which limits inductor current) should be selected so that inductor current about equals transistor-base current during the transistor's turn-on time.**



Simply the best low cost counter you can buy.....$299.

Now you can buy an economical counter with noise immunity and programmable offset to measure frequency, read rpm directly, or totalize events.

From lab to the production line, here's a rugged low-cost counter with all the most needed features to make industrial and laboratory measurements.

A unique digital frequency counter, the new Fluke Model 1941A operates over a frequency range of 5 Hz to 40 MHz. It measures frequency, reads rpm directly and totalizes. Sensitivity is better than 40 mV rms. Aging rate is a low 6×10^{-7} /day.

All functions are easily selectable and clearly marked. Read out is a big six-digit display clearly readable from a distance in high ambient light.

frequency

rpm

totalize

Functional "burn-in" eliminates marginal parts.

Options include programmable offset for fast, accurate go-no-go decisions even with an unskilled operator and a four line BCD output to directly drive printers and other peripheral equipment.

Best of all, there's no need to wait to put the 1941A to work. Throughout the U.S., Canada, and western Europe, this counter is in stock and available for immediate demonstration or delivery. A worldwide network of service centers provides 48 hour turn-around repairs.

In the continental U.S., dial our toll free number 800-426-0361 for the name and address of your nearest local source. Abroad and in Canada, call or write the office nearest you listed below, John Fluke Mfg. Co., Inc., P.O. Box 7428, Seattle, Washington 98133. Phone (206) 774-2211. TWX: 910-449-2850. In Europe, address Fluke Nederland (B.V.), P.O. Box 5053, Tilburg, The Netherlands. Phone 013-67-3973. Telex: 844-52237. In the U.K., address Fluke International Corp., Garnett Close, Watford, WD2 4TT. Phone, Watford, 33066. Telex: 934583. In Canada, address ACA, Ltd., 6427 Northam Drive, Mississauga, Ontario. Phone 416-678-1500. TWX: 610-492-2119.

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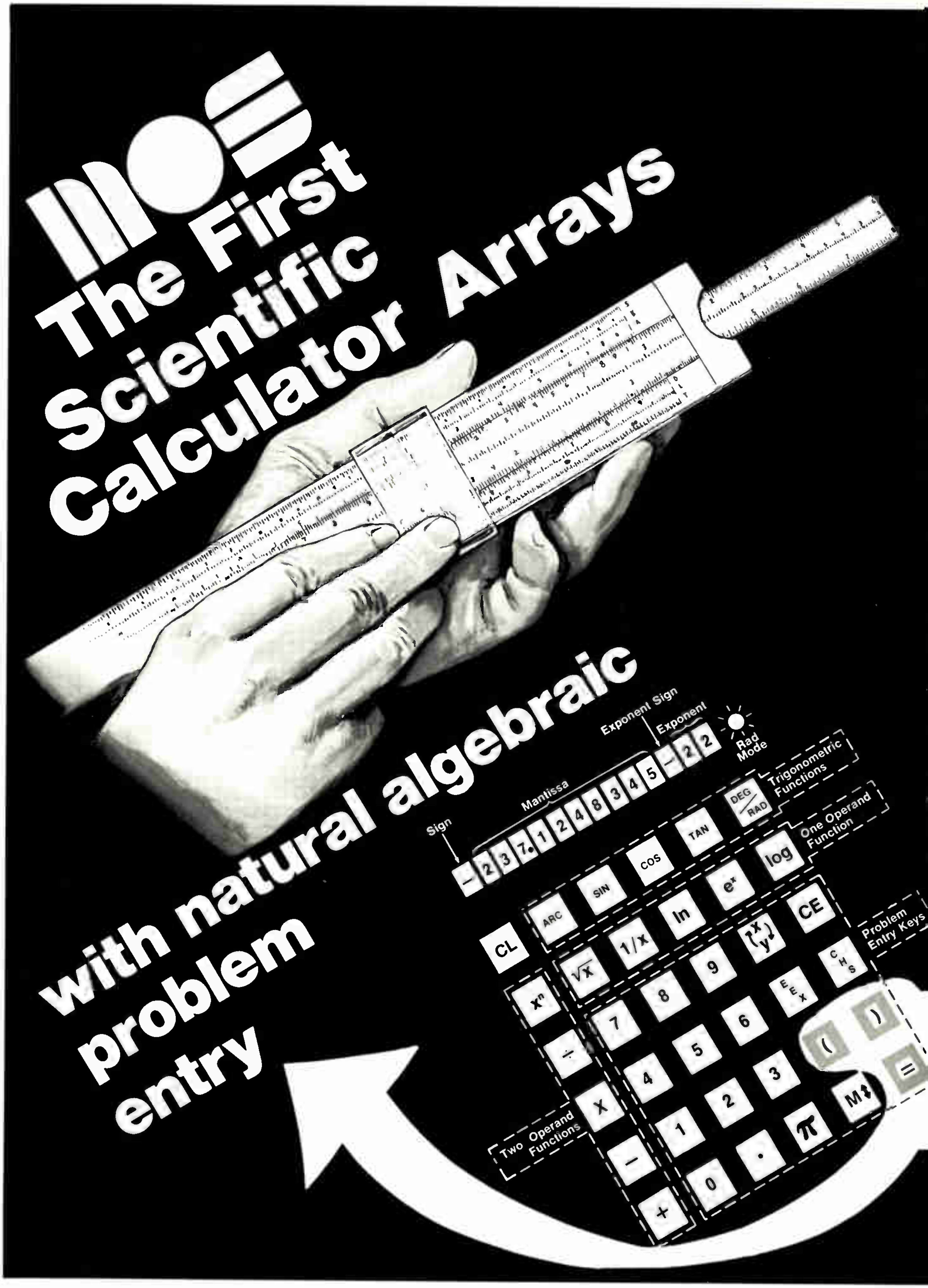
Circle 137 on reader service card


The First
Scientific
Calculator Arrays
with natural algebraic
problem
entry
Sign
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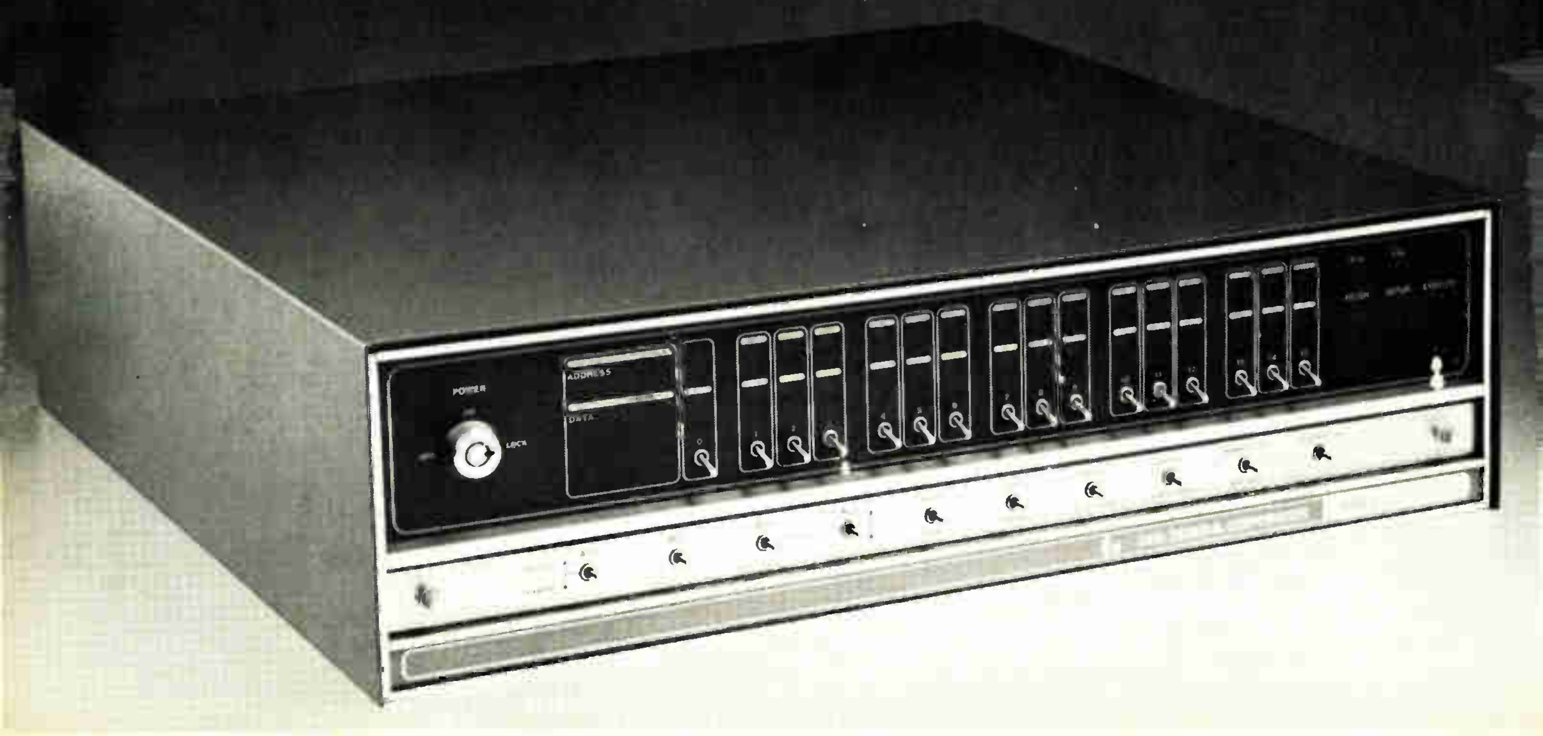
Exponent
Rad Mode
Trigonometric Functions
One Operand Function
Problem Entry Keys
Two Operand Functions

The $5,600 computer you don't have to talk down to.



We've got an idea that ought to interest any OEM who's trying to bring down the price of his product.

Go buy yourself 5* Nova 2's with the new 16K memory boards. (Yes, we know you can probably get away with less memory. Bear with us.)

Now take a look at what you get: a high speed multi-accumulator 16 bit CPU, an I/O system with programmed data transfer, 16 levels of programmed priority interrupt, high speed Direct Memory Access, programmer's console, 4-slot mainframe, power supply and 16,384 words of 1 microsecond memory, expandable to 32K. With 4K and 8K memory modules also available.

That, you'll have to admit, is an awful lot of computer for the money. With twice the memory of other computers in that price range.

Hold on. It gets even better.

With that 16K memory, you won't have to talk down to the computer in machine language. You're going to be able to program in higher level languages.

So your programmers will be able to spend more time on what they want it to do and less on how to say it.

Which means they'll get the job done faster. And you'll get your product out on the market faster.

Both of you are going to save yourselves a lot of time and money.

Think about that for a minute.

Consider how your system costs go down when your programming time goes down.

The $5,600 price tag looks even better now, doesn't it?

And that's before the quantity discounts get figured in.

*Five systems is the minimum order.

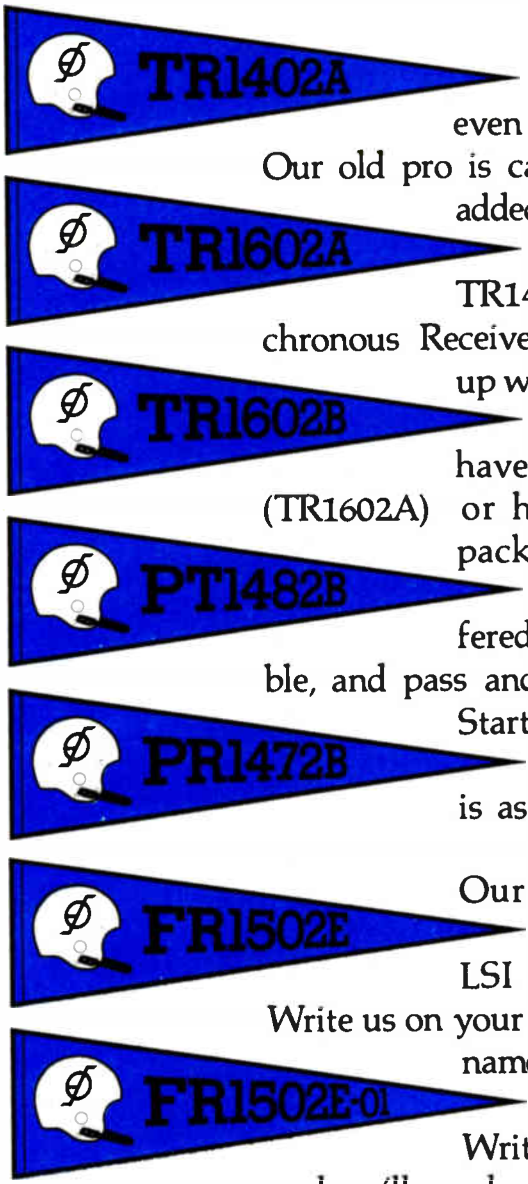
The 16K Nova 2

Data General

Southboro, Massachusetts 01772 (617) 485-9100.

Circle 141 on reader service card

Our Data Com Team: Champions of the MOS/LSI League.



More and more systems engineers are picking the winners—Western Digital MOS/LSI. That's why we have more devices working in more data com applications than any team in the league. Look at our lineup of outstanding players:

The Rookie of the Year is our FR1502E FIFO (First-In First-Out) buffer memory. It's in a formation 9 bits wide to match your data. Features like tri-state data lines, master reset and status flags, optional 500 kHz or 1 MHz asynchronous input/output, and easy expansion with no external hardware make you stand up and cheer. It's the most cost effective method of data speed buffering available.

If speed is your data com game, try our Programmable Synchronous/Asynchronous Transmitter P/SAT (PT1482B) and Receiver P/SAR (PR1472B). Whatever data transmission play you are calling, this programmable duo upgrades systems with speeds to 100 kilobits/second or more. And you call signals in synchronous, asynchronous or even isochronous modes.

Our old pro is calling new plays. We've added 1.5 stop bits capability to our seasoned favorite TR1402A MOS/LSI Asynchronous Receiver/Transmitter and come up with a new league standard—the TR1602 series. You have the option of ceramic (TR1602A) or hermetic plastic cavity packages (TR1602B). These compatible, double-buffered devices are programmable, and pass and receive simultaneously. Start and stop bit generation is automatic. Delivery is as fast as you can call it.

Free NFL Pennant

Our data com devices are champions of the MOS/LSI League. Find out why. Write us on your letterhead and tell us the name of your favorite National Football League team. Write before January 5, 1974, and we'll send you an NFL pennant for your favorite, along with literature on our winning team. Write Western Digital Corporation, 19242 Redhill Ave., Newport Beach, California 92663. Tel: 714/557-3550. TWX: 910-595-1139.

WESTERN DIGITAL
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Go with the action...Go Western Digital!

Digital meters in wide variety hit market

Attracted by the huge sales volume of the analog VOM field, makers of DMMs offer novel measurement capabilities, low prices

by Michael J. Riezenman, Instrumentation Editor

No one can doubt the power of competition as a force for innovation after looking at the digital-multimeter marketplace. Low-cost digital multimeters—typically 3½-digit units priced at about \$250 to \$300—are currently selling at a rate of about 25,000 to 40,000 units per year, corresponding to a dollar volume in the \$5 million to \$10 million area. However, the analog VOM market, which has prices in the \$70 to \$180 range and is estimated at perhaps 150,000 units per year in the U.S. plus another 100,000 units per year in Europe, has a \$20 million to \$30 million volume that the digital-meter manufacturers see as their big chance to get into a really high-volume business.

So far, no digital instrument has been able to match the \$70 price of the bottom-of-the-line analog VOMs. The manufacturers, however, are counting on users being willing to pay a premium for the advantages of digital instruments. In the case of portable multimeters, these include light weight, improved ruggedness, greater accuracy, and, perhaps most important, elimination of the errors caused by misreading the complex, multi-scaled readouts of the analog meters.

The differences in the various manufacturers' approaches, accordingly, seem to reflect differing appraisals of just how much extra the users are willing to pay for just how much extra capability. Some companies, like Data Precision of Wakefield, Mass., and Schneider Electronique of Rungis, France, maintain relatively high prices while offering more capability than the user would normally expect for the money. Data Precision's model 245 multimeter, for example, is a compact 4½-digit (20,000-count) instrument. At \$295, it is about \$100 cheaper than its closest 4½-digit competitor and is reasonably priced when compared with 3½-digit units.

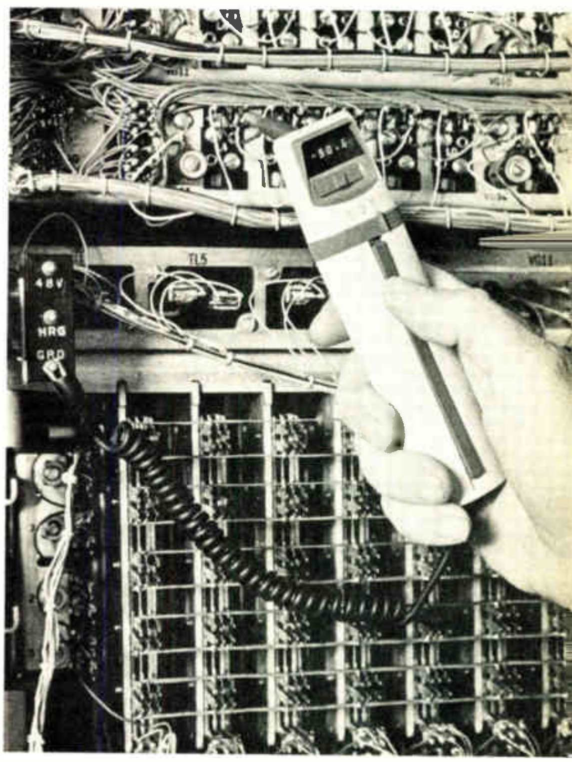
At \$440, Schneider's Digitest 610 sounds like even less of a competitor than the Data Precision unit. However, the 610 is not only a 4½-digit (11,000-count) instrument, it measures temperature in addition to the usual parameters of voltage, current, and resistance. And, since malfunctioning circuits often contain components that are running at abnormally high temperatures, a thermometer can be a very useful tool for both field service and laboratory troubleshooters.

