March 1, 1973

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Electronics®

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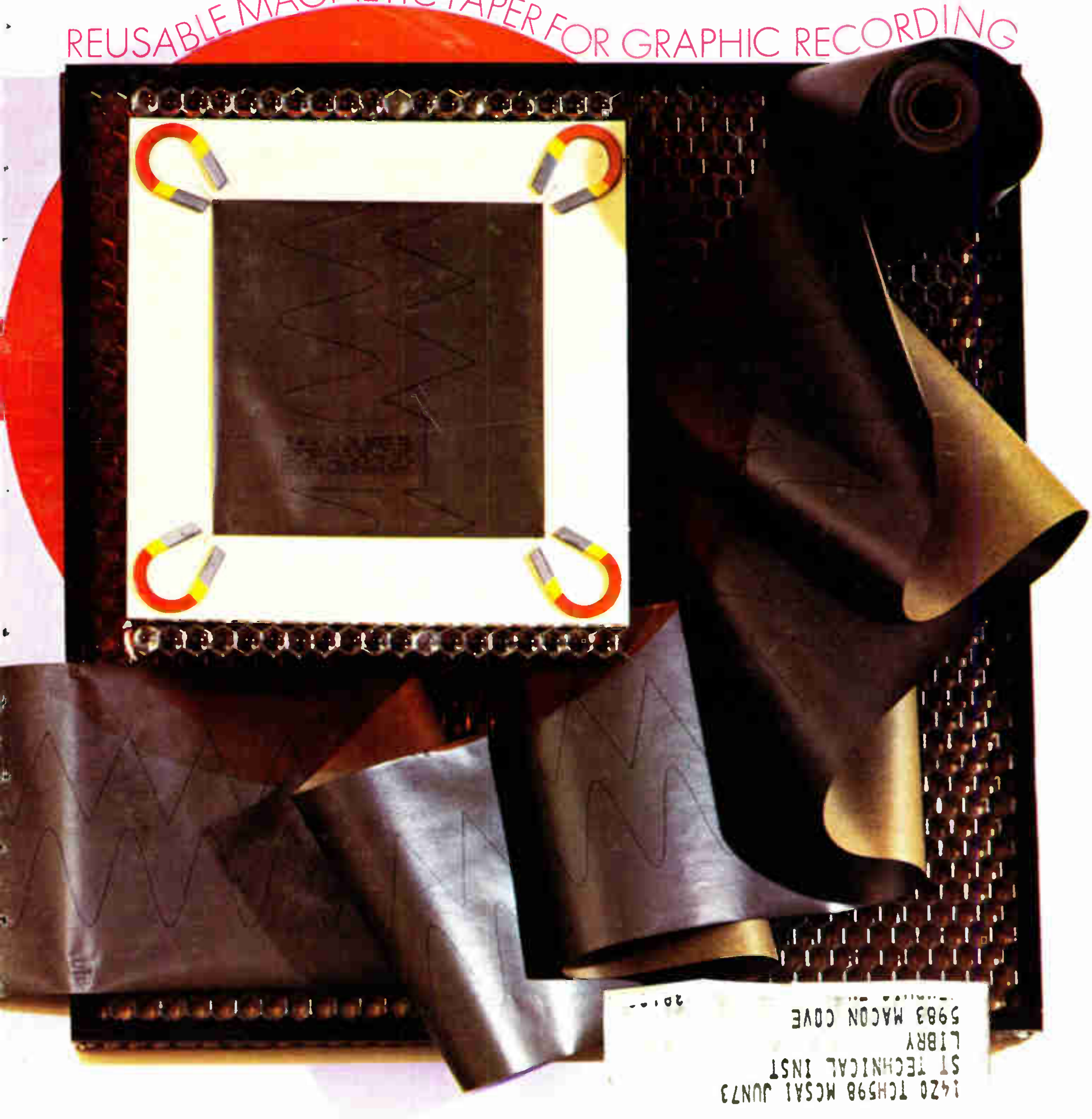

Circle 900 on reader service card

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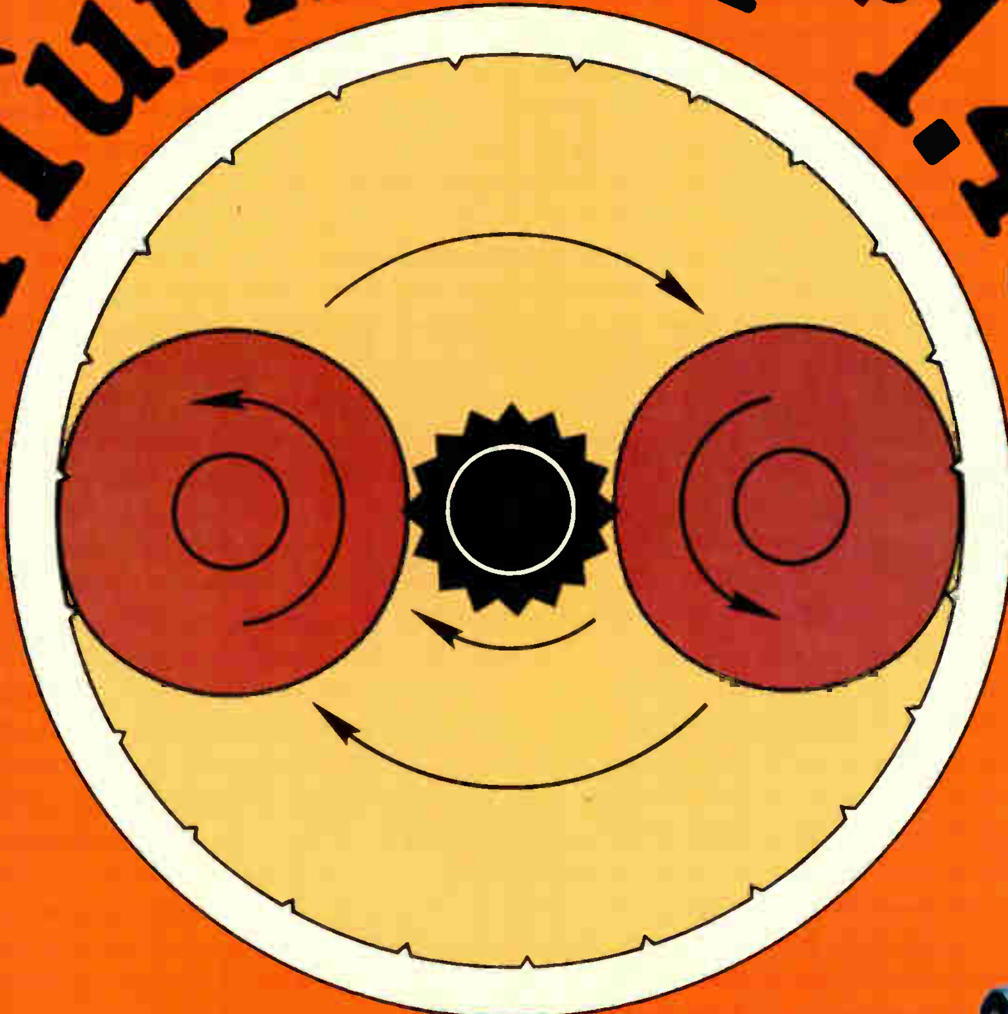

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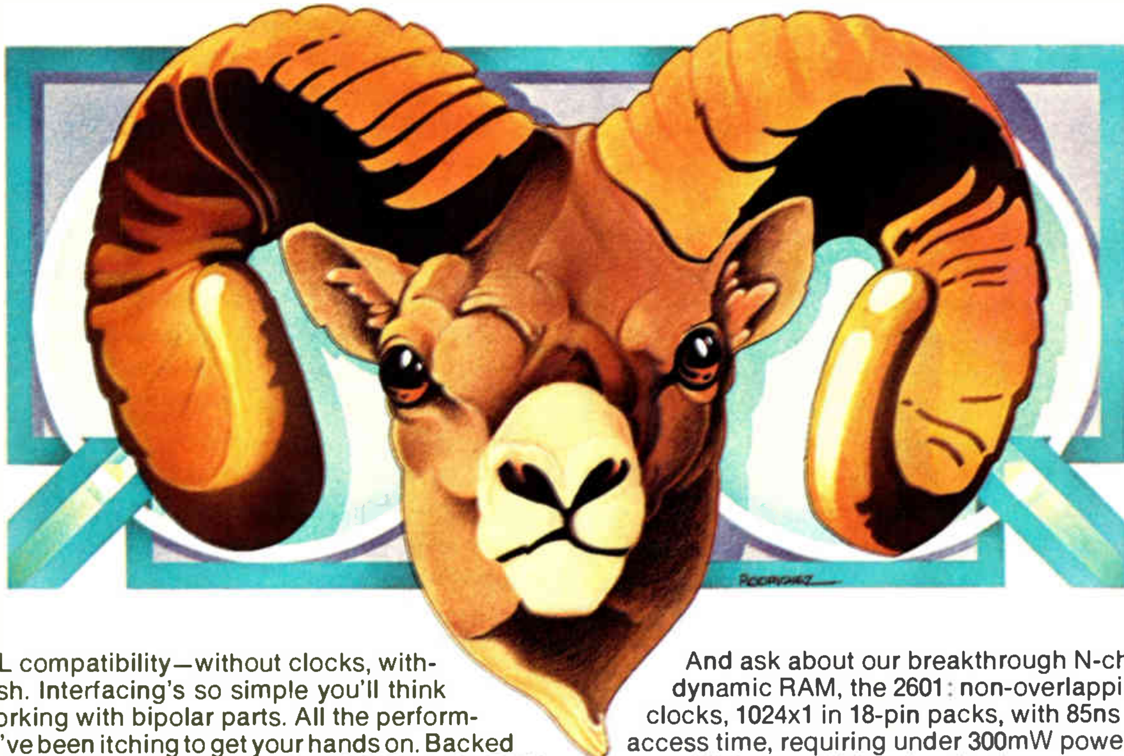

100% TTL compatibility—without clocks, without refresh. Interfacing's so simple you'll think you're working with bipolar parts. All the performance you've been itching to get your hands on. Backed by the smoothest specs ever put into MOS static RAMs. 1024 bits. 500ns access time. Single +5V supply.

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Electronics

The International Magazine of Electronics Technology

Vol. 46, No. 5 • March 1, 1973

Departments

Highlights

Here come the microcomputers, 63
Four- and 8-bit processor chips are rapidly supplanting hard-wired logic controls in numerous applications too slight for minicomputers. Together with supporting memory and peripheral circuitry, the microcomputers should total $50 million sales by 1975.

Reusable chart paper will cut recording costs, 73
Paper in which minute magnetic particles tilt to record data can be erased and used over again repeatedly. Existing recording instruments can readily be adapted to the needs of the paper by conversion kits containing magnetic styli and erasers.

How to choose the right oscilloscope probe, 88
Various measurements that can be made with an oscilloscope require distinctly different characteristics in a probe if the scope/probe system's loading effects on the signal are to be accurately estimated.

Interfacing gas-discharge displays with MOS, 97
Gas-discharge displays need too high a voltage to be run directly by an MOS calculator chip. But a level-shifting interface circuit will protect the chip while providing enough added potential to fire the display.

And in the next issue . . .
Intercon special: the career concerns of EEs . . . the economics of pluggable IC packages . . . system reliability through functional redundancy.

The cover
Erasable magnetic paper from Honeywell Test Instrumentation division will record alphanumerics as well as continuous shapes. Assemblage was created by graphic designer Ann Dalton.

Electronics

Publisher's letter

Microcomputers, like minicomputers before them, promise to vastly change the way engineers work—and the way that the products they design work. More and more, sophisticated products will be designed in software and set into motion by firmwiring standard microprocessors for the particular application. You'll find our report on the trend toward microcomputers on page 63.

The story, by the way, carries the first Probing the News byline of George Sideris since his return to *Electronics* as San Francisco bureau manager. When he left the magazine in 1967, Sideris was associate managing editor in New York. In the five years, he has worked out of Los Altos, Calif., as a free-lance writer and editor, producing about 150 articles, books, and technical reports on electronics subjects.

Sideris began with *Electronics* as a business news reporter in 1956 and, becoming more interested in technology, switched to technical article writing. A series of articles on integrated circuit assembly and interconnection that he prepared in the 1960s was published as a book in 1968 by McGraw-Hill.

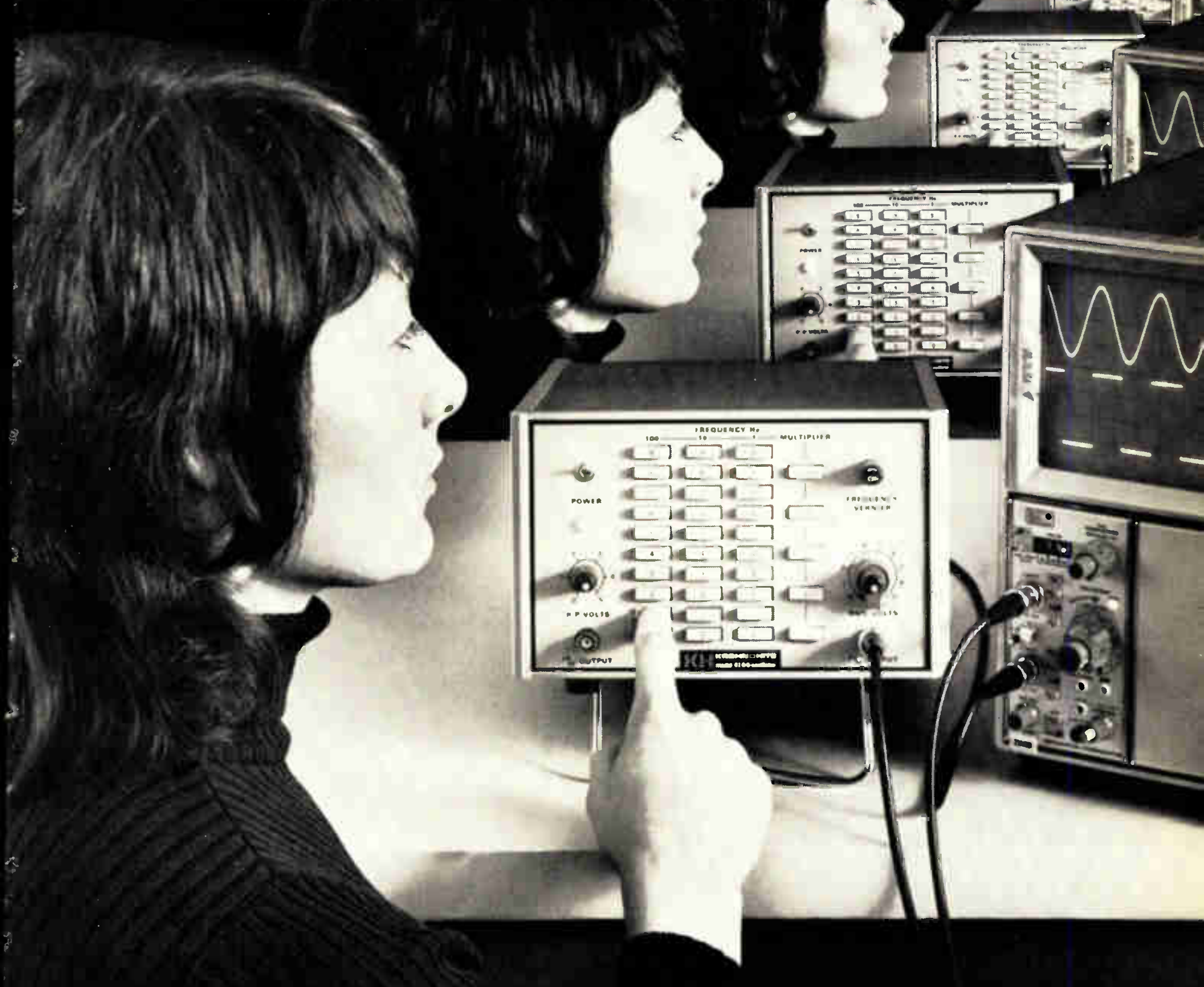
While doing reporting for the microcomputer story, our other West Coast bureau manager, Paul Franson in Los Angeles, was struck by the potential and pitfalls of microprocessing. One executive told him: "New products will be designed by microprograming—just like developing a new bookkeeping system—not by circuit design." Another said: "It's the most economical way to have custom systems with the shortest turnaround—months or weeks, not years."

"The implications for the circuit designer are obvious," says Franson. "He had better get involved. Already custom microprograming houses are springing up, yet the burden must fall mostly on the designer."

Who is this man and why is he selecting a horse on which to wager at a New York Off-Track Betting "store"? He's Howard Wolff, associate editor in charge of our

Probing the News section. He's doing some research to help him handle Alfred Rosenblatt's page 66 story on how OTB's first hardware approach failed—basically, because handling bets is a communication problem rather than a computational one. But Wolff's research did not pay off: he lost $4.

Precision waveforms at everyone's fingertips with KH pushbutton oscillators.



The Model 4100A is as simple to use as a pushbutton telephone—yet it's as precise, stable and distortion-free as instruments costing much more—more to purchase and more to operate. The 4100A is only $595.00 and you don't need technically skilled people to operate it. Its simplified operation and outstanding speed and accuracy make it ideal for production line testing. The 4100A provides sine and square waves simultaneously from 0.01Hz to 1MHz. Frequency accuracy is within 0.5% and distortion is less than 0.02%. For fast action call (617) 491-3211, TWX 710-320-6583, or contact your local representative listed below.

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Readers comment

Zero drift has a past

To the Editor: An article, "Dynamic zero-correction method suppresses offset error in op amps," by Richard C. Jaeger and George A. Hellwarth of IBM General Systems division, Boca Raton, Fla. [*Electronics*, Dec. 4, 1972, p. 109] was amusing to many of us here at Doric. You will note that in an article, "Defining the need—and filling it" [*Electronics*, Oct. 2, 1967], you announced formation of Doric Scientific Corp. and its entry into the market for special-purpose digital voltmeters.

Because most of the applications involved the measuring and conditioning of low-level signals, minimizing zero drift was a major consideration. Your 1967 article mentioned "an automatic zero-drift-compensation circuit, which checks out and computes drift."

Our Auto-Zero, first introduced in 1967, has a zero-correction similar to the one described in your current article. Paul Haas, who was responsible for the original design, has had ample opportunity to evaluate his approach over the past five years, during which time Doric has delivered well over 5,000 instruments incorporating Auto-Zero.

Tom O'Rouke
Doric Scientific Corp.
San Diego, Calif.

■ *The authors reply: We knew that our article was not the first published on zero-correction. Unfortunately, the references included in the original manuscript were not printed. Two of the older references on automatic zero-correction are cited in another technical correspondence, "A Differential Zero-Correction Amplifier," accepted for publication by the* IEEE *Journal of Solid State Circuits. These are D. G. Prinz, "DC Amplifiers with Automatic Zero Adjustment and Input Current Compensation," Journal of Scientific Instruments, pp.328–331, December 1947, and F. F. Offner, "A Stable Wide-Range DC Amplifier," The Review of Scientific Instruments, Vol. 25, No. 6, pp. 579–586, June 1954. We share your desire to acquaint others with the advantages of this powerful technique, and this was one reason for our* Electronics *article.*

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40 years ago

From the pages of Electronics, March 1933

If a program for stabilization can be carried out by the receiving-set manufacturers, its good effects will be felt all along the line to their parts suppliers as well. A move for higher prices on the part of the set makers would automatically reduce the pressure on the parts makers for lower prices. Instead, there would be a demand for better-quality parts to bring better set values, in turn giving the public solid values and higher quality and so fully justifying a higher price level.

Parts prices have been pushed down to an unsound bottom, where operating quality and durability have been seriously impaired. The public interest now lies in quality.

Undoubtedly the industrial designer is destined to play a more active part in the radio set field than he has in the past. As results of designers' work in increasing sales is demonstrated in other fields, the call will come for more such aid to radio.

But if the designer is to be consulted, he should be called in at the beginning of the job. After the tools have been made, and the chassis form is fixed, the stylist can make only minor suggestions regarding design—changing details or adding decoration and color. The full benefit of the artist's help can be realized only if he is consulted from the very beginning and urged to co-operate fully with the sales and production departments.

Exports of radio sets from the United States during 1932 were $13,312,136, a sharp drop-off from the $22,000,000 exports of the preceding year. Yet to 43 out of the 103 countries to which export sales were made, increases in purchases were registered. These customers whose buying of radios increased included Belgium, Irish Free State, Holland, Norway, Yugoslavia, Panama, Haiti, Bolivia, Colombia, China, Paraguay, Turkey, and Australia.

Loss of $3,000,000 exports to Canada can be ascribed largely to the new Dominion law requiring a percentage of Canadian-made parts in Canadian sets.

Until recently, if you wanted broadband RF power, you had to settle for bulky tube-type power amplifiers. No more. Starting at the top, we developed a full line of all-solid-state Class A power amplifiers, covering the frequency spectrum of 100 kHz to 560 MHz, with power outputs ranging from 300 milliwatts to over 100 watts. And we're still climbing.

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We also designed our amplifiers to be unconditionally stable and failsafe—you need never fear damage or oscillation due to severe load conditions (including open or short circuit loads).

ENI instrumentation amplifiers come complete with an integral AC power supply and an RF output meter. Ruggedized amplifiers capable of operating under severe environmental conditions are available.

To find out more about our RF power amplifiers write: ENI, 3000 Winton Road South, Rochester, New York 14623. Call 716-473-6900. TELEX 97-8283 ENI ROC.

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Circle 9 on reader service card

ENI

The world's leader in solid-state power amplifiers.

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The Beautiful Bugs: This is the year of the DL-4 line of high brightness, low power 0.19 inch digit displays. Its integrated magnifier construction provides a handsome, clear, readable digit. It's bright: 500 ft-L at 10 mA per segment and carries many optional features; electrically isolated decimal point, left or right, pin for pin compatibility with either the MAN-1 or MAN-4. Priced at $3.90 in 100 quantities.

The Two-Seater Coupe: DL-44 is a matching two digit display in a single package. The integrated magnifier construction provides a 0.19 inch economy digit. Designed for multiplexing, the desired digit is displayed by selecting the appropriate cathode. Offers 500 ft-L high brightness at a low power of 10 mA and shipments are categorized for uniform brightness. Priced at $6.80 in 100 to 999 quantities.

The Sporty Model: RL-50 is a small, solid-state lamp with pick-up to 750 ft-L at 20 mA. Its rugged body construction allows superior lead-to-package integrity. The 80 mil package

the bright guys

width permits mounting within .087 mil centers of a common card reader. Operates from 5 volt IC supply and will give you many years of carefree operation. Options: red diffused, red color or white diffused. Priced at $.39 in 1,000 quantities.

Lights Mounted Where You Can See Them: The RL-4403/4440 have a viewing area that extends .140 inch beyond the face of the mounting clip. Its full flood 0.2 inch diameter viewing area allows extra wide, off-angle viewing. And it's bright, .8 mcd (minimum) at 20 mA on only 1.7 volts. It can be easily soldered directly to the PC board, or mounted from the front of a panel with a snap-in clip. Direct replacement for the 5082-4403/4440. Priced at $.49 to $.65 in 1,000 quantities.

The Little Old Lady from Burbank loves her tiny T1 solid-state lamp. It will last forever, requires no gas, it flashes, and is IC compatible. Such a little

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..S 1973 MODELS

thing giving off .5 mcd at 20 mA, imagine! Has standard 1 inch leads. Options: red clear, white diffused, water clear. Priced low at $.33 to $.42 in 1,000 quantities.

No Hassle Delivery on Calculator Displays: If you're building calculators, and you want *the* standard of excellence, the DL-33 three digit display will allow you to extend battery life, reduce pin count and cost per digit. It draws less than 1 mA (average) at 1.6 volts per segment. Comes in standard 12-pin DIP package designed for multiplexing. Many options available. Prices you gotta hear to believe!

The Swiss Had a Word for it, but we can't print that here because watchmakers are now turning to LED displays. Litronix has a line of low power, high brightness compact digits specifically designed for carrying around on your wrist. Call the factory for timely details.

The Ugly Bugs: They sure don't look like it, but our phototransistor opto-isolators can handle up to 2,500 volts of isolation

with minimum CTR's from 2% to 50%. Now you can rid yourself of those Model-T relays and transformers with sleek solid-state opto-isolators. The new IL-74 is optimized for easy steering in and out of TTL. It's especially useful for elimination of noise and ground loop problems. Prices from $1.19 to $1.75 in 1,000 quantities.

litronix

Overdrive Models: The ILCA2-30 and ILCA2-55 photo-Darlingtons can drive up to 100 mA DC load current—plenty of

drive for power relays, solenoids, triacs, SCR gates and power transistors. They turn on in 10μs, stop in 35μs. Solid-state reliability with 2500 volts of isolation. Second source for MCA2-30/MCA2-50 models. Prices from $1.70 to $1.95 in 1,000 quantities.

Péncil Beam Headlights: The sharpest solid-state indicator light you can buy is the new RL-5054. You can select a high brightness beam at low currents—1 mcd at 10 mA or 2 mcd at 10 mA. It projects a 0.25 spot of light that is super for back-lighting applications. Priced at $.65 to $.85 cents in 1,000 quantities.

Test Drive Before You Buy: LED solid-state displays, lamps and circuit components will give you years and years of driving pleasure, no gas problems and no maintenance bills. And don't be fooled by the cheapee models, kick the tires.

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Circle 11 on reader service card

The Same Technology Instruments Makes Them

Take DVMs for example...

Today you can buy more performance for your dollar with HP's new "Self Test" 3490 and "Snap-On" 3470. Both have the features you've told us you wanted, and both were designed to make them easy on your budget. The key is HP's advanced technology. Look what your dollars will buy with these four quality members of HP's DVM family.

Self-Test 3490 makes double use of its internal ICs to bring you HP's exclusive "Self-Test" capability without extra cost. The basic 5-digit 3490, ready to measure AC, DC and Ohms sells for only $1,650 (and at low added cost you can have isolated BCD output and isolated remote control, or the highly-useful remote control with ASCII bus). Compare the 3490 with any other multimeter in its class and you'll find an unusual blend of features and performance for the money.

Snap-On 3470 provides you with an economical 4-digit LED display unit that you can equip to meet your exact measurement needs. Get DC only for $475 total, AC/DC/Ohms for $600 total, or DCV/DCA/Ohms for $875 total (5-digit versions are $700, $825 and $1,100). Add on a battery pack center for $200, BCD output center for $175 or an exclusive

HP That Makes Better...Now Cost Less

HP "Self Test" accessory for only $50. You end up with a modern custom-tailored system for very little money.

Multi-Mode 3450 lets you add up to 12 modes of high-accuracy measurement capability to your automated system. You can have true-rms, 4-terminal ratio, 4-terminal ohms and the unique limit test in addition to the usual functions. The 3450 is both fast and accurate, with 15 readings/sec. and accuracy to (0.008% of reading +0.002% of range). Prices start at $3,300 for the 5-digit DC volts and Ratio model, go to $5,900 for total 12-mode capability.

Speed Star 3480 is systems oriented, but fine for the bench as well. This 4-digit, ±0.01% unit delivers an unmatched 1,000 readings/sec. Get the exact capability you need by selecting plug-ins. For example, you can have DC, Ohms and true-rms AC for $2,900 (isolated BCD output and isolated remote control are low-cost options). You can even turn the 3480 into an inexpensive A-to-D converter with a sample and hold option that also lets you take peak readings or do transient analysis. Or, add data storage that stores up to 50 readings or do transient analysis. Or, add data storage that stores up to 50 readings at the 1000/sec. rate and employ a low-cost printer to output the data.

Check your DVM measurement needs. You'll find that HP can fit them closely, whether they call for state-of-the-art performance or real economy. For more information on the entire HP family of DVMs and multimeters, contact your local HP field engineer. Or, write Hewlett-Packard, Palo Alto, California 94304. In Europe: HPSA, P.O. Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan: Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-Ku, Tokyo, 151.

Send for our 70-page Application Note 158. RS 13.

093/42

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DIGITAL VOLTMETERS

People

Harmon rocks to four-channel audio

"There's overwhelming evidence that four-channel audio is more significant than the development of stereo. It's marvelously expressive of the times when 95% of the music is created, not in the concert hall, but in the recording studio." This sociological observation is the philosophy of Sidney Harmon, founder of Harmon-Kardon and president of the parent Jervis Corp., Plainview, N.Y.

He believes that quadraphonic sound equipment and records will sell handsomely, despite the competition between incompatible four-channel systems. His belief is supported by heavy back-orders to produce four-channel amplifiers at his Harmon-Kardon division and more speakers at his J.B. Lansing division.

"The transformation in the market during the last eight to nine months has been remarkable," he reports. The 54-year-old former educator and hi-fi pioneer says that audio-equipment dealers now understand how to demonstrate four-channel equipment, and this is why sales are picking up.

Harmon brushes aside what he calls the "chattering about confusing the consumer" by some manufacturers when quadraphonic equipment was introduced. "People will buy what they want to hear, whether it's Columbia's SQ (matrix system) or RCA's discrete. I think there is room for both systems, but my job is not to decide which one is better. My job is to have equipment that can play it all."

The youth market, says Harmon, will make four-channel go. Anybody who listens to music today, Harmon contends, knows that there is an enormous sense of participation. "Music is invented and created in the studio, controlled by engineers, and we've now given the engineers a means of surrounding the listener," Harmon muses.

"Early in the hi-fi business we used to say that we were duplicating the concert hall at home. The traditional approach was to separate the music and the audience. This is no longer applicable."

"Actually," he adds, "the greatest four-channel music was created 200 years ago during the Baroque period. Choruses were spread around the hall and the audience was swimming in the glorious stuff."

It's happening again today in four-channel recordings. "Any development that triggers such a profound change in music has got to be significant," Harmon concludes.

Stata strategy is $49 million in 5 steps

Ray Stata, president of Analog Devices, Norwood, Mass., likes to found companies and make them work. And now the 39-year-old Stata—who was graduated from MIT with a BSEE and went from Hewlett-Packard to co-founding Solid State Instrument Corp. before co-founding Analog Devices—has a five-year plan to exploit what he views as broad trends in the industry and put them to use.

Analog is a manufacturer of converters, operational amplifiers, and panel meters, primarily priced at $100 to $200. Stata plans to progress from manufacture of components to

On 4-channel. Harmon says there's room for competition.

functional circuits, to modular instruments, and to subsystems, with emphasis on sales moving along the scale and increasing in dollar volume from $15.9 million now to $48.7 million by 1977.

New trends. The trend toward modularity, says Stata, has accelerated in the past two years. He contends that the big companies want to make big systems, and this has created a void that Analog intends to fill: making the general-purpose building blocks that a user can configure himself.

Part of Analog's strategy will be to use basic analog technology for all applications. And the company will particularly utilize monolithic technology, eventually converting all its discrete components in ICs. One of Analog's first steps in that direction will be to introduce a 10-bit digital-to-analog converter in about four months.

The second phase of Stata's five-year plan is to connect instruments to minicomputers. This will move analog signals around cheaply and conveniently, while further eliminating custom in-house engineering. Analog Devices will vertically integrate input-output devices into minicomputers: a bus system will act as the interface, and a multiplexer will handle digital-data transmission. Finally, to complete the plan, the company will push for a more complex central computer to increase capability.

One of the keys to Analog's success is Stata's personality. Since founding the company in 1965 with a partner whom Stata bought out three years ago, Stata has commanded the respect of his 600 employees while remaining naturally informal: he often eats in the company cafeteria, and all employees address him as Ray.

Meetings

Annual Meeting, Association for Advancement of Medical Instrumentation: AAMI, Washington Hilton, Washington, D.C., March 21–24.

IEEE International Convention (Intercon): IEEE, Coliseum and Americana. March 26–30.

Reliability Physics Symposium: IEEE. Dunes, Las Vegas, April 3–5.

Southwestern IEEE Conference and Exhibition (Swieeeco): IEEE, Houston, Texas, April 4–6.

International Symposium on Circuit Theory: IEEE. Four Seasons Sheraton, Toronto, Ont., Canada, April 9–11.

International Magnetics Conference (Intermag): IEEE. Washington Hilton Hotel. Washington, D.C., April 24–27.

Carnahan Conference on Electronic Crime Countermeasures: IEEE, University of Kentucky, Carnahan House. Lexington. Ky., April 25–27.

Electron Device Techniques Conference: IEEE, United Engineering Center, New York, May 1–2.

National Relay Conference: NARM, Oklahoma State U., Stillwater, Okla., May 1–2.

Electronic Components Conference: IEEE, EIA, Statler-Hilton, Washington. D.C., May 14–16.

Naecon: IEEE, Sheraton, Dayton, Ohio, May 14–16.

International Symposium: SID Statler-Hilton, New York, May 15–17.

Measurement and Test Instrument Conference: IEEE. Skyline Hotel, Ottawa, Ont., Canada, May 15–17.

Electron, Ion, and Laser Beam Techonology: MIT and IEEE, MIT. Cambridge, Mass., May 21–23.

Aerospace Instrumentation Symposium: ISA, Frontier, Las Vegas, Nev., May 21–23.

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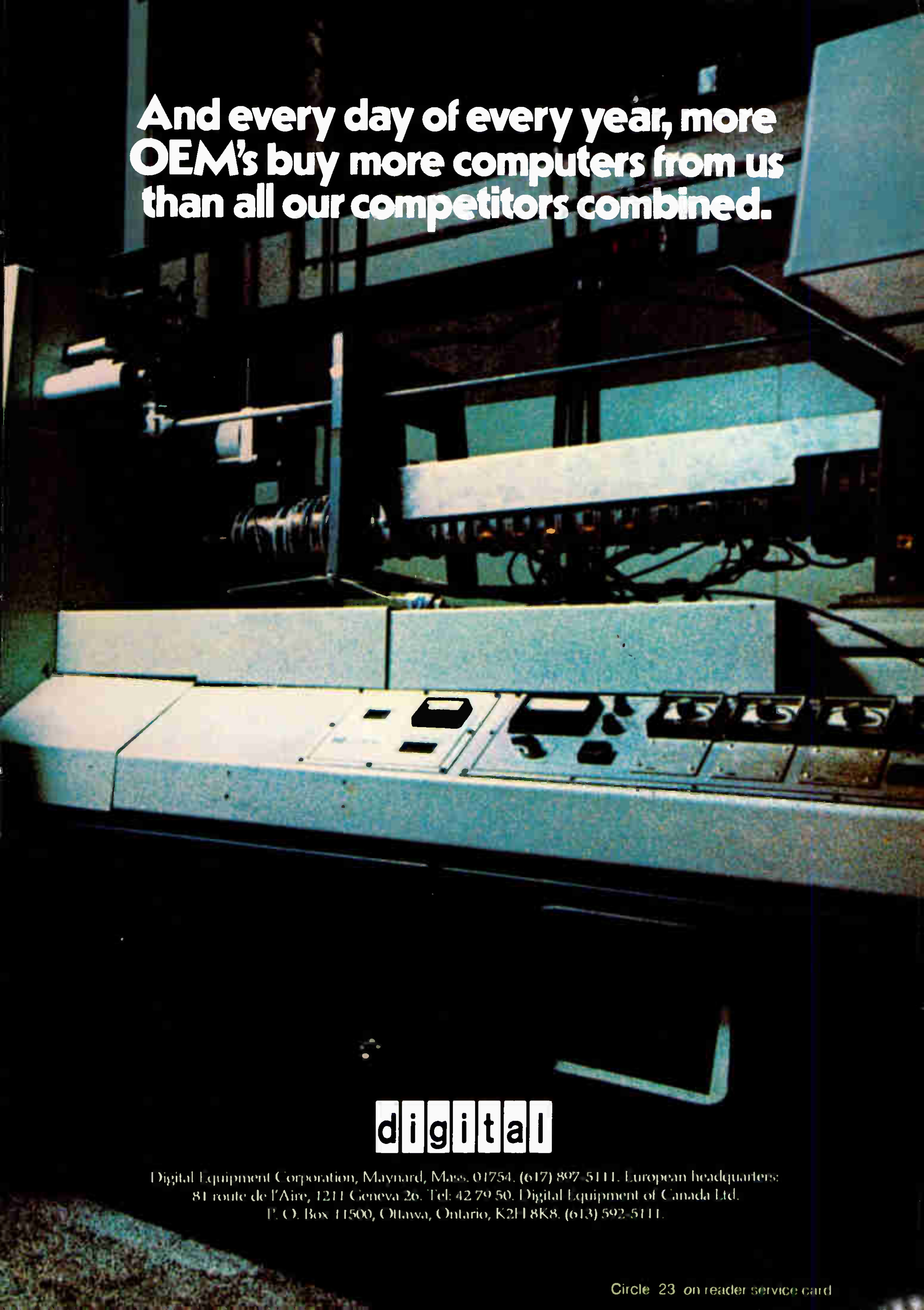

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Publication 5414: type MT, MS by-passing capacitors for 50 KHz to 1 GHz.

Publication 5416: type BE filters for RFI/EMI suppression.

Publication 5417: type SF filters for RFI/EMI suppression.

Publication 5418: type AB broad band filters in Pi, T and L configurations.

Publication 5419: type DA feed-thru capacitors for VHF/UHF interference.

Publication 5421: type SU tubular feed-thru filters for 30 MHz to 10 GHz range.

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FAA readies R/NAV plan; pinpoints large avionics market

The head of the Federal Aviation Administration has on his desk for approval an Agency plan to nationally integrate Area Navigation (R/NAV) into the air-traffic-control system, which would define an estimated $1.5 billion market over the next 10 to 15 years. The phased 10-year plan, in giving operational target dates to navigation-aids manufacturers, avionics makers, and airplane users, calls for providing "users with sufficient incentive to equip their aircraft at an early date" during the first five years; requires R/NAV at high-density airports and for high altitude en-route traffic at the end of five years; and finally mandates R/NAV at medium-density airports and requires sophisticated vertical R/NAV at crowded airports and for high-altitude en-route traffic. **The proposed FAA plan would ban some existing R/NAV gear from certain areas and cause others to be retrofitted or modified, and it would eliminate some portions of the present market, say knowledgeable sources.**

AT&T could lose network-protection issue to industry

Makers of data-communications terminals for use with AT&T's private-line network have moved closer than ever to a technical-standards program that will permit them to build-in the necessary circuitry to protect the telephone network, rather than use Bell System couplers. The long-sought case for industry standards was advanced by the Federal Communications Commission with a 90-day suspension until May 15 of a proposed AT&T tariff covering installation of protective equipment. All six of the commissioners present approved the action and called for a hearing and recommendation by the FCC's Common Carrier Bureau. **The decision, made after a protest by Microwave Communications Inc., said, "A valid question is raised as to whether, in lieu of giving AT&T a monopoly in this area, there should not be a standards program by which the customer or other persons other than AT&T could provide such protective arrangements" needed to prevent harm to the telephone system.**

EIA fears repeal of Item 807

Semiconductor, consumer, and industrial product manufacturers **fear the White House may accept repeal of Item 807 of the U. S. Tariff Schedules** if it can get equivalent concessions from other trading nations. The fears have produced a strong appeal to President Nixon by the Electronic Industries Association. The Hartke-Burke bill pending in Congress also favors repeal of Item 807, **under which manufacturers ship U. S. parts to offshore plants for assembly and then pay import duties only on the value added when the finished product is returned to the U. S.** The industry believes many millions of dollars annually are at stake, as well as millions more in overseas plant investments.

Oxide-isolated TTL implanted by Bell Labs

The expectation that ion implantation will soon replace diffusion as the most popular way of building semiconductor structures has received another boost with the disclosure by Bell Laboratories of its oxide-isolation process. The Bell Labs technique, called OXIM for oxide-isolated mask, has its isolating ring around a transistor that is completely implanted. The collector, base, and emitter, as well as resistors, are all implanted, instead of diffused, as in Fairchild's Isoplanar technique.

Bill Evans, member of the technical staff at Bell Labs, who spoke on OXIM at ISSCC, says that **"implanting structures offers better control of device parameters." What's more, the high-value resistors needed for MSI and LSI logic circuits can be more readily obtained in small areas by implanting.** Some of the new Bell circuits—current-mode and TTL gates—have operated at very impressive power-delay products, as low as 1 picojoule, compared with 5 to 10 pJ for earlier gates.

Pension-fund abuses charged in Congress

Advocates of a fresh Federal look at electronics-industry pension funds have received unexpected support from charges by Sen. William Proxmire that a number of defense contractors are abusing the system. The Wisconsin Democrat, chairman of the Joint Economic Committee says a number of military contractors withhold DOD reimbursements to company pension programs—defined as a necessary, and thereby a reimbursable business expense—for as long as 21 months, and they use the money for corporate needs without paying interest. **Proxmire lists Aerojet General, Boeing, General Dynamics, Lockheed, and Rockwell International among the offenders, and he calls the practice "a misuse of Government funds."** He has asked the Defense Department, Atomic Energy Commission, General Services Administration, and NASA for further information on the reimbursements.

Fairchild's new MOS products to use Isoplanar process

Although the excitement about Fairchild's Isoplanar process has been directed at bipolar memory products, the company is applying that high-density process to MOS devices, as well. Bob Seeds, manager of Fairchild's MOS department, says the first Isoplanar MOS product will be a 1,024-bit static shift register, to be ready for sampling by mid-year. **Thanks to Isoplanar, this device, which will have a speed of 2 MHz, can be built on a smaller chip than comparable registers—130 mils by 135 mils, compared with the typical size of 154 mils by 165 mils.** The first of a family of MOS shift registers built by the Isoplanar process, this device will be followed by general-purpose static and dynamic shift registers, as well as special types, such as first-in, first-out products.

Word processor takes on large documents

A minicomputer-based word-processing system announced by the Documate division of Index Systems Inc., Cambridge, Mass., is expected to have major applications in such complex document-preparation jobs as proposals and reports, publishing of books and magazines, and lengthy internal documentation. The system consists of a Data General Nova minicomputer, a Mohawk Data Sciences line printer, a Diablo Systems disk memory, and three to 15 IBM Selectric I/O typewriters. Documate says the system can handle through its software nearly all of the jobs involved in document production.

Addendum

Computer equipment and service sales will reach $23 billion this year, according to a study of computer user spending plans made by International Data Corp. That will be an increase of $3 billion over the 1972 figure, and a boost of $4.5 billion over the 1971 level of $18.5 billion.

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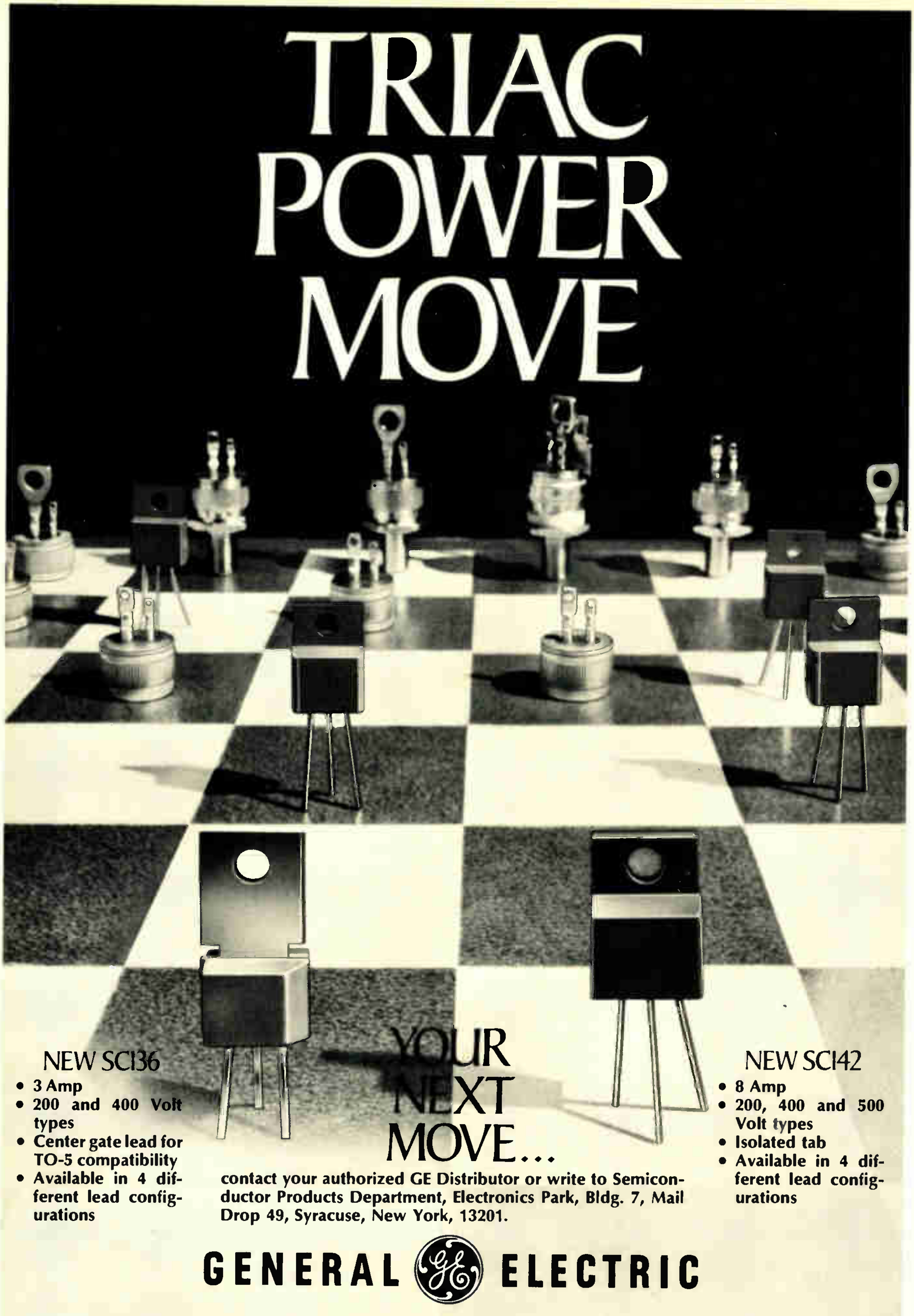

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GENERAL ELECTRIC

Navy under pressure from DOD, Congress to switch to F-15

Air Force planes may be flying from the Navy's aircraft carriers if the Pentagon clips the F-14

Navy tradition is on the verge of being sunk by procurement economics as the Defense Department ponders switching from Grumman Aerospace Corp.'s troubled F-14 fighter for fleet air defense to the McDonnell Douglas F-15 being built for the Air Force.

It is a prospect that disturbs the Naval Air Systems Command, which has been working feverishly with Deputy Defense Secretary William P. Clements to reach agreement with Grumman, apparently without success. Now under contract to build 86 planes, Grumman has steadfastly refused to build the fifth lot of 48 without receiving another $105 million to offset soaring costs.

The Pentagon is adamant, however, and the issue seems headed for the courts. Earlier, the Office of the Secretary of Defense, Navair, and Grumman had worked to find ways to restructure the F-14 contract so as to keep the program alive in a manner acceptable to Congress. But DOD insiders say Grumman was unbending in its position, and now the Pentagon has become similarly hard-nosed.

Leverage. Unable to work out a compromise, despite heavy leverage on the Navy and Grumman from within DOD and Capitol Hill, sources in both places say that the service is unlikely to get the minimum of 313 F-14s it says it needs and that sooner or later the Navy will have to turn to the F-15 to take up the slack. Present estimates are that F-14 program will end with the fourth lot now in production, leaving the Navy with 86 planes. Otherwise, the Navy may buy lots five through seven at a higher price for the minimum total of 230. The Navy, which had planned to buy 88 planes in a sixth lot to be contracted in fiscal 1974, has already had its allotment quietly cut to 48 planes [*Electronics*, Feb. 15, p. 71]

Leverage being placed on Navair involves both political and practical considerations. For one thing, there's Melvin Laird's final recommendation as defense secretary to successor Elliot Richardson that "assignment of Air Force tactical squadrons to Navy carriers" is not only possible but also "highly desirable during the coming months and years." Beyond violating Navy tradition in a way that has left its ad-

Why F-14 avionics cost so much

More than 50 cents of every dollar spent by the Navy for Grumman's F-14 Tomcat for fleet air defense goes to subcontractors for avionics and other hardware. The total of these subcontract dollars has risen sharply above original estimates [*Electronics*, Jan. 18, p. 105]

The rise is attributable largely to engineering-change proposals that boost costs and cut performance, reliability, and life expectancy, as well. The experience of Garrett Corp., Los Angeles, subcontractor for the F-14 Center Air Data Computer (CADC) provides a graphic example of the aircraft's problems last year.

The Garrett CADC, proposed originally as a dual-channel system, was styled as "the most complex piece of equipment in the aircraft—containing over 175,000 active electronic elements and 47,500 bits of memory storage."

In April 1969, Garrett received a purchase-order award of $10.5 million for 469 systems. Then came the change orders—some 65 through last spring, including 31 that required design changes. These drove the system's complexity, size, and weight up so high that a simpler single-channel system became necessary. The new contract price is $19 million—nearly double the original figure.

Why the higher price? After 65 change proposals, the dual-channel CADC required 24 custom MOS LSI chips of six different types, instead of just two per channel. Similarly, the 30 standard ROMs had been changed to 38 custom units; double-sided printed-circuit boards had become multilayer, and although no custom hybrid circuits had been planned, the computer now had 36 hybrids of five different types. The system's 10% growth potential had vanished; there was now a requirement for a spray-bar cooling system; weight had climbed from 18.4 lb to 29.5 lb, and MTBF had been cut in half to 1,250 hours.

Thus, the decision was made in December 1971 to make a major redesign to a single-channel configuration. The decision, Garrett testified, increased costs of the CADC program by $8.3 million—an increase over and above earlier escalations of $3 million that were later held to $2.2 million by cutting back on the number of systems to be delivered. □

mirals apoplectic, Laird's comment to Congress is being interpreted by military readers of Washington's political tea leaves as saying: "If the Navy can't buy aircraft econmically, we'll let the Air Force do it."

For another thing, there are the congressional committee staff estimates that Grumman's F-14 arrangements with its key subcontractors are "a mess"—one that may not be capable of satisfactory resolution, even if the Navy and its prime can come to terms. Depite reports in Washington that the Navy is considering letting Grumman perform on the 48 planes of lot five at cost—an estimated $100 million over the $570 million in the contract—there is mounting Congressional opposition to the idea. And opponents have carefully noted another of Laird's departing observations in January: "The Defense Department must not become a bail-out agency for companies that cannot live up to valid and binding contracts."

