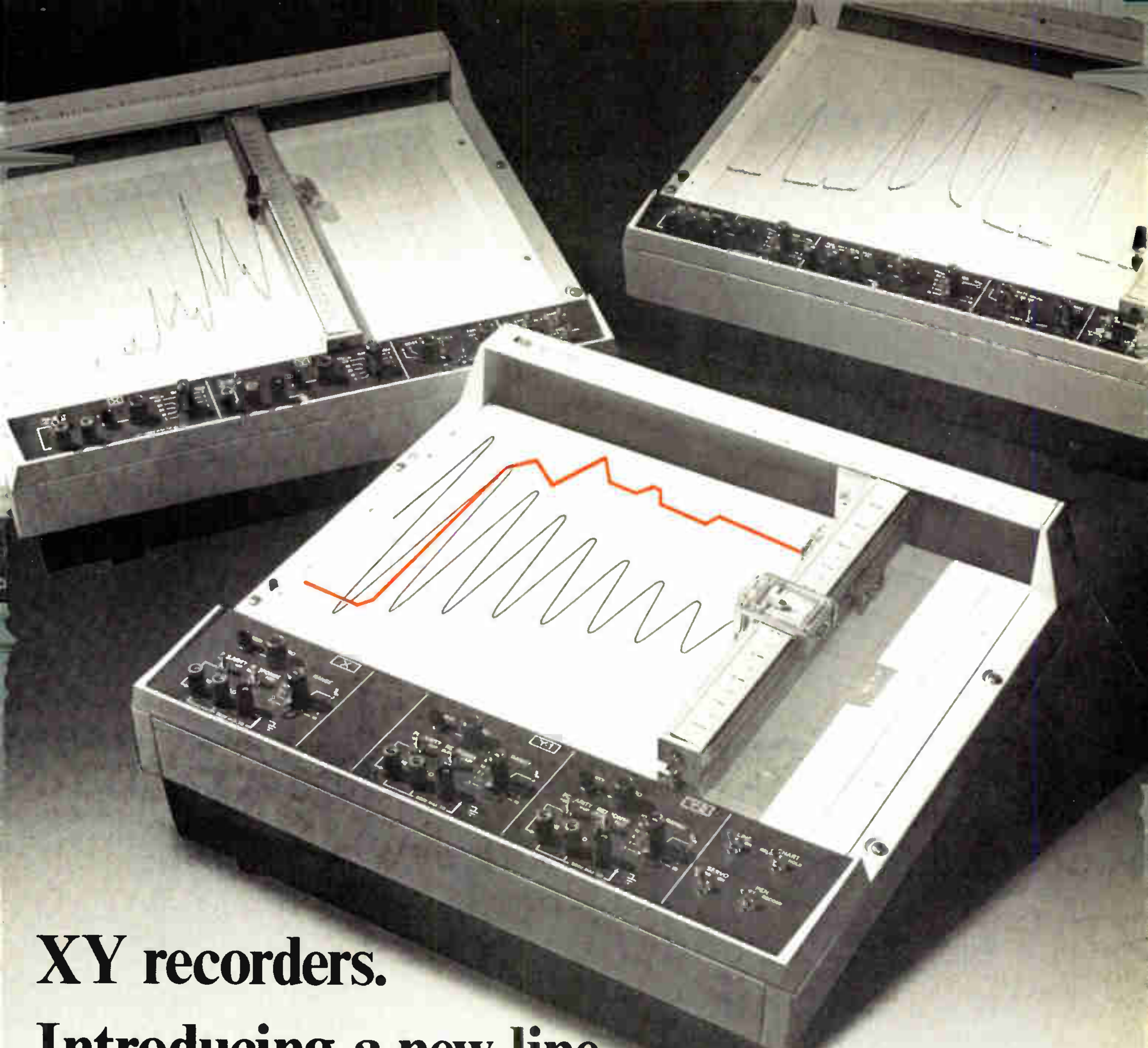
March 29, 1973

A McGraw-Hill Publication

Electronics®

A new series: MINICOMPUTERS IN ACTION

Circle 900 on reader service card



XY recorders.

Introducing a new line from Hewlett-Packard.

For labs that demand fast, high-sensitivity two-pen recording, HP's versatile 7046 picks up where our newest XYs leave off. It furthers a line of recorders engineered around a rugged design concept: A one-piece, cast aluminum mainframe that provides a firm, permanently aligned base.

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For smooth, reliable one-pen recording, choose from two: the fast 7044 or the faster 7045. Top acceleration in the Y axis is 3000/sec², 2000 in/sec² in the X axis.

All HP's new high performance XY recorders share special features that appeal to laboratory users. There are no complicated slip clutches ... just strong, continuous-duty servo motors that are unaffected by noisy signals. They're so tough you can drive them off scale indefinitely without damage. "Autogrip," our solid state paper holddown, has no moving parts — insuring silent, trouble-free operation.

By now, we hope you'll be wondering about options. For starters, think what you can do with a plug-in event marker, internal time base, retransmitting pots, TTL remote control and a convenient rear input connector.

For complete details on this great new line of competitively priced XY recorders, drop a line to Hewlett-Packard, 1501 Page Mill Road, Palo Alto, California 94304. In Europe, Post Office Box 85, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan, Yokagawa—Hewlett-Packard, 1-59-1, Yoyogi, Shibuya, Tokyo, 151. 113-02

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Circle 1 on reader service card

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One look at an operating SELF-SCAN® panel display and you will know why you should be featuring one in your system. SELF-SCAN displays are a new solution to the operator machine interface that provides advantages to the system builder, to the system user, and to the system operator.

You can offer your customer the advantage of a custom-stylized unit that his operators can use efficiently. SELF-SCAN panels are measurably superior to CRT for operator accuracy while significantly reducing fatigue level in day in-day out high volume production applications.

The 0.2" high characters are in the popular 5x7 dot matrix format and are made up of dots on .040" centers. The unit is ASCII compatible and displays a modified 64-character ASCII character set.

256-character display subsystems are available from stock for immediate delivery. Call or write Burroughs Corporation, Electronic Components Division, Box 1226, Plainfield, New Jersey 07061, Phone: (201) 757-3400. Ask to have a Burroughs sales engineer stop by your office and show you his 256-character SELF-SCAN panel, keyboard, and power supplies packaged in a standard Samsonite® briefcase.

Burroughs

Circle 2 on reader service card

Electronics

The International Magazine of Electronics Technology

Vol. 46, No. 7 March 29, 1973

Highlights

The cover: Minis go anywhere, do anything, 72
Reliable, intelligent, and occupying little space in office or plant, minicomputers attract more and more customers for more and more end-uses. Kickoff article for a new series, "Minicomputers in action," explores the range of industries that now use the machines—and cartoonist Jerry Zimmerman makes merry with the same theme on the cover.

Amdahl one-ups the IBM 370/165, 51
Much faster and much smaller than rumor maintained, Amdahl Corp.'s new computer packs the capacity of today's large machine into the volume of today's medium-size computer. To be introduced this summer, the production model will be four times as fast as IBM's 370/165 but will sell for "a little less," says president and originator Gene Amdahl.

High-density bipolar ICs make the big time, 65
The only way to pack 1,024 bits on a bipolar chip is to use space-saving passive isolation between the active elements. In volume production with the Isoplanar process are 128-bit, 256-bit, and 1,024-bit random-access memories, which are becoming increasingly popular as high-performance computer memories.

Flat, flexible cable as an IC interface, 86
Designers of commercial equipment who encounter problems in connecting cable to the small, close-set terminals of LSI circuit packages should borrow a solution from the aerospace industries—flat, flexible cable, made on printed-circuit principles with conductors 6 mils apart. Ease of assembling the interconnection cuts costs.

And in the next issue . . .
Special report on alphanumeric displays . . . next in the "Minicomputers in action" series: minicomputers in numerical control . . . combining an oscilloscope with a counter for better measurements.

Electronics

Publisher's letter

Minicomputers are becoming as pervasive in electronic control applications as electronics itself is becoming in all facets of modern life. And the pace of new and unusual applications of these little machines with big ideas shows no signs of slowing. Thus, we are kicking off in this issue a series of user-oriented articles, which we are calling "Minicomputers in Action."

In the first of the series (see p. 73), our Computer Editor, Wally Riley, leads off with an overview on where minicomputers stand today. In the next issue, we're planning to run an article about harnessing the ubiquitous machines to run numerically controlled equipment. Following that, we'll have articles about how minicomputers are helping in sonar-system design, weather-data acquisition and processing, and a host of other jobs.

In a way, this new series parallels the articles we started running back in 1966 on "Integrated Circuits in Action." That was only seven years ago, but ICs were only beginning to become available in quantity, and the designer was faced with some tradeoffs that don't apply today. For example, one article in that series said: "Metal-oxide semiconductors will compete with monolithic silicon ICs in some areas, but are expected by the experts to offer cost, rather than performance advantages."

You can see from that quote how fast developments in electronics technology move. And now that minicomputers are being thought of as a kind of component, we're sure you'll be interested in reading our series on how users are reaping benefits from "Minicomputers in Action."

Speaking of pervasiveness, take a look at the spread of electronic calculators—both pocket and desktop models. These little machines are showing up in increasing numbers on engineers' and designers' desks, where they are challenging the sliderule as the basic instrument for quick computation.

The inexpensive machines are usually limited to the four basic arithmetic functions—addition, subtraction, multiplication, and division. Yet our readers have found simple ways to take reciprocals and find square roots with only a few keystrokes. After we published some of these approaches in our Engineer's Notebook in recent issues, the letters started to pour in. There seems to be no end to the ways a simple four-function calculator can be used for complex number juggling.

So in this issue, Lucinda Mattera, our Circuit Design Editor, has rounded up the best of the algorithms we've received so far. On page 92, you'll find—in "More computation short-cuts with pocket calculators"—an easier way to obtain a square root, two techniques for finding the nth root, and two ways for squaring a number and finding multiple powers.

We still have not heard of any simple algorithms for finding logs or trigonometric functions. But, as we point out in the article, we will pay $50 if we print a suggestion that simplifies an engineering computation on a four-function calculator.

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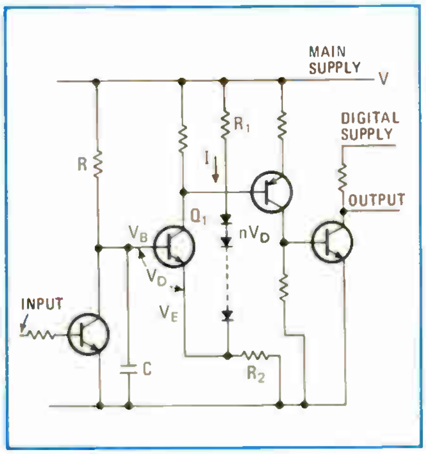
Readers comment

Add one diode

To the Editor: In your recent article entitled "Building timing circuits for noisy environments" [*Electronics*, Engineer's notebook, Dec. 18, 1972, p. 112], T. C. Matty suggests adding a diode in the emitter circuit of the sense amplifier to temperature-compensate the one-shot. In general, however, one diode will not be enough.



Assuming one diode drop exactly matches one transistor base-emitter drop:

$$I = (V - nV_D)/(R_1 + R_2)$$
$$V_E = I_{R2} = R_2(V - nV_D)/(R_1 + R_2)$$
$$V_B = V_D + V_E$$
$$V_B = V_D + R_2(V - nV_D)/(R_1 + R_2)$$

For temperature compensation:

$$\Delta V_B/\Delta V_D = 1 - nR_2/(R_1 + R_2) = 0$$

Therefore,

$$n = (R_1 + R_2)/R_2$$

For example, if $R_1 = R_2$, then $n = 2$, and two diodes are required to fully temperature-compensate the base-emitter voltage drop of transistor Q_1.

Bruce Komusin
Director of Programing
Sugarman Laboratories Inc.
Plainview, N. Y.

■ *The author replies: I agree with your analysis and conclusions. Even an empirical analysis will demonstrate the required relationship, i. e.,*

Assume $\Delta V_{BE}/\Delta T = \Delta V_\Delta/\Delta T = K$ *For a divider, the actual change will be proportional to the divider ratio. Therefore, if the divider ratio is 0.5, two diodes are required to achieve compensation.*

Radiation accumulation

To the Editor: It is absolutely unbelievable that an otherwise competent publication would publish such unsubstantiated hogwash as ". . . resulting in radiation dosages so low that they can detect guns or grenades without fogging film or endangering nearby personnel" [*Electronics*, Feb. 15, p. 91].

All ionizing radiation is cumulative. Every bit fogs silver and causes some biologic damage. What one 1-nanosecond pulse does is irrelevant; what is the cumulative effect? A traveler undergoes many inspections at many airports—not just one.

Instead of accepting an advertising blurb as factual news, how about "getting with it" and ascertaining the facts? What is the X-ray voltage? What is the integral dose for, say, 5,000 pulses per day? What are the distances contours with the hard reflecting surfaces common to air terminals?

It is amazing that so many are tolerating and rationalizing so many identifiable hazards and infringements of what-used-to-be constitutional rights over the hysteria of a petty hazard. It seems incredible that as we outlaw X-ray machines for shoe fitting and tuberculosis survey work, we condone this apparatus.

Richard G. Devaney
Williamsburg Conference Center
Kingsport, Tenn.

Will CCD match LCD?

To the Editor: The article, "Charge-coupling improves its image, challenging video camera tubes" [*Electronics*, Jan. 18, p.162], has prompted me to wonder if anyone has thought about combining this technology with liquid-crystal displays. The signal levels and power consumptions look as if they should be in the same ballpark, and the advent of a small camera will undoubtedly increase the incentive for a flat display. The techniques involved in overlaying a CCD array with a display-electrode structure should be interesting.

John Carroll
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Circle 7 on reader service card

40 years ago

From the pages of Electronics, March 1933

The figures on radio production picture the condition that exists in radio today. Reduction in unit values, and the drop in total units sold, both point the need for stabilization. The time has come to get the radio industry onto a profit-making basis.

It can be done. The popular interest in radio is as great or greater than ever. Broadcast programs increase in interest and in importance. The public continues to buy sets, and there are still millions of homes to be equipped.

Leadership in the job of building back toward stabilization must come from the manufacturing end. Distributors and dealers, of course, need to reform practices that too often spread merchandising destruction and carry down their own businesses in the melee. But changes in the manufacturing set-up are fundamental to any continuing reforms that come in the distribution end.

Components and raw material manufacturers, supplying the radio industry with the parts out of which sets are made, like the rest of the world, have felt the east wind. Prices have dropped during a year from 25 to 50 per cent and even more in some cases. Coils, condensers, resistors, insulation, metals—all have come down and seem to be approaching, asymptotically, a more or less stabilized level.

Tube manufacturers have engaged in a money wasting campaign to increase the numbers of tubes; each new model a manufacturer takes on costs about $5,000, which represents the profits on many tubes. And yet so anxious are the manufacturers to hurry the day of doom they will bring out a new type only to discover that an existing type with slight variations will produce exactly the same result!

Old-line set manufacturers, caught napping by the "universal" fad, have watched 100,000 of the a.c.-d.c. sets go into the market each representing a profit to the maker, to the dealer, and supposedly to the buyer; and in this case the maker is a manufacturer from whom little has been heard previously.

The new Wang 2200. Some people call it a mini; others call it a calculator.

For under $7,000, call it a miracle!

Plug in the new Wang 2200 and you're in business. If your data handling has been constantly delayed or reshuffled by crowded, expensive time-sharing . . . here's a cost/efficient alternative. If you are thinking of time-sharing to meet growing needs; here's a way to beat high terminal costs and programming time. If you run a smaller engineering or technical/scientific group; the Wang 2200 may be all the computing power you will ever need.

BASIC Programming With Hard-Wired R/O Memory: You get 4K (field expandable to 32K) of unimpaired memory. And BASIC programming; the easiest to work with language yet developed. And it's *pure* BASIC, not some manufacturer's version that really requires learning a new language.

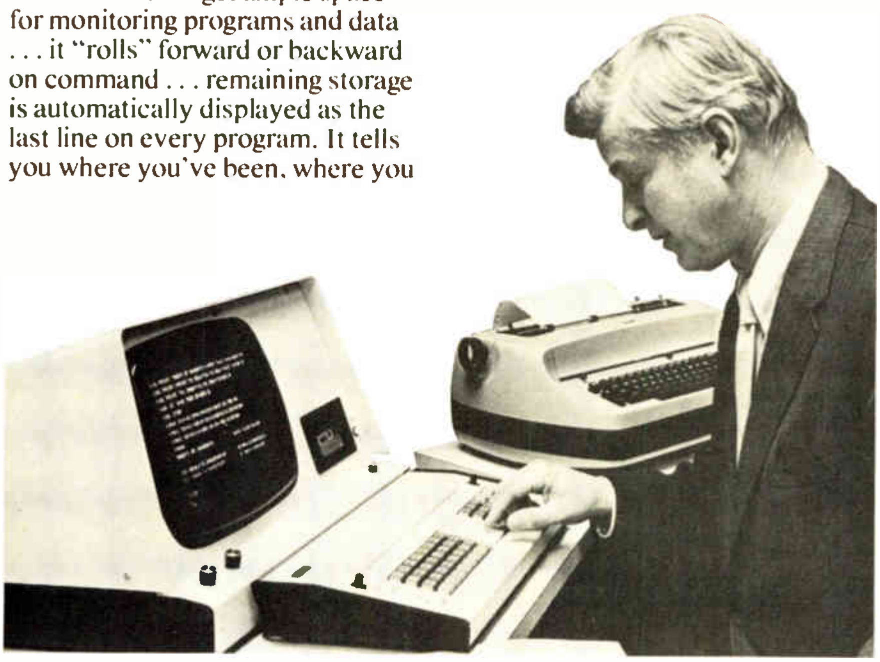
Programming Doesn't Byte Off Much Storage: In the Wang 2200, program statements are a single keystroke and single byte. Example: The statement "Print Using" takes only one byte of memory; not ten! This almost doubles capacity compared to the usual system.

Big 16 Lines (of 64 Characters) CRT Display: It's hard to crowd this tube. You'll get ample space for monitoring programs and data . . . it "rolls" forward or backward on command . . . remaining storage is automatically displayed as the last line on every program. It tells you where you've been, where you are and how far you can go. You can go a long way on the 2200.

Read/Write/Modify Programs On Cassette Tape. This could put big tape consoles to shame. With our optional cassette drive, you can search programs and data files by name and read, write and up-date in place. This usually requires two tape drives to carry off. Additional Tape Drives may be added to increase the file handling capability.

Two Keyboards, Two Printers and Other Goodies: Our 2200 lets you tailor a system to your needs; not vice versa. Take either an Alpha keyboard or a traditional calculator (with alpha) arrangement. Your choice. We have two fast printers and both handle carbon forms. There's even a plotter typewriter and a graph plotter that prints letters too.

For under $7,000, Try To Match The Wang 2200 For Price/Performance and Flexibility. Even if you call the 2200 a small system, you've got to admit it's a big idea. For the price, you can't match the storage or its power in handling tough problems. Compared with anything on the market today, it's cheap, fast, powerful and flexible.



A Low Cost Alternative To Time-Sharing: Since the 2200 can tackle big problems, many users are installing them to replace more expensive time-sharing terminals. And, they are eliminating the waiting, scheduling and priority problems of time-sharing. They're getting more done at lower cost.

Faster Problem Solving: "Basic" programming on the 2200 is almost literal. You get to the heart of problems and examine alternatives faster. And, the Wang *special function* feature gives you 32 additional keys that allow you to "tailor" the system to facts, figures and constants that are particular to your business or your company . . . or your department.

Drives Wide Range of Peripherals: Our new 2200 gives you more ways to solve problems. We have 15 (more soon) peripheral devices like flat bed plotters, additional mag tape cassette drives, a typewriter that makes graphs and a 3 million byte high speed disc.

It's Got The Price, Performance and Delivery: If you need more calculating and computing power now or if you want to examine cost/efficient alternatives to time-sharing, the new Wang 2200 system could be your answer.

For More Information Write or phone today and we will rush details on how the new Wang 2200 can help you get more done; at lower cost.