The opposing school of thought holds that only such essential features as overload protection, ruggedness, and the maintenance of long-term accuracy should be allowed to prevail over cost in any cost-performance tradeoff. Reflecting this type of thinking are the new Danameter by Dana Laboratories of Irvine, Calif., and the model 3/24 digital multimeter by Ballantine Laboratories of Boonton, N. J. Both of these instruments sell for \$195, and both of them are powered exclusively by cheap, disposable batteries.

Somewhere between these two schools of thought lies the idea that minimizing cost is important, but that it is equally important to offer the customer something a little different. Data Technology of Santa Ana, Calif., for example, has a 3½-digit (2,000-count) multimeter that measures ac and dc volts, ohms, and capacitance. The capacitance-measuring capability, like the temperature-measuring capability of the Schneider unit, is not a common multimeter feature, and Data Technology feels that this useful function will give its \$269 model 20 an important competitive edge.

While some of the preceding instruments are unusual, one that is unique is the H-P model 970—a \$275 multimeter entirely contained inside its probe. Designed to require only one hand for its use, the 970 is a completely autoranging instrument with a single three-position function switch that is easily operated by the operator's thumb. An

Compact. Because readout of H-P 970 is close to probe tip, operator can see display without moving his eyes from test circuit.



additional switch, operable by the same thumb, inverts the display for easy reading when the meter is used in an inverted position. Like the Data Technology meter, the H-P 970 measures ac and dc voltage and resistance but not current.

One of the most striking features of the H-P 970 is the fact that its display is up near the front of the probe, where the user can read it while keeping an eye on the exact location of the probe tip. The only other meter that puts its display in its probe (although at the rear, not up front) is the model 167 multimeter by Keithley Instruments of Cleveland, Ohio. Like the H-P instrument, the $325 Keithley 167 is autoranging and does not measure current.

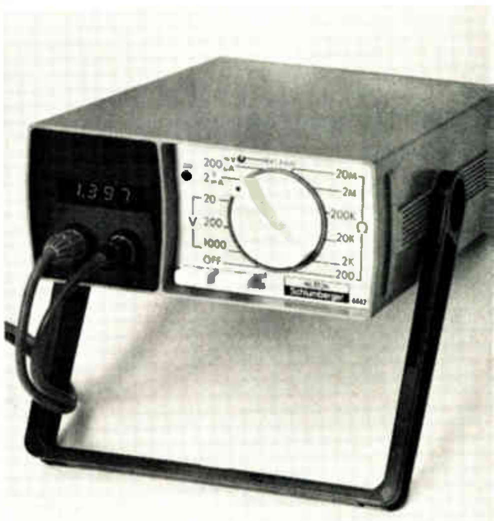
A Keithley instrument that does measure current is the model 165—an autoranging instrument that measures ac and dc voltage and current, and resistances up to 200 megohms. At $495 this meter is not exactly low-cost, but Keithley's vice president for sales, Anthony Oliverio, says that a new version with lower cost and improved performance will be put on the market in January.

Meanwhile, back in Newark, N. J., Weston Instruments—the people who started the low-cost digital multimeter business in the first place—have been expanding their line so as to have a catalog item to satisfy just about any customer need. In addition to their basic 4440—a 3½-digit (2,000-count) instrument with a basic dc accuracy within 0.3% of reading and a price of $250—they have a model 4442 with a price of $275 and an improved accuracy spec of within 0.05%. Both of these instruments contain internal rechargeable batteries and can be line-operated through the battery charger. For the user who wants the accuracy of the 4442 and only wants to pay for a 4440, Weston has two additional low-cost meters: the 4443, a dc-only version of the 4442; and the 4449, a line-operation-only version of the same instrument.

Despite all of this low-priced competition, the $299 model 8000A by the John Fluke Manufacturing Co. of Seattle, Wash., is still one of the best-selling meters around. The success of this 3½-digit-instrument, which has no autoranging capability, no special functions, and no gimmicks, is, however, no puzzle to the people who use it and the others who compete against it. It succeeds, they all say, because of its ruggedness, reliability, and long-term electrical stability.

Some makers of analog VOMs regard the digital meters as complementary rather than competitive. Says an official at Triplett Corp., Bluffton, Ohio, which sells both types: "The key here is to offer people a choice. The market is that broad. Some people will prefer to stay with analog meters; others will opt for the digital multimeter." □

What's a half-digit? Both the Weston 4442 (right) and the Data Technology 30 are 3½-digit meters. But Weston's is a 2,000-count unit and the model 30 has 5,000 counts.



Circle 147 on reader service card

ECL, TTL get together on same board

Socket panels designed for wire-wrap interconnections have power planes for both logic families; applications seen in computers, peripherals, testers

by Stephen E. Grossman, Packaging & Production Editor

Combining emitter-coupled and transistor-transistor logic families becomes a relatively simple matter with an ECL socket panel developed by Augat as part of a series designed for wire-wrap interconnections. Both ECL and TTL devices can be mounted on the same circuit board because Augat has provided power planes for both types. The company expects the panels to be useful in design of computers, peripherals, test equipment, and digital-communications systems.

The skeptic may raise an eyebrow at the thought of wire-wrapping devices operating at ECL data rates. "But wire-wrapping works out fine," says William Blood, manager of the Systems Logic Development section at Motorola Semiconductor Products. "What's more, packaging ECL and TTL on a single board enables a circuit designer to perform his operations at ECL speeds, yet interface with TTL-compatible systems by employing the Motorola series of translators." These include the MC10124, which translates TTL to ECL, and the MC10125, which translates ECL to TTL and has a fanout capability of 10 TTL loads.

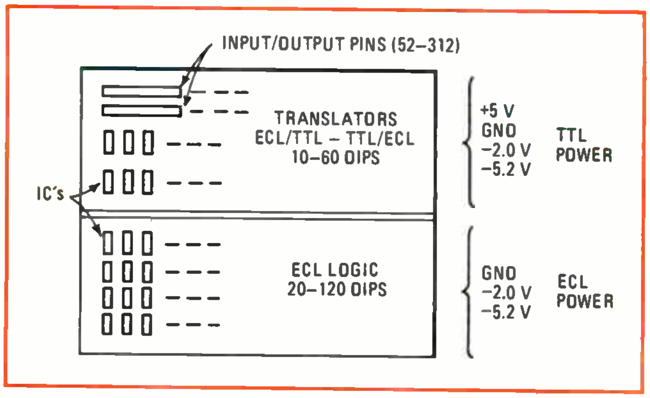
Leonard A. Doucet, engineering manager, ECL products at Augat, says that point-to-point interconnection wrapped with No. 30 wire can provide less than a 10% undershoot for a pulse signal with a 3-nanosecond rise time. (Digital designers usually consider 12% or less as acceptable.) This performance is achieved by terminating the point-to-point wire at the second-level wrap position 0.370 inch above the board. Doucet reports that the impedance is between 100 and 120 ohms so that a ⅛-watt load resistor of 120 ohms at the far end provides a satisfactory termination. These resistors can be wire-wrapped in place. Source matching is unimportant to achieve the necessary waveshape performance. A general rule when working with ECL is to terminate ECL interconnections that are 5 inches or longer.

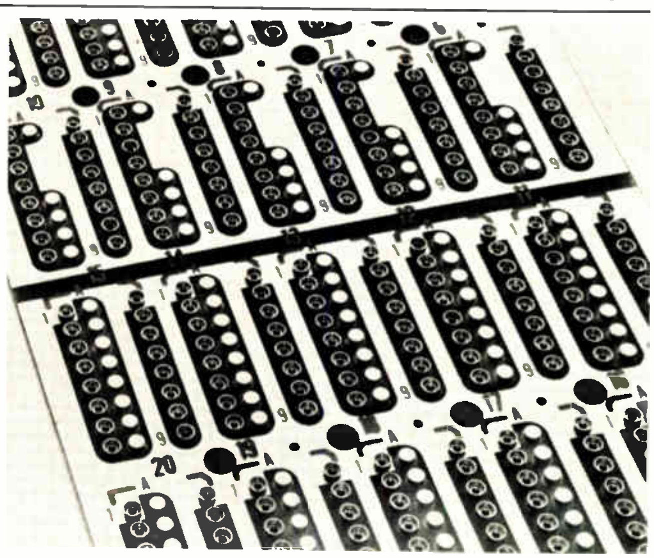
Although designed for the Motorola transistor series, the 8136-ECL-6 panel can also be employed for other devices in the ECL and TTL families. The panel is supplied in multiples of 30 patterns (or sockets), with each group of 30 having 10 sockets committed to TTL and 20 patterns committed to ECL. The panels are glass-epoxy, the conductive foils are 2-ounce copper (2.8 mils thick), and the sockets for the IC pins are beryllium-copper with gold-over-nickel plating.

Augat has also announced another version of its ECL panel series, known as the 8136-ECL-5, which can mount 12 24-pin devices such as Motorola's ECL10181 arithmetic units in addition to 150 standard 16-lead ECL ICs. These devices are capable of performing 16 logic and 16 arithmetic operations on two 4-bit words. Prices of the ECL panels range from $1.50 to $2.50 per IC pattern, depending on style and quantity.

Augat Inc., Attleboro, Mass. 02703 [339]

Matchmaker. Upper portion of translator panel (right) is designed for translator ICs that can interface high-speed ECL devices (lower part) with TTL-compatible peripherals. As shown below, power required by each device family is applied to distinct bus systems.





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I_{RMS}		5 amps	5 amps	10 amps	35 amps	35 amps
T_{OFF} (Microseconds)		2-6	6-10	5-10	10-15	6-10
1K Price:	200V	1.67	.90	3.00	7.24	7.89
	600V	2.89	1.30	12.20	15.60	17.20

Fast Recovery Rectifiers		TA7895	44938	43884	43894	43904	40960
Package		DO-26	DO-15	DO-4	DO-4	DO-5	DO-5
I_{AV}		1 amp	1 amp	6 amps	12 amps	20 amps	40 amps
T_{RR} (Nanoseconds)		50-500	150-500	150-350	150-350	150-350	150-350
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	600V	.72	.66	3.13	4.37	6.00	6.70

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Instruments

Analyzer has 120-dB range

Spectrum measurement unit offers interchangeable analyzer heads

Despite a hefty price disadvantage caused by successive dollar devaluations, a small French company is bidding to break into the U.S. market with a high-performance spectrum analyzer selling at about $11,600. Adret Electronique will turn out the instrument in a plant near Paris and will sell it in the U.S. market soon through its Lancaster, Pa., subsidiary, Adret Corp.

The main feature of the analyzer, designated the model 6303, is its wide dynamic range—up to 120 decibels. The unit comes in modular form for installation in an existing Adret mainframe. In addition, there are two interchangeable analyzer heads—the first for measurements in the range from 0 to 11 megahertz, and the second from 1 to 110 MHz.

Adret says it has overcome two principal restrictions of some spectrum analyzers—poor short-term stability in the first voltage-controlled oscillator and the low dynamic range of the entry mixer. The answer was to use the high spectral purity that is characteristic of modern synthesizers by linking a synthesized local oscillator to a quartz oscillator, instead of using a voltage-controlled oscillator alone. The arrangement solves the frequency-stability problem and also allows precise frequency measurement because of the use of the quartz component.

The dynamic range was widened through development of a new type of signal-entry mixer. Adret engineers say the mixer was designed to operate at a high level and to be free from nonlinear characteristics. A new field-effect-transistor integrated circuit was developed to change the frequencies, but the number of active circuits in the measuring system was reduced to a minimum to cut down noise levels.

The synthesizer and oscillator unit, together with the entry mixer, feeds the signal through the eight-element quartz filter with a narrow 10-hertz bandwidth. The shape factor is 10 at 100 dB attenuation. The central frequency of this filter is 84.08 gigahertz to a five-stage logarithmic amplifier that uses very-low-noise field-effect transistors.

To get optimum dynamic range, the unit is fitted with an interchangeable "analyzer head" that incorporates the entry mixer and, in one mode, includes a device to reduce the synthesizer frequency by a factor of 10. The effect is to reduce phase interference of the synthesizer to 10% and, as a result, to raise the maximum dynamic range. At the same time, the frequency range is also divided by 10.

Since the instrument shows its best paces in measurements beyond 80 dB, it is best suited to analysis of very low modulated signals, which can be up to 110 or 120 dB below and as far as 100 Hz away from the carrier.

Depending on the dispersion selected, ranging from 200 Hz to 100 kHz, analysis duration ranges between 100 and 2,000 seconds, and frequency accuracy is within ±5 Hz. The measured level is displayed on a galvanometer, and the spectrogram is plotted on an X-Y table.

Adret Corporation, 1887 Lititz Pike, Lancaster, Pa. 17601 [351]

Calibrator covers six thermocouple ranges

A portable thermocouple-control calibrator, designated the model 900, can measure the output of a thermocouple or other transducer or it can simulate the output of a thermocouple to calibrate a thermocouple instrument. These instruments can be either the potentiometer type that draws no current or the power-consuming fixed-input-resistance type. The model 900 handles all six commonly used thermocouples (J,K,T,E,R, and S). It also offers three millivolt scales, from 0 to 75 mV, for other, less commonly used thermocouples, and for load cells, strain gages, and other transducers that produce low voltages. Price is $398.

Victory Engineering Corp., Victory Rd., Springfield, N.J. 07081 [353]

Panel-meter plug-ins can change ranges

The model 253 digital panel meter with a 20-millivolt full-scale basic range also offers 10-microvolt sensitivity. Four additional dc voltage ranges and seven dc current ranges are selected by changing one internal plug-in 16-pin DIP. The model 253 is also offered without the range-change module, handling

New products

range and function as necessary, thus reducing the required inventory. Standard features of the

253 include parallel BCD outputs, 3-wire ratio measurement, and readout-blanking. Price is $120.

Newport Laboratories Inc., 630 E. Young St., Santa Ana. Calif. 92705 [354]

Measuring bridge is battery-operated

Working from ordinary batteries, a measuring bridge checks resistance, capacitance, and inductance. The resistance-measuring range is 1 mil-

liohm to 1 megohm and can be performed with either a dc Wheatstone-bridge configuration or an ac Kohlrausch bridge. Inductance range is from 0.01 microhenry to 11 henries, and capacitance range is from 0.1 picofarad to 1,100 microfarads.

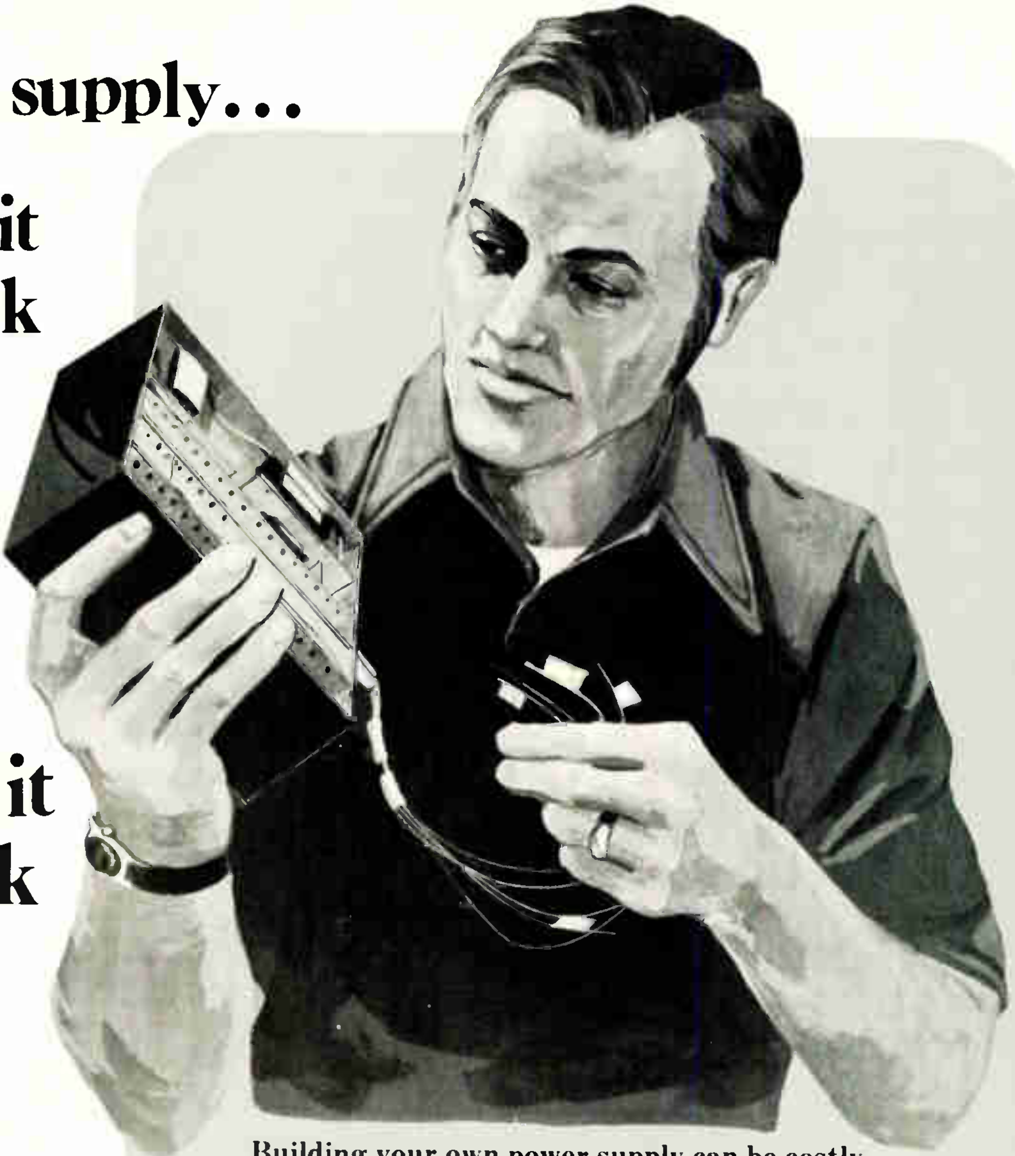
Tettex A.G., CH-8042 Zurich, Switzerland [355]

Active filters can be used in pass or reject mode

General-purpose two-pole active filters are for use in either bandpass or band-reject configurations. Center

Your power supply...

if you build it it <u>might</u> work



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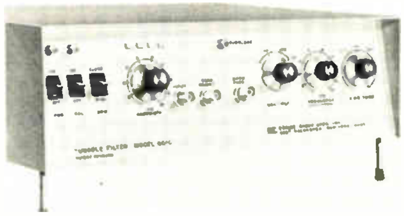
Circle 153 on reader service card

frequency is tunable from 1 hertz to 10,000 Hz, and bandwidth at any frequency is controllable over a two-decade range. Bandwidth and center-frequency adjustments are independent and noninteracting. The



model 8010 filter offers circuit Qs to 1,000, while the 8020 is available with Qs to 10,000. Price starts at $750.