Among other points being made in favor of the Navy switch to the McDonnell F-15 are proposals to strip the F-14 of some of its avionics subsystems to hold down costs but "because then the Navy wouldn't be getting the plane it wanted . . . the unit cost still would be high," observes one congressional source. The Navy's case for the F-14 has not been helped by the Marine Corps decision to buy 10 of McDonnell's F-4J Phantoms for $130.7 million in fiscal 1974. The F-4J is a new version of the aircraft.

Although the Air Force privately argues that a Navy switch could boost the size of its procurement of 729 F-15s, and presumably lower the $10.5 million unit cost, the target price for the first 107 production planes is $12.4 million each, with a $15.3 million ceiling.

Fiscal 1973 procurement and RDT&E costs for the F-15 are $908.1 million, almost equally split between procurement of the first 30 planes with spares and RDT&E, while the new fiscal 1974 budget request calls for just under $1.15 billion, of which $918.5 million is for 77 more production models with spares. □

TI figures to add more electronic products to its consumer line

After nine months in the consumer calculator business, Texas Instruments in Dallas is reviewing electronic candidates for its first noncalculator product, says Jay Rodney Reese, vice president of the Solid State Products division. A rough timetable calls for a decision by midyear. Then it's a matter of how long it will take to get the product to the marketplace.

Meanwhile, with calculator sales zooming and production sold out through the first quarter, TI is expanding its consumer operation. In nine months the company has:

- Introduced four calculators, and Reese says they'll be announcing another one every 60 to 90 days for the rest of 1973.
- Set up retail channels through retail chains both in the U. S. and in Europe.
- Started the development program for products other than calculators, with the first to come in early 1974.

Reese says "It's all part of a plan to saturate the world with TI consumer products. We are using the calculator to establish our thrust into the area."

Reese, a former president of TI Supply where he quadrupled sales in four years, reports that one of his biggest startup problems was getting enough components because the tremendous consumer demand for calculators created a market that gobbled up all the parts that TI's Components division could produce. Reese says he found himself standing in line behind established customers of TI Components. He is making sure that he doesn't face that particular problem again—he's not only ordered components for the rest of 1973 but has placed orders for 1974 and 1975 as well.

TI has thus far avoided problems of its own consumer operation competing with its components customers. Edward A. White, president and chairman of the board of Bowmar Instrument Corp., a major TI customer, says "They've lived up to their commitments"—though he does admit he'd welcome a second source for TI calculator circuits.

Another problem has been labor. TI, unlike some calculator manufacturers who are assembling units in Mexico, is manufacturing its portable units in Dallas. It had trouble finding direct labor but is now hiring about a 100 people a week for the calculator lines. The company will manufacture table models in Sherman, and will also produce calculators in Riete, Italy, for the Common Market, in Madrid for the Spanish market, and in Campinas, Brazil, for the Latin American market.

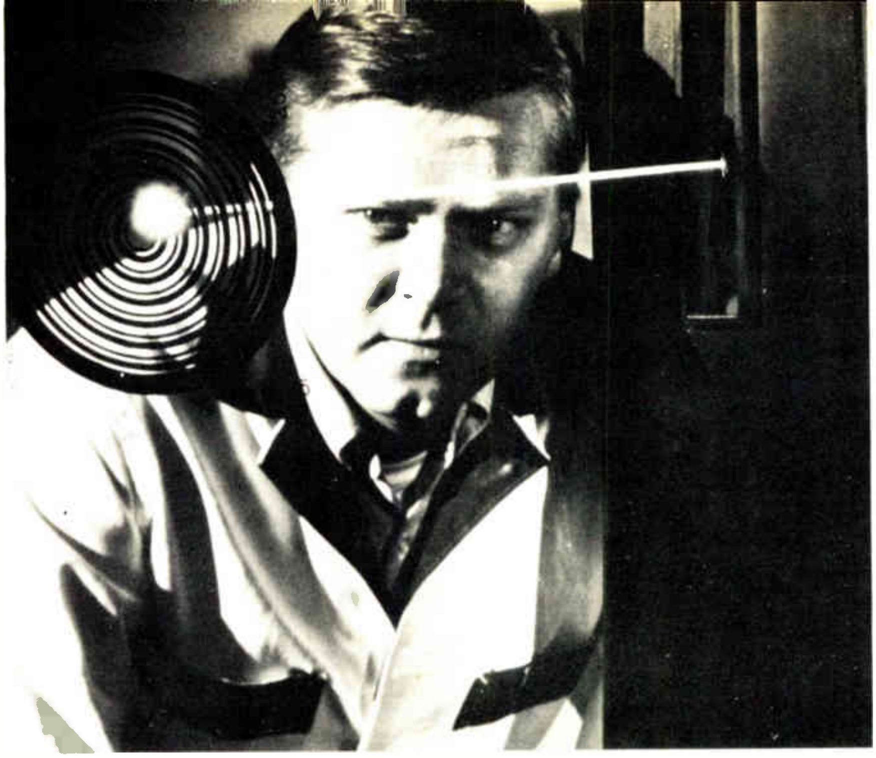
TI will continue in the private-brand calculator business. Reese comments that business with Radio Shack is still expanding and there are also other contracts.

Commercial electronics

Laser system sorts airline baggage

The harried airline passenger, scrutinized by magnetometers, and sometimes frisked by grim-looking security guards, may soon be spared at least the ultimate indignity—lost or mishandled baggage. An automatic baggage-sorting and handling system, developed by Bendix Recognition Systems of Southfield, Mich., identifies, sorts, and routes baggage automatically at speeds up to 300 feet per minute to the passenger's flight. The first Bendix model 300 baggage-control system, being installed in the Eastern Airlines terminal at Miami's International Airport, is scheduled to be in operation by fall.

The key to the Bendix system is a



Laser baggage sorter. Automatic label-reading device developed by Bendix senses codes that define flight numbers and destinations. This system will be used at Miami airport.

coded label, which is applied to each item of baggage. The label, which resembles an optical encoder disk, has a circular code format that can define up to 1,024 separate flight numbers or destinations. Because of the circular format, precise orientation of the label isn't required.

The adhesive-backed labels are produced by printers located at baggage check-in points in the terminal. To print, an operator enters the flight and destination data through a keyboard and depresses the "print" bar. The required number of labels, imprinted with the right code and also man-readable alphanumeric characters, are then automatically produced.

As the bags move on a conveyor belt, they pass under a gas laser, which reads the code, and decoding logic, which relays the data to a digital controller. Each controller contains a stored program that sends control signals to a sorting device, which routes each bag to the correct spur line. Here, tilt trays or other mechanical means route the bags to the assigned spurs.

The controller program typically contains a seven-day master schedule defining the correlation between coded label numbers and sorting-spur numbers as a function of time. Changes in schedule can be easily entered into the program through CRT-terminal keyboards or teletypewriters. The system also maintains a running total of baggage by flight number.

The Eastern Airlines system in Miami, which will cost $2.5 million, will be able to sort 70 bags per minute. □

Government electronics

Devaluation to spur multinationalism

The growth of multinational electronics corporations is expected to accelerate as manufacturers throughout the world move to counter the threat of tougher international trade barriers spawned by America's second dollar devaluation in 14 months. This is a principal conclusion being drawn by industry analysts while the dust continues to settle from President Nixon's mid-February decision to devaluate the dollar by 10%.

Nixon's post-devaluation calls for a tougher U.S. trade stance—through legislation empowering him to selectively raise tariffs and impose import quotas—has startled free traders in the U.S. electronics industries, who see in the proposal all the ingredients for an international trade war. Reform of the international monetary system is also high on the Nixon priority list, says Treasury Secretary George Shultz, who has indicated concrete efforts in that direction will begin in Washington late in March with a ministerial-level meeting of the 20 top trading nations.

Uncertainty. While the positions of individual nations will continue to be shaped until the July meeting in Geneva of the so-called Nixon round at the General Agreement on Tariffs and Trade, a sampling by *Electronics* of the world's industry shows a growing interest in multinational operations.

"That's the safest way," contends one industry analyst in Washington, "as long as things are as uncertain as they are. Put plants in the markets you sell to, or want to sell to, and you become 'a local enterprise' "—one that is least affected by tariffs and other trade barriers.

Multinational operations cut both ways, as Japan's Sony Corp. has indicated by moving to complete a second San Diego area plant this year to make color-picture tubes for its TV-receiver operation. Increased capital investment by other Japanese firms in U.S. installations is expected in Washington—although not enough to offset the U.S. deficit which topped $4 billion last year with that nation.

Reaction. In Japan, the devaluation was not entirely a surprise, although the percentage was reportedly larger and timing quicker than had been anticipated. Hirokichi Yoshiyama, president of Hitachi, contends he is more worried by the secondary effect on Japan's over-all economy, which is beginning an upturn from a slight recession last year, than he is about the revaluation's impact on Japanese exports.

Although the Japanese consensus is that, because of higher prices, color-TV exports will be slowed severely, especially to the U.S., Sony is of a different mind. It expects to increase its U.S. sales by 50,000 receivers this year, despite the Trinitron system's higher price.

The Japanese believe that exports

of tape recorders and stereo gear will be less affected by the currency differential because there is less competition from U.S. makers. American Government sources concur in this, but they hint that tariffs or quotas may be sought to leverage Japan for these and other products.

With Japan's agreement to float the value of the yen to let it find its own higher level in relation to the dollar, some companies stand to lose on earlier deferred-payment exports—even those figured on a yen basis. During the past few months, Nippon Electric has switched to figuring export contracts in yen, rather than dollars, at a ratio of 280 to 1. NEC not only stands to lose on the contracts it has placed at that price, but it also found orders harder to come by.

Although some U.S. component and instrument makers with operations in Malaysia and other parts of Asia, like California-based National Semiconductor, initially feared a possible increase in labor costs there stemming from devaluation, that prospect seems unlikely now as many smaller Asian countries devalued their currencies to match the hard-pressed dollar.

Europe. Throughout the European Economic Community (EEC), there was generally less reaction to the immediate impact of dollar devaluation than to the trade agreements that are expected to follow. Virtually no one expects U.S. price changes in semiconductors sold in Europe to go up a full 10% until the heavy demand creating an American seller's market cools down.

In Zurich, Gerard Tremblay, president of Sprague World Trade Corp., expects that, on reexamination of price lists, "we'll wind up with a modest advantage." U.S. semiconductor price boosts, in Tremblay's view, may not come soon because of stretchouts in delivery times in the booming U.S. industries. Moreover, the full 10% devaluation advantage won't be realized, since U.S. imports of raw materials will cost more now. The initial devaluation disclosure burned some European producers, of course, like France's largest, Thomson-CSF. That company stands to lose on some "several tens of millions of dollars worth" of export business contracted in dollars instead of francs before the 1971 devaluation, says marketing vice president Eduoard Guigonis. Beyond such specific instances, however, Guigonis sees relatively little damage to European electronics. For components he sees few price cuts now, but expects some later when the present U.S. sellers' market cools down. American-made capital equipment will be more competitive, he believes.

In West Germany, where the predevaluation dollar was taking its worst beating on the currency exchange before Nixon acted, little direct impact is forecast for electronics. Some indirect effects will be felt, however, in third countries, such as those in South America, where U.S. and German products compete, says the German Association of Electrotechnial Industry (GAEI). As for U.S. electronics and electrical exports to West Germany, which dropped about 5% in 1972 from a level of nearly $500 million the year before, a GAEI official believes this downturn will reverse itself.

The reaction in the United Kingdom, where the pound sterling is being allowed to float and reach its own level in relation to other currencies, is similar to that in other parts of Europe. ITT Semiconductor summarizes the view of many British producers that both import and export extensively. It points out that the net effect will be slight because gains to be realized on U.S. imports will be lost on higher-priced and less-competitive exports. □

Communications

Radio call boxes on highway aid motorists in Florida

Motorists stranded along a 20-mile stretch of highway between Miami and Fort Lauderdale discovered last month that they could talk to a Florida Highway Patrol dispatcher by walking less than a quarter-mile to a motorist-aid call box.

But the phone is really a radio. Thanks to a recent Federal Communications Commission allocation in the 450-megahertz band, radio call boxes on limited-access highways now offer full-duplex voice communications. In developing and installing this system, Motorola Communications division decided to emulate the ubiquitous telephone—from the user's standpoint.

"Our call boxes are designed so anybody and everybody would know what to do with them, even if he had never seen them before," says Fred Tuke, national product consultant for Motorcall, the name that the Schaumburg, Ill., division has given the system. "He has a handle to open the box, and a telephone handset, and nothing else.

Motorcall is a full-duplex system. The 450-MHz terminal stations are connected to a 960-MHz backbone to route signal and voice information between the control console and 90 roadside call boxes. The installed cost of the system was $328,000.

Besides eliminating telephone cabling and continuing cost-per-call charges, Motorola designed in fea-

tures not found on ordinary telephone motorist-aid call boxes:

- Vandalism alarms to notify the dispatcher when someone steals the handset or breaks into the interior of the box.
- Automatic identification of the location of the calling box.
- Notification to the console of a second caller and his location when the system is in use, via a second frequency.
- Remote interrogation of the condition of the handset and outer and inner doors.
- A rechargeable, alkaline manganese-dioxide battery.
- Capability for automatic routine interrogation of all boxes once a day.

The system can also collect and transmit data from roadside and roadbed sensors to determine traffic count and speed, or relay such safety information as ice on bridges, fog, and dust storms. Motorcall can also transmit information to the boxes. □

News briefs

Holographic memory works

RCA Laboratories, Princeton, N. J., has demonstrated the feasibility of a holographic computer memory, developed jointly with NASA and RCA funds. In the laboratory, the memory performs all of the operations of write, store, read, and erase [*Electronics*, Jan. 18, 1971, p.61]. An argon laser writes and reads data, a liquid-crystal page-composer encodes 1,024 bits of data in a hologram, and an erasable thermoplastic records 32 by 32, or 1,024 pages.

However, only 10 bits on any page are alterable. The memory capacity of a million bits is contained on a piece of thermoplastic 3 inches in diameter. The next step is to improve the components, particularly the thermoplastic recording medium, which just isn't fast enough yet, say the RCA researchers.

Collins, RCA get AF Fleetsat awards

Air and ground communications for the Air Force to use with the Navy's fleet satellite communications system, known as Fleetsat, will be provided under a $9.7 million contract to Collins Radio Co., Cedar Rapids, Iowa, and a $6.5 million award to RCA Corp., Camden, N. J.

The cost-plus-incentive-fee competitive awards from the AF Electronic Systems division cover uhf terminals, transceivers, aerospace ground equipment, and data.

Displays

Monolithic display cuts size, cost

Going monolithic with alphanumeric displays fabricated from gallium arsenide phosphide may overcome the cost and reliability problems of hybrid techniques.

With conventional hybrid five-by-seven GaAsP arrays, 35 discrete diodes must be interconnected to each other. The wire and die-bonding required constitute a large part of the reliability and cost problems. Furthermore, misalignment of many individual diodes can mar the appearance of a display.

These difficulties are avoided by the monolithic approach developed by researchers at Oki Electric Industry Co. of Tokyo. Using an npn triple-layer gas-epitaxy process, they have fabricated planar monolithic five-by-seven arrays. They claim this approach substantially reduces fabrication costs, primarily because of reduced bonding time.

What's more, Oki says its process makes possible much smaller displays. Hybrids, it says, are limited on the low end by the electrical resistivity of the metalized stripe used for die bonding. As a result, the standard size of most devices on the market is 6.2 by 8.7 millimeters. By contrast, the monolithic array produces a character measuring 3.3 by 4.7 mm, and even smaller ones—comparable in size to a standard typewriter character (2.3 by 3.3 mm)—are possible.

Light from junctions. In the Oki device, the structure consists of alternating npn epitaxial layers on n-type gallium arsenide. The first layer is doped with tellurium, the second with zinc, and the third with tellurium again. Isolation of each row is achieved by selective diffusion through the surface n layer into the p layer, using masks of Al_2O_3 and SiO_2. The light-emitting pn junctions are selectively diffused.

Ohmic contacts of gold and germanium alloy for the n layer are evaporated and etched into the lead pattern to connect five pn junctions in each row. A titanium-aluminum lead pattern connects seven junction spots in each column through windows in the silicon oxide.

With this process, Oki has produced prototype quantities of four-character displays in packages with outside dimensions of 10 by 21 mm. The devices have been operated in a set of 16 characters, pulse-driven at a frequency of 40 hertz, at a 14% duty cycle and a peak pulse value of 18 milliamperes. This is equivalent to an average current of 1.2 mA. Oki has delivered samples of the display to Nippon Telegraph and Telephone Public Corp. for the company's evaluation. □

Computers

Exchange unsnarls TI's EDP tangle

As in most multinational companies, EDP at Texas Instruments has proliferated into a web of computer networks and dedicated on-site facilities that handle data communications ranging from real-time order-entry and inquiry to remote-batch processing and data collection. To unsnarl the tangle of systems, TI has developed a new on-site Data Exchange System, dubbed DXS, and the system is so successful

TI is offering it for sale.

DXS ties remote terminals to an on-site minicomputer that can exchange information with a local data base, the host-processor network, or other DXS systems' data bases and terminals. DXS allows users to amass thousands of terminals with access to a centralized computer, but it pares communications costs by channeling the various data systems through a single voice-grade line.

"DXS is basically an on-line transaction-oriented system for inputting or retrieving data from the local machine, or host network, or for passing information back and forth," says Robert A. Thomas, manager of systems development for TI's Digital Systems division, Dallas. A communications adapter buffers communications between the DXS computer and the host processor, and emulates nearly any other processor network terminal.

Built around the firm's 960A minicomputer [*Electronics*, Nov. 8, 1971, p. 111], DXS uses video- or printer-keyboard terminals or Touch Tone phones, or all three, to handle inputs and inquiries to the system in a full tutorial mode. The dial-up system includes a 31-word-vocabulary answer-back unit. DXS also accommodates special-purpose terminals, such as attendance stations.

While DXS was designed to upgrade TI's internal communications, the firm will offer three commerical versions, to be shown first in Dallas at the industry's first Data Communications Interface Show, March 6–8. Prices start at $65,000 but TI has a six- to eight-month backlog of internal orders to fill, says Thomas. The company is also using the system to quietly show a couple of new peripherals—TI-built CRT terminals and attendance stations.

DXS is being added first in the manufacturing end of TI's businesses. "We found out—frankly through experience, rather than insight—that data-collection is most critical," explains Carl Hopper, manager of corporate management systems. "But since we now have equipment that can inquire, as well as collect, it has much potential for expanding into offices, as well as manufacturing," he adds.

The keys to cost-control on a systems level are distributed data bases—local disk units that contain manufacturing information, such as job status, schedules, and inventories. "In short, 85% of what it takes to run a factory, whether communications lines or host computer, goes up or down," he says. "However, when the computer needs to access terminals, programs, or data bases anywhere else, it can."

TI expects to effect most of the savings by cutting communications costs. "From a hardware standpoint," Thomas says, "there may be an appreciable saving. But from a communications standpoint, the savings are enormous. With DXS, you use lines of any speed because the system is responsible for all the remote equipment." Thomas explains. "And with a local data base, we can really save on the amount of traffic up and down the line—cutting both central-computer time and communications costs."

In the future, DXS will be tied directly to machines to get people entirely out of the entry process. "We'll start moving to that later this year—but that means we must either go in and modify existing machines, or add new machines with controllers that can report the information," Thomas explains. □

Unsnarls the tangles. TI's DXS smoothly interfaces various types of data-communication systems to create an efficient network that cuts computer time and transmission costs.

Solid state

Metal-gate unlocks speed in MOS RAM

Some old notions about MOS-memory design may be dispelled by a new n-channel dynamic random-access memory from Advanced Memory Systems Inc., Sunnyvale, Calif. The 1,024-bit device is made by a process most designers consider archaic—metal-gate.

Yet, AMS says the AMS7001 can outperform most silicon-gate RAMs. It also operates continuously without refresh interruption, although it is not a static RAM. A tiny charge pump in each memory cell provides a continuous refresh current to replenish data-storage charges lost through leakage currents. The charge pump reduces power dissipation to 2 microwatts per bit when the RAM is switched into a power-down standby mode.

The AMS7001 has been clocked at access times around 55 nanoseconds and complete read-write cycle times of around 180 ns, about the same speed as new TTL 1,024-bit RAMs. Those times represent preliminary measurements of pilot-line chips, states Millard Phelps, AMS vice president. Company engineers think it possible to develop an improved version accessible in 25 ns—a

speed comparable to that of ECL RAMS.

One reason for the unusual speed is that the AMS7001 was designed to dissipate considerably more power when accessed than most RAMS. Running at top speed, it burns 450 to 500 milliwatts. On normal standby, the circuit consumes 75 mw

However, the new power-down mode allows most modules in a large memory system to operate at very low current. This cuts the dissipation to 2 mW per chip in memory segments that aren't being accessed.

Charge pumps. A dynamic MOS RAM must be refreshed because charges in the parasitic capacitances of the storage-cell transistors must maintain internal data levels. Without refresh currents, leakage would reduce the charge to an indeterminate level. Data would be lost within about 2 milliseconds in an n-channel RAM, which has higher leakage than p-channel RAMS.

Ordinarily, memory addressing is interrupted to rewrite data in the cells. The extra write operations recharge the capacitances. One exception is the EA1500, an n-channel RAM made by Electronic Arrays Inc., which can be refreshed "invisibly" by putting a refresh pulse into each read cycle. However, invisible refresh extends the read-cycle time to about 500 ns from the normal read-cycle time of 200 ns.

Refresh. AMS employs charge-pumping, a "transparent" continuous-refresh technique. It was conceived a few years ago by the General Electric Co., but GE has never used it, and apparently it has been overlooked by other companies, Phelps says.

Except for the pump and n-channel processing, the AMS7001 cell is almost identical to the cell structure used in the AMS6002 1,024-bit p-channel metal-gate RAM.

Phelps says the company's distributors will be stocked with AMS7001's by March 12. The single-unit price will be $40, and $22 in quantities of 250 to 999. The initial high-volume price to equipment manufacturers will be around 1 cent per bit, or about $10 a unit.

The first company licensed by AMS to second-source the 7001 is Toko Inc. of Japan. □

Memories

Super-dense memories made at IBM's labs

Semiconductor memories starred at the ISSCC; microwave FETs and CCDs performed well

Now that IBM has decided unequivocally that semiconductor memories are the way to go for low cost and high packing density in its newly expanded models 145, 158, and 168 of the System 370 line [*Electronics*, Feb. 15, p. 43], the giant computer manufacturer has mounted an awesome advanced-memory development program. Although largely underground, some of IBM's memory effort surfaced for the first time at the International Solid State Circuits Conference in Philadelphia.

The results are impressive:

- While most semiconductor manufacturers are still struggling with 4-kilobit memory arrays, IBM's Systems Products division, Essex Junction, Vt., has built an 8,192-bit MOS dynamic RAM on a single chip.
- At the company's Boeblingen, West Germany, laboratories, a completely static bipolar memory structure has been developed. With its projected 1.1-square-mil cell size and low power dissipation, it not only compares favorably with MOS packing densities and power requirements, but also offers the high performance—50 nanoseconds access time—of bipolar memories. Using a form of passive isolation to build arrays, these structures could accommodate 16,000 bits of static bipolar memory on a single chip.
- At the Watson Research Center, Yorktown Heights, N.Y., researchers are using electron-beam lithography to build random-access memory arrays with the incredible packing density of 8 bits per square mil. This works out to 320,000 bits on a chip 200 mils square, although none that size has yet been made.

One-transistor cell. The 8,192-bit RAM is built with standard p-channel silicon-gate processing, using a one-transistor cell design to achieve the high density. And although the company takes great pains to call the device experimental, it is fully functional and includes all the important circuitry: the data array, data register, decoders, word-line biasing, phase drivers, input biasing, and chip-select.

The bits are organized uniquely. Built essentially as a pair of 4,096-bit arrays, the chip contains a central data register that acts as a high-speed buffer store into which a single 64-bit word can be transferred from either array. Once this block of data is in the buffer, which contains both the sense amps and shift register, any bit in the word can be accessed randomly.

Although it takes 1.7 microseconds to access a bit from scratch, a bit, once in the central data register, can be accessed in 500 ns. That speed is fast enough for many applications, particularly for the company's virtual-memory system.

The big bipolar. The static bipolar array is an extension of IBM's Boeblingen laboratories' super-dense structures described a year ago [*Electronics*, Feb. 14, 1972, p. 83]. In the early structures, the resistive loads were eliminated and active pnp load functions were integrated directly into the npn flip-flop array, so that minority carriers could be injected directly from the drive line into the emitters of the npn transistors. The result: a three-fold savings in cell size when built with conventional processing and

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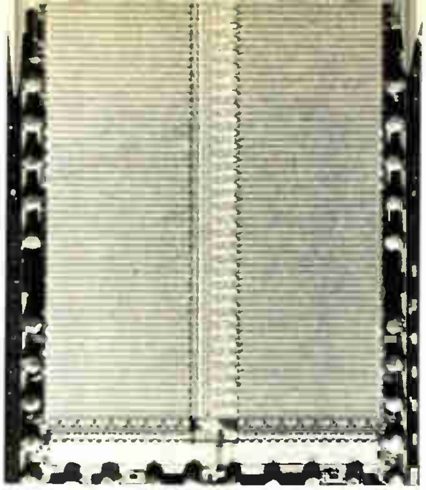
another halving of area using a passive isolation process. Now IBM has eliminated the output npn structures that were used to drive the bit lines as well, simply using the npn flip-flops to directly drive the bus lines. Therefore, direct injection can be used both at the input and the output of the memory flip-flop, saving still more space.

The new structure is called an injection-coupled memory. The new cell size is 3.1 square mils with standard processing, and 1.1 square mils if built with oxide isolation, compared with last year's 4 square mils and with 8.4 square mils of an advanced present-day commercial cell. This cell area, as small as that predicted by even the most optimistic MOS designers, points to a bipolar memory with 8,000 to 16,000 bits on a chip, with standby power of less than 0.1 microwatt per bit, and with an access time of 50 ns. IBM workers project an 8,192-bit chip, including all peripheral circuits, on a chip measuring 160 by 170 mils.

For really dense memories, IBM is developing an electron-beam fabricating technique that yields MOS cell geometries measured in micrometers and nanmeters. The 8-bit array is contained in 1 square mil; conventional MOS cells require 3 to 6 square mils per bit.

Electron beam fabrication is still a laboratory technique. But it can lead to line widths of 1 micrometer or less, oxide thicknesses of 200 angstroms, diffusions of 0.5 micrometers, speed increases by orders of magnitude over today's circuits, and power dissipation of less than 10 nanowatts per cell. □



Unique organization. IBM's experimental 8-k RAM is built as a pair of 4,096-bit arrays

Components

Microwave FETs challenge bipolars

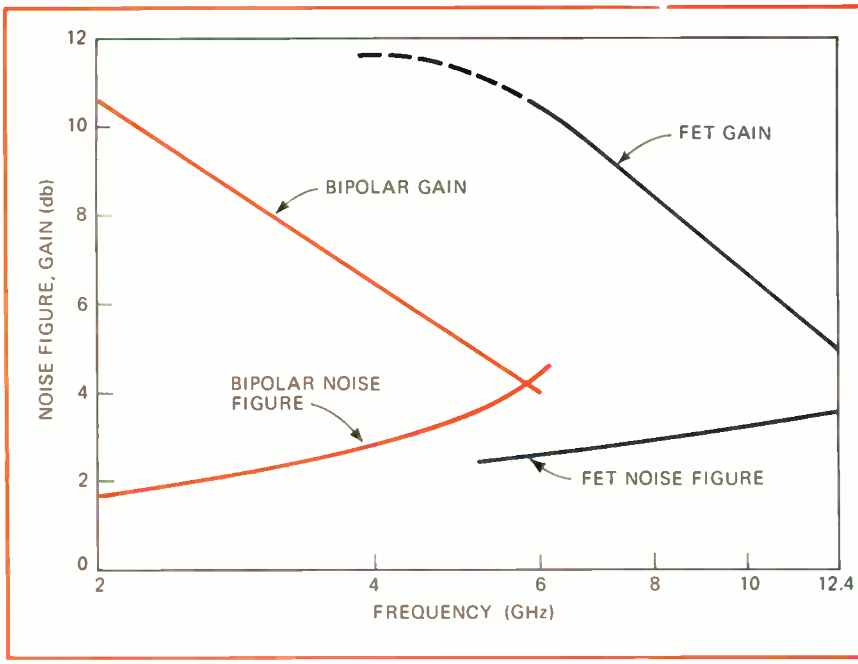
Bipolar transistors have been nudging aside traveling-wave tubes in microwave circuits over the past decade, but the bipolar devices themselves now face a serious threat from field-effect-transistor technology. The threat exists especially for low-noise applications above 6 gigahertiz, although researchers developing S-band FET devices are also optimistic that their circuits can potentially outperform those using bipolar power transistors.

The latest performance of both low-noise and high-power FET designs was presented at the International Solid-State Circuits Conference. Charles Liechti, who is responsible for GaAs FET development at Hewlett-Packard Laboratories, Palo Alto, Calif., summarized the state of the art in both bipolar and FET devices for small-signal applications (see graph).

Because bipolar transistor noise figures rapidly degrade with increasing frequency while noise figures for FETs remain relatively constant, the FET has a distinct advantage above 5 or 6 GHz. The FET also exhibits superior gain, but problems in obtaining a stable gain at the lower microwave frequencies have so far limited its usefulness to above 5 GHz.

Liechti has also overcome tricky impedance matching problems in FET circuits by developing a three-stage amplifier with a gain of 25 decibels. Its center frequency is just over 8 GHz, while noise figure for the total unit is 6 dB.

For power applications, FETs still trail bipolar devices. But a basic problem in fabricating high-power FETs has been overcome by Louis S. Napoli, a researcher at RCA's Princeton, N.J., laboratories. He has developed a multiple-gate device on a single chip that delivers an 800-milliwatt output at 4 GHz. Previously, such multiple-electrode structures were not considered practical because all three FET electrodes



Challenger. Above 5 GHz, FETs give more gain, lower noise figure than bipolar devices do.

exist on the same surface and cannot be interconnected monolithically as is the bipolar transistor. In Napoli's design, gate pads are deposited to allow the bonding together of eight parallel gates on the same device. Carrying the multiple-gate approach one step further, Masumi Fukuta of Fujitsu Ltd., Kobe, Japan has developed a mesh-like geometry to fabricate a 1.6-W device at 2 GHz.

But microwave FETs still face the transition from device development to use in production systems. Fairchild's Microwave and Optoelectronics division now markets its Model FMT-900, a low-noise device that delivers an 8-dB gain and 4-dB noise figure at 8 GHz. Unit price is $500, but is expected to drop below $300 by year's end. □

Solid state

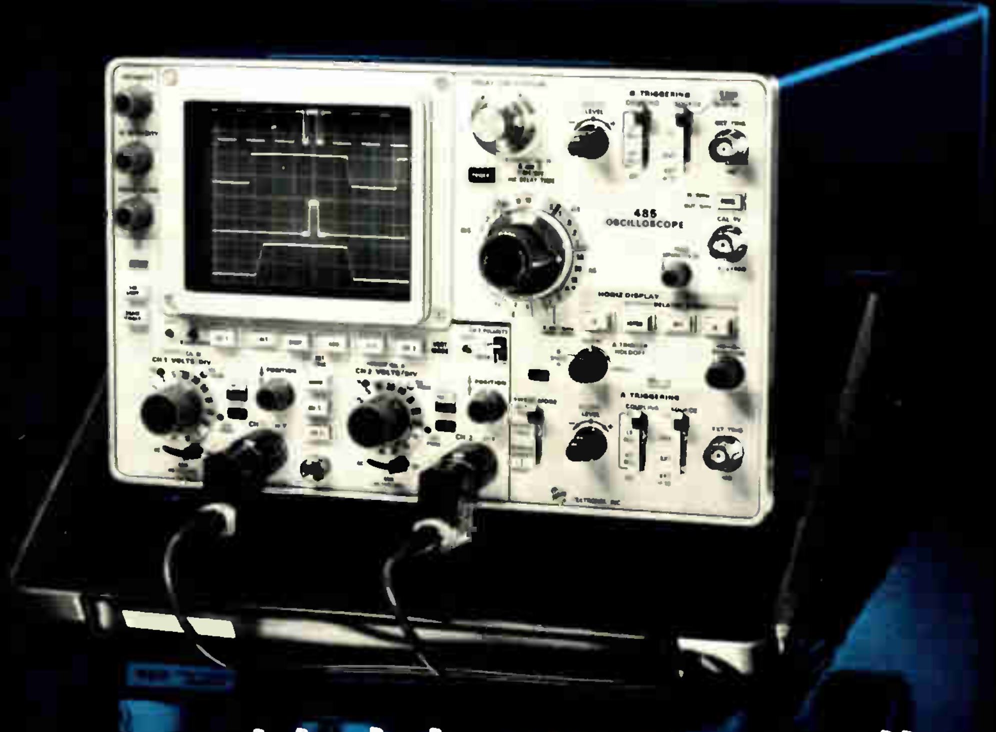
TI makes 4,096-bit CCD shift register

The options available for achieving very high bit densities in memories has been dramatically increased by the 4,096-bit charge-coupled shift register shown by Texas Instruments at ISSCC. Using the aluminum metalization system that TI developed for its CCD analog-signal processing work and a design that the company calls serial-parallel-serial (SPS), the register operates with three-phase clocking and has a monolithic output amplifier on the chip.

This design permits considerable layout compactness: even with a single metal layer, each bit is 30 micrometers square, which means that equivalent high-density serpentine-type registers would require 50% larger channel separation because of clock-line crossovers needed for its zig-zag data flow. What's more, since the SPS design reduces the number of charge transfers required to access a bit, more bits can be stored without the internal registers required by the serpentine-type register.

TI claims that double-level metalization makes possible registers with still greater density, and company officials foresee chips with as many as 32,400 bits. This double-level configuration, which has aluminum as the conductor on both levels and anodized aluminum as the interlevel insulator, results in essentially gapless CCDs, which permits closer spacing and improved yields because photolithographic tolerances can be relaxed. □

350 MHz



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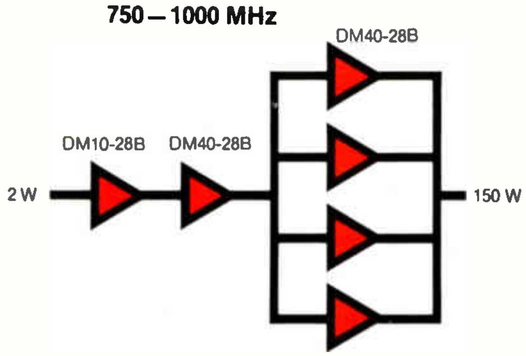

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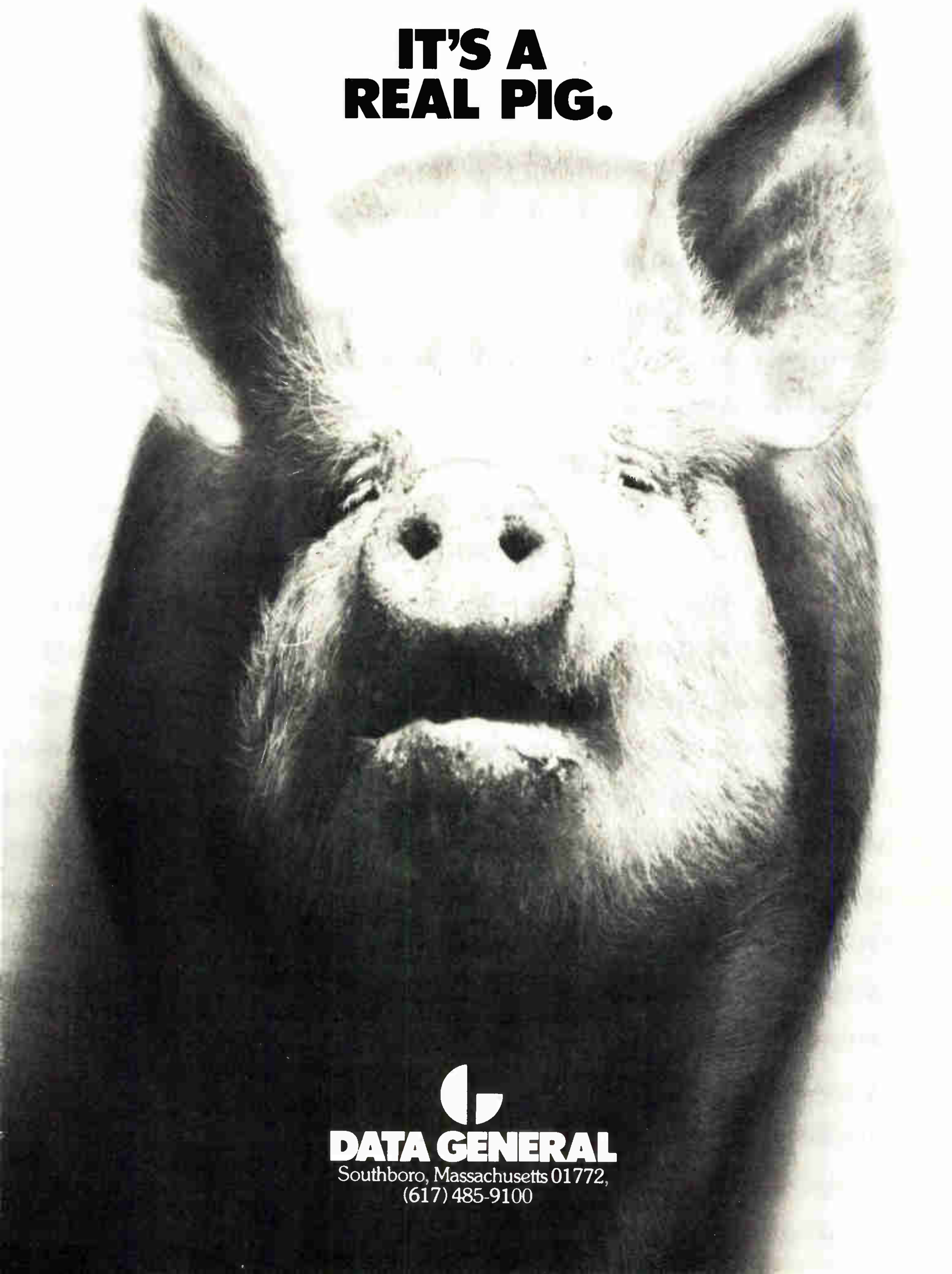
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Loran A and C hit by plan to review navigation nets

An Office of Telecommunications Policy proposal calling for fewer maritime navigation systems will come shortly, say agency sources, following **questions by the increasingly powerful Office of Management and Budget about the need for four systems**—Loran A and the follow-on C, the Navy's Omega program, plus the Transit and proposed follow-on satellite systems. The OMB initiative has **already halted the Coast Guard's fiscal 1974 procurement plan** to begin a five-year period of upgrading the Loran C network [*Electronics*, Dec. 18, 1972, p. 36] with $50 million, plus another $54 million to replace Loran A follow-on satellite systems.

Sikorsky, Vertol lead fight for AAH prototype awards

Two contract awards, each for **three prototypes of the Army's Advanced Attack Helicopter** (AAH), are to be named in May. Leading contenders for one award are United Aircraft Corp.'s Sikorsky division and the team of Boeing Co.'s Vertol division and Grumman Aerospace Corp., both of which were **finalists last year for the Army helicopter called Uttas** (for Utility Tactical Transport Aircraft System); Uttas and AAH are to have at least half their components in common. The other award is expected to go to Hughes Aircraft, Lockheed Aircraft, or Textron Corp.'s Bell Helicopter Co.

Planned to begin production in 1978, the AAH is to **substitute for the Lockheed AH-56 Cheyenne gunship, canceled last year** before production when its life-cycle unit costs rose to more than $4 million. **Eventual life-cycle unit cost for the proposed 500 AAHs will hit $3.2 million.**

DDR&E's Gansler wants price-limited subsystems

A new attempt at "price-limited development" of standardized military electronic subsystems for multiservice use is under way at the Directorate of Defense Research and Engineering as **part of DOD's design-to-cost program** [*Electronics*, Aug. 28, 1972, p. 25]. Under the program, DOD will specify unit production price, minimum acceptable performance, and electrical and mechanical interfaces **to ensure standardization and leave competing contractors with "maximum design flexibility,"** says Jacques S. Gansler, DDR&E assistant director for electronics.

Communications clearly will get first emphasis, say industry sources who heard Gansler lay out his plan at a closed Air Force symposium in late February. They liken it to **the program for airline avionics procurement developed by Aeronautical Radio Inc.,** the airline-owned communications company, and known to be admired by Gansler.

Companies vie for FAA parallel processor award

"At least half a dozen" companies are competing for a Federal Aviation Administration award to build a prototype parallel processor, **a super-computer that will handle the air-traffic-control volume of the 1980s,** say knowledgeable agency officials. After choosing one or more contractors in the next few months for a six-month design study, the agency will select one **to assemble an estimated $500,000 to $1 million prototype from existing hardware for a one-year evaluation.** The FAA is considering procurement, possibly in 1975, of units to interface with the Advanced Radar Terminal System 3. Companies working on parallel processors include Control Data Corp., Honeywell, IBM, TI, and Goodyear.

The price of cheaper dollars

The February dollar devaluation means more to the American electronics industries than a small and probably temporary price advantage in some overseas markets or an increase in the cost of the minuscule quantities of gold used in semiconductors. On the domestic market, devaluation also carries the threat of escalating inflation.

It is a threat that Treasury Secretary George Shultz says the Nixon Administration recognizes as one of devaluation's tradeoffs. In simplest terms, the inflationary potential of devaluation in the domestic market has its roots in the higher prices that will be charged for imports. "Those higher prices will take the pressure off domestic manufacturers of competing products to hold prices down," explains one Federal economist.

Compact circles

One popular example has been dubbed the Datsun-Toyota-Pinto-Vega Circle. It goes around this way: if the average price of a small Japanese imported car goes up by, say, $200, then Ford and General Motors can ease their compact prices up by $150 each and still be "competitive." A different kind of example with the same end result might be called Logrolling. It works this way: Japan is a heavy consumer of U.S. logs, already in heavy demand. With the yen more valuable after its upward float and the dollar's devaluation, Japan can and does pay more for American lumber, driving up the price. Thus, homes cost more, and rents rise.

Then there is the case of consumer-electronics imports from Japan in product areas for which there is no effective U.S. competition. High-fidelity stereo equipment is one example. Sony Corp.'s popular Trinitron color TV with its one-gun picture tube is another. "If the customer wants it, he's got to pay the price," says an official of one large, Washington-based retailer flatly. "We sell Sony 17-inch color for $479. We also sell 19-inch U.S. brand labels from Taiwan for $288. We have no trouble selling Sony now, so what difference will it make if they jack up the price?"

The difference common to all of these examples, of course, is to the U.S. consumers who must pay. And a large number of those consumers are also union members—unions that want their bite at the apple to match the price increases now and later. Those wage increases to come threaten to fuel inflation further.

Organized labor's reaction to offset inflation goes beyond pushing for higher wages, however. It is also leaning harder than ever on Congress to pass the controversial Burke-Hartke bill, introduced last year as labor's counter to what it believes is the wholesale export of U.S. technology and jobs by multinational corporations to low-wage offshore tax shelters.

It is well known that a large segment of the domestic electronics industries—which abound in multinationals ranging from IBM in New York to National Semiconductor in California—is opposed to Burke-Hartke. James Binger, Honeywell's chairman and a former member of the President's commission on International Trade and Investment, is part of this opposition. He argues that research on operations of 74 U.S. multinationals between 1960 and 1970 shows they provided 900,000 new domestic jobs while increasing foreign operations; nearly doubled their sales from domestic plants to $113 billion; nearly tripled their exports to $12.2 billion, and more than doubled their net surplus of exports over imports to $6.6 billion.

The need to act quickly

The White House trade-legislation package is another matter, however, and many in industry are not yet sure they favor all of the Nixon propositions. Neither is Congress, still involved in its power struggle with a President who now wants even more power to effectively raise or lower selected tariffs and/or establish import quotas. The White House view, of course, is that these are merely necessary bargaining chips in what the President hopes will be still another successful international negotiation for his Administration. Yet the authority sought by the President is great and can be censured as favoring either protectionism or free trade, depending on your bias.

The potential for the abuse of such powers is also great, of course, but their delegation may be the only way of capitalizing on the breathing spell that devaluation has provided and moving on to successful multinational resolution of world trade and monetary system imbalances. Even the Senate's resident expert on economic affairs and long-term Nixon antagonist, Wisconsin Democrat William Proxmire, sees some value in the kinds of leverage the President wants to exercise on trading partners such as Japan.

However, none of the proposals now being advanced, either by the White House or in the Congress, can prevent at least a short-term renewal of inflation in America. The best that can be hoped for is that it will be only for the short term.

—Ray Connolly

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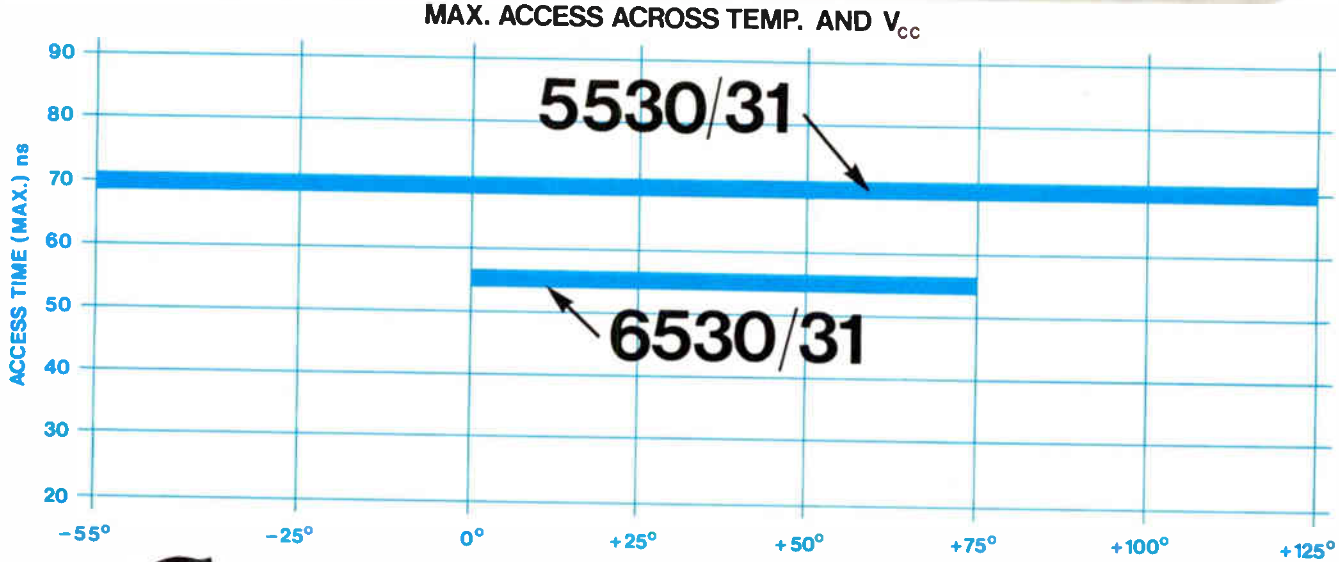

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ACR2000	2000			$ 575
ACR3000	3000	95	47-53	$ 700
ACR5000	5000	to	to	$ 850
ACR7500	7500	130	57-63	$1025
ACR10000	10000			$1450
ACR15000	15000			$1775

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Sorensen
POWER SUPPLIES

Apartment-complex developer tries local CATV programing

CATV has come a long way since the days when it was Community Antenna TV, bringing service to people living behind hills or long distances from stations. It is going through its CAble TV phase and is now approaching the CAble Telecommunication and Video phase. Tokyu Corp., a Japanese private railway and developer, has just completed the first part of a test to see if it can add third-phase CATV to its new housing projects.

To a great extent, Japan has leapfrogged the first phase and is trying to come to terms with the second and third phases. The first phase was not needed because NHK, Japan's public service broadcasting system, almost completely blankets the country with a large number of stations and translator repeaters.

Experimental. Perhaps the most ambitious project so far has been carried out by the real estate development division of Tokyu Corp. at a condominium-type project built by the company along one of its railway lines. The first part of the project tested the feasibility of supplying locally originated programing to the residents of the project. The second part will be finding sponsors.

The test site, Tokyu Eda Village, has 208 apartments in two adjacent buildings in the suburbs of Tokyo. It is more deluxe than the average Japanese condominium and features a master antenna and distribution system for TV signals, its own swimming pool, and a small building with common rooms for meetings or gatherings. It is here that the television studio is installed.

Schedule. Average programing each day runs for 1.5 hours. On a typical day, the program might include news from the local kindergarten and a video-taped interview with advice from the teacher, news for the lady of the house, a guide to the best buys at the local markets and a taped interview with a local merchant giving buying suggestions, assorted news and announcements from the community, a reading from a fairytale book, and a studio interview with an expert on proper kimono wearing.