WANG

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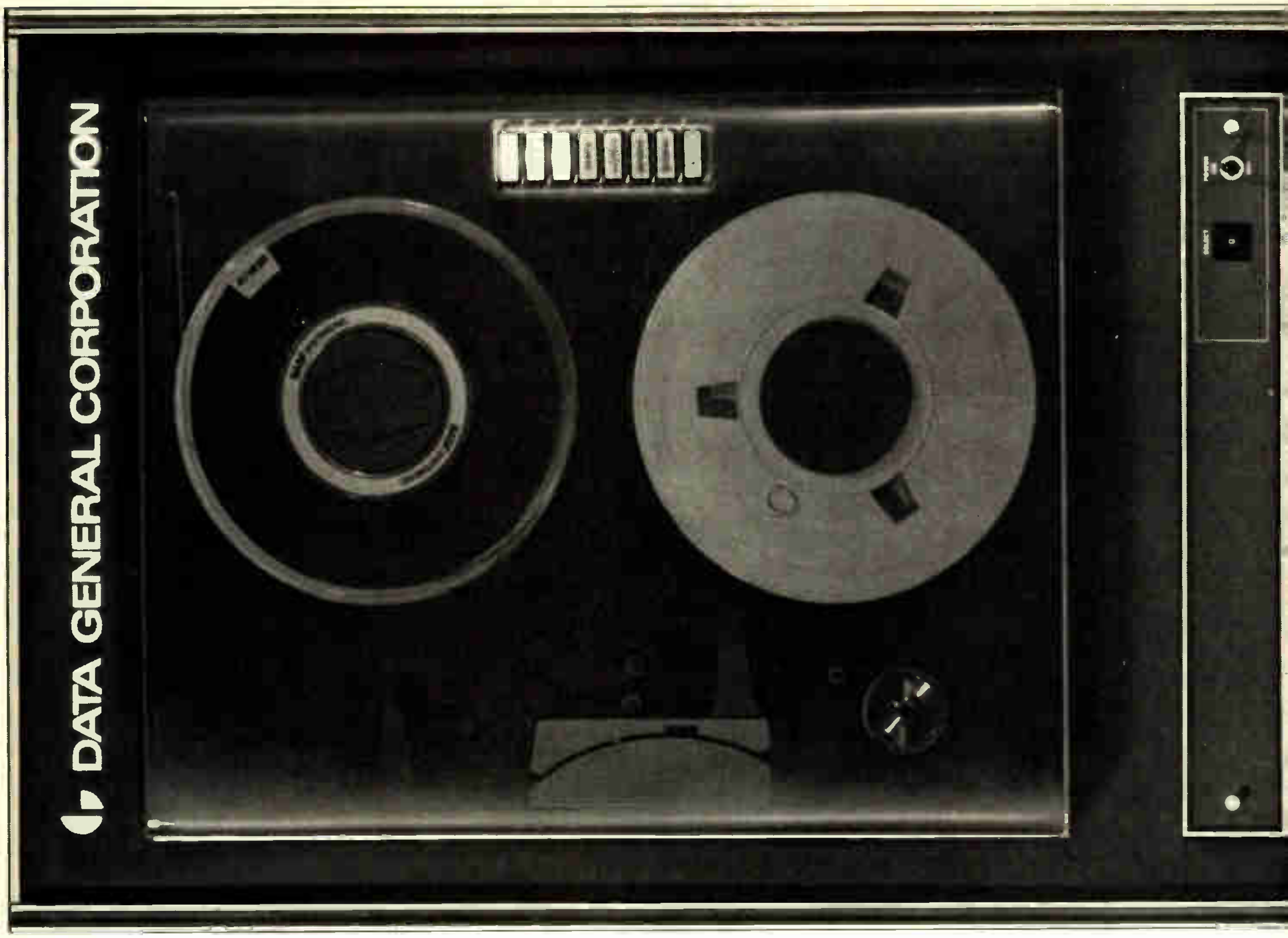


DATA GENERAL INTRODUCES THE LOADED NOVA.

The loaded Nova is the new Nova 840 and the most comprehensive set of software/hardware capabilities ever available with a Data General computer.

It comes with a built-in Memory Management and Protection Unit that lets you expand main memory to 128K 16-bit words. Base price with 16K of memory is $16,530.

Nova 840 runs a comprehensive Real-time Disc Operating System (RDOS) for dual programming operations.

A new BATCH executive lets you pick your I/O devices, load your jobs, and walk away.

It has our new Fortran 5, Extended ALGOL, Extended Timesharing BASIC, and a whole library of proven Data General software; proven software that we can deliver now.

And our Remote Job Entry software can let the 840 double as a high-powered terminal to a big computer someplace else.

With the right kind of configuration (like the one shown), all that software is available free.

THE POSITIVES TO OUR NEW FIXED VOLTAGE REGULATORS.

If you're looking for a simple regulator, this may turn you on.

Our new LM340 series TO-220 fixed voltage regulators.

Available in the plastic package and also the TO-3 package, in all temperature ranges, and in 5, 6, 8, 12, 15, 18 and 24 volts (see the page on the right, also).

They're the height of simplicity (no additional circuits to perform the function). Short circuit proof. And virtually indestructible (can't be destroyed by having inadequate heat sink).

Another thing. Our LM340's have a package with a plastic material and mounting material that results in an excellent matching coefficient of expansion and contraction. It'll withstand thousands and thousands of temperature cycles.

A third positive advantage is that we have a big supply on the shelf, ready to go. (A bird in the hand...)

So much for positives.

THE NEGATIVES TO OUR NEW FIXED VOLTAGE REGULATORS.

Minus 5 volts and minus 5.2 volts (how 'bout that, ECL users), minus 12 volts, and minus 15 volts. The LM320 series, available in the TO-3 package in all temperature ranges.

And by the way, these are the only negative fixed voltage regulators available today.

Which is another positive.

Want to try 'em out? A Digital Designer's Sample Kit, containing a +5, and −5.2 volt regulator, in the TO-3, and a Linear Designer's Sample Kit, containing a +15 and a −15 volt regulator are available for $6.45 each. That's 1/3 off the standard list price. They're available from distributors.

For further fascinating details write: National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, California 95051.

NATIONAL

*Regulator Designers Kits are available from the following distributors: Almac/Stroum Electronics • Cameradio • Carlton Bates Century Electronics, Inc. • Elmar Electronics • Fort Wayne Electronics Supply, Inc. • Gibson Electronics Components Graham Electronics Supply, Inc. • Hall-Mark Electronics • Hamilton/Avnet Electronics • Hammond Electronics • Harvey Electronics Kierulff Electronics East • Liberty Electronics • Mace Electronics • Newport Industries • Pioneer Standard Electronics Powell/Gulf Electronics • Radio, Inc. • Taylor Electric Company • Western Radio Corporation

People

Bell Labs' Baker: science needs goals

As the new president of Bell Telephone Laboratories, William O. Baker is the chief of one of the world's most prestigious research organizations. What's more, in line with the traditional impact that Bell Labs officials have had on national science policy, he is a major influence in how the course of technology and science affect society.

While his personable manner and graying blond hair remind one of a kindly professor, Baker, unlike many academicians, is not a believer in science for its own sake. His view is that "science must be intrinsic to the course of human progress." As chairman of the newly formed Science and Engineering Council, an informal industrial and academic group set up to advise the National Science Foundation and President Nixon, Baker is a strong proponent of goal-oriented science as a national policy and as an organizational responsibility.

Technology chief. William O. Baker directs Bell Labs and advises Government.

Does he feel that the Nixon Administration's abolition of both the Office of Science and Technology (headed by former Bell Labs executive Edward E. David) and the President's Science Advisory Committee [*Electronics*, Feb. 15, p. 78] means a de-emphasis of the Government's role in science? Baker says no. He explains that the Office of Science and Technology had been necessary to help then-young Federal agencies like the Department of Transportation recognize the need and establish a capability for research. But by now, Baker says, this capability has been transferred to the agencies, and the role of the National Science Foundation has been elevated to that of lead coordinator between the President and the scientific community.

In the tradition of nearly all top Bell System officers, Baker has never worked for any other company. He joined Bell Labs in 1939 after obtaining a Ph.D. in physical chemistry at Princeton. Twenty-seven years later, he won chemistry's highest honor, the Priestley Medal. Rung by rung, he moved up the administrative ladder. In 1954, *Fortune* magazine referred to him as one of the nation's 10 leading industrial scientists. The next year he became research and patents vice president at Bell Labs. He has been an adviser to all the U.S. Presidents since 1958 on matters relating to science and international policy.

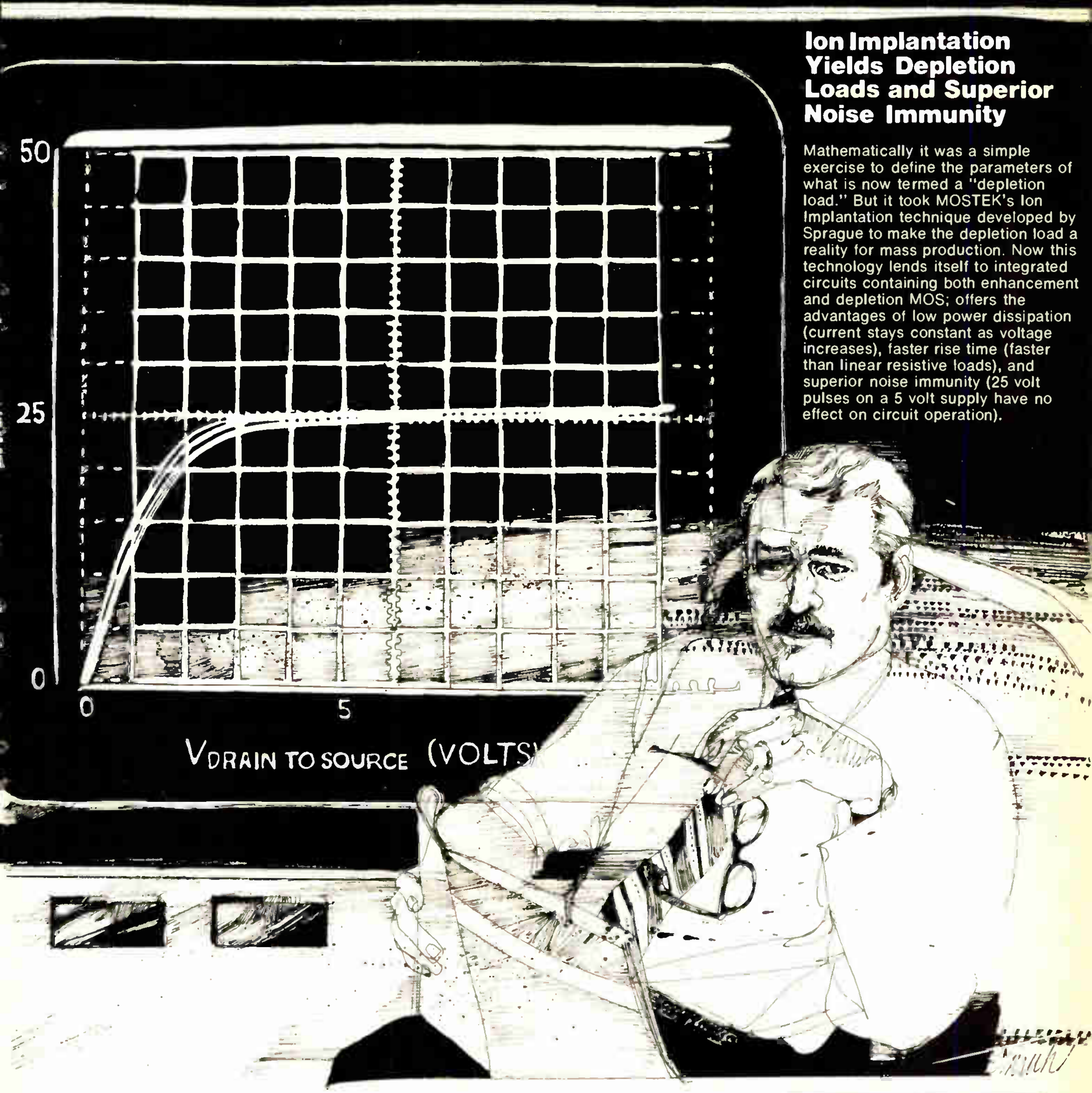
New Potter president unplugging from IBM

He's the second president that Potter Instrument Co. has had in its 30 years—or, as the new helmsman says with a burst of laughter, "the first that wasn't a founder."

As he takes over as chief operating officer of the Plainview, N. Y., computer peripheral-equipment manufacturer, George W. May ap-

Beautiful. To stay in the black, George May seeks new markets and products for Potter.

GREAT MOMENTS IN MOS



Ion Implantation Yields Depletion Loads and Superior Noise Immunity

Mathematically it was a simple exercise to define the parameters of what is now termed a "depletion load." But it took MOSTEK's Ion Implantation technique developed by Sprague to make the depletion load a reality for mass production. Now this technology lends itself to integrated circuits containing both enhancement and depletion MOS; offers the advantages of low power dissipation (current stays constant as voltage increases), faster rise time (faster than linear resistive loads), and superior noise immunity (25 volt pulses on a 5 volt supply have no effect on circuit operation).

MOSTEK was the first to put Ion Implantation to work in volume manufacturing of MOS devices, and we were the first to use this same technology to develop the depletion load. Now it's a practical and economic reality. As with all original efforts, our lead is being followed. Once MOS itself was little more than a promise. MOSTEK is now applying the economic advantages of MOS to areas of operation as diverse as electronic organ manufacturing, temperature sensing, meter reading, and multi-functional calculator systems. One of the most rewarding aspects of MOSTEK's service has been the introduction of MOS technology to new areas of application. Whether it's off-the-shelf or customized IC's, we welcome the opportunity to challenge new problems and offer workable solutions. The depletion load technology has made much of this possible; yet, it is but one of a number of great moments in MOS. There's a lot more to come.

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People

pears to be in far better position than might be expected. Potter Instrument's near-disastrous loss of last year—$13 million for the fiscal year ending June 30—seems a thing of the past.

The new first half is in the black, and sales for the entire year could hit $50 million, May predicts, well up from last year's $35 million.

How did things turn around so fast? For a start, most of the loss came from the write-off of development and marketing costs of Potter's IBM plug-compatible equipment after the computer colossus dropped its prices, and this loss won't recur. In addition, sales of plug-compatible gear to original-equipment manufacturers have been increasing, particularly in Europe, says the 47-year-old May.

But even though he intends to remain in the plug-compatible business, May is investigating new markets that will free the company further from the vagaries of IBM's pricing. A stand-alone key-to-disk data-entry station has already been announced, and so has a stand-alone high-speed chain printer.

May's background seems ideally suited to this expansion concept. He comes to Potter after a stint as president of Victor Comptometer Corp., and after seven years, the last three as president, at Kimball Systems division, Litton Industries. This background brought experience in retail point-of-sale terminals and business-data processing— both candidates for Potter's new diskette.

A native of Long Island, N. Y., May is a sailboat-racing enthusiast and an avid downhill skier. Tall and bespectacled, he has the deep, authoritative voice of a television news reporter—or a company president.

May expects Potter Instrument to continue to grow, with considerable assistance from new marketing and financial vice presidents who have also joined the company. And John Potter, who directed the company virtually single-handedly for so many years, will continue as chairman of the board and chief executive officer. "He's a technical genius," comments May, who has known him for years.

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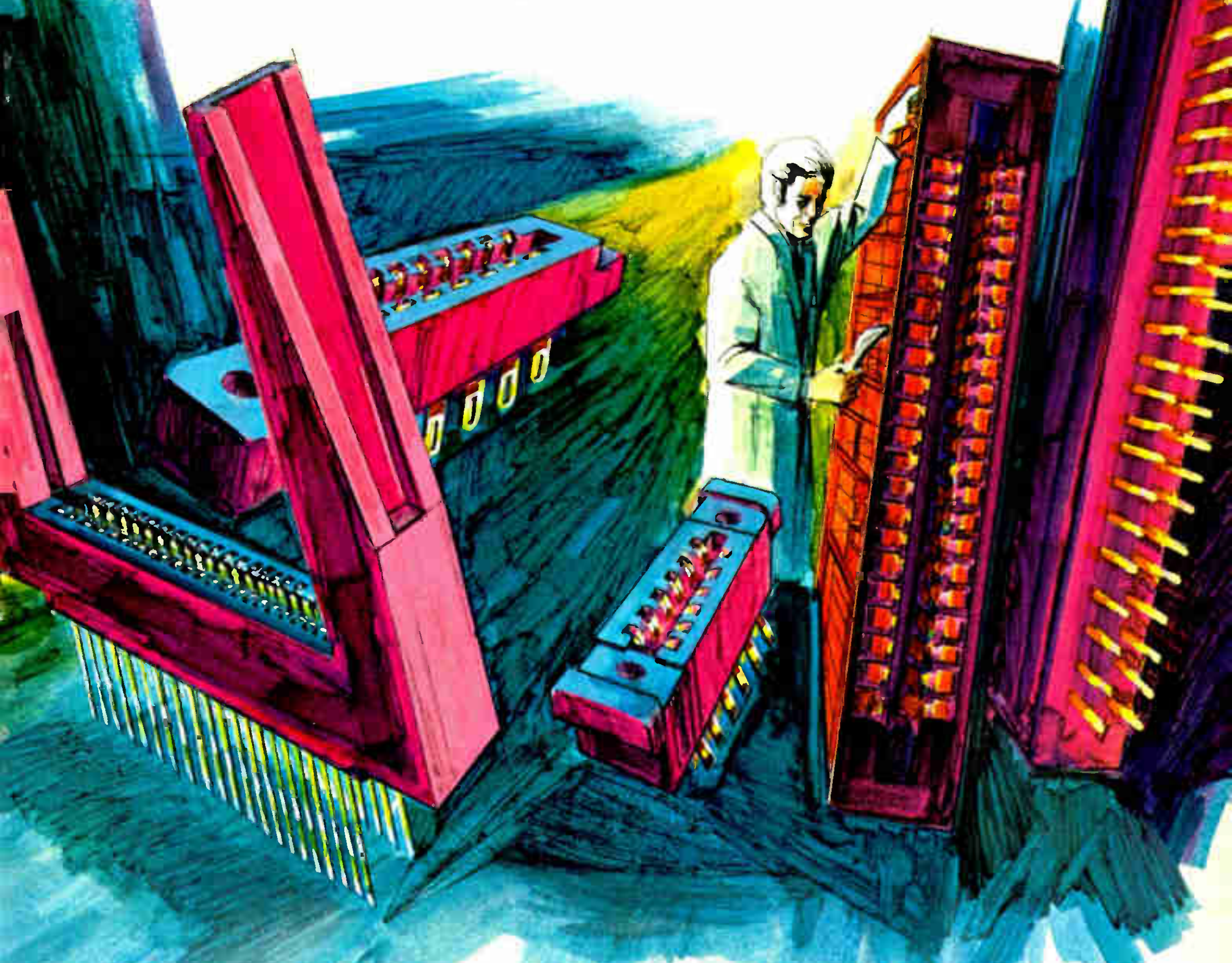
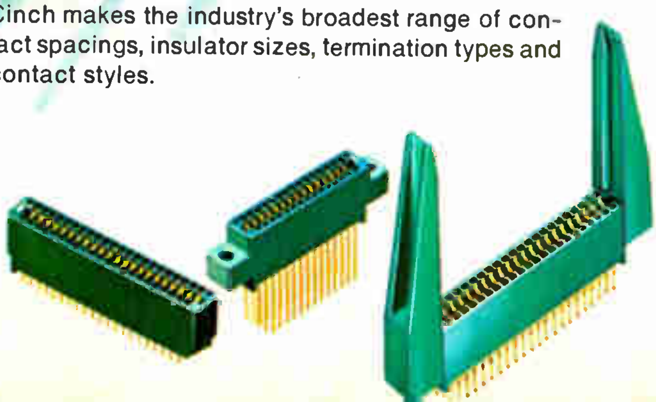


. . . because we've already made it for you.
Your best combination of cost and reliability lies in a connector that already exists—that has been tooled, tested and has proven itself in use. Next best is a custom combination of available insulators and contacts that provide the functions you require. Either way you've got it made with Cinch because Cinch makes the industry's broadest range of contact spacings, insulator sizes, termination types and contact styles.

Whether you'll need large quantities for long range production scheduling—or smaller quantities for immediate delivery (through our nationwide network of stocking distributors), you'll save yourself a lot of trouble if you think of Cinch first.

Get a copy of the latest Cinch edge connector catalog from your local Cinch sales office, or write to Cinch Manufacturing, an Electronic Components Division of TRW Inc., 1501 Morse Avenue, Elk Grove Village, Illinois 60007; phone (312) 438-8800.