Edmac Associates Inc., 333 W. Commercial St., E. Rochester, N.Y. 14445 [357]

Multimeter delivers 20 readings a second

Up to 20 readings per second with 60 decibels of noise rejection can be delivered by the model Cimron DMM-50 multimeter. The full auto-

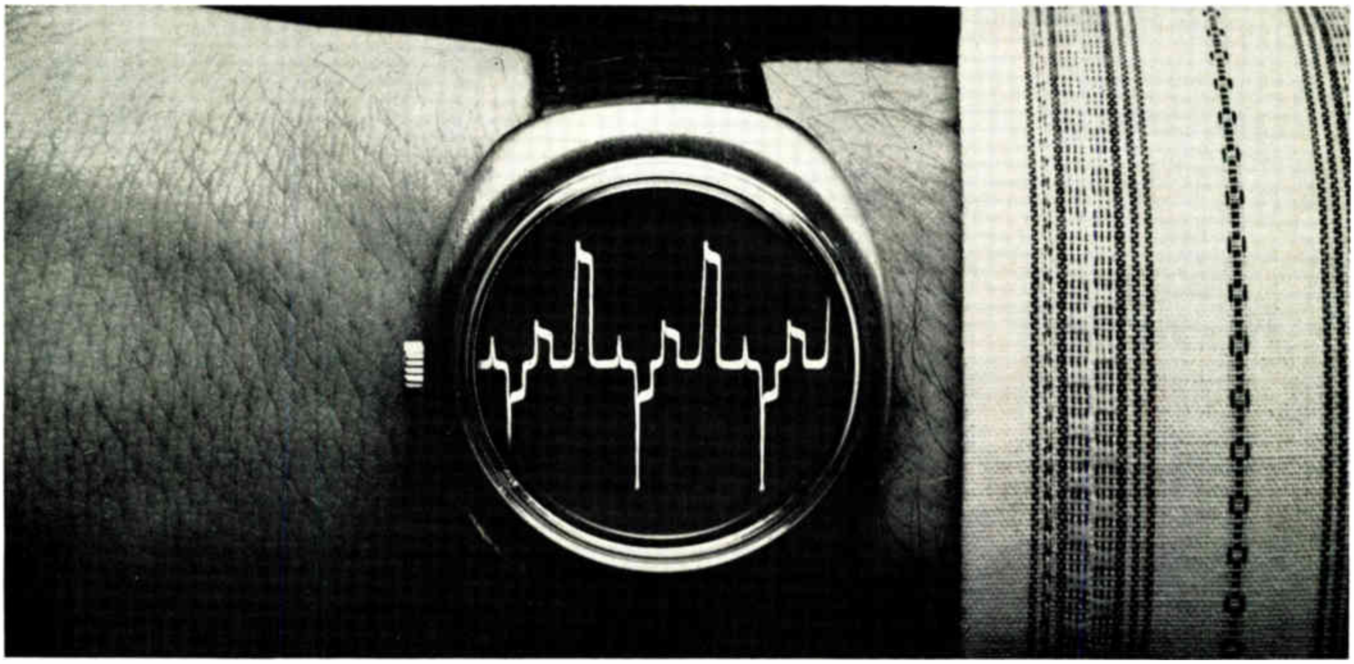
ranging autozero meter provides a 5½-digit readout and combines successive-approximation and integration logics (the former for high speed, the latter for inherent noise rejection). Five ranges of dc voltage are offered from 100 millivolts to 1,000 mv full scale. Price is $1,195.

California Instruments Co., 5150 Convoy St., San Diego, Calif. 92111 [358]

Digitizer offers built-in computation

Designed for use by OEM firms in measurement and process-control systems, a digitizer called the

If you've got the timepiece, we've got the electronics.



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New products

AN7000 P(C)³ incorporates an analog-to-digital converter, a fully preprogramed processor, random-

access and read-only memories, and an input-output bus, so that it is capable of built-in computation. The digitizer is about 6 inches high, 8 in. wide, and 10 in. deep. The compact unit also offers a resolution of 1 part in ±40,000 and an error of ±0.01%. Price in quantity is $600.

Analogic, Audubon Rd., Wakefield, Mass. 01880 [356]

Minicounters replace electromechanical units

Designed for the direct replacement of electromechanical counters, the 500M miniature preset counter is suitable where a high count rate and repetitive reset would wear out or degrade an electromechanical version. Available in both count-up and count-down models, the solid-state instrument has a 10-kilohertz count rate.

Dynapar Corp., 1675 Delany Rd., Gurnee, Ill. 60031 [359]

Circle 157 on reader service card

"Scotchflex" Flat Cable Connector System makes 50 connections at a time.

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Reliability is built in, too, with "Scotchflex" interconnects. Inside of connector bodies, unique U-contacts strip through flat cable insulation, grip each conductor for dependable gas-tight connections.

"Scotchflex" offers you design freedom, with a wide choice of cable and connectors. From off-the-shelf stock you can choose: 14 to 50-conductor cables. Connectors to interface with standard DIP sockets, wrap posts on standard grid patterns, printed circuit boards. Headers for de-pluggable connection between cable jumpers and PCB. Custom assemblies are also available on request.

For more information, write Dept. EAH-1, 3M Center, St. Paul, Minn. 55101.

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Components

Process guards chip capacitors

Multilayered terminations protect ceramic from stress during thermal cycling

While working on a contract for high-reliability components, engineers at AVX Corp., Braintree, Mass., realized that the difference between the expansion coefficients of palladium-silver terminations and ceramic-chip capacitors could lead to stress and cracking of the ceramic during thermal cycling. After working on the problem for several years, AVX has made commercially available a termination that consists of layers of silver, nickel, and gold. The company says the termination, called NiGuard, withstands thermal cycling better than does a palladium-silver alloy.

Silver is first fired onto the capacitor in a layer from 0.2 to 2 mils thick. Fully annealed silver is soft enough not to cause cracking; it conforms to the shape of the ceramic. Silver's expansion coefficient of 10.9×10^{-6} at 25°C is closer to ceramic's 7 or 8×10^{-6} than palladium's 11.6×10^{-6} at 25°C and 14×10^{-6} at 500°C.

In the next step, nickel, which has an expansion coefficient of 9.2×10^{-6} at 25°C, is electroplated onto the silver in a layer 50 to 100 microinches thick. This nickel barrier ties up any free silver, prevents leaching, and adds toughness to the termination.

Finally, a thin layer of gold is plated on. "Its thickness is adequate to maintain solderability and bondability," AVX engineers say. "This is the trick; it took us four and a half years to find the right thickness." The company says that applying the elements in layers divides the stress evenly in the termination area.

NiGuard terminations are available on a variety of multilayered ceramic chip capacitors in a wide range of sizes, and they meet EIA and MIL-C-55681A specifications. Cost is slightly higher than the cost of palladium-silver alloys, says AVX. Delivery time is about normal now for components—about 30 weeks [*Electronics*, Oct. 25, p. 32].

AVX Ceramics, P.O. Box 867, Myrtle Beach, S.C. 29577 [341]

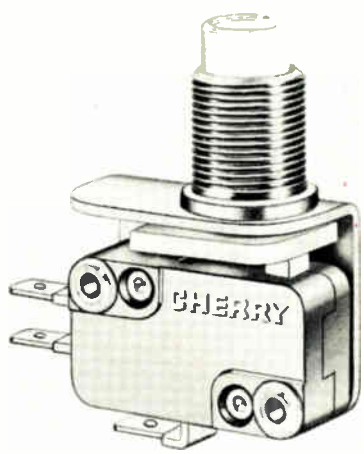
Piezoelectric transducer offers wide range

A miniature piezoelectric pressure transducer, P200 series, offers a sensing element that is said to show neglible response to spurious vibration, heat transients, body strains and other adverse conditions. Pressure range is from 0.01 to 4,000 pounds per square inch. Alternating variations of 0.01 psi can be detected in a static pressure field of 4,000 psi. Price ranges from $155 to $195.

Columbia Research Laboratories Inc., MacDade Blvd. & Bullens Lane, Woodlyn, Pa. 19094 [410]

Miniature switch is easy to mount

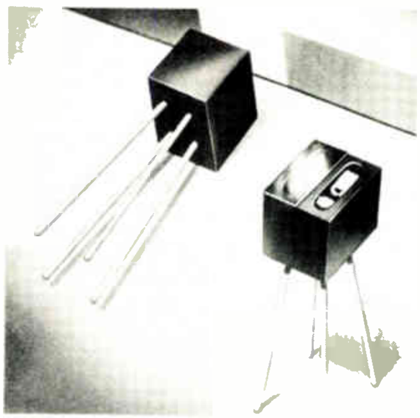
A threaded bushing facilitates panel-mounting of the model E-34-00J miniature snap-action switch. The unit also offers a nylon push button ⅜-inch in diameter, in addition to a coil-spring mechanism. The switch is intended for use at 15 amperes, 125/250 volts ac, and is available with screw, solder, or quick-connect terminals. Price is $1.35.



Cherry Electrical Products Corp., 3600 Sunset Ave., Waukegan, Ill. 60085 [409]

Reflective transducers combine emitter, detector

A series of optical-pair reflective transducers combines an emitter and detector in a single compact package. Each device also incorporates an infrared bandpass filter over the phototransistor detector to assure operation under adverse ambient conditions caused by stray fluorescent or other short-wave-



length lights. The transducers are designed for beginning- and end-of-tape sensing, character recognition, mark sensing, and similar applications. The STRT-850 series offers a typical photocurrent output of 125 microamperes.

Sensor Technology Inc., 21012 Lassen St., Chatworth, Calif. 91311 [343]

LEDs are resistant to shock and vibration

Both wide and narrow high-intensity light sources are featured in a family of miniature light-emitting-diode lamps, which are resistant to shock and vibration. Easily read over a wide viewing angle, the LEDs are designed for fiber-optic and imaging systems or front-panel status indication. The units are also

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(**Need:** The right switch for the right price.)

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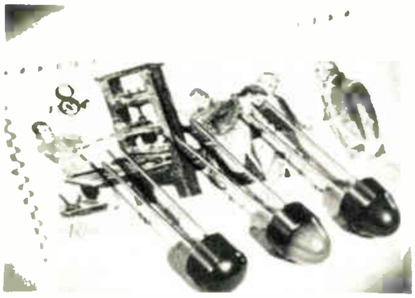
For the switch buyer, choice of function and esthetics, reliability, ease of mounting, and low cost are his prime concerns. He may need a pushbutton switch for panel, sub-panel or snap-in mounting. He may need a choice of bezels with or without barriers in black, gray, dark gray or white. He may need a legend that's positive, negative, or hidden until energized . . . one that's white when "off" and red, green, amber, blue or light yellow when "on" . . . or colored both "on" and "off." He may need a highly reliable switch proven in thousands of installations . . . available in momentary or alternate action . . . N.O., N.C. or two circuit (one N.O., one N.C.) or for low level, low voltage and current applications . . . that accommodates a T-1¾ bulb with midget flanged base, incandescent, in voltages from 6 to 28 V. Matching indicators with same front-of-panel appearance are also available. These are some custom needs he may face, and these switches are some off-the-shelf answers from Dialight.

New products

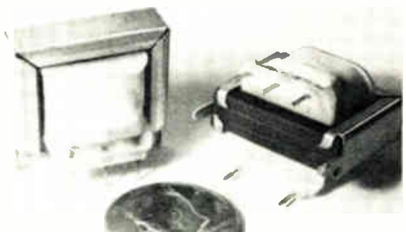


compatible with digital integrated circuits and can be driven directly from low-level digital IC outputs.

Eldema division, Genisco Technology Corp., 18435 Susana Rd., Compton, Calif. 90221 [344]

Power transformer includes printed-circuit pins

A power transformer with printed-circuit pins for fast, economical mounting is of laminated construction. Designated the model IPL-1029-4, the unit is rated at 1.5 watts, and it will transform an input of 100



volts at 60 hertz to 35 v minimum at 50 milliamperes and 45 v maximum at 25 mA. Price in quantity is $1.25 each.

Dale Electronics Inc., East Highway 50, Yankton, S.D. 57078 [345]

Ceramic capacitors are glass-enclosed

The CG series of glass-enclosed ceramic capacitors is offered in subminiature sizes with capacitances of 10 picofarads through 10,000 pF and 2,200 pF to 100,000 pF. Ceramic dielectric materials available are NPO and W5R in 25, 50, and 100 volts. The devices conform to military standards. Lead taping for automatic equipment is available on request.

Elpac Components, 3131 S. Standard Ave., Santa Ana, Calif. 92705 [346]

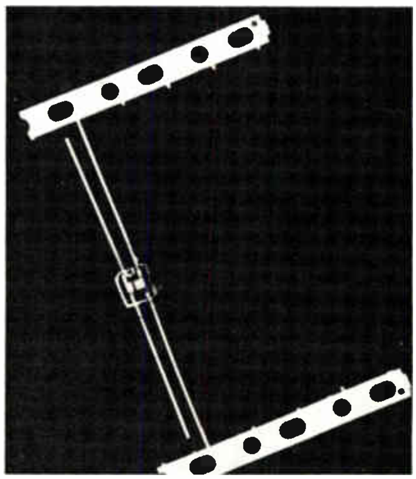
Rf power capacitors have Q of 5,000 at 1 MHz

A line of rf ceramic capacitors are general-purpose types designated the MJ series. The devices exhibit a Q of 5,000 when measured at 1 megahertz, and stability over a temperature range of -55 to +125°C is +90 ppm/°C. The capacitors are available in chip, stripline and cased axial and radial configurations. In the chip configuration, 13 case sizes are offered.

ITT Jennings Monrovia Plant, 1960 Walker Ave., Monrovia, Calif. 91016 [347]

Miniature opto-isolator aimed at hybrid work

An opto-isolator in a miniature package can eliminate groundloop feedthrough and isolate floating grounds, voltage transients, and logic signals. The model MCT10 is a gallium-arsenide LED, coupled to a silicon planar transistor mounted in a four-lead clear-epoxy package. The unit is compatible with hybrid circuits where reflow soldering is used and with TTL logic without additional interface circuitry. Price is



New products

about $3.15 to $5.40 each, depending on quantity.

Monsanto Commercial Products Co., 3400 Hillview Ave., Palo Alto, Calif. 94304 [348]

Longitudinal-shaft motion provides switching functions

A series of printed-circuit-board switches, called the 2439, provides standard and modified coded outputs and novel functions that are switched by longitudinal shaft movements. The shaft switches have momentary-spring-return or de-

tented contact positions and are actuated by pulling on the shaft. The unit measures 0.675 inch in diameter; length depends on circuitry desired.