On other days there may be a chance for children living in the project to say a few words about whatever interests them or for a broadcast of a swimming meet from the pool. This involvement brings the community closer together, and mothers are very glad that their children can get involved with the originating end of television. □

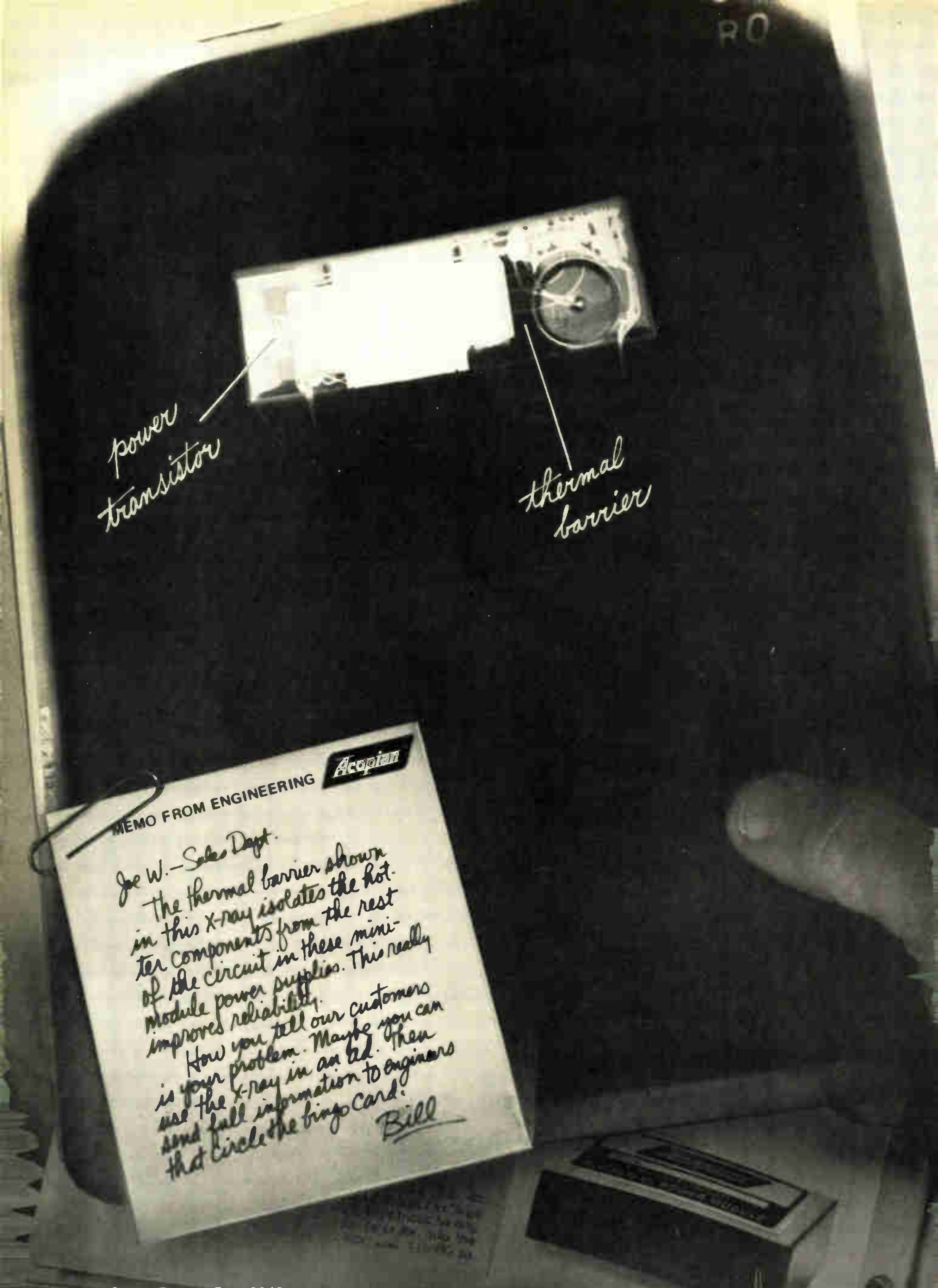
700-W laser aims at industrial cutting jobs

Furniture and cabinet makers may trade their scroll saws for lasers when Mitsubishi Electric Corp. starts production of a commercial version of high-power continuous-wave carbon dioxide laser developed at its Central Research Laboratories. Researchers say that they have almost reached their 1,000-watt continuous output target for a laser to be used for cutting wood, metal, fused quartz, plastic, paper, and cloth.

The laser's continuous power output is now more than 700 W for a unit with a resonant cavity only 1 meter long, inside which is a discharge tube only about 900 mm long. The output is approximately 800 W per meter of discharge tube length. Wavelength of the infrared beam is 10.6 micrometers.

What facilitates high output power from a compact discharge tube is the use of mutually perpendicular directions for glow discharge, gas flow, and laser beam. This geometry decreases the distance between the glow discharge electrodes and makes it possible to utilize most of the region potentially capable of giving gain for laser operation. Thus efficiency is held at a high level, typically 8% to 10%. □

All in the family. Experimental CATV system serves to tie together the residents of an apartment complex near Tokyo. On-site studio and control room are supplemented by programs taped at remote locations—supermarkets, for example.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Growth in Japan's electronics industry will slow this year

Slower growth for Japan's electronics industry this year was forecast even before the dollar's change in value, according to pre-devaluation studies made by the Electronics Industries Association of Japan. **Over-all growth is forecast at 10%, compared with last year's 14%.** Furthermore, growth in the previously bright consumer section looks to be only 3%, and the important TV and radio categories will be down, partly because of competition from developing countries. Color TV sales are expected to be static because the number of households owning one is already at the 75% mark. **Bright spots are tape recorders, up 15%, and high-fi sets, up more than 20%.**

Professional electronic equipment should show an over-all gain of about 20% to fulfill the needs of a prosperous economy. Especially noteworthy is a **27% increase forecast in computers and a 24% increase in non-communications wireless equipment.** Gains of almost 30% are forecast for various categories of monolithic ICs and for thick-film hybrids, and gain of more than 50% for thin-film hybrids.

Philips offers integrated-scanning photodiode arrays

The Philips Group is getting into the growing market for linear photodiode arrays integrated with MOS scanning circuitry, offering devices developed by Mullard Ltd. at its Southampton plant. Mullard's devices follow closely the pattern set by Integrated Photomatrix Ltd., pioneers in self-scanned arrays, using diodes measuring 50 by 100 micrometers spaced at 100 micrometer centers, sequential scanning up to 15 megahertz, charge storage operation and p-channel enhancement-mode construction.

However, Mullard uses silicon-gate processing instead of IPL's aluminum gate, which Mullard says gives cleaner switching along the array. Arrays with 16 and 128 diodes will be standard, in 16- and 18-lead dual in-line packs. Some of the output will go into Philips' own character-recognition systems, but—like IPL—the company is looking to find industrial applications where the incident-light pattern can be used as the basis of a control system. Production of the devices will start in about two months.

Active antenna for industrial use hits market

The active antenna, which was the subject of much controversy several years ago [*Electronics*, June 12, 1967, p. 145], is finding jobs in communications. **Now that it has been successfully marketed in the consumer field as a car aerial and tested in a flight-control application, the approach is being offered for industrial and military uses.** A new industrial version has been developed by Rohde & Schwarz, in cooperation with Munich University's Institute for High-Frequency Technology— whose head, H.H. Meinke, is the originator of active antennas. The industrial unit is designed for a 100–156-megahertz range.

The tests, held at Munich Airport's flight-control installation, put the antenna's signal-to-noise ratio at an average of 3 to 4 decibels higher over the whole range than is obtainable with conventional coaxial dipole designs. Peak values showed an improvement of 10 dB. **With relatively weak signals from a transmitter 60 miles away, the antenna exhibited an 8-dB increase over coaxial dipole versions.**

The antenna that Rohde & Schwarz is marketing is about 35 inches high and weighs roughly 5.5 pounds. Its voltage-standing-wave ratio is smaller than 2 and its noise temperature is less than 600°K. Operating off 12 volts, the antenna consumes about 20 milliamperes. Its input impedance can be set to either 50 or 60 ohms.

Eurocontrol's second en-route center follows set equipment pattern

The equipment complex in Eurocontrol's second en-route air-traffic-control center at Karlsruhe, West Germany, **planned to start controlling Southern German upper-air space in late 1975,** will be based around twin IBM 370/158 computers. It will also include four AEG-Telefunken TR-86 computers for peripheral functions, such as display driving, and 70 controller console positions. Approximately 37 synthetic plan-position displays and 67 electronic data displays will be provided by Thomson-CSF, and the controller input system will be engineered by Plessey Co. Thomson-CSF will also provide a hard-wired plot processor to extract radar data and drive the displays while the main computer system is gradually brought into operation, after which it will act as a permanent standby.

This hardware follows the pattern developed at Eurocontrol's first center at Maastricht in the Netherlands, but Karlsruhe's capacity is larger—it can cope with 300 flight plans simultaneously, compared with 200 at Maastricht—because Karlsruhe will control military overflying, as well as civil. Another difference is that Eurocontrol plans to develop its own operational software for Karlsruhe, instead of contracting it out, as at Maastricht.

Need a German Telex number? Dial Darmstadt

An automated Telex information system has been put into service in Darmstadt, West Germany. The system, developed by AEG-Telefunken together with the German post office, makes it possible for any of the country's 80,000 teletypewriter users to obtain another subscriber's Telex number and call letters if he knows the name and address. At the heart of the system are two AEG-Telefunken TR-86 digital computers, each with a core store capacity of 64,000 24-bit words. Connected to the computers are 25 Telex lines over which the information exchange can take place. **In addition to its regular function, the system updates subscriber listings and helps in the automatic production and printing of Telex number books.**

Siemens sells first traffic-control computer to South America

With the delivery of a traffic-control computer for the city of Buenos Aires, West Germany's Siemens AG has established a bridgehead for its traffic-control equipment in the Western Hemisphere. At the same time, the computer is South America's first in a traffic application. **It will initially control 300 intersections in the Argentine capital and will later be expanded to handle as many as 3,000 intersections.**

While the system's central processor, a Siemens VSR 16000, comes from the company's facilities in Germany, all peripheral gear—such as vehicle detectors and signal-handling devices—are built at the company's plants in Argentina. Siemens, a heavyweight in computerized traffic control, **has more than 90 systems for traffic control on order or installed. These systems, 18 of which are installed outside Germany, are worth nearly $35 million.**

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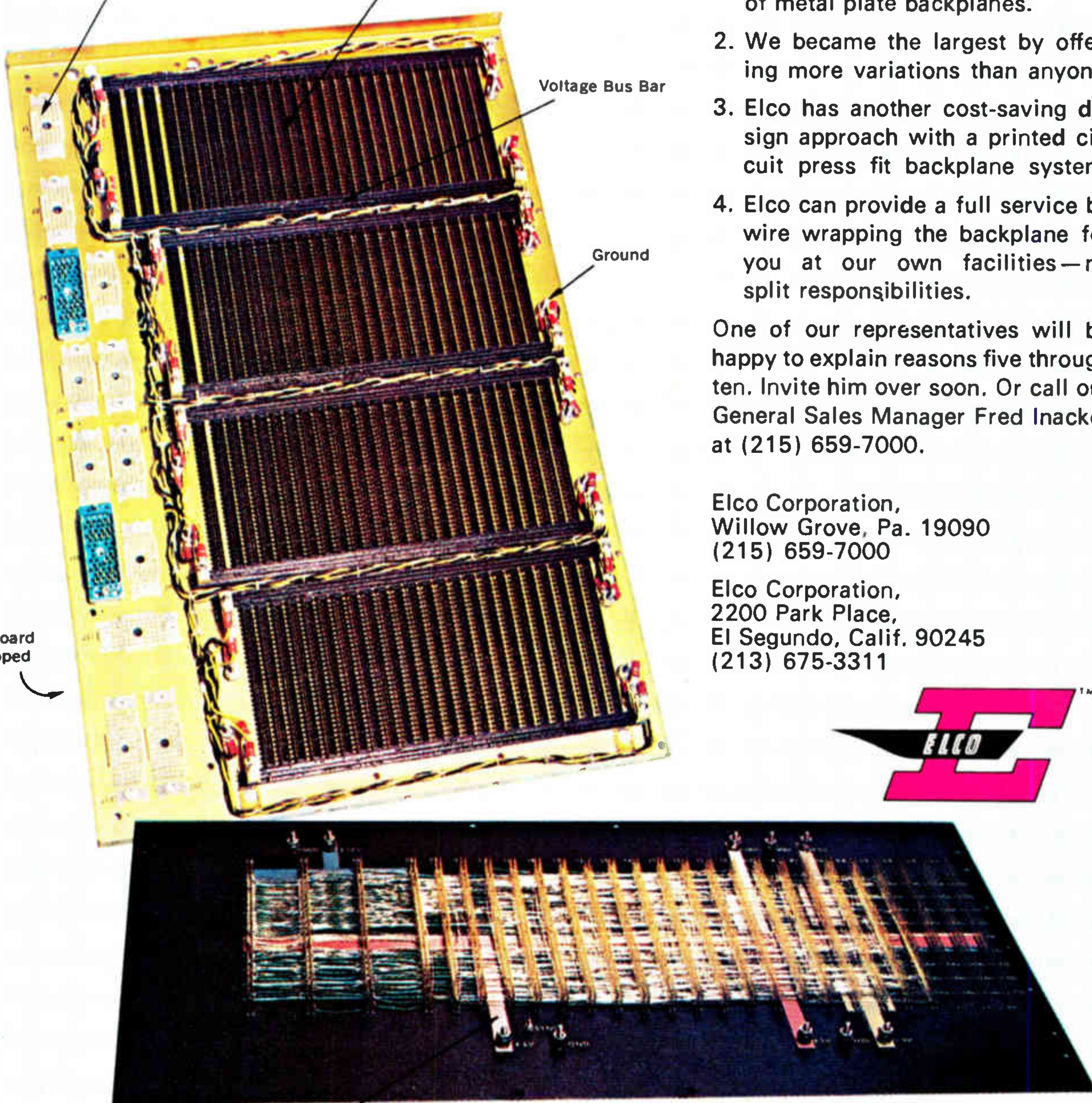

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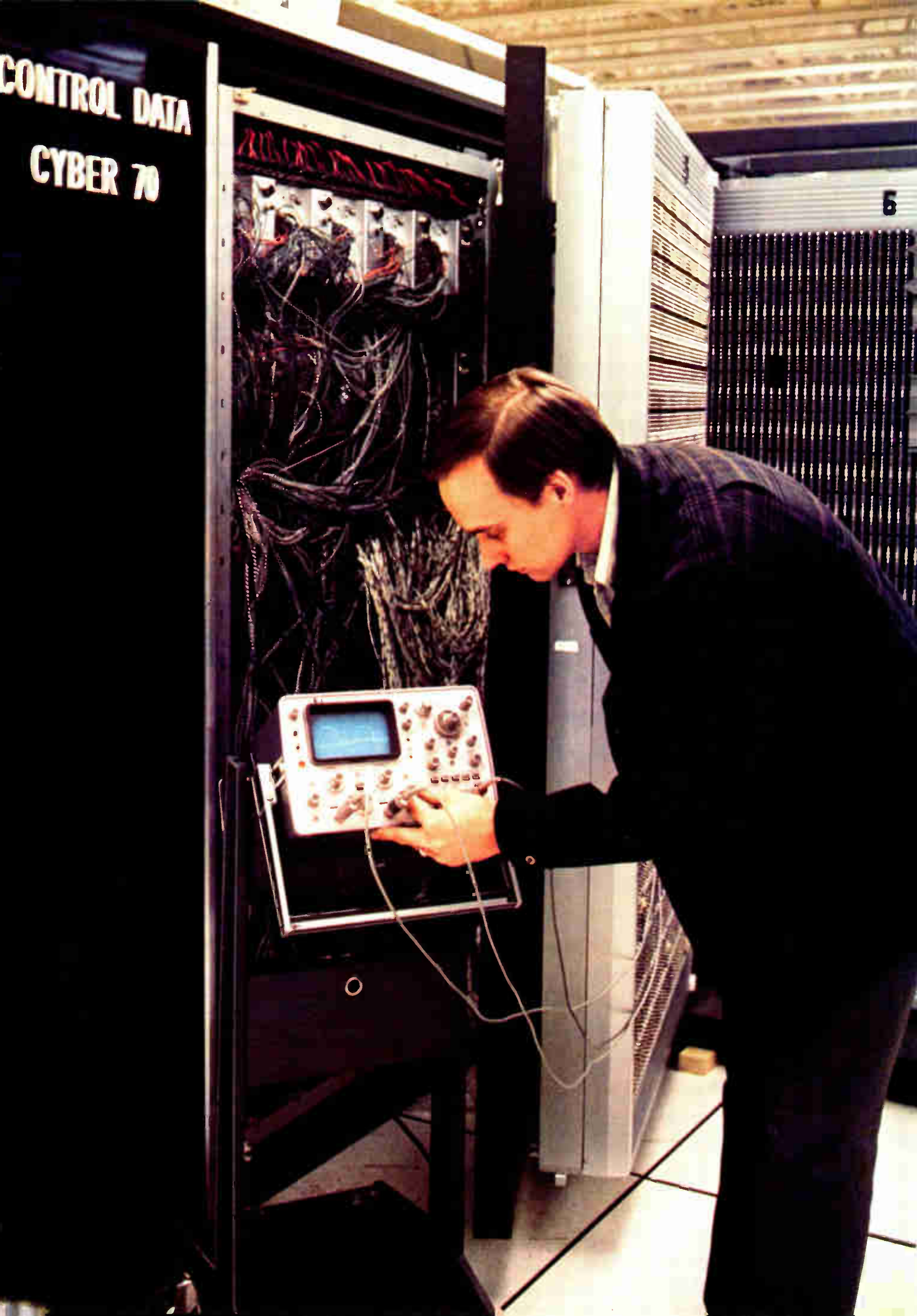
Circle 57 on reader service card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Analyze your total measurement needs, then ask both manufacturers to submit prices. On currently available models, you'll find that HP can save you money—lots of it in most cases. Check carefully on all aspects of cost and performance. Whether you are comparing real-time systems with or without delayed sweep, or sampling units, you'll find that HP still offers a cost/performance advantage.

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Microcomputers muscle in

Low-cost kits expected to sell in hundreds of thousands by 1975, with total market topping $50 million

by George Sideris, San Francisco bureau manager

Microcomputers—a cross between calculator-chip sets and minicomputers—are finding a seemingly bottomless pit of applications. They are increasingly serving as dedicated controllers and data processors in systems too small or slow to warrant use of minicomputers.

Intel Corp. of Santa Clara, Calif., which started the business about a year ago with 4-bit and 8-bit systems, is already shipping microcomputer kits to some 200 customers, and it reports that another 800 or so are planning to build new equipment around microcomputers. Henry Smith, manager of microcomputer systems at Intel, says he has counted more than 60 applications, from smart-terminal controllers to preprocessors for minis.

Excluding scientific calculators, a high-volume application now, microcomputer sales are expected to climb into the hundreds of thousands of kits by 1975. As low-cost kits, they may only account for $5 million or so in chip sales. But the average kit is supported by more than 10 times its worth in memory and peripheral circuits, raising the total market to over $50 million, predicts Smith.

Gene Carter, marketing manager at National Semiconductor Corp., goes along with Smith: over $50 million in 1975. While chip sets may cost only about $20 by then, he estimates that each will generate up to $200 in memory business.

Most of this market will be new business for manufacturers of MOS large-scale integrated circuits—and much of it will be lost bipolar logic business. New versions of microcomputers generally replace hard-wired logic controls, while doing some arithmetic processing. And, warn microcomputer suppliers, logic-control designers had better get used to manipulating programs rather than organizing logic functions.

The going price for chip sets ranges from $50 to over $100 in small quantity and averages about $30 in high volume. Assembled prototypes cost from about $400 to over $2,000 with software.

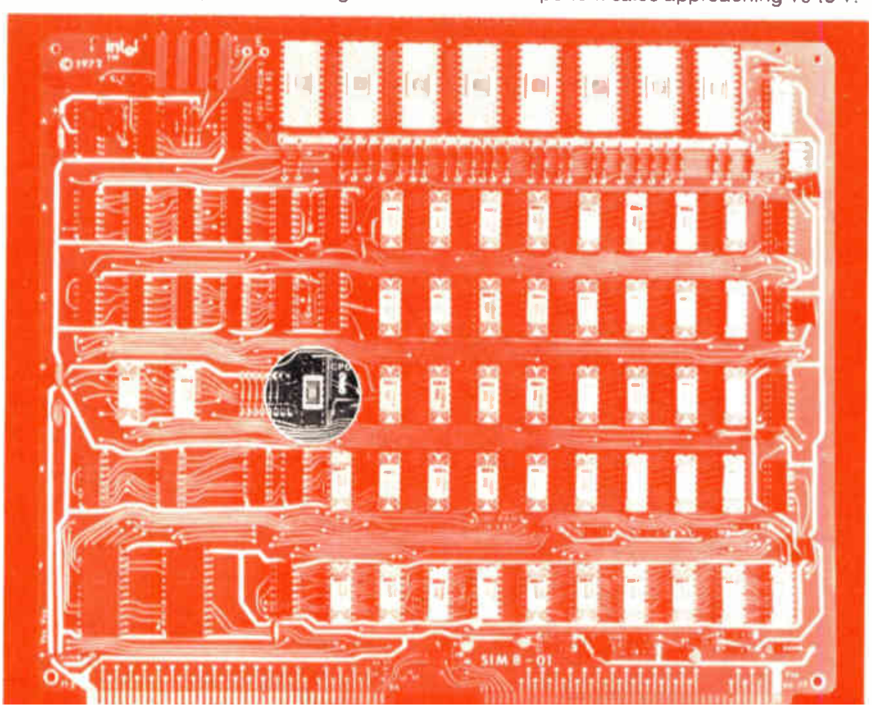
Tradeoffs. Though some microcomputers can handle longer words than the most popular types of minicomputers, such as the Digital Equipment Corp.'s PDP-8 and the Data General Corp.'s Nova, they generally are much slower and not as flexible. However, some new microcomputers can perform low-level operations as fast as minicomputers.

Consequently, while the smaller systems have displaced minicomputers in a few scattered applications, the minicomputers in these cases represented "overkill"—far more computing power than the system required. Microcomputer manufacturers agree that they would rather supply preprocessors and peripheral-equipment controllers to minicomputer manufacturers than get involved in high-overhead software and servicing support.

But four California companies now producing microcomputer chips—Intel, Fairchild Semiconductor division, National Semiconductor Corp., and Rockwell Microelectronics division of Rockwell International Corp.—offer designers simulators and prototypes. These can be operated as computers once they are programed. Intel already supplies program-assembler software and sponsors a users' group that trades programs among equipment manufacturers.

And about 30 new companies

Lots of action. Package in center with lid off is CPU chip; the rest are memory and interface circuits. A microcomputer sale can generate add-on component sales approaching 10 to 1.



have been formed, says Smith, to design products for equipment manufacturers. At least three companies in the Los Angeles area have started selling microcomputer subsystems based on the Intel sets. They include Applied Computing Technology Inc., Pro-Log Corp., and Varitel Inc.

Beginning. Intel's first two microcomputers command about 99% of the market, Smith says. The MCS-4 processor uses 8-bit microinstructions to process four-bit words in a bit-parallel mode. It runs 45 macroinstructions. The basic set consists of four chips, which can be expanded with up to 512 bytes (8-bit words) in special arrays.

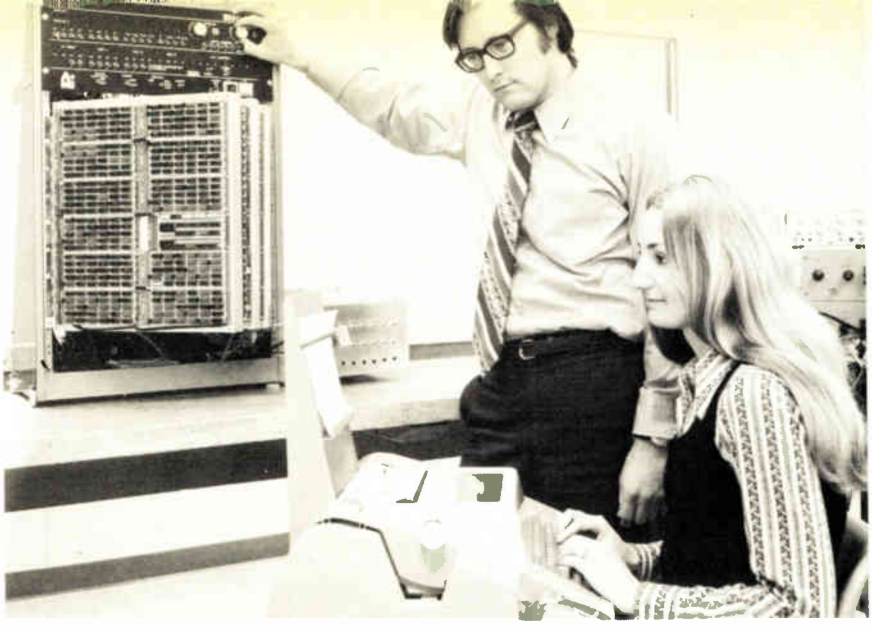
The other is an 8-bit central processor unit on a single chip, supported by up to 16 kilobytes of program and data words in standard read-only, random-access, or shift-register memories. The MCS-8 cannot be microprogramed—there are 48 fixed program instructions.

By fall, Intel hopes to be making a high-speed, 8-bit, single-chip CPU by an n-channel MOS process. The instruction cycle will be 2 microseconds—10 times faster than the initial p-channel designs, and about one-third to one-half as fast as a minicomputer. It will have 75 fixed instructions. Smith thinks that minicomputer speeds may be attained in about two years with further improvements in architecture.

Fairchild's PPS-25 has a two-chip CPU that processes 25 binary-coded-decimal digits in a 4-bit parallel stream or 12 8-bit words. A microprocessor, it has 95 macroinstructions and a microinstruction storage capacity of 6,656 words.

While the PPS-25 is primarily used as a scientific calculator—Fairchild is producing more than 5,000 a month—Elvet Moore, MOS planning manager, says that it is being designed into point-of-sales equipment and other smart terminals. It is much faster than Intel's kits, Moore says, because operations are overlapped in an instruction cycle.

National's General-Purpose Controller/Processor has a 4-bit CPU that can be paralleled to process words up to 32 bits long. The macroinstruction set is variable, as in some conventional computers. National says that any type of program can be performed by arranging 23-bit microinstructions in 100-word read-only memories.



Getting the bugs out. This logic assembly is being used to debug the logic of a microcomputer under development at Intel. Each "page" simulates an MOS chip.

Because of the bit-sliced architecture, long words can be processed at about the same speed as short ones—typically 1.4 microseconds per microinstruction and about 7 microseconds per macroinstruction.

Rockwell's 4-bit Parallel Processing System, which is also microprogramable, starts with one CPU chip and one special read-only and random-access memory. Its memory expands to 24,000-words. The basic cycle time is 5 microseconds, and there are 50 macroinstructions.

An expandable microprogramable kit—8, 16, and 24 bits—is being developed by American Micro-systems Inc., in Santa Clara, Calif. Robert McInturff, processor marketing manager, says that it will run with only a 600-nanosecond cycle time, giving it a speed near that of a minicomputer. In addition, the 120-instruction program includes some direct minicomputer-like operations, such as direct memory-to-memory transfers. Main memory capacity will be set by the word length—65 kilobytes, for example, at the 16-bit word length.

Signetics Corp., Sunnyvale, Calif., is working on new encoding techniques that should bring memory requirements down by as much as half, says Joseph Kroeger, MOS applications manager. The techniques will be used in an 8-bit, fixed-program, integrated processor dubbed Pipchip. It will consist of a single CPU that will run more than 60 instructions in 12 microseconds or less per instruction. Support memory capacity will be 8 kilobytes.

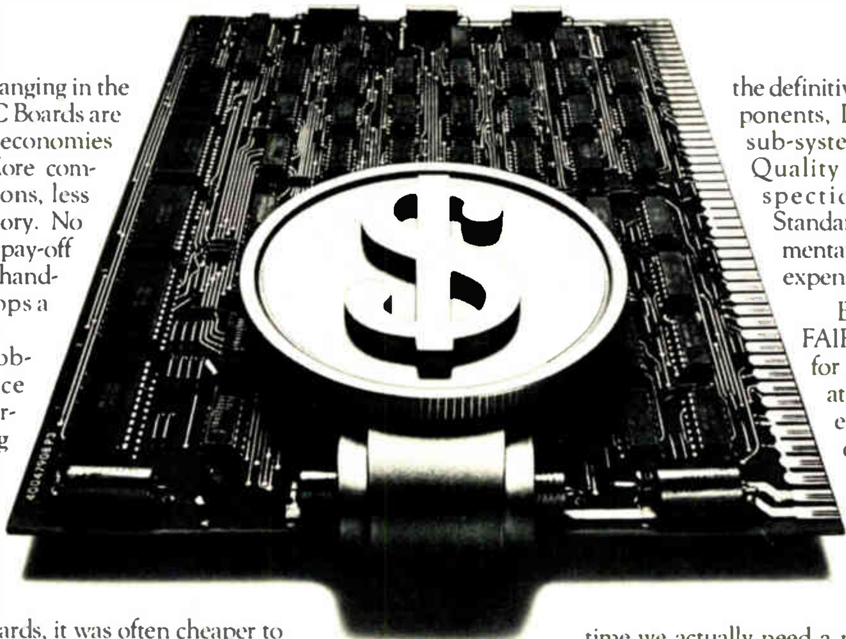
An 8-bit n-channel design that will look like a 16-bit one when microprogramed is in the works at Western Digital Corp., Newport Beach, Calif. Details haven't been disclosed, but William H. Roberts, vice president for R&D, says, "with good logic organization, n-channel microcomputers could rival today's minicomputers."

National's expandable design is based on the expectation that the market will split into three groups:

- Small controllers, costing $100 to $800 when assembled.
- Eight- and 16-bit smart terminals and point-of-sales systems with up to 4,096 words of memory, worth up to $1,200.
- Sixteen- to 32-bit processors with as many as 12,000 words, costing the system manufacturer $1,000 to $2,000 to build.

McInturff and Kroeger both doubt that a ceiling could be put on the market at this time. McInturff points out that automobile control computers alone could sop up $50 million, while Kroeger sees the possibility of such a large memory market that Signetics may give away the CPUs to get the memory orders. "My example of a mass market," he says, "is pinball machines. I think I mean that literally but most people think I am exaggerating." □

Speculation is too expensive on the big board.



With pin counts ranging in the hundreds, complex PC Boards are already way into big economies and bigger profits. More components, more functions, less work and less inventory. No question about it; the pay-off from the big board is handsome. Until it develops a a glitch.

Isolating the problem is the hook. Once found, repair is comparatively easy. But finding it, with certainty, had been cause enough to doubt the profitability of using big boards. And especially of reclaiming them. With smaller boards, it was often cheaper to throw the board away and replace it with a new unit. But as costs went up with packing densities, that choice began to resemble throwing the baby out with the bathwater.

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Fairchild Systems

Fairchild Systems Technology, a division of Fairchild Camera & Instrument Corporation

Making the scene. The action at OTB store in New York boils down to a few numbers.

Commercial electronics

How GI captured the OTB stakes

American Totalisator division relied on parimutuel experience to jump into rich market for off-track betting systems

by Alfred Rosenblatt, New York bureau manager

The end was melodramatic that cold Sunday night in January. Harried engineers at the headquarters office of the New York Off-Track Betting Corp. raced to beat a midnight deadline as they checked out the new "back-room" bet-processing system supplied by American Totalisator Co., a subsidiary of General Instruments Corp. The deadline was imposed so that OTB could, if it had to, switch back to the old system in time for Monday morning business. As they worked, a special courier waited at a phone in a Falls Church, Va., motel room.

The courier finally got his call. The next morning he strode into the nearby office of Computer Sciences Corp. with a notice to cancel in 30 days CSC's contract to handle New York City's off-track betting system.

AmTote had won a victory worth $2 million a year for the next three years. But even more important, it had achieved a dominant position in the market for off-track betting systems that many predict will mushroom across the country [*Electronics*, July 17, 1972, p. 61]. And CSC, the pioneer, had finally lost—but only after a string of delays and system malfunctions that had plagued OTB ever since the first operational target of January 1971.

For OTB, the switch to the AmTote system, which uses 16-bit Varian 620Ls that have 950-nanosecond cycle time, means that computer charges will drop dramatically—to an estimated $175,000 per month from a whopping $425,000. AmTote's charge is based on 1.1 cents for each transaction, whether to issue a betting ticket or to cash a winning ticket. The AmTote system, which uses duplexed master/slave minicomputers, is entirely different from the original CSC setup, which relied on a pair of redundant IBM 360/50s.

The result is a far more reliable system, says GI chairman Moses Shapiro. It will handle 70 transactions per second and can be expanded to 110 transactions, which is about four times the old rate.

The switch to AmTote, which has headquarters in Towson, Md., also came at a time when OTB was finally beginning to pay off on its promises. Last December, OTB handled revenues at a rate of $600 million per year. It turned back to New York City and the state some $3.5 million in profit, reports OTB president Howard Samuels, who aims for both these figures to increase. Profit in 1973 should approach the oft-proclaimed goal of $50 million, he asserts.

Already the OTB, with its functionally austere "stores" popping up all over the city, is the largest retail operation in New York City, Samuels points out. And it reached this pinnacle from a standing start in a mere two and a half years.

By March 31, AmTote should be tied into 950 remote betting terminals at 101 branch betting offices. Back in January, CSC was serving 501 terminals, and the Ticketron subsidiary of Control Data Corp., brought in when CSC faltered, served 291. All of these, plus additional installations, will be served by AmTote. Thus, OTB will continue to use the CRT betting terminals (built by Wyle Laboratories) and ticket-issuing machines (from Di/An Controls) bought originally for the CSC system. Indeed, this was a requirement OTB set when it began shopping around for another system.

In its design, AmTote drew upon software and hardware experience gained in providing the computer equipment for the parimutuel operations at 185 race tracks in the U.S., Canada, Puerto Rico, and Mexico. Altogether, its equipment handled $6 billion worth of bets in 1971.

Phones work. Another important plus, as far as OTB was concerned, was AmTote's successful operation of OTB's 32-terminal telephone betting center.

The AmTote installation—it's about one-third the size of CSC's IBM computer center—is divided into front-end and back-end processors. The front end, with five active and five backup 620Ls, each with 32,768 words of memory, is a "total communications-processing facility," says General Instrument vice president John A. DeVries. "It polls the OTB terminals, detects when one needs to be serviced, takes and analyzes messages, and preprocesses and passes the messages on to the back end." A single 620L handles up to 50 telephone lines with four or five terminals. By contrast, CSC used 20 model 112 minis by Digital Computer Controls to handle the preprocessing.

The AmTote back-end installation consists of a pair of 620Ls operated in a master/slave mode—parallel processors working so that one carries the load while the other is ready to take over if the first should fail. However, the slave machine doesn't have to be "initialized," or loaded with data, should the master fail; it can be cut over in minutes.

The back end performs such chores as determining from its memory files whether or not a bet is valid—that is, for example, whether a particular horse is indeed running in a given race. Valid bets are confirmed to the front end, which maintains a bet queue, and for each valid bet, a message is sent back to the remote OTB terminal to print and issue a ticket. The back end also does such things as confirm whether or not a ticket presented as a "win" at an OTB office should be paid. And it stores and integrates into the pools the bets made through the telephone betting system.

Crucial for these transactions is a 4-million-word magnetic storage drum, one for each processor. This store maintains such things as profiles on each race, files on every bet, including the code number of each bet ticket, so that counterfeit tickets won't be paid, and betting totals.

GI's Magnahead division builds the drum memories, which soon will be upgraded to 8 million words. Magnetic tapes also are used to store all transactions following a race, so that a complete history, or "audit trail," of every race can be recorded. Both magnetic and punched tapes store betting-pool information to be transmitted to the tracks before each race.

Why did CSC fail? One reason certainly is the deadline CSC accepted for delivery— five months after receiving the go-ahead in August 1970. To meet it, the company made maximum use of both existing hardware and software [*Electronics*, Jan. 4, 1971, p. 79]. This probably was its biggest mistake.

Also faulted is CSC's basic approach to the over-all problem. Says an OTB computer specialist: "They must have thought it was a big data-processing job, and so they relied on big machines like the redundant IBM 360/50s.

"The data-processing itself is nothing; it's really a problem of communications-control involving queueing, line-switching, and handling interrupts." Software also is tailored for the OTB function; CSC relied on IBM's generalized OS software and then tried to write special instructions for OTB.

Many delays. So the system creaked unreliably along. Betting terminals often appreciably slowed down, and frequently they failed entirely during peak periods. Switchover from one IBM mainframe to another was also unpredictable. It took anywhere from a minute to an hour—or long past the betting day had ended.

The hours spent by both CSC and OTB personnel adjusting programs and getting the system to operate were long indeed. But with so much effort concentrated on designing the back-office system, CSC apparently paid too little attention to the equipment out at the remote OTB offices—the modems, teletypewriters, data-entry and ticket-issuing terminals, and the leased telephone lines connecting the branches to the central computers.

"The first we'd hear anything was wrong was when someone called up and said, 'I can't take a bet,'" says Frederick Kupersmith, executive director for OTB technical services. "Just about anything could be wrong, of course, and sometimes we'd spend the entire day finding out what before we could send a repairman to fix it."

Maintenance. Thus, OTB began in October 1971 to beef up its own system-engineering expertise. Under its executive vice president for computer operations, Henry Lion, an old ITT hand, this group grew from a nucleus of 17, set up originally merely to monitor CSC's work, to 140. They also took over the maintenance chores for OTB.

The core of the operation is the technical-control facility directed by Kupersmith. This is a multipurpose center in the headquarters building that allows OTB to do such things as check out the leased phone lines, the integrity of the data and Teletype communications, the data modems at the branches, and the branch-office terminals. This is done through a manual patch panel—"a $200,000 switchboard" is what OTB's Samuels calls it. Failed or noisy lines can be patched at the facility. Failed modems at the branches are changed there manually. Dial-up lines can also be introduced, if the spare lines also fail. □

The end. OTB pays off a winner, which will happen more often with new, faster system.

Computers

European accord to combat IBM

CII, Siemens, and Philips are ready to marry product lines and form a single marketing operation; the British are expected to join later

by Michael Johnson, World News, Paris

For an industry where everyone is always making deals with everyone else, Europe's native computer makers have been notoriously slow to arrive at a formula for real collaboration—and ultimate survival—in the face of IBM superiority. But three of the four general-purpose computer firms in Europe finally have gotten together. They are launching an ambitious joint rescue scheme this spring, confident they'll lure in the last holdout, Britain's International Computers Ltd., within the next couple of years. Not only that, but they foresee a group including major American IBM competitors within a decade.

Man and machine. Michel Barré, president of France's CII, says computer combine is "the beginning of something big." Below is one of CII's Iris machines, which would be marketed by joint worldwide operation under terms of the three-way computer accord.

West Germany's Siemens AG, France's Compagnie Internationale pour l'Informatique (CII), and Holland's N.V. Philip Gloeilampenfabrieken expect to sign an agreement before June that will bind them to the principle of collaboration. At the same time, or shortly after, they will announce the creation of a joint worldwide marketing subsidiary and a "plans and programs" committee to define and assign product responsibility for a new line of machines to be sold under a single trademark. The first of the machines will be announced in about 1975.

The accord will be unique in that it combines the three firms' activities without sacrificing their identity through a formal merger. Thus CII and Siemens will continue to produce process control and military computers separately, satisfying their governments' desire to maintain some independent national computer-making entity. "We are at the beginning of something big here," says CII president Michel Barré. "We are open to a fourth partner, or even a fifth."

The aim of the regrouping effort is to capture 15% to 20% of the European computer market by 1980, up from a current combined share of about 8%, excluding ICL. IBM currently holds just under 50%, according to Diebold-Europe's year-end estimates.

The rocky road. The road to cooperation has been rocky thus far, and the charter members of the new group have no illusions about the obstacles yet to be cleared. Indeed it has taken CII, Siemens, and Philips a full year of talking to get this far.

Although feelers for a European union have been extended by all the firms off and on for the past three years, it took RCA's withdrawal from the computer business to touch off the first serious negotiations. Siemens, which had been manufacturing RCA's Spectra series under license, was shaken by the sudden RCA decision, and quickly signaled CII to start serious talks.

Sticking to the Teutonic axiom that in good business partnerships

"1 + 1 must equal 2.2," the Germans made peace with the French and started planning ways to combine their product lines and market them as one. By the end of January 1972 they had an agreement in principle. But, on the eve of the signing, Philips computer officials told CII and Siemens to hold the door open, that the partnership could be three-way, encompassing Philip's successful office minicomputer line. "This complicated things enormously," says Barré. "Philips brings many assets into the accord, including bottom-of-the line hardware and a big international commercial network. But the company is so different. For one thing, it is not government-supported, as are CII and Siemens."

Add to this the fact that three-way partnerships are considerably more complex than two-way arrangements, and you have the past year of secret negotiations.

Deal a must. Now, with the signing just around the corner, officials of the Délégation à l'Informatique, the government agency that administers state aid to CII, are enjoying a sense of "very great satisfaction," says Pierre Audoin, the number two man in the delegation. "I don't think this kind of cooperation would work in any other industry," Audoin goes on. "But with IBM's peculiar domination, if we three cannot work together, we will disappear.

"Not a single computer company (except IBM) can continue very long without collaboration. The rules of competition are twisted in this business. Either you accept this compromise and you make a little money, or you drop out."

The French, who have always been the most enthusiastic backers of the linkup philosophy, believe ICL will have no choice but to join by 1975 or 1976. And, if their prediction that the group will include U.S. firms within 10 years comes true, they see themselves "forming a real counterforce to IBM," says Audoin. "The industry needs this massive convergence because the threshold of self-sufficiency is not 15% to 20% of the market when the scene is dominated by another who has 60%. The threshold we are searching for is around 40%."

The group is starting from a modest position. Siemens is the strongest, with fiscal 1971–72 data processing sales of $310 million, and about 16% of its domestic market against IBM's 53%. In France, CII hit sales of $165 million in 1972, but could claim only 8% of the French market against IBM's 51%. And in Holland, Philip's computer activities totaled about $160 million last year, accounting for 12% of its home market versus IBM's healthy 50%.

Assembly. CII worker will soon be laboring for a French-Dutch-German operation.

The strength of the union comes not so much from its combined assets as from new potential the broadened line of machines will give it. Although no new trademark has been chosen yet, the three partners are already jostling for responsibility over specific size machines known inside the talks as the "X-1", the "X-2", the "X-3", and up the line through the biggest machine. Barré says there will be about 10 machines in the line, with Philips limited mostly to minis, while CII and Siemens build alternate mediums and large models. "We had to make sure that each partner had some high-production machines," says Barré, so it was impossible to stick one company with the large and another with the mediums."

Philips chips in. Philips is making perhaps the biggest contribution to the troika in potential customers. With 15,000 mini office systems already installed, normal customer loyalty will keep users in the family as their data processing needs grow.

Philips negotiators did not give away their assets for nothing in the partnership. The new marketing subsidiary will be sliced in two parts, possibly even to the point of creating two separate marketing companies—one for the Philips minis, the other for the mediums and large models. □

Automotive electronics

Seat-belt interlock deadline nears

Semiconductor makers gear up to supply parts to Detroit for safety system; but car makers, who would like more time, worry about reliability, delivery

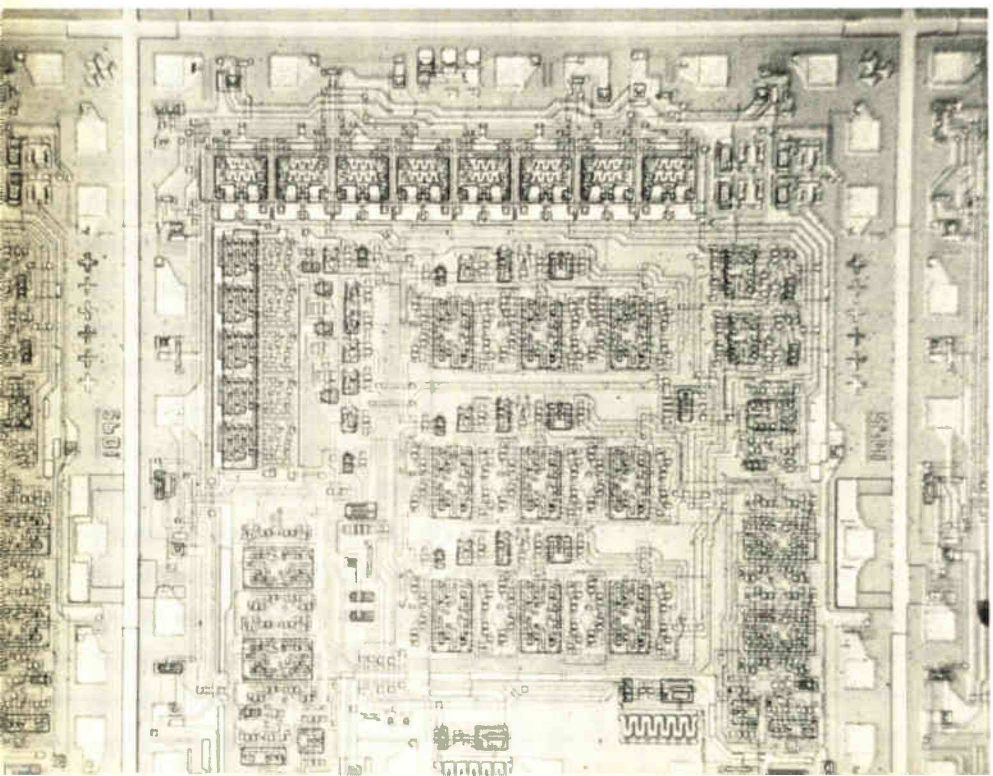
by Lawrence Curran, Managing Editor, News

The long courtship of automobile manufacturers by semiconductor makers is turning into a shotgun wedding. Federal legislation requires seat-belt interlocks in all 1974 American-made cars. Despite pressure that they deliver reliable parts on time, semiconductor makers are eager to supply devices, but the auto makers would rather not move that fast.

The interlock systems, using mostly discrete devices, are designed to prevent the driver from starting his engine unless he and anyone in the front seat weighing more than 47 pounds have fastened their lap and shoulder belts. Linked to sensors, integrated circuits at the heart of the interlock units handle the complex sequential logic that monitors the opening of the front door, occupancy of the three front seat positions, and locking of belts in each occupied seat, and only then can the starter solenoid work.

The circuits must work under demanding conditions—a noisy environment and temperature extremes. For example, the motorist who returns to his car after it's been parked at an airport for days in subzero temperatures wants to drive away immediately. That means the interlock units must operate on low standby power—typically 5 milliamperes of current drain—and function when the car's battery drops to 5 volts or so during such a cold start.

Complementary MOS circuits are being backed by some IC suppliers because of their low power consumption and relative noise immunity. Bipolar approaches have been adopted by others, and at least one auto maker—General Motors—is going with an electromechanical backup in case there are delivery or reliability problems with the solid state units.



The systems have to be reliable, or unhappy motorists who can't start their cars will be screaming at the auto makers. Perhaps H. Blair Tyson, director of electronic control systems at the General Motors Technical Center, Warren, Mich., best summarizes the auto industry's view of the legislated systems. He says he's not sure the pace at which the industry has to move is in everybody's interest.

"We wouldn't have made this decision at this speed in an open market," he says. "We never before broke in a system like this across the board. We're scared about fast changes." Tyson adds that GM traditionally tries out new systems on limited-production cars, such as the Oldsmobile Toronado, to get experience with them in 30,000 to 50,000 cars a year.

Jumping in. Nevertheless, semiconductor makers are lining up to make the ICs that go into interlock systems. Signetics Corp. is already delivering a bipolar IC to an automotive customer as one of three suppliers; each has a third of the customer's business. Louis Johnson, Signetics automotive marketing manager, says his firm will build up to its peak rate by about mid-April, and estimates that the three vendors will ship between 2.5 million and 3 million bipolar ICs for the 1974 model year. The customer is believed to be General Motors, although Johnson wouldn't confirm it. Solid State Scientific Inc., Montgomeryville, Pa., will begin shipping C-MOS devices to Chrysler in April

Belt chip. This circuit from Solid State Scientific is destined for seat-belt interlock system due in cars for 1974 model year.

after receiving a $1 million order. This came on the heels of another $1 million contract from Philco-Ford, acting for the Ford Motor Co. Philco-Ford's units will start coming in from Solid State Scientific around May 1. Walter F. Kalin, the company's sales applications manager, says the firm will ship "big quantities" of seat-belt chips in April and May, but won't say how many units are in each order.

RCA's Solid State division, Somerville, N.J., is also in on the seat-belt interlock action with a C-MOS circuit. C-MOS product manager Harry Weisberg says that the division is working with the big three domestic auto makers, and will ship as many as 3 million circuits for 1974 models. As with most other designs, the RCA chip goes into a module that's mainly discrete. RCA, however, is also providing assembled modules including both the C-MOS chips and outboard discretes, and is supplying bipolar ICs to perform the logic for one auto maker's interlock system.

Nor are the big three in semiconductor sales—Texas Instruments, Motorola Semiconductor, and Fairchild Semiconductor—passing up a chance to work with Detroit's big three. Fairchild has to ship its bipolar ICs to General Motors and Ford in April and May. The Fairchild effort at Philco-Ford is termed developmental by Will Steffe, manager of design and development for analog products in Mountain View, Calif. However, Steffe describes it as "equal to that of Solid State Scientific—we're one of a number of suppliers." The Fairchild circuits, he says, use linear bipolar processing "optimized for low current drain, high noise immunity, and high voltage excursions."

Motorola is supplying both a logic IC and discrete components to module makers, although Motorola sources don't specify which auto makers get the modules. TI is believed to be supplying bipolar ICs to GM's Fisher Body division, which is GM's focal point for the seat-belt units.

The seat-belt pie splits roughly this way: GM makes 4.5-5 million autos a year, Ford builds 3 million, and Chrysler accounts for roughly 1.8 million, says Solid State Scientific's Kalin. It's a lucrative business for semiconductor manufacturers, but the pressure is on them to deliver reliable devices and meet delivery dates (see "Semiconductor houses on the spot").

The auto makers don't regard seat-belt systems as necessarily lucrative for them, however. Peter Ansbro, automotive electronics engineering representative in Philco-Ford's Dearborn engineering office, calls them "far from economical, and their costs will be recovered to a lesser degree than for radios, for example." His rough estimate is that the interlock units will add $35 to $50 to the price of a car. □

Semiconductor houses on the spot

One of the chief concerns about seat-belt interlock systems among auto makers is the semiconductor industry's ability to deliver. Auto makers are not confident that semiconductor manufacturers can meet their tight delivery schedules. GM's H. Blair Tyson, for one, questions the credibility of traditionally optimistic semiconductor delivery claims. GM is also developing an electromechanical seat-belt interlock system using relays as a backup for the solid state units. Says Tyson: "When they back up an electronic seat-belt interlock with a relay system, you know how they feel about the electronics industry's credibility."

Beyond that, it is not clear what will happen if slippages occur in installation of the units in 1974 models. Walter F. Kalin, sales applications manager at Solid State Scientific Corp., says Federal legislation requiring the systems in next year's models "has forced the auto makers to deal with electronics manufacturers. The only recourse if semiconductor manufacturers fail to meet 1974 model year requirements is for the auto makers to ask the Government to postpone the requirement until the 1975 model year."