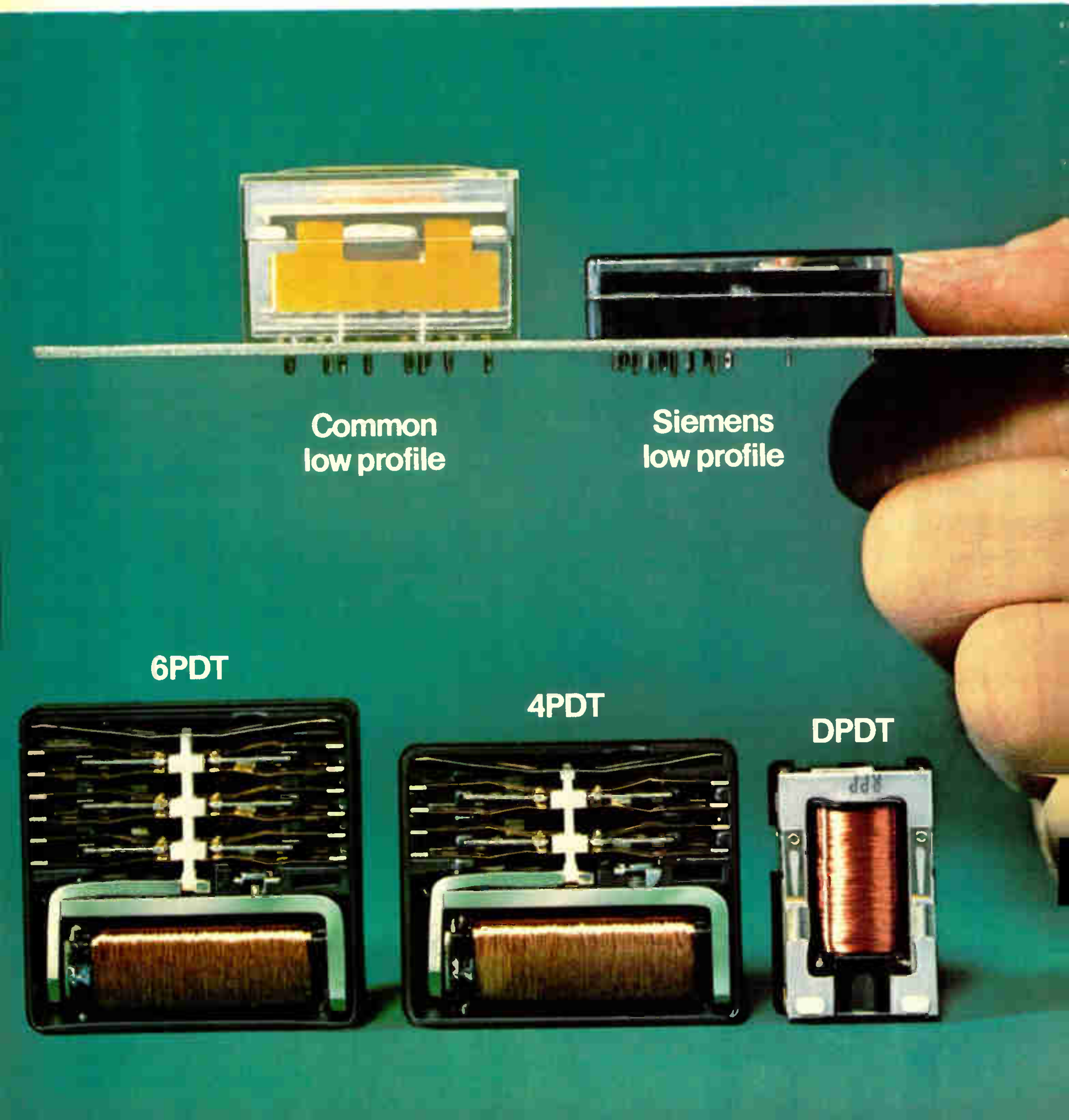
CM-7306



TRW® CINCH CONNECTORS

Circle 17 on reader service card

Siemens introduces the lowest profile in PC-board EMR's.



Meetings

International Colloquium on Alphanumeric Display Devices and Systems: FNIE, Unesco Palace, Paris, France, April 9–10.

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

Electro-Optics Principles and Applications: SPIE, OSA, Sheraton, Boston, April 30–May 1.

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.

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

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

National Aviation System Planning Review Conference: FAA, Washington Hilton, Washington, D.C., May 21–23.

Electronic Component Show: RECMA, Olympia, London, England, May 22–25.

Conference on Laser Engineering and Applications: IEEE, OSA, Hilton, Washington, D.C., May 30–June 1.

International Microwave Symposium: IEEE, U. of Colorado, Boulder, June 4–6.

National Computer Conference and Exposition: AFIPS, New York Coliseum, June 4–8.

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Circle 21 on reader service card

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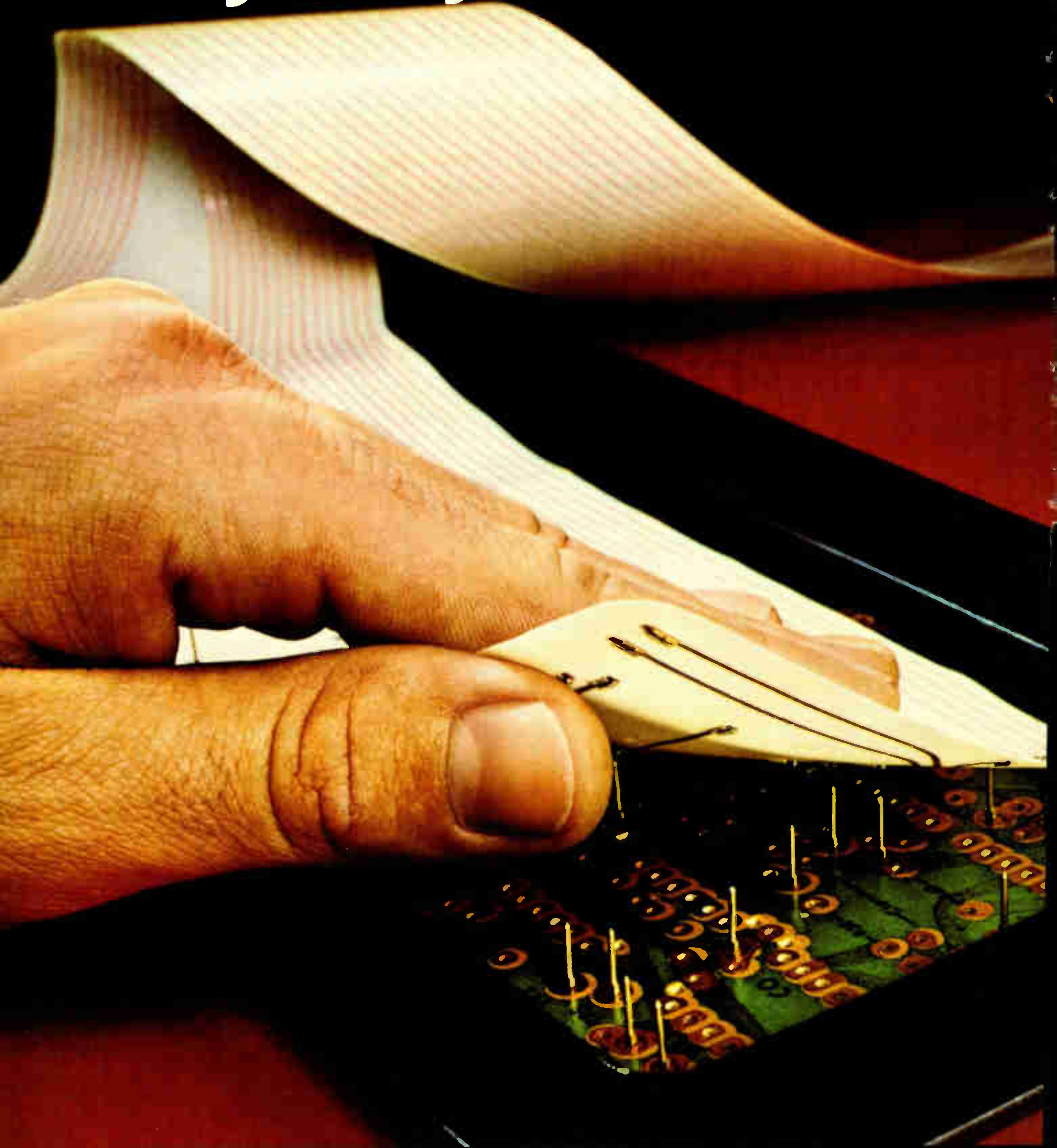

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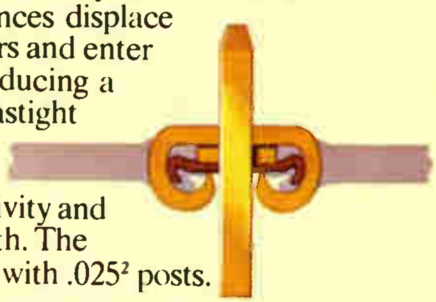

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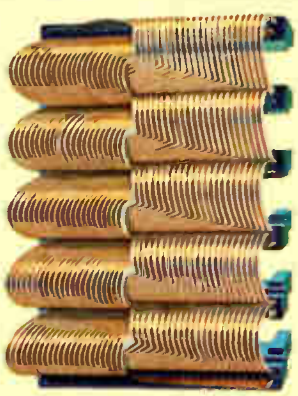

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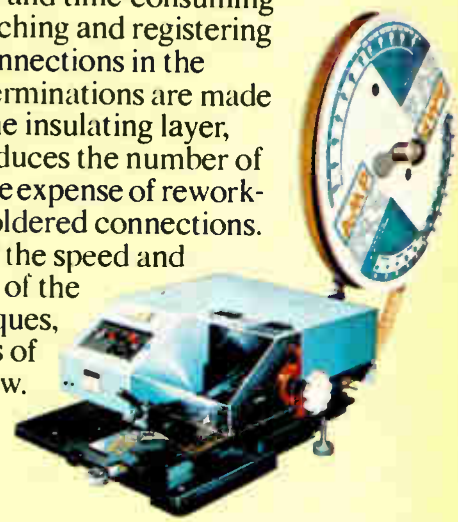

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Circle 24 on reader service card

'Phone phreaks' may whistle another tune

"Phone phreaks" will have to learn a lot of new tunes if telephone companies adopt a new signaling system being field-tested by GTE Lenkurt Inc., of San Carlos, Calif. Instead of sending dial tones on the regular voice channels, **the system multiplexes the signals for up to 24 channels, encodes them, and transmits the code at 2,400 bits per second** on a single voice channel that is separate from the other channels.

A phone phreak bypasses toll-ticketing equipment by whistling tones into a telephone after dialing information or toll-free numbers. Once he makes the toll-free connection, the phreak whistles the tones for a new number or uses a "blue-box" tone oscillator to simulate dial tones. [*Electronics*, July 3, 1972, p. 41].

Lenkurt figures the chances that the new system eventually will replace conventional signaling equipment are good. Because the signals are multiplexed, the new equipment is about 20% cheaper than conventional systems, reduces loading on voice channels, and is immune to "talk-down and talk-off" problems that interfere with signaling.

Wacker readies 4-in. and 5-in. silicon wafers

Before the semiconductor industry has fully come to grips with 3-inch silicon wafers, even bigger ones are in the works. German-owned **Wacker Chemical Corp, New York City, will shortly introduce polished wafers measuring 4 and possibly 5 inches.** General manager Donald Pisarcik says that the 4-in. wafers are coming, and 5-in. ones are possible in the not-too-distant future. MOS makers with their big dice are the biggest prospects. Pisarcik says the company has no firm orders yet, but it could begin delivering early next year if the demand is there. And he warns that **manufacturers should consider the larger wafer sizes when planning new facilities.**

Fairchild to launch CCD image sensor in April

Unless somebody else gets to market with a CCD (charge-coupled device) image sensor before April, Fairchild Semiconductor Components Group, Mountain View, Calif., will have produced the first commercial CCD arrays. **Tom Longo, vice president for digital products, says the company will announce prices of CCD linear arrays in April.**

The first of the new products will be a buried-channel, 500-element linear array [*Electronics*, Feb. 15, p. 31].

Longo says the arrays will be priced initially to compete with 512-diode linear sensors, which cost about $1,600 each. Because CCDs are monolithic, he expects their prices to drop rapidly as they go into volume production. **And, as the price comes down, he expects them to generate an equipment market of several hundred million dollars.** The CCD share of the market could be about 10% he says.

Longo says the most promising markets are for solid-state duplicating machines, sensors that measure flow or televise pictures of objects passing in front of the array, digital facsimile equipment, and optical character and page readers.

Astronomical bird cut, but may still fly

When NASA's $280 million High Energy Astronomical Observatory got caught in a budget squeeze, it looked as if the satellite program would die, but now **NASA officials think they can save the observatory idea**

with a scaled-down version, launched with smaller boosters and perhaps later, by the space shuttle. The original spacecraft would have been 30 feet long and weighed 10 tons; **the new one would be 12 ft. long and carry 2,800 pounds of equipment.** Total program cost is now estimated at $140 million. Plans call for three flights between 1977 and 1979 to study such phenomena as pulsars, "black holes," neutron stars, and supernovas.

Now, a CMOS building block for linear applications

RCA has a head start on the rest of the semiconductor industry in applying complementary-MOS to linear applications. The firm's Solid State division in Somerville, N. J., has developed a three-transistor-pair linear C-MOS array, the CA3600E, that operates at supply voltages between 3 and 15 V and at frequencies to 5 megahertz. Each transistor can conduct current to 10 mA. **This is believed to be the first C-MOS device designed as a standard linear building block.** Applications include high-input-impedance, general-purpose amplifiers, differential amplifiers, op amps and comparators, micropower amplifiers and oscillators, timers, choppers, and mixers.

Lithium ferrite advances may help microwave circuits

Following recent improvements in production methods for lithium ferrites that increase uniformity of magnetic properties, **several microwave-materials suppliers and component makers are debating the usefulness of the compound in microwave circuits. Preliminary tests indicate that lithium ferrite, which is used extensively in computer core memories,** may offer combination of higher temperature stability, lower dielectric loss, and lower production costs than yttrium iron garnet, which is now used widely in microwave circuits. A workshop session at the Intermag Conference, April 27 in Washington D.C., is expected to compare the latest test results and help determine the prospects for this expanded use of lithium ferrites.

Motorola LED now leads in price

Unwilling to sit on the sidelines as Hewlett-Packard and Fairchild drum their 17-cent (in very large quantity) light-emitting diodes, Motorola is now selling a LED **for only 10 cents—in quantities of 1 million—and for 17 cents in 1,000 piece orders.** The LED comes in Motorola's popular plastic TO-92 package, with the emitted light magnified from the curved side. For side viewing on circuit boards, the leads don't have to be bent, as they do with most other LEDs, but the diode is not for panel mounting.

Addenda

With FCC prodding, AT&T will be selling its nearly 2.9 million shares of Comsat stock, worth as much as $185 million. The money may go into the Bell System construction program . . . Four-Phase Systems Inc. will start this summer shipping its IV/40 small business computer, which rents for as little as $538 a month. Four-Phase says a comparable IBM system would cost five times that much . . . Undeterred by recent unfavorable reports by Consumers Union on the safety of microwave ovens, Litton Industries' Atherton division will expand its microwave-oven plant in Plymouth, Minn. [see p. 62]. The company expects sales to be 500,000 this year vs 300,000 in 1972.

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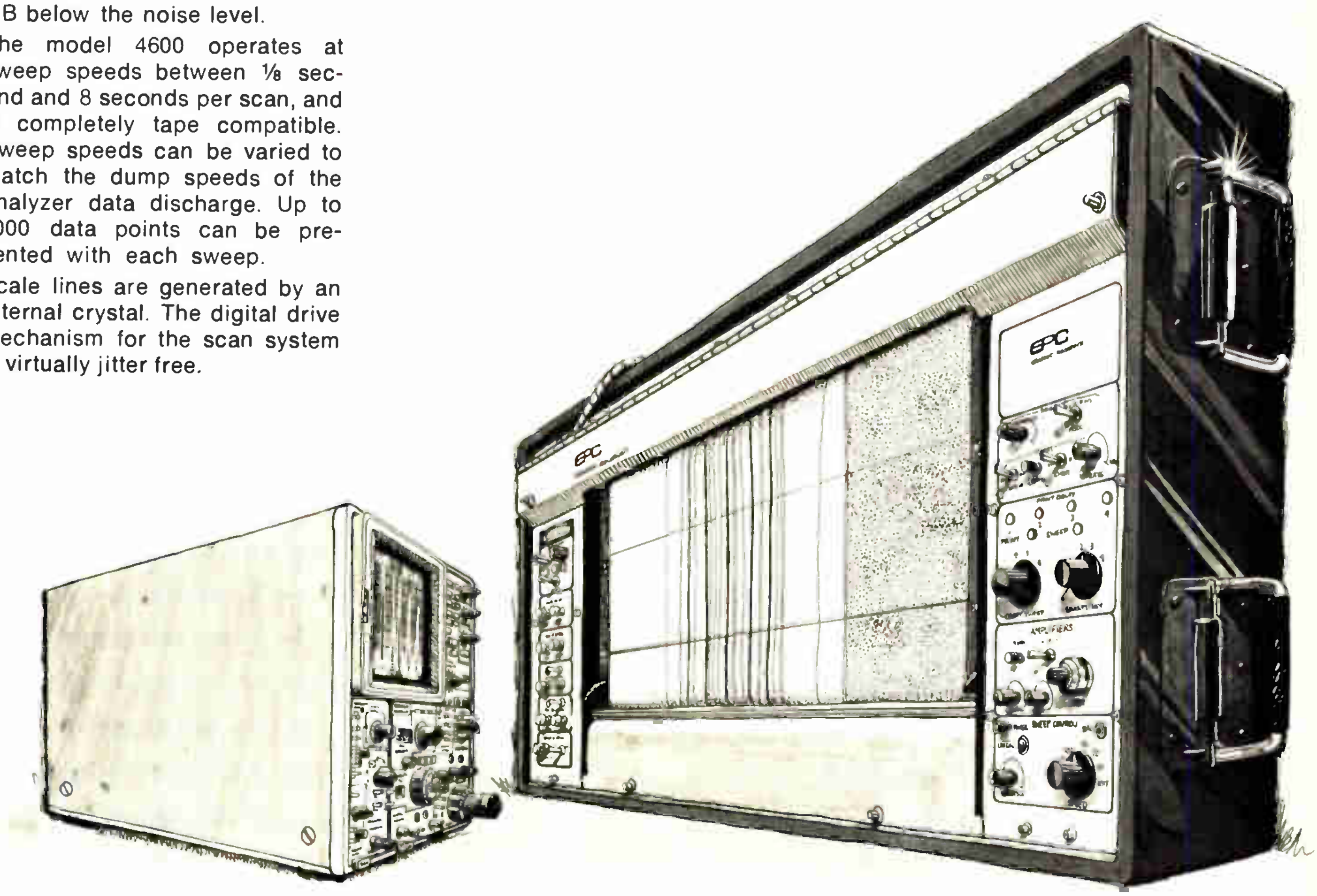
CONTRAST	Print current limiter, adjustable by front panel control.
INPUT THRESHOLD	Adjustable by front panel control.



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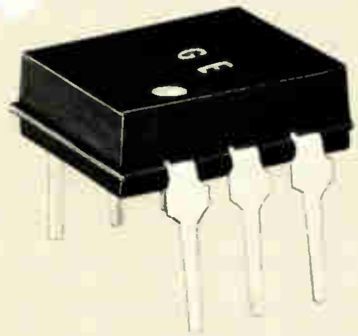
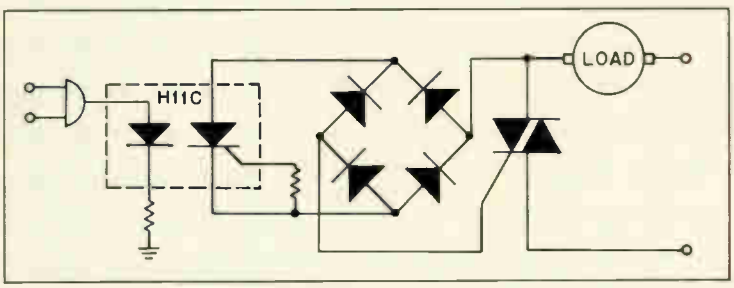


FROM GENERAL ELECTRIC

H11C1 H11C2



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GENERAL ELECTRIC

Federal EDP outlays jump 33% in fiscal 1973, as minicomputer sales soar

Univac can be considered the No. 1 computer vendor to the Government, as DEC holds to No. 3 slot

The data-processing capital cost of keeping the U.S. Government running will jump one-third—to $286.5 million—in the fiscal year ending June 30. This accounts for roughly 11% of the $2.68 billion spent in fiscal 1973 by the 12 executive departments on general and special management systems, personnel, and support services.

If those outlays follow the pattern of fiscal 1972, when hardware expenditures came to $214.2 million in a data-processing budget of $2.42 billion, minicomputers will account for the largest number of systems bought, and Digital Equipment Corp. will rank as the biggest of their suppliers.

Univac tops. Overall, Sperry Rand's Univac division took over the role of No. 1 Federal vendor in terms of total installations from long-time leader International Business Machines Corp., but Univac's accession to that role came as a result of its taking over RCA Corp.'s business base last year when that company pulled out of the computer business. Thus, by adding RCA's 199 Federal installations to Univac's 1,266, the Sperry Rand operation's total of 1,465—nearly 21.8% of the Government market—puts it slightly ahead of IBM's 1,429 total, accounting for 21.2% of the market (see chart).

All these numbers and more are contained in the General Services Administration's new "Inventory and Summary of Federal ADP Activities" for fiscal 1972, the Government's annual breakout of all general-purpose digital machines—excluding all analog and those digital machines integral to a weapons or space system.

The GSA inventory shows a continuing sharp rise in the purchase and lease of "special management" systems, which includes minicomputers, compared to what the Government calls "general management" systems. The number of specials increased almost 30% to 3,298, nearly equal to the 3,433 general management installations.

Compared to the GSA figures of a year earlier, IBM registered a net gain of one computer installation, while Univac's total (excluding RCA machines) rose by 213, and the DEC figure jumped by 266 installations. The combined gains of Univac and DEC account for well over half of the total increase of 797 systems installed throughout the Government between fiscal 1971 and 1972. Those gains, however, do not all represent new sales made during the year. As a Univac spokesman points out, for example, some 34 or more of its "new" installations represent Federal Aviation Administration ARTS-3 air-traffic-control systems that were turned over to the agency in fiscal 1972.