Janco Corp., 3111 Winona Ave., Burbank, Calif. 91504 [349]

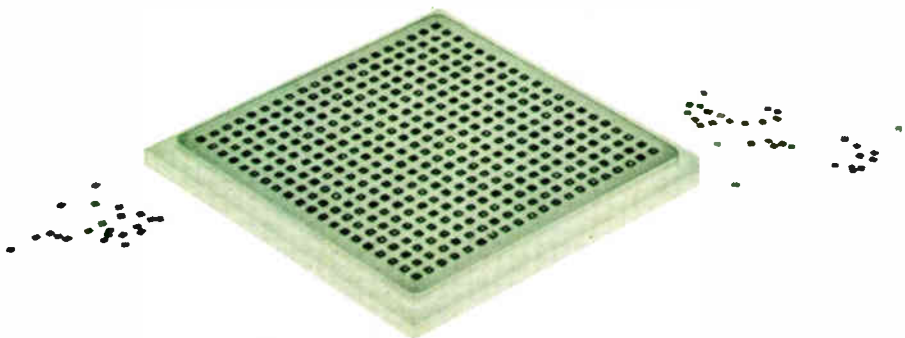
Interference filters are rated at 440 volts

A series of general-purpose interference filters is rated for operation at 440 volts at 50 to 60 hertz. The filters are designed for application in office, data-processing, and computer-peripheral equipment. The series JX5500 provides a minimum insertion loss of 60 decibels at 150 kilohertz and 80 dB over the range from 0.5 megahertz to 1 gigahertz.

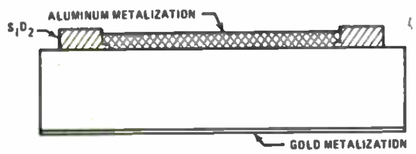
Sprague Electric Co., 35 Marshall St., North Adams, Mass. 01247 [350]

Improve your hybrid yields with

SINGLE-CHIP TC ZENER CHIPS from DICKSON



You can now design temperature compensated voltage reference diodes in your hybrid circuits with assurance that temperature coefficients will meet your design requirements. Dickson provides them on a single-chip, 100% tested, to help save time, simplify circuit fabrication and improve your yields.



CROSS SECTION OF SINGLE CHIP TC ZENER

Each 37 mil square Dickson chip contains *two totally passivated* junctions with a 6.2 Volt or 6.4 Volt temperature compensated reference. Temperature coefficients to 0.0005%/°C are available. The chips are electrically equivalent to the JEDEC 1N821-829 and 1N4565A-4584A series.

The Dickson chips have gold metalization on the back, compatible with all common die bonding and soldering techniques. Aluminum metalization on upper surface is compatible with ultrasonic and thermocompression wire bonding.

FOR COMPLETE TECHNICAL INFORMATION contact your local Dickson Sales Representative, or write to Dickson.

AVAILABLE IN ASSEMBLIES, TOO!

Dickson "single-chip" TC diodes are also available bonded in a ceramic channel for ease of handling and testing. These *LID's* are available with solder coated runners for reflow mounting or with gold runners for wire bonding. In addition, Dickson supplies a wide variety of components in chip assembly form to hybrid manufacturers. Ask for details.

T.C. ZENERS — TANTALUM CAPACITORS — ZENER DIODES — HYBRID CIRCUITS

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Semiconductors

Huge SCR handles 2,500 A

Hockey-puck type for industrial applications uses 60-millimeter wafer

The unexpected popularity of a 1,600-ampere silicon-controlled rectifier introduced last year has prompted its maker, International Rectifier, to develop a family of SCRs with still higher current and voltage ratings—2,500A rms (1,600 A average) and up to 1,200 volts, and future versions are planned to reach 2,000 V. Comments David Cooper, IR vice president of sales and engineering, "It is apparent that there is a widespread need, through many segments of industry, for SCRs at power levels that were unheard of only a few years ago."

Believed to be the largest in production, the hockey-puck SCRs replace earlier assemblies of paralleled, smaller devices. This reduces manufacturing costs since fewer parts have to be assembled, and it also eliminates the cost of multiple-firing circuitry. Moreover, the parts' high surge capacity (35,000 A for a half cycle of 60-hertz current) can simplify protective circuitry, sometimes even doing away with the need for fuses.

Major uses for the large device are in chemical processing and furnace controls, in dc motor drives for such applications as rapid transit, ships, earth-moving machinery, and drilling rigs, and in power supplies for welding and radio transmission.

As might be expected, new technology was needed to make a device able to handle this level of power. The semiconductor "chip" is a whole wafer more than 60 millimeters (2.4 inches) in diameter. Cooper says this part, to the best of his knowledge, is the largest chip ever used in a semiconductor device. IR uses an epitaxial, rather than alloy or diffused, process for high voltage rating and consistent performance. The hermetic ceramic package is a new one, 3.875 inches in diameter and 1.38 inch thick. The part has a thermal resistance of 0.02°C per watt, with heat-sinking very important for full power rating. Laurence R. Carver, manager of applications engineering, says that this level is about the limit for air-cooling, but liquid-cooling offers advantages. The company also sells heat dissipators and will supply the SCR mounted in an assembly.

Other parameters include maximum "on" voltage drop of 1.65 V at 1,600 A average current (the average rating of 1,600 A is more relevant in hockey-puck SCRs than the rms rating, which is better for stud-mounted parts affected more by package limitations). Maximum di/dt is 800 A/s, and dv/dt is 200 V/microsecond. The part typically requires a 60-milliampere drive current at 1.6 V, comparable to the smaller 1,600-A rms part.

The device is rated at an I^2t of 5,100,000 square-ampere-seconds for fusing purposes. Maximum holding current required is 500 mA, typical delay time is 1 μs, and typical turn-off time is 120 μs. Junction operating-temperature range is -40°C to +125°C.

Mounting force is 8,000 pounds, and the newly developed device weighs 36 ounces.

The 1,200-V part, 1600 PA120, is priced at $805 in small quantities.

International Rectifier Semiconductor Division, 233 Kansas St., El Segundo, Calif. 90245 [411]

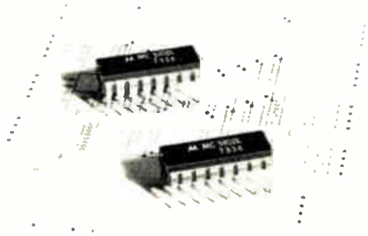
Power transistor is rated at 50 watts

Two hermetically sealed broadband radio-frequency power transistors offer internal matching and are specifically designed for pulsed and continuous-wave service in the Tacan/DME and phased-array-radar bands. The PH-1114-50 is rated at 50 watts broadband under long pulse conditions of 1 millisecond, 20% duty, or at 50 watts cw for narrowband applications. Power gain is 6 decibels minimum. Ratings are at 28 volts. Price is $350.

Power Hybrids Inc., 7231 Garden Grove Blvd., Garden Grove, Calif. 92641 [407]

Quad driver, receivers are for data transmission

A series of quad devices consists of two line receivers and a line driver. The MC3450 receiver offers active pull-up, TTL-compatible outputs, and a three-state strobe input. The MC3452 is a similar receiver but with open collector outputs which facilitate the implied AND connection. The MC3453 is a 12-milliampere current driver. Designed for data-transmission applications, the devices are priced from $4.20 to $5 in 100-lots.



Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Ariz. 85036 [413]

RAM can be used as scratch pad, file or buffer

A random-access memory, called the model 10145, is designed for use as a scratch pad memory, a register

Twelve new answers for the display designer

MAN 51
Common Anode;
Right Hand
Decimal

MAN 52
Common Anode;
Left Hand
Decimal

MAN 53
Common Anode;
Overflow (±1)

MAN 54
Common Cathode;
Right Hand
Decimal

MAN 71
Common Anode;
Right Hand
Decimal

MAN 72
Common Anode;
Left Hand
Decimal

MAN 73
Common Anode;
Overflow (±1)

MAN 74
Common Cathode;
Right Hand
Decimal

MAN 81
Common Anode;
Right Hand
Decimal

MAN 82
Common Anode;
Left Hand
Decimal

MAN 83
Common Anode;
Overflow (±1)

MAN 84
Common Cathode;
Right Hand
Decimal

Introducing twelve new .3″ displays: sharp looking readouts in narrower packages; common cathode or common anode; right hand or left hand decimal; red, yellow and green. All from Monsanto, where light-emitting diode displays got started, and all priced at $2.70 (suggested distributor price for 1,000-lot OEM orders.) Get in touch with any of our distributors: Alta, Elmar, Hamilton/Avnet, Hammond, Kierulff, Kierulff/Schley, Liberty, Schweber, Semiconductor Specialists, Wesco; Cesco in Canada; and Havulina Oy, Helsinki; Neye-Enatechnik, Hamburg; Nordisk Elektronik, Stockholm; Omni Ray, Switzerland; RTF, Paris; Scansupply, Copenhagen; Silverstar Ltd., Milano; Techmation, Brussels; A.F. Ulrichenson, Oslo; New Metals and Chemicals Ltd., Tokyo; Takachiho, Tokyo.

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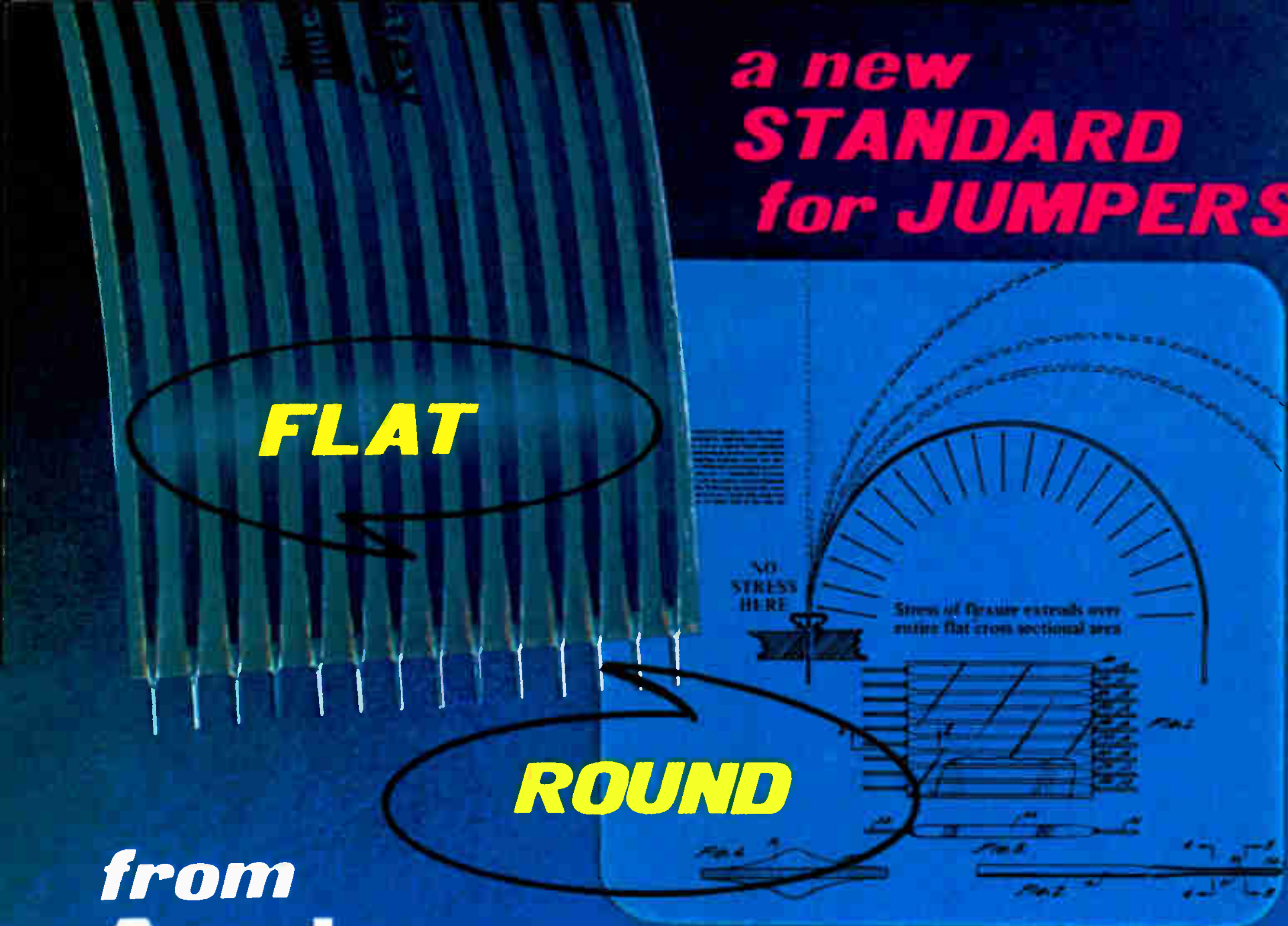

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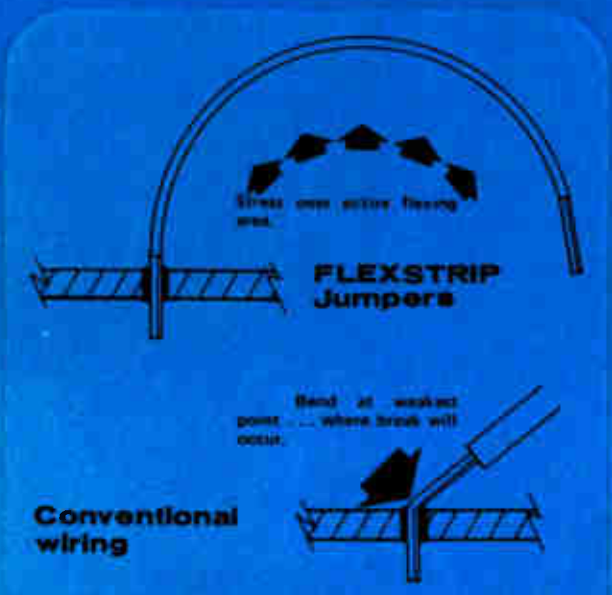
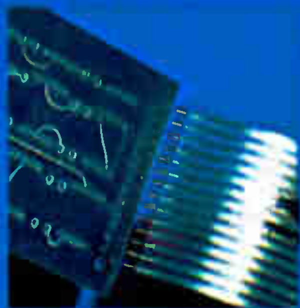




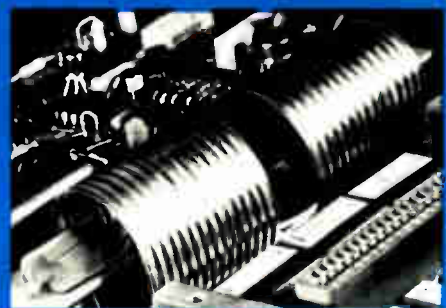


Photo courtesy of Computest Corp.

Circle 166 on reader service card

Ansley

ANSLEY ELECTRONICS CORP.
Subsidiary of Thomas & Betts Corporation
3208 Humboldt St., Los Angeles, Ca. 90031
Tel. (213)223-2331, TWX 910-321-3938

file, a buffer memory, or control storage in mainframe computers, data communications systems, and high-speed test equipment. The device is organized into 16 words of four bits each and is fully compatible with the 10,000 series of emitter-coupled-logic circuits. For memory systems larger than 16 words, the 10145 offers a chip-enable input and open emitter outputs, which allow corresponding bits from different words to be directly tied together in wired-OR configurations with a minimum of additional circuitry.

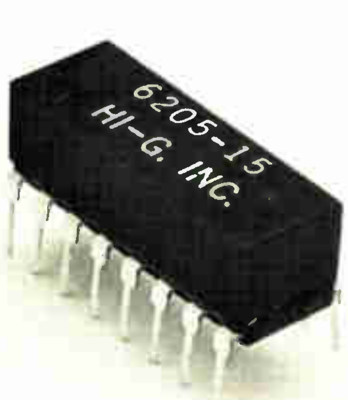
Signetics, 811 E. Arques Ave., Sunnyvale, Calif. 94086

Monolithic counter-timer generates long time delays

A monolithic counter-timer that generates time delays of from 1 microsecond to 5 days by means of an external setting, combines an analog time-base oscillator with a programable eight-bit counter on the same chip. Designated the model XR-2240, the device is accurate to within 0.5% and has a temperature stability of 40 ppm/°C. And because of the binary counting method, it is possible to cascade two units to generate programable time delays of up to three years. Price is $3 each in 100-lots.

Exar Integrated Systems Inc., 750 Palomar, Sunnyvale, Calif. 94086 [415]

TTL-compatible timing module offers six fixed-delay periods



A timing module that is compatible with TTL devices is offered in a 16-pin dual in-line package. The device does not depend on external components for normal operation. Two models are offered: the Inter-

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2151 North Lincoln Street ▪ Burbank, California 91504 val-On, in which output becomes low on application of power and high following delay period; and the Delay-On, in which output remains high for the delay period and then becomes low. Each model is available in six fixed-delay periods. Price of the modules start at $9.95, and delivery is from stock.

Hi-G Inc., Spring St. and Rte. 75, Windsor Locks, Conn. 06096 [417]

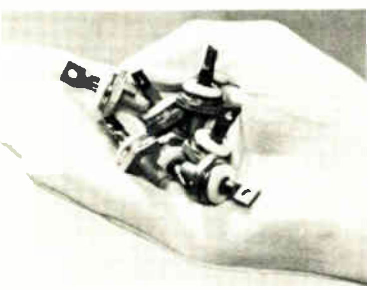
Microprocessors built as prototyping aids

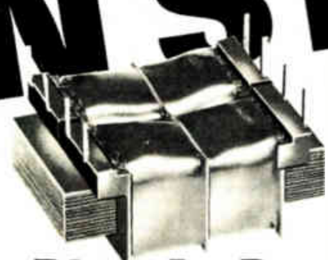
Two general-purpose 16-bit microprocessors, called the IMP-16L and IMP-16P, are intended as prototyping and development aids for systems designers. The model 16L offers a microprogramed 60-instruction set, while the 16P offers 43 instructions. With these units, the OEM can debug a program assembled in software, using either a cross-assembler or the company's self-assembler. The 16L is priced at $3,950 and the 16P at $3,850. Accessories are available at additional cost.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051

Power Schottky diode is rated for 125°C

A power Schottky diode rated for a junction temperature of 125°C is called the SD-51. The device is also rated at 50-ampere average forward current with a forward voltage of 0.5 volts at the junction temperature. Blocking voltage is 35 volts, and maximum reverse current is 200 milliamperes at a case temperature



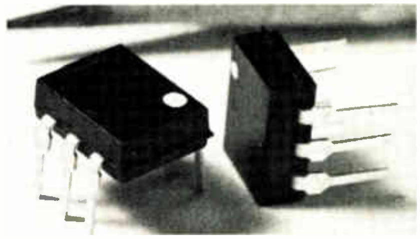


of 125° at 35 volts. In addition, reverse recovery time in inverter circuits is less than 10 nanoseconds. Price ranges from $9.91 to $11.20, depending on quantity.