Will Steffe, Fairchild Semiconductor's manager of design and development for analog products, wants both Philco-Ford and GM to stabilize their interlock system designs now "or they'll have to do running changes" as the model year progresses.

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by Dale O. Ballinger, *Honeywell Test Instruments Division, Denver*

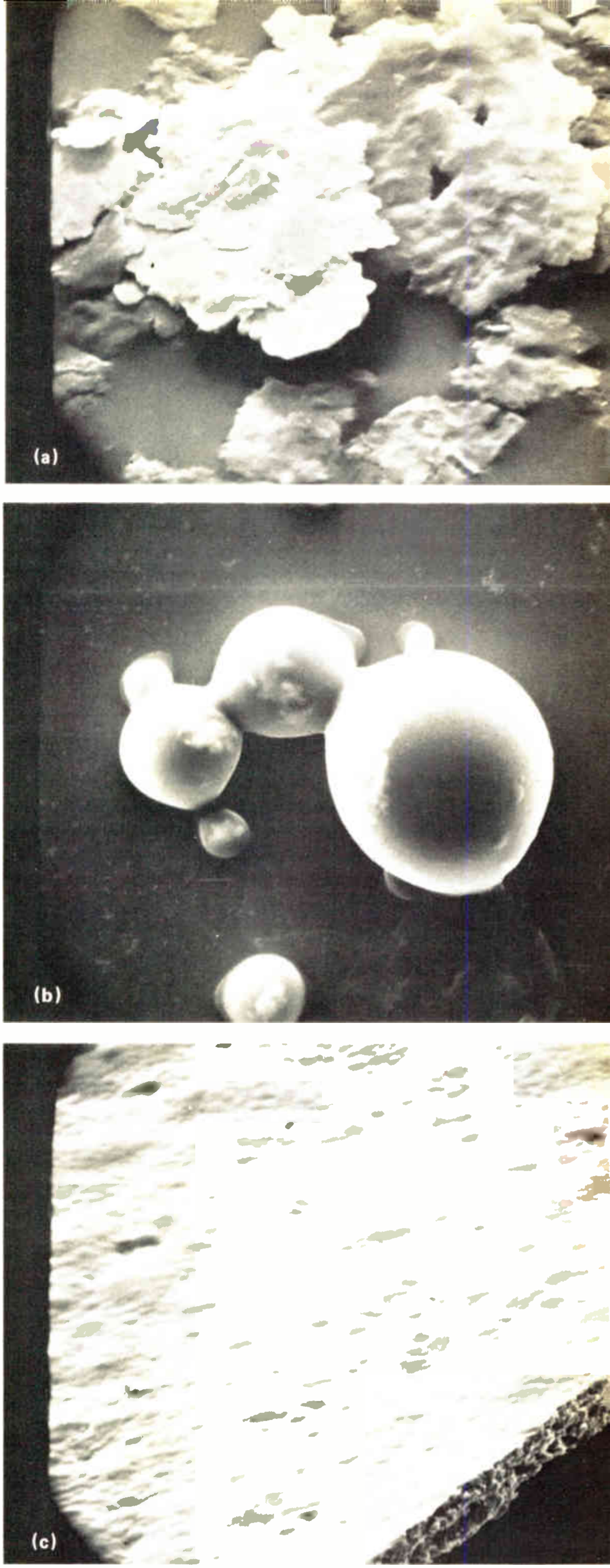
☐ Recording by tilting millions of tiny magnetic flakes embedded in a stock no thicker than ordinary bond paper promises significant reductions in costs and labor of instrumentation because the paper is instantly erasable and reusable. By comparison, a sheet of conventional chart paper, whether marked by ink, heat, electricity, or light beam, has a built-in restriction—it can be used only once. And this one-time usability costs industry millions of dollars each year.

Although the cost of common chart paper that records such measurements as temperature and pressure for extended periods is only a few cents a sheet, total costs mount rapidly, large amounts of paper must be either stored or discarded, and there is the periodic task of replacing paper in the recorder.

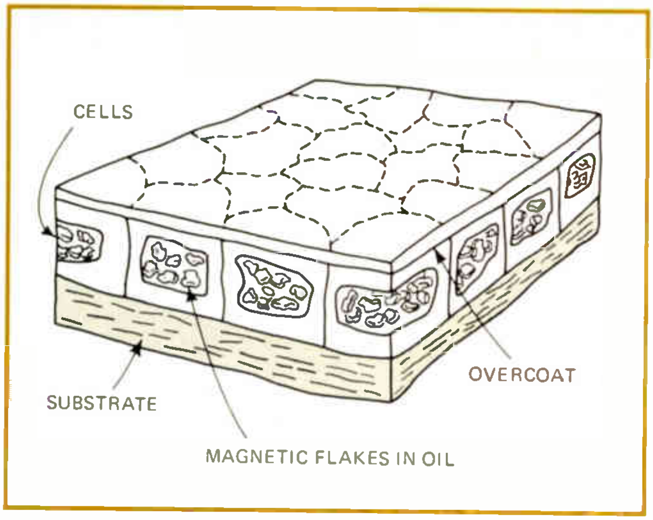
For example, a 12-hour circular-chart recorder that typically records a continuous trace of temperature or pressure consumes more than 700 sheets a year. It is necessary for many processing and manufacturing companies to have hundreds—even thousands—of such recorders in round-the-clock operation.

The new magnetic recording method permits writing and erasing fields to be built into the recorders. But the recording medium is by no means limited to displaying continuous traces. From a multistylus writing head, the paper will print alphanumerics and other symbols. And because the continuous traces and symbols have remanent magnetism they can be made machine-readable. Further, the paper can be backlighted to suit specific ambient light conditions. Thus, the paper will prove useful in such applications as computer readouts, hard-copy printing in conjunction with CRT displays, facsimile printing, sonar and radar, and even toys.

Developed and patented by Honeywell Inc., and now in limited production by the National Cash Register Co., the new recording medium, called POP for particle-oriented paper, is being extensively field-tested. The magnetic chart paper, which can be made in circular and rectangular sheets, rolls, and even endless loops, is



1. Microscopic. In particle-oriented paper, magnetic flakes (a, enlarged 2,000×) are coated with oil, forming droplets (b, 1,200×), which are then rendered into an emulsion that is coated onto a paper or clear plastic substrate (c, 75×).



2. Cross-section. Completed stock, containing substrate, tiny flakes in oil cells, and overcoat, is about as thick as bond paper.

slated to be available in commercial quantities by year-end at a cost of about 10 cents a square foot. Furthermore, the use of POP charts does not require buying new or special recorders. Conversion kits can be made to retrofit present ink-type recorders with magnetic writing styli and erasing fields.

Magnified magnetics

Three photomicrographs show the essential steps in manufacturing particle-oriented paper (Fig. 1). Magnetic flakes of varying sizes, some as small as three micrometers, but averaging 15 μm across, are suspended in droplets of clear oil. Flakes consist of such materials as pure iron, nickel, and stainless steel. Figure 1a shows flakes enlarged 2,000 times. Droplets are then encapsulated in cells ranging from 5 μm to 50 μm in diameter, with smaller flakes tending to group into the smaller cells and larger flakes into the larger cells. The middle photograph shows several encapsulating cells enlarged 1,200 times. Next, an emulsion of cells is coated on a paper or a clear plastic substrate.

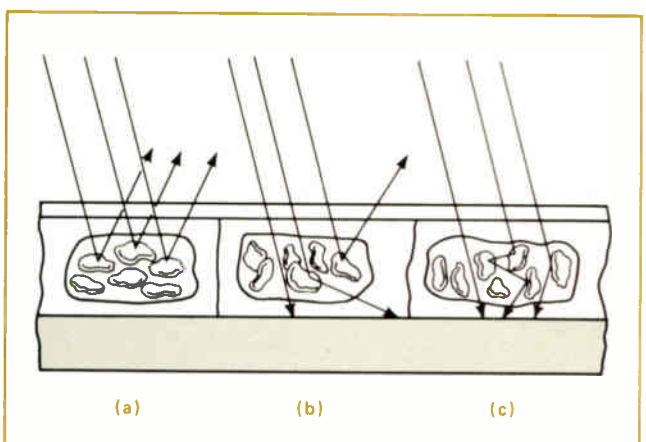
As the emulsion dries on the substrate, the cells tend to conform to the substrate surface and to their neighbors, resulting in an irregular cell-wall structure. This irregularity is an important aspect of the mechanism by which the flakes can be made to produce permanent traces. Figure 1c shows the emulsion-coated paper, magnified 75 times. A protective overcoat completes the fabrication of the recording material (Fig. 2). Depending on application requirements, coordinate grids can be printed on either side of the chart. Furthermore, the magnetic writing stylus can be placed on either side of the chart paper.

The sheet still requires magnetic prealignment, as explained later. Once prealigned, though, the magnetic flakes are parallel to the paper's plane (Fig. 3a), and they thoroughly reflect incident light. The sheet appears light, and it has an optical reflection density of about 0.5. However, a small-diameter stylus produces a magnetic field that is perpendicular to the paper's surface. This field rotates affected flakes away from the flat plane. These rotated flakes then scatter, or absorb, the incident light (Fig. 3b). The trace's optical reflection density increases to about 1.0 (dark gray) compared with a background of 0.5 (light). As the writing magnetic field is increased even more, flake rotation is greater (Fig. 3c), and the trace is even blacker.

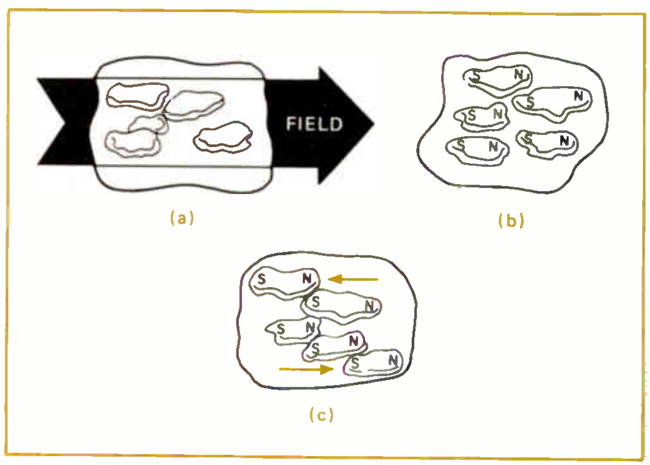
Chaining the flakes

What happens after the writing field is removed is shown in Fig. 4. As mentioned, a prealignment field forces all the flakes to be parallel to the paper's surface (Fig. 4a). The writing stylus tilts the flakes in its magnetic field, thus scattering incident light. When the writing field is removed, the flakes have sufficient residual magnetism to produce local fields (Fig. 4b). Here, each flake behaves as an individual permanent magnet, complete with a north and south pole. As the like poles repel each other, and the unlike poles attract, the residual forces thus cause the flakes to move relative to each other in search of the smallest possible energy state.

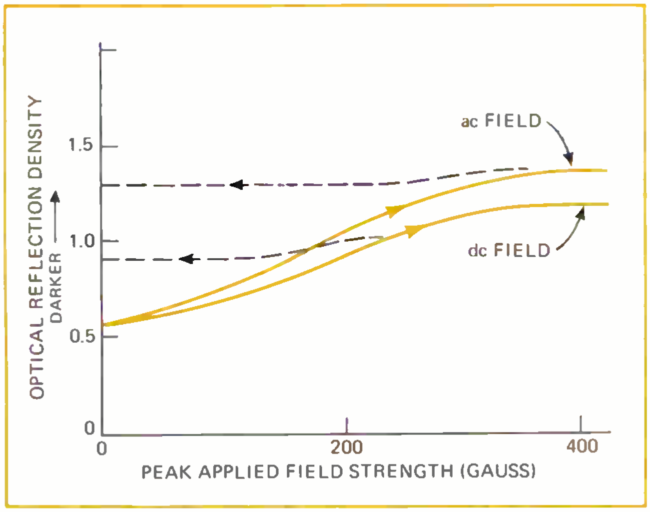
In achieving a low-energy state, the flakes are "chained" and held in place by force against the cell's irregular surface. Cell-surface irregularity is essential for the flakes to remain locked in their light-absorbing state. The relaxation time required for the flakes to align to their permanent, or memory, state is about 0.5 millisecond after the writing field has been removed.



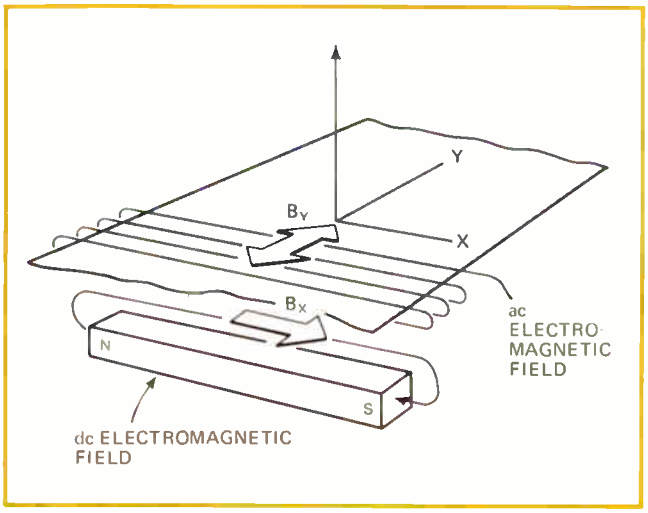
3. Light trap. Parallel flakes (a) reflect incident light, but magnetically rotated flakes (b) scatter light to mark a trace, while additional tilting (c) increases magnetic-trace darkness.



4. Chaining. Starting with flakes parallel to surface (a), magnetic stylus tilts and polarizes flakes, then removal of field allows residual magnetic forces to move and lock the flakes.



5. Shades of gray. Peak applied field strength determines trace blackness, but ac fields write darker than dc fields.



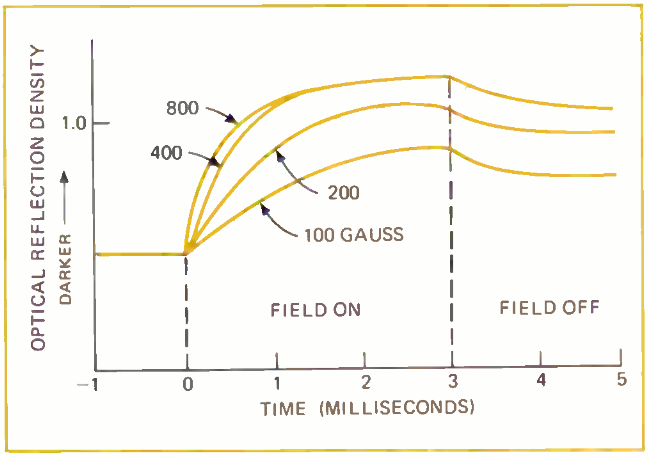
7. Wipe out. Rotating magnetic vector in plane of paper created by a combination of an ac and a dc field prealigns the flakes.

The trace is permanent—until deliberately erased. The exact realignment time depends on the oil's viscosity. Therefore, the time required for the trace to stabilize will increase as ambient temperature is lowered.

Optical reflection density, and hence the degree of trace blackness, depends both on the field's strength (Fig. 5) and exposure time (Fig. 6). Therefore, both these factors determine the maximum relative speed between paper and stylus for a given trace quality. As Fig. 5 shows, an ac writing field produces blacker traces than do dc fields of the same peak strength because alternating fields give the flakes more than one opportunity to rotate out of the plane before chaining into permanent light-absorbing positions. The minimum frequency of an alternating writing field depends on stylus diameter and paper speed. A 40-kilohertz field is adequate for a 0.01-inch diameter stylus and a paper speed of 40 inches per second.

Shades of gray

The dashed lines in Fig. 5 indicate the loss of energy during chaining and the slight reduction in blackness after the writing field has been removed. These curves also show that varying the peak intensity produces traces ranging from light gray to heavy black, a characteristic that may suit this new writing technique to such special applications as facsimile recording.



6. Writing time. Because of the damping factor related to oil's viscosity, optical reflection density, a measure of blackness, depends on how long paper is exposed to field.

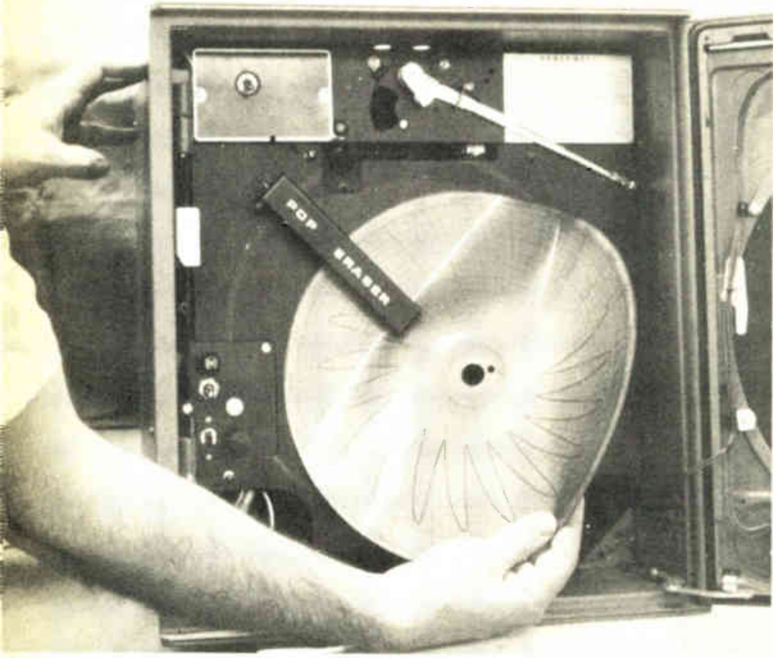
As previously mentioned, trace darkness also depends on how long a given peak field strength is applied to a given area. Test results show that a field strength of 400 gauss exposed to the paper for a few milliseconds appears to be the optimum value for maximum light absorption (Fig. 6). Doubling the field to 800 gauss reduces exposure time, but it does not increase blackness; reducing the field to 100 or 200 gauss not only reduces trace visibility, but it increases required writing time and thus slows down the recorder's response time.

Magnetic markers

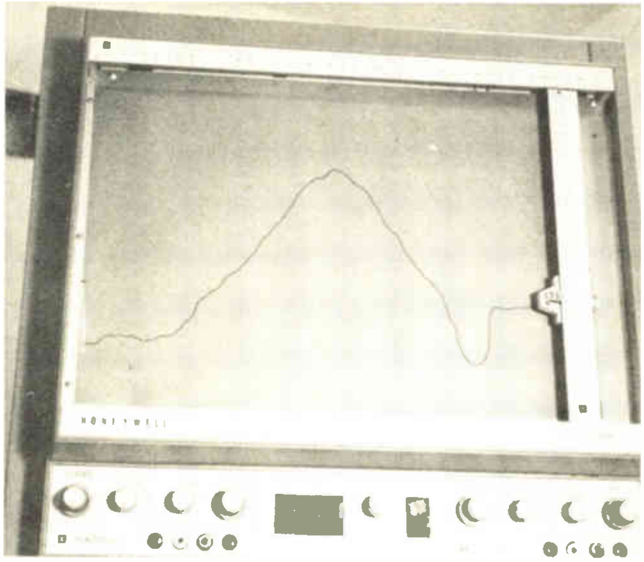
The magnetic chart paper can be marked in several ways. An adequate writing stylus for a conventional recorder can be a simple 0.01-inch-diameter pin of magnetized carbon steel, with its writing arm driven by a relatively slow servomotor. As the paper moves at a fixed speed, the pin on the writing arm traces the amplitude of the recorded variable. Because of the limited random wear contact between pin and paper, the paper should last almost indefinitely.

Another type of writing mechanism is an electromagnetic stylus, mounted singly or in an array. Electromagnetic styli have been built in linear arrays, with each stylus 0.01 inches in diameter. Mounted on 0.01-inch centers, there are 100 styli along each inch. In operation, the array is permanently fixed on the recorder perpendicular to the direction of paper movement. The amplitude of the recorded variable is then digitized through an analog-to-digital converter, whose output addresses a corresponding stylus. The selected stylus is then pulsed to produce a very black dot. If the pulse rate is fast enough, successive dots overlap, creating a continuous trace. With paper moving at 10 inches a second, such a writing stylus can faithfully reproduce a sine wave of 10 kHz with adequate resolution.

By appropriate programing, addressing, and pulsing of the styli in the linear array, the writing head could then produce alphanumeric and other symbols, as well as draw single or multiple continuous or analog records



8. Continuous chart. Erasing fields built into circular chart recorder wipe out magnetic trace written several hours earlier.



9. Stand-alone. Particle-oriented paper, such as used in laboratory X-Y recorder, would be erased in a separate device.

as the paper or writing head moves at a constant rate.

Before the POP medium can be used, all the embedded flakes must be oriented so that their surfaces are parallel to the paper's surface. Two dc magnetic fields, both in the plane of the paper, can produce the magnetic torques required in the two mutually perpendicular axes to align the flakes parallel with the paper's flat surface.

A more efficient method of prealignment uses one ac field and one dc field (Fig. 7). The paper moves in the Y-direction. By using ac and dc fields, instead of two dc fields, prealignment can be achieved by only one pass over the paper, and the alternating field provides more chances for flakes to be reoriented during the prealignment sweep. The ac and dc fields combine to produce a vector field of about 400 gauss that continuously rotates in the plane of the paper, thus creating aligning torque over a flake's total periphery rather than only at two mutually perpendicular points.

Prealignment, or erasing, fields can be built right into the recorder as suggested in Fig. 8. Here, the writing pin traces the recorded variable, which is immediately viewable. Eventually, the record passes under the eraser to wipe out the trace. Thus, if the recorder motor rotates the chart once every 24 hours, the eraser could wipe out traces more than, say, 18 hours old. Hence, the chart always shows 18 hours of history. And the same chart is used again and again. Of course, should the record indicate some kind of failure or alarm condition in the recorded variable, the chart can be removed for later analysis, and it could be readily duplicated on a copying machine.

When an installation has many similar recorders or when the size of the chart paper makes it impractical to have a built-in magnetic eraser, stand-alone prealignment machines may prove more practical and economical. For example, erasing the chart paper in an X-Y recorder would probably be done in a stand-alone prealignment machine (Fig. 9).

Practical prospects for POP

Although the obvious application for particle-oriented paper is in charts for industrial and laboratory recorders, the material may well fill other practical needs. For example, the chart paper can be made machine-readable because the trace itself is magnetic, and its field of about 20 gauss can be readily detected by a chip-sized Hall transducer. In one application, trace amplitude could be sensed magnetically and converted to digits for computer analysis. Or the trace could be used as a function generator to, say, serve as the input to a piece of test apparatus.

Because particle-oriented paper is light-absorbing, it is suited for displays that must operate in high ambient light. This property makes POP an excellent prospect for large radar and sonar displays, which would not need the refresh storage required in present types of displays.

Just as a circular chart can be allowed to run continuously because the paper is erasable and reusable, the same technique can be applied to quick-look and trend recorders that use endless loops of paper to record information for fixed time intervals.

When properly backlighted, special compositions permit the paper to transmit light through magnetized areas and traces. Thus, the paper can be used in displays requiring light emission, rather than absorption.

Although particle-oriented paper is just now entering a commercial phase, other characteristics may bear fruit later. The main prospect is for electrostatic particle-oriented paper that will make possible faster writing speeds, which will then permit the recording of higher-frequency, faster phenomena. Electrostatic forces can rotate the magnetic flakes in much the same way the magnetic field does. And the electrostatic traces can also be erased. However, material characteristics must be different for electrostatic operation, and various materials are under laboratory investigation to determine optimum relationships. □

Enhancing an LSI computer to handle decimal data

A medium-scale processor has been squeezed onto an 8- by 11-inch pc board by adding to an existing successful system two newly designed large-scale IC chips that have decimal and byte-string capability

by Joseph P. Murphy, Wallace Chan, and Robert Greiner, *Four-Phase Systems Inc., Cupertino, Calif.*

☐ Imaginative design that exploits the advantages of large-scale integration of MOS circuits has packed a medium-scale computer with roughly the power of an IBM 360/30 onto a single 8-by-11-inch printed-circuit board. Furthermore, this new machine adds decimal-arithmetic capability and byte orientation to the binary-processing capability of the earlier Four-Phase Systems model IV/70, introduced two years ago, which processes only full 24-bit words. Although numerous microprocessors built around LSI chips have been introduced recently, all are only small-scale machines.

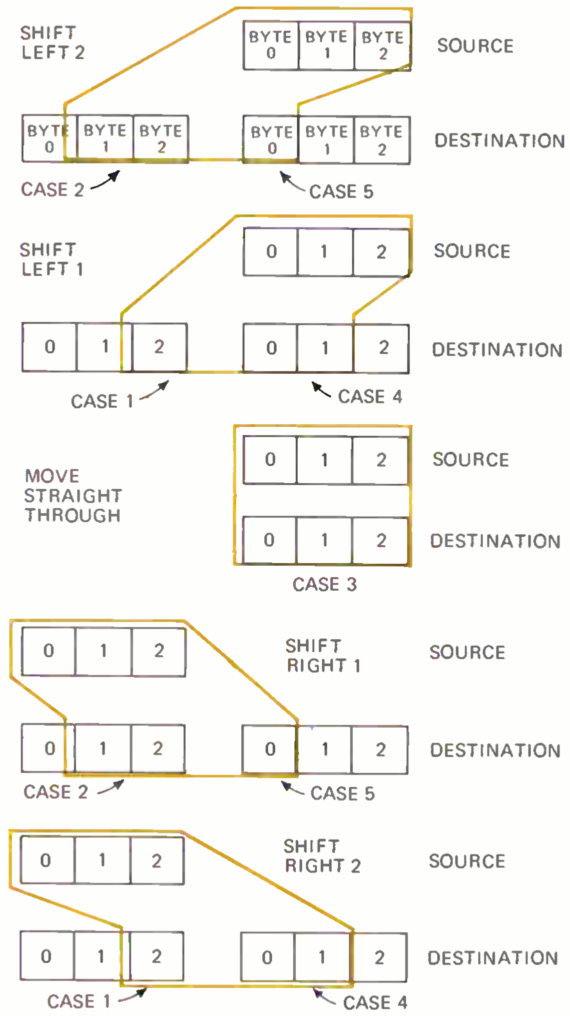
The computer is based on three MOS chips—the basic chip in the original System IV/70, the AL1, plus two new ones. The decimal-arithmetic capability has been integrated on a huge chip, the AL3, and a slightly smaller device, the AL2, takes care of byte alignment. The larger of the two new ICs, the arithmetic and logic unit (ALU), is more than a quarter of an inch across—one of the largest chips in production—and it had to be divided into four parts so that it could be processed by conventional photolithographic equipment.

To make room for these chips and to incorporate the necessary microinstructions to execute the decimal-arithmetic macroinstructions, the enhanced System IV/70 contains a new 18,432-bit read-only memory, enlarged from the previous 8,192 bits. On a separate pc board, the main memory is expanded through use of a new 2,048-bit read-write memory, replacing the older 1,024-bit unit [*Electronics*, Feb. 16, 1970, p. 109].

Design objectives

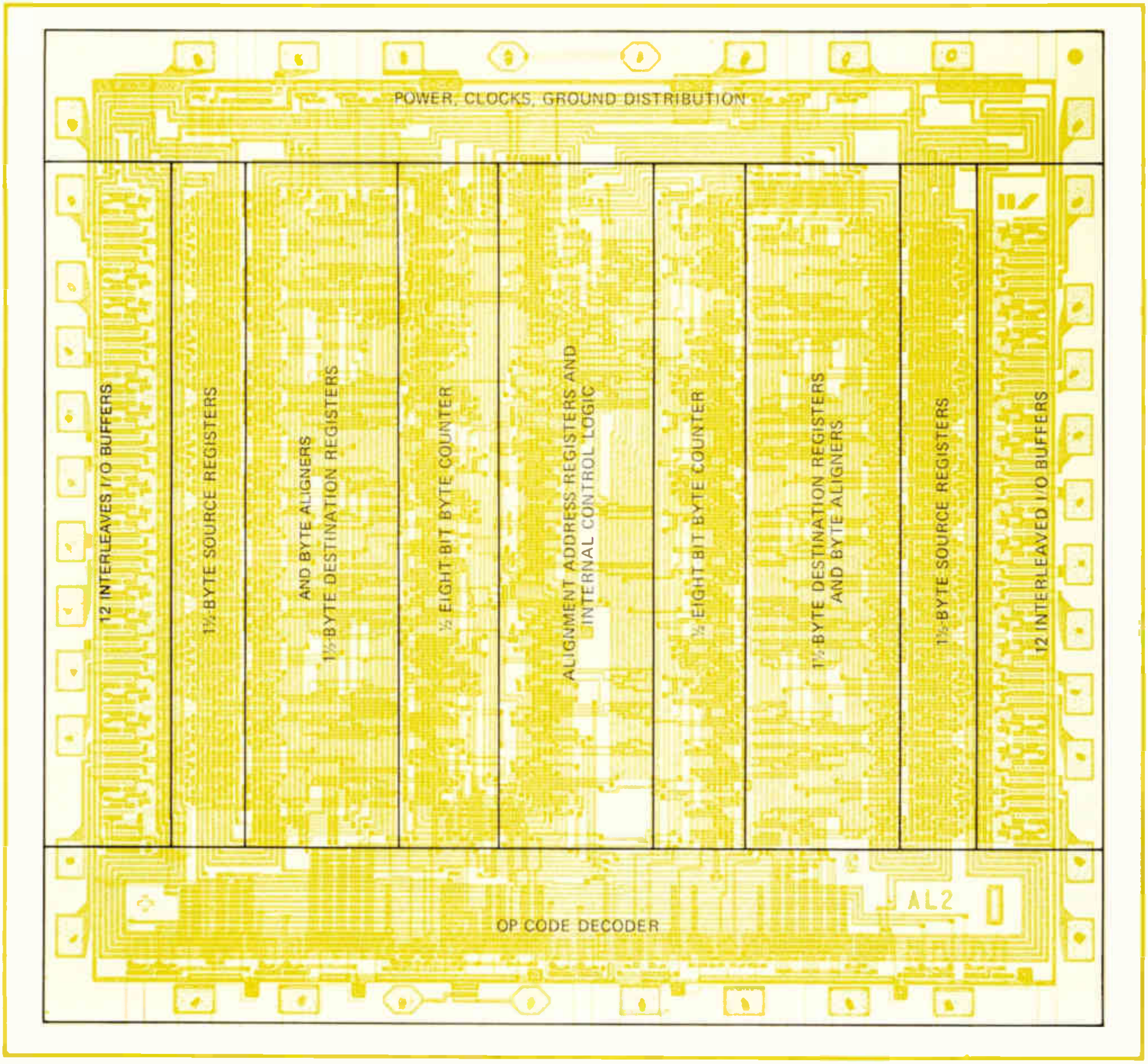
The new capabilities took the shape of four new kinds of operations:

- The ability to move a string of up to 256 bytes, starting from either end of the string, regardless of where the starting point lies relative to word boundaries, either before or after the move.
- The ability to compare logically two strings of up to 256 bytes each, bit for bit, without changing any byte in either string, and producing an output of "A less than



BEFORE	MOVE	A B C
CASE	1	A B C
CASE	2	A B C
CASE	3	A B C
CASE	4	A B C
CASE	5	A B C
CASE	6	A B C

1. End conditions. Byte-handling capability produces five different byte-alignment possibilities, as shown in color in the diagram, and six different end conditions, as shown in the table, where color represents a new byte moved into the word. Case 6 of the table, not shown in the diagram, occurs when a "string" of one byte moves into the middle byte position of a destination word.



2. Alignment chip. This integrated circuit realigns data being moved from one area in the memory to another, if the byte boundaries relative to the word boundaries differ in the two areas. It is just under 200 mils square and contains about 1,000 gates.

B," "A equal to B," or "A greater than B."

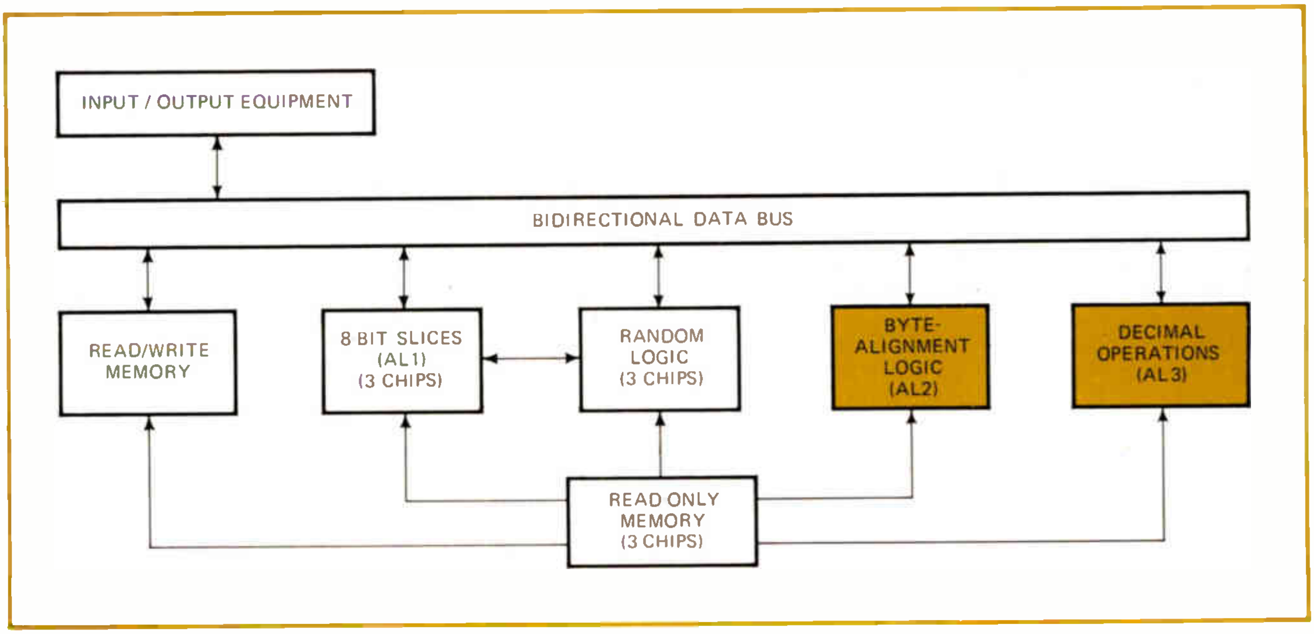
■ The ability to subtract or add a string of up to 64 signed decimal digits to a second string of as many as 95 digits. Each digit is a byte in either the American Standard Code for Information Interchange (ASCII) or IBM's Extended Binary-Coded Decimal Interchange Code (EBCDIC), and the signs are carried in the upper "zone bits" of the least-significant byte of each string.

■ The ability to compare a string of up to 64 digits numerically with a second string of up to 95 digits, producing the same outputs as the logical comparison mentioned previously. This numerical comparison is made on only the four lower bits of each byte and the four upper bits of the least-significant byte in either ASCII or EBCDIC, ignoring the remaining bits, which is a common process in Cobol programs.

In the most general terms, these new capabilities involve two types of operations: moving data, byte by byte; and manipulating the bytes arithmetically.

Implementing these instructions would be relatively straightforward if they did not require extracting multiple bytes from memory. However, adding the capability to a computer with a data path that is three bytes wide presents two additional problems: First, the ALU must be very complex to operate on three bytes in parallel, both decimally and logically, while assigning any byte position within the ALU as the most- or least-significant byte of the string. Second, five alignment shifts are possible, as well as six end conditions at the destination (Fig. 1), making a total of 30 possible boundary conditions. The five alignment possibilities take into account the possible overlapping of source and destination areas. If overlapping could not occur, a shift-left 1 and a shift-right 2, for example, would be essentially identical.

The six end conditions are treatments of the three bytes already stored in the destination address when new data is moved in from a source. Case 3 is the sim-



3. Eleven chips. The entire processing unit of the System IV/70, with decimal capability, is in 11 ICs on one board. The read-write memory, which comes in modules of 6,144 bytes, is on separate boards. Bidirectional bus and ALU slice are characteristic concepts of the system.

plest, when three bytes of new data replace three bytes of old data. In other cases, some old data is retained, and some is replaced. Moving a string of more than three bytes simply replicates one of the alignments and one or two of the six end conditions. A string of two bytes can move in any of the five ways but a Case 2 or Case 4 end condition always results. Moving a "string" of one byte can result in the unique Case 6, when only the middle byte of a destination word is replaced and the first and third bytes are retained.

One simple, one complex

To provide System IV/70 with its new capabilities, a two-chip subsystem was adopted—for three reasons: the ease of functional division between the two kinds of operations, the resolution of the problems of moving data and manipulating bytes, and practical restrictions on the size of the chips. The resulting subsystem includes AL2, the byte-alignment chip, and AL3, the arithmetic and logic chip.

The byte-alignment chip function is relatively simple; its functional layout is shown in Fig. 2, and its logical position in the computer in Fig. 3. In conjunction with general-purpose registers in a chip called AL1, carried over from the former unenhanced System IV/70, the byte-alignment chip realigns the data brought from the source area in the main memory to fit the destination area, whose word boundaries may be different, relative to the byte boundaries.

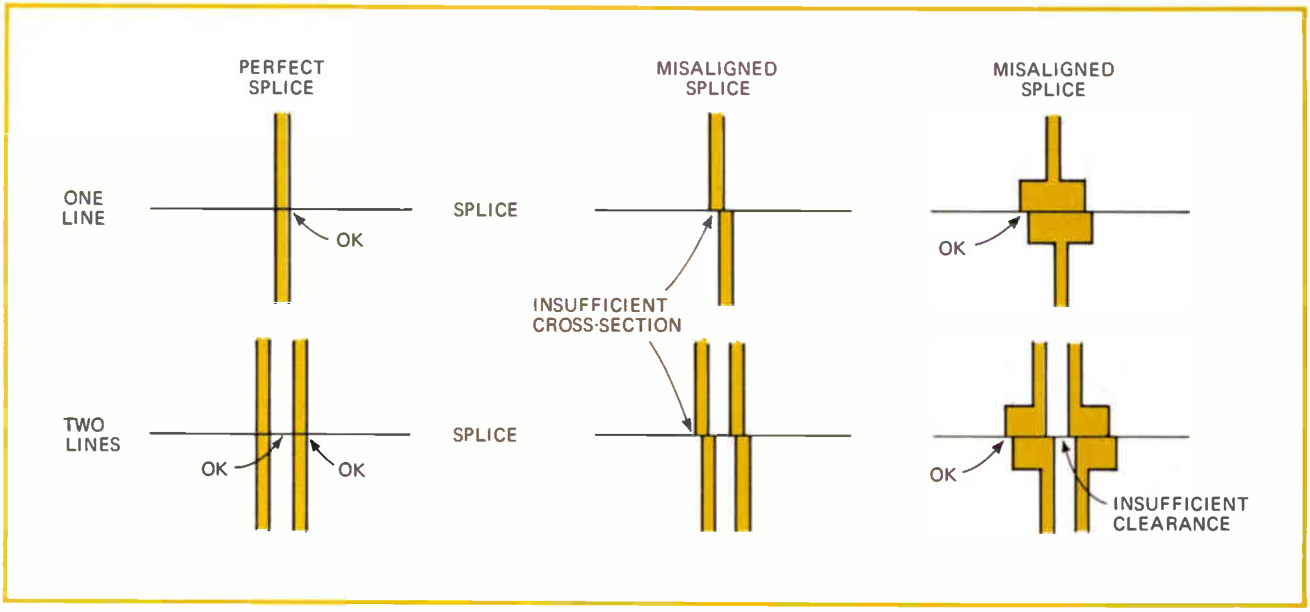
The arithmetic and logic chip, AL3, can be more easily understood in the context of the architecture of the System IV/70, the first MOS LSI computer. This architecture includes the advanced concepts of the single bidirectional bus structure and the ALU slice—in which a single integrated circuit can do all the processing of one or more bits, and any number of identical ICs can process in parallel a multiple of the number of bits each IC can handle. In the original System IV/70, one IC (the AL1) processes one byte (eight bits); three of these handle the computer's 24-bit-wide data path.

The architecture also includes microprogramed control logic in a 1,024-word-by-54-bit read-only memory for all of the 117 macroinstructions. The ROM is packaged in three chips of about 18,000 bits each. The read-only memory recirculates in the sense that the address for each microstep is generated during the preceding step, rather than by an external counter; the recirculating logic includes the instruction-fetch processing and decision logic used when the next microstep depends on the result of a current step or on the details of a particular macroinstruction. Working in conjunction with the read-only memory circuits are three identical one-byte arithmetic/logical/shifter chips (AL1) and three random-control-logic chips.

Without the functional division of the decimal and byte-oriented logic into two chips, an integrated circuit about 350 mils square would have been necessary. This exceeds the practical capabilities of the equipment that would be needed to produce such a device. Thus the decision to design two chips was made. Of the two, the

System IV/70 basics

The System IV/70, a business-oriented machine, is used with a keyboard and cathode-ray-tube display as an operator's console, plus whatever additional standard peripheral equipment is needed. Although it is a full-fledged general-purpose computer, it is most economical when used in clusters that replace groups of remote terminals connected to a larger computer. In its business applications, it is frequently called upon to process decimal and alphabetic data occurring in long strings of characters, as opposed to binary data represented by individual words or small groups of words. With the computer's new capability, it can process these strings four to five times as fast as it could previously.



4. Splicing tricks. To assure sufficient width of conductors at the points where the AL3 mask splices were made, the lines were widened more or less as shown here—provided that by so doing, the misalignment did not cause insufficient clearance between two parallel lines.

AL2 chip was almost routine. It presented no particular problems during development, and it was transferred easily into production, even though it measures almost 200 mils square and contains about 1,000 logic gates.

Four sections

The AL3 is quite another matter. Even after the functions of AL2 were separated to another chip, AL3 required an exceptionally large chip, too big to handle with conventional production techniques. To understand how these problems were overcome requires an understanding of the conventional techniques.

When a random-logic LSI chip is produced at Four-Phase Systems, the circuit design is translated into artwork at a scale 400 to 500 times the finished size of the chip. This artwork is reduced twice: first to 10 times the size of the finished dimensions, and then, while making the photographic working plate, it is reduced again to the actual size of the chip. The process is repeated for each of several masks.

For conventional LSI circuits, a step-and-repeat process exposes the photographic working plate many times during the second reduction to reproduce the mask design repeatedly. Through this working plate, a large wafer of semiconductor material is then exposed to the repeated design in one "snapshot." After the wafer has been exposed to all the masks, with appropriate intermediate processing between exposures, it is cut into individual chips at the design boundaries.

When the designers realized that the AL3 chip would be more than 200 mils square—the limit of the company's photographic equipment—they decided to split the circuit into four approximately equal pieces and to assemble the component parts during the second reduction, while making the working plate. Thus for AL3, the entire step-and-repeat process goes through four complete cycles, once for each part of the circuit. Each cycle leaves unexposed areas of the plate between the parts, and after the four repetitions, all the intervening spaces have been filled.

The design of the AL3 had to take this four-part layout into account. The four segments were not required to be divided along straight lines, although excessively convoluted boundaries would have made fitting difficult. Also, since the MOS process has four critical layers—p^+ material, oxide, contact holes, and metalization—the partitioning had to account for the requirements of all four layers. A fifth layer, passivation, is continuous across the wafer, except for bonding holes; its registration is not critical.

The designers were lucky; they had to split components on only two of the five layers, the metal layer and the p^+ layer. At first, they feared that during the photographic phase, device geometries would not align properly along the boundary, so that the permissible tolerance might be exceeded. In some cases, optical and photographic aberrations might permit perfect alignment at one point on the boundary and troublesome misalignment at another. To assure that alignment is always proper, a few tricks were required—for example, where a cut through a p^+ line was necessary, the line could be widened at the splice, if at the point of widening, two parallel lines requiring a minimum clearance were not present (Fig. 4). Numerous test splices using tricks like these were made, and the photocomposition technique was tried out while the chip design was progressing. These tests showed that the total misalignment could be kept within design specifications.

One-quarter inch square

The chip layout finally produced a circuit measuring 235 by 289 mils, with about 6,000 active elements in random logic—one of the largest integrated circuits in commercial production. It is mounted in a standard 64-pin ceramic package.

While wafer yields have remained below 15%, low-volume requirements—one circuit per system—enable AL3 to be a viable production device. The photograph of a complete CPU card (Fig. 5) demonstrates again—as did the circuits of the original binary System IV/70—

that LSI and the computer are closely related.

In the upgraded machine, strings of up to 256 digits, each represented by an 8-bit byte, may be moved from one location in memory to another without regard to word boundaries. Addition, subtraction, or either logical or decimal comparison can be performed in parallel.

The memory-cycle time is a modest 2 microseconds. But the three-byte parallel structure of the computer, combined with the new ALU and alignment circuits, which process three bytes at a time, results in execution times for memory-to-memory string instructions ranging from 2.8 to 5.8 μs per byte. This speed escapes today's faster minicomputers, even those with memory cycle times of a microsecond or less. (A memory-to-memory instruction is one whose operands are fetched from the main memory, rather than from a high-speed local register, and whose results are stored in the main memory; a single occurrence of a string instruction in a program causes the operation to be repeated over and over for many bytes or words stored in sequential locations in the memory—a "string.")

Although the original computer had several byte-handling instructions, most of them operated by shifting a three-byte word by one byte left or right and masking the two bytes not involved in the particular program step. This procedure is time-consuming, and it unnecessarily complicates the program subroutines that manipulate byte strings. Otherwise the computer worked only with pure binary numbers. To overcome these difficulties required a hardware development that could operate on three bytes in parallel without regard to word boundaries and without relying on shifting.

Manipulating bytes

At the beginning of a byte string instruction, the source and destination addresses are placed in two of eight general-purpose registers in the AL1 chip. These addresses locate the two words containing the first byte of the data string before and after the move. The addresses are incremented or decremented by one each time a three-byte word is brought from the source area in the memory, realigned in AL2, and returned to the location specified by the destination address.

The source and destination addresses contain two extra bits that define which byte within the word is the first byte of the string. These bits are loaded into a special register on AL2, along with a portion of the operation code that defines whether the move begins with the most-significant or the least-significant byte. At the same time, the number of bytes to be moved is loaded into an eight-bit counter, also on AL2. This counter is decremented by three with each three-byte cycle.

The extra bits and the counter set up all internal-shifting and end-condition logic on the chip. This logic is extensive because it must account, not only for all possible combinations of byte positions within a word, but also for the cases when source and destination fields overlap or even fall within a single word.

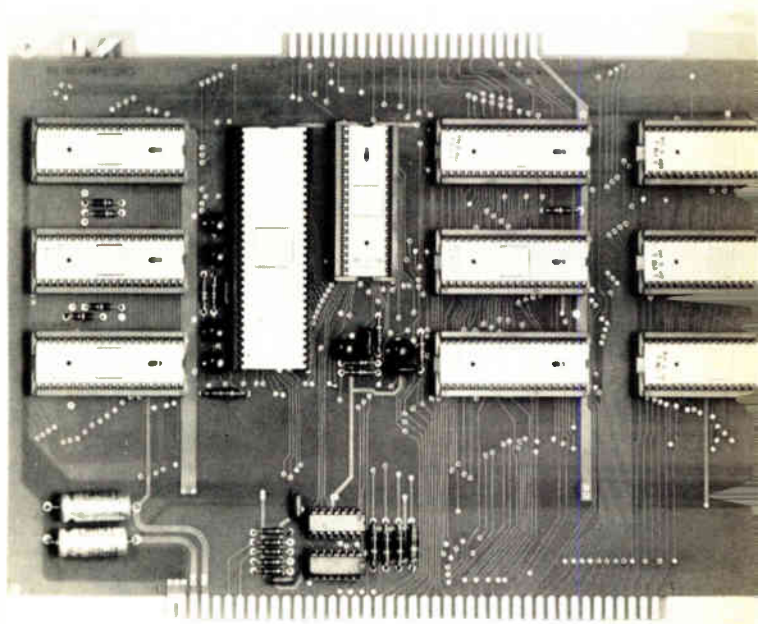
In addition, the chip contains six byte registers—three for the source and three for the destination. These extra registers are necessary because some bytes within the words containing the first and last bytes of the string may not belong to that string and must not be modified by the operation. In these cases, the first and last words must be brought out of memory, masked appropriately by AL2, and returned to memory unaltered.

When characters are representations of parts of pure binary words, as in the original System IV/70, character-string moving operations are handled by standard word-moving methods from the microprogram of the System IV/70 and by controlling the way the source and destination registers are read to and from the data bus (Fig. 3). Under control of the microprogram, the binary-arithmetic logic would generate source and destination addresses, fetch the operands, send control signals to chips, test condition-code status, and determine recomplement requirements and similar conditions.