Shares. Nevertheless, the one big gainer in the Federal marketplace has been DEC, which picked up 5 percentage points over its position two years earlier to solidify its position as the No. 3 vendor with 976 in-

Agency \ Manufacturer	IBM	Univac	DEC	Honeywell	CDC	Xerox	Burroughs	NCR	RCA	Other	Total
AEC	105	8	589	61	74	46	2	–	–	263	1,148
Agriculture	34	2	2	–	9	–	1	1	–	17	66
Commerce	25	12	26	8	7	6	–	–	2	56	142
Gen. Services Admin.	6	3	–	18	2	–	–	–	–	–	29
HEW	40	1	6	1	3	–	–	–	14	2	67
Interior	16	2	10	2	11	–	5	–	–	5	51
NASA	84	167	99	79	88	170	–	–	1	246	934
Transportation	109	54	13	36	6	6	–	–	5	7	236
Treasury	42	1	–	55	1	–	5	–	1	1	106
Veterans Admin.	40	–	29	4	1	–	–	–	–	3	77
Other Civil	62	5	7	22	8	5	3	2	10	18	142
Dept. of Defense	866	1,011	195	264	272	81	255	236	166	387	3,733
(Army)	(290)	(245)	(22)	(78)	(53)	(13)	(21)	(120)	(48)	(78)	(968)
(Navy)	(265)	(356)	(101)	(67)	(107)	(31)	(14)	(5)	(40)	(151)	1,137
(Air Force)	(238)	(382)	(61)	(79)	(93)	(33)	(218)	(111)	(57)	(147)	1,419
(Other DOD)	(73)	(28)	(11)	(40)	(19)	(4)	(2)	(–)	(21)	(11)	(209)
Total	1,429	1,266	976	550	482	314	271	239	199	1,005	6,731

stallations. Conversely, IBM's share has dropped more than 5% from its position two years earlier, when the Government had 1,400 fewer machines.

Most significant is the fact that 84% of DEC's computer sales to the Federal Government—some 822 machines—fall in the category of $500,000 or less. And its total sales of 853 special management systems put it far ahead of the second-ranking Univac with its 518 installations in that category. IBM, with 218 systems, ranks fourth in the special management competition behind Xerox Data Systems' 279. Honeywell Information Systems follows closely behind IBM, however, with 215, and is trailed by Control Data Corp. with 163, NCR, whose systems are all leased, with 81, and Burroughs with 52 systems.

Gamesmanship. Containing 516 pages of data—much of it a massive computer printout of installations by user agency, location, manufacturer's model number, and type of system—GSA's latest inventory will permit a good corporate statistical gamesman to say something nice about almost every manufacturer.

For example, IBM reportedly still tops the dollar list as a Federal supplier and still has the largest number of general management systems across the board of federal agencies. Univac, on the other hand, tops the Department of Defense list and might claim the greatest versatility with its growth in the special management category. Honeywell has boosted its position in the Federal market to fourth place in 1972 from sixth two years ago and now has 8.2% of the total. Control Data, on the other hand, can point to its two-thirds share of the 1972 market for central processors costing $1.5 million or more. □

Government electronics

As the Navy settles on the F-14, the Air Force faces F-15 overruns

In the wake of the Navy's trying, if temporary, settlement of its contract dispute with Grumman Aerospace Corp. over the costly and controversial F-14 Tomcat fighter, it has become difficult to make an admiral smile. Yet the Defense Department turned that trick when it confirmed the existence of a Pentagon systems-analysis study that indicates costs are rising and performance slipping on the Air Force's new F-15 Eagle fighter just ordered into production at McDonnell Douglas Corp.

The less costly alternative? The F-15, increasingly touted by some congressmen and defense officials as a less costly alternative to the Grumman plane, [*Electronics*, March 1, p. 29] was also confirmed to be having difficulty in meeting engine-performance tests.

The DOD study, performed by the Cost Advisory Improvement Group, contends that the cost of a 749-plane buy of the twin-engine, single-seat F-15 could run to $9.7 billion, or roughly $13 million per aircraft. The figure is strongly disputed by the Air Force, which puts the total at $7.83 billion in its latest published estimate.

While the service argues that the F-15's unit price should average $10.5 million over the course of the full buy, it has acknowledged that the target price for the first 107 planes is $12.4 million for each aircraft, with a $15.4 million ceiling.

Settled? One congressional source called the news of the F-15 overrun "damned disturbing," but added that "any of these Air Force prices—even if you add a million or so per plane so it can operate on carriers—is still cheap," compared to the Navy's mid-March settlement with Grumman. Under the terms of that settlement, Grumman will limit production to only the 48 F-14s called for under the program's fifth lot. This would leave the Navy with 134 Tomcats, or 179 fewer than the 313 it has proposed as a minimum buy, and escalate the F-14 program's unit cost from $16.8 million to $25.8 million.

The agreement lets Grumman off the hook of its fixed-price contract for two more lots. Future buys, if any, will be negotiated on an annual basis at prices that will be higher.

Navy steams ahead. Nevertheless, the Navy is reportedly steaming ahead with plans to buy more F-14s in later years through annual contract negotiations with Grumman and to make the plane its fleet-standard fighter. Although each of these future contracts is conceived as ultimately raising the Navy inventory to 722 planes—the number originally proposed in 1971—each of the procurements would have to receive congressional authorization and appropriation.

"Right now," says a congressional military-appropriations specialist, "They don't stand a chance of getting any more money." As for future years, when the heat is off the program, the source concedes, "unfortunately, there are a lot of people with very short memories here" on Capitol Hill.

Still fresh in the minds of the Congress, however, is a classified report on the F-14 by its investigative arm, the General Accounting Office. While the GAO says the F-14 has "elements of a superior weapon system," it faults the program for "a number of problems and areas of concern." Among them are:

- Reliability problems in the central air-data computer, as well as maintenance problems.
- Transmitter problems in the airborne weapon-control system, the AWG-9.
- The airborne weapon-control system in certain situations does not meet specifications for detecting and tracking multiple targets.
- Commitment to production of the Hughes Phoenix missile used in the AWG-9 before its capabilities have been fully demonstrated.
- Engine stalls during flight tests and development problems with the advanced-technology engine (developed by United Aircraft's Pratt & Whitney division and used in the F-15), which caused the Navy to in-

definitely defer its purchase of the F-14B model.

- Considerable concurrency in production and development, reducing the amount of flight-test data available when production decisions must be made.

The Navy, said GAO, responded to its criticisms by saying it is not unusual to encounter such problems in developing a major weapon system, and adding that the service is satisfied that progress is being made by Grumman in resolving the technical difficulties. □

FAA picks team for second MLS phase

The Federal Aviation Administration has narrowed the race for development of the universal microwave landing system (MLS) by choosing four corporate teams to go on with the program's second phase. The FAA has awarded these contracts, totaling about $15.5 million: ITT's Gilfillan division, Van Nuys, Calif., teamed with Honeywell, $4.8 million; Hazeltine Corp., Greenlawn, N.Y., with Marconi of Canada, $4.4 million; Bendix Corp., Baltimore, Md., with Textron's Bell Aerospace division and Lockheed Georgia Co., $3.2 million; and Texas Instruments, Austin, Texas, with Thomson-CSF of France, $3.1 million.

In the first phase, a doppler-scanning technique knocked out two scanning-beam proposals to qualify for the second-phase competition [*Electronics*, Jan. 3, 1972, p. 43]. Now, after an 11-month evaluation of brassboard hardware, the FAA will select either the doppler scan, proposed by Hazletine and ITT, or the conventional scanning-beam technique, from Bendix and TI.

For the third and final prototype-development phase, Jack W. Edwards, chief of the Microwave Landing System branch of the FAA's Systems Research and Development Service, says, "Phase 3 will be a design and cost-definition phase within a particular technique" between the two winners. Program completion is set for mid-1976.

Timetable. Although it is slipping some from the initially tight five-year $50 million development plan [*Electronics*, Nov. 22, 1971, p. 46], the MLS program is designed to be a universally compatible all-weather system for commercial, civilian, and military use by the end of the decade. It remains to be seen just how many systems the FAA now plans to buy after the development is completed, but originally it wanted 454 ground units for about $100 million. A vast potential military and commercial aviation market in ground and airborne equipment will also fly with the winning system.

Scanning beam vs doppler. With increasingly congested air-space, conventional instrument-landing systems, which basically provide pilots with single approach paths, are becoming inadequate. MLS promises to give broader coverage and multiple flight paths, leading to greater flexibility in handling traffic. MLS will give a pilot precise course and glide-slope information, which can be displayed in the cockpit or fed into an automatic flight-control system.

MLS entry. The Bendix-Bell-Lockheed scanning-beam antenna has 81 elements and operates in C band.

Of the two types of MLS systems, the conventional scanning-beam approach gives angular guidance information with ground-generated fan beams that scan both for azimuth and elevation. Doppler scan uses the constant-frequency-shift principle to give the angular position of an aircraft relative to the ground station. Doppler proponents allege that the technique is potentially cheaper and lighter, although

First Awacs awaits test

The modified Boeing 707 testbeds for the Air Force's E-3A Airborne Warning and Control System carry huge radomes to house Westinghouse Electric Corp.'s rotating radar. The prime contractor, Boeing, recently awarded Westinghouse about $70 million for further Awacs development. Last year Westinghouse received about $44 million for a competitive fly-off with Hughes Aircraft Co., which got a similar amount. The Air Force disclosed plans last month to cut the cost of the proposed 42-plane program by nearly $200 million to $2.46 billion. The planes will have four engines, instead of eight [*Electronics*, Feb. 15, p. 51].

less well proven than the conventional scanning-beam approach.

In the next 11 months, each contractor will have to build a civilian and a military transportable ground station, as well as airborne receivers for both, and a low-cost receiver for general-aviation users. ☐

Aerojet system to help scout oil spills

The U.S. Coast Guard will use one of the Air Force's venerable Albatross seaplanes, equipped with multiple sensors, data processors, and a multicolor display. to monitor 50 miles of ocean surface for oil spills. The airborne surveillance system is being developed by Aerojet Electrosystems Co., Azusa, Calif.. under a $1.6 million contract. and is due to be checked early next year against calibrated spills.

But the Coast Guard may have trouble finding a target, since there are usually few ships in any part of the area that the Coast Guard is assigned to monitor. And 95% of the oil dumped in the ocean comes, not from wrecks and other disasters, but from pumping and flushing the bilges and ballast from freighters, says R.C. Olson, manager of microwave products at Aerojet. He adds that 2% of all oil put in ships for fuel ends up in the ocean.

Pollution of the oceans by oil is one of the most serious environmental problems because oil doesn't degrade; it floats on the water's surface, collecting into hard billiard-ball-size clumps.

The surveillance equipment will include wide-range side-looking radar made by Motorola. passive microwave detectors made by Aerojet, an infrared line-scanner from Texas Instruments, and a low-light-level TV from Dalmo Victor. The multiple detectors are necessary to ensure detection under all conditions, including night and adverse weather.

The system will have visual and audible alarms to indicate when a ship is detected. The multicolor display will provide extensive information by integrating data from the various sensors. The operator will see a real-time picture corresponding to the same area he would see if he looked out the bottom of the plane, but the display will offer far more information and will be usable at night.

All data also will be recorded for later analysis or action. The violator will have to be caught in the act. and the recorded data will require court acceptance as evidence. The system will therefore record definite position reference, record of spill area. thickness and distribution. and identification of the violator by such means as optical or low-light level images.

The system will also be useful for such missions as search and rescue. sea/lake ice reconnaissance, water-temperature mapping, fisheries surveillance, and flood/hurricane assessment. ☐

Computers

IBM's seventh 370 spins a sealed disk

IBM has added a new low end to its System 370 line of computers, the Model 115, seventh in the series. The most innovative feature is the disk-storage unit, the Model 3340, which uses "data modules" that have their disk-recording surfaces sealed into single cartridges, together with the access arms and their read/write heads.

There is no disk cover to remove. The operator merely places the cartridge on the drive. When the cartridge is in place, an access door opens. and the drive mechanism reaches through it into the cartridge to operate the access arms, which carry the read/write heads.

The transfer rate of the new unit is 10% faster than that of the 3330 disk drive, and the price of the drive on a straight monthly basis is 42% less. However, the purchase price per stored megabyte is more than four times the price of storage in the 3330 because of the added mechanism inside the cartridge. However, taking into account the rental of the drive, and applying the same purchase-to-rent ratio to 3330 disk packs as to 3340 data modules (disk packs are not available for rent), IBM points out that the cost per megabyte per month for the new units is only 8% more than for the 3330 (see table).

Two recording densities are available—34.9 million or 69.8 million characters per module. Presumably, the presence of individual heads and access mechanisms within each module eliminates difficulties

NEW AND OLD IBM DISK UNITS

	3340	3330	2314
Seek time, milliseconds	25	30	60
Rotational time, ms	20.2	16.6	25
Data rate, kilobytes per second	885	806	312
Capacity, million bytes per spindle	34.9 and 69.8	100	29.2
Tracks per surface	348 and 696	404	200
Characters per track	8 368	13,000	7,300
Spindle monthly rental (without extended term plan)	$426*	$732	$530** $827***
Price (purchased media)	$1,600 / module $2,200 / module	$775 / pack	$525 / pack
(rented media)	$ 59 / module $ 82 / module	N.A.	N.A.
Price per megabyte (purchased media)	$31.52	$7.75	$18.15
4 spindles, per month	$1,704	$2,927	
8 media units, per month	$ 656	$ 232†	
Total rental	$2,360	$3,159	
Megabytes on line	280	400	
Cost per megabyte per month	$8.43	$7.82	

*In four drive system
**On System 370 / 145 with integrated file adapter
***On other models of System 370
†If available for rent

Sealed. IBM's new data module is used with the 3340 direct-access storage facility.

created by possible head-to-track misalignments when a module is recorded on one drive and read on another. However, the internal mechanism could possibly create additional adjustment problems that could compound these difficulties rather than relieve them.

IBM traditionally keeps most of the technical specifications close to its corporate chest, but some information about the modules can be deduced. For example, the modules are known to contain 12 recording surfaces, which means they contain either six disks recorded on both sides, or seven disks with six spaces between them. If it is the latter arrangement, the top and bottom disk surfaces would remain unused. This format was used in disk packs for 3330 and 2314 disk-storage units.

A new printer to replace the venerable 1403 is also available with the 370/115. Its top speed is 1,200 lines per minute, compared with 1,100 for its 15-year-old predecessor. Otherwise the new machine is similar to the old, except for an electronic forms-control unit that replaces a loop of punch paper tape to control the vertical spacing of the printed paper.

Other than the disk-storage unit and the printer, the 370/115 offers little in the way of technical surprises. Like all other models of the 370 since last August, it has a virtual memory. Like other recently introduced models, its memory is MOS, made with 2,048-bit chips. And like the previous low end of the line, the model 125, which is now second from the bottom, the computer is organized around a series of satellite processors. □

Memory is MOS in Univac 9480

Sperry Univac may be abandoning its reliance on plated-wire memories, which it once said would replace ferrite cores as memory components. The firm's latest computer, the Univac 9480, is its first commercial machine to have a semiconductor main memory. Significantly, the machine is part of the 9000 series, through which Sperry Univac has been promoting plated wire.

A medium-scale system, the 9480 has memory capacities of 65,000 to 262,000 bytes and a 600-nanosecond memory cycle time, during which two bytes (16 bits) are retrieved from the memory. The memory itself is an MOS system assembled from Intel 1103 units, the well-known 1,024-bit arrays that have led the scramble toward semiconductor memories. The usual line of peripheral equipment, communications gear, and software comes with the machine.

Officially, Sperry Univac would not comment about the future of plated wire. The company's current development effort, however, is said to include several machines with semiconductor memories and no machines with plated-wire memories. Nevertheless, plated wire, though on the way out, won't disappear tomorrow. Univac is still producing four other models of the 9000 series, all with plated-wire memories, although the older models are approaching the end of their production life.

Univac also is producing its large-scale 1110 computer, announced in late 1970, with a combination of plated-wire and ferrite-core memory—up to 262,000 words of the former, cycling at 520 ns, and 1 million words of the latter at 1.5 microseconds. Furthermore, the core-memory portion of the 1110 is said to be slated for replacement by an all-plated-wire array sometime soon, at a lower cost than the combination memory.

Just over a year ago, when the Univac 9700, largest and most recent of the 9000 series, was announced, George H. Geick, executive vice president of Univac, said that the cost of plated wire was decreasing and that it therefore remained competitive with other forms of memory, but that the 9700 did use semiconductor general registers and buffers. □

Consumer electronics

Backer sought for 'information center'

The consumer electronic market may be pushed to new levels of sophistication by an idea for what Burroughs, the developer, calls a "home information center." As yet, it is a product looking for a producer.

For although Burroughs makes

No plated wire here. Univac's 9480 has a semiconductor main memory; it is a medium-scale system using 1103s.

the Self-Scan gas discharge display that is an integral part of the system, it does not make the other components—a cassette tape player and recorder, a standard keyboard, and some off-the-shelf large-scale ICs. When these are combined, the result is a compact programable console that can be used in homes, offices, schools, and even autos.

While Burroughs is not interested in getting into the consumer electronics market, the company wants to expand the market for its display and is therefore strongly interested in working with a manufacturer to develop the product at a reasonable price. And with this end in view, Saul Kuchinsky, who directs marketing development for Burroughs' Defense, Space and Special Systems group in Paoli, Pa., has for the past few weeks been quietly demonstrating the unit to executives in a variety of enterprises.

Executive schedule. One of Kuchinsky's demonstration cassettes is for a unit that might sit on an executive's desk. Each morning his secretary would load it with a tape listing all appointments and other schedule reminders. The executive could scan the schedule and plan his day. Or, the unit could be coupled with a clock and programed to produce an audible and visible reminder at appropriate times during the day. Other cassettes could bring the executive updated sales and pricing or other management data. Of course, he could make his own tapes.

Another suggestion by Kuchinsky is an auto trip guide. Here, a display on the dashboard would provide mileage and directional information to guide a driver over a specific route, while the audio message would provide sight-seeing information. Electronically coupled to the odometer, the display would show the driver the miles remaining to the next route change. At zero, the audio would call the driver's attention to a new instruction coming on.

Almost anything is possible. The point Kuchinsky wants to make with his demonstration unit is that the technology now makes "almost anything possible with electronics, at reasonable cost." He conceives of whole new services made possible by the information-center idea, because the console can be connected to any type of communications system, including telephone and cable TV.

Taped programs could be loaded and unloaded locally or remotely by these means. The telephone could deliver weather, stock information, or other types of information to the home or office. And because the user can easily program the tape himself simply by addressing the keyboard in ordinary language, the uses of the device are limited only by his ingenuity.

Other applications conceived by Kuchinsky include programed teaching machines that can be used at school or home, as well as easily updated information centers for airports, hotels, restaurants, banks and financial institutions. □

Information center. Developed by Burroughs, the combined display, keyboard, and tape player and recorder may kick off a new level of sophistication in consumer electronics.

Solid state

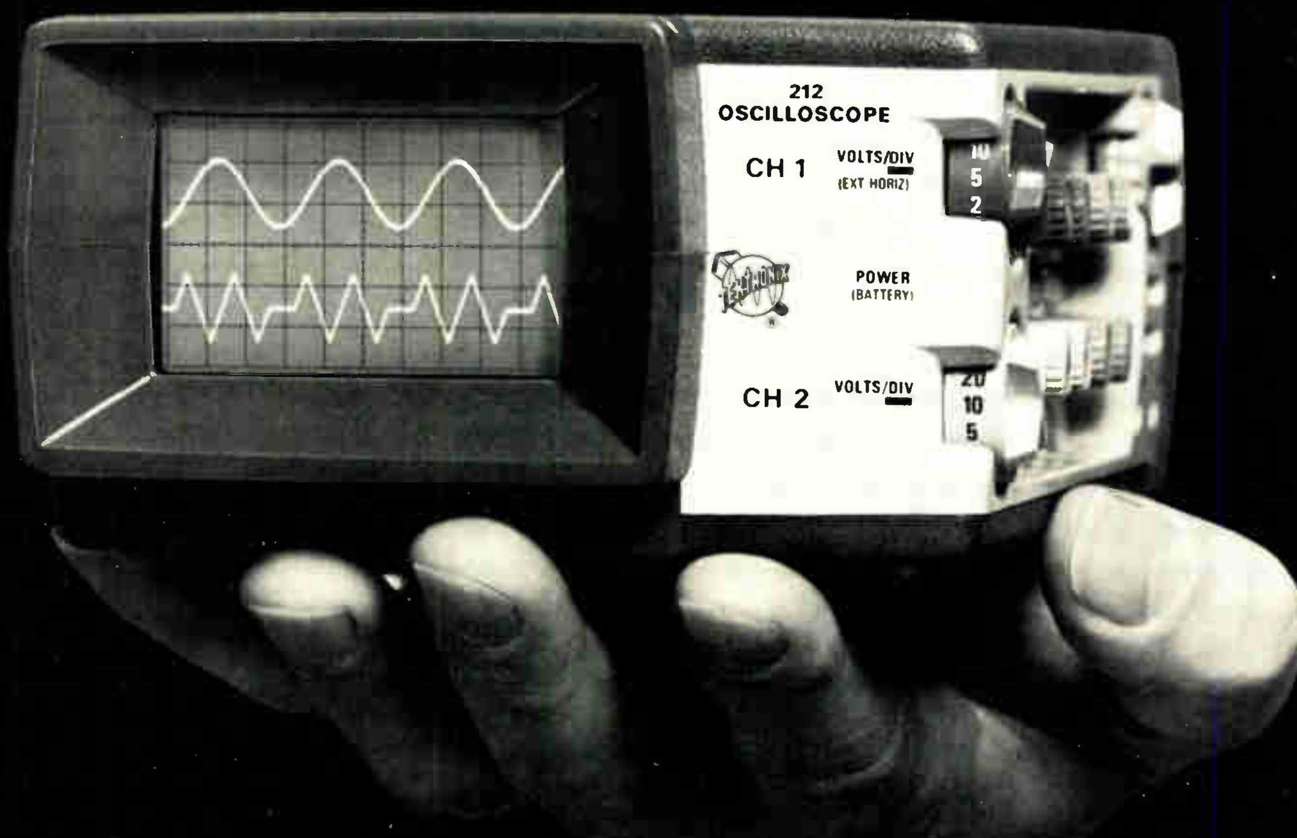
D-MOST frequencies top MOSFET range

When Signetics Corp. conceived a double-diffused-MOS technology—D-MOST, for short—in 1971, the process was expected to lead to high-speed logic circuits. But researchers soon discovered that the process resulted in uhf and microwave transistors with unusually low noise figures and high gain at gigahertz operating frequencies.