TRW Semiconductors, 14520 Aviation Blvd., Lawndale, Calif. 90260 [418]

Photon-coupled isolators handle 3,500-V peak

Three high-isolation-voltage photon-coupled isolators, the 4N35, 36 and 37 series, consist of gallium-ar-



senide lamps optically coupled to silicon phototransistors in dual in-line packages. The model 35 offers an isolated voltage of 3,500 v peak and a 100% current-transfer ratio. Price of this model is $1.85 in 1,000-lots.

General Electric Co., Electronics Park, Building 7, Mail Drop 49, Syracuse, N.Y. 13201 [419]

Capacitive memory aimed at disk controllers

A factory-alterable capacitive read-only memory organized as 1,000 words by 48 bits is designated the model CR-0244. It is particularly suited for use in disk controllers. Specifications include an access time of 150 nanoseconds and a cycle time of 400 ns. Higher speeds can be obtained with a minor change in timing, and more than one module can be connected to an interface board, with pin connectors, to form a larger system. OEM purchase price is $568 for a full system, but parts of the system can be purchased at a reduced price.

Integrated Memories, 495 Andover Industrial Center, Andover, Mass. 01810 [420]

Pay a little more for <u>our</u> products. <u>Get</u> more for yours.

In wound film and solid tantalum capacitors, TRW offers you a capability second to none. For one simple reason.

We figure you can't make quality capacitors and me-too capacitors under the same roof. Because sooner or later, one operation will foul the other one up. So we take the quality route. Count on it.

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TRW® CAPACITORS

Data handling

Program eases design task

General-purpose software system provides interactive circuit-analysis tool

Written for engineers who have little or no experience with computer-aided-design, another powerful circuit-analysis computer program is now available on an interactive basis. Called I/Spice (Interactive/Simulated Program Integrated Circuit Emphasis), the program was originally developed at the University of California at Berkeley, where it is available on a batch basis. It was converted by National CSS Inc., a computer services company, into a user-oriented interactive package.

With I/Spice, the user can treat his simulated design as though it were breadboarded and being checked out with an oscilloscope. As a matter of fact, if the user's communications terminal includes a CRT display, the program output duplicates what would be seen on a scope screen.

I/Spice can perform nonlinear dc analysis, small-signal ac sinusoidal steady-state analysis, and nonlinear transient analysis. Additionally, any parameter in the circuit description can be varied, and the temperature dependence of passive as well as active elements can be described with functions for performing thermal analysis.

Circuits can consist of linear elements (resistors, capacitors, inductors, independent voltage and current sources, and voltage-controlled current sources) and nonlinear elements (regular diodes,Schottky diodes, zener diodes, bipolar transistors, junction field-effect transistors, MOS transistors, or a voltage-controlled current source that is described by a polynomial function). The program also provides built-in models of commonly used transistors and operational amplifiers.

The user does not have to describe circuit elements. He merely indicates where they are used, and I/Spice automatically inserts them. The designer can even create and store models of circuits for use as standard devices in describing other circuits. Also, there is no restriction on the number of levels of model nesting.

Another convenience provided by I/Spice is its save/restore feature. The status of output-node voltages and voltage-source currents is automatically stored so that this data can be referred to later without rerunning the entire simulation.

Since I/Spice incorporates many of the latest numerical-analysis techniques, it minimizes computer time and maximizes execution speed. Nodal analysis is used to formulate network equations, and sparse-matrix techniques are used to find the solutions. The program generates a set of internal node numbers and optimally orders the matrix so that the user need not consecutively number the nodes. Circuit size depends on how much storage space is available at the computer facility; the National CSS system provides up to 2 million bytes of storage.

National CSS Inc., 300 Westport Ave., Norwalk, Conn. 06851 [361]

Low-profile keyboards use flip-chip process

Taking aim at the keyboard needs of 1975, a low-profile line of keyboards, called series SD, will be available in 1975 at a price of about 40% below that of current models and will sell for approximately $50 each in quantity. The keyboards will

Circle 174 on reader service card

use a flip-chip process to package Hall-effect integrated circuits and, instead of wire bonding, will employ the batch process of solder reflow to a ceramic substrate. Moreover, module panel-mount metal plates will replace the mounting rails that hold present key modules. The modules of the SD line will be inserted into the mounting plate automatically. Applications of the keyboards are in traditional batch-data-entry as well as point-of-sale terminals and word-processors.

Micro Switch, Division of Honeywell Inc., Chicago & Spring Sts., Freeport, Ill. 61032 [363]

Point-of-sale keyboards are programable

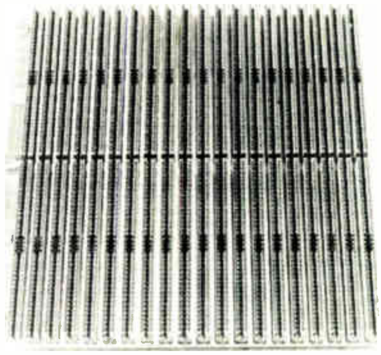
A 256-bit PROM coupled with a standard TTL scanning circuit provides the means to program any or all of

the 25 keys located on a point-of-sale keyboard with any eight-bit code specified by the user. Also included are an error-free two-key roll-over and two-shot molded keytops with legends to be specified by the user.

Key Tronic Corp., Building 14, Spokane Industrial Park, Spokane, Wash. 99216 [366]

Bus expander is designed for PDP-8/E computers

A bus expander, designed for use with PDP-8/E computer systems, provides 20 plug-in slots and is compatible with the computer's Omnibus. The unit, which is shipped with power cable and bus-signal jumper boards, is made with two pc



boards of FR-4 glass epoxy. Price of a 20-slot board is $450. A 10-slot expander board is also available.

Douglas Electronics Inc., 718 Marina Blvd., San Leandro, Calif. 94577 [364]

Process computer system's memory is doubled

A medium-size computer system for process management and control is available with memory capacity of the original system doubled to 65,536 words. The enlarged memory capability allows the FOX I system to support larger tasks and new

communications modules and software packages. A variety of remote CRT terminals, teleprinters, and video monitors are also available. Price starts at $200,000.

The Foxboro Co., Foxboro, Mass. 02035 [367]

Memory module packages 16,000 16-bit words

A core-memory module packaging 16,000 16-bit words on a single printed-circuit board is for use with

Carpenter controlled-expansion alloys. Uniform. Optimum fabricability. Every time.

Carpenter Kovar® is the most widely used glass-sealing alloy.

Stamp, deep-draw, etch, form, or coin. Many grades are available tailormade for the process you use. You get the best possible fabricability.

Users will tell you.

A call to your Carpenter Service Center will bring some of the finest technical assistance in the industry.

You get a broad selection of low and high expansion, as well as glass- or ceramic-sealing grades. In every form and size. For every job.

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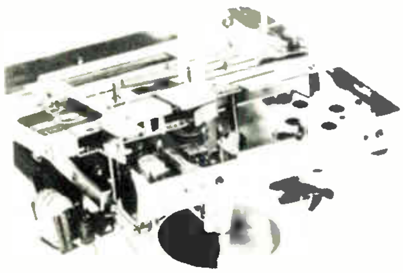
High-quality surfaces, uniform temper, minimum orange peel, and camber.

Computer Automation's Naked Mini/LSI and Alpha/LSI minicomputers. The memory is designed to allow users of those computers to expand memory capacity in the mainframe with significant cost savings; the module is priced at $2,750. It can also be intermixed with MOS or other core memories of various capacities. First deliveries of the module will be made during the first quarter of 1974.
Computer Automation Inc., 18651 Von Karman, Irvine, Calif. 92664 [365]

Audio cassette transport is tamper-proof

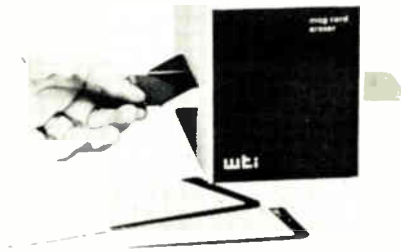
The model CAS-4 audio cassette tape transport is a three-motor, unidirectional device that is capstan-driven. The transport features key-slot loading that makes it impossible to insert the cassette incorrectly. In addition, the cassette mechanism is interlocked and tamper-proof to prevent damage from misuse. The CAS-4 provides a two-channel, two-track record/play head and uses no mechanical controls. Price is $90 each in quantities of 1,000.



Conrac Corp., Mill Rock Rd., Old Saybrook, Conn. 06475 [368]

Desktop unit erases IBM magnetic cards

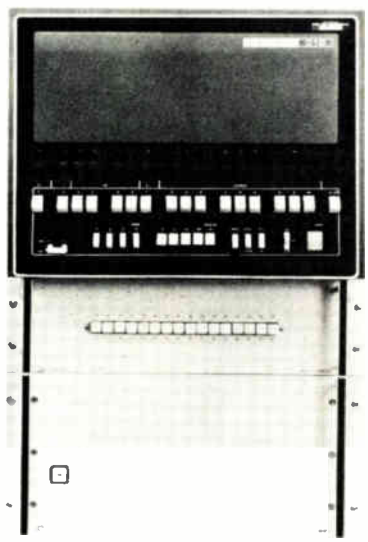
To simplify reuse of IBM Selectric typewriter magnetic cards, a magnetic card eraser restores any cards passed through it to blank condition. Cards can be passed through the eraser as often as required without scratching or harm to the magnetic surface. Price is $75.



Western Telematic Inc., 3001 Red Hill Ave., Costa Mesa, Calif. 92626 [369]

Disk memory system has access time of 8.4 ms

A 3,600-rpm disk memory system for Honeywell 316/516 minicomputers, called the model 1747, is a head-per-track peripheral with capacity available in five levels from 32,000 to 524,000 words. Average access time is 8.4 milliseconds, and average data-transfer rate is selectable at the time of purchase in four increments from 8 to 64 microseconds per word. Track advance is automatic so that variable-length records may be written. Price is less than $7,600 for OEM applications.
Data Disc Inc., 686 W. Maude Ave., Sunnyvale, Calif. 94086 [370]



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Our 21-inch PDP-11/35 minicomputer for OEMs. All the big-system power of our PDP-11/40 at a much lower price.

With 32K words of our newly designed high-density 980ns memory.

And memory management capability is standard.

Plus the ability to run high-level operating systems like RSTS/E and RSX-11D. And ANSI-standard FORTRAN. CAPS 11. BASIC. BATCH. RT 11. And much more, from the world's largest library of minicomputer software.

There's plenty of room for system expansion. Up to 128K of memory. Floating point. Interfaces, controllers, communications devices. And over 60 PDP-11 family peripherals.

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And all for only $13,117.*

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Our 10½-inch PDP-11/35 minicomputer with 8K of memory.

For the OEM who needs 11/35 power and expansion, but in a smaller package at a lower price.

Memory expands to 32K within the chassis. And memory management is available.

Plus all those options. And peripherals. And software.

It comes in a rack-mountable chassis for packaging convenience and flexibility. And includes power supplies, programmer console, and pre-wired connector slots for floating point and memory management. $6,077.*

It's a small price to pay.

Introducing $4,156.

Our 10½-inch PDP-11/05 minicomputer. The new big box version of Digital's famous 5¼-inch model, but for OEMs who need greater expansion and flexibility.

Memory starts at 8K and grows to 28K.

Standard features include four-level automatic priority interrupt, direct memory access, power fail/restart, line frequency clock, serial communication line interface, and programmer's console.

Plus, again, all those 11-family options, peripherals and software. At only $4,156.*

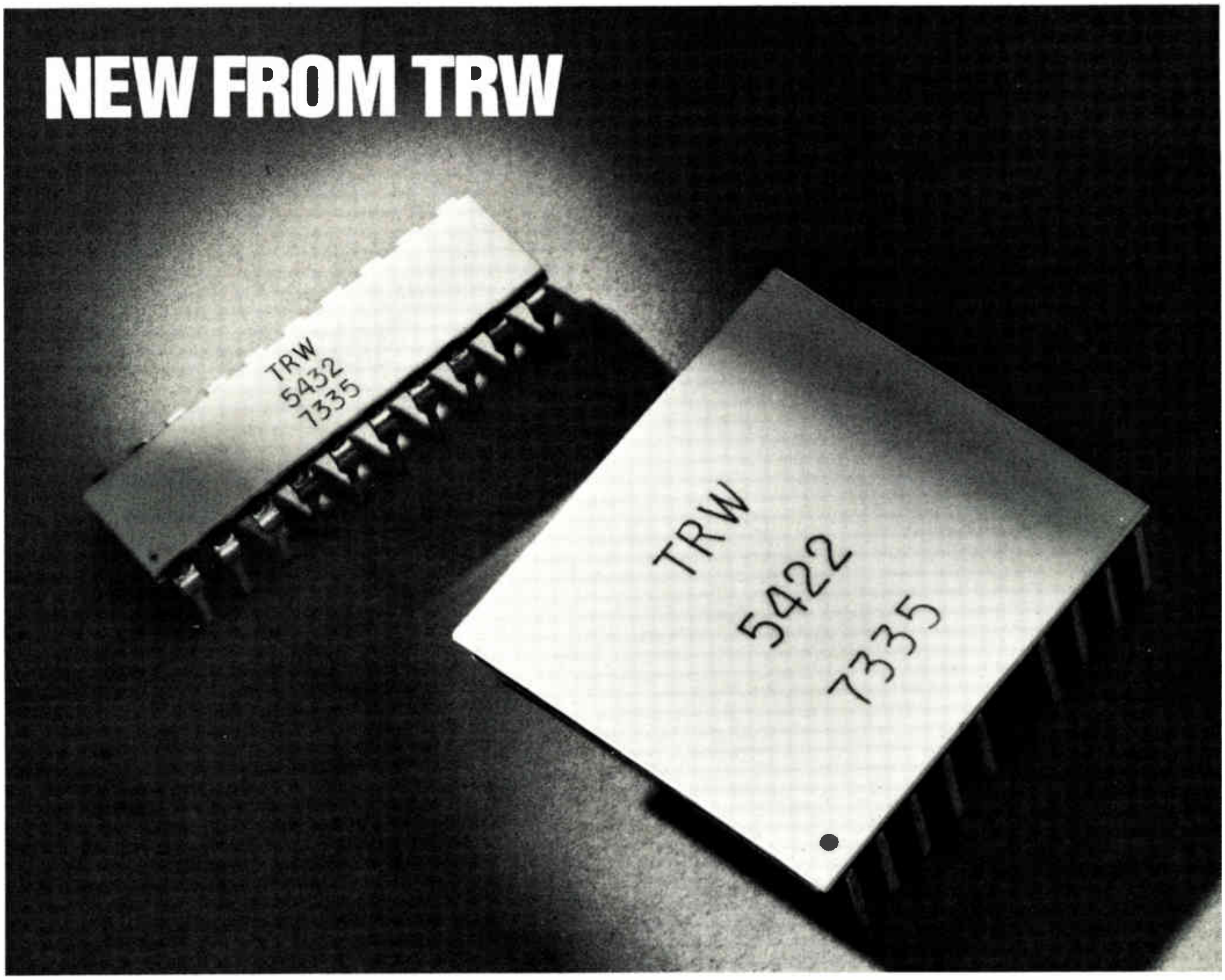
No wonder the PDP-11 outsells all other 16-bit computers on the market.

digital

Contact your local Digital office. Or write: OEM Products Group, Digital Equipment Corporation, Maynard, Mass. 01754 (617) 897-5111. Ext. 3115. European headquarters: 81 route de l'Aire, 1211 Geneva 26. Tel: 42 79 50. Digital Equipment of Canada Ltd., P.O. Box 11500, Ottawa, Ontario K2H 8K8. (613) 592-5111.

Circle 179 on reader service card

*QUANTITIES OF 100.



12-Bit TaNFilm® Binary Ladder Networks

These networks—representative of TRW/IRC's tantalum nitride film capability—are now available in standard DIP configurations in 12-bit accuracies. They are also available in a larger version that is pin compatible with an earlier, popular design.

TaNFilm networks — designed for digital-to-analog and analog-to-digital conversion—offer excellent stability, high accuracy, low noise, fast switching and fast settling time. Due to the inherent passivation of TaNFilm, they provide hermetic performance *without* hermetic cost. They retain half LSB accuracy over the entire operating temperature range and after extended operating life.