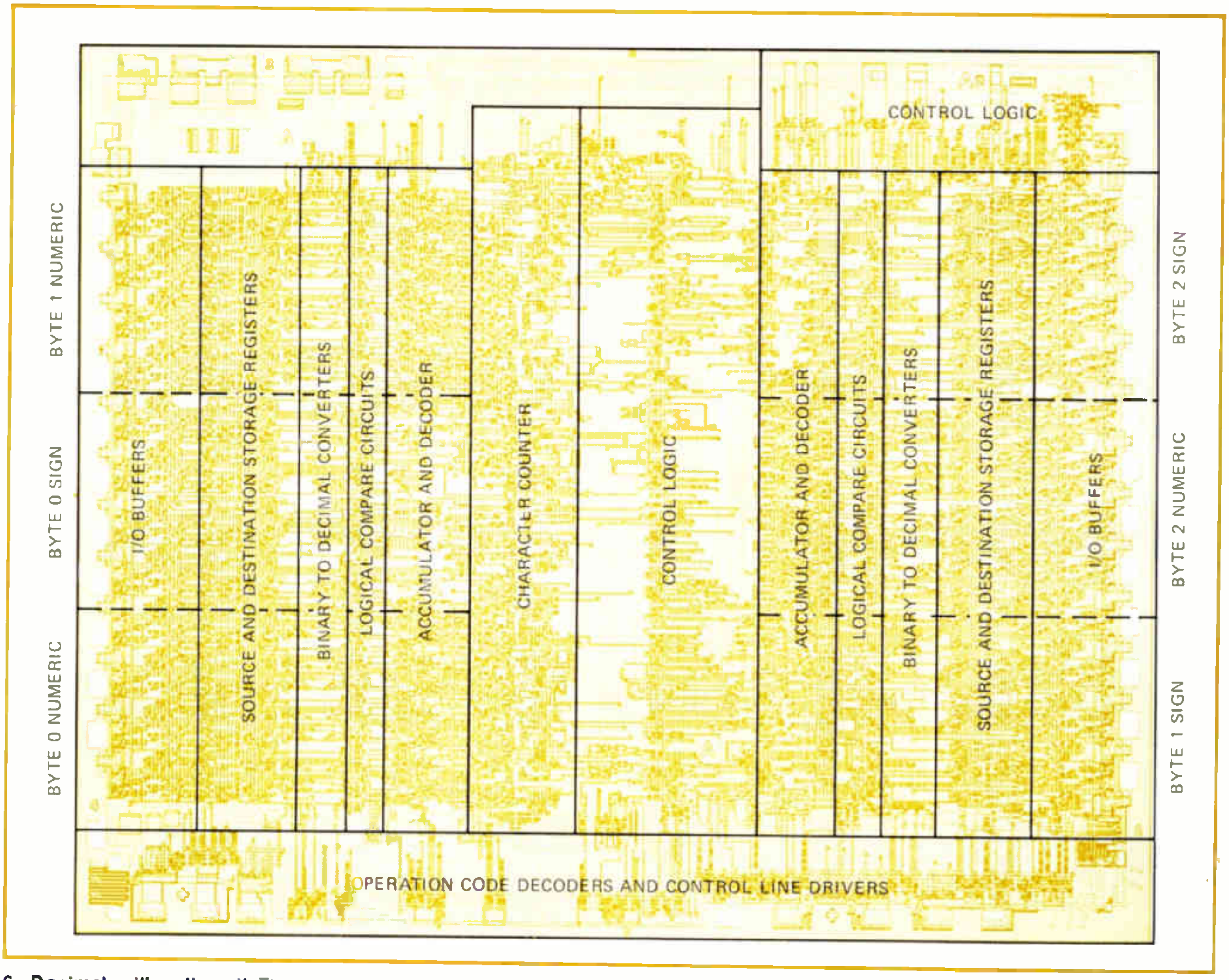
Purely binary operations are executed the same way in the enhanced Systems IV/70. But if decimal-arithmetic operations are required during the execution of a string instruction, AL3 is required. Out of the 54-bit microprogram word, four bits of control information not used in the microprogram are decoded into 14 signals that control AL3. The four condition codes—zero, overflow, minus, and carry—are generated in AL3 itself, which also generates the remaining control signals from the seven instruction codes.

While AL3, shown in Fig. 6, performs decimal-arithmetic functions, AL1 decrements the source and destination address, and AL2 aligns the bytes. Then, even after the bytes to be decimally processed are properly aligned, the sign of the decimal string, held in the upper four bit positions of the least-significant byte of the numeric string, may fall in any of three byte positions. Here, as in AL2, the logic circuitry has identified the least-significant byte, the sign bits are stored within the chip, and the operation proceeds.

This least-significant byte is the one with which most arithmetic operations begin; its location is stored in logic that generates a different four-bit sign in the least-



5. Processor. This circuit card, approximately 8 by 11 inches, contains the entire central processing unit for System IV/70. The largest of the packages is the AL3, the decimal-arithmetic unit. The three chips at the left are the 18,000-bit read-only memories.



6. Decimal-arithmetic unit. This enormous circuit, measuring 235 by 289 mils and including 6,000 active elements, contains all the logic for byte-oriented processing in the enhanced System IV/70. A 64-pin dual in-line standard package accepts the chip without modification.

significant byte if the operation requires the sign of the result to be changed. Furthermore, the most-significant byte generates the condition codes used by instructions that follow. This byte, like the least-significant one, must be identified, regardless of its position in the word. Finally, when the number of digits in the source is smaller than in the destination, AL3 must force zeros into the higher-order positions, but allow the carries to propagate from the lower orders.

For addition, subtraction, and numerical-compare operations, AL3 contains two counters to keep track of operands of different lengths. These counters operate independently, with no control from the microprogram: it only tests them from time to time to determine whether or not the operation is complete.

An important distinction should be made between System IV/70 and the numerous small-chip microprocessors that have appeared in recent months. These microprocessors have rightly stimulated interest in MOS LSI systems, but they remain limited in performance—they are small-scale machines, and no one pretends that they are more than that. But the System IV/70 is a true medium-scale machine.

The comparison between small and medium systems can also be made in terms of the packaging. Four typical single-chip microprocessors would fit in the same area as one AL3—but the latter is only one of 11 complex circuits that make up the CPU.

Some day, possibly even these 11 circuits may be integrated on a single chip. However, until then, clearly the present design, in which the CPU semiconductor parts cost is less than $200, shows that the role of the classic medium-scale computer is sure to be reevaluated. With advances in technology, the computer industry is dividing into two parts—one featuring huge machines with vast data bases, and one featuring small local smart terminals at very low cost. Recent announcements of large machines show that their end of this "dumbbell-shaped market" is fast approaching, and the availability of machines like the new System IV/70 shows that their end of the dumbbell may be already here—thanks to LSI.

In just the past few years, LSI has enabled the cost of such machines to be reduced by a very significant factor. Today, even if the semiconductor hardware were free, it wouldn't materially reduce the total cost of the system, which includes extra memory, peripheral equipment, software, and support. Thus, no future cost reductions will ever be as significant as those made in recent years through the development of LSI. □

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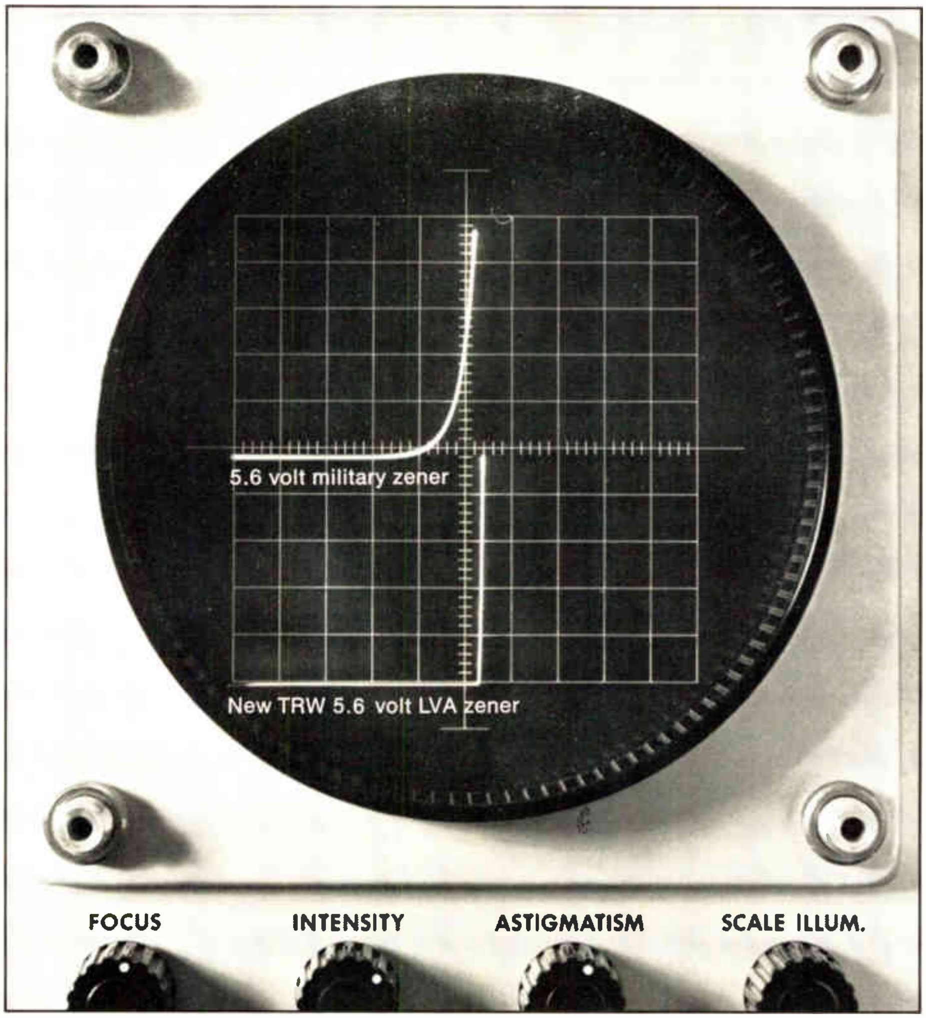

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TRW® SEMICONDUCTORS

Designer's casebook

High-power counter drives 20-watt loads

by Christopher Strangio
Villanova University, Villanova, Pa.

A high-current ring counter, which sequentially drives a series of resistive loads, develops an output power level of 20 watts at 2 to 5 amperes. A four-stage version of the circuit is shown here, but the design may be extended to an unlimited number of stages. Typically, this type of counter can be used as a low-voltage lamp driver.

There is one silicon controlled rectifier in each stage. When any one of these SCRs conducts, the stage associated with that SCR will also be in its conduction mode, and the load driven by that stage will be energized.

Initially, all the stages are nonconducting. A SET pulse must be applied to the gate terminal of any one of the SCRs (SCR_1 is used for this circuit) to enable the counter. Conduction can then be passed from the first stage to the succeeding stages by successive trigger pulses. Circuit operation is the same for each stage.

Assume that SCR_2 is in its conduction mode. Prior to triggering, capacitor C_2 is charged to the supply voltage measured from point A to point B, since SCR_2 is conducting, and its anode terminal is at ground level.

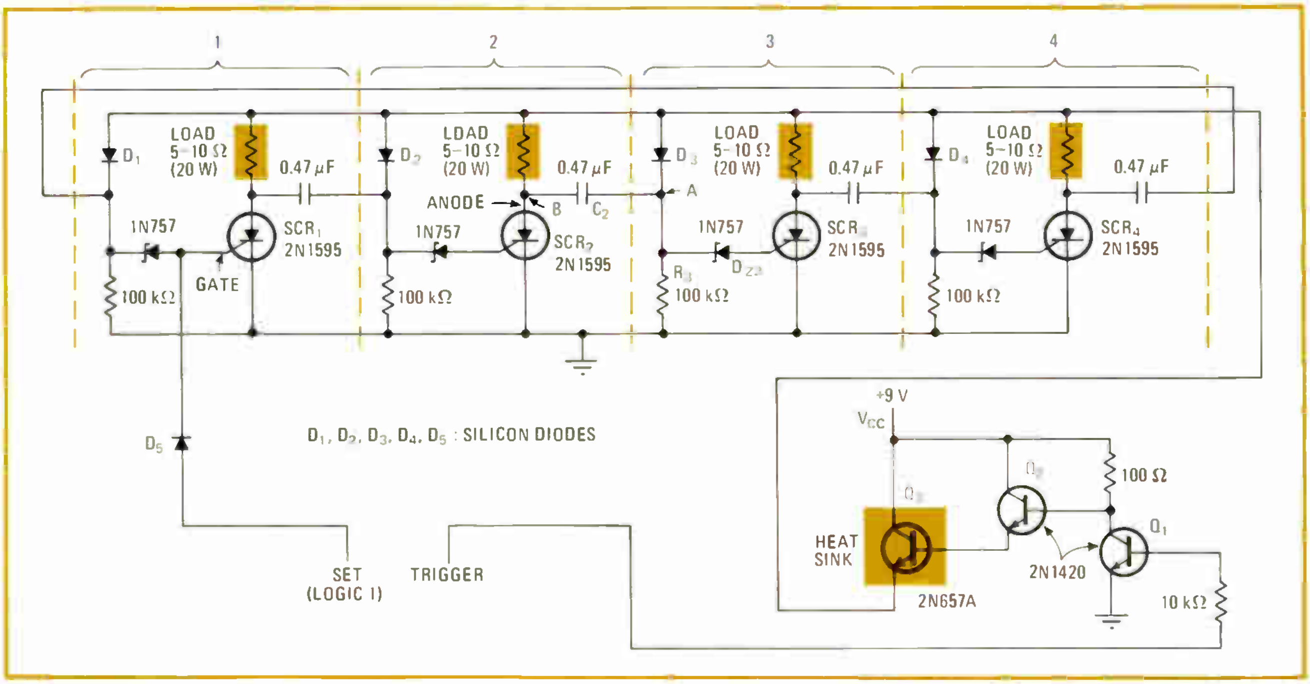
When a trigger pulse is applied to the base of transistor Q_1, the bias current feeding transistor Q_2 is shunted to ground. Drive transistor Q_3 then turns off, the SCR power source is blocked, and any SCR that was conducting will switch off. During this power-off interval, capacitor C_2 retains its charge because all possible discharge paths are blocked. The capacitor in each stage, therefore, serves as a memory that indicates what SCR was previously conducting.

When the trigger pulse terminates, a bias current again flows to transistor Q_2, and power is returned to the SCRs. The anode of SCR_2 now rises to the supply voltage, along with the voltage across capacitor C_2. Because the capacitor is still holding its charge, capacitor voltage increases to the supply voltage at point B, and to twice the supply voltage at point A.

Zener diode D_{Z3}, which is connected to the gate terminal of SCR_3, has a reverse breakdown voltage that is about 20% greater than the supply voltage. Therefore, as point A rises to twice the supply voltage, zener D_{Z3} will conduct, providing a gate trigger for SCR_3 and turning this device on.

Resistor R_3 drops the voltage at point A from the zener breakdown voltage, which is the SCR's gate-current cutoff point, to the supply voltage. Since R_3's resistance is considerably larger than the equivalent SCR gate resistance, resistor R_3 does not disturb the discharging of capacitor C_2 during triggering.

The trigger input pulse should have a minimum width of 200 microseconds, a maximum frequency of 1 kilohertz, and an amplitude of 6 to 9 volts. When SCRs with low firing points are used, put a resistor between each SCR gate and ground to inhibit noise. □



Sequential pulser. High-current ring counter can drive 5-ohm 20-watt load resistors. This four-stage version is enabled by SET pulse applied to gate terminal of SCR_1. Each stage operates identically, producing a drive pulse in response to a trigger input. Only one stage at a time conducts. During triggering, the capacitor in the previously conducting stage retains its charge equal to the supply level.

C-MOS voltage monitor protects Ni-Cd batteries

by William Wilke
University of Wisconsin, Madison, Wis.

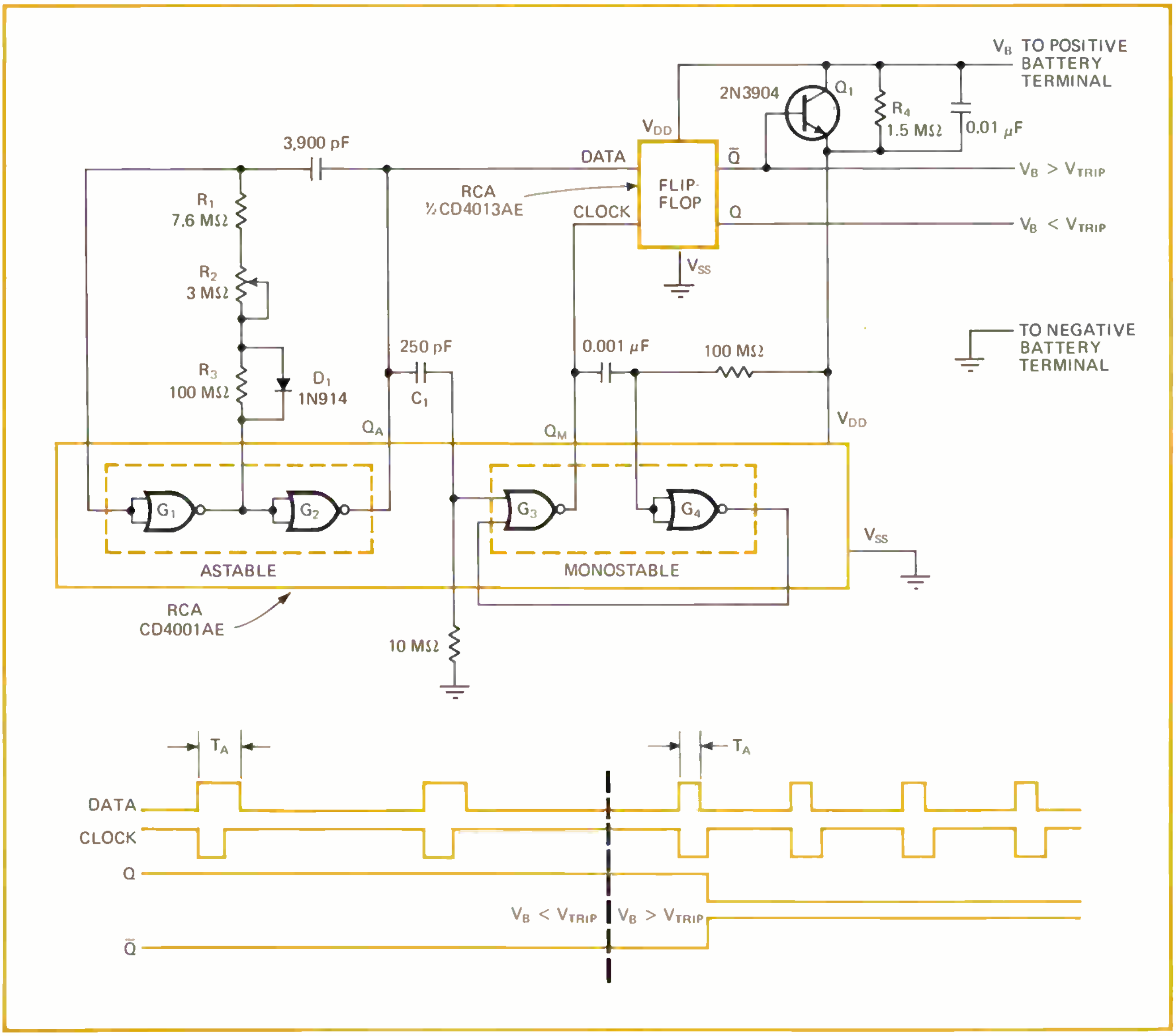
If nickel-cadmium batteries are permitted to discharge completely, they can be permanently damaged. To prevent this, a voltage monitor can be employed to turn off the equipment being supplied by the batteries when their voltage falls below a safe level. The monitor circuit shown draws as little as 0.5 microampere, has an adjustable voltage trip point and hysteresis, and it turns itself back on when the batteries are recharged.

The circuit basically consists of two complementary-MOS multivibrators—a monostable and an astable—and a network that compares their outputs. NOR gates G_1 and G_2 form the astable multivibrator, which has a period that varies with changes in the supply voltage, V_{DD}, obtained from the battery. On the other hand, NOR gates G_3 and G_4 make up a positive-edge-triggered monostable multivibrator that has an output pulse width that remains relatively constant even with some changes in the supply voltage.

The astable output, Q_A, is coupled through capacitor C_1 to fire the monostable, and the output is also fed to the DATA input of a D-type flip-flop. The monostable's output, $\bar{Q}_M$, drives the CLOCK input to this flip-flop.

Resistors R_1 and R_2 are adjusted so that the periods of the astable and the monostable are equal to each other when battery voltage V_B is at the desired trip voltage (V_{trip}). If battery voltage becomes higher than the trip voltage, the astable's period, T_A, decreases, and when the positive edge of the CLOCK pulse from the monostable reaches the flip-flop, its DATA input is low so that its $\bar{Q}$ output goes high.

At battery voltages below the trip voltage, the



Battery watchdog. Voltage monitor for nickel-cadmium batteries detects when battery voltage (V_B) is above or below desired level (V_{TRIP}). Here the trip point is 3.6 volts, and hysteresis is 0.2 V. C/MOS circuitry keeps current drain to as little as 0.5 microampere. The period of the astable varies with changing battery voltage, while the period of the monostable stays constant. Circuit costs under $6 to build.

astable's period increases. The flip-flop's DATA input, therefore, is still high when the clock fires, forcing the flip-flop's Q output to be high. In this way, the flip-flop Q and $\bar{Q}$ signals indicate whether battery voltage V_B is less than trip voltage V_{TRIP} or V_B is greater than V_{TRIP}.

Diode D_1 and resistor R_3 are added to give the astable a duty cycle of approximately 10%. This addition assures that the output pulse width of the monostable remains independent of the rate at which the monostable is retriggered.

Circuit hysteresis is proportional to the value of resistor R_4, which bypasses transistor Q_1. When battery voltage falls below V_{TRIP}, the flip-flop $\bar{Q}$ signal goes low, shutting transistor Q_1 off and further lowering the effective V_{DD} supply voltage by the size of the IR drop across resistor R_4.

For the components shown, the voltage monitor has a trip point of 3.6 volts, which is appropriate for three series-connected batteries. Hysteresis is 0.2 V, and current drain is 3 μA when V_B is greater than V_{TRIP}, but only 0.5 μA when V_B is less than V_{TRIP}. Total parts cost is approximately $5.50. ☐

Switching large ac loads with logic-level signals

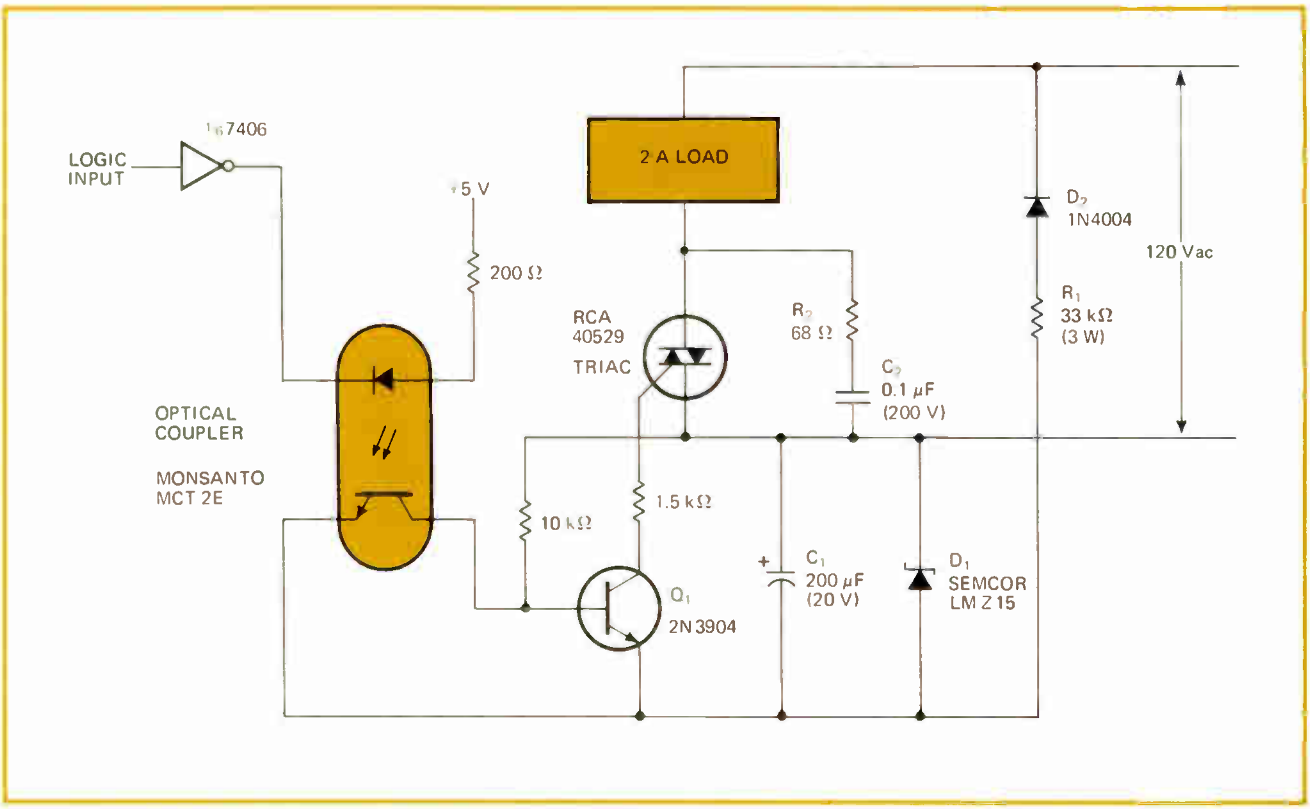
by Lynn S. Bell, *Bell Engineering, Tucson, Ariz.,*
and R. M. Stitt, *University of Arizona, Tucson, Ariz.*

An optical coupler makes it possible for integrated-circuit logic signals to switch safely and without isolation problems ac loads as large as 2 amperes.

In the circuit, capacitor C_1, zener diode D_1, diode D_2, and resistor R_1 provide a −15-volt supply, referenced to point A of the ac line source. A low-input logic signal to the inverter turns off both the light-emitting diode and the phototransistor in the optical coupler. For this circuit, the coupler provides 2,500 V of isolation.

After the coupler turns off, transistor Q_1 saturates, supplying a current of −10 milliamperes to the gate of the triac and turning this device on so that the load is energized. The triac will stay on through a complete half-cycle of the line voltage, once the logic input to the inverter goes low. The triac turns off at the first zero crossing of the load current that occurs after the logic input goes high.

Resistor R_2 and capacitor C_2 suppress possible radio-frequency interference and provide safe di/dt and dv/dt triac operation when driving inductive loads. ☐



Logic-driven ac load switch. Ac loads as large as 2 amperes can be safely switched by logic signals because of optical coupler, which provides up to 2,500 volts of isolation. A low logic input turns off the coupler's LED and phototransistor, causing transistor Q_1 to saturate. This triggers the triac's gate terminal, firing this device and energizing the load. The R_2C_2 network suppresses transients and rfi.

Matching oscilloscope and probe for better measurements

Several tradeoffs must be weighed for best results; to measure rise time, low input resistance is needed; for amplitude accuracy, it should be high; capacitance can nearly always be ignored when checking for pulse amplitude

by Vic Bunze, *Hewlett-Packard Co., Colorado Springs, Colo.*

☐ The well-known relationship between chains and their weakest links is particularly applicable to measurement systems. One inaccurate or poorly matched component can completely invalidate the results obtained from an otherwise well-designed test setup. Modern oscilloscopes are particularly susceptible to this weak-link phenomenon because their broad bandwidths can be easily compromised by selection of probes that are inappropriate for a given measurement situation.

Nor is this a trivial consideration. Selecting the best combination of scope and probe for a particular measurement and then estimating the errors caused by that scope/probe combination is not necessarily a simple task—especially when high-frequency signals are involved. To understand why, consider how the probe resistance and capacitance act to load down the signal source, and then analyze how this loading affects amplitude and rise-time measurements.

Resistive and capacitive loading

Oscilloscope input impedances come in two basic classes, high and 50-ohm impedance (Fig. 1). Each can be characterized as a resistance shunted by a capacitance. When a probe is added to the scope input, the scope/probe combination may still be represented by a parallel RC circuit. The values and tolerances for R and C are normally specified in the probe data sheet. These values, along with the probe's division ratio, are the basis for estimating the loading effects of the probe/scope input system.

If the input resistance of the probe/scope combination is of the same order of magnitude as that of the signal source, significant measurement errors will result because of resistive loading. Small amounts of loading may simply lower the amplitude of the observed signal, while heavy loading may draw so much current from the signal source that it may force a circuit into saturation or nonlinear operation, or it may cause the circuit under test to stop operating altogether.

Since the probe/scope input resistance, R_{in}, and the signal source resistance, R_g, form a simple resistive voltage divider, the measurement error caused by resistive loading is given by

$$\text{Error in \%} = 100R_g/(R_g + R_{in})$$

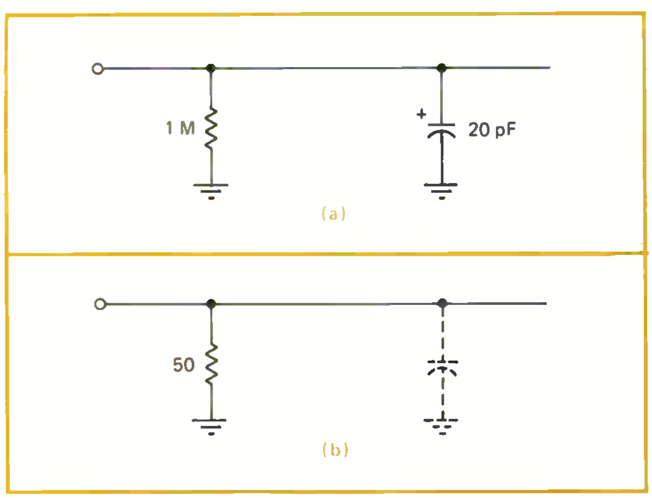
A simple rule of thumb for keeping resistive loading errors below 1% is to select a probe/scope combination having an R_{in} at least 100 times greater than the source impedance.

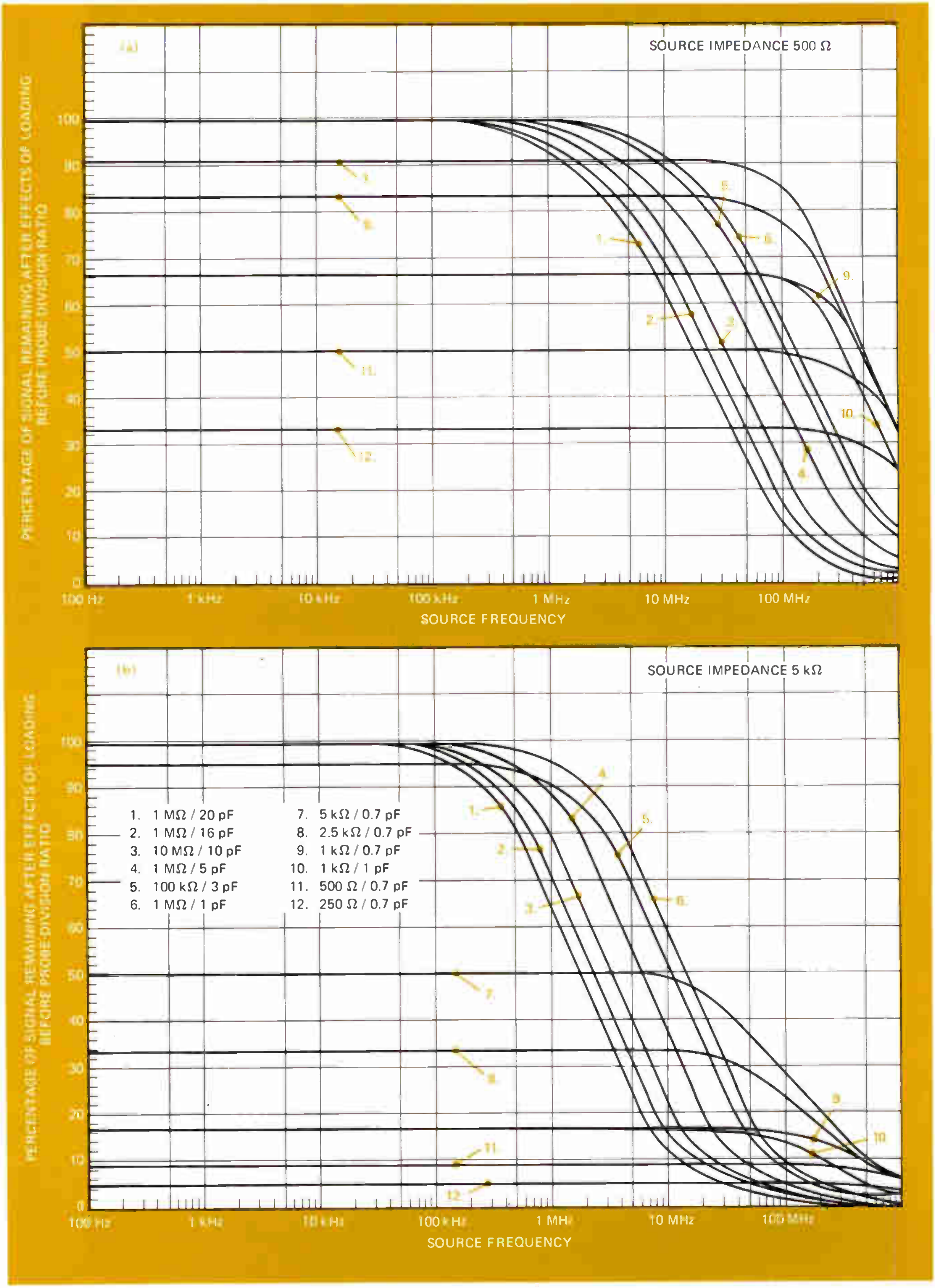
Purely resistive loading effects, of course, are independent of frequency. The shunt capacitance, however, causes measurement errors that are frequency-variable. Like resistive loading, capacitive loading can cause amplitude attenuation and abnormal circuit operation; in addition, it can cause phase shifts and pulse perturbations, and it can introduce errors in rise-time and propagation-delay measurements.

The effect of input shunt capacitance at high frequencies is greater than might at first be assumed: The input characteristics of a high-impedance probe with an input impedance of 1 megohm in parallel with 20 picofarads are almost completely determined by the shunt capacitance at even moderately high frequencies. At 30 megahertz, the capactive reactance is 265Ω, and at 100 MHz, this drops to 80Ω.

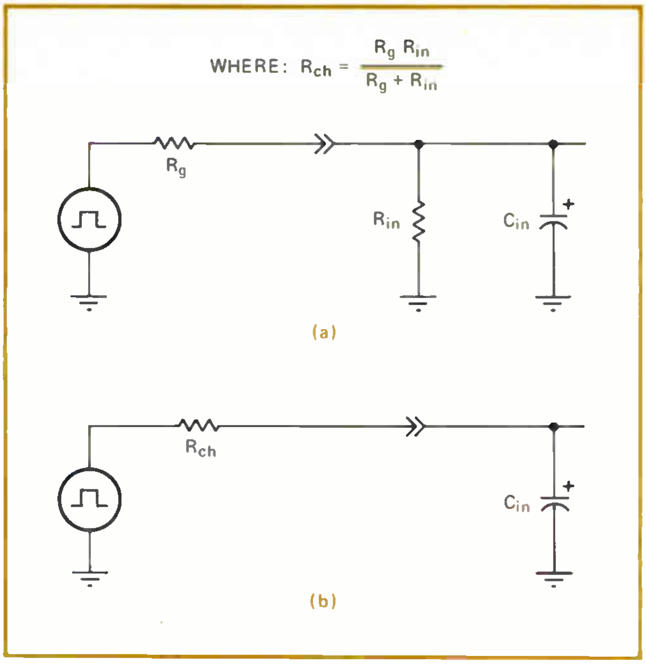
Since the input impedance of a probe/scope pair consists of the parallel combination of R_{in} and X_c, both must be considered in selecting a probe for a given job. To aid in this selection, Figs. 2a and 2b show the effect of source loading by giving in percent the signal remaining as a function of frequency for source impedances of 500 and 5,000Ω. In both figures, the effect of the probes' division ratio is ignored—only losses caused

1. It goes in here. Typical high-impedance input (a) has 1-MΩ resistance shunted by a capacitance of 20 pF. The 50-Ω input (b) is shunted by a capacitance whose X_c is very much larger than 50Ω.





2. Loading effects. Loading of a 500-Ω source caused by various probe/scope resistance-capacitance combinations is shown as a function of frequency (a). For both this case and that of the 5,000-Ω source (b), the effects of the probes' division ratios are ignored.



3. Equivalent circuit. Input circuit consists of C_{in} in parallel with R_{in} and fed from R_g (a). Equivalent circuit (b) shows C_{in} being charged through equivalent charging resistance, $R_{ch} = R_{in} \| R_g$.

by loading of the signal source are taken into account.

As an example of the proper use of Fig. 2, assume that a choice must be made between two probes for a cw amplitude measurement from a 500Ω source. Probe 1 is rated 10 MΩ and 10 pF, with 10:1 division ratio, and probe 2, 500Ω, 0.7 pF, with 10:1 division ratio. The problem is to determine which probe to use for a 50-MHz cw-amplitude measurement. Figure 2a shows that for source frequencies above approximately 33 MHz, probe 2 (500Ω/0.7pF) causes less source loading than probe 1, and therefore it provides a more accurate measurement solution. Conversely, for frequencies below 33 MHz, probe 1 (10 MΩ/10 pF) creates less loading. The input impedance of probe 2 is lower than probe 1 at dc, it is higher than probe 1 for frequencies above 33 MHz, and it is relatively constant over a broad frequency range. The relatively high input capacitance of probe 1 causes its input impedance to decrease rapidly with an increase in source frequency.

Division is constant, loading is not

This example points out that because of the effects of input capacitance, probes with high values of input resistance can be much less accurate than probes with a much lower input resistance.

It is important to recognize the distinction between signal loss caused by variable loading and signal loss caused by the constant probe-division ratio. Both combine to reduce the signal level available for display. However, the probe-division ratio is specified as constant within a certain percentage over a stated frequency range, and it is therefore easily accounted for. Loading losses, on the other hand, are not easily estimated because they depend on source impedance and frequency. It should be noted here that a probe's division ratio is constant to within a few percentage points only if it is properly compensated so that its RC time-constant matches that of the input of the scope to which it is connected.

Voltage probes may be grouped according to their ability to minimize resistive, capacitive, or both types of loading. Probes can be classified into three groups that have unique capabilities and limitations. They are group I, high resistance; group II, miniature passive divider; and group III, active. Table 1 lists typical probes available from various manufacturers. Group I probes are noteworthy for their low resistive loading, wide dynamic range, and their ability to withstand signals up to several hundred volts. Their input impedance is high at dc, but due to high input capacitance, impedance falls off rapidly with increasing frequency. Their high input capacitance can be reduced somewhat if high division ratios (100:1) are practical (this depends on the test-signal level and scope vertical-amplifier sensitivity). The group I probe is best used where capacitive loading is not a critical factor; for example, in measuring pulse amplitude or when the source impedance is known to be in the 50-Ω region.

Group II devices provide the lowest input capacitance available in a probe. They are used mainly when resistive loading is not a major consideration and the fastest possible rise time is desired. They come with divider ratios ranging from 1:1 to 100:1, depending on the divider tips. The maximum input voltage for a group II probe is not as high as that of a group I unit. Group II probes are best used for fast-rise-time measurements, phase-shift measurements, and high-frequency measurements in which some resistive loading is acceptable. Their source loading is relatively high at dc, but since it remains constant over a broad frequency range, loading is easy to predict (see Fig. 2).

The group III probe is probably the best general-purpose probing device within its dynamic range. Two of its disadvantages are larger size (not convenient for very dense circuits) and slightly higher pulse perturbations than passive probes. Group III probes have less capacitive loading then group I probes and more than those in group II. Their resistive loading, however, is negligible. Because they are active devices, they have limited dynamic range. By using divider tips, however, their dynamic range may be extended to as much as ±50 V. Offset is commonly available. Group III probes offer the highest R and lowest C of all probe types without reducing the input signals. They are excellent for high-frequency, low-level signals.

Measuring amplitude

The most important factors to be considered in selecting a probe for an amplitude measurement are signal frequency (or pulse-repetition rate), probe/scope impedance, source impedance, scope bandwidth and sensitivity, probe compensation, and division ratio.

For measuring cw amplitude, unlike pulse-rise-time, the main idea is to choose the scope/probe combination that provides the highest input impedance at the source frequency. A group I probe is often an excellent choice at low frequencies, but it is quite possible, as the frequency of the source increases, for the input impedance of the group II probe to overtake that of the group I probe and provide more accurate measurements.

TABLE 1: TYPICAL PROBES AVAILABLE COMMERCIALLY

Group	Model or Type No.	R_{in}	C_{in} (pF)	Division ratio	Scope input		Type	Manufacturer
					High-Z	50-Ω		
I	10004B	10 MΩ	10	10	X		Passive	Hewlett-Packard Co.
	1124A	10 MΩ	10	10		X	Active	Hewlett-Packard Co.
	P6007	10 MΩ	25	100	X		Passive	Tektronix, Inc.
	4290B	10 MΩ	11	10	X		Passive	Dumont
	4292B	10 MΩ	11	100	X		Passive	Dumont
	7994B	10 MΩ	7	10	X		Passive	Dumont
	10000A	10 MΩ	9	10	X		Passive	Dumont
II	P6048	1 kΩ	1	10	X		Passive	Tektronix, Inc.
	10020A	250 Ω	0.7	5		X	Passive	Hewlett-Packard Co.
	10020A	500 Ω	0.7	10		X	Passive	Hewlett-Packaed Co.
	10020A	1 kΩ	0.7	20		X	Passive	Hewlett-Packard Co.
	10020A	2.5 kΩ	0.7	50		X	Passive	Hewlett-Packard Co.
	10020A	5 kΩ	0.7	100		X	Passive	Hewlett-Packard Co.
III	P6045	10 MΩ	5.5	1	X*	X*	Active	Tektronix, Inc.
	P6045	10 MΩ	2.5	10	X*	X*	Active	Tektronix, Inc.
	P6045	10 MΩ	1.8	100	X*	X*	Active	Tektronix, Inc.
	1120A	100 kΩ	< 3	1		X	Active	Hewlett-Packard Co.
	1120A	1 MΩ	< 1	10		X	Active	Hewlett-Packard Co.
	1120A	1 MΩ	< 1	100		X	Active	Hewlett-Packard Co.

*Switchable by means of a control that puts a 50-ohm resistor across a high-Z scope input.

Surprisingly enough, accurate pulse-amplitude measurements pose less of a problem than cw-amplitude measurements. An accurate pulse-amplitude measurement can be made with almost no concern for the input capacitance of the system. The only proviso is that the pulse duration must be at least five times longer than the input RC time-constant of the probe/scope system. This will ensure that the pulse is present long enough to charge the input capacitance to the 100% amplitude level. The main concern when making pulse amplitude measurements is that R_{in} be large, relative to the source impedance.

An error can be introduced by the scope because the vertical-amplifier response changes as a function of frequency. Errors introduced by amplifier rolloff can usually be neglected if the bandwidth is about five times greater than the input-signal frequency.

The probe compensation should be checked and adjusted before any measurement. If not indicated on the probe, the division ratio can be obtained from a data sheet or operating note.

Trading off loading and sensitivity

Here is an example illustrating the major considerations for choosing a probe to measure a 35-MHz signal from a 500-Ω source. The choice is between a 100-kΩ/3 pF probe with a 1:1 division ratio (HP 1120A), and a 5-kΩ/0.7-pF probe with 100:1 division ratio (HP 10020A with 100:1 divider tip).

The 5,000Ω/0.7-pF probe clearly minimizes the loading error (it leaves 89% of the signal vs 76% for the first probe), but its 100:1 divider ratio reduces a 1-V input signal to only 8.9 mV. This means that for a vertical amplifier with a deflection factor of 10 mV/division, less than 1 centimeter of input signal would be displayed. To minimize reading errors, it is always more accurate to display several divisions of signal. If the signal amplitude in the previous example were 250 mV instead of 1 V, the measurement would be much more difficult. If it were possible to trigger the display properly, there would be a large error resulting from readout accuracy because the signal would only be 2 mm high.

The 100-kΩ/3-pF probe allows a full-screen display of even the 250-mV signal, assuming a vertical-deflection factor of 20 mV/division. The loading error in this case, however, would be 24%, compared with 11% for the other probe.

The choice here is between loading errors and reading errors, and the optimum solution is to estimate both and to try to minimize the combined effect of the two.

General rules for amplitude measurements

In general, maximizing the accuracy of an amplitude measurement involves following three basic rules:

- If there is a choice, select a minimum-impedance source. For example, the emitter-to-base impedance of a transistor is generally lower than the collector-to-base impedance.
- Select a probe with the highest possible Z at the frequency of interest. When measuring pulse amplitude, low capacitance is not as important as having resistance high relative to the source impedance. While probe capacitance distorts pulse shape, the flat portion of the pulse top (maximum amplitude) can provide an accu-

TABLE 2 : CALCULATED PROBE LOADING FROM A 500-OHM SOURCE

Probe	R_{ch}	$2.2\,R_{ch}C_{in} = t_{input}$	Percent signal loss caused by resistive loading	Probe division ratio	Specified t_r of probe only (25-ohm source)
1. 10 MΩ / 10 pF	500	11 ns	0 %	10 : 1	2.5 ns
2. 100 kΩ / 3 pF	500	3.3 ns	0.5 %	1 : 1 (active)	0.75 ns
3. 1 MΩ / 1 pF	500	1.1 ns	0.05 %	10 : 1 (active)	0.75 ns
4. 1 kΩ / 0.7 pF	333	0.514 ns	33 %	20 : 1	0.5 ns
5. 5 kΩ / 0.7 pF	455	0.7 ns	9.1 %	100 : 1	0.5 ns

rate amplitude measurement because it contains low-frequency information. Conversely, if the pulse width is short with respect to the measurement-system rise time, input capacitance can introduce errors because the source cannot fully charge the input capacitance while it is present. This problem increases as source impedance increases.

■ If the source voltage is totally unknown, use a 100:1 divider to reduce the possibility of damaging the probe. This will also indicate if there is enough signal available to capitalize on the relatively low capacitance of a 100:1 divider. If the source voltage is too low for a 10:1 divider, then the use of an active probe is advisable.

Measuring rise time

Measuring pulse rise time is one of the most frequent and challenging applications for an oscilloscope. Since there are few alternative devices for this measurement, accuracy of the over-all measuring system is especially important. Conditions affecting the measurement accuracy are:

■ Source impedance should be as low as possible to reduce charging resistance of the probe/scope input capacitance.

■ Probe rise time should be short relative to the signal rise time because the observed rise time can generally be approximated as the vector sum of the combined rise times of the parts of a system.

■ Input R and C of probe/scope combinations both should be as small as possible.

■ Oscilloscope rise time should be at least twice as fast as the signal to be measured if errors are to be kept below 10%.

■ The signal source should be terminated with an impedance that closely matches the source impedance if reflections and perturbations are to be kept to a minimum. For example, a 50-Ω source does not operate cleanly into a 1 MΩ/20pF input. A feedthrough termination in shunt with a 1-MΩ input can reduce the displayed rise time, which reduces the observed error when working with high-impedance inputs, but reflections remain from the 20-pF input capacitance.

■ When the source resistance is much greater than 50 Ω, the displayed rise time error can be reduced by increasing the resistive loading of the source.

■ If signal amplitude is small in relation to the oscilloscope vertical-amplifier deflection factor, less flexibility remains for using divider probes because a small displayed signal can lead to large readout errors.

■ Vertical-amplifier deflection factor, in combination with the signal amplitude, can be a limiting factor in selecting a probe.

The observed rise time of any displayed signal is approximately the square root of the sum of the squares of all of the rise times in the system. These rise times are the actual rise time of the signal source, the specified probe rise time, the specified scope rise time, and the rise time of the scope/probe input system—including the effects of the source impedance. Other than selecting a fast oscilloscope, the only way the user can minimize rise-time errors is to minimize the rise time of the scope/probe input system—t_{input}.

What is t_{input}? As Fig. 3 shows, the input capacitance of the scope/probe combination, C_{in}, is charged through the parallel combination of the source resistance, R_g, and the scope/probe input resistance, R_{in}. This parallel combination may be thought of as the charging resistance, R_{ch} of the input capacitance.

It can be shown that the rise time of the RC network of Fig. 3b is approximately $2.2\,R_{ch}C_{in}$, which is also called t_{input}; thus, to maximize the accuracy of a rise-time measurement, both R_{ch} and C_{in} should be minimized.

Since R_{ch} is the parallel combination of R_g and R_{in}, if either is large, then the other should be kept small. Given a choice, it is preferable to minimize R_g because this will also minimize resistive loading and allow a more accurate amplitude measurement. When R_g is high (say, 500 Ω or more), some resistive loading will be unavoidable to obtain the most accurate rise-time measurement. In this situation, select the lowest R_{in} that the circuit can tolerate without going into an abnormal mode of operation. This is the most difficult type of rise-time measurement because some resistive loading is unavoidable if R_{ch} is to be minimized. A resistive-divider probe set (such as HP 10020A) with several divider tips is convenient for optimizing the tradeoffs of this measurement.

If both R_g and R_{in} are large, then R_{ch} will increase accordingly, and accuracy will be degraded unless C_{in} can be made very small. This is best accomplished by using a 50-Ω oscilloscope input, which has almost zero capacitance. However, if 50 Ω causes too much resistive loading for the circuit, a probe can be added to increase R_{in} to as high as 1 MΩ. There will be a slight increase in input capacitance when the input resistance is raised by

Measuring rise time. When high-impedance (10MΩ/14 pF) probe is used, displayed rise time is strongly dependent on source impedance (top). Switching to a 500-Ω/0.7-pF probe working into a 50-Ω input makes the display less dependent on the source impedance (bottom).

a probe.

As an example, consider the selection of the best probe for measuring the rise time of a signal with source impedance of 500 Ω. Assume that the source will saturate if resistive loading exceeds 30%. Five probes are to be considered:

1. 10 MΩm/10 pF, 10:1 (HP 10004B).
2. 100 kΩ/3 pF, 1:1 (HP 1120A)
3. 1 MΩ/1 pF, 10:1 (HP 1120A with 10:1 divider tip).
4. 1 kΩ/0.7 pF, 20:1 (HP 10020A with 20:1 divider tip)
5. 5 kΩ/0.7 pF, 100:1 (HP 10020A with 100:1 divider tip).

This example covers many of the tradeoffs and considerations necessary for selecting the best probe to make an accurate transition-time measurement. Table 2 summarizes the probe-loading effects.

The results in table 2 indicate that probe 4 (1 kΩ/0.7 pF 20:1 passive divider) is the fastest, but it fails the acceptable resistive-loading criterion of 30% signal loss. The reasons this probe is so much faster are that R_{eh} is the lowest, and the input C is very low. The next fastest probe that is capable of meeting the loading criterion is No. 5 (5 kΩ/0.7 pF, 100:1 divider) with only 9.1% resistive loading. The choice of this probe would depend on whether or not there is sufficient signal remaining after the 100:1 division ratio to present an acceptable display on the CRT. If not, then the next choice would be probe 3 (1 MΩ/1 pF, active), which is only slightly slower than the 100:1 divider probe.