So, now that D-MOST development has been completed, Signetics has abandoned its integrated-circuits-only manufacturing policy and has set up a transistor group. The first D-MOST field-effect transistors will be introduced next month, and high-volume shipments will start within three months. Four types will be produced initially—two triodes and two double-gate tetrodes. The tetrodes are designed for use in circuits with automatic gain control.

Four times higher. These specs are cited by George V. Urbani, the group's marketing manager: The new devices will operate to as high as four times the useful frequency of conventional MOSFETs. In metal cans, they operate to 1 GHz with gains of 10 dB or more, and have noise figures around 5 dB and power dissipation of 300 milliwatts. In microwave stripline packages, they operate at 2 GHz with similar ratings. And, unlike uhf bipolar transistors, the new FETS exhibit linear power-frequency characteristics, Urbani adds.

All four of the new transistors are n-channel, enhancement-mode FETs with channels only about 1 micrometer long—two to three times shorter than channels of conventional depletion-mode FETs. A wide drift region between the channel, which is next to the source, and the drain allows the channel to be made



212
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CH 2
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very small without voltage breakdown problems [*Electronics,* Feb. 15, 1971, p. 99]. Short channels and relatively high drain-source voltages are two keys to high-frequency, high-gain operation.

The first four operate at 25 volts maximum, but transistors with voltage ratings from 5 to 300 V have been built experimentally. Much higher powers than 300 mW are also practical. Urbani says that 1-W, 1-GHz transistors are being developed. Another attraction of the D-MOST structure is extremely low parasitic capacitances at the inputs and outputs of the transistors, a characteristic that reduces spikes on the outputs of analog switches.

The highest-volume application of the discrete transistors is expected to be amplifiers and mixers in uhf television tuners. TV manufacturers who don't require complete testing of the transistors will be able to buy them in large quantity for 30 to 40 cents each, Urbani says. Designers of communications and navigation systems will be able to use these in "textbook, rather than twiddle-type, amplifier designs," Urbani remarks.

A process change. It has taken Signetics two years to bring D-MOST to production readiness and to determine what types of transistors would sell best. Apparently, the most significant process change is supplementing the original double-diffusion technique with high-energy ion implantation. While company spokesmen won't discuss why implantation is used, a favorite joke around the plant is, "We now own the largest linear accelerator south of SLAC." (Stanford's Linear Accelerator Center a few miles north of Signetics' plant has a famous two-mile-long accelerator.) □

Marketing

IC prices stabilize, increases cited

Although it is difficult to get semiconductor manufacturers to say that they are raising prices on the devices they sell, it is clear from what they are saying that prices have at least firmed, particularly in the last two months, because of a tremendous shortage of most device types. Add to the economics of supply and demand the fact that semiconductor makers' costs are soaring, and it is apparent why some parts—notably operational amplifiers—have increased in price.

Most device makers are heavily backlogged: delivery quotes of less than 16 weeks are a rarity. Volume discounts, which have been traditional in the industry, are disappearing in what is becoming known as discount stiffening. This is especially true for TTL, Schottky TTL, and DTL.

Semiconductor makers point out that they have to pay their suppliers up to 28% more for silicon, 15% more for lead frames, and twice as much for gold. They add that labor costs are also on the upswing.

A long-range demand. "I don't think we need to raise prices," says John Welty, "but just have a pause in the reductions and hold prices at the present level for a couple of years." Welty is vice president and assistant general manager at Motorola's Semiconductor Products division. He adds, "We in the industry have been raising productivity 12% to 13% a year, but we've been passing it all on to our customers, and I don't think margins are what they should be."

Welty regards semiconductor undercapacity as a long-term proposition: "Unless there's a major readjustment of the economy, we won't be able to catch up with the demand for the next three or four years," he maintains. National Semiconductor Corp.'s president, Charles Sporck, agrees. Sporck says the IC shortage—industry undercapacity—will continue for three to five years and possibly longer. A good deal of the demand will be from auto companies, in Welty's view. "They will lay about $130 to $140 million in business on the industry in the next year—that's about 10% of the total—on top of the rising demand in other areas."

Gene Hnatek, linear IC marketing manager at Signetics Corp., says there is an op amp shortage that he doesn't expect to be alleviated until the fall. He says op amp backlogs are considerably longer than three months. Hnatek pegs the current industry price range in high volume for the 741 op amp at 40 to 50 cents, compared with 27 to 29 cents in 1971, "before the flood gates were opened." The 747- and 1458-type devices have moved up from about 50 cents to a range of 70 to 80 cents.

Hnatek says he's heard of companies still quoting the 741 at 25 cents, but he maintains these are companies that haven't got 741s to deliver; they're trying to force competitors to take orders at a lower price.

At Fairchild Semiconductor, Thomas Longo, vice president and general manager of the Digital Products group, says, "The demand has been enormous over the last few months in all product lines, with the exception of ECL." ECL is in demand, but at a lower level than TTL or DTL because ECL is still largely in the systems-engineering phase of use. "TTL demand is significantly in excess of forecast."

Where the emphasis is. Longo says small-scale devices, primarily gates and flip-flops, were underpriced during the recession, and they have now risen to the point where they are profitable. During the recession, the gates were loss-leaders. They are now in short supply, compared with medium-scale functions, because in the more recent buildup of production capacity, the industry has emphasized MSI rather than SSI production.

The shortage is severe in DTL. The total DTL market will not be significantly greater this year than last year, Longo says. However, many producers backed off DTL in order to meet the production demand for TTL. Longo says Fairchild is continuing to support DTL, but cannot handle the industry demand.

Over the last four months, SSI prices at the volume levels have risen 30% to 35%. "SSI was unprofitable," says Longo. "The low prices could not be justified in terms of strong future yield improvements." Yields were already so high that any

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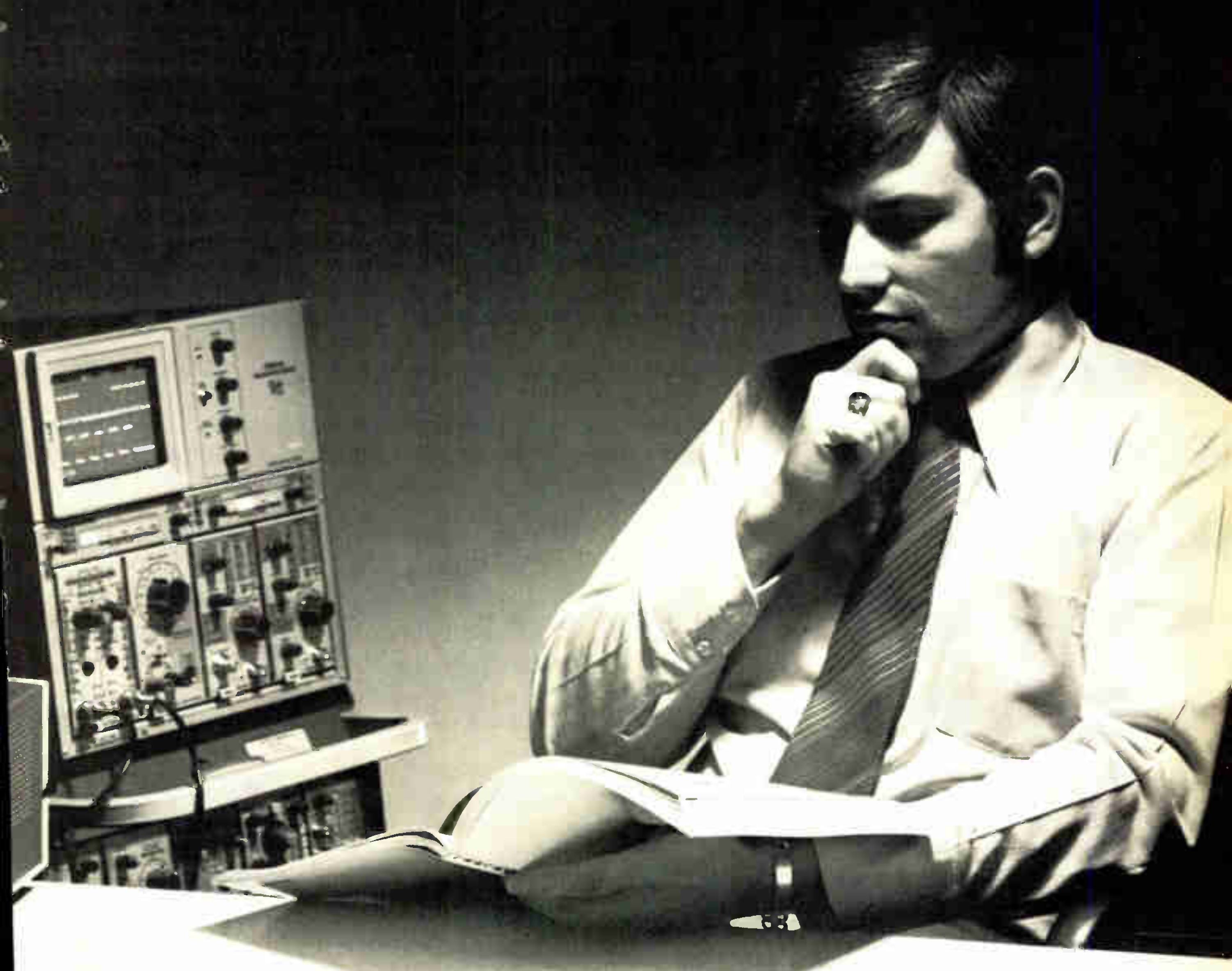

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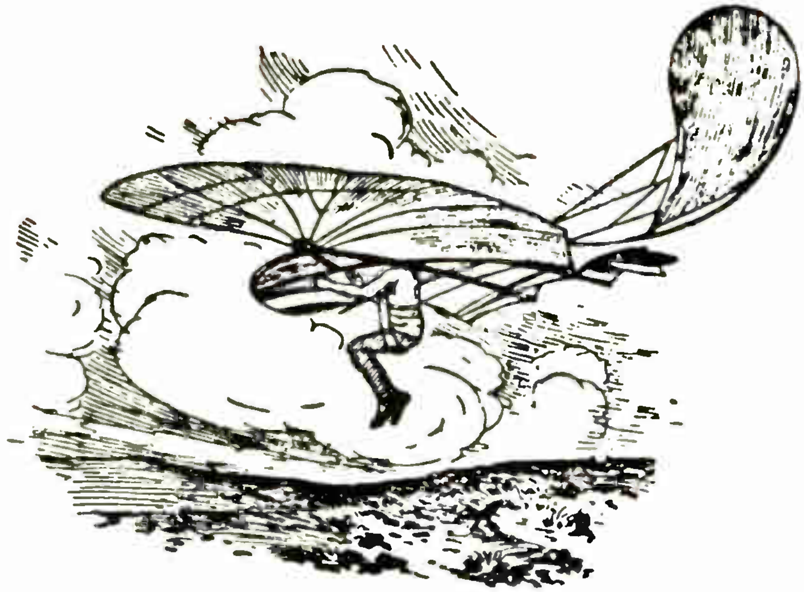

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South, 713-785-0581, 817-268-3505, 305-894-4401, 919-227-2581, 305-773-3411, 813-867-7820, 205-534-9771
West, 303-744-3301, 505-523-0601, 602-946-4215, 505-296-8303, 714-540-7160, 408-374-5220, 206-762-7664, 503-646-6064, 503-646-3416
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ANALOGIC

manufacturing cost-increases were directly reflected in losses or, later, in price rises. By this, Longo means that SSI had bottomed out on the cost learning curve so that quoting low prices for long-term deliveries, as is generally done with new semiconductor products, meant that the vendor would be setting himself up to sustain a loss. □

News briefs

Tape gets increased density

IBM and Storage Technology Corp. have managed a radical jump in data packing density, and therefore in performance, of magnetic-tape systems. IBM's new 3420 models 4, 6, and 8 magnetic-tape drives and STC's 3600 and 3800 series can record data at 6,250 bytes per inch—almost four times the previous density of 1,600 bytes—thus upping the maximum data transfer rate from 320,000 bytes per second to 1,250,000.

Motorola to appeal Fairchild decision

Motorola will appeal the recent U.S. District Court decision that dismissed its $220 million suit against Fairchild Camera & Instrument Corp. over the resignation of C. Lester Hogan and other Motorola executives who joined Fairchild in August of 1968. Motorola claimed that, as a result of the move, it suffered a decrease in net profits and damage to its "human organization."

The court opinion states that the evidence presented by Motorola "demonstrates a lack of liability and lack of damages . . . chargeable to the defendants or any of them under any theory advanced by the plaintiff." And, it added, there was no conspiracy by Fairchild to injure Motorola.

Ex-Cogar crew gives thanks for the memory

Although Cogar Corp.'s memory-systems operation gave up the ghost several months ago, five of its expatriates are still plugging away at the memory-systems business. Tom Kwei, Bob Meade, Stan Anderson, Bob Kincaid, and Dan Sappe bought Cogar's parts inventory and the rights to the Cogar design. They converted the design to ferrite-core and went into business under the name Intermem. The operation now occupies an old factory building in Wappingers Falls, N.Y., where the new entrepreneurs assemble and sell add-on memories for IBM computers.

Oak consummates sale of relay line

After sitting on the offer a year, Oak Industries has finally sold most of its Hart-Advance line of relays to Magnecraft Electric Co., Chicago. Magnecraft will immediately stock 320 items of the 500-plus line, including 2 through 8 form C miniature industrial relays. Telephone-type relays were sold to Olympic Controls, Elgin, Ill.

A big "if" looms for IBM's customers

IBM's new pricing structure is likely to have a strong impact on the economics of the computer industry. If a customer signs a contract to keep the computer installed for four years, IBM won't add charges for night and weekend use of a computer system to the standard monthly rate, which covers usage up to eight hours a day, five days a week. But if the customer wants to remove or even upgrade the machine before the four years have passed, he has to pay a stiff penalty. These provisions will tend to arrest the trend toward purchase of IBM computers, which has been eroding IBM's huge rental base.

Calculator kits go up in volume, down in price

Closely tracking the calculator market's price declines, the Heath Co., Benton Harbor, Mich., has phased out its $130 desktop calculator kit, the firm's all-time best seller. Replacing it will be two four-function models using Texas Instruments calculator chips: the IC-2108 desktop unit at $79.95, and the IC-2009 pocket-calculator kit for $92.50.

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FCC plans May reopening of land-mobile issue

Watch for increasing Federal Communications Commission and industry interest in the issue dubbed "pseudo common carriers" when **May 7-8 oral presentations ordered by the FCC reopen the whole issue of 806-947-megahertz broadband radio common carrier service.** "Pseudo common carriers" are those who offer unregulated land-mobile radiotelephone service and include some land-mobile equipment makers. The growth of "pseudo carriers" is opposed by the regulated carriers, who, however, according to their critics, are unable to keep up with demand. An Electronic Industries Association official **calls the issue "one of the most critical and unpublicized . . . facing the industry."**

U.S. airlines hit Congress on Aerosat

In face of strong opposition by U.S. air carriers, Congressional support is vanishing for the Federal Aviation Administration's revised plan for a joint U.S.-Canadian-European aeronautical services satellite program, in which the participating U.S. common carrier is to be chosen by the European Space Research Organization [*Electronics*, Jan. 18, p.107]. At a mid-March briefing for the Commerce subcommittee chaired by Sen. Howard W. Cannon (D., Nev.), representatives from the airlines' communications company, Aeronautical Radio Inc., warned that the program for the one-ocean, two-satellite system gives ESRO "undue influence" and ignores the additional communications capacity obtainable at a fraction of the Aerosat's cost by the use of high-frequency single-sideband technology.

The FAA puts total U.S.-ESRO cost at $150 million, but the airlines say "add-ons and overruns . . . may well cause it to exceed $200 million." The airlines want Congress to block any Aerosat appropriation.

American Satellite to buy 3 domsats from Hughes

Action on the domestic communications satellite front has American Satellite Corp. **issuing hardware contracts for three satellites and four of eight proposed ground stations** and also making a $600,000 down payment to NASA for Thor-Delta launch vehicles that will cost $8 million to $9 million each. The company, which is jointly owned by Fairchild Space and Electronics Co. and Western Union International, plans to spend $85 million in the next two years.

The three 12-transponder spacecraft that American Satellite has contracted to buy for about $25 million from Hughes Aircraft are similar to Canada's Anik domsat, and the company **intends to launch the first of them in the fall of 1974.** Actual service is to start sooner, however—before the end of this year—with leased transponders from Canada's Telesat interconnecting four U.S. earth stations. At the same time, Fairchild Space and Electronics is designing a second-generation domsat of 24 transponders for later use.

Addenda

American Satellite Corp. president Emanuel Fthenakis believes **some domsat applications are "in limbo."** He notes that RCA, for example, has only just applied to the FCC for an "interim" system using Canadian Telesat channels and RCA earth stations this year but has not yet moved on hardware. . . . Data Transmission Co., special-service microwave carrier, has **received FCC approval for a 34-station, $10.5 million link** in its switched net between Dallas and St. Louis.

Washington commentary

Environmental pollution and the electronics industries

"A striking feature of the environmental movement is its general public origin. . . . There have been no high-priced lobbyists in Washington working for this cause, no vested interests to push the legislation along. . . . I wish to suggest that this process of mandating change in the structure of our society is far from over. . . . The environmental problems of our country have not yet been solved. Some of the more insidious problems have not even been addressed."—John R. Quarles Jr., assistant administrator for enforcement and general counsel, Environmental Protection Agency.

There is a message for the electronics industries in the remarks of EPA's John Quarles before the March meeting of the Pennsylvania Environmental Council. At the moment it is not a very loud message. Yet those manufacturers and engineers who are not listening for it would do well to begin, since those who are not tuned in will very likely find themselves soon confronted with a new popular issue: electromagnetic pollution of the environment.

That title, incidentally, is not one assigned by us. Indeed it is one devised by the White House Office of Telecommunications Policy, whose director, Clay T. Whitehead, is perhaps better known to readers for his January identification of some television newscasting as "ideological plugola" and "elitist gossip." Nevertheless, Whitehead's more recent observations on "electromagnetic pollution" never got off the ground by comparison.

A nation's ignorance

While Whitehead is frank to admit that there is a larger problem, one that he says he wants to do something about, he also concedes a great deal of ignorance in America about its precise nature. "While indications are very preliminary, in the past year we have learned that there may be more effects at lower energy levels than were previously thought to exist," he advised the Senate Commerce Committee in March, noting that "much more research must be conducted."

What OTP wants to achieve through its direction of the Government's "modest" program, consisting of widely scattered and sometimes duplicative efforts in a large number of Federal agencies, is a balance between "a sound scientific foundation for protecting man and his environment, while at the same time permitting continued effective use of communication equipment with its great social and economic benefits." So far, unfortunately, the United States does not have that. And it is quite some distance from achieving it, even though professional interest in the subject began to jell in 1968 with the publication of a report called "Spectrum Engineering—The Key to Progress." That massive document was the product of extensive effort by the joint technical advisory committee of the Institute of Electrical and Electronics Engineers and the Electronic Industries Association.