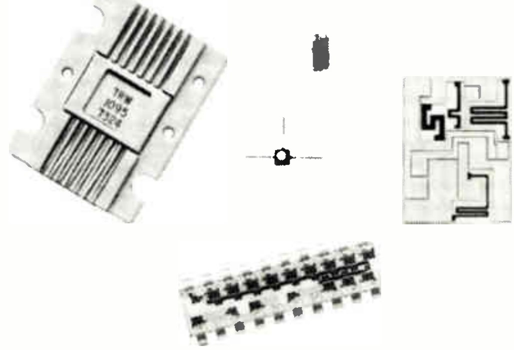
TaNFilm R-2R ladder networks include application resistors, permitting use of a variety of circuit configurations. Compensation to −5% can be provided in both input and application resistors.

Performance Characteristics

Ladder resistance values (R)	5K, 10K, 20K, 25K ohms
Ladder resistance tolerance	±1%
Absolute temp. coeff.	−75 to −125 PPM/°C
Maximum input voltage	20 volts
Operating temperature	−55 to +125°C
Storage temperature	−65 to +150°C
Conversion accuracy*	½ least significant bit (122 ppm)
Switch compensation	to 5 ohms
Settling time	to 20nSec.

*Ladder voltage ratio accuracy is the maximum voltage ratio error expressed in ppm of full scale with any combination of bits activated.

Also available in special configurations—to meet your needs. Request new bulletin detailing performance, cost savings, mechanical characteristics. TRW/IRC Precision Network Operations, an Electronic Components Division of TRW, Inc., 2850 Mt. Pleasant St., Burlington, Iowa 52601. (319) 754-8491.

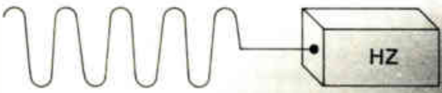


TRW® IRC RESISTORS

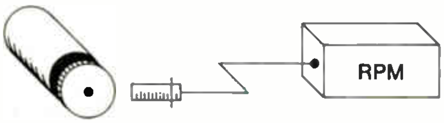
Measuring flow rates, draw ratio, rpm, rates, totals, speeds or time periods?

1.89"H x 4.39"W x 4.50"D

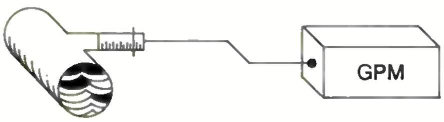
The DigiTec Model 810 Digital Process Indicator can be used to measure an infinite variety of parameters through the use of state of the art design.



Featuring programmable normalization for direct reading in engineering units, the 810 uses an internal crystal clock for precise, measurement.

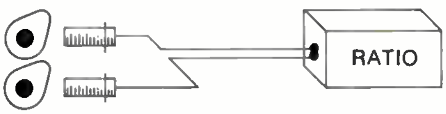


Available in models with 3, 4 or 5 digit non-blinking, LED displays, they have a basic input sensitivity of 10mV RMS for use with the outputs of magnetic pickups, photo cells, shaft encoders or any other pulse generating transducers.

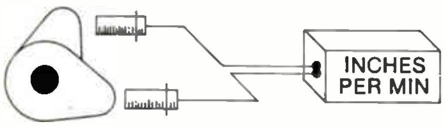


The 810 has an input frequency range beyond 100KHz.

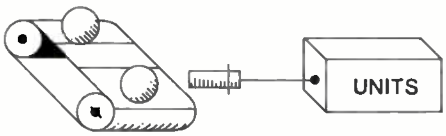
Although sensitive, the input can withstand up to 500V peak to peak without damage.



Once programmed for normalization and input sensitivity (both on a rear connector) the Model 810 Indicator becomes a "Hands off" readout, usable by non-technical personnel.



Optional stored BCD output for use with limit detector, recording peripherals and computer interface is also available.



To see a DigiTec Model 810 Digital Process Indicator and obtain quantity prices, contact your nearest DigiTec or Monsanto Representative or write United Systems Corporation.

Prices start at $234.

United Systems Corporation
918 Woodley Road, Dayton, Ohio 45403
Ph. (513) 254-6251 Twx: (810) 459-1728
a subsidiary of Monsanto

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Circle 181 on reader service card

Packaging & production

Boards handle all ECL circuits

Modular wire-wrap panels can be combined, using busing, special hardware

New wire-wrap boards for emitter-coupled-logic circuits may simplify a problem that has discouraged some users from trying ECL in their systems. Augat has been making boards for 18K ECL, and Standard Logic has now developed panels suitable for all ECL, even 500-MHz MECL III. Don Nash, designer of the Standard Logic systems says, "We wanted a wire-wrap system that a customer can use for all ECL without problems." He adds that many users want to mix the families.

The boards are compatible with the company's earlier CASH (computer-automated systems hardware) TTL boards, and, like them, are suitable for computer layout and simple wire routing. Nash says that the boards permit full 10K and MECL II speed with minimal restrictions, run connecting lines in series, terminate with proper resistor values, and keep connections under 10 or 12 inches in length.

The Standard Logic system is modular; small cards hold 16 16-pin sockets (or three 24-pin plus eight 16-pin sockets or other combinations). These are combined into larger panels using special busing and grounding hardware designed for low impedances (The ground bus is 3/16-inch by 1-inch bar stock, for example).

An important consideration in using ECL is the requirement for large quantities of terminating and pull-up resistors. One approach to this in standard hardware is the use of DIP-resistor networks, but Nash points out that a resistor package is required for each two to three ICs, since only eight can be used per package in high-speed circuits. This cuts density by one-third. Another approach is to hang resistors from wire-wrap pins—obviously an expensive approach, since it interferes with high-speed wire-wrapping. Standard Logic's approach is to have small plug-in resistor cards available between each row of ICs. Each card can hold up to 43 resistors, and no input or output pin is more than one-half inch from a resistor, he says. Each row is equal to about six plug-in packages. He adds that the resistors must be optimized for best results.

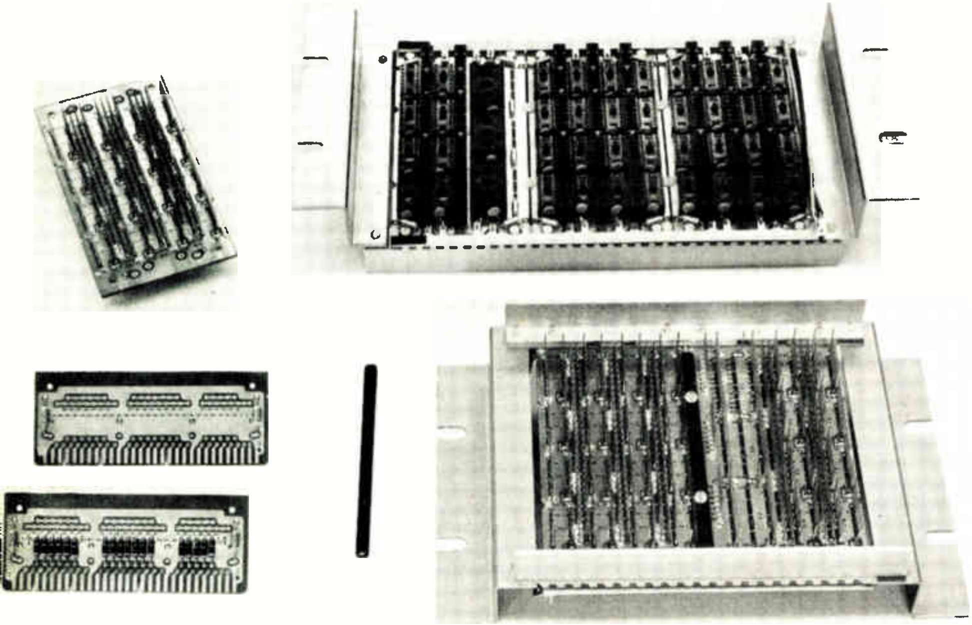
Using ECL requires careful attention to bypassing and low-impedance power connections. Standard Logic uses a ceramic disk bypass capacitor for each IC socket and four tantalum capacitors per board. In addition, thin-circuit laminate provides a significant distributed capacitance for high-frequency bypassing. Low-impedance power uses are also laminated with the ground plane. The company incorporates a ground plane on the pin-side of the board, rather than on the top of the board, which permits the interconnection wires to be right against it for constant low impedance.

The cards have extra ground pins for use with twisted pairs, and all power and ground pins are shorter than socket pins for ease of identification. Socket pins are higher for testing and troubleshooting, the company points out.

Standard Logic finds that, for optimum use of ECL, it's best to group logic into small subsystems, then connect them. This requires extra receivers, but minimizes long interconnections. And, says Nash, it "is the price for playing the high-speed game and winning."

The ECL cards are priced at $46 each, with accessories and variations available. Delivery is from stock for small quantities.

Standard Logic Inc., 2215 S. Standard Ave., Santa Ana, Calif. 92707 [391]



Reflow soldering system handles ceramic hybrids

The model AR-7 automated reflow soldering system is designed for high-speed production soldering of ceramic hybrid circuits. The system features a free-standing solder station and add-on belt extensions that connect work stations directly to the solder-reflow area. Also provided is bottom-side heating, which offers the advantage of absolute tempera-

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Our Hustler 44 — the IC tester that's bought by people who really understand automatic testing — is KO'ing our big competitors time after time.

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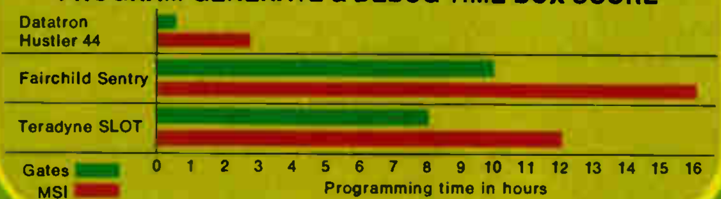
Job Classification	Datatron Hustler 44	Teradyne SLOT	Fairchild Sentry Series
Technician	Yes with just a few hours of training in your facility	Doubtful. Might take a semester of training at factory	A long shot. Could botch things up
Production Engineer	No problem after a few hours of training in your facility	Possible, but only after weeks of training at factory	"Ditto"
Computer Programmer	Not required but could learn in couple of hours	Recommended. But would still need weeks at factory	"Likewise"

PROGRAM GENERATE & DEBUG TIME BOX SCORE



Datatron Hustler 44

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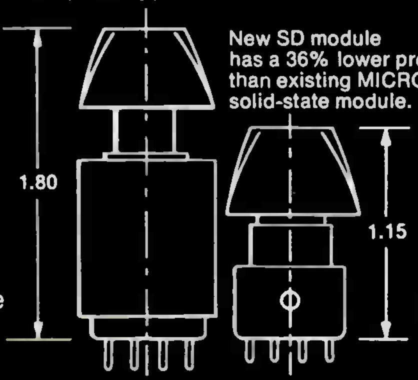

New SD module has a 36% lower profile than existing MICRO SWITCH solid-state module.

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Circle 184 on reader service card

ture control for substrates and heat-sensitive components.
Browne Corp., 212 E. Gutierrez St., Santa Barbara, Calif. 93101 [405]

Mask-aligner station minimizes vibration

A laminar-flow mask-aligner station provides a work surface that is independent of the overhead blower-filter module. This prevents transmission of vibration from that source. The mask aligners can be serviced from the rear, and the Plexiglass panels of the blower-filter frame slide out to enable work to be passed to an adjoining work station. The new model operates at very low noise levels.
Agnew-Higgins Inc., 7091 Belgrave Ave., Box 857, Garden Grove, Calif. 92642 [406]

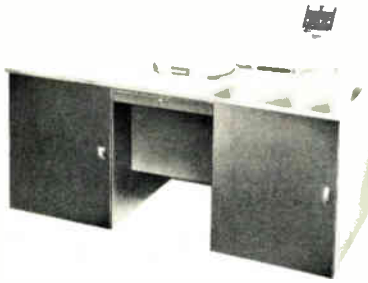
Test system handles semiconductor memories

A computer-operated test system designed for semiconductor memories with capacities of up to 4,096 4-bit words is designated the model

J384. It performs functional and parametric tests on static and dynamic MOS and fast bipolar memories. The instrument features vector-list autocalibration that automatically compensates for time delays inherent in the system and ensures accurate timing, either closed- or open-loop, at each test station. Thus, once the test plan is prepared, it may be used thereafter at any test station without modification. Price starts at $85,000.
Teradyne Inc., 183 Essex St., Boston, Mass. 02111 [393]

Baking unit processes 450 wafers per hour

During a typical 19-minute cycle, which includes the time required for loading and unloading, an automatic baking machine develops, rinses, dries, and bakes 150 3-inch wafers. The system offers process control and includes a five-stage ex-



plosion-proof developer, forced-nitrogen ducted heater, pressure gages, two tanks and all the necessary controls.
Corotek Corp., 2812 Knott Ave., Garden Grove, Calif. 92640 [394]

Dual-view comparator speeds board inspection

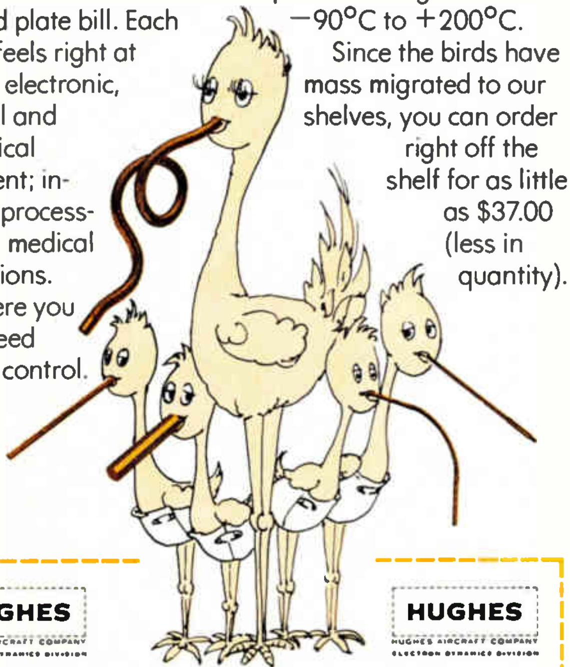
A dual-view comparator for inspecting printed-circuit boards is designed to replace blink- or flicker-type machines. The unit provides a comparison of the new board with a master board and shows a limited area of both boards side by side on a lighted ground-glass screen. Images are magnified to more than double the original size, and addi-

The long-billed heat sucker would like you to meet her family.

Our good friend, the Heat Sucker (better known as a Hughes heat pipe), is now the proud mother of an entire flock: round and flat bills, flexible round bills and the cold mounted plate bill. Each variant feels right at home in electronic, chemical and mechanical equipment; industrial processing; and medical applications. Anywhere you might need thermal control.

Heat Suckers come in various sizes: 3/16" to 1" diameter, 6" and 12" lengths. They have thermal transport capabilities of 10 to 2,000 watts covering temperature ranges from: −90°C to +200°C.

Since the birds have mass migrated to our shelves, you can order right off the shelf for as little as $37.00 (less in quantity).



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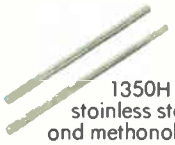
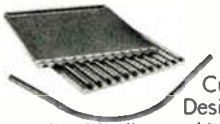


1350H Series — stoinless steel ond methonol.

1370H Series — copper ond woter.

1333H — stoinless steel ond ommonio.



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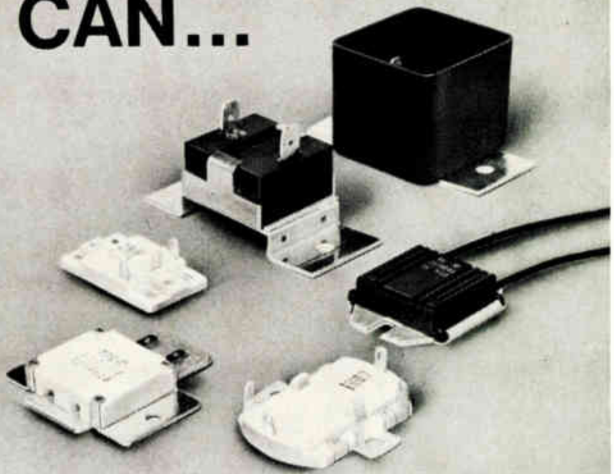

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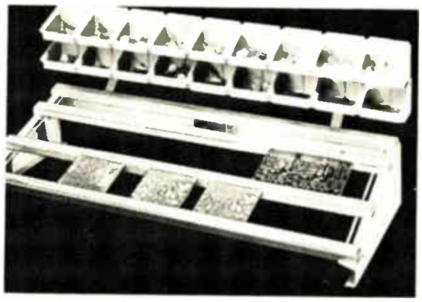
tional magnification of a limited scanning area is available.

Metron Optics, P.O. Box 690, Solana Beach, Calif. 92075 [396]

Assembly stations load printed-circuit boards

A line of assembly stations for printed-circuit-board production is designated Para-Trak. The stations, which are portable, can be coupled

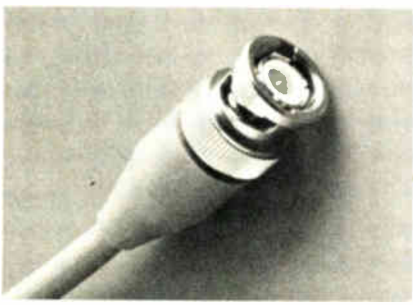


together in a continuous assembly line for sequential board-loading operations. Other features include adjustable tracks and a variety of accessories.