The general rules for making accurate rise-time measurements can be summed up in two sentences: Always try to probe the lowest impedance point that contains the waveform of interest. The fastest input system will generally have the lowest R_{in} and C_{in}. (This rule is limited only by the maximum resistive loading that the source can tolerate.) □

Transformer-coupled transceiver speeds two-way data transmission

New line driver/receiver can transmit serial data at 20-MHz rates for several hundred meters and improve cost-effectiveness in certain applications that only parallel-line data buses could previously handle

by Thomas R. Blakeslee, *Consulting engineer, W[illegible]*

☐ The number of interconnections between elements in computer systems is a major factor in determining overall system cost and reliability. Because of the many advantages offered by serial transmission techniques, they are rapidly replacing earlier parallel transmission methods in many applications. Serial transmission, in addition to a radical reduction in the number of wires, connectors, and other system components, cuts crosstalk and usually simplifies parity checking. Serial transmission has not been used extensively because transmission speeds are too low, especially to replace large numbers of parallel lines. However, single serial lines can operate now at speeds to 20 megahertz, which is adequate for many applications.

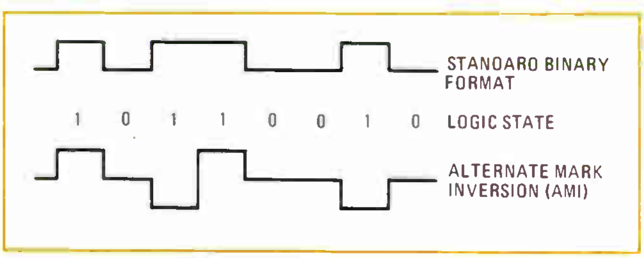
To reduce the costs of cumbersome parallel lines in a computer-controlled telephone exchange, a serial databus system was recently designed, and tests have proved it successful. Since the data transceiver that interfaces with the serial bus is capable of operating at speeds to 20 MHz, the design can be applied to numerous applications where many peripherals time-share a common data bus.

Conversion to serial operation in the exchange decreased by a factor of 48 the number of transmission wires, connector pins, line drivers, and receivers. Furthermore, because the upper limits of the transmission rate imposed by timing skew between parallel lines is eliminated, the total time required for the serial system to transmit a 48-bit word (32 information bits plus 16 address and control lines) remains approximately the same as it was for the parallel system.

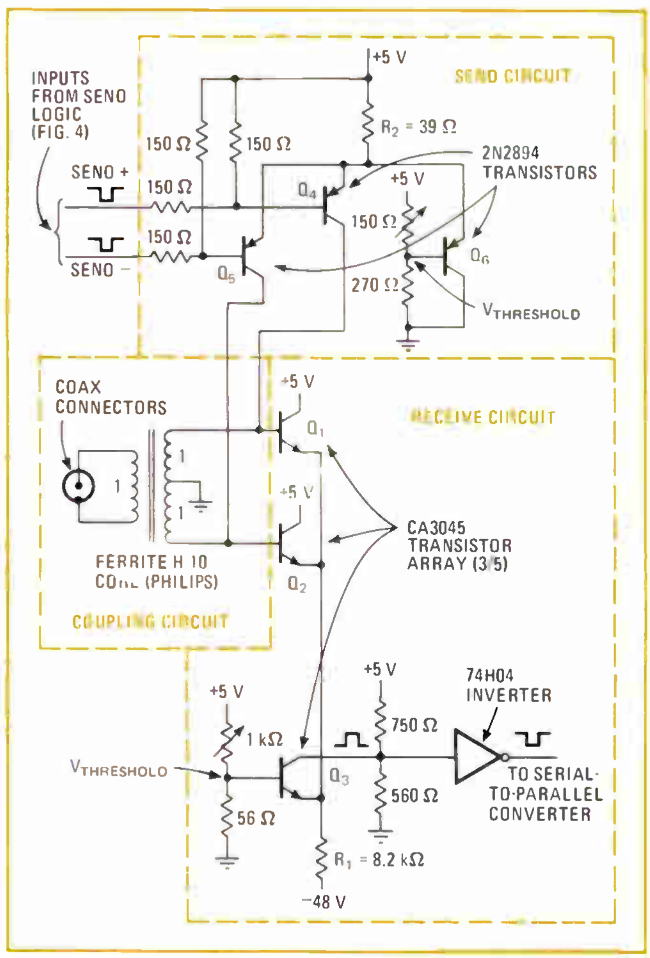
Data-bus characteristics

When data is transmitted over distances greater than 1 or 2 meters, either in serial or parallel, it becomes necessary to use senders and receivers that are terminated with an impedance that matches that of the transmission line. When the distance is farther than about 15 meters, grounding and noise problems make transformer coupling desirable. And since the dc component of the common binary signal is blocked by the transformer, special coding and decoding of the transmitted signal is required.

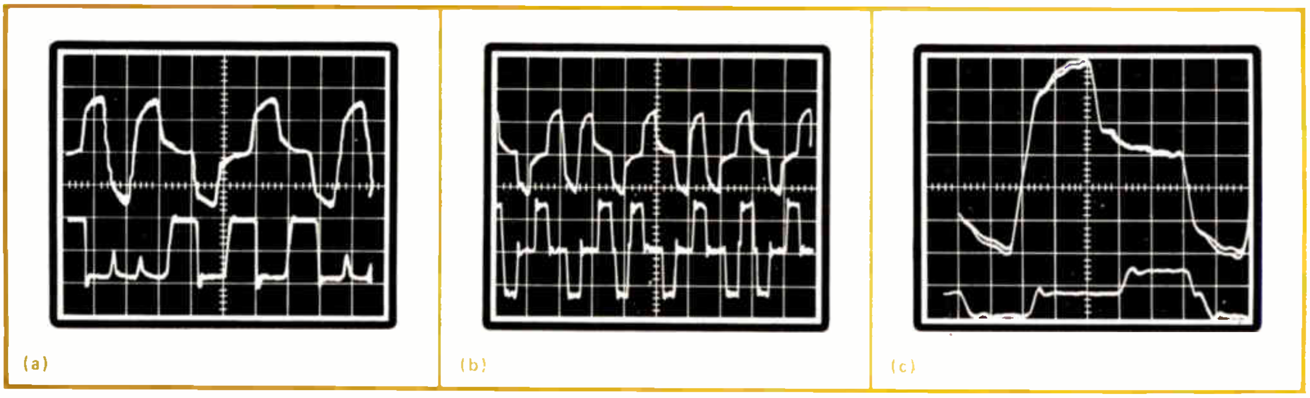
Thus, any digital transmission path longer than about 15 meters requires connector pins, transformers, drivers, receivers, and coding and decoding logic at each end.



1. Bipolar. Transformer coupling is made possible by the use of alternate-mark-inversion (AMI) coding of binary logic signals. Resulting waveform contains no dc components in its frequency spectrum.



2. Transformer coupled. Two-way communication is achieved by using a center-tapped transformer. Emitter-coupled-transistor configurations allow higher speeds, since saturation never occurs.



3. Twenty-megabit performance. Receiver accepts bipolar inputs (a, top trace) and converts them to standard TTL format (a, bottom trace) for use by a serial-to-parallel converter. Transmitted waveform (b, bottom trace) is well maintained (b, top trace) after transmission through 150 meters of coax. Amplitude (c) is attenuated little by the addition of one load on a line that already has three loads attached.

As a result, the use of parallel transmission can be quite expensive and unreliable. Moreover, timing skew problems between parallel transmission paths limit the speed of such a system to a transfer rate of about 400 kilohertz for each line.

Why serial transmission helps

Transmitting data serially, however, eliminates skew problems, and the transmission speed is limited only by that of the send and receive circuitry. In fact, transmission rates as high as 6 MHz are commonly used by the telephone industry to send pulse-code-modulated data over ordinary twisted-pair cables with repeaters spaced about one mile apart.

Other characteristics of serial transmission make it more desirable than parallel-line designs. First, the problem of crosstalk in large parallel-line cables is inherently reduced. And since only a single transmission line is needed in serial systems, the use of coaxial cable, which effectively reduces sensitivity to external noise, becomes much more economical.

The use of a serial bus also simplifies parity error checking. While parallel data is usually checked by relatively complex decoding circuitry, serial data is easily processed by a single flip-flop sequential counter as it arrives.

Pulse polarity patterns

In the prototype system, which demonstrates 20-MHz transformer-coupled transmission, a bipolar pulse format removes the dc component that characterizes the normal binary-pulse train. The coding system chosen was alternate mark inversion (AMI), which represents 1s by current flow in either direction, and current direction reverses with each successive logic 1 (Fig. 1). Of major importance is the fact that there is no dc component associated with the AMI format. Thus, AMI-coded data is easily transmitted through the transformer coupler.

Such a bipolar transmission also facilitates transmission-error detection. Erroneous pulses tend to violate the alternating polarity of the AMI pattern, and very simple circuitry in the receiver is easily capable of detecting such errors.

The transformer-coupled line-driver/receiver circuit for the bidirectional bus is shown in Fig. 2. A center tap on the coupling transformer offers a convenient method of implementing the bipolar format. The single transformer couples both send and receive circuits to the transmission line.

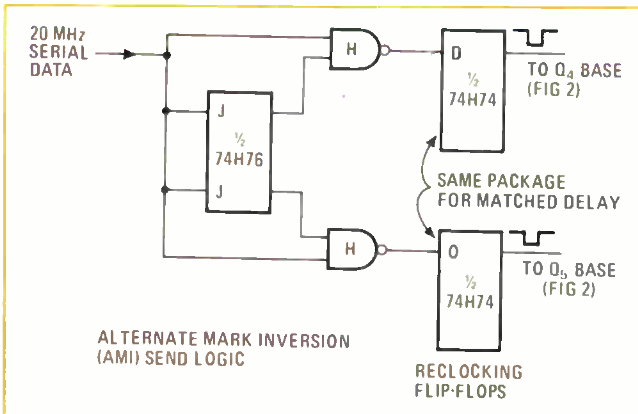
Both send and receive circuits use transistors in an emitter-coupled configuration. This allows the choice of almost any general-purpose transistor, even for the higher operating speeds, since transistor saturation never occurs.

A monolithic transistor-array package (3/5 of an RCA CA3045) is used in the receive circuit. Besides being economical, the matched-transistor integrated circuit allows accurate setting of the decision-level threshold at the base of Q_3.

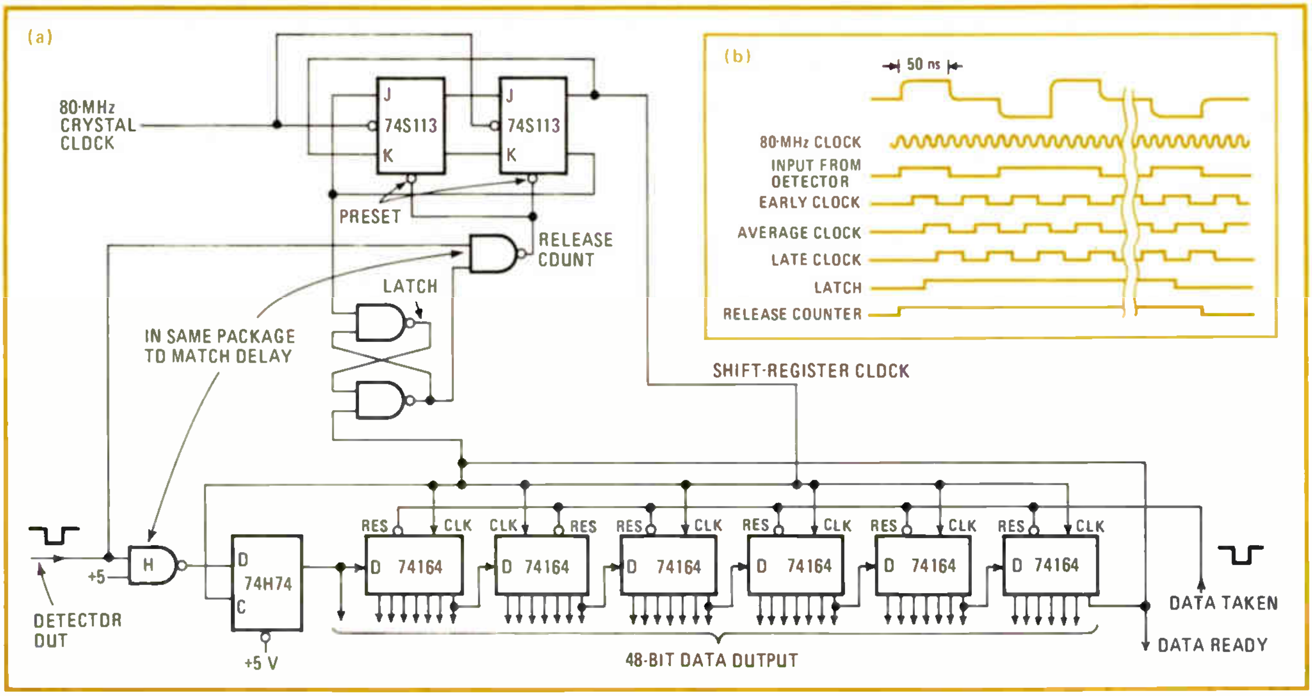
When the signal at the base of Q_1 or Q_2 is below threshold, a current through Q_3 results, placing a logic 0 at the input to the TTL inverter. When a logic 1 is received, the base of Q_1 or Q_2 (depending on polarity) goes more positive than the threshold voltage set at Q_3, causing Q_3 to switch off and place a logic 1 at the input to the inverter. A sample of the bipolar receiver input, and corresponding output of the inverting gate, are shown in Fig. 3a.

Send circuits

The bipolar send circuit in Fig. 2 is much like that described for the receiver, but it contains pnp transistors (2N2894). The current through R_2 flows through Q_6 to ground in the quiescent, or non-transmitting, state. To transmit pulses, however, input lines feeding transistors



4. Bipolar coding. Simple coding logic converts the unipolar serial data to the two-line format needed by the line driver in Fig. 2.



5. Back to parallel. Serial-to-parallel converter (a) prepares the received serial data for transfer to a parallel-data sink. Converter timing (b) synchronizes incoming pulses with an internal 80-MHz clock. Receipt of a bit at right end of register signals that register is loaded.

Q_4 and Q_5 alternately go negative. Thus, current through R_2 is diverted through Q_4 and Q_5 and into alternate sides of the transformer.

The resulting waveform (Fig. 3b, bottom trace) is well maintained, even after 150 meters of transmission through coaxial cable (Fig. 3b, top trace). The top trace lags by about 675 ns because of propagation delay in the transmission line.

The effect of loading by multiple receivers is illustrated in Fig. 3c. The amplitude of the waveform in the top trace is slightly reduced by the addition of one load on the line, which already has three loads attached. With this loading, a line with 16 receivers has about 60% the amplitude it had with a single load.

The original parallel output of the data source is changed to serial format for transmission simply by loading the parallel data into shift registers and clocking it out with a 20-MHz crystal clock. The circuit shown in Fig. 4 can convert the unipolar serial data to the two-line format that drives the sender in Fig. 2.

Some caution must be exercised to avoid timing distortion in the final logic stage, which drives transistors Q_4 and Q_5. To reduce such distortion, two flip-flops in the same package (such as the two halves of a 74H74) can be placed in each of these lines to reclock the outputs.

Receiver decoder

To convert back to parallel format at the data receiver, the circuit shown in Fig. 5 is suggested. Since each transmission commences with a logic 1 start bit, the leading edge of this pulse sets the proper phase for a shift-register clocking pulse. The 48-bit serial word is then clocked into the shift register in the same phase.

To accomplish this, a dual J-K flip-flop divides an 80-MHz crystal oscillator down to 20 MHz. This counter circuitry remains inactive until the start bit has been detected and the counter has consequently been released.

If after two 80-MHz clock pulses, the input bit is still present, a latch is set to prevent the reset to the flip-flops from being released until the start bit has progressed all the way through the 49-bit shift register. At this time, the 48 parallel information bits will be available for use by the data sink.

Depending on system requirements, additional logic can be used at each terminal for such functions as acknowledging received data and requesting retransmission. Such functions, however, are generally chosen independently from the type of transmission system and are therefore not considered here.

Farther and faster

The prototype serial transmission system will operate at distances up to 150 meters with a maximum of 16 terminals. However, by use of regenerative repeaters, the length of the data bus and the number of terminals attached can be extended indefinitely.

Each repeater contains two senders, two receivers, and reclocking logic. Thus, timing and voltage levels out of each repeater are fully reconstructed. An interlock between the two receivers in a repeater must also be included to disable the reverse channel for the duration of a message.

Even higher data-transfer rates can be achieved with multiple data channels. With three 20-MHz parallel channels, for example, 48 bits could be sent between two terminals in slightly more than 80 ns, plus propagation time.

Since each channel in such a three-channel link clocks its data independently, the problem of skewing between parallel transmission lines is overcome. After the start bits have been propagated to the final stage of each shift register, the 48-bit parallel data is ready for transfer into the data sink. □

MOS chip plus level-shifting circuit drives gas-discharge display

The low-voltage output of MOS calculator chips can be made to trigger a high-voltage display if the interface circuit is already maintaining the display electrodes near the potential necessary to fire them

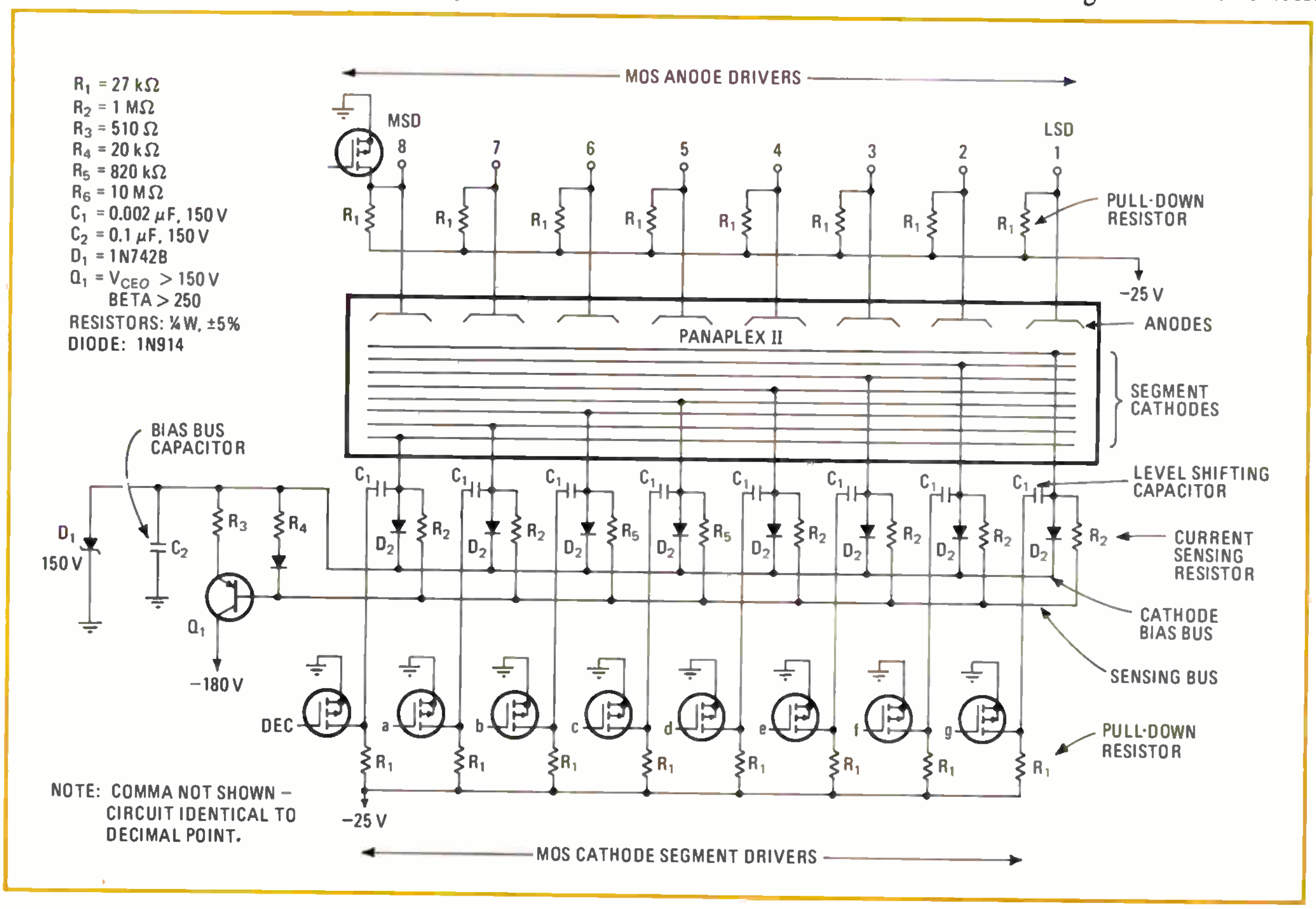
by James Y. Lee and Ed Lord, *Burroughs Corp., Electronics Components Division, Plainfield, N.J.*

☐ Although flat-cell gas-discharge displays have been on the market for several years, the high voltages required by such devices have hindered their use in desk calculators, where low-voltage metal-oxide semiconductors are the dominant technology. Changing that situation is a new interface circuit design. It provides a high enough voltage to trigger such a display, while at the same time limiting the voltage on the MOS elements that drive the display.

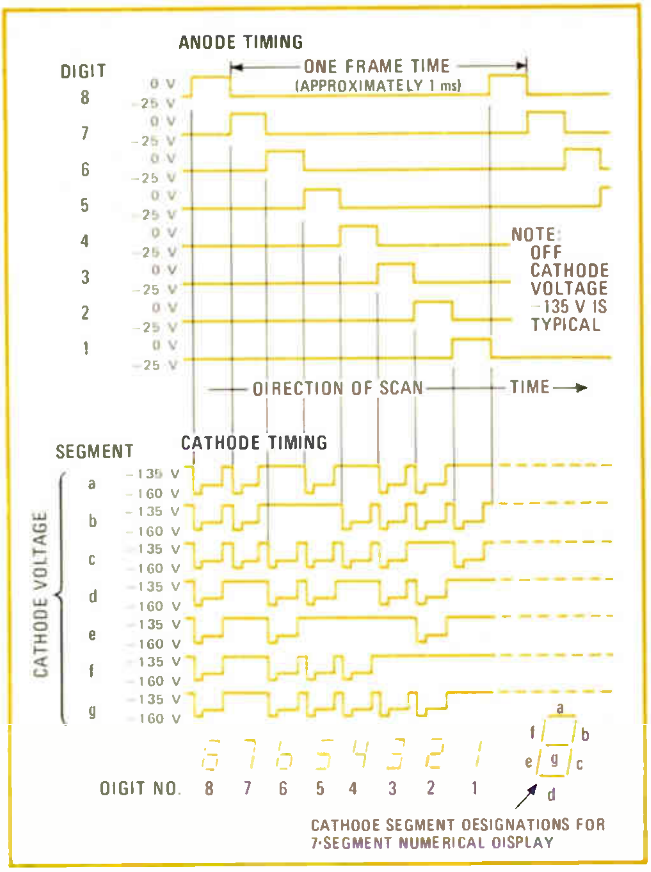
The trick is to regulate the voltage on the electrodes in the display about 50 volts short of the potential necessary to fire the tube. Then the MOS devices can swing the anodes up a mere 25 V and the cathodes down 25 V to provide the firing or ionization voltage.

The display for which the interface circuit was developed is the Panaplex II Panel (see "The search for the ideal display," p. 99). Each digit in the display has its own anode. The corresponding cathode segments of each seven-segment digit are tied together and brought out to a single terminal, so altogether there are only 10 cathode terminals for the seven segments, the decimal point, comma, and minus sign.

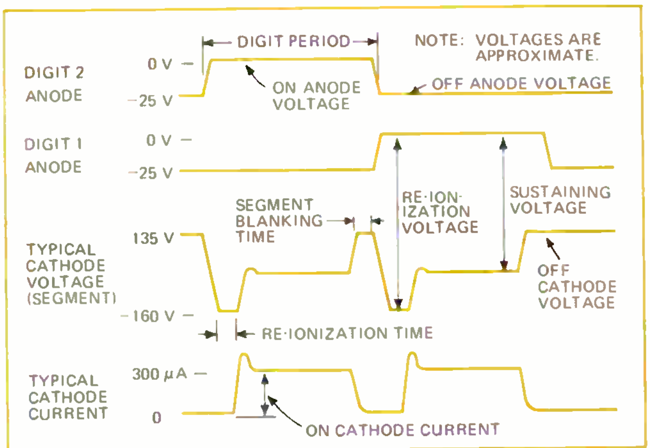
Because there are so few electrodes, a minimum of interface components are needed. As shown in the circuit in Fig. 1, the MOS anode drivers are the digit select devices. When a digit is off, its driver is off, and the anode is clamped to the −25-V bus by a pulldown resistor R_1. The MOS cathode drivers are the segment select devices,



1. MOS Interface. A self-regulating current amplifier Q_1 maintains capacitor C_2 at the cathode bias bus voltage. Capacitor C_2, in turn, recharges cathode level-shifting capacitors C_1. Voltage on the MOS anode drivers and MOS cathode segment drivers is limited to 25 V dc.



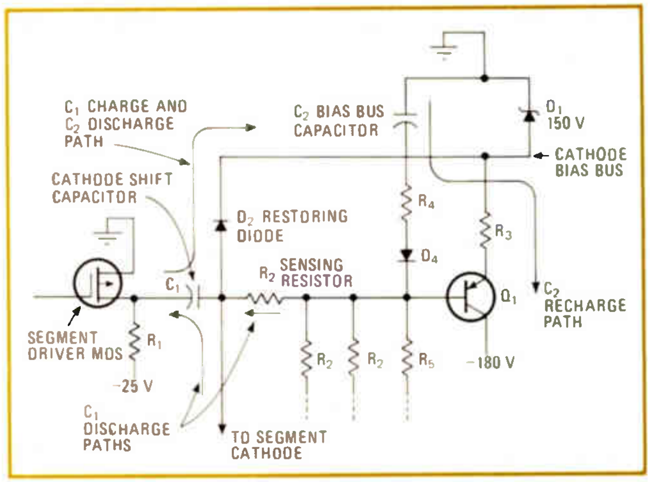
2. Multiplexed. Digits are scanned in reverse order by driving the digit anodes positive. Simultaneously, the selected digit segment cathodes are driven negative.



3. Waveforms. Each digit scan period is divided into portions for re-ionization, on-time and blanking. The blanking time enables the cathode shift capacitors to recharge in preparation for the next digit.

and each is coupled to a segment (decimal point, etc.) through a capacitor C_1. Under cathode-off conditions, the cathode segment is clamped to the cathode bias bus by diode D_2. The cathode bias bus potential is regulated by a feedback network at approximately -135 v.

The display timing shown in Fig. 2 represents a time-division multiplexed mode of operation with a scan period of approximately 1 millisecond. Each digit is strobed by driving the anode for that digit with a positive voltage pulse (from -25 v to zero) and by simultaneously driving the selected segment cathodes with a



4. Key capacitor. Capacitor C_2 maintains a cathode bias voltage of approximately -135 volts. Its function is to recharge the cathode shift capacitors during the blanking periods, and it itself is recharged during the re-ionization and sustaining time intervals.

negative voltage pulse (-135 v to -160 v). When this combination of events occurs, the potential exceeds the ionization voltage, and a glow discharge occurs about the selected segments. Following ignition, the anode-to-cathode voltage drops to the sustaining voltage. This voltage, shown in Fig. 3, is the voltage necessary to maintain the discharge.

The voltage and current wave forms are shown in detail in Fig. 3. Note that prior to the firing of a digit the anode-to-cathode potential is -25-(-135)V = 110 V.

Where the charge goes

The key to circuit operation is the cathode bias bus (Fig. 1), which is regulated at approximately -135 v (depending on the individual panel characteristic). This voltage is developed across bias bus capacitor C_2, which alternately charges from the -180-v power source and discharges into various C_1 capacitors through the companion restoring diodes D_2. The details of this charge-discharge sequence appear in Fig. 4.

When the circuit is first energized, the cathode bias bus voltage is at an arbitrary potential, V_{int}, and zero volts is across capacitor C_1. When the first segment is selected, the anode of this selected digit is driven from -25 v to 0v once every millisecond. Assume that only the decimal-point segment at the first digit is driven during the recurrent scans. The first cathode select signal drives the MOS driver for that segment into cutoff, thereby driving the C_1-R_2 node to -25 v (Fig. 4). The base of transistor Q_1 swings negative, and capacitor C_2 charges so that its voltage shifts from V_{int} to ($V_{int} - \Delta V$). However, this is insufficient to fire the segment.

The voltage developed across capacitor C_2 is sustained during the next scan, and when the decimal point is next scanned, a millisecond later, the same event occurs, driving the capacitor C_2 from ($V_{int} - \Delta V$) to ($V_{int} - 2\Delta V$). This continues until the cathode bus reaches approximately -135 v. Then the cathode shift capacitor C_1 shifts the segment cathode from -135 v to -160 v each time the segment driver MOS is driven into cutoff. When this shift occurs, the drain of the segment driver MOS is pulled down to -25 v. This swing fires the segment cathode, and C_1 partially discharges.

Toward the conclusion of each digit scan, a blanking signal is applied to each cathode (Fig. 3). This blanking signal, which is applied by the segment select circuits, pulls the cathode up to −135 V. During the blanking period, any cathode shift capacitor C_1 which has been active just prior to blanking is recharged by means of the restoring diode D_2, along the C_1 charge path shown in Fig. 4. The capacitor is then ready to perform another shift when the segment is again selected.

The cathode bias voltage is the same as the cathode-off voltage and is self-regulated when the system is in equilibrium. This regulated voltage is brought about because the cathode shift capacitors C_1, which discharge during cathode shifting, regulate the current flow from transistor Q_1 base through a like number of R_2 sensing resistors. (The number of capacitors C_1 that discharge equals the number of segments driven into conduction.) Therefore the charge restored to capacitor C_2 equals the amount of charge lost by capacitor C_1 through the

The search for the ideal display

When the boom in calculators became apparent, display manufacturers began aiming at the optimum design for a calculator display. Such a panel would:

- contain all digits in one envelope, so that no assembly time would have to be spent on straightening and aligning the digits.
- be directly MOS-compatible so that no interface circuits would be required.
- be low-voltage and low-power to reduce power supply costs.

No one has yet built the perfect display, but the Panaplex II Panel makes substantial strides toward it.

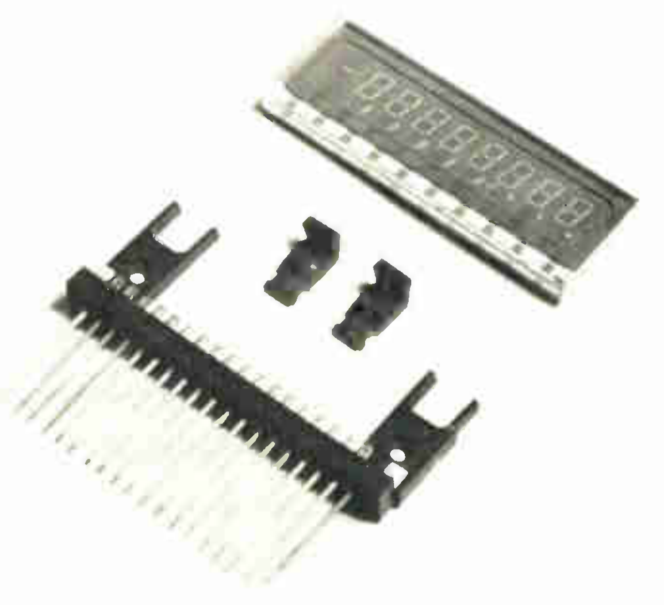
The Panaplex II is a gas-discharge panel display that can mount as many as 16 digits in a single housing. A 12-digit, 0.25-inch-character model is only 3.5 in. long, 0.9 in. high, and 0.2 in. thick (exclusive of the connector). Each digit is made up of seven segments, plus decimal point, comma, and minus sign.

As shown below, a conductive material is screened on a ceramic substrate to form the segment pattern. A black dielectric mask, also screened on the substrate, creates a light-absorbing background that serves to enhance contrast. The digits are neon red and can be read at a distance of about 15 feet.

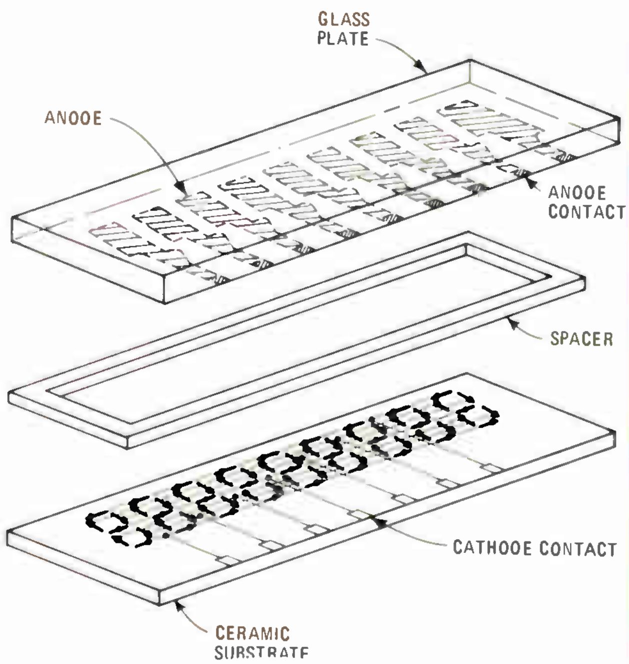
Transparent conducting anodes and anode contacts are applied to the top glass plate, and the plate and substrate are then sealed together, in sandwich fashion, with a spacer providing a hermetic chamber. The device is evacuated and filled with a neon-mercury gas mixture (the mercury reduces cathode sputtering and provides long life).

The interface circuit for the Panaplex II is designed for time-division-multiplex operation of the display. This means that the digits are addressed and illuminated, one at a time, in sequence, so that power need be delivered to only one digit at any instant. The segments require about 5 milliwatts each, and so the worst-case power requirement (assuming all were number eights and a decimal point, a minus sign, and a comma are on) is about 50 milliwatts. If the multiplex (or scan) rate is 80 hertz or higher, then operation will be free of flicker. At that frequency, each segment is refreshed often enough for the eye to be insensitive to the variations in its illumination level.

Direct MOS compatability remains out of reach. But the interface circuit described in the accompanying article provides direct capacitive coupling between MOS chip and display for a minimum of external components.



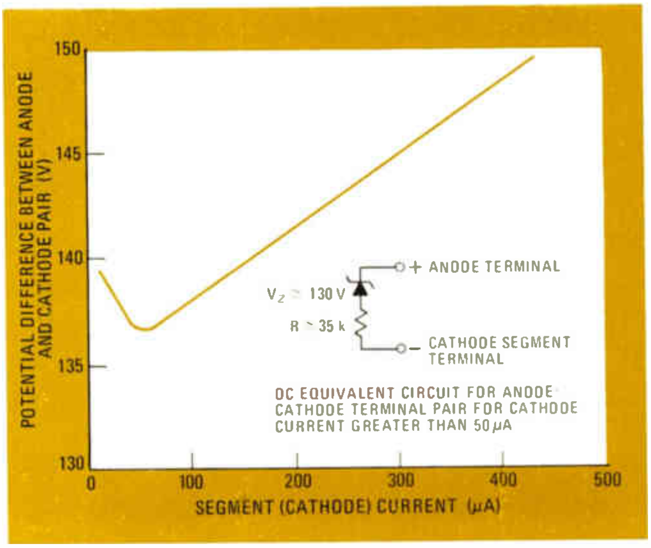
Packaged digits. Up to 16 digits may be enclosed in a single gas-filled package so that they are in permanent alignment. Entire device may be plugged into a companion socket.



Sandwich. Hermetic package, formed by a rear substrate with screened segment cathodes and glass plate with transparent anodes, become a multidigit, gas-discharge display.

Panaplex II Panel and the sensing resistor R_2. This same amount of charge is then transferred to the C_1's during the next blanking interval. This implies that the sum of all charges in all level shift capacitors and the cathode bias bus capacitor C_2 remains constant.

Once the system is in this equilibrium state, it will remain so. Should the cathode bias voltage become more positive than the equilibrium value, there will be a reduction of re-ionization voltage, and the re-ionization voltage will remain longer across the sensing resistor R_2 (see Fig. 4). This will result in a greater Q_1 base current time product which will thereby charge the bias bus capacitor more negatively. The condition is reversed if the restoring bus is more negative than the equilibrium value.



5. Dc behavior. The plot illustrates the volt-ampere characteristic of a single digit segment. The equivalent circuit applies for a current that is in excess of 50 microamperes.

In general, the volt-ampere characteristic of the anode and cathode pair (Fig. 5) is important because it enables a designer to select the proper current-limiting circuits. This current is 300 microamperes for the segments, the comma, and the decimal point, and is the value that ensures uniform cathode illumination of the chosen segments.

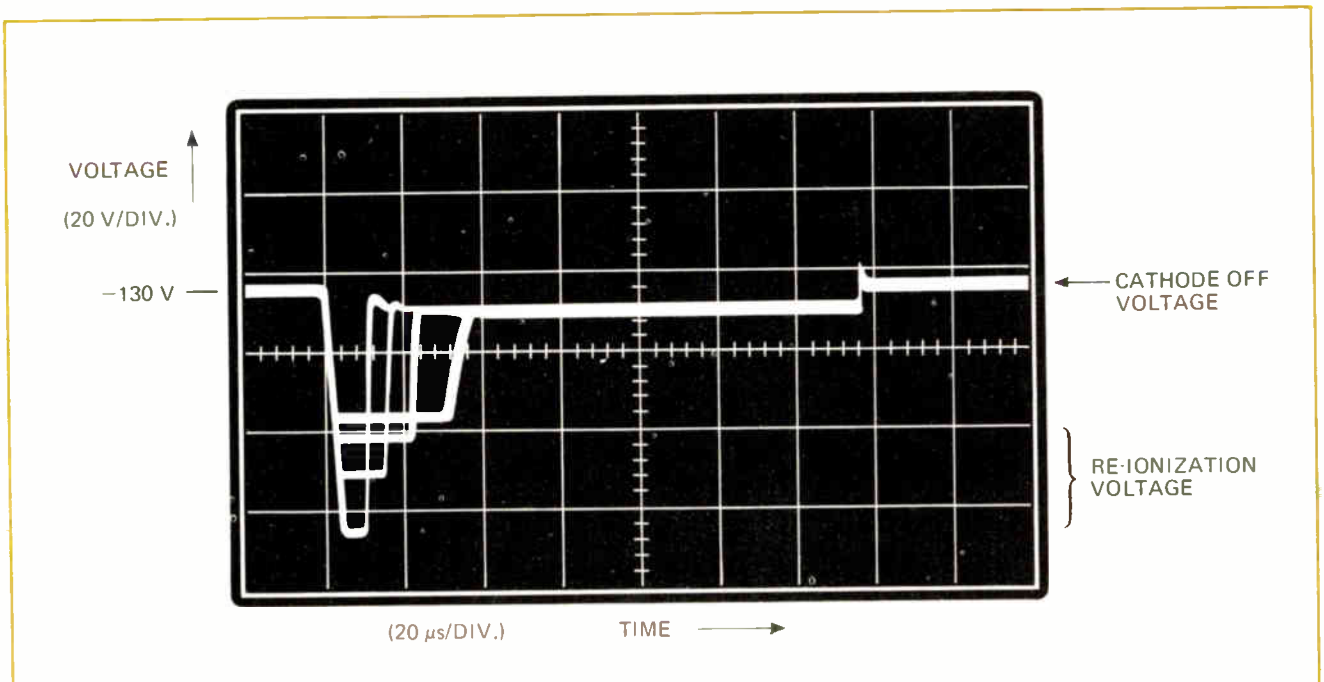
A useful portion of the curve is to the right of the knee, or where the cathode current is above 50 microamperes. A segment operated in this region may be approximated by a zener diode in series with a resistor, as also shown in Fig. 5.

Re-ionization time

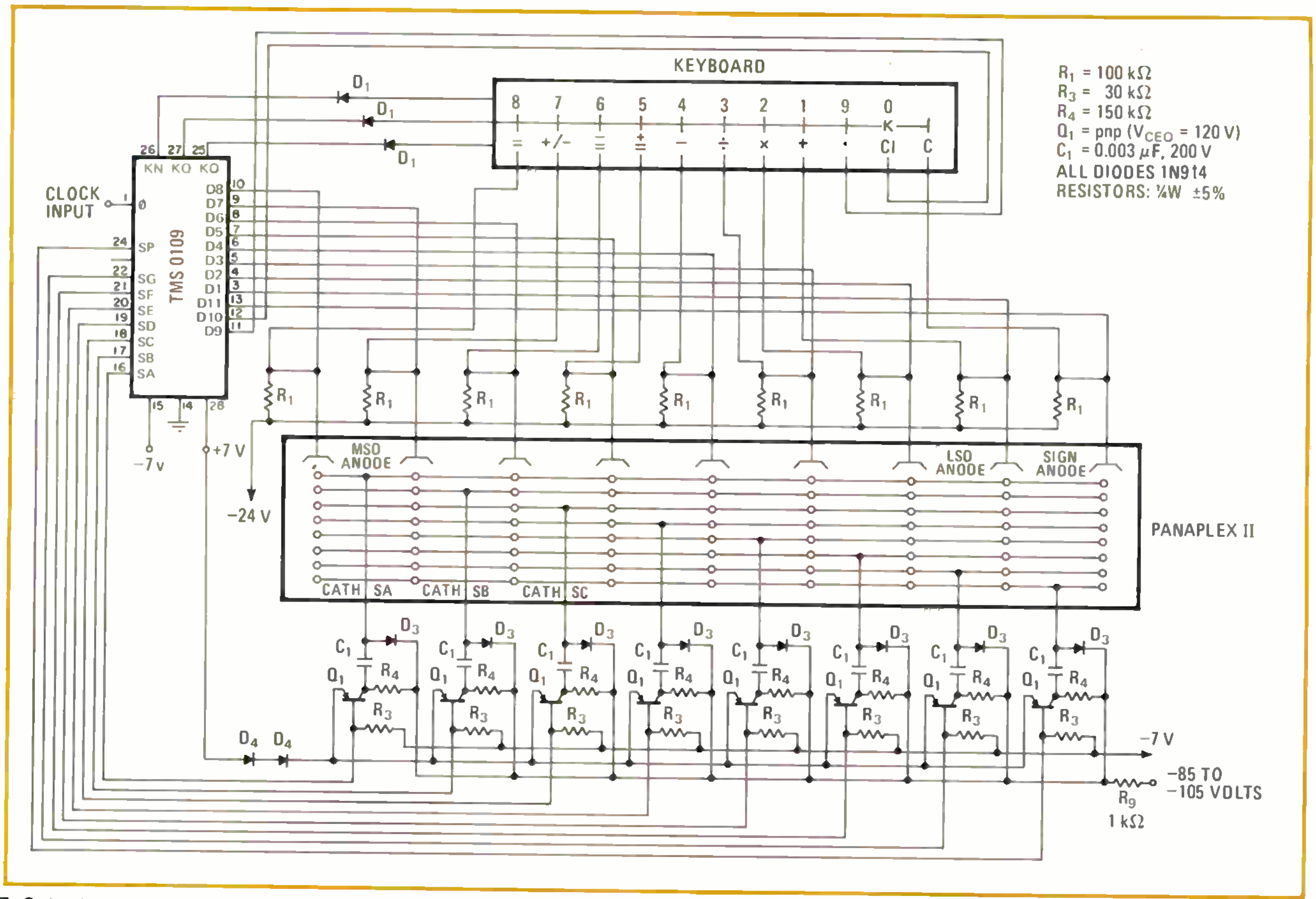
There is a time delay between the instant that the voltage is applied to a given segment and the instant that illumination occurs. This delay is important because it sets an upper limit on the rate at which the digits can be scanned by the multiplex circuits. If the scan rate is too high, then the segments will not glow at all or they will glow for too short a time to provide adequate illumination. This delay is termed re-ionization time.

Shown in Fig. 6 is an oscillograph of the segment cathode voltage which illustrates the re-ionization times for four different applied voltages. The voltage swings negative from –135 V to approximately –160 V to exceed the ionization voltage. After a re-ionization time of 10 to 30 microseconds, depending on the applied voltages, the segment is ignited, and the cathode voltage drops to a value determined by the volt-ampere characteristic of the circuit comprising the display and driver components.

The re-ionization delay time is a function of both the applied voltage and the availability of charged particles. In a multidigit display like the Panaplex II, charged particles are available from an adjacent digit, which means the delay is shorter for a given applied voltage



6. Re-ionization delay. A delay of approximately 20 microseconds occurs following application of the segment re-ionization voltage until conduction occurs. Nine-digit frame period is 1.224 milliseconds, digit period is 136 microseconds for this 0.25-inch-high-character display.



7. Calculator interface. Bipolar transistors interface the Texas Instrument one-chip calculator TMS 0109 with a Panaplex II display. Blanking is provided by the TI device. A doubler circuit (shown in simplified form in Fig. 8) develops a -180-V dc re-ionization voltage.

than if the digits were in individual envelopes.

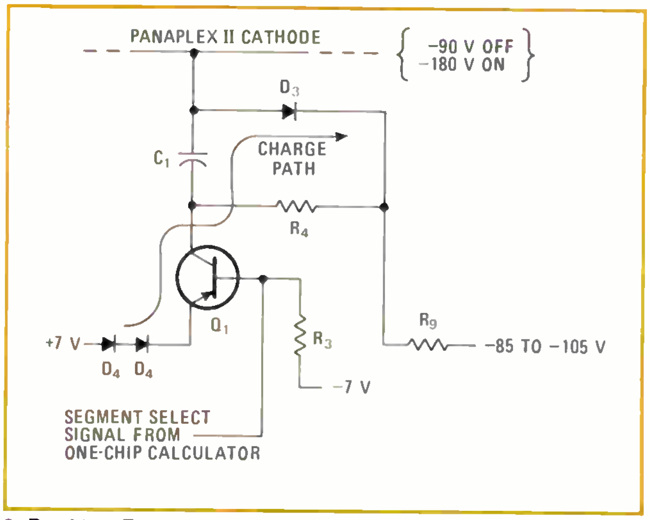
If a designer wants to reduce re-ionization time, then scan rate may be reduced, and/or applied voltage and cathode current increased. The reduction of re-ionization time with increased voltage is apparent in Fig. 6. Of course, decreasing the scan rate much below the recommended 80 hertz will introduce flicker. As for applied voltage and current, if the voltage is increased beyond the maximum limit of 250 v dc or if current is raised beyond 600 microamperes, then the life of the device will suffer.

Other factors that will increase re-ionization time are: the direction of scan when it is opposite the direction of data entry, and the reduced availability of particles that occurs whenever the preceding digit is blanked.

A one-chip calculator interface

Several different versions of this interface circuit have already been designed. The one shown in Fig. 7 was designed for the TI one-chip calculator TMS 0109. This MOS chip itself provides the cathode blanking required by this interface circuit. The anode is a direct-drive configuration with R_1 serving as the pulldown resistor from a -24-v dc bus.

The cathode drivers use a voltage-doubler scheme to provide the necessary cathode ionization potential. This is the sequence of events. When transistor Q_1 saturates, capacitor C_1 charges through diodes D_3 and D_4 to approximately -90 v (Fig. 8). Therefore, when Q_1 cuts off, the cathode is driven to approximately -180 v and triggers the segment. Resistor R_4 limits cathode current. R_3 provides base current to Q_1 during Q_1's on period.



8. Doubler. Transistor Q_1, capacitor C_1, resistor R_1, and diode D_3 perform as a doubler to develop the necessary potential to fire the Panaplex II segment cathodes. Firing occurs following Q_1 cut off.

The sign anode, which is usually located to the left of the numeric, is shown in Fig. 7 positioned on the right side of the Panaplex II. There are two reasons for this: the right-most character in this display does not function properly with the TMS 0109 if it is a digit; also, a single minus sign in the left-most position represents a difficult initial re-ionization condition. □

Converting a digital panel meter into a linear ohmmeter

by Jon L. Turino*
Xerox Corp., El Segundo, Calif.

For voltage and current measurements, digital panel meters are rapidly replacing analog meters in production test equipment. Resistance measurements, on the other hand, are still frequently being made with an analog meter, a resistance bridge, or a digital multimeter. But any standard voltage-type digital panel meter can be converted to a linear ohmmeter with the addition of a simple constant-current source. This not only eliminates many erroneous readings, but also makes a binary-coded-decimal output available for automated measurements.

The basic converter circuit is shown in the diagram. The value of the source resistor, R_S, for the field-effect transistor is computed from:

$$R_S = V_{GS}/I_D$$

where I_D is the drain current, and V_{GS} is the gate-source voltage:

$$V_{GS} = V_P[1-(I_D/I_{DSS})^{1/2}]$$

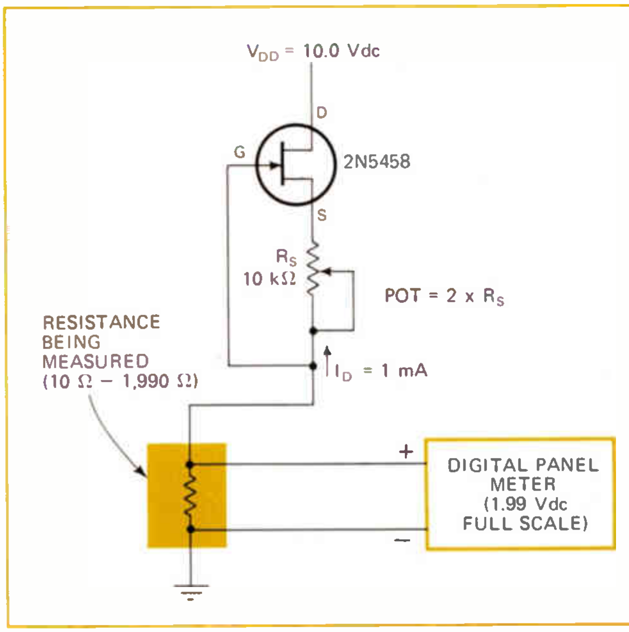
where V_P is the pinchoff voltage, and I_{DSS} is the zero-gate-voltage drain current.

The V_{DD} power supply should be selected to provide 2 to 3 volts across the FET, plus the required gate-source voltage for constant-current operation, plus the maximum voltage needed across the resistance being measured. The value of drain current I_D should be set at 1 milliampere, or some multiple or submultiple of this, to minimize conversion mathematics.

If more than one resistance range is needed, a switch to select different values of source resistance R_S can be added. A potentiometer that is twice the calculated value of R_S should be used instead of a fixed resistor. This permits the circuit to be calibrated and allows unit-to-unit variations in transistor parameters to be accommodated.