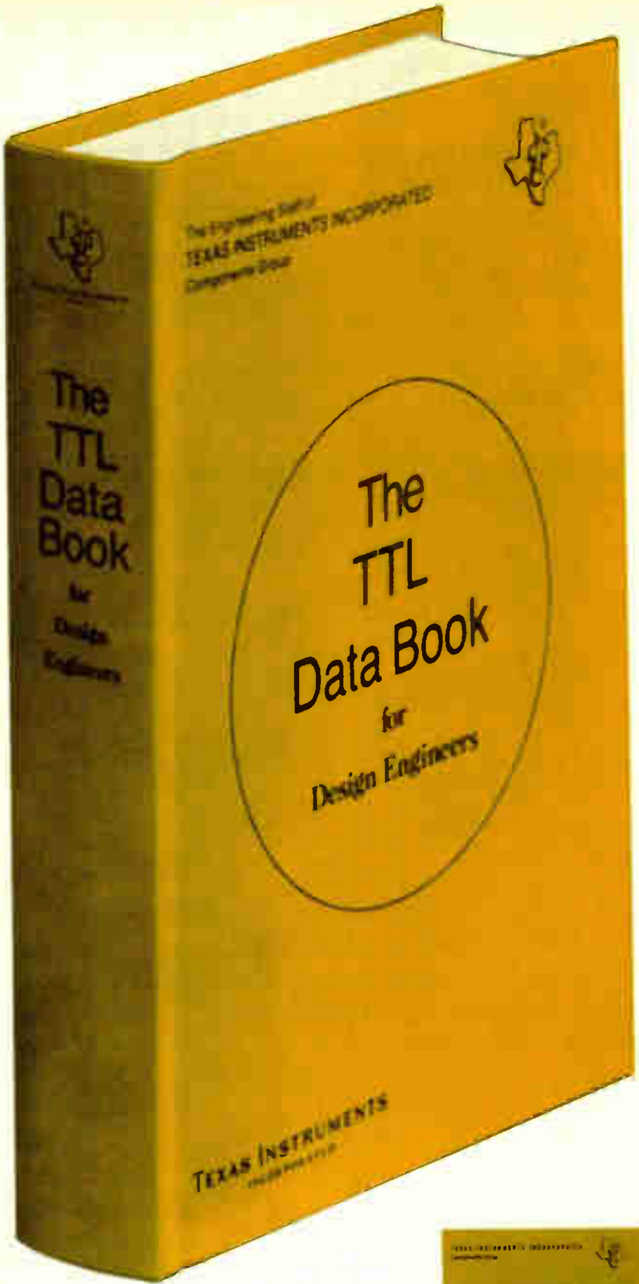
The committee's study concluded, among other things, that "a central interdisciplinary coordination body for 'side effects' should be developed." The conclusion was based on the somewhat pathetic observation by the country's leading lights in electronics technology, who comprised the panel, that "the area of side effects is very sketchily understood." It did not take Whitehead long after his ascendancy as director of telecommunications policy to take those recommendations as OTP's mandate to become the coordinator and focal point for Federal electromagnetic radiation studies.

Industry's apathy

As promising as all of this might have been, it needs to be noted that in a city like Washington, where there is but one industry, most of OTP's efforts have produced little thus far apart from some interesting reports and the creation of a somewhat prestigious and in effect powerless organization called the Electromagnetic Radiation Management Advisory Council. Though this council has recommended a Government-wide research program for radiation effects, specifying assignments and recommended funding, the OTP has yet to bring it up to speed simply because it does not have the power either. All the pertinent legislation is administered by other agencies.

In the face of all of this, there is an astonishing degree of apathy among most U.S. electronics manufacturers on the matter of electromagnetic pollution. As one of them put it when asked about the OTP program, "I'm not familiar with the specifics, but I know it is work that needs to be done, and I am glad that someone is doing it." Unless such attitudes of ignorance and apathy begin to change quickly, the electronics industries will live to regret it. That time will come when environmental activists read the literature on electromagnetic radiation and address themselves to the problems that John Quarles has called "some of the more insidious."

—Ray Connolly



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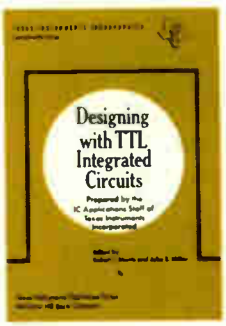

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87

Paris hosts busiest Components Show since 1969

The market rebound in electronic equipment will make this year's Paris Components Show the busiest since everybody's boom year of 1969. About 875 firms will display their technology and new products April 2–7 at the Porte de Versailles exhibition hall in an atmosphere bordering on euphoria.

- In Germany, components are being rushed in private cars to equipment makers to keep assembly lines humming.
- In France, orders for some semiconductor products are backed up more than three months.
- In Britain, most standard components now have lead times of more than eight weeks.
- And in Italy, SGS-Ates says demand is going to outstrip supply throughout 1973 in Europe.

The sponsoring Fédération Nationale des Industries Electroniques (FNIE) says to watch for innovations at the show in three major fields—semiconductor memories, optoelectronic devices and consumer integrated circuits.

France, which will dominate with 410 exhibits—nearly half the total show—is just emerging from crucial parliamentary elections that saw the Socialist-Communist coalition fall short of gaining control of the government. "We just missed getting into a real mess," says an official of Thomson-CSF, referring to the nationalization program that the leftists had threatened to introduce. Indeed, the Thomson group was at the top of their list.

Breathing more easily now, Thomson-CSF sees the 1973 electronics market as maintaining a strong upswing in the color-TV, telecommunications, and computer-components sectors. "The industrial market is good, too," says Bernard de Charentenay, marketing director of the Semiconductor division, "but it could be better. We are expecting to witness a new surge in industrial investment this year."

In Germany, suppliers report that the sales spurt is due to the big boom in entertainment electronic products, particularly color-TV sets. But in other areas, too—in industrial electronics equipment for example—the components demand is far higher than originally expected. The demand is for all types of devices—for consumer applications, for professional uses, and particularly for ICs.

Nevertheless, there is a certain reluctance on the part of suppliers to drastically increase capacity to cope with the demand. Instead of over-expanding production facilities as companies did during the late 1960s, "we are seeking a balance between capacity and demand," says Fritz G. Hoehne, director of sales and marketing at Intermetall GmbH, a member of the ITT Semiconductor Group.

Boom and backlog. In Britain, the backlog of orders is particularly acute. Capacitor orders may have to wait five to six months. For tantalum types it can be much longer. Another bad item is potentiometers, a 16- to 20-week wait being common, and many transistors are on 12-to-16-week backlogs.

One cause of the shortages is the consumer electronics boom, particularly in color television, which will not reach its peak till the early summer. Equipment makers generally believe component makers are being cautious.

There's no general tendency to increase prices, partly, at least, because of the price freeze in Britain. Hence, component suppliers suffer harassment from buyers and get no financial compensation.

Exports bring smiles. In Italy, SGS-Ates managing director Giancarlo Maimone says, "We are absolutely certain that the first half of 1973 is going to show an expansion over last year." In semiconductors, demand is more buoyant for some lines than for others—linears and MOS, for example, are looking good, he says.

It is mainly the export markets that are keeping a smile on Italians' faces. The failure to resolve the color-TV problem in Italy means that the home market cannot take off this year. □

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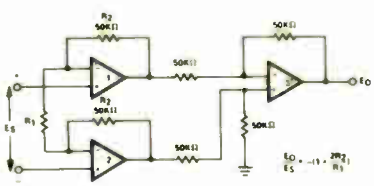

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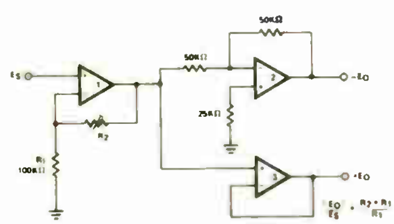

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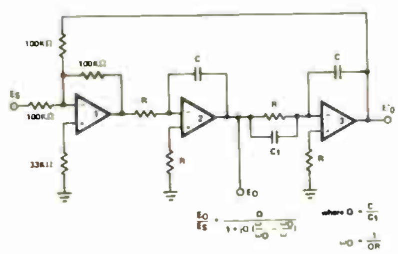

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Siemens cuts computer prices

Following the example of IBM, West Germany's Siemens AG has announced drastic price and rental cuts for many of its computer models. **For large systems, such as the Siemens 4004 models 150 and 151, the reductions amount to about 18% and for some customers to even 20%.** In the company's range of medium-sized systems, like the 4004 models 35, 45, and 135, rentals have also been significantly slashed, by amounts depending on capacity, installation date and other factors. **For small computers, however, prices remain unchanged.**

The Siemens move has also been motivated by the successes the company has achieved in streamlining production and by the healthy state of West Germany's EDP market. Experts predict a near-term market growth of at least 20%, a rate scored also in the recent past. Siemens, West Germany's largest native computer maker, has performed even better than that. On an if-sold basis, the company increased its EDP business to $390 million last year, up nearly 30% from $300 million in sales the year before. **Siemens says its share of the West German computer market is about 16%, which puts Siemens in a solid No. 2 position behind IBM.**

Laser beam controls crystal growth

The growth of synthetic crystals can be controlled far more precisely than is possible with conventional seed-pulling and crystal-rotating schemes in a method devised by researchers at the Philips Laboratories in Aachen, West Germany. With the new Philips method, which is **based on laser techniques, the diameter of the crystal throughout its growth can be measured and controlled with an accuracy to within 1%.** It thus solves the problem of irregular diameter variations, which in normally grown crystal can give rise to structural imperfections. The laser method exploits the surface tension effects that cause the free liquid surface of the melt from which the crystal is grown to curve upward near the crystal. **The surface inclination at a fixed point close to the crystal is a measure of the crystal diameter.** The magnitude of this slope is then detected by the laser beam and measured with an arrangement consisting of an optical reflection system and a pair of photodiodes.

Japanese companies work out PAL license with AEG-Telefunken

It looks as if four Japanese companies will complete soon a license deal for PAL color with AEG-Telefunken that will meet with approval of Japan's fair trade commission. The new contract—with Matsushita Electric Industrial Co Ltd, Tokyo Shibaura Electric Co Ltd, Sanyo Electric Co Ltd., and Sharp Corp.—will be revised to remove two objections to the earlier contract that the commission disallowed.

First, **the sale in Europe of "simple PAL," developed by Japanese manufacturers such as The General Corp. and Sony Corp., will not be prohibited.** But the manufacturers of simple PAL must put on these sets some kind of label indicating that they are of the simple PAL type. **However, although Telefunken is withdrawing objections to sale of these sets, it still maintains that these sets infringe on its patents** because they receive programs broadcast in PAL. Second, Telefunken is withdrawing its condition that the contract contain provision for a quota for PAL color TV from Japan.

Mullard plans large-scale production of microwave IC

Mullard Ltd. is tooling for volume production of a microwave integrated circuit containing all items needed for a Gunn-diode doppler radar, except the antenna, doppler signal amplifier, and power supply. **The company claims that its move will lower significantly both the component and the assembly costs in manufacture of Gunn-diode intruder alarms**—which are selling well in Europe, with around 1,000 being made every week in Britain alone.

The circuit is essentially a three-port circulator, filters, and an interdigital capacitor in gold on a polycrystalline ferrite substrate measuring ⅜-inch square. One port has the Gunn-diode oscillator and fine-tuning varactor diode, another is the main signal output and input through a single antenna, and the third passes the transmitted and received signals to a doppler detector diode. The Gunn diode is stabilized to 1 megahertz per °C by a high-Q resonant microstrip line adjacent to its output. **The main problem that Mullard will face in selling it is not likely to be cost or performance but persuading alarm makers to shift from present twin-antenna to new single-antenna designs.** Because so many authorities have to approve microwave alarm designs, there's a tendency to stick to approved designs while sales are good.

Light sensor uses planar silicon

AEG-Telefunken has gone to market with a light sensor that the company claims is far superior to the cadmium-sulfide types normally used as sensors in optical measuring or photographic equipment. The new sensor, designated BPW 21, is **a fall-out from the company's activities in developing and supplying solar cells for space satellites.** It is essentially a p-n planar silicon element, which is matched to the human eye's spectral response by a built-in conversion filter. The BPW 21 is suitable either for photoconductive or photovoltaic operation. Among its prime features are: high linearity, absence of residual voltages and currents in absolute darkness, small dark-reverse current, short response time even at small light levels, and good calibration characteristics because of high long-term stability. **The sensor's output is linear with illumination from 10^{-2} lux up to 10^5 lux.** Typical dark-reverse current is 10 nanoamperes, and typical spectral response from 420 to 675 nanometers.

ITT to market capacitors in dual in-line packs

The ITT Components Group's capacitor plant at Paignton, England, is developing 14-lead dual in-line capacitor packages of 74-TTL pattern so that **the same automatic board-assembly equipment can handle both ICs and capacitors.** Tantalum or ceramic capacitors will be used, possibly three or four in a package, so that most of the leads will be electrically redundant. The main application in view is decoupling capacitors on high-density TTL boards as used by computer makers, and ITT engineers say that savings on board-assembly costs should more than outweigh the higher cost of the capacitors' more elaborate packaging.

Addenda

Hitachi Ltd. has followed Tokyo Shibaura Electric Co. Ltd. in production of color picture tubes with in-line guns, a shadow mask with brickwall arrangement of apertures, and phosphor stripes on the inside of the faceplate. Right now it is only being made in the 14-inch version. . . . **The Soviet Union will build Cuba a new consumer-electronic plant** capable of producing 100,000 TV sets and 300,000 transistor radios annually. It will be completed in the second half of 1974.

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'Mystery' computer unveiled

Amdahl's A System, to be introduced this summer, is the first small, superfast, architecturally simple 'large' machine

by George Sideris, San Francisco bureau manager, and Wallace B. Riley, Computers Editor

For two and a half years, the Amdahl Corp. has been developing a computer that sometimes has been called Amdahl's mystery machine because of the secrecy surrounding its design. The development has been backed by $27.5 million from Fujitsu Ltd. of Japan, Nixdorf Computer of Germany, Heizer Corp. of Chicago, and other private investors. Rumors had the system using emitter-coupled logic in the largest and fastest general-purpose computer ever built.

There is indeed a giant ECL computer in the Amdahl plant in Sunnyvale, Calif. The central processor occupies seven huge bays stretching across the plant's main room. But that system is only the breadboard of a production model, tentatively named the A System, which is to be introduced this summer. It will drastically reduce the breadboard's size through large-scale integrated ECL design.

The event marks a turning point in computer development—the birth of small, superfast, architecturally simple, large-scale computers. And although the rumors exaggerated the computer's size, they were conservative about its speed.

When completed, the A System will be a little larger—physically—than today's medium-scale computers. The man-high mockup is about 20 feet long. The breadboard was built with conventional ECL circuits, most of them containing only three or four gates or a few flip-flops. In the A System, each circuit-board assembly in the mockup will be replaced by one large-scale integrated circuit containing as many as 100 gates. And each of the new cards—called MCC, for microcircuit carriers—will carry 50 LSI arrays.

Amdahl estimates the speed of the A System will be four times that of the IBM 370/165, but it will be sold for a little less than the approximately $3.5 million IBM charges for the 370/165. Throughput will also be higher, depending on the speed of the input/output channels. Amdahl considers it a generation beyond the System/370. But, to attract business buyers, the A System remains IBM-compatible.

This month, Gene Myron Amdahl, chief architect and president, started inviting outsiders to see the progress on the production model. The occasion was start-up of production-testing and installation of the MCC cards. The cards go into a door-sized "LSI gate" that operates as a central processor. (Gate is an IBM term for a swing-out logic-card assembly.)

Fast, faster. The standard ECL gates in the breadboard operate with propagation delays of 2 or 3 nanoseconds. Those in the A System's LSI arrays exhibit average delays of around 600 picoseconds and switch on and off in 50 ps.

The arrays, all designed by Amdahl's staff, use matrixes, which cuts design time to several hours. The design equipment, the wafer-fabrication mask sets, and even the production-test equipment used by Amdahl's vendors were also developed by the staff. In fact, all critical parts and production machines needed to put the A System together—down to LSI packages and wiring—were developed by Amdahl's people in-house.

Two companies have been identified as manufacturers of circuits for Amdahl—Motorola Semiconductor Products, which has been promoting the use of ECL in computers for many years, and Advanced Memory Systems Inc., which operates a custom ECL LSI plant in nearby Santa Clara, Calif. Another company that appears to be in the running is Fairchild Semiconductor, which recently announced a low-power, 600-ps ECL process [*Electronics*, Feb. 15, p. 41].

The blazing speed of the arrays will give the system a cycle time of less than 25 ns at a clock rate in the 40-megahertz range, Amdahl says. To go with the arrays, the staff has designed a solid-state memory with an access time of two machine cycles—less than 50 ns.

Architecture. The organization of the A System is far from rudimentary. Up to six instruction cycles can be overlapped. But the system depends mainly on fast circuitry, rather than a highly complex architecture, to get high system throughput. Some operations take more instruction cycles than a third-generation design would employ.

Amdahl compares A System's processing capability per cycle to that of the 370/168, IBM's newest large-scale computer. While the hardware is different, the programing is compatible with the software of the IBM series.

A "pipeline" byte-organized structure adapts the A System to numerous applications. The computer processes a stream of 8-bit bytes rather than words of fixed length.

The fastest operating loop consists of the LSI gate and a bipolar buffer memory. The LSI gate can access four bytes at a time from the cache-like buffer in less than 50 ns. (A cache is a high-speed buffer memory, which makes immediately available to the processor that pool of information currently in use. Data is transferred automatically under hardware control between the cache and the main memory, so that the cache is invisible to the programer.)

In turn, the buffer accesses up to 32 bytes from a main memory built with MOS random-access memory circuits. The main-memory access time is about 200-ns. A standard main memory consists of two modules, each storing 1 million bytes. Six more 1-megabyte modules can be added to the system, bringing the total to 8 megabytes.

Power supplies, an input/output system, and cable bays complete the system. It is operated and maintained through a simple display console, but an IBM-style control console is being added for the convenience of operators accustomed to IBM computers.

Rf operation. While the packaging-form factors resemble those of a conventional computer, the packaging design is conceptually akin to a vhf radio-communications network that is surrounded by microwave noise that it cannot detect. Actually, ECL gates constitute a special kind of differential amplifier. In the Amdahl system, they operate faster than 40 MHz.

The wiring in the microcircuit carriers resembles microstrip. Each MCC card has six buried signal layers, a ground plane, and a power plane. There are no interconnections on the top surface, where the 50 LSI arrays are mounted. The printed circuitry inside the card is supplemented by miniature twin-lead wiring bonded to the back of the card. And the carriers are interconnected in the LSI-gate frame by miniature coaxial cables.

Each array dissipates about 3 watts, a fraction of the power consumption of standard ECL. This allows the circuits to be air-cooled, despite their density. A molybdenum stub bonded to the top of each LSI package conducts the heat into the air stream.

Part of the reduction in power requirements results from the fact that arrays need fewer drivers than small-scale functions. But much of the saving is the result of terminating only long lines. Unterminated lines are usually considered anathema in high-speed computers because the signal reflections generate large amounts of noise. However, Amdahl points out that the very shortness of the lines in the A System causes the noise-frequency spectrum to be so high that the ECL circuits don't respond to it.

Amdahl predicts that the computer will capture a major share of the large-computer market. Estimates of the total sales of large computers between now and 1976 run around $5 billion. □

Logic. Amdahl's ECL chip carries 100 gates and a finned heat-sink arrangement.

Dream machine

The A System is the kind of computer that Gene M. Amdahl, one of the world's top computer designers, has longed to build for many years. After he got his doctorate in theoretical physics at the University of Wisconsin in 1952, Amdahl spent four years at IBM. He was project designer and chief engineer of the vacuum-tube IBM 704 and prepared initial plans for the IBM 709, also a tube version, and 7030. He left IBM in 1956 for four years with Ramo-Wooldridge and Philco-Ford's Aeronutronic division.

After rejoining IBM in 1960, he was managing architect of the System/360 and then director of advanced computing systems and an IBM fellow, the company's highest scientific position. His goal in his last years with IBM was to develop large computers that would be so fast they could be architecturally simple. At the time, complex architecture was needed to increase the apparent speed of large machines.

But Amdahl says that he found no solutions because fast LSI technologies were not available then. Amdahl left IBM in October 1970 to form his own company. The Heizer Corp. provided the initial capital of $2.5 million, which in almost binary fashion other investors later increased by $5 million and then by another $20 million. Meanwhile, a number of other IBM staffers from the plant at San Jose and nearby laboratories had also left to work elsewhere. Amdahl Corp. gathered in about 20 of them.

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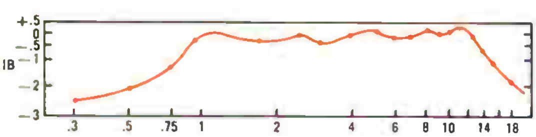

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Communications

Datran has new game plan

The firm will use local phone lines in a regional microwave system, postponing plans for an all-digital national switched network

by Harry R. Karp, Special Issues Editor

The sights have been lowered at Datran. When Glenn E. Penisten joined the Data Transmission Co. a year ago as president and chief executive officer [*Electronics*, March 13, 1972, p. 34], he decided there were two immediate ways of improving Datran's chances of finally becoming an operating common carrier serving data-communications customers.

Decision one was to call a halt to the precocious statements about the company's plans to launch a nationwide, all-digital, switched, data-communications network by 1974. Penisten accepted the fact that Datran's failure to raise the necessary financing—over $300 million of venture capital—and its consequent inability to initiate network construction had left a questionable image in the minds of users, vendors, and the financial community. Decision two was to reassess Datran's total business and technological plan.

Now, a year later, Penisten and his team have evolved two separate but related goals. One is short-term, through about 1975, and the other long-term, through 1980. If all goes well, says Penisten, the company will receive some operating revenue in 1974, show a profit in 1976, and enjoy total revenues of about $208 million in 1980. Each plan interweaves the complex factors of raising capital, building microwave stations, obtaining communications equipment, and establishing a timetable.