Production Systems Inc., 2021 Via Burton, Anaheim, Calif. 92806 [395]

BNC connector is molded into place

A BNC bayonet cable assembly is part of the Molded-On connector product line of Component Manufacturing Service Inc. Every connection is soldered and meets military specifications. Molding is a process in which a high-impact plastic body is formed in place so that each contact solder joint and wire is permanently embedded. Several types

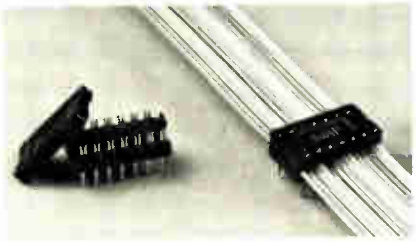


New products

of termination are available.
Component Manufacturing Service Inc., 1 Component Park, W. Bridgewater, Mass. 02379 [397]

Flat-cable latch connector offers multiple terminations

A latch connector provides multiple terminations for flat cable having round conductors on 0.050-inch centers, as well as for woven flat cable. The conductors can be #28 AWG stranded or #30 AWG solid wire, and all terminations are made simultaneously without the need for prestripping or insulation. Connectors can be applied at the end of the cable or anywhere in its length.
AMP Inc., Harrisburg, Pa. 17105 [398]

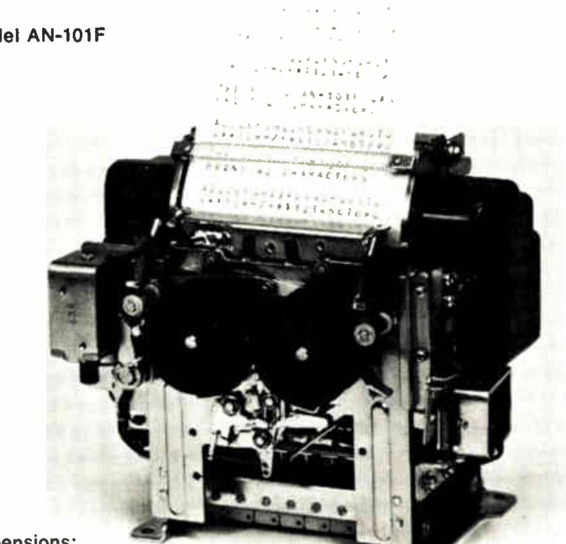


Wafer-washing system reduces operations costs

Called the Hydronomic system, a wafer-washing unit is said to reduce costs in three ways. One way, point-of-use polishing, ensures high-quality rinse water, thus avoiding variable yields caused by sporadic contamination. Another way is selective recirculation and repurification, which can conserve as much as 80% of the high-purity water that is often wasted. And the third cost-saver is a downstream resistivity meter, which shortens rinse cycles by eliminating arbitrary elapsed-time criteria for wafer-rinsing. The design of the system is modular, so that the user can tailor an installation to the particular need or add to an existing system. The Hydronomic produces particle-free water of 18 megohm-cm resistivity and uses cylindrical wash tanks.
Millipore Corp., Bedford, Mass. 01730 [399]

Another fine OEM product from C. Itoh.

Model AN-101F



Dimensions:
Height 6", Length 4.4", Width 6.4"

Alpha-Numeric Printing Mechanism.

Designed for the computer peripheral market, this model AN-101F has a capability of printing all 26 alphabetic characters and 10 numeric characters. It can handle up to 21 columns with 42 characters per column, including six special symbols, at a speed of up to 1.2 lines per second.

The Model AN-101F provides a permanent printed record of management information, hospital information, order processing, production scheduling and warehouse inventory. Other features include two-color printing, low electrical power consumption and compact design.

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Circle 190 on reader service card

Circle 246 on reader service card

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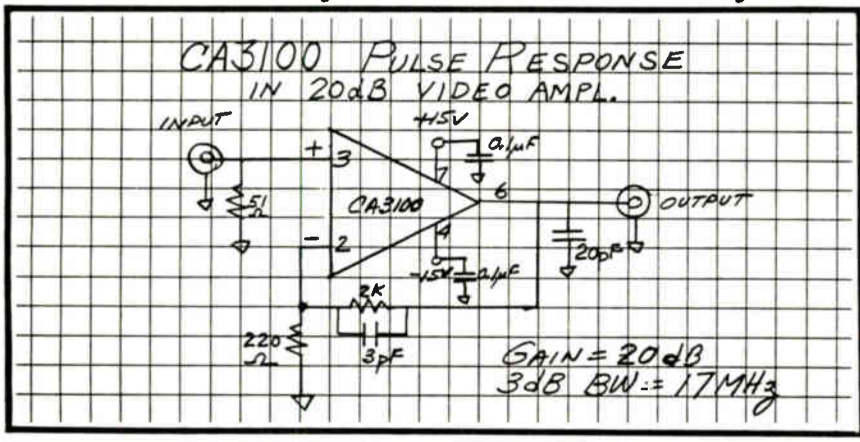

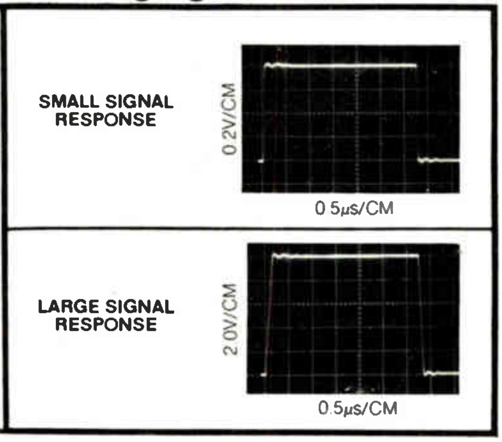

That's because we've combined all of the following features in a single device:

- ☐ High open-loop gain at video frequencies—42 dB at 1 MHz.
- ☐ High slew rate—70 V/usec (unity-gain, voltage follower, input compensated).
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- ☐ Fast settling time—0.6 usec.
- ☐ High output current—± 15 mA (min.).

These features are achieved with simpler circuitry because we've combined P-MOS and bipolar transistors on a single chip.

Compare the CA3100 with other wideband op-amps. You'll see the difference. Large signal or small... output waveforms are true reproductions of the input—virtually free from ringing and distortion. Also, compare open loop gain at Video Frequencies—22 dB at 10 MHz.

The CA3100 features dc offset adjust terminals for applications requiring offset null. It can be compensated with a single external capacitor and is pin compatible with other op-amps such as the LM118, LM307, and UA748.

Whatever your applications... high-speed comparators, instrumentation, video... take advantage of the CA3100's characteristics. You get all these features and more... with no tradeoff in price—$3.50 for 1000 unit quantities.

The CA3100 is available in the standard TO-5 hermetic package, CA3100T, or the dual-in-line version, CA3100S. You can get them in production quantities from your local distributor or direct from RCA.

Interested? Let us send you the complete DATA SHEET! Write: RCA Solid State, Section 70L-6 Box 3200, Somerville, N.J. 08876. Or phone: (201) 722-3200.

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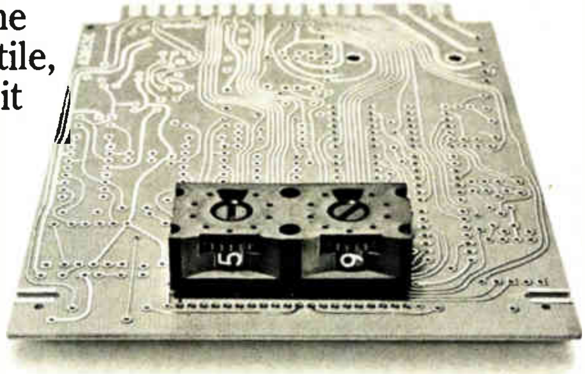
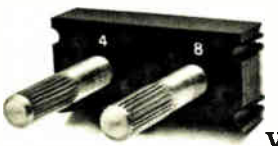
INTRODUCING THE TWO-FACED SWITCH



EECO introduces the Stripswitch™—a versatile, low cost printed circuit switch that's available in strips of one to eleven stations, for ease of handling and installation.

Because it's two-faced, you can mount it either horizontally or vertically.



And you can wave-solder it directly to the printed circuit board.

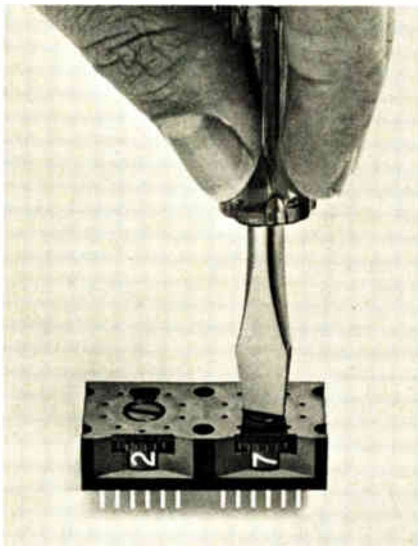
Saves you money

Stripswitch is inexpensive to begin with—less than $1 per station in quantity.

And, because you can wave-solder it directly to the printed circuit board, the need for rivetting, eyeletting, mounting hardware, switch-to-board wiring or expensive special plating is normally eliminated.

Actuates three ways

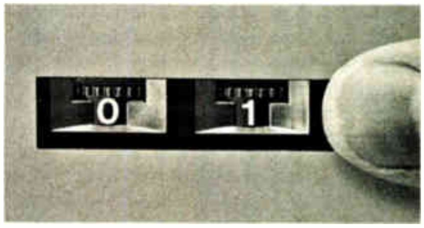
You can actuate Stripswitch by means of



knurled wheels. Or, if you mount it behind a panel, you can actuate Stripswitch by means of a screwdriver or shaft extension and knobs.

Guaranteed rugged

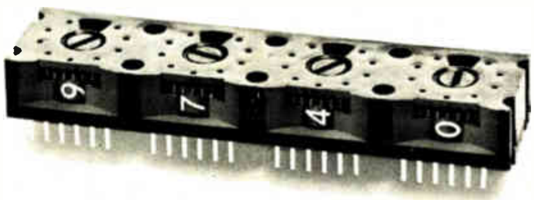
The Stripswitch is a simple, rugged design available in a variety of



codes and switching functions, backed by an exclusive two-year warranty. And it's constructed from materials that can withstand caustic cleaning solutions.

That's the straightforward story of our two-faced switch.

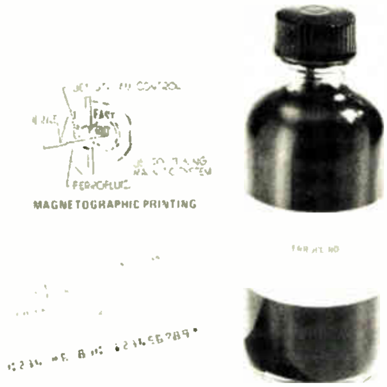
For more information write to Electronic Engineering Company of California, 1441 East Chestnut Ave., Santa Ana, California 92701. Or phone (714) 835-6000.



Stripswitch by EECO

Distributed by Schweber, Hall•Mark and G.S. Marshall

Circle 193 on reader service card



Ink-jet printing systems are among the applications for magnetic fluids, a new class of materials that are said to solve ink-settling and clogging problems in traditional, as well as new, printing techniques. Magnetic fluids are available in a wide range of carrier liquids, allowing printing on various surfaces. Signal output from magnetic-ink characters meet American Banking Association standards. The material, also called Ferrofluids, is suited to ink-jet printing systems because these systems require passage of the ink through tiny orifices and the printing jets are magnetically controlled.

Ferrofluidics Corp., 144 Middlesex Turnpike, Burlington, Mass. 01803 [476]

A clear encapsulating resin designed specifically for use with discrete and display-type light-emitting diodes is designated Epocast 2013 A/B. The line consists of four products for specific applications, but all four types of resin are two-component systems with long working life, fast-cure properties, good light transmission, and high heat-distortion temperatures.

Furane Plastics Inc., 5121 San Fernando Rd. West, Los Angeles, Calif. 90039 [477]

Epitaxial gallium-arsenide-phosphide for visible LEDs provides ranges of about 650 nanometers, with wavelength and layer thickness to meet customer specifications. Over-all composition thickness is held constant.

Texas Materials Laboratories, 2716 National Circle, Garland, Texas 75041 [478]

An epoxy powder called DK16 is said to exhibit good moisture resistance on film and ceramic capacitors. The coating powders of the D16 series gel in seconds, cure in minutes, and coat at low temperatures without pinholing. They also offer good heat resistance and self-extinguishing properties. Red powder is available from stock, but other colors can be formulated.

Hysol Division, The Dexter Corp., 211 Franklin St., Olean, N.Y. 14760 [479]

A gold process with high deposition rate for plating connectors, switches, and other electronic parts, is called Autronex CC. The acid-type formulation for gold electroplating produces deposits with a purity of 99.8% and a hardness range of 140 to 190 knoop. The gold is deposited at about twice the rate of other processes, the company says. Coatings are bright and exhibit constant electrical resistivity.

The Sel-Rex Co., 75 River Rd., Nutley, N.J. 07110 [480]

Screen-printable thick-film pastes are being offered in sample packets for evaluation and include a range of resistor, conductor and dielectric materials for hybrid microcircuit and discrete component applications. Each of the three basic packets contains five one-ounce containers of different pastes, processing data, and engineering test property information. In addition, a number of combinations of packets can be selected from the company's full line of thick-film pastes. Prices are $150, $200, and $295 for the evaluation packets.

Thick Film Systems Inc., 324 Palm Ave., Santa Barbara, Calif. 93101 [401]

For use in potting electronic components and circuits, and as an electrical surface coating, Eccofoam VIP is a urethane resin supplied as two components, that are mixed, cast and cured into a unicellular material. The resin has low density and a low dielectric constant of 2.1 at 1 megahertz. Dissipation factor at the same frequency is 0.03. The material is priced at $24.15 for a 1-gallon kit.

Emerson & Cuming Inc., Canton, Mass. 02021 [402]

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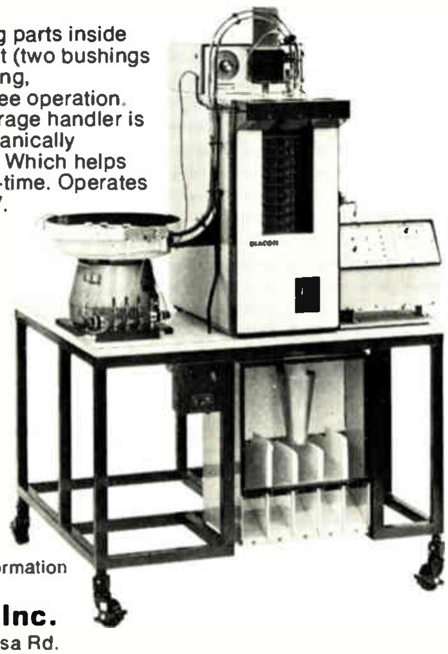
Circle 195 on reader service card



New literature

Resistors. An eight-page brochure is available from the Stackpole Carbon Co., Electronic Components division, Kane, Pa. 16735, describing fixed-composition resistors. Performance characteristics and applications information are given. Circle 421 on reader service card.

Microwave amplifiers. Singer Instrumentation, 3176 Porter Dr., Palo Alto, Calif. 94304. Unattended, remote-control operation such as that required for remote microwave links and CATV distribution is discussed in a brochure on the series 5000 microwave amplifiers. [422]

Relays. A line of medium-duty ac or dc general-purpose, 10-ampere relays is described in a two-page bulletin available from North American Philips Controls Corp., Frederick, Md. 21701 [423]

A brochure describing miniaturized traveling-wave tubes for phased arrays and other airborne applications is being offered by RCA Electronic Components, 415 S. 5th St., Harrison, N.J. 07029 [424]

Rectifiers. International Rectifier Corp., Semiconductor division, 233 Kansas St., El Segundo, Calif. 90245. A series of 300-ampere high-voltage rectifiers, called the 301U series, is described in a data sheet that contains specifications and ratings. [425]

Circuit packages. Tekform Products Co., 2770 Coronado Ave., Anaheim, Calif. 92806, is offering a 10-page bulletin describing and illustrating the company's line of Dihedral microelectronic circuit cases, in which the terminals enter the case at an angle of 45°. [426]

White noise. A four-page data sheet providing information on a white-noise generator is available from Codi Semiconductor division, Codi Corp., Pollit Dr. South, Fairlawn, N.J. 07410 [427]

Hardware catalog. Seventy-eight types of panels, socket boards, connectors, and special boards incorpo-

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New literature

rating decoupling capacitors are described in a 28-page catalog now available from Tekmar Electronics Ltd., 102 High St., Harrow-on-the-Hill, Middlesex, England [428]

Pc connector. A zero-insertion-force printed-circuit connector, designed to eliminate high engagement forces and to permit dense packaging, is described in a bulletin being offered by Amphenol Industrial division, Bunker Ramo Corp., 1830 S. 54th Ave., Chicago, Ill. 60650 [429]

Potentiometer. A four-page brochure from West Instrument division, Gulton Industries Inc., 3860 N. River Rd., Schiller Park, Ill. 60176, describes the Pyrotest, a direct-reading-scale potentiometer used to check and calibrate all types of industrial and laboratory thermocouple pyrometers. [430]

Silicon rectifiers. Edal Industries Inc., 4 Short Beach Rd., East Haven, Conn. 06512. Bulletin 133 provides information on miniature high-voltage rectifiers for commercial and industrial applications. [431]

Screening guide. Continental Testing Laboratories Inc., 763 U.S. Highway 17-92, Fern Park, Fla., has prepared a guide to screening for users of integrated circuits and discrete semiconductors. The guide compares various screening programs and test methods. [432]

Digital tape recorders. Digi-Data Corp., 4315 Baltimore Ave., Bladensburg, Md., has published a six-page catalog describing incremental and synchronous tape transports for generating IBM-compatible magnetic tape. Specifications are set in tabular form. Formatters, minicomputer interfaces and dual buffers are included in the short-form catalog. [433]

Computer solutions. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. A 32-page bulletin describes a variety of computer solutions for instructional, administrative and research problems of colleges and universities. [434]

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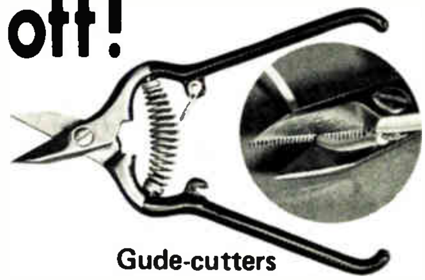

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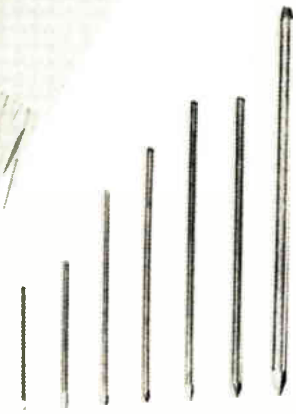

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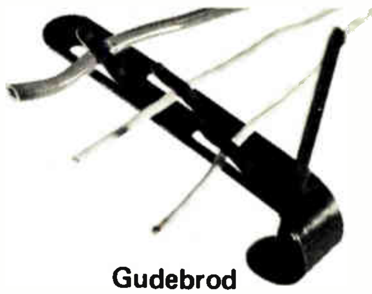

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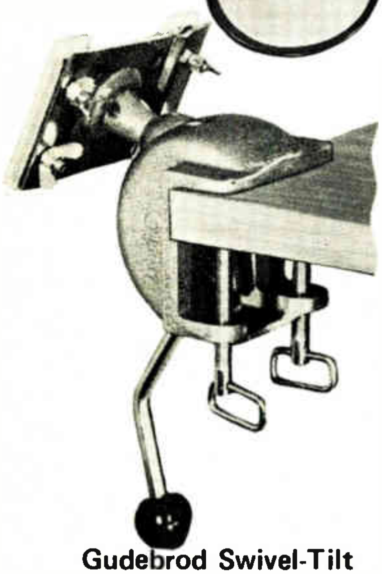

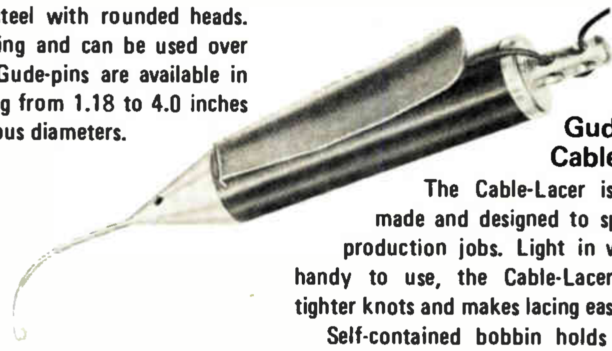

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New Books

IBM System 370 Medium Systems, An Auerbach Computer Technology Report, Auerbach Publishers Inc., Philadelphia, 51 pp., $25.00.

Auerbach, a Philadelphia market-consulting and publishing firm, has put together a good collection of unbiased information about the middle seven of the 13 models in IBM's System 370 series. The report, intended for computer users, is expensive, but it is also comprehensive and apparently accurate.

The book—actually a collection of loose-leaf pages in a semipermanent plastic binder—summarizes the principal features of the entire line of System 370 computers, then gives more detail on the seven middle models. There are brief discussions of four kinds of input-output attachments (all different from the System 360), four kinds of operating systems, virtual memory, and the differences between core and semiconductor memory.

There is a generally laudatory description of the reliability and maintainability of the machines, but the section dealing with applications software contains some unwarranted assumptions about what the reader already knows. For example, the book says, "VSAM, or virtual storage access method, is a functional replacement for ISAM." ISAM, which actually stands for indexed sequential access method, isn't defined in the book, as it should be.

After these introductory remarks, the report gets into a detailed evaluation of the various models. It discusses the levels of compatibility, considers domestic and foreign competition, and takes an occasional swing at the competitive equipment, as well as at IBM. It also looks at the independent manufacturers of plug-compatible peripheral equipment, software houses, and third-party lessors, and reports two users' divergent reactions.

The differences between the various mainframe models are discussed. There are accounts of such features as reloadable control storage, two-level storage (cache memory), storage protection, addressing facilities, and the three principal kinds of input-output

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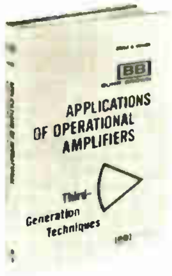

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channels. Also, there is a list of available peripheral devices with specifications, communications equipment, and terminals.

Finally, a section on software gives program classifications and definitions, more on operating systems and virtual memory, and descriptions of system-support and data-communications software, and applications programs.

Maverick Inventor, My Turbulent Years at CBS, Peter Goldmark, Saturday Review Press, 222 pp., $7.95.

Goldmark's book is one man's entertaining inside view of what it's like to be head of a corporate research facility, CBS Laboratories, in which, Goldmark relates, the mandate was: "Go forth and make money." For the EE in management, there may be lessons to be learned from it, especially if he's curious about what happened to electronic video recorders.

EVR was invented by Goldmark, the man who brought us the long-playing audio record. It was one of those developments that had a lot going for it, but the project seemed to head down-hill from the day it was finally let out of its box by CBS Laboratories. Behind the whole project was CBS, a giant in TV programing. Yet, EVR was all but dead by 1972, when CBS shut down U.S. EVR operations and left its development to European and Japanese "partners."

How did this happen, and who is to blame? Well, for one readable and colorful side of the issue (and this may be the only side ever to see print), there is Goldmark's new book issued last month in which he covers this phase of his career in a chapter called, "The Great EVR Sleighride." This title will give a pretty good indication of how he assesses EVR's failure. In short, Goldmark points the finger at top management for the lack of consistency in pushing the development, and not at any intrinsic technical weakness in the EVR system. Specifically, he cites CBS chairman William Paley's fear that EVR would invade the corporation's television-broadcasting market.


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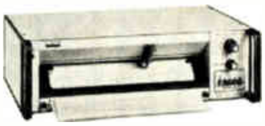

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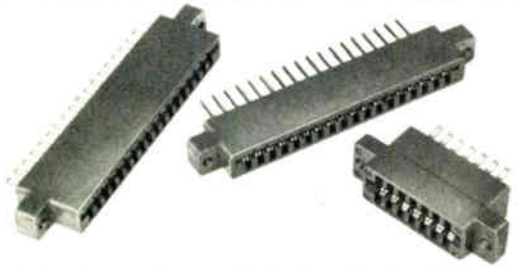

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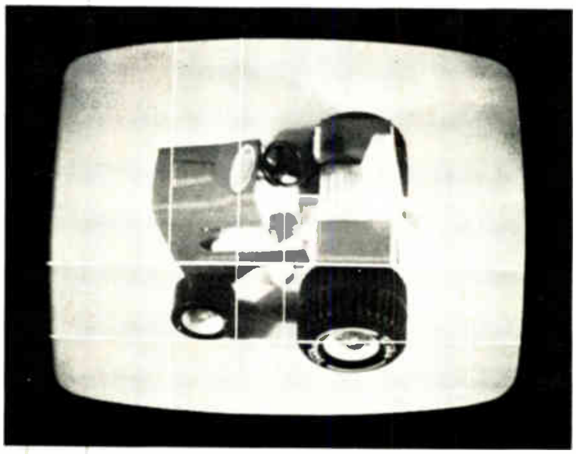

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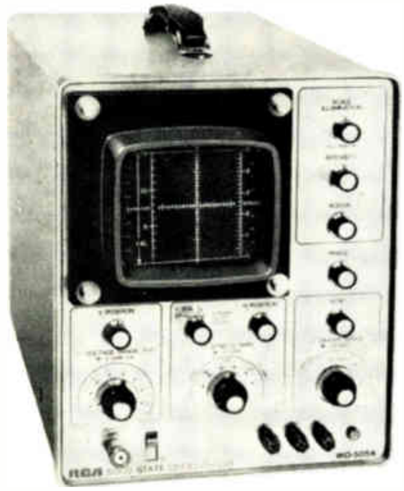

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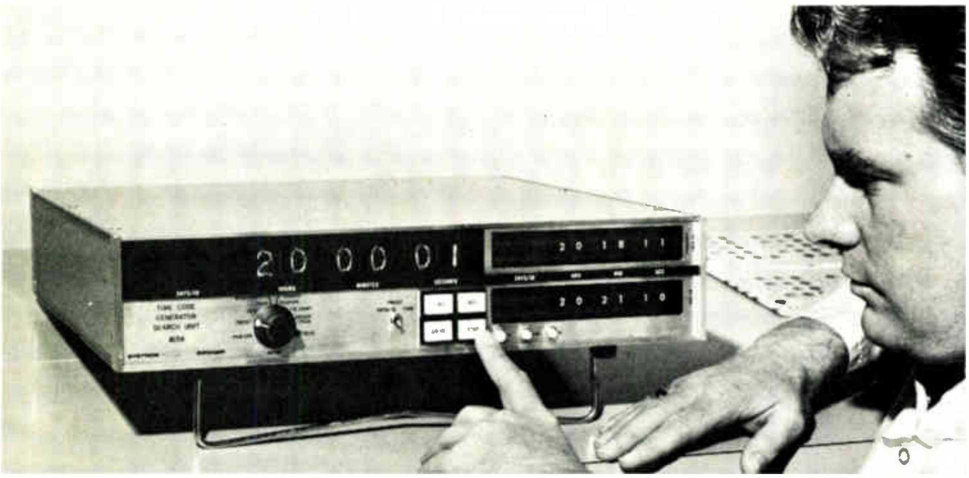
Circle 209 on reader service card

Is it a time code generator? Reader? Tape search unit?



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For full details contact S-D at 10 Systron Drive, Concord, CA 94518. Phone (415) 682-6161.

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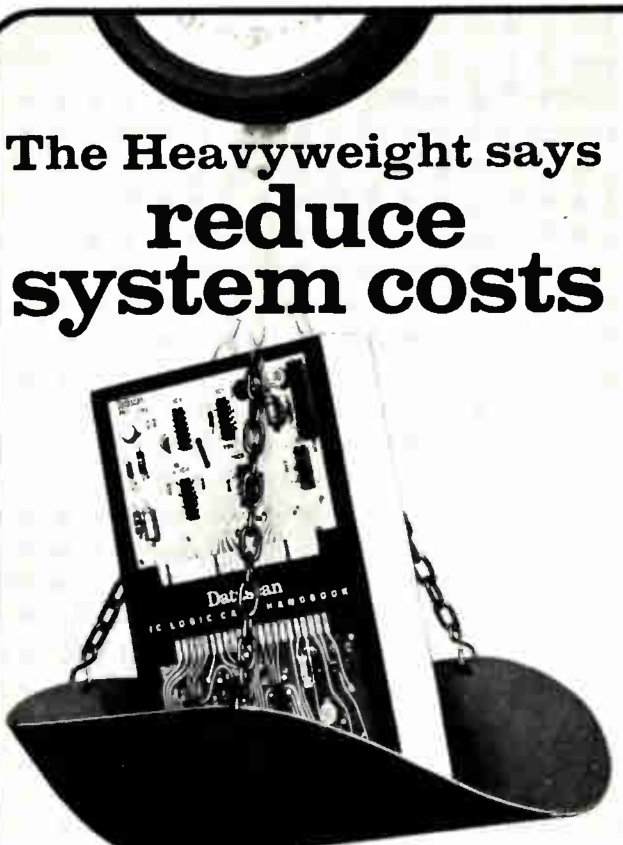

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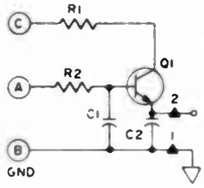

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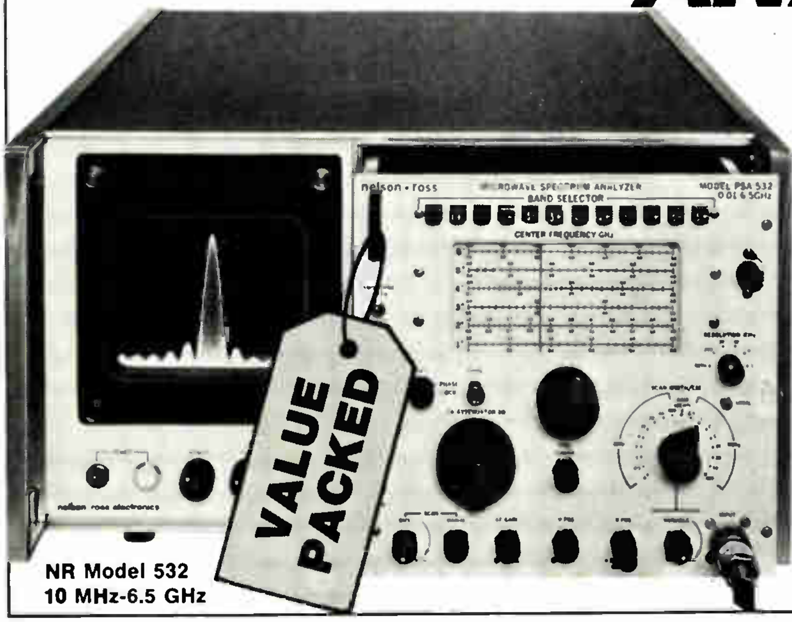

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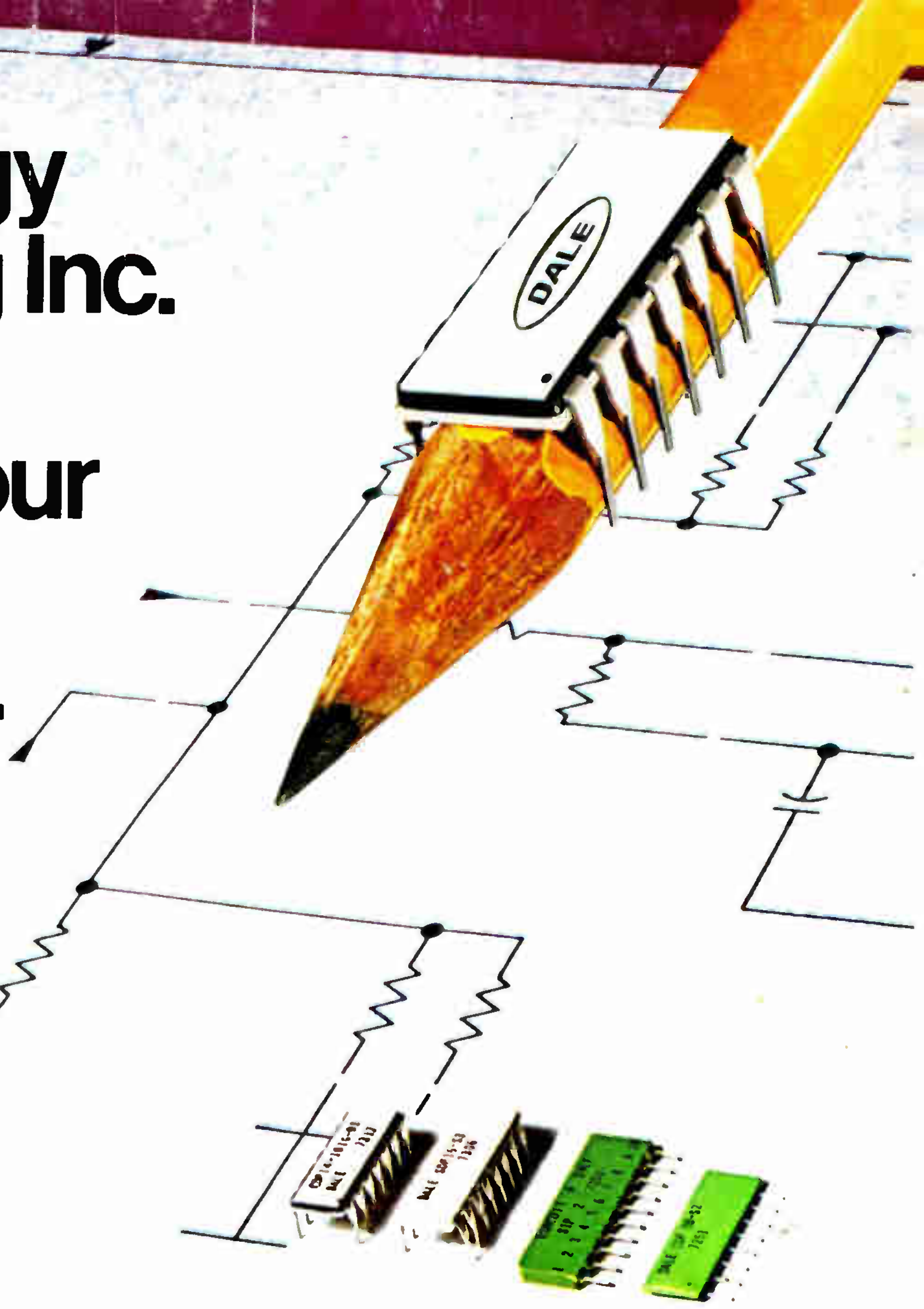

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