With the circuit shown, resistances from 10 ohms to 1,990 ohms can be measured with a 1-mA current source and a digital panel meter having a maximum full-scale reading of 1.99 volts. The test voltage for the resistors can never rise higher than 10 V, so that operator safety is assured and the front end of the meter will not be harmed. □

* Now with Tektronix Inc., Beaverton, Ore.



From voltage DPM to ohmmeter. FET constant-current source converts conventional voltage-measuring digital panel meter to linear ohmmeter. Resistance range, which can be made switch-selectable, is determined by value of source resistor R_S.

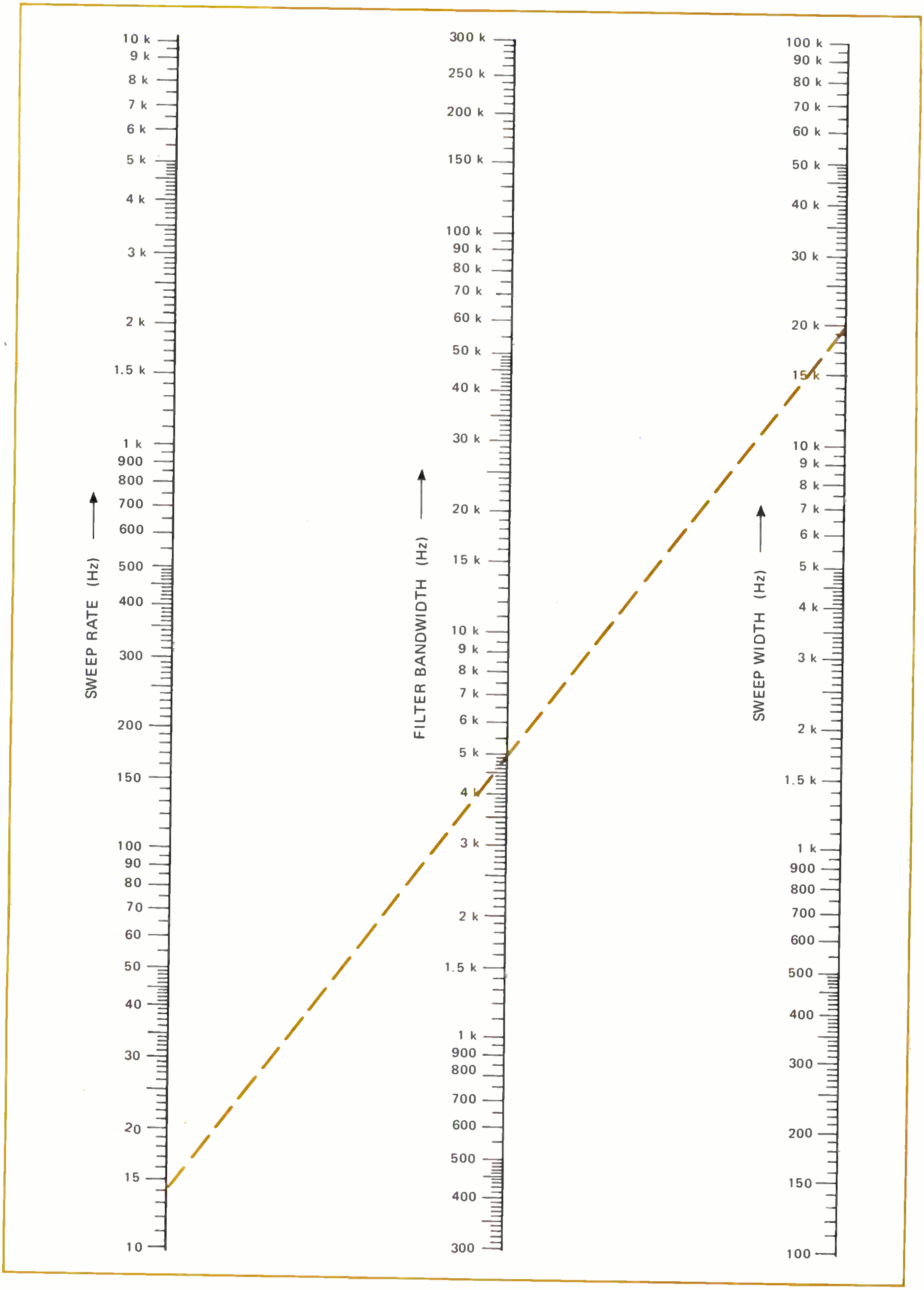
Filter bandwidth nomograph gives sweep-rate limits

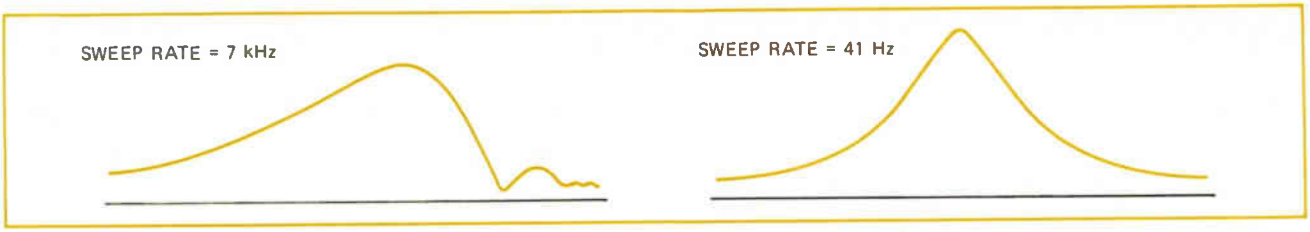
by Roger T. Stevens
The Mitre Corp., McLean, Va.

Because it is convenient, the sweep frequency generator is commonly employed to obtain the bandwidth and bandpass characteristics of narrow-band filters. However, these characteristics will be seriously distorted unless the proper sweep width and sweep rate are used. The nomograph shows the maximum permissible values of sweep rate and sweep width allowable to assure that the measured filter bandwidth will be within 1% of the true bandwidth.

The illustrated filter "characteristics" demonstrate the effect of too fast a sweep rate. When a filter having an 11-kilohertz bandwidth is tested at the excessively fast rate of 7 kHz with a 70-kHz-wide sweep, the apparent filter bandwidth is much wider than the true bandwidth, and the bandpass curve is highly distorted. But if the same filter is swept with a 7-kHz-wide sweep at a rate of 41 hertz, the shape of the bandpass curve and the bandwidth produced are the same as would be obtained by point-to-point measurements.

The explanation as to why this occurs is complex, but it can be simplified. Roughly speaking, the filter responds in turn to each instantaneous frequency during a very slow sweep; but for very fast sweep speeds, the in-


SWEEP RATE (Hz)
FILTER BANDWIDTH (Hz)
SWEEP WIDTH (Hz)



put that is applied to the filter begins to approach an impulse function, causing the filter to produce an output over the entire frequency spectrum.

The apparent bandwidth, B, of the swept filter is:

$$B = (4s^2 + b^4)/b$$

where s is the sweep rate in radians per second, and b is the true filter bandwidth in radians per second. From this equation, it can be seen that, as the sweep rate approaches zero, the apparent bandwidth is the same as the true bandwidth. For very fast sweeps, the apparent bandwidth is larger than the true bandwidth.

For most measurement applications, it is desirable to keep the apparent bandwidth within 1% of the true bandwidth. By substituting $B = 1.01b$ in the above equation (to achieve the 1% accuracy) and converting from radians per second to hertz, the product of the sweep width (W) and sweep rate (R) becomes:

$$W \times R = 0.01128b^2$$

This equation is represented by the nomograph.

To use the nomograph, simply draw a straight line connecting the desired points. Remember that the figures given for sweep rate and for sweep width are maximum permissible values, while those given for filter bandwidth are the minimum permissible values.

As an example, let expected filter bandwidth be 5 kHz, and, to show the significant portion of the bandpass curve, let sweep width be 20 kHz. The dashed color line drawn across the nomograph indicates that the maximum permissible sweep rate is 14.5 Hz. Therefore, if a commercial sweep generator with a 60-Hz sweep rate were used to check this filter's characteristics, the results would be highly distorted. □

C-MOS gate package forms adjustable divider

by David Newton
Abbott Transistor Laboratories Inc., Los Angeles, Calif.

A single complementary-MOS package—like RCA's type CD4001 quad two-input NOR gate—is readily connected as an even-order digital frequency divider circuit. The division modulo, N, is easily varied by adjusting an external potentiometer.

The circuit accepts pulses at frequency f_1 and generates complementary square waves at frequency f_2:

$$f_1/f_2 = N$$

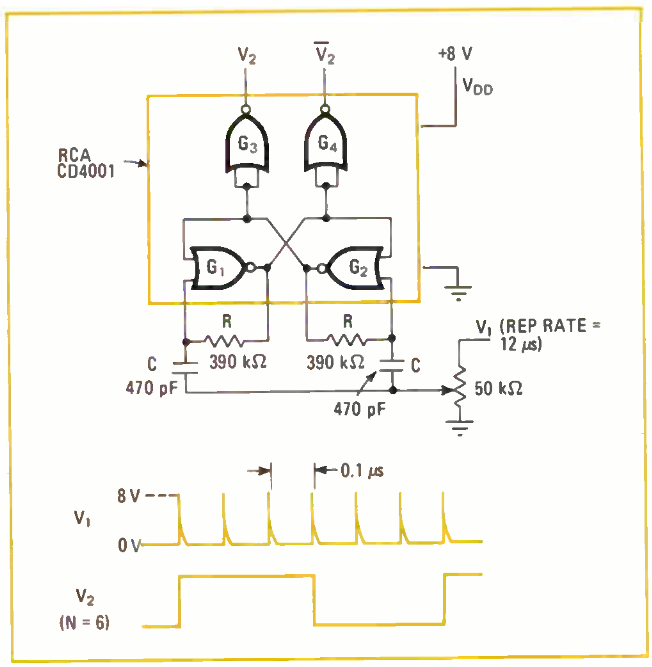
where N is an even number. Two of the four gates in the IC package, G_1 and G_2, are cross-connected in a simple bistable latch configuration.

The feedback resistors (R) permit the capacitor (C) at the input of the gate that is enabled to charge to the supply voltage. Input pulses are then steered to the inhibited gate, causing the latch to change state, in the simplest case, on every pulse (modulo 2).

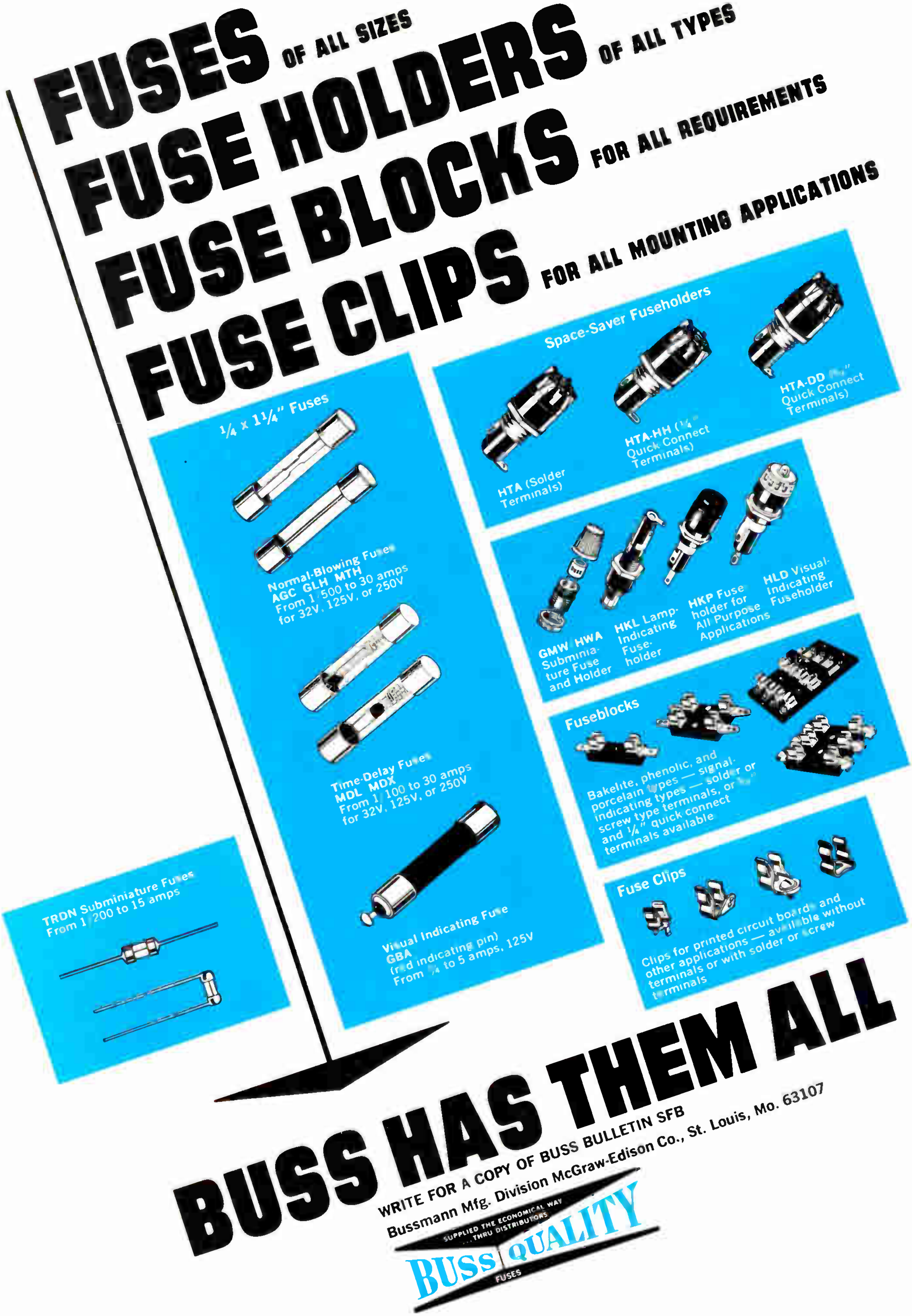
For higher division ratios, the 5-picofarad capacitance inherent at the input of each MOS gate is put to work. The potentiometer decreases input pulse amplitude so that the pulses can be integrated by the inherent capacitance of the inhibited gate. The latch, therefore, will change state only every four, six, eight, or more pulses. (The limit is determined by the allowable system noise margin.)

Naturally, the value of modulo N is a function of input pulse amplitude, operating voltage, and discrete component values. For the circuit shown, N can be varied between 2 and 30 with the potentiometer. Gates G_3 and G_4 are used to correct for the signal droop that occurs at the outputs of gates G_1 and G_2 as N approaches its maximum value. □

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.



C-MOS digital divider. Even-order frequency divider consists of two C-MOS NOR gates, G_1 and G_2, which are connected as a simple latch. Division modulo N can be varied from 2 to 30 by adjusting the potentiometer. For high values of N, inherent capacitance of MOS gate is used to integrate input pulses and keep latch from changing state. Gates G_3 and G_4 act as output pulse shapers.



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FUSE BLOCKS FOR ALL REQUIREMENTS
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for 32V, 125V, or 250V
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MDL MDX
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for 32V, 125V, or 250V
Vi ual Indicating Fu e
GBA
(r d indicating pin)
From to 5 amps, 125V
TRON Subminiature Fu e
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HTA-HH Quick Connect Terminals)
HTA-DD Quick Connect Terminals)
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Isolation plus gain equals an isolated amplifier

If you're using an optically coupled isolator to get good circuit isolation and following it with a discrete transistor to get good gain, you should check out the new **isolators that have the high-speed transistor built right onto the chip.** For example, Hewlett-Packard's 5082-4350 isolator can give you 2,500 volts of isolation, as well as a typical current gain of 100. This device is **ideal for building an optically coupled ac amplifier:** the isolator, put between the output stage and the load, perfectly decouples the amplifier circuit from the load.

TI extends more design help to the weary

TI's Information and Automation Service division is now making available to outside customers the **design automation system that it's been using to debug its own computer designs.** It used only to offer TTL chip and pc board layout assistance, but it has now been expanded to include such design aids as circuit analysis, package partitioning, design documentation, and, **most important, design simulation.**

The service is fast—typically five weeks from submission of logic diagrams to prototype pc board—and even faster service may be arranged. Contact Karl W. Hunter, P.O.B. 5012 M/S 907, Dallas, Texas 75222.

Panel meter adds another digit

Equipment makers who've been forced to use an expensive digital multimeter for five-digit resolution because they couldn't get their hands on a panel meter with more than four digits are about to have their problems solved: Data Precision, Wakefield, Mass., is now offering **a 5½-digit panel meter at a lower price than the equivalent multimeter.** The first of a new 3000-series panel-meter line, the 5½-digit DPM is a stripped-down version of the company's 2000-series DPMs. You can see it at Data Precision's booth this month at IEEE Intercon in New York's Coliseum.

Clean up those messy grounds

For those breadboard designs that seem always to need just one more ground, Appleton Electronics, 1701 Wellington Ave., Chicago, Ill. 60657, is offering **a ground terminal block** which accommodates up to ten crimp-type pin contacts. **The ground contacts can be removed and inserted at will** into the block, which mounts (and grounds) to a 10⅜-inch stud.

Ohm's law creates precision ammeter out of any voltmeter

Remember Ohm's law? The schoolroom way of using it to turn a voltmeter into an instant ammeter is still valuable. Sensitive ammeters are expensive, but even **the cheapest of today's voltmeters have precision input resistors that can convert them into good ammeters.** Indeed, when used on its most sensitive scale, the ordinary bench voltmeter can measure currents **accurately down to the picoamp range.**

For those quick odd-lot buys

Got a hot tip and need a fast broker to take an odd-lot order? Write the New York Stock Exchange, P.O. Box 1971, Radio City Station, N.Y. 10019, and ask for its "directory"—a list of 392 brokerage firms in 807 cities in 50 states **that handle transactions of less than 100 shares.**

Push-button promises.

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A Fairchild career...more than a pretty package.

New products

Flexible circuitry has strong anti-peel

Copper foil in composites for multilayer boards, hybrids, other packages offers peel strength between 3 and 5 pounds per lineal inch at 500°F

by Stephen E. Grossman, Packaging & Production Editor

After serving an apprenticeship in military and aerospace applications, flexible circuitry is becoming increasingly popular among high-volume commercial users when space weight-saving and ease of assembly are important.

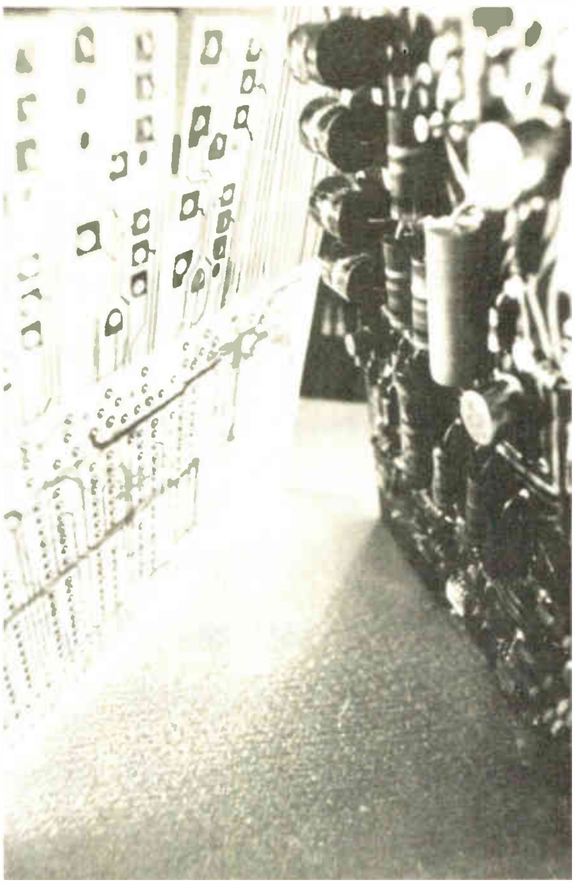
Fabrication of flexible circuits, however, has been plagued by separation problems in which the copper foil "swims" or peels free from its polyimide substrate. To minimize this problem, Du Pont's Industrial Products division has developed a new line of flexible circuitry, called Pyralux, that provides peel strengths ranging from 8 to 12 pounds per lineal inch, and the company says this kind of performance represents a 50% improvement over many earlier systems.

"What's even more important," says Jerry Ansul, development manager for the Du Pont division, "is that the peel strength remains 3 to 5 pounds per lineal inch at solder-pot temperatures (500°F). By contrast, most systems drop to very low strengths—typically 1 to 2 pounds—when raised to this level of temperature."

The high-temperature resistance of the Pyralux system will permit the circuit manufacturer to better use other properties of the polyimide film than those of similar composites, Du Pont says.

Dimensional stability in the surface plane results in a variation of less than 2 mils per inch following etching and heating at 250°F.

Du Pont says the electrical properties of the composites for the flexible circuits are essentially the same as those of Kapton film, also that the flexible composites have good mechanical properties, particularly flexibility and cohesive strength, good chemical resistance, and good but not excessive flow during lamination.



Flexible composite. Materials system at left can be adapted for flexible printed circuits, multilayer boards.

The composites can be used for flexible printed circuits, both single and multilayer, as well as for hybrid (a combination of flexible/and rigid) printed-circuit boards.

The product line is designated WA/K and includes flexible metal-clad laminates (Kapton polyimide film bonded to copper foil), adhesive-coated polyimide cover sheets, and bond ply and unsupported sheet adhesive.

Single-layer and double laminates are available in combinations of 1-, 2-, 3-, and 5-mil polyimide and ½-ounce, 1-ounce, 2-ounce, and 3-ounce copper foil. The material is able to withstand solder reflow temperatures of 450°F for 10 minutes without blistering or delamination.

Pyraflux clad laminates are available in development quantities in 12-inch-by-12-inch and 12-inch-by-24-inch sizes. Pyralux bond ply and cover sheet can be supplied in roll form (24 inches wide) or sheeted.

Du Pont recommends the following multilayer lamination cycle: pre-dry both the etched circuitry and the bonding plies for 10 minutes at 100°C; laminate with pressures ranging from 200 to 400 pounds per square inch at 350°F to 500°F for 10 to 30 minutes; then cool the laminate prior to pressure release.

Du Pont claims that the coefficient of thermal expansion in the Z (thickness) axis is far lower than with conventional systems and is essentially linear to 275°C.

Du Pont's Industrial Products Division, Du Pont Company, Wilmington, Delaware 19898 [338]

DPM entry rides on 3-year warranty

Varian enters panel-meter race with one of smallest instruments in field; power dissipation is less than 1 watt; family includes 16 models

by George Sideris, San Francisco bureau manager

What's up front is not what counts most in a line of digital panel meters that marks the entry of Varian Associates into that bustling sector of the instrument market. Each of the 16 DPMs produced by the company's Velonex division has a light-emitting-diode display, but behind this is a self-calibrating digital voltmeter that is approximately the size of a pack of cigarettes and guaranteed to satisfy for three years.

The cigarette analogy is not too far-fetched. When Velonex—better known for pulse generators and high-voltage power suppliers—decided to get into the DPM business, its first step was a survey of DPM users. The survey revealed that, unlike cigarette smokers, DPM buyers have little brand loyalty. Many of them change suppliers annually, seeking instruments that are smaller, easier to use, and more reliable than the previous year's models.

After digesting this information, Velonex design engineers developed the concept that is now the family name—Impac, for instrument meters packaged as components—each member of the family weighs only 3½ ounces.

The volume of the Impacs behind the panel is about 3 cubic inches, and power dissipation is below 300 mW in the "blanked" mode, in which the display is operated at a very low duty cycle, providing a dim but usable readout. Three factors—a low component and connection count, a lack of high potential gradients, and low power dissipation—have led reliability engineers to conclude that the DPM could operate without failures for more than three years.

Velonex, therefore decided to break with tradition and lengthen the warranty from the usual six months or one year to three years. There is one slight catch—the rated operating temperature is 0°C to 50°C, while many industrial panel meters are specified to 60° C.

The Impacs avoid the necessity for frequent manual adjustment by automatically resetting the linear circuitry to zero before each measuring cycle to compensate for any short-term drift. The only required manual adjustment is a full-scale calibration every three to six months, Velonex says.

The basic meter takes supply inputs of +5 V and -12 V, which are standard voltages in many instrumentation and control systems. Power modules, about half the volume of the instrument, convert +5 V dc, 115 V ac or 230 V ac to the standard input voltages. The modules either can be piggybacked onto the instrument or mounted separately.

There are four series in the family, each with four voltage ranges, running from 200 mV to 200 V full scale. Over-voltage protection runs from 25 V to 500 V, depending on full-scale range. If the full-scale voltage is exceeded, the display will blink to indicate an over-range. Plus and minus voltages are measured.

The four series are: series 30, 3 digits; series 35, 3½ digits; series 40, 4 digits; and series 45, 4½ digits. Accuracies are to within 0.1%, 0.05%, 0.02%, and 0.01% of full scale, respectively, and 0.1%, 0.1%, 0.05%, and 0.05% of reading. The temperature coefficient is 0.01%/°C.

Sample rates are: series 30 and 40, 10 samples per second; and series 35 and 45, seven samples per second. Digital-control inputs include convert-and-hold, display, and sign-blanking. Outputs are BCD signals, strobe, end-of-conversion, sign, and overload.

Prices for single units are: series 30, $112, dropping to $89 in 100-lots; series 35, $125, dropping to below $100; series 40, $169, dropping to $135; and series 45, $225, dropping to $174.

A 5-V power module costs $6, and a line-power-converter module, $7. Modules that will power multimeter systems are available on special order.

Varian Velonex Division, 560 Robert Ave., Santa Clara, Calif., 95050 [339]

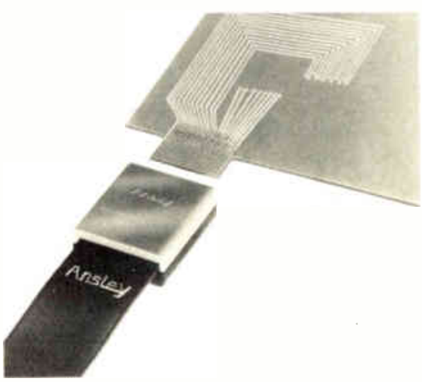
Components

Connector mates flat cable, pcb

Molded nylon assembly terminates 1-nanosecond transmission line to board

A general complaint among users of flat cable is the shortage of commercial-grade connectors. One answer is offered by Ansley Electronics Corp. with its series 607 connector. The unit was designed primarily for Ansley's Black Magic cable, a 20-channel, 50- and 93-ohm transmission line which the company says handles the 1-nanosecond-rise-time signals with extremely low, far-end cross-talk. The new connector will also terminate conventional flat cable used in less critical applications. Also, connector-pairs can be furnished to connect to lengths of flat cable.

Joseph Marshall, director of research, points out some of the attractive qualities of Ansley's new connector: "The high density (50-mil spacing) connector employs preloaded bifurcated beryllium contacts. The bifurcation ensures reliability because contact interconnection is redundant, while preloading ensures that adaquate contact pressure is applied when the connector is mated to either 35-mil or 62-mil printed-circuit boards." The housing is molded of glass-filled nylon in two colors so that polarity can be observed when mating either board or connector. The contacts are plated with 20 microinches of gold and rated at 0.5 ampere for a 6°C rise. The voltage drop at 0.5 A is 5 millivolts maximum. Board insertion depth is 0.330 inch, and insertion forces are 3.10 pounds for a 0.035-in. board and 6.21 lb for a 0.062-in. board. Ansley supplies both connectors and companion flat cables. In addition, the company can supply complete cable assemblies ready for installation.



Ansley Electronics Corp., a division of Thomas & Betts, Old Easton Rd., Doylestown, Pa. 18901 [341]

TV-tuning tube is a neon-filled diode

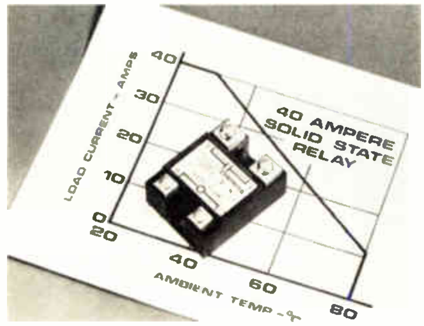
A subminiature tube for television touch-control tuning and channel indication, designated the model

ZA1006, is a neon-filled diode. A large and stable difference between ignition and maintaining the voltages permits a reliable response when triggered by the body impedance of the person who touches it. The unit has no moving parts, and operation is silent. Switching is faster than in mechanical devices, and switch status is self-indicating.

Amperex Electronic Corp., Hicksville Division, Hicksville, N.Y. 11802 [380]

Solid-state relay is rated at 40 amperes

A solid-state relay achieves a 40-ampere nominal rating when operating on a 1°C-per-watt heat sink in a 30°C ambient temperature. The unit can be used for switching 120 or 240 volts and operates with ac or dc signal inputs. The relay will operate as high as 60 A continuously when operated on a heat sink that will hold the case at 50°C max-

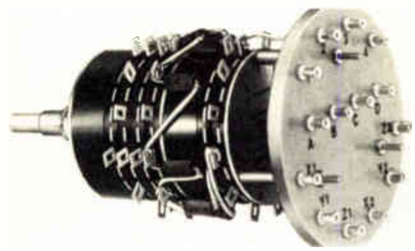


imum. Surge rating is 500 A rms for one cycle and 110 A for 0.5 second. Package size is 2.25 by 1.75 by 0.9 inches. Unit price for the model D1240 in quantities of 100 is $24.

Crydom Controls Division, International Rectifier Corp., 1521 Grand Ave., El Segundo, Calif. 90245 [343]

Attenuator is completely sealed

Using close-tolerance resistors, an attenuator developed by the Specialty Switch Engineering Department of RCL Electronics is completely sealed to eliminate problems

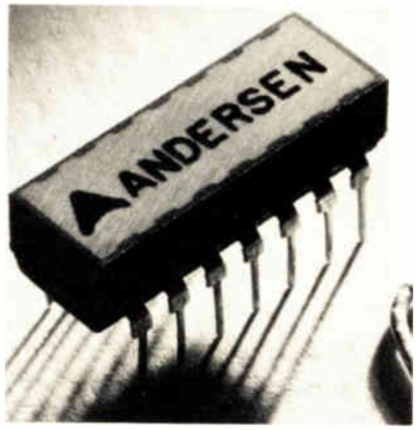


caused by dust, humidity, and corrosive atmosphere. The unit, which includes a concentric shaft, is a 20-step device with linear control. The attenuator is designed approximately 65% smaller than comparable units.

RCL Electronics, 700 S. 21st St., Irvington, N.J. 07111 [346]

Delay lines are designed for computer applications

Packaged in dual in-line cases, lumped-constant delay lines are intended for computer applications. The units range in delay from 10 nanoseconds to 200 ns, and taps are located at increments of 10% of total



delay. Tolerances on delay are ±5% or 1 ns, whichever is greater. Attenuation is less than 0.5 dB and the units are designed to operate over the −55°C to +85°C temperature range. Price is $10 each in small quantities.

Andersen Laboratories, 1280 Blue Hills Ave., Bloomfield, Conn. 06002 [345]

Beam-lead trimmers can replace chip capacitors

The series 9401 beam-lead trimmers feature Qs of greater than 10,000 at 100 MHz and have lead configurations suitable for stripline, hybrid-circuit, and printed-circuit-board mounting. The units can replace many chip capacitors and provide a means of trimming without cut-and-try adjustment techniques that use abrasives. Applications include impedance matching and trimming solid-state circuits. Five models have values ranging from 0.2 pF to 4.0 pF. Price is 95 cents in volume.

Johanson Manufacturing Corp., 400 Rockaway Valley Rd., Boonton, N.J. 07005 [344]

High-voltage capacitors are reduced in size

The size of tubular high-voltage capacitors, ranging from 1.0 kV dc to 200.0 kV dc, has been reduced 20 to 40% below that of competing products. The PHV series, featuring rigid phenolic housing, and oil-impregnated and oil-filtered types, which are hermetically sealed, operate at 85°C without derating. A typical capacitor of 0.005 microfarad rated at 10 kV dc ±10% costs $2.37 in 100-lots. Delivery of the high-voltage capacitors is from stock.

The Elmag Corp., 54 Clark St., Newark, N.J. 07104 [349]

Cermet trimmers are rated to 1 megohm

The 522 series of ½-inch rectangular cermet trimmers has values ranging from 10 ohms to 1 megohm. The series measures 0.50 by 0.17 by 0.10 inch and offers infinite resolution, ±100 ppm/°C coefficients, and has an operating temperature ranging from −55 to +150°C.

Weston Components, Archbald, Pa. [350]

Keyboard switch offers millions of operations

A single-pole, Form A, momentary-contact keyboard switch, number 261-0100, is not affected by exposure to moisture-resistance tests or thermal-shock environment. Life tests have indicated no significant changes in switch resistance, contact bounce, or operating characteristics after 100 x 10^6 operations. Price without key cap is 29 cents each in 250,000 quantities.

Cherry Electrical Products Corp., 3600 Sunset Ave., Waukegan, Ill. [348]

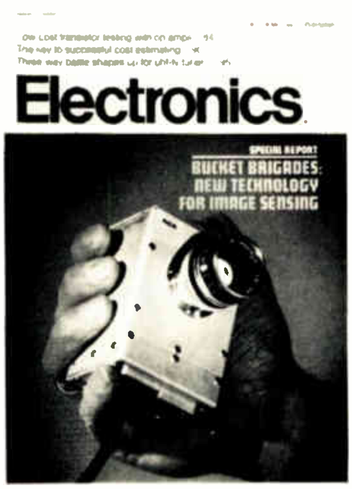
Trimming potentiometers have clear tops

Standardizing an option previously available only by customer specification, the series 3800 trimming potentiometers are now available with clear tops at no extra cost. The semitransparent tops, which allow easier contact-carrier inspection and setting, also permit a saving in time and money in servicing printed-circuit boards. The ¾-inch devices are designated Vista Trim.

Amphenol Connector Division, Amphenol Controls Operations, 2801 S. 25th Ave., Broadview, Ill. 60153 [347]

24,940 KEY PEOPLE WHO DON'T READ THESE,

READ THIS.



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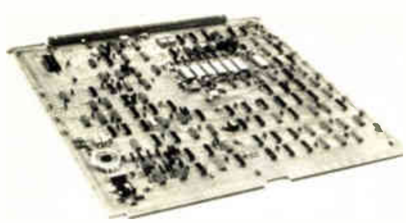
Data handling

Display controller built for Novas

Circuit board allows user to choose among keyboards, cathode-ray-tube displays

Lexicon Inc., of Waltham, Mass., has developed a low-cost CRT keyboard input-output controller on a single large printed-circuit board that is plug-compatible with Data General's line of Nova minicomputers. Called the Lexiscope 2000, the unit can be purchased as a circuit board alone, without either CRT or keyboard. Its operation is flexible enough to enable users to pick and choose among off-the-shelf and custom keyboards, as well as displays. The Lexiscope 2000 circuitry accommodates any TV-monitor display with a bandwidth of 11 megahertz and any of a variety of synchronizing formats.

The unit generates up to 25 lines of text at 80 characters per line, refreshing displayed alphanumeric materials from its own random-access IC memory 60 times per second.



The characters are in a 5-by-7 dot matrix, and a 64-character ASCII font is standard; a 128-character font is available as an option to quantity purchasers.

The Lexiscope 2000 is fully buffered, takes less than 15 minutes to install, and no elaborate reprograming is necessary. The controller has been designed to use the Nova DATA-IN and DATA-OUT instructions, and it includes decode logic, which enables users to edit text—also through standard instructions.

Since display operations are triggered through software, they are performed quickly. The system's basic character-transfer rate is 4.4 microseconds per character, and the longest editing operation—insertion or deletion of a line of text—takes an average of only 32.3 milliseconds. Most operations take tens of microseconds or less.

To the OEM, the Lexiscope board offers an opportunity to configure computer-terminal systems in an unconstrained fashion. The board derives its power from the Nova's mainframe, using 2.8 amperes at +5 volts and 40 mA at +15 V. As many boards can be added as the Nova's power supply can support and its back panels can accommodate. The Lexiscope can drive up to five duplicate displays simultaneously, and more if line amplifiers are used.

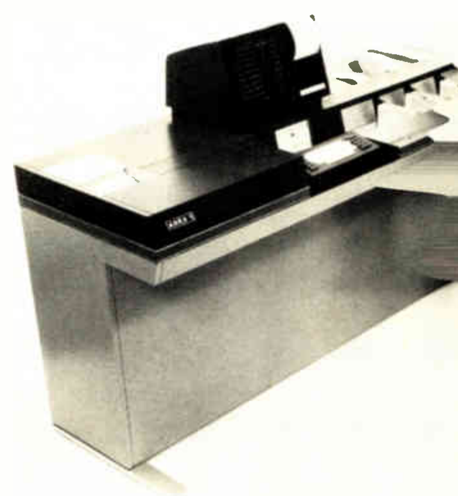
Why are RAMs used for display refreshment rather than more common shift registers? Francis Lee, president, points out that cyclical shift registers have a built-in latency time, but RAMs are faster because desired data can be accessed or changed directly without electronically riffling through unwanted material. The RAMs also make programing easier, removing the worry about mainframe interrupts.

Users need not sacrifice teletypewriters in favor of video with the 2000. The teletypewriter can remain as a hard-copy printout device, and its keyboard can be used directly as a Lexiscope input console. The Lexiscope board costs $1,585 in single units, and a suggested 12-inch display, including keyboard, adds $600. The Lexiscope system also has editing features. Prices drop by about one-third in OEM lots.

Lexicon Inc., 60 Turner St., Waltham, Mass. 02154 [361]

Data system reads hand-written numerics

An automated data entry system is designed especially for direct computer entry of handwritten numeric source documents. Designated the Ades-1, the multimedia system eliminates the constraints of previous handwritten-character recognition because a software resident in each minicomputer allows loosely written characters to be recognized. The system also provides the flexibility of keyboard second entry by one or more operators. In this way, source numerics that are unreadable



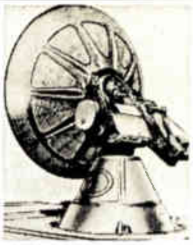
by the Ades-1 can be entered in proper sequence through the key-to-disk buffer. Applications are in reading numerics used by utility meter readers, department store sales personnel, service technicians, inventory control clerks, and other data organizers.

Data Recognition Corp., 908 Industrial Ave., Palo Alto, Calif. 94303 [363]

Two-card memory has 16,384 words per card

A two-card memory system with a capacity of 16,384 words per card is called the Super ExpandaCore-16 and permits expansion of memory capacities from 16,000 to 144,000 words. The storage board is pin-compatible with the company's 8,192 word storage board, allowing users to intermix the two different boards while using the same control board and backboard wiring. The

AUTOTRACK MOUNT



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Dual Mode, Ion or Electron. RF Drive. 300 KHZ at 45 KW. Includes control console, RF unit, accelerator, etc.

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Instrumentation radar: freq. 8.5-9.6 GHz. Pwr: 250 KW. .1 mil tracking accuracy. 6' Fresnel lens antenna with 4 horn monopulse feed. Tracking range 50 or 200 miles. Formerly used as range safety radar at Cape Kennedy.

MIT MODEL 9 PULSER 1 MW—HARD TUBE

Output 25kv 40 amp., 30kv 40 amp. max. Duty cy. .002. .25 to 2 microsec. Also 5 to 5 microsec. and .1 to .5 microsec. Uses 6C21. Input 115v 60 cycle AC. Mfg. GE. Complete with driver and high voltage power supply. Ref. MIT Rad. Lab. Series. Vol 5. p. 152.

2 MEGAWATT PULSER

Output 30 kv at 70 amp. Duty cycle .001. Rep rates. 1 microsec. 600 pps. 1 or 2 msec. 300 pps. Uses 5948 hydrogen thyratron. Input 120 / 208 VAC 60 cycle. Mfr. GE. Complete with high voltage power supply.

17 MEGAWATT LINE PULSER

Output 17KV at 1000 Amps. Rep. rate 150-2000 PPS 2.5 Microsec. Keyer tube 5948 thyratron. Pwr: 208V. 3Ph. 60HZ. 38KVA.

HV POWER SUPPLIES

5KV @ 1 Amp: 20KV @ 1.3 Amps: 35KV @ 1.5 Amps: 28KV, 70MA: 12KV @ 800MA: 18KV @ 2.25 Amps: 17.5KV @ 1.8 Amps.

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S BAND 1 MEGAWATT PULSE NIKE ACQ.
L BAND 1 MEGAWATT PULSE AN / UPS-1
L BAND 500KW PULSE AN / TPS-1D / E
L BAND 5 to 20KW PULSE
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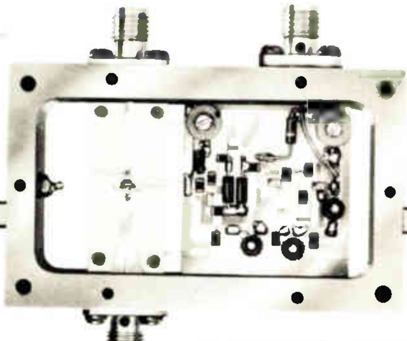
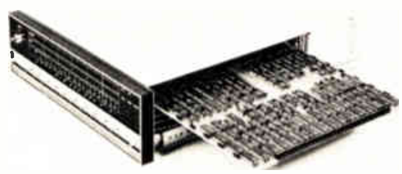


unit is especially suited for minicomputers.
Cambridge Memories Inc., 696 Virginia Rd., Concord, Mass. 01742 [366]

Array processor speeds capabilities of computer

The Apgen 1 is a hardwired, array-processing arithmetic and logic unit that speeds up the array-processing capabilities of any Data General computer by a factor of six to 70. For example, the multiplication of two 1,000 element arrays takes 2.8 ms using the Nova 800 and the Apgen 1, as opposed to 19 ms using only the Nova 800 with hardware multiply and divide. The unit performs multiplication, division, addition, and subtraction of two arrays composed of 16-bit words. It can also take the square root, integrating, accumulating and performing logical operations in the element of arrays. The size of the arrays may be as small as two or as large as 8,192 words. Price is $4,000.



Elsytec, 212 Michael Dr., Syosset, N.Y. 11791 [365]

Keyboard generates 7-bit parallel ASCII output

Available in two basic models to meet user requirements, the series KB200 freestanding alphanumeric keyboard provides 53-key arrangement. The KB200A generates 7-bit ASCII parallel output. The KB200B has a separate cursor, as well as numeric and function keyboards. The model KB200B-1 is intended for external synchronous applications. Prices start at $250.

Ann Arbor Terminals Inc., 6107 Jackson Rd., Ann Arbor, Mich. 48103 [367]

Digital data system includes an indicator and printer

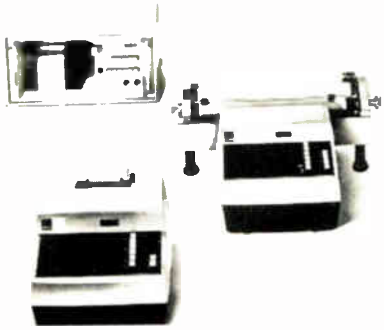
By incorporating a digital indicator and a printer, the recording speed of the model H4200 digital data system reaches 20 points per second. The unit reads out directly in engineering units, can monitor up to 1,000 points, and provides either one or two alarm limits per point. It accommodates up to four different

ranges, which include types E, J, K, R, S, and T thermocouples and resistance probes, and two linear ranges for use with signal conditioners. Recording options include two printers, an electric typewriter, and a teleprinter.

Howell Instruments Inc., 3479 West Vickery Blvd., Fort Worth, Texas 76101 [368]

Digital printers operate to five lines per second

A family of digital printers includes paper-strip and programable carriage printers in bench or rack-mounted configurations. The units offer five to 16 digits and their maximum speed is five lines, or 64 characters, per second. They accept one-in-ten or BCD code and are equipped with an interrogation unit. Each decade can be interrogated



simultaneously, permitting printout of all digits at the same time.

General Rand Corp., 100 Menlo Park, Edison, N.J. 08817 [369]

Packaging & production

One-piece lid seals packages

Solder preform is attached, thus improving alignment, production rate, and yield

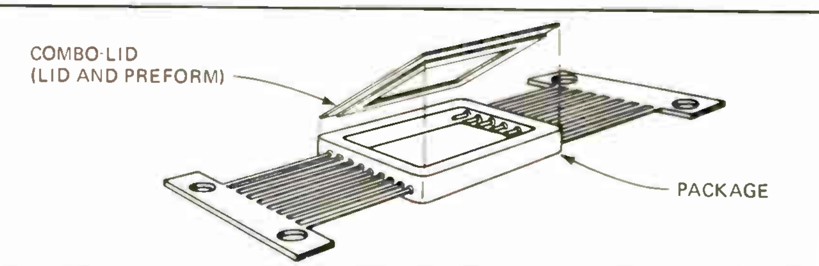
Hermetically sealing the ceramic packages that protect semiconductor circuits can present a major problem to production managers. But they have a promise of major assistance in a system devised by Semi-Alloys Inc. of Mount Vernon, N.Y. Called Combo-Lid, the technique combines the lids with solder preforms that are already attached, and the combination duplicates the separate lid-and-preform technology conventionally used for dual in-line, flatpack, and hybrid packages.

Attached as it is to the lid, the solder preform, "fragile and difficult to align," does not have to be handled separately, points out Semi-Alloys technical director Samuel W. Levine. Thus, production may be increased by a factor of two or three, he asserts, and, because it's so much easier to align the lid and package, yields are improved, as well. Moreover, there is little or no loss due to broken preforms, and much less chance that a broken preform can be used and cause a nonhermetic seal. Another advantage is that separate inventories of lids and properly sized preforms do not have to be maintained; if the lid is available, so is the preform.

Semi-Alloys supplies Combo-Lids for all the popular-size packages of each major manufacturer, Levine says. Sizes range from ¼ by ⅜ inches to ¾ by ¾ in. for dual in-line ceramic packages; from ¼ by ⅛ in. to ½ by ½ in. for flatpacks; and ½ by ½ in. to 1¾ by 1¾ in. for hybrid packages. And the lids come domed, extruded, or flat.

Price of the Combo-Lids is anywhere from $70 to $120 per thousand. This works out to roughly 5% to 12% more than separately purchased lids and preforms. But because of the better lid-preform-package alignment that's obtained, Levine says, it's possible to use a slightly smaller Combo-Lid, and that swings the cost downward.

Semi-Alloys Inc., 20 North MacQuesten Parkway, Mt. Vernon, N.Y. 10550 [391]



SMA termination offers VSWR of 1.1 to 4 GHz

A 50-ohm coaxial SMA termination is suitable for production use in military and commercial equipment. Specifications include an average VSWR of 1.1:1 over the range of dc to 4 GHz with a maximum of 1.3:1, and dissipation of ½ watt continuous wave, 1 kilowatt peak over the temperature range of −25° to +85°C. The design uses a male or female gold-plated connector and a MIL RCR resistor element. Price is $4.50 in 100-lots. Delivery is from stock.

Elcom Systems Inc., 151-15 W. Industry Ct., Deer Park, N.Y. 11729 [393]

Inserter handles eight terminal-pin clusters

A dual-headed inserter with automatic positioning inserts clusters of up to eight wire-wrapped-type terminal pins at one time into circuit

boards. Production rates can reach in excess of 580 pins per minute. The machine allows the use of low-cost bulk-packaged pins rather than the reel-fed pins required by other types of machines. Also, the dual head of the unit permits two identical circuit boards to be processed simultaneously. Price is $40,000.

Synergistic Products Inc., 1902 McGaw Ave., Irvine, Calif. 92705 [395]

Test handlers are designed for DIP applications

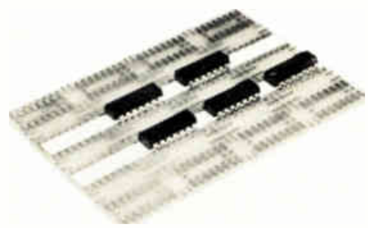
Two manually controlled semiconductor test handlers are designed for applications involving naked DIPs for relatively low-speed DIP testing.

The model CHS 250 with test leads for 8-, 14-, and 16-lead packages, is priced at $1,475. The model CHS 500 is priced at $1,875. Both models are offered for OEM and end-user sales.

Components Handling Systems Inc., 2974 Scott Blvd., Santa Clara, Calif. 95050 [396]

Bus bar is for dual in-line applications

A ground- and voltage-distribution laminated bus bar is for dual in-line integrated circuits. The bus concept

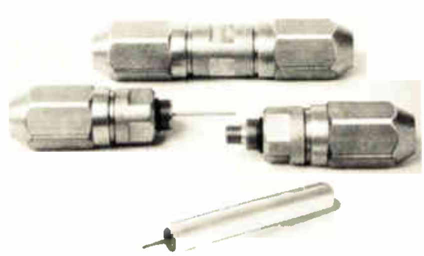


provides a voltage and ground termination for every package assembled on the DIP bus. The series 140 units are used with 14-pin DIP sockets, mounted in a row with constant spacing. The series 160 unit is for use with 16-pin sockets. A fixed capacitance contributes to noise suppression. Capacity per linear inch is 75 picofarads at 1 MHz.

BH Electronics 245 E. Sixth St., St. Paul, Minn. 55101 [398]

CATV connector line is for use with fused-disk coax

A CATV connector line is designed for use with General Cable Corp.'s fused-disk coaxial cable. The cable uses air dielectric with polyethylene



disks fused at intervals between the center and outer conductors. Attenuation values of the connectors are low, and return loss is rated at better than 35 dB across 5 to 300 MHz—a value that does not cancel out the performance of the fused-disk cable.

EG&G Inc., Electro-Mechanical Div., CATV Products, Georgetown, Mass. 01833 [399]

Soldering system provides 22 interchangeable tips

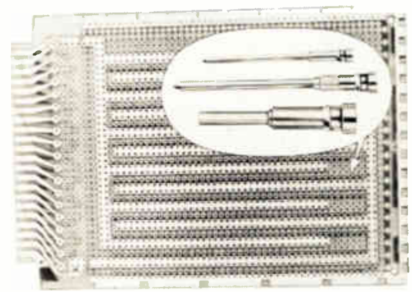
Providing control of solder, flux, rise time, and temperature for soldering small components, the Pulse Dot II uses 22 interchangeable tips and offers manual or automatic timing on the length of the heating pulse. The small size of the heating element in each tip makes it useful where adja-

cent areas are heat-sensitive. Temperature is controlled from ambient to 2,200°F. A panel meter provides tip voltage readout. Footswitch operation is another feature.