An essential element in the short-term plan is to abort part of the original all-Datran network, and rely instead on the use of telephone company lines for local, or short-haul, links. Accordingly, says Penisten, financial requirements have been considerably reduced, and he now has a firm plan on how to obtain the required capital. Here are the essential elements of Penisten's short-term plan:

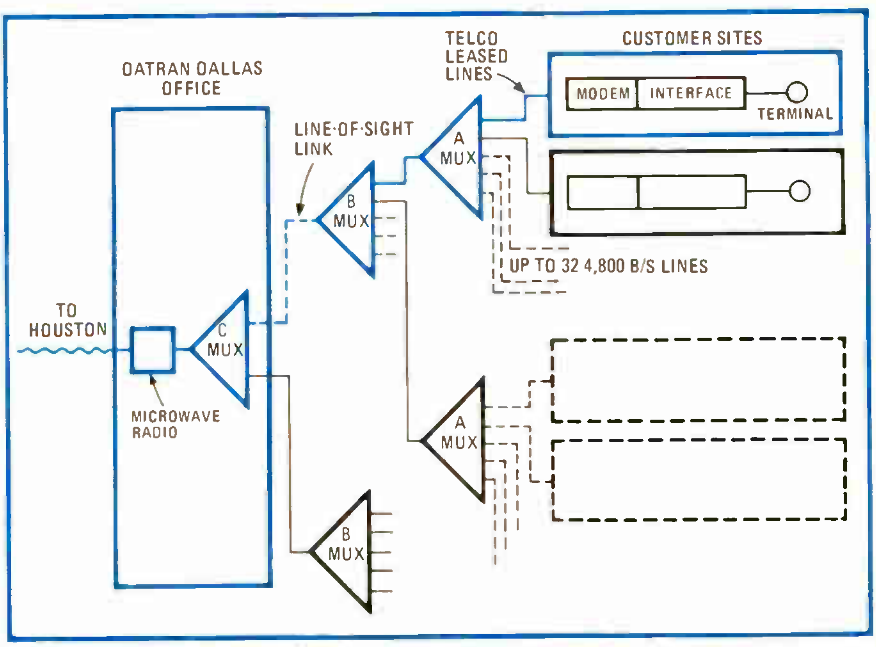
▪ **Network configurations.** Temporarily postponing its original all-digital, switched-service, short-connect-time concept, Datran's system will instead use private-line local loops, supplied by the telephone company, to connect a customer's data terminal to the nearest Datran multiplexer which will output to its long-haul digital-microwave transmission link. At first, then, Datran will serve only customers who want 2,400-bit-per-second, 4,800-b/s, or 9,600-b/s point-to-point service—because switched service will not be available until 1975, and then only on a limited basis at low speed.

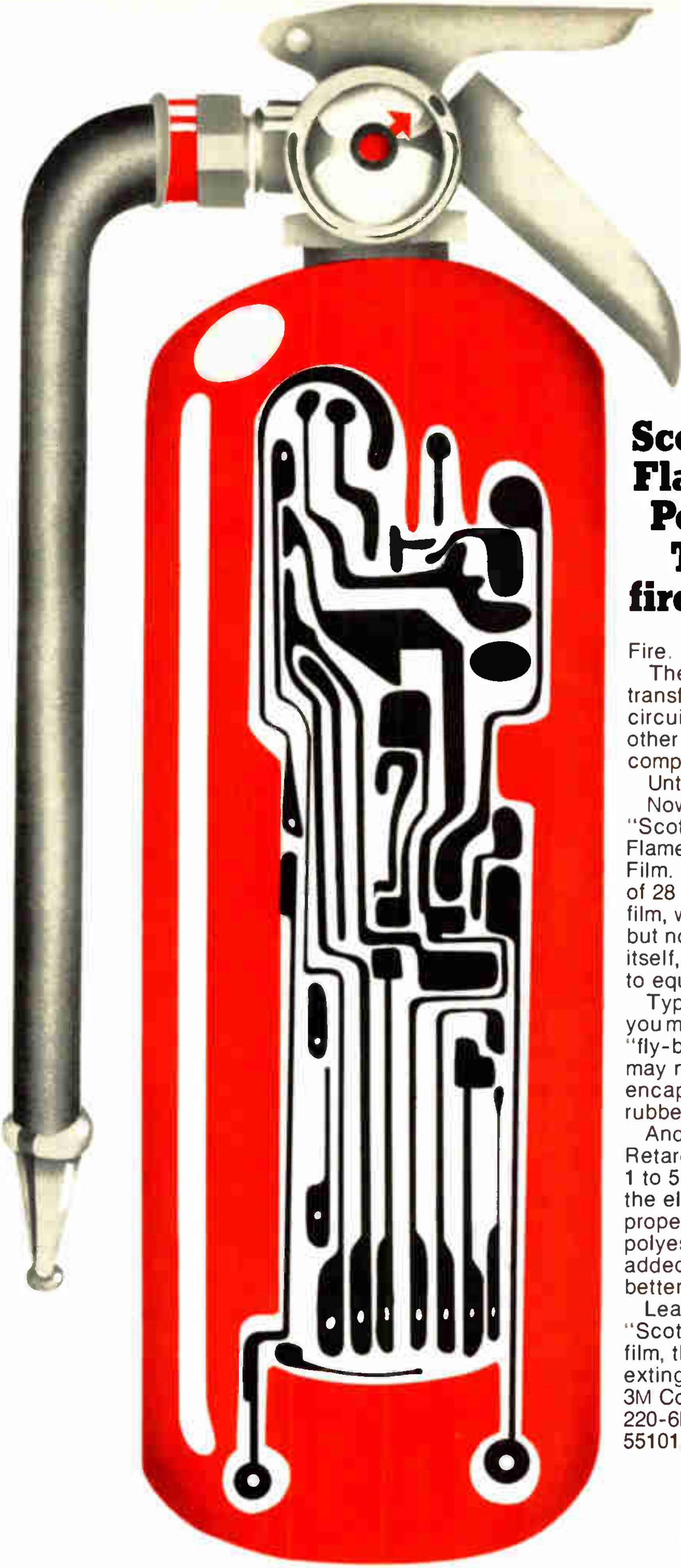
This combination service will be built piecemeal. The first subnet will run from Houston to Dallas–Ft. Worth, and will then be expanded to a regional network also serving Austin, Oklahoma City, Tulsa, Kansas City, and St. Louis. Eventually Datran will be coast to coast.

The importance of using local loops to reach Datran's "backbone" digital microwave link is emphasized by the assignment of David E. Gourley, who had been Datran's director of market research and planning, to the new post of director of business planning for local distribution. Gourley explains the local setup in this way:

A hub city—Dallas, for example—will contain a microwave radio station to send and receive data from

Stepping up. Datran will use local loops to link its subscribers to the "backbone" digital microwave link. System will work through a hierarchy of multiplexers.





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another hub city—Houston, for example. A customer in Dallas who has enough traffic to send at such high data rates as 4,800 or 9,600 b/s will have his data terminal connected to a Datran digital communications console (the customer terminal interface unit now being developed by Burroughs) at the customer site. The Burroughs unit will contain the Paradyne high-speed modem which will convert terminal pulses to analog signals for connection to the telephone company's leased line. A leased line will be routed to a multiplexer which will concentrate local traffic onto one higher-speed channel.

Three types of multiplexers, being made by Nippon Electric Co., form a hierarchy for data concentration. The line from a terminal will feed into a type-A multiplexer, which can handle the output of up to 32 4,800-b/s lines. When traffic volume is high enough, the type-B multiplexer will concentrate traffic from several A multiplexers, and when necessary, B-multiplexers will feed into an even higher-speed type-C multiplexer.

The multiplexer hierarchy will be located close to the customers' sites to keep down the length of the dedicated telephone lines. The output of the highest-speed multiplexer is then transmitted, over a line-of-sight link that uses, for example, wideband infrared transmission, to a C-multiplexer at Datran's district office and onto the hub-city microwave tower. Thus, the channel will carry data rates as high as 1.344 million bits a second between Dallas and Houston.

■ **Financial.** The sole owner of Datran, at present, is the University Computing Co. Earlier, UCC sold off two subsidiary operations to raise an additional $20 million this year for Datran, thus increasing its investment in Datran to over $40 million. But, says Penisten, he needs $30 million for such 1973 activities as construction, operation, and marketing. Thus, for this year, he now has a capital shortfall of $10 million. And through 1975, Datran is slated to spend somewhere between $125 million and $150 million.

How will Datran raise the money? Penisten expects to take Datran $50 million into debt and obtain the other $100 million from future private and public financing.

The key to obtaining this year's $10 million shortfall is vendor financing and vendor-guaranteed loans. Although Datran has signed contracts with seven major suppliers of equipment and services, Penisten will not reveal the specific amounts involved, or the payment scheme. He did, however, say that some contracts provide for as much as 80% delayed payment stretched out over five years. On the other hand, Datran has also laid out "front-end" money to help in the development of products and services specifically needed for the Datran network.

For example, one Datran spokesman said that his company subsidized development the high-performance, low-cost Paradyne modem that is required by Datran to enhance the performance of the telephone company's local loops. This modem, says Gourley, will permit Datran to provide a guaranteed error rate of less than one bit for every 10 million transmitted bits.

About all Paradyne spokesmen will say is that the company has a modem contract with Datran. However, what is known is that the Paradyne all-digital modem is now in the discrete IC brassboard stage at its plant in Largo, Fla. It will be shipped to Datran for testing on Datran's pilot 38-kilometer microwave link between Vienna and Manassas, Va. When thoroughly debugged and proven, the modem design will be committed to large-scale integration.

Paradyne, which has a contract running to tens of thousands of units, is slated to ship about 1,000 finished LSI modems, each mounted on one printed-circuit card, to Datran by late summer. For Paradyne, the Datran contract may be a double windfall. Not only has it captured the largest sale of independently made modems, according to Paradyne's James Wylie, but it can convert the design to an end-user-type modem. The expected sales price of about $4,000 for the packaged, end-user modem is well below that of any present 9,600-b/s modem. □

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Companies

National flexes new muscles

Expects sales to reach $100 million in '73 while dipping into point-of-sale business

by George Sideris, San Francisco bureau manager

Few integrated-circuit manufacturers went through the electronics recession of 1970-71 with only a hitch in sales and earnings. But National Semiconductor Corp. did, and although it lost a year's growth in fiscal year 1971, the company remained profitable, used the slack period to prepare new product lines, and bounced back to a 50% growth rate in 1972. By any measure, the company emerged from the recession stronger, and its officers even claim that it drew abreast of Motorola and Fairchild in IC sales.

Transfusion. Sales probably will reach $100 million in this calendar year, if not in the fiscal year ending May 31. Sales now are rolling along at a clip of about a $90 million year. A $100 million year would represent a 14-fold increase since 1967, when Peter Sprague, National's young chairman—then 27 years old—revitalized the Santa Clara, Calif., company with a transfusion of Fairchild Semiconductor executives and engineers. And that was the last year that National lost money—$724,000 on sales of $7.2 million. The staying power of the company through the recession, followed by the crunch to build capacity, speaks well for the pay-as-you-go, plain-pipe-racks-management philosophy of Charles Sporck, president of National since he quit as general manager of Fairchild in 1967.

National's early growth was based on advanced linear designs by Robert Widlar—he invented the 709 operational amplifier at Fairchild—complex transistor-transistor-logic functions designed under the guidance of Jeff Kalb—he came from Texas Instruments—and early production of TTL-compatible MOS. Widlar is now living the good life as a millionaire in Mexico, and Kalb has moved up at National to head digital-IC production.

The company's growth strategy originally was to get its proprietary circuits designed into new equipment, thus paving the way for tie-in sales of the high-volume, second-source "jelly beans," as Sporck calls them, that followed. Sporck wouldn't permit custom-circuit development then for fear of straining the company's slim engineering resources or having a few large customers overwhelm its small production capacity. His aim, then as now, was to build a broad production base in standard product lines.

But during the recession, the

Putting it together. National's president Charles Sporck (top) heads a management team including Floyd Kvamme, vice president and director of marketing (center left); Gene Carter, product marketing manager (center right); and Pierre Lamond, vice president and director of microcircuit operations (below). They hope to bring company up to the $100 million sales mark in 1974.

game plan for making money changed perceptibly. National started gearing up to produce complex MOS LSI subsystems, starting with so-called complex standards that could be modified with mask changes to make them semi-custom products—calculators and interface subsystems, for example. The result is a full-blown custom operation involving linear and bipolar digital circuits, as well as MOS. National also started tackling the big guns in the consumer-IC field, while continuing its second-source backfilling with complementary-MOS, Schottky TTL, MOS random-access memories, emitter-coupled logic, and a variety of linear circuits and transistors.

Systems, now. During the bounce-back period last fall, the most significant event was that Sporck allowed National to dip a big toe into the systems market. National's systems sales to date have been minuscule, but the market being tested—point-of-sale terminals for grocery stores—is potentially huge. Five prototype systems are installed.

Referring to the custom-circuit and systems operations, Sporck says: "That doesn't mean we have changed our directions. By and large, we intend to get involved in all the broad growth markets for semiconductors. I recognize that National will have to diversify at some time, but right now, our prime interest is to exploit our position in the semiconductor market."

Sporck has named Fred Bialek to head the new Systems division. Bialek, who has a reputation for getting new operations rolling fast, was responsible for setting up five overseas plants when he was international operations manager, a post he had also held at Fairchild.

The team. As for Sporck himself, he has changed little—which is probably the reason most of his original management team has stuck with him. Team members include Pierre Lamond, vice president and director of microcircuit operations; Floyd Kvamme, vice president and director of marketing; John Hughes, vice president of finance; and Bialek. At Fairchild, Lamond had responsibilities similar to his present ones, as did Hughes at Perkin-Elmer Corp. The most notable departure from National has been Donald Valen-

Probing the news

tine, director of marketing.

Sporck is still noted for trimming everything he can, except possibly his striking handlebar moustache. Periodically, he calls a halt to expenditures or hiring until some wheels squeak out for grease. He even applied this technique during the intensive buildup last winter, but he could hardly be called tightfisted. The company's spending for production facilities has been expanded from $4 million in 1968 to $24 million in 1972, and will increase by another $11 million in this fiscal year.

Applications. While National's 50% growth rate is almost twice the semiconductor-industry average, company officials agree that their main concern is keeping up with the exponential growth in semiconductor applications. Kvamme uses words like "pervasiveness" and "omnipresence of semiconductors" to try to describe how semiconductor applications have been expanding far beyond conventional electronic systems. The company's main emphasis in this regard has been what it calls a system-sell plan for new-product development—which means producing all the popular lines—as well as the custom operation.

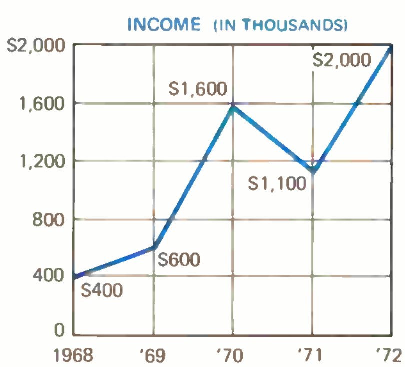
At least 25 product lines are in the National catalog. The company sells such components as transducers and multiplexers. Now, it is readying input analog-to-digital converters. For outputs, there are power ICs, display drivers, light-emitting diodes, and, to come, light-emitting-diode display assemblies. A number of interface, timing, and control subsystems, including microcomputers, also are being made. □

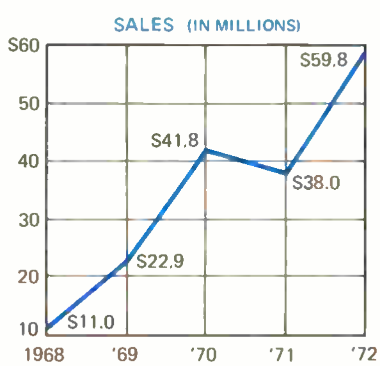
That magic number

Possibly the biggest problem in pushing a company beyond the $100 million barrier is getting enough good people fast enough.

National restarted with some—at Fairchild's expense—and assembled an impressive engineering staff from Fairchild and other companies. But insiders admit to having difficulties expanding capacity fast enough to exploit that exponential applications curve. For instance, building of a new wafer-fabrication plant in Scotland was postponed during the recession. The plant is now almost completely on-stream; Lamond is converting production in his division from 2-inch to 3-inch wafers and adding new plant space; and a third assembly plant has been opened in the Far East, and another will be completed soon.

But $100 million in fiscal 1973? Questioners are told that predictions of such magnitude are barred by the Securities and Exchange Commission. In the first half of fiscal 1973—the 28-week period that ended Dec. 10, 1972—National sales totaled $43.8 million and net earnings $1.44 million. "Sales averaged $1.5 million a week in the first 28 weeks. To get to $100 million in the last 24 weeks, we would have to average over $2.3 million in the last 24 weeks, which isn't easy when you are already pushing very hard," Kvamme says. In the 12-week third quarter, sales rose to $22.9 million—a rate of $1.9 million a week, or close to an annual rate of $100 million. In the first 40 weeks of the fiscal year, sales totaled $66.8 million and net earnings $2,264,000.





Microwave oven safety at issue

Consumers Union questions the radiation-emission standard of the fast-selling appliance, but the Government sticks to its numbers

by Gerald M. Walker, Consumer Electronics Editor

Consumers Union has brought the microwave oven safety issue back to a boil. In a report that brands 15 units tested "not recommended" (one is no longer on the market), the union calls the Federal microwave emission standard inadequate. This report, which will appear in the April issue of Consumer Reports, hits at a time when both U.S. and Japanese microwave oven makers were anticipating a hot sales year. [*Electronics*, July 31, 1972, p. 54].

The aftermath may be more confusion for consumers, because oven makers and the Association of Home Appliance Manufacturers have fired back a flurry of counterclaims to the effect that microwave radiation in low levels is "as safe as moonbeams." Behind the scenes, industry officials were angrily roasting CU for making judgments that they say are beyond its technical competence.

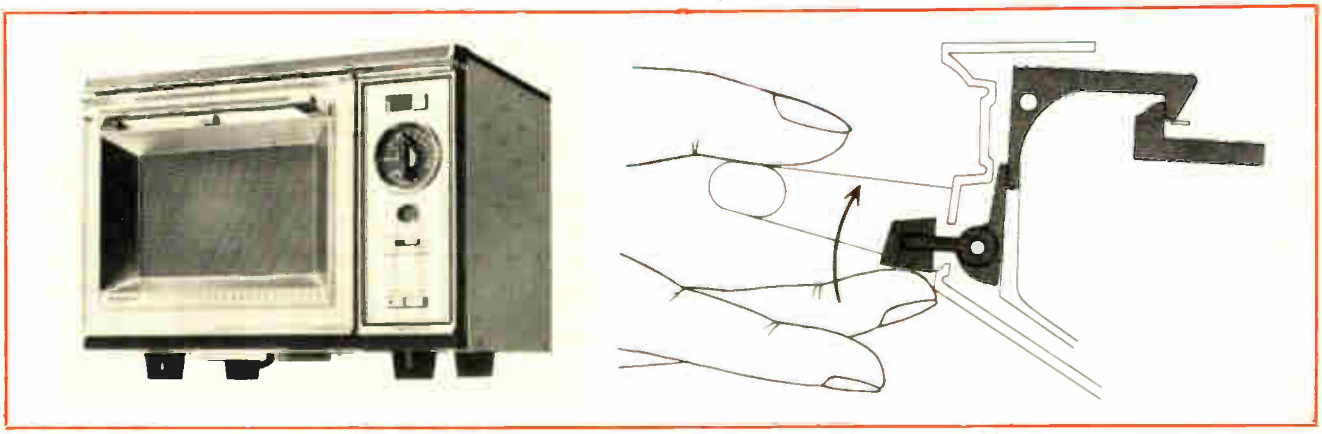
Caught in the middle was the Bureau of Radiological Health of the Department of Health, Education, and Welfare. The bureau drew up the present emission standards and is responsible for overseeing the industry's compliance. But put on the defensive by CU's harsh conclusions, it rallied with claims of its own, stating that all the evidence compiled so far shows the permitted level of radiation from microwave ovens to be safe.

Denials. It is too soon to tell whether CU has created a tempest in an oven, as the industry claims, or raised reliable doubt. Once again it depends on who's talking. CU says that, in the period since it publicized its findings in the mass media, most consumers contacting the nonprofit organization indicated enough concern to postpone purchase of a microwave oven. Manufacturers contacted during that same period reported continued confidence that projected 1973 sales of 500,000 to 600,000 units in the U.S. will be reached. CU estimates that there are about 250,000 units already in use in U.S. homes. The industry association puts the total population—home and institutional—at between 500,000 and 700,000.

In Japan, where sales of 900,000 units were predicted for fiscal 1973 alone, the CU report has not created a ripple. Neither manufacturers nor government agencies admit knowing of any illness attributable to microwave ovens. They say there have not even been any complaints of illness, justifiable or otherwise, blamed on these products.

Nevertheless, Consumers Union was adamant in its recommendations (see "What the report says"). The response of the Bureau of Radiological Health was just as adamant. "Informally, our opinion is that they [the Consumers Union] have overreacted to the bio-effects literature," which is "spotty" and "imprecise," says Roger H. Schneider, deputy director of the bureau's division of electronic products. "When we developed this regulation, it was done with a lot of fanfare . . . we held symposia . . . we got a lot of advice. What you see in the regulation is sort of the vector sum of the bio-effects literature," he adds. "And we haven't seen any information to cause us to change our minds."

Safety feature. Some Sharp microwave ovens, like the one at left, have safety latch like the one shown in drawing at right.



What the report says

Consumer Reports' 10-page review of microwave ovens gets right down to cases. In the first paragraph the magazine states, "After thoroughly testing 15 popular models of counter-top microwave ovens, and examining available literature, we are not convinced that they are completely safe to use. We've therefore designated them all Not Recommended."

The report points out that all of the ovens tested met Bureau of Radiological Health emission standards. "Until much more evidence is available regarding the safety of low-level microwave radiation, we do not feel we could consider a microwave oven Acceptable unless there is no radiation leakage detectable," it continues.

All the ovens tested operated at a frequency of 2,430 megahertz. Radiation measurements were taken two inches from the doors and windows. CU found, among other things, that by simulating dirt buildup on the doors, radiation far in excess of the Federal standards occurred.

In addition, CU polled its readers to find out what they think of microwave ovens. Of the 410 owners who replied, most were pleased with them. According to the report, only 50 expressed concern about radiation hazards, while seven volunteered that they were not concerned about radiation.

The report makes a specific point of cautioning pacemaker wearers to stay away from microwave ovens and demands that manufacturers inform purchasers of the possibility of interference with pacemakers by microwave radiation.

The bureau's current standard, measured at 5 centimeters from the oven, is 1 milliwatt at manufacturer's level (new oven) and 5 mw at the dealer's level or for the useful life of the oven. This means that 14 inches from the oven, the exposure level should be 0.1 mw. Consumers Union made much of the fact that the Russian standard is much lower. However, there is a difference that makes direct comparison difficult—the Russians measure by exposure rates, rather than emission rates, and limit exposure to no more than 0.1 mw/cm^2 for two hours or no more than 0.01 mw/cm^2 for a day.

The bureau points out that microwave radiation can affect the human eyes (which can't dissipate the heat quickly), testicles, and chromosomes—but only at extremely high levels. In animal tests, it required 100 mw/cm^2 microwave radiation before damage was first detected in rabbit's eyes. Finally, the bureau argues that Consumers Union has not tested enough ovens.

There are two proposed amendments to the existing standard that were in the works well before the CU bomb exploded. One, when passed, will require a microwave oven to shut down if an interlock fails and remain inoperative until the interlock is repaired. The second amendment, to be printed later in the Federal Register for comment, would require manufacturers to make interlocks more difficult to defeat. It seems that on some units it's possible to disengage the interlock, which CU confirms.

While stunned by the CU indictment, manufacturers were quick to calm nervous dealers and retail merchants as well as to reassure consumers. "We are confident that the Bureau of Radiological Health has established standards to assure that all microwave ovens are safe. We are also confident that the industry will continue to meet those safe standards established by the Government," commented Robert T. Bruder, president of Litton's Atherton division. He added, with an unintended double meaning, that oven sales should continue to grow at a "very healthy rate."

Two types. John M. Osepchuk, research scientist with the Research division of the Raytheon Co., whose Amana division also manufactures ovens, says there is confusion between non-ionizing microwaves on one hand, and effects produced by the ionizing radiation of X rays and nuclear radiation on the other. Non-ionizing radiation does not cause cumulative damage to tissue, while ionizing radiation, such as X radiation, strips an electron from an atom or molecule, which then looks for an electron to replace it, causing bodily damage. □

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Oxide isolation brings high density to production bipolar memories

By increasing density and improving performance, the Isoplanar process has opened up the computer market to bipolar random-access memories; so far, they are the only passive-isolation RAMs being produced in volume

by W.D. Baker, W.H. Herndon, T.A. Longo, and D.L. Pelzer, *Fairchild Camera and Instrument Corp., Mountain View, Calif.*

☐ In the short two years since its introduction, the Isoplanar oxide-isolation technique [*Electronics*, March 1, 1971, p. 52] has done more than change the structures of some bipolar memories—it has altered the direction of digital technology. Before, the space a bipolar memory had had to waste on separating active isolation regions from active device regions had limited it to a read-only role or to the lowly, 256-bit end of the random-access-memory scale. After, designers could use the space-saving virtues of oxide isolation to pack 1,000 bits and more onto a single bipolar chip. In one step parity was restored with the metal-oxide-semiconductor RAM, which is as dense, cheaper, but three to four times as slow.

Today's 1,024-bit bipolar RAMs, with typical access times of 60 nanoseconds (TTL-compatible) or 45 ns (ECL-compatible), are in growing demand for high-performance and distributed main memories, as cache and buffer stores, as high-speed scratch pads, and wherever high speed combined with random accessibility can give a system the edge.

And, the end is not yet in sight. Still greater density and performance have been achieved by the recently developed, second-generation process, Isoplanar II [*Electronics*, Feb. 15, 1972, p. 41], which is now being applied to developmental logic circuits. Because device geometry is tighter with Isoplanar II, parasitics are smaller. So performance is better—speed is increased and power reduced. Indeed, Isoplanar II is already being applied to developmental logic chips. The result is tighter ECL circuits that operate at subnanosecond speeds and reduced power dissipations.

And it's flexible

What's often overlooked about oxide isolation is the large number of different memory and logic components it can accommodate. Table 1 catalogs the variety of basic components available with the conventional Schottky TTL process and the Isoplanar techniques. The two variants of the Isoplanar process that are listed are the double-diffused process and the epitaxial-base process. The epitaxial-base method, which has been used in production for more than two years, was chosen for the first family of products because it is compatible with the circuit designs presently used to build bipolar memories and is easy to reproduce in volume production.

With either Isoplanar process, all the important memory components can be made: npn transistors for the memory array, 10–50-kilohm load resistors, and the 10-kΩ/square p-type sheet resistors. The double-diffused process can handle pnp transistors and Schottky diodes as well, equalling the conventional TTL process in its ability to offer the whole range of MSI and LSI logic functions.

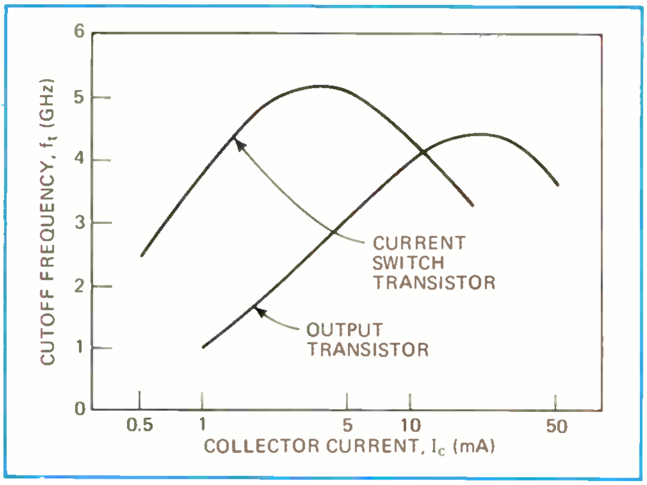
There is a good reason why all the Isoplanar devices manufactured so far have epitaxial bases. The approach is ideal for large-scale and therefore high-density bipolar processes because, with a minimum of design variables, it minimizes the size of the isolation area and

TABLE 1: CHECK LIST ON PROCESS CAPABILITY

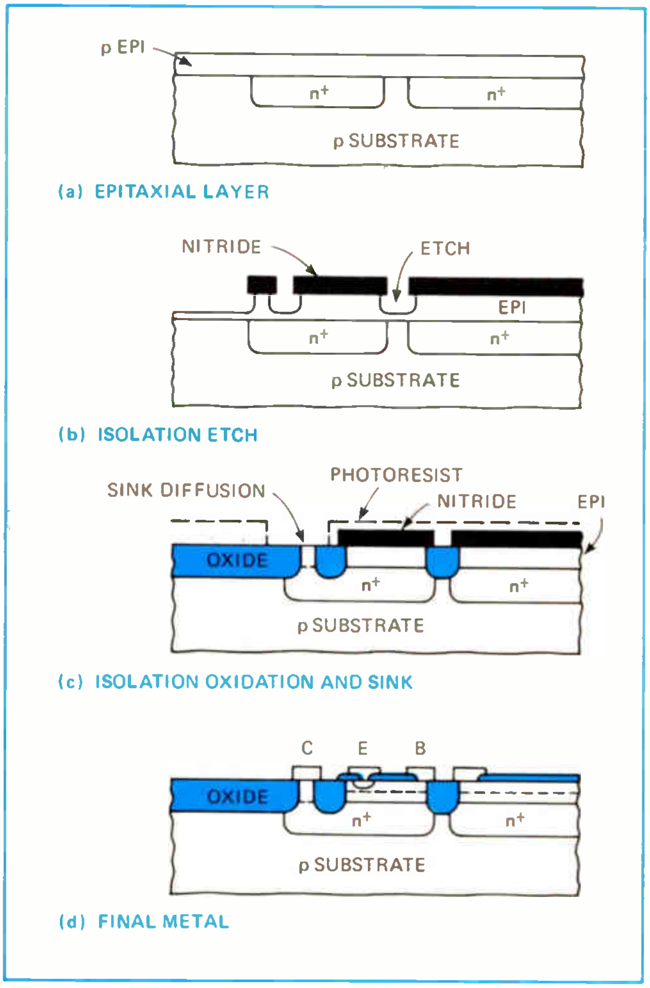
	Schottky TTL	Isoplanar double-diffused	Epi-base
npn transistors	✓	✓	✓
pnp transistors	✓	✓	
Schottky diodes	✓	✓	
High-value resistors	n epi ≈ 10 kΩ/□	n epi ≈ 10 kΩ/□	p epi ≈ 10 kΩ/□
Base p-type resistors (100 – 600 Ω/□)	✓	✓	✓

TABLE 2: TYPICAL ISOPLANAR TRANSISTOR CHARACTERISTICS

	Epitaxial-base	Double-diffused	Isoplanar II
Static forward current transfer ratio (h_{FE}) @ 1 mA	50	50	50
Emitter-to-collector breakdown voltage with base open (LV_{CEO}) @ 1 mA	7 V	10 V	5 V
Breakdown voltage, collector-to-base, emitter open (V_{BR} CBO) @ 10 A	22 V	30 V	14 V
Saturation voltage (V_{SAT}) @ 5 mA	0.13 V	0.27 V	0.2 V
Maximum frequency of oscillation (small signal) (F_{MAX})	1–1.5 GHz	1.5–3 GHz	5 GHz
Transistor emitter size	0.2 mil x 1.0 mil	0.2 mil x 1.0 mil	0.1 mil x 0.5 mil



1. High and mighty. The new Isoplanar II structures are not only small—they are fast. Cutoff frequency for current switch transistors built with the new process is about 5 MHz. For output transistors it's 4.5 MHz. Both speeds are faster than those achieved with any other high-density bipolar process in production today.



2. The process. On a substrate that has been patterned with buried n-collector diffusions, the appropriate p- or n-type epitaxial layer is grown (a), after which a layer of silicon nitride is deposited and masked for transistors and resistors (b). Next the isolating oxide is thermally grown (c). In the subsequent process step, resistors are grown, and crossunders are defined. The process ends when emitters are diffused, following which base and resistor contact areas are opened and metal is deposited (d).

maximizes the sheet resistance to achieve optimum design parameters. It also reduces the collector-to-emitter leakage current (I_{CEO}), a highly desirable feature in, say a large RAM where, to avoid refresh, a charge pattern must remain intact across the array throughout the read cycle.

Typical transistor characteristics for the epitaxial-base process, the double-diffused process, and Isoplanar II are shown in Table 2. Characteristics shown are for devices of relatively large geometry operating at relaxed conditions so that accurate data measurements could be made. For example, maximum frequency of operation (f_{max}) was measured at 1-volt collector-base bias.

Here the basic strength of the Isoplanar II structure is clearly seen. In an area of only 0.05 mil^2, an Iso-II transistor achieves a maximum frequency of operation greater than 5 gigahertz, compared to the 1-3 GHz of the 0.2-mil^2 epitaxial-base and double-diffused transistors. The entire structure of an Isoplanar II transistor's maximum operating frequencies is shown in Fig. 1 for two circuit functions, a current switch transistor and output transistor.

The Isoplanar process

Crucial to the small size and high speed of any Isoplanar transistor is the process's capacity for creating narrow base widths and narrow walled collectors. Fabrication starts with a silicon substrate with an n+ layer. Then a thin p- or n-type epitaxial layer is grown over the wafer surface (Fig. 2a)—p-type for epitaxial-base transistors, n-type for double-diffused transistors, and thin to create narrow bases for 1-3-GHz F_t transistors.

The epitaxial layer is covered with silicon nitride, which is masked into the patterns required for transistors and resistors (Fig. 2b). Areas now stripped of nitride are etched still more deeply, right through to the buried layer, in order to reduce the surface step heights of the thick isolation oxide. Next follows a long low-temperature oxidation, which fills the deeply etched areas with isolation oxide, but leaves the nitride-covered areas unoxidized (Fig. 2c). The silicon regions that will serve as resistors, diodes and transistors have now been defined.

In the epitaxial base process, an n+ sink diffusion is required to contact transistor collectors. The nitride over the silicon islands is selectively removed without appreciably etching the isolation oxide. Oversized masks are used for easier mask alignment. The sink regions are surrounded by isolation oxide to separate them from transistor bases.

Further selective masking permits the diffusion of various p+ regions into the wafer surface to serve as resistors of various values. Examination of Fig. 2c shows that all the various types of resistor can be provided, including p+ base resistors, epitaxial resistors, buried-layer resistors, and sink diffusion resistors. In addition, the sink and buried-layer diffusions can be used for an isolation cross-under.

To complete the process, any remaining nitride is stripped from the wafer surface and replaced by oxide. Emitters are masked and diffused into the wafer. Base and resistor contact areas are opened, again using oversized masks, and the metal interconnection layer is de-

Dense, denser, densest

The Isoplanar process substitutes passive insulator-oxide regions for the active p-type diffusions that isolate active elements on conventional bipolar devices. Since the isolation also serves as an insulator, no space need be wasted on separating the isolation region from the transistor base. Hence the oxide-isolated device is much smaller than its diode-isolated counterpart.

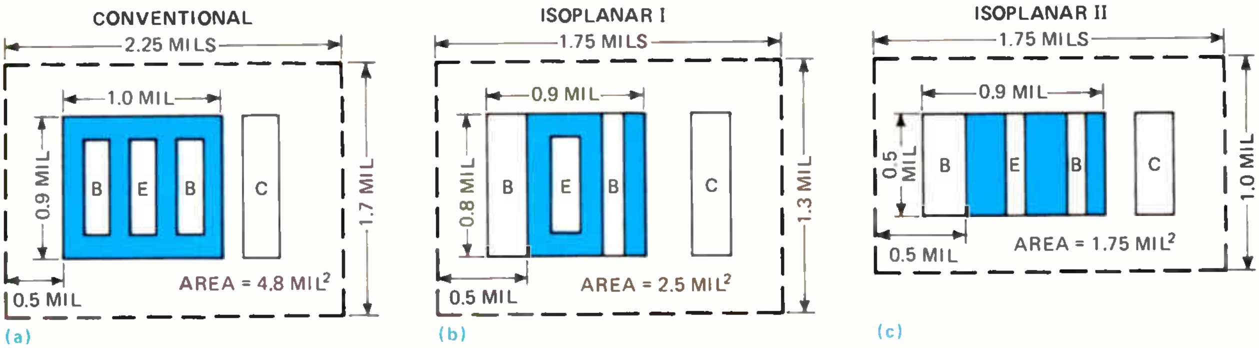
In a conventionally fabricated npn transistor, the collector is buried beneath an epitaxial layer, through which contact is made, and a diffused p-type region isolates the collector region of one transistor from that of an adjacent device.

With the oxide isolation, the p regions are replaced by selectively grown thermal oxide regions formed to the depth of the buried collector. The electrical contact to the buried collector is surrounded by an additional oxide region that is located between the collector sink area and the base region.

Clearly, the implementation of the Isoplanar process requires a new method of masking the active regions while the oxide is being thermally grown. Consequently, layers of silicon nitride, which remains practically inert during the oxidation, are used as the mask. Actually, the silicon nitride does change into silicon dioxide, only very slowly—1,000 angstroms of it will resist oxidation for at least 10 hours at 1,150°C in steam, leaving plenty of time for the oxide to be grown.

The space-saving features of the Isoplanar processes are shown in the accompanying schematics of a conventional transistor (a), along with Isoplanar I (b) and Isoplanar II (c) devices.

Isoplanar II produces the smallest devices because, by a natural extension of the earlier process, the emitter as well as the base is built right to the oxide region. This walled-emitter technique halves the space required by the original process.



posited and defined completing the structure (Fig. 2d).

With this standard Isoplanar process are built the transistors for the memory cells that make up an array. The structure illustrated in Fig. 3 occupies only about 10 square mils. It is the cell used in the 93415, a 1,024-bit RAM now in production. Similar configurations are used in all the five Isoplanar memory products available to date: a TTL and an ECL 1,024-bit RAM, a TTL and an ECL 256-bit RAM and, just recently built, a 128-bit ECL RAM.

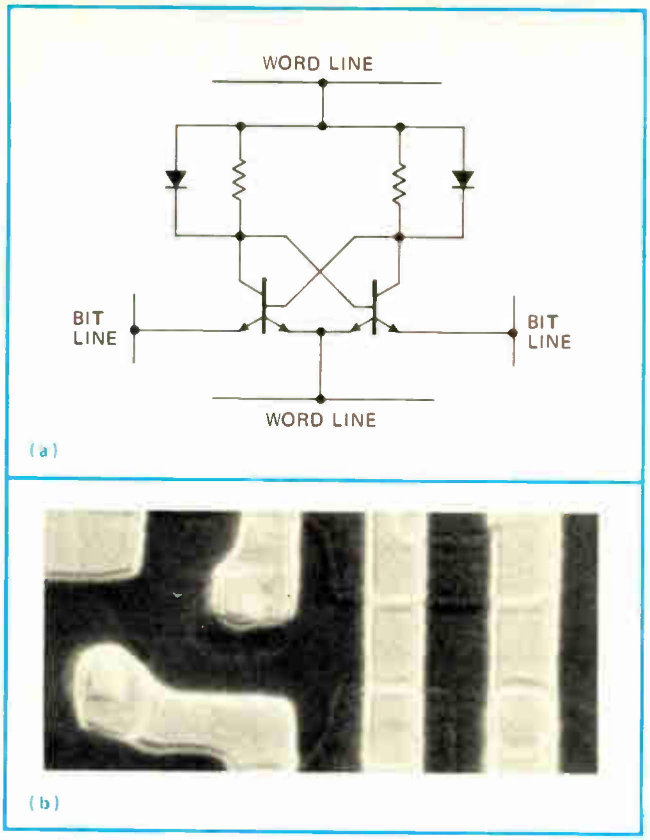
The internal circuitry

The cell is designed around a simple cross-coupled flip-flop. A diode bypass around the collector resistors allows the cell current to be substantially higher in the selected mode (when the cell is addressed and in a write or read operation) than in the standby mode. In the 93415, the selected-to-standby-current ratio is approximately 5:1. Since only one of the 1,024 bits is addressed at any given time, the average power dissipation is quite close to the standby value, which is approximately 500 mW per 1,024 bits.

In both the TTL and ECL memories (i.e. having TTL or ECL inputs and outputs), emitter-coupled logic was chosen for the internal circuitry for a variety of reasons. Since ECL is nonsaturating, it does not require gold doping, Schottky-barrier diodes, or substrate pnp transistors either to control storage time or to invert emitter current. And since circuit power dissipation varies as the square of the logic swing for a given propagation delay and capacitive loading, the smaller logic swing of ECL enhances the speed-power product. Moreover, ECL design makes it possible to get two designs for one, since the same internal array can be used with both TTL- and ECL-compatible products simply by changing the input/output buffers.

Performance is still another reason for choosing ECL-type cell designs. Indeed, ECL arrays are 50% faster while dissipating no more power than the TTL equivalents. And because the delay-power product of a 1,024-bit ECL RAM is considerably lower than in other types, more bits can be crammed into an ECL chip without creating a need to dissipate more power than standard dual in-line packages normally dissipate.

The high performance of an ECL RAM stems from its ability to operate at high speeds without needing such added complications as Schottky barrier clamps, which must be used to eliminate the storage delay of TTL configurations. The difference is that ECL is nonsaturating and therefore inherently fast. And again, by using buffers, TTL-compatible functions can be obtained from the same basic ECL design. Significantly, since input and output buffers are necessary for all memory designs anyway, the additional level converters needed to make an ECL array into a TTL device consume hardly any extra chip area of power. In ECL arrays, ECL input and output buffers simply replace the converters. On the chips that are currently in production, these buffers or



3. Primal cell. The new bipolar RAMs use this cross-coupled flip-flop cell design (a). Basically