Circon Corp., Santa Barbara Airport, Goleta, Calif. 93017 [397]

Socket pins accommodate IC, other device leads

Three socket pins directly accommodate integrated-circuit and other semiconductor device leads to provide maximum circuit density by eliminating large socket castings. Inserted in 1/16-in. circuit boards, the gold-plated sockets allow DIP devices with any number of terminals to be mounted end-to-end or side-



by-side. The R30 and R31 models extend 0.30 inch above the board and the knurled R32 extends 0.135 in. The posts are interconnected using either wire-wrapped or solder techniques. Price ranges from $55.73 to $84.25 in 1,000-lots.

Vector Electronic Co. Inc., 12450 Gladstone Ave., Sylmar, Calif. 91342 [400]

Semiconductors

Simpler design cuts prices

On-card op-amp dual tracking regulator goes in standard 8-pin package

When a new monolithic linear circuit comes out at half the going price, the immediate reaction is that it must be a Humpty-Dumpty design. But the RC4195 dual tracking voltage regulator is not. Introduced by the Semiconductor division of Raytheon, it has ±15-volt outputs that track within 50 millivolts and give typical line regulation of 2 mV and load regulation of 5 mV with only 0.005% voltage drift per degree centigrade.

What's more, the RC4195 goes into standard eight-pin packages including a low-cost molded mini-DIP (competing on-card op-amp regulators have nine or 10 pins). Also, it needs no external RC network (others require two resistors and two capacitors).

The RC4195 delivers 100 mA on each side (150 mA peak, 220 mA short circuit). That's enough to power 20 to 40 standard op amps, such as the 741.

For the standard ±15-V supply levels, only five connections are made: two unregulated inputs at ±18 to ±30 V, the two outputs, and ground. The chip carries the compensation capacitors and current-limiting resistors. A sixth pin couples the two sides so that with a two-resistor divider, the device will operate as a positive regulator adjustable between 15 and 50 V. The last two pins allow booster transistors and added compensation capacitors to raise the output currents to as high as 10 amperes.

Output currents are limited to safe values by an emitter resistor on each output transistor and a temperature-sensitive diode that cuts output drive current if junction temperature rises above the rated maximum of 175°C. If an excessive load continues, the diode and the emitter resistors take over alternately as the chip heats and cools, allowing the output currents to fluctuate between minimum and maximum drive.

Why the low price, then? Harry A. Gill, who designed the RC4195, explains:

- The chip is only half the size of a conventional design, so that chip yield from wafer processing is tripled.
- The mini-DIP and standard eight-pin packages are cheaper than the nine-pin or 10-pin packages formerly required.
- Design costs are low.

Gill says that a simple differential amplifier in series with an emitter-coupled complementary transistor can correct voltage errors as well as two op amps can. For a reference, he simply put two zener diodes in series between the two stages. Then he added unmatched output transistors, current sources, and the protective components.

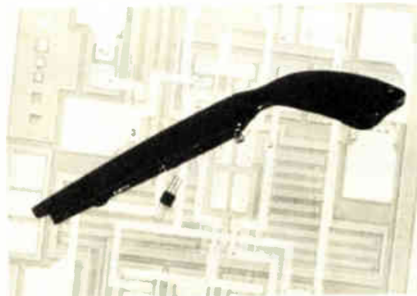
Alan Borken, manager of linear interfacing marketing at Raytheon's Analog Devices, promises to sell the RC4195 for "under $1" to high-volume customers. The lowest previous price for fixed duals was "under $2." List prices in 100 to 999 quantities are $3.40 in a TO-66, $2.50 in a TO-5 and $2.18 in the mini-DIP packages.

The military-temperature TO-5 will stay about the same at $5.40, while the military TO-66 will cost more than $1 more at $8.34. However, the TO-66 dissipates a whopping 2.4 watts without a heat sink or 9 W with a heat sink at 25°C. The mini-DIP dissipates 600 milliwatts, and the TO-5 version dissipates 800 mW at 25° C.

Raytheon Co. Semiconductor Division, 350 Ellis St., Mountain View, Calif. 94040 [411]

IC audio amplifiers offer a typical gain of 72 dB

A series of integrated-circuit audio amplifiers typically provides a gain from 70 to 72 dB while drawing 600 to 900 microamperes from a 1.5-volt battery. Designated MPS5003H and MPS50003L, the circuits feature a maximum harmonic distortion of 2% with a 40-μV, 1-kilohertz input signal. Amplifiers are available in six-lead flatpacks and have appli-



cations in hearing aids, recorders and radios. The units achieve high gain and wide bandwidth with a minimum number of stages through the use of active loads integrated onto the chips.

Micro Power Systems Inc., 3100 Alfred St., Santa Clara, Calif. 95050 [413]

Miniature hybrid amplifier has gain of 150 MHz

A subminiature hybrid amplifier, designated the model HVA-23, can operate from dc into video frequency ranges. When used as an inverting amplifier, the unit operates at a frequency for unity gain of 100 MHz minimum, 150 MHz typical. Frequency for full output is 10 MHz minimum, 12 MHz typical. Other features include a slew rate of 1,000 V/μs and output voltage of ±10 V.

ILC Data Device Corp., 100 Tec St., Hicksville, N.Y. 11801 [414]

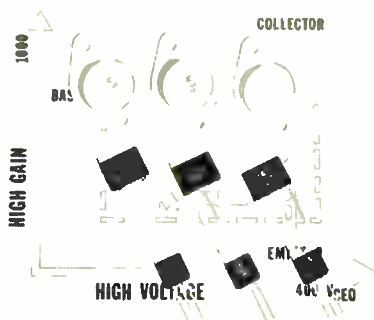
FET op amp delivers bias current to 1 pA

A guaranteed maximum bias current as low as 1 picoampere at 25°C is offered by the series 3522 FET operational-amplifiers. Also offered is a noise specification of 1 μV peak-to-peak, a common-mode rejection of 90 dB, and a maximum offset voltage as low as 500 μV. Input offset-voltage drift from 0° to +70°C is ±50 μV/°C for the model 3522J,

and ±25 μv/°C for the models 3522K and 3522L. Small quantity prices range from $10.50 to $18.50.
Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85706 [415]

Power transistors have 400-V collector-emitter breakdown

Nine high-voltage Darlington power transistors are designated the TIP series, and six of the devices are offered in plastic packages. Minimum collector-emitter breakdown voltage is 200 v for models 150, 160. 660, it is 300 v for the 151, 161, and 661,



and it is 400 v for the models 152, 162, and 662. Collector current for the 150 through 152 is 2 amperes; it is 5 A for the 160-162 and 660-662 units. Price ranges from $2.05 to $5.80 in 100 lots, depending on packaging.
Texas Instruments Incorporated, Box 5012, M/S 308, Dallas, Texas [416]

Decade-counter/decoders combine two technologies

Two devices to be included in the 4400A line of logic devices are decade-counter/seven-segment decoders. The first unit, the 4426A, offers display-enable and bipolar outputs, and the second, the model 4433A, offers ripple-blanking with bipolar outputs. C-MOS front-end counting and decoding are employed to assure high noise-immunity as well as low power consumption. The combination of bipolar transistors onto the basic C-MOS integrated circuits eliminates the necessity of purchas-

"Let's kill all the lawyers!"

"The first thing we do, let's kill all the lawyers!"
—Henry VI, Part II, Act III

Jack Cade, in Shakespeare's play, was leading a rebellion and looking for a scapegoat.

He hit upon a somewhat bloodthirsty, but extremely popular, idea.

There is a new and different kind of rebellion in America today. An angry revolt against the pollution and despoilment of our environment.

And some people, again seeking a scapegoat, have also hit upon a popular idea.

Put the blame, and the burden, on business.

Indict U.S. industry as "The perpetrator of an irresponsible assault on the environment."

Demand that industry immediately stop all pollution, end all depletion, and forthwith "restore our natural heritage."

And enforce these demands with new, harsh and punitive, laws and regulations. Impose criminal penalties on the owners and officers of offending companies. Launch an onslaught of "Citizens' and workers' suits for environmental damages." Attack, harass, threaten, punish and compel.

The idea has its appeal. It focuses on a convenient, conspicuous and vulnerable target. It offers immediate action and immediate release for accumulated frustration and anger. Most temptingly, it promises a quick, easy and painless solution to the whole environmental problem.

Against this attack, and in the face of this appeal, industry is at a crippling disadvantage. It has, to put it bluntly, been hit with charges that cannot be denied—demands that cannot be satisfied. And, backed into its corner, it is in an awkward position.

A position in which anything it says is likely to be taken as defensive or evasive, anything it does is questioned in advance as inadequate.

Nevertheless, some things *need* to be said.

First, that industry *is* guilty of an assault upon the environment, and *is* responsible for the consequences.

But, second, that the guilt has long since been acknowledged, the responsibility long since accepted. Today, however belatedly, U.S. industry stands firmly and fully committed to the environmental cause.

The commitment is sincere. It is also specific and binding. The U.S. Commission on Environmental Quality has designed a massive program to cleanse and restore the American environment in the 1970's, at a total cost of $287-billion. Industry's share of this cost is set at $195-billion.

Clearly, this assigned task and this imposed burden will strain the financial, and test the technical and managerial, capacities of U.S. industry to the utmost. It adds an enormous responsibility and a formidable challenge to all of the other responsibilities and challenges that industry must continue to confront in a competitive and demanding world.

The responsibility has been accepted, the job will be done. But beyond this assigned task, beyond this designated goal, beyond these outer limits of the possible, industry probably cannot go. It is not a question of will, but of capacity. The issue is not what industry *ought* to do, but what industry *can* do.

To the extremists' premise that industry can be threatened, harassed and driven to exceed its utmost capacities—that it can somehow be *made* to do what it manifestly cannot do—a frank and unequivocal response must be made.

Industry cannot immediately stop all pollution, end all depletion, and overnight restore our natural heritage. It is impossible. It is financially impossible, technically impossible, economically impossible, morally impossible, and physically impossible.

It is financially impossible for industry to immediately allocate and spend $195-billion. There is not that much money to be had, from any source, by any means, using any device.

It is technically impossible, at any price, to totally eliminate all forms of pollution.

It is economically impossible to bring all of U.S. industry to a complete halt while pollution control is given absolute priority over production.

It is morally impossible to close every offending plant, shut down every faulty operation, and throw thousands of people out of jobs, whole communities into bankruptcy.

And it is physically impossible, even if everything else could be done, to compress the work of a decade into a day, a month, or a year.

To these obvious impossibilities, one more must be added. It is impossible to separate industry from the society to which it belongs—and which it serves and reflects.

The environmental crisis is not an isolated, but a total, national crisis. The result of universal neglect and unanimous irresponsibility. And of a prolonged, overwhelming, devastating *mass* assault on the environment, made by millions of American citizens and consumers, in ignorance or blithe disregard of the consequences.

We are no longer ignorant. We are no longer quite so blithe. But the assault continues. Because the insistent, unrelenting pressure of consumer needs, wants, desires and demands continues.

And this, ultimately, is the problem. Not for industry alone, but for the whole of a truly interdependent society. Any major solution to the environmental crisis requires a profound change in the personal expectations, habits, attitudes and actions of millions of individual Americans.

But the point, with regard to industry's responsibility, is simple. Industry cannot dictate change. It can control its own actions and reform its own habits. But it cannot refuse to meet needs, ignore wants, desires and demands, and reform the habits, attitudes and actions of 200-million Americans.

Killing lawyers does not further the cause of justice. Persecuting and punishing industry will not advance the cause of a better environment. The sacrifice of a scapegoat solves nothing and gets us nowhere.

Except off the track. A common, national problem demands a common, united, national effort. The job belongs to us all.

It is time to forget the diversion and get on, *together*, with the job.

We at McGraw-Hill believe in the interdependence of American society. We believe that, particularly among the major groups—business, professions, labor and government—there is too little recognition of our mutual dependence, and of our respective contributions. And we believe that it is the responsibility of the media to improve this recognition.

This is the sixth of a series of editorial messages on a variety of significant subjects that we hope will contribute to a broader understanding.

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John R Emery

John R. Emery, President
McGraw-Hill Publications Co.

ing bipolar transistors or multitransistor ICs for this application. Price in 1,000-lots is $5.65 each.
Solid State Scientific, Montgomeryville, Pa. [417]

Eight-diode array requires only 16 mW per diode

An LED array, designed for continuous-line and bar-graph applications, is designated the ARL-18. It is a common-cathode eight-diode array with 75-mil lead spacing and 100-mil centers between lights. Any number can be placed end-to-end for a continuous line-of-light source. The output of an individual diode is 100 foot-lamberts, and the array requires only 16 mw of power per diode. Price for 100 to 999 units is $5.10 each, for 1,000 units it is $3.95. Delivery is from stock.
Litronix Inc., 1900 Homestead Rd., Cupertino, Calif. 95014 [418]

ICs are designed to drive gas-discharge displays

Four dielectrically isolated monolithic integrated circuits, designated the DI series 267N, 277N, 287N, and 297N, are for the constant-current driving of seven-segment gas-discharge displays, such as the Sperry SP-734 and SP-754 panels, and the Burroughs Panaplex I and

Panaplex II displays. The units, available in 18-pin DIPs, are capable of operating at up to 200 V. Output current levels are programable from 0.2 to 2.0 mA. Price ranges from $1.50 to $3.77 each in 1 to 99 quantities, depending on voltage rating.
Dionics Inc., 65 Rushmore St., Westbury, N.Y. [419]

New products/materials

A paste solder for applications in electronics hardware contains good-purity, low-oxidation-state, and 60 Sn/40 Pb per-alloyed solder powder suspended in an activated rosin flux that prevents flux and solder segregation. Designated Multicore Paste Solder XM 27.298, the material functions as a fluid preform. It can be preplaced accurately in controlled amounts and shapes, with good adhesion of the solder and flux to the component parts. Since the paste remains tacky, it can be used as a temporary adhesive, and soldering can be delayed.
Multicore Solders, Dept. SC 122, Westbury, N.Y. 11590 [476]

A graphite resistance coating for printed circuits, vacuum tubes, shielding, pre-plating nonconductors, and communications cables offers good adhesion to plastics, making it especially suited to applications as a replacement for other conductive materials. Electrodag 154 is an air-drying material and has controlled electrical resistance and good film formation.
Acheson Colloids Co., Box 288, Port Huron, Mich. 48060 [477]

A submicron boron carbide abrasive compound, dispensed in a smooth paste and universally compatible with aqueous and nonaqueous solutions, is used to generate close-tolerance, low-microinch finishes on hard electronics crystals and substrates such as YAG, sapphire, ferrites, and, in particular, coated-memory disks. The material is odorless and nontoxic and is applied directly onto the surface of the polishing pad.
Geoscience Instruments Corp., 435 E. Third St., Mount Vernon, N.Y. 10553 [478]

A chemically synthesized, water-soluble foaming flux, called Ecoloflux-F, is a rapid, high-rising deoxidizer The material requires low air pressure for the creation of a constant adjustable, fine bubble foam for use in wave-soldering machines. Priced at $12 per gallon, the flux is available in one or five gallon bottles.
Controlyne Inc., Box 502, Allwood Sta., Clifton, N.J. 07012 [479]

New literature

Epoxy resin. An epoxy resin selector guide is available from Northern Labs, 20 Bridge St., Box 1355, Greenwich, Conn. The four-page guide outlines data for 21 different systems that handle most adhesive or encapsulating applications. Circle 421 on reader service card.

Cathode-ray tubes. English Electric Valve Co. Ltd., Chelmsford, Essex, England CM1 2 QU, is offering a 24-page booklet on storage cathode-ray tubes that covers principles of operation and the storage mechanism used. [422]

Switch drivers. LRC Inc., 11 Hazelwood Rd., Hudson, N.H. 03051, has issued a 44-page catalog detailing a wide range of TTL-compatible switch drivers with a total switching time of less than 10 ns. [423]

Relays. Magnecraft Electric Co., 5575 N. Lynch Ave., Chicago, Ill. A 32-page catalog describes over 740 stock relays available for custom applications. [424]

Lamps. General Electric Co., Nela Park, Cleveland, Ohio, 44112, is offering a variety of catalogs describing the company's miniature lamps. The catalogs include: 3-6253, lamps for low-voltage applications; 3-6251, sealed-beam lamps for vehicles; 3-6252, subminiature lamps; 3-1240R, solid-state lamps; and 3-6254, glow lamps. [425]

MECL design. A revised and expanded edition of the MECL System Design Handbook is available from Motorola Semiconductor Products Inc., Box 20912, Phoenix, Ariz. 85036. [426]

Encoders. Programable pulse-code-modulator encoders are described in a six-page folder available from Spacetac Inc., Burlington Rd., Bedford, Mass. 01730 [427]

Core memory. The model DMS add-on core memory for the PDP-15 is described in a four-page technical sheet available from Dimensional Systems Inc., 393 Totten Rd., Waltham, Mass. 02154 [428]

Test system. Teradyne Inc., 183 Essex St., Boston, Mass., has published a nine-page brochure discussing the model Z337 zener-diode test system. The brochure includes sections on productivity, device protection, test modes, and automatic distribution analysis of results. [429]

Waveform generators. Ailtech, 19535 E. Walnut Dr., City of Industry, Calif., is offering an eight-page catalog describing the series F200 waveform generators. Specifications are provided, along with how-to-do-it information for generating a variety of waveforms. [430]

Radio communications. A brochure on portable two-way radio equipment for sea-to-shore-communication with the U.S. Navy and Coast Guard is available from Motorola Communications and Electronics Inc., 1301 Algonquin Rd., Schaumburg, Ill. [431]

Film-resistors. A 48-page film-resistor design guide has been published by Mepco/Electra Inc., Columbia Rd., Morristown, N.J. 07960. The guide discusses how to select and apply resistors. It includes definitions and interpretations of resistor parameters, designation codes, and a special section on temperature derating. [433]

Diode tester. A data sheet on a medium-power diode and SCR tester is available from Dantronics Inc., 3175 Hafner Ct., Saint Paul, Minn. 55112 [434]

Generator theorem. A monograph, number 25, is available from Sercolab, Box 78, Arlington, Mass., and deals with the topic: The equivalent generator theorem: network problems solved many ways. [435]

Timers. Curtis Instruments Inc., 200 Kisco Ave., Mount Kisco, N.Y. A booklet describes the general characteristics of digital and analog timers and counters and compares them from the viewpoints of equipment designers and users. Detailed comments and suggestions are provided. [436]

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Fred Hammond

SPECIAL REPORT:

THE SMALL INVESTOR

... An A-to-Z look at the "little guy," his stocks, his bonds, his mutual funds, his advisers ... and how he can make his way in Wall Street through the rest of 1973.

THE MARKETS

The "little guy": Should he run with the bulls?

It was the year the nation's most closely-watched barometer of the stock market finally managed to climb its own Everest. After repeated passes, the Dow-Jones Industrial average of 30 Big Board stocks topped the 1,000-point level in 1972—and probed still higher. Perhaps more important, a market dominated by institutional giants—banks, insurance companies, pension and mutual funds—began again to hear the footfall, faint but getting stronger, of the returning small investor. The "little guy" who played so big a role in the bull markets of the 1960s was heading back.

So, how is the stock market of 1973 shaping up for the investor with, say, $20,000 more or less in his portfolio? Indeed, what factors will influence the market's movement this year? Where are the pitfalls? In short, how can the average small investor prepare himself for the remainder of 1973?

Perhaps more than ever, the market this year will turn on two factors: economic well-being at home and America's maneuvering abroad. The latter, of course, remains uncertain, with large question marks clouding the picture in Southeast Asia, the Middle East, in attempts to reform the international monetary system, and in world trade. But on the domestic front, the business recovery that began last year has shown encouraging staying power.

Gross national product should rise nearly 10% this year, according to most economists; and despite a lingering inflation—higher than President Nixon and his brain trusters would like—most of the expansion will come in real terms. At the same time, unemployment should dip below 5%, and in such areas as capital equipment expenditures, consumer spending, corporate profits, and inventory accumulation, record or near-record levels should be reached.

But there are still disturbing signposts along the road to recovery, and they will clearly influence any investor's stock market decisions—especially the little guy whose chips need to be handled with care. Most analysts believe that, despite a few valleys, the market will respond to general economic health with a broad, upward movement through 1973 and perhaps into 1974.

Yet impediments do threaten. For one thing, the Federal Reserve System may find it difficult to hold the growth in the money supply to non-inflationary limits. At any rate, its efforts to do so may create tight credit conditions, and force interest rates higher. By most estimates, yields in government, municipal and corporate bonds will be up in 1973, though not dramatically so; this means that investors, large and small, may find attractive alternatives to the stock market. One area to watch is convertible debentures (corporate bonds that can be exchanged

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for company stock). Although they pay less than straight bonds, a rising stock market invariably pulls up their value.

As this scenario indicates, the stock market will hardly be the only game in town these next several months. The mutual fund industry, for one, expects an advance this year, synergized both by a general stock market rise and small investors feeding desperately-needed liquidity into many issues. The age of the "go-go" fund is gone, and the painful lessons learned during the 1969-70 bear market are still fresh. Even so, aggressive growth and growth-with-income funds are expected to do well in general in 1973.

For those investors with the stomach for it, commodity futures trading offers another alternative to the stock market. Margins are usually a mere fraction of those required in stock trading, profits can be enormous, and the action is frenetic.

There are, of course, other investment opportunities—REITs, real estate syndicates (with entry cash as low as $2,000), the so-called "tax shelters" (useful mainly to the wealthy), and in such exotic areas as vintage wines, autographs, coins, stamps, antiques, gems and art. The latter, of course, demand a special expertise, and the stock market may well be a more logical choice for the average investor.

What stock groups, then, seem most likely to succeed in '73? A majority of analysts contend that cyclical issues (steels, consumer hard goods, capital equipment such as machine tools, and the like) will be active this year, as opposed to the blue chips and high-quality growth stocks that led 1972's market advance. Beyond that, several groups rank among the analysts's favorites for the year. Among them:

■ Airlines. At the end of 1972, the airlines group was selling at 16 times estimated '73 earnings—and those earnings should be big, perhaps 75% greater than in 1972. By most counts, airline traffic should rise at least 10%, and the analysts are confident, despite such sad tales as Pan American's vast routing and profit problems and public dismay over skyjackings.

■ Drugs. Earnings will rise in 1973, and sales of non-drug products—chemicals and household goods, for instance—should benefit from the broad upward movement of the economy. But price-earnings ratios have stayed high right along, and some analysts pick drug company investments for long-term purposes rather than the near-term.

■ Autos. Hardly a glamour industry by most standards, autos nonetheless should be attractive this year. The industry sold a record 13.6-million cars and trucks in 1972 (including imports), and the industry figures that it can probably match those figures this year.

Industries to watch

Oil: Higher profits expected

Autos: Another big year ahead

Airlines: Earnings headed up?

■ Oils. The deepening energy crisis, slowly rising prices and greater refining capacity, among other factors, will serve to make 1973 a turnaround year for oils after the doldrums of 1972, when markets softened. Profits for the industry are expected to be up.

There are other industries, too, with somewhat smaller coteries of fans for '73. The aerospace and machine-tool industries, for instance, appear entering periods of recovery. Banks and insurance companies are expecting higher earnings this year. As consumer spending grows ever stronger, retailers also have reasons to grin.

All this, of course, pivots on the nation's economic forecasts coming true. If they don't, and small investors begin to scurry from the market once again, impairing liquidity as they go, the decisions of large institutional investors could do what they did last year—cause dramatic swings in a number of Big Board stock prices.

But, by and large, the outlook is good, and the brokers for the most part again exude confidence— as they often do with *your* money. No one, of course, is so bold as to suggest that the boom years of the Sixties have returned. "Sure, it's always possible for a little guy to get burned," one Wall Streeter concedes, "But this year I don't expect anyone will become scarred for life."

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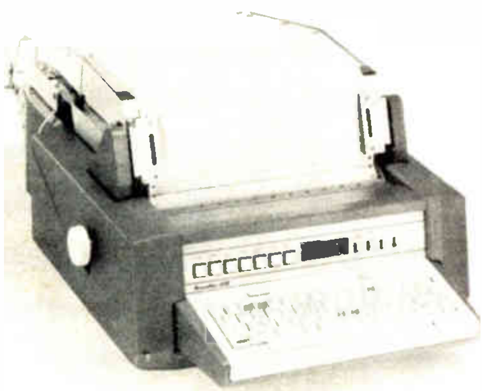

GENERAL ELECTRIC

CIRCLE 711 ON READER SERVICE CARD

The hand-holders: Reaching down to small potatoes

The investment advisory business is edging ajar a few more doors to squeeze in the man who has good prospects, a confident smile, faith in common stocks— and maybe $10,000 or so to place in the hands of a professional. Banks, along with independent advisory services, have started a modest new trend that reaches from Boston to San Francisco. It will gather steam.

Not that all doors to private counseling offices have been opened to the man whose assets are limited; far from it. T. Rowe Price, the Baltimore mutual fund company, for instance, is talking of "small" individual investment accounts starting at $100,000; and Scudder, Stevens & Clark, the big New York fund and advisory outfit, is still talking a carriage-trade of $300,000-and-up.

But there is a trend going on that should prove of interest to anybody with, say, $5,000 to $50,000, who does not want to rely on a broker for advice, and whose penchant is to remain aloof from the giant mutual funds. "Today a lot of activity is being aimed at helping the small investor who wants equity with safety," says John Orr, vice-president of New York's Irving Trust Co., which will introduce this spring a new $10,000-minimum personal account service.

Among front-ranking banks in the country, First National City, in New York, pioneered the idea of a personalized investment advisory for "the little guy." Today, Citibank's "Individual Selection Service" has a $10,000 account minimum, with a fee attached of $250 per year. Beyond this level, the charge runs 1% of assets per year, up to $200,000. Portfolio recommendations are mailed to clients on a regular basis, and the client is responsible for handling his own buys and sells through brokers.

Citibank's aim—like that of most banks in the advisory business—is to attract the small investor who seeks portfolio *growth* rather than income. New customers are encouraged to think in terms of a 10% to 13% rate of growth in asset value per year, though no promises are made. Bank officials state that Citibank's record for 1972 "exceeded" the approximate 18% increase in the Dow-Jones Industrial average—assuming that the client accepted all of the recommendations.

Marine Midland, another large Manhattan bank, offers a similar service. The minimum account size is $8,000, with a fee of $160 per year, or 2%. Over $22,000, the fee figures at ¾ of 1%. Clients are sent mailed recommendations, and must agree to them before portfolio changes are made by the bank. Marine Midland also claims to have bested the Dow in 1972. New York's Chase-Manhattan bank also offers a $10,000-minimum account service—a new advisory concept that operates much like the plan at First National City.

In the Midwest, there are fewer options for the small investor, but the indication is that the limited-minimum-account concept will spread in the next year or two. Today, Continental Illinois National, biggest bank in Chicago, will provide individual management advice for the investor with $20,000 or more. "The advantages of this type of account as compared with a mutual fund can be considerable," says P. J. Hamel, vice president in Continental's trust investment department. "No 'load' is paid. Also people get an actual confirmation of each transaction for their own account. When we recommend a switch, we tell them why—we talk to them, and that's important."

The First National Bank of Chicago, though presently offering no similar service, is interested. "We are all looking for ways to address this problem," says the bank's Terrance Lilly, vice president for personal asset management.

On the west coast, San Francisco's Wells Fargo Bank has a $25,000 minimum account service, but Chester Boltwood, vice president in charge of the department, notes that smaller accounts are considered on an individual basis.

Bank of America, the nation's largest bank, last year started a personalized portfolio service on a test-market basis; the plan was a success, and is now being offered statewide in California. Minimum account: $50,000. Even those

"Advantages . . . compared with a mutual fund . . . can be considerable."

who most heartily endorse the idea of the bank-operated advisory service—particularly those designed for the small investor—point out this word of advice: Before laying out a dime, ask the bank for its track record over the previous year or two. Some banks will give this information only if pressed.

The small-account trend extends, too, to a growing list of several hundred firms in the country that bear the label "independent investment adviser."

The independents come in a vast array of shapes and sizes, from small one-man shops whose services, like as not, depend on the investment whimsey of the proprietor, to big-time operations that maintain a battery of consultants and thousands of customers. With the exception of a few of the biggest, such as Lionel D. Edie, owned by Merrill-Lynch, and T. Rowe Price, which operates a string of mutual funds, the independents are mostly just that: independent. They are not connected with a bank, brokerage, insurance company, or mutual fund.

Currently many such firms will take clients with as little as $25,000 to invest, and a fast-increasing number are now reaching down to the $10,000 man.

The 50-member Investment Counsel Assn. of America, a carriage trade group, is increasingly aware of the problem of the small man who wants his place in Wall Street, according to ICAA Executive Director Page Pyle. "At least two members," notes Mrs. Pyle, "already accept $25,000 accounts: Wisdom and Kelly, of New Orleans, and Trainer, Wortham, of New York; and there's quite a trend in this direction."

Lionel D. Edie, the big New York firm with 12 branch offices in major cities, is now taking $25,000 accounts and

"Trouble is, most are just too new to have established records."

charges a 1% fee up to $100,000. Unlike most bank-managed accounts, Edie's are mostly fully discretionary—that is, the firm provides complete management and is permitted by the client to use its judgment on all portfolio switches. The service, with 80% of its clients scattered across the U. S., and 20% abroad, is too new for much track-record discussion. Says Duncan Smith, executive vice president: "We started very small two years ago, and it's too early to come up with meaningful figures."

A growing number of advisory services across the country are centering in on mini-investors whose accounts run as low as $5,000. Danforth Associates, Wellesley Hills, Mass., for example , offers a personal portfolio service at the $5,000 level, and charges 2% a year up to $25,000. "There's a big push in this area, and a number of brand new companies have opened services for the mini-investor," says old pro Mansfield Mills, who heads up his own firm in La-Jolla, Calif. "The trouble is, most of them are too new to have established records."

Coast to coast, reputable advisors stress these words of warning: Do some careful investigation before signing on with *any* advisory firm. Says Mills, whose name is well placed on the west coast: "Pick your firm with the same care you'd use to pick a stock broker. In fact, today some of the highest quality brokers are referring small investors to reliable independent advisors. They don't want the little account of $5,000 or $10,000."

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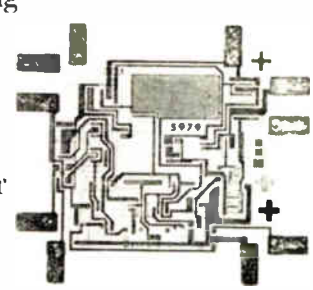

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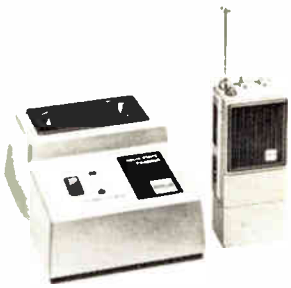

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CIRCLE 712 ON READER SERVICE CARD

The little guy's ticket to the big-money game

The bond market is an arena where big-money borrowers and lenders gather, and traders play for multi-million-dollar scores in miniscule decimal points. It's an arcane, elite sort of game where $100,000 goes a very short way—it will buy a newcomer one round-lot seat in the bleachers—and the little guy, perhaps for his own good, is usually turned away at the gate.

There is a way, however, for him to get in—by pooling with other mini-investors and buying into one or another of the not-so-new but certainly newly popular bond funds or trusts. Here he can enjoy many of the benefits the big boys have, principally a steady return (7½% is not uncommon these days) with far fewer risks to his capital than he would find in the stock market. Or, if his tax bracket merits the choice, he can opt for any of an increasing number of municipal-bond funds, where the return will be lower (perhaps 5.5%), but is all tax-free. A word of caution here, though: Tax-exemption does not do much for anyone below the 28% bracket—a couple filing a joint return should have a taxable (not gross) income of at least $16,000 to $20,000 before they will save more through the tax break than they could earn in the higher-return, taxable funds.

Until fairly recently, bond funds were most popular in two basic forms. Most are closed-end investment companies. They manage a changing portfolio for the holders of a fixed number of shares, for an annual fee (.5% to 1%, usually). The shares are traded on the market, sometimes at a discount from the underlying portfolio's value. The second type, open-end funds, operate much like mutual funds. New units, or shares, can be continuously created, sell at prices that vary with the market, and the funds are required to redeem them (at the market price) at any time. These portfolios, too, are constantly being changed by their managers.

Sparked by rising bond yields a couple of years ago—in times when the stock market has been less than predictable—the bond funds have ballooned. The assets of open-end funds, less than $500-million in 1967, were close to $1.5-billion as this year began. The closed-end funds now top $600-million in assets, mostly due to new formations in just the past year.

With assets quadrupling in the past four years (while stock-based mutual fund assets only grew 22%), their popularity cannot be denied. Nonetheless, both types have shortcomings of which a prospective investor should at least be aware: Open-end funds are vulnerable to adverse times, in that they must hold onto cash to meet redemptions, thus crimping their style in the bond market. And, for reasons even veteran observers can't clearly define, the price of shares in closed-end funds almost invariably recedes once the enthusiasm of the initial offering wanes.

Latest fillip on the bond fund idea—not a new one, but one that is also enjoying a booming revival—is the unit investment trust. Normally, these portfolios remain unchanged once they are assembled, and interests in them are sold in basic units of $1,000 each, the price of newly issued bonds. A $25-million fund, then, has a maximum of 2,500 units to sell. A modest sales charge is levied—3½% to 4½%, compared to up to 8½% for some other types of funds. Since the portfolios are fixed, there's no management fee, although trustees do charge a minimal amount (less than 12-cents per unit per month, in one case) for "supervision." The trusts are ultimately self-liquidating.

the unit-holders sharing in receipts as the underlying bonds mature, are redeemed, sold or prematurely called by their issuers.

The big draw of the new funds for smaller investors is their "spendable income" appeal—many mail a monthly check, representing one-twelfth of the current annual yields of the underlying portfolio. (Unit-holders also get checks from time to time as underlying bonds mature or are otherwise removed from the portfolio, but these can only be considered as "capital.")

The eagerness of investors for just such a vehicle has surprised even its sponsors, which include some of the nation's largest brokerage houses—including Merrill Lynch, Pierce, Fenner & Smith, Bache & Co., John Nuveen & Co., and Walston & Co. Biggest sellers have been the municipal trusts, whose sales topped $530-million last year. Corporate bond trusts, offering higher yields to the less tax-conscious, are newer, but gaining fast. Merrill Lynch, the managing sponsor for a growing stable of UIT's, launched its first monthly-payment corporate fund last September, and had sold $77-million worth by the end of the year.

What is a small investor buying when he gets into the new funds? For one thing, he is getting the benefit of a diversified portfolio which he otherwise could not afford, and a certain amount of liquidity—the sponsors promise to buy him out whenever he wants at the "offering" (or higher) price his units are currently worth. But essentially, the investor is in a vehicle built for the long-term—cutting out early can cost him.

For instance, on the day it was launched last November, Merrill Lynch's ninth monthly-payment municipal trust bore a $1,022.78 public offering price per unit (the current offering price of the bonds in the roughly $60-million fund, plus 3½% commission). If an investor had to turn around and sell it the same day, Merrill Lynch would have paid him $987.50 (redemption value was a bit lower: $979.90).

On the other hand, he could look forward to a monthly check for $4.74 for every unit he held. On a $10,000 investment, that's $568.80 a year, which, providing all things remain equal, he could consider tax-free money to spend—if spend he will. It represents his share of the trust's prospective net annual interest rate of 5.688%. For a man in the 30% tax bracket, the tax-free $568.80 is worth $812.57 in income on which he has to pay taxes.

A lower-income investor who bought into the Merrill Lynch corporate bond fund (its third) issued last December, would have paid $1,009.69 per unit (with a resale value to the sponsors of $975), and would receive a monthly check for $6.29 on every unit he held. That's 7.548% annually—taxable, of course, but well over what he could get at the bank or in a savings and loan account.

But before either one of them spends their monthly yield money, or even before they sign up for any fund, they should read the prospectus that every fund is required to file. They would find, for instance, that the stated interest rates are not fully guaranteed. *"This rate will change,"* says a small-print passage in a typical prospectus, *"as bonds are redeemed, paid, sold, or exchanged, or as expenses of the fund change."* It's prudent to expect that any changes will be downward.

On the other hand, a modest investor in a UIT has some assurance of being involved in a portfolio of breadth and quality he could not dream of putting together himself. The Merrill Lynch funds, for instance, stock up with bonds rated at least Bbb (medium grade) by Standard & Poor and Baa (lower medium grade) by Moody's Investor Service—all within "investment grade" levels. Note, though, that this is not true of all the bond funds—many portfolios are ever-changing—and some have been rapped by the SEC for filling up in lower-grade bonds to beef up current yields. Best idea, of course, is to take a close look at what you're buying.

Seasonal forecast: Tougher sledding for mini-investors

Caution lights are flashing this year over several types of real estate investments, including some syndications, real estate investment trusts (REITs), and other recent favorites of smaller dabblers in the land and construction game.

There still are good opportunities for tax shelter (for those who *need* it), capital gains, or income—if rarely all three together—but it will take a lot more savvy and careful shopping to find them this spring.

Spectres haunting real estate investment areas this year include:

New, tougher regulations by both government and the investment industry.

Hidden hookers in the tax law that have only begun to hit investors.

Overbuilding in many once-favored investment markets, notably apartments and office buildings.

Scandals in subsidized housing that have cast a long shadow over government programs.

Financial troubles among certain syndicators.

Accelerating costs that make economically viable deals harder to find.

Ecological considerations that more and more are stalling or shelving once-promising projects.

Higher interest rates and stiffer competition in capital markets.

Now, more than ever, it's important to get expert, *impartial* information on any real estate deal, however small. That doesn't mean from your broker, whose firm may have a big chunk of the deal,—or the syndicator, if any.

Much of the flak has been directed toward the syndicates, but there is plenty of concern over some REITS, as well. Much of the distressed property on the market is owned by REITs that ventured outside their own area of expertise. Aaron Lurie, head of Denver-based Revac, Inc., a national association of real estate investors, syndicators and developers, says flatly, "REITs never had property management worth a damn."

This is not to say that all REITs no longer are a good investment. Many of the biggest and best continue to flourish. But even these are concerned over the upward trend of interest rates, particularly on short-term loans.

Where, then, is smart money going in real estate these days? Shopping centers, for one place. The housing boom of the past couple of years has generated a strong market for them in newly developed areas.

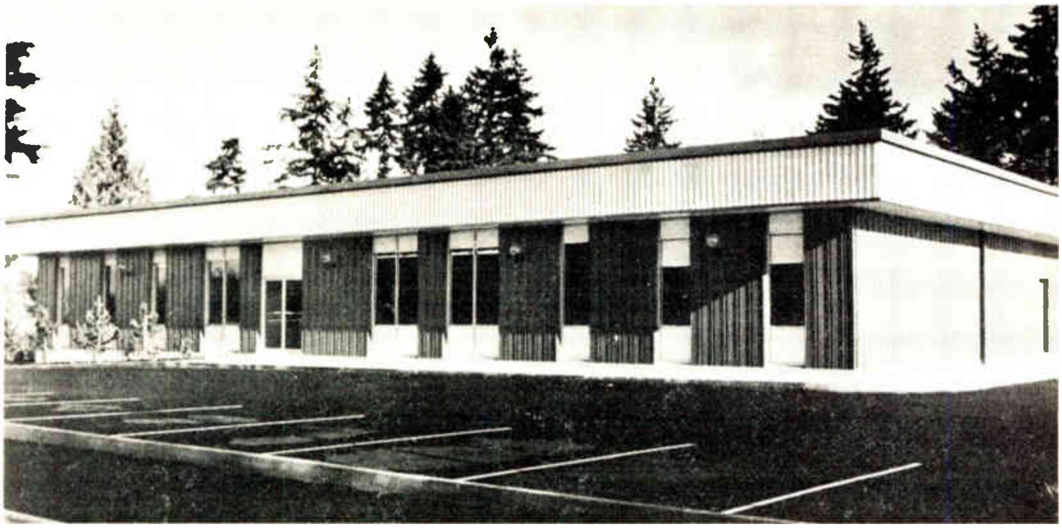
For all the unfavorable publicity, there still are good deals to be found in subsidized housing, according to one tax shelter consultant to the Mercer Allied Corp., New York personal financial counselors. It's a question, he says, of good analysis of location, a strong general partner, favorable climate, and access to public transportation. Most of the subsidized housing deals coming along now were already in the pipeline before the government's January fund freeze. But don't overlook good opportunities in state subsidized housing program—the Mercer consultant favors those sponsored by the Massachusetts Housing Authority and New York's Urban Development Corp., among others.

Good sales-leaseback deals (where investors buy and sometimes develop a commercial or industrial property for a major tenant under a long lease and a guaranteed yield) are harder to find these days, but still highly desirable. Lurie also encourages his Revac affiliates to concentrate on buying distressed properties in areas where investment in rehabilitation plus sound management could bring solid returns.

Investors more interested in quick turnover of their investment have been finding opportunities in the condominium boom. By getting in on a soundly conceived and marketed project at the pre-development stage, investors have often reaped a healthy profit and complete return of capital within two or three years.

Condominiums, however, are heavily overbuilt in some markets. "Drive down the Florida Gold Coast between Palm Beach and Miami Beach, and you'll go by condominium after condominium that's empty," cautions the Mercer consultant. "I've seen flags flying offering 100% financing on apartments." Early this year, moreover, resort condominiums came under stiffer federal regulation. The process could mean a longer wait for the payoff to investors.

More than ever, then, real estate is a "buyer beware" situation. The party is not over by any means, but extra care is being prescribed. The pros strongly advise the investor to have good, impartial advice; know his partners and be sure they have some of their own money in the venture; avoid "blind pool" syndicates (where the investment is not identified), and be certain the project is economically viable and soundly managed. Steer clear of raw land deals, they say, unless you are prepared to wait a long time for your return—with so many environmental pressures, it may never come. In real estate today the old advice is still the best: *Never invest money you can't afford to lose.*



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CIRCLE 714 ON READER SERVICE CARD

Panning for gold in the get-rich literature heap

Ever since Ben Franklin's *Poor Richard*, the American "little guy" has had somebody telling him how to handle his money. It took the stock market fever of the 1950s and '60s, however, to turn a trickle into a torrent. Today, get-rich literature commands broad shelves in booksellers's stores, and the flood of new titles goes on unabated.

All too seldom, the advice comes from successful pros, and is worth the price of the book. Gerald M. Loeb's *The Battle for Investment Survival* (Simon & Schuster) was one of the earliest and still better of these. Too often, however, the best part of the book is its title—the insides belaboring the obvious much of the time. Lately the genre has taken some quirky turns.

In *The Astrological Guide to Financial Success*, for instance, Sybil Leek, whose autobiographical *Diary of a Witch* sold well, ventures to advise investors according to their stars. "There is a right stock or commodity for everyone," she writes. "Trouble often starts when people are tempted to go against their natural zodiacal tendencies and therefore not attract the right vibrations to them." She offers financial tips to individual investors according to their zodiacal signs, and analizes the stars of various major industries. Electronics, ruled by Uranus, for example, can expect only one really bad time—in June (Grosset & Dunlap, $6.95).

The key to success in the market is largely a matter of *wanting* to succeed, according to another author, Claude N. Rosenberg, Jr. His *Psycho-Cybernetics and the Stock Market* is an interesting study in psyching oneself to the financial heights, even if it's not much of a tool for picking the stocks to get you there. It has a price advantage, though in paperback (Playboy Press, $1.25).

Market investment technique is more the forte of Thomas W. Phelps, author of *100-to-1 in the Stock Market*. His contention is that there is a fortune to be made by picking the right stock and hanging on to it. He lists 365 stocks that have, indeed, appreciated at least a hundredfold over the past 40 years. Phelps offers some sensible guidelines on picking stocks for his prescribed long haul (McGraw-Hill, $6.95).

With *The Smart Money—How to Invest*

in the Stock Market Like an Insider, the small investor gets down to the nitty-gritty. Author William A. Kent is a successful broker with an insider's eye for Wall Street shenanigans. He inspires a healthy skepticism of the brokerage fraternity in his reader, and makes the point that thinking and acting like an "insider" is the only way the lonely investor is going to share in the loot. While he skitters away from picking stocks for you, he does sharpen the early-warning senses (Doubleday, $6.95).

Charles Neal takes a somewhat less sophisticated slant in *How to Keep What You Have, or What Your Broker Never Told You*. The book, like many of the new ones, is for beginners in the game, but it's one of the better efforts. Having been one himself, he's particularly helpful with sound advice on picking a broker (Doubleday, $7.95).

How to pick the stocks to buy is the special contribution of *Shaking the Money Tree*, by Winthrop Knowlton and John L. Furth. With hand-holding care, they lead the reader through the basics of investment, then tell him how to evaluate a company before buying its stock (Harper & Row, $7.50).

William P. O'Conner, Jr., has his own formula for judging a stock, and he sets it forth in *The 14 Point Method for Beating the Market*. As the title says, he has 14 points on which companies should be checked, and the data to do so can usually be unearthed in their annual reports. Using the formula—and perhaps an hour's homework—a reader can come up with a relative rating "score" on a company. O'Connor's idea is sound and useful, as far as it goes. The one flaw from the short-run "little guy's" point of view is that the market itself may not give the company of his choice an equally high score (Regnery, $8.95).

On the downbeat side, John L. Springer's *The Mutual Fund Trap* casts a wary eye over that medium, but notes: "Mutual funds may be a poor vehicle, but for millions of Americans they provide the only wheels in town." He then offers some sound advice on how to pick them (Regnery, $7.50). Two veteran commodities traders, Stanley Kroll and Irwin Shisko, similarly raise warning flags on their market for the small investor in *The Commodities Futures Market Guide*: "It is our intention to discourage all those who . . . are ill-suited to the hazards of futures trading." The book's price may discourage many (Harper & Row, $15).

There are so many books on the market, you could expect there would be a book on the books, and there is: *Best Books on the Stock Market*, which contains capsule reviews of 150 titles, by Sheldon Zerdon. Trouble is that you may find many titles in the bookstores that have arrived since Zerdon went to press (R.R. Bowker, $12.95).

Healthy, wealthy and wise

by Joseph Wiltsee

A commentary: Look in the mirror before cussing out your broker

One of the favorite sports these days among investors with stockbrokers is to cuss out the "registered rep" and blame him for all the ills and uncertainties that plague the market. ("We get paid to take some of that flap," says one pro, "—but too much of it jars the nerves. You make mistakes.") . . . Before raising this kind of hell, an investor would be smart to sit down and quietly review his *stockbroker relations.* This is wise even if the broker is only used occasionally for advice and information. Remember: It's oftentimes the investor—not the broker—who is neglectful of an account. True, there are incompetent registered reps, and sharpies such as account "churners" who artificially rev up trades for commissions. But some investors contribute to the churning of their own accounts. Do you? . . .

The man who's apt to demand unneeded action in his account, and thereby suffer, is the man who (1) jumps from broker to broker (a habit that gained steam in 1969-70 when many brokers failed), or (2) has little real experience in the market. For this investor, the best fundamental advice is: Get a clear view of your *longterm investment objectives.* . . . But even with goals defined, broker relations can turn sour. Some people who've been in the market for years become clam-like and fail to tell their brokers of changing investment goals—caused, perhaps, by a death in the family, a marriage or divorce, or an inheritance. Or, simply a change in basic attitude. Here the advice is simple: Open up—especially with those who are expected to keep your best interests in mind. . . . Others too often confuse their brokers. "A known blue-chip customer—a conservative—will suddenly get restive and want to get into a couple of high flyers," says a carriage trade broker. "In a little while the rep won't know where his client wants to go." The advice? Set aside maybe 10% or 15% of your account for flyers—and make sure your broker clearly understands this. "*Define* your goal," he urges, "it's a must!" . . .

An investor's basic duty: to know what's going on

In any general review of broker relations, let your registered rep know what you're reading in the way of market letters, tip sheets, and other reports. Some of these remain a menace to the unwary despite efforts by the SEC and Wall Street itself to curb their publishers. "If you lack the kind of confidence in your rep that this implies," warns the head of a respected brokerage, "—then it's time you moved on to a new broker." . . . He adds: "Knowing what's going on is *your duty* as much as the rep's. If you have a meaningful portfolio and lack the time needed to study the market—then you don't want a broker at all. You want an outside manager or maybe a mutual fund."

Some suggestions: (1) Read not just annual reports, but interim ones, plus company surveys by Standard & Poor's and Moody's—and if you don't already know, take the pains to learn precisely what makes a report tick, footnotes included; (2) meet with your registered rep monthly—if your account is at all active; (3) learn to use "open orders" that permit your broker to buy or sell at a certain price (especially if you travel a lot); (4) tell your wife of your plans, at least generally—and see that she meets your broker.

If a review puts you to seeking a new broker, remember that you are probably quite safe with any good, well-known house that has superior research facilities. But picking the registered rep is something else. . . . The branch manager will—after you've done some sifting, in view of your objectives—point you to a man. *But nobody can screen him for you.* Idea: When you've found a man you like, be sure of him by placing just small transactions at first (and tell him what you're doing). If he proves out over a span of, say, six months, up your ante and give him more and bigger business. . . . And remember: The investor, like the broker, has a responsibility. Dealing in the market is a two-way street.

March 1, 1973

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8	28	48	68	88	108	128	148	168	188	208	228	248	268	350	370	390	410	430	450	470	490	510	720
9	29	49	69	89	109	129	149	169	189	209	229	249	269	351	371	391	411	431	451	471	491	701	900
10	30	50	70	90	110	130	150	170	190	210	230	250	270	352	372	392	412	432	452	472	492	702	901
11	31	51	71	91	111	131	151	171	191	211	231	251	271	353	373	393	413	433	453	473	493	703	902
12	32	52	72	92	112	132	152	172	192	212	232	252	272	354	374	394	414	434	454	474	494	704	951
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15	35	55	75	95	115	135	155	175	195	215	235	255	275	357	377	397	417	437	457	477	497	707	954
16	36	56	76	96	116	136	156	176	196	216	236	256	338	358	378	398	418	438	458	478	498	708	956
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19	39	59	79	99	119	139	159	179	199	219	239	259	341	361	381	401	421	441	461	481	501	711	959
20	40	60	80	100	120	140	160	180	200	220	240	260	342	362	382	402	422	442	462	482	502	712	960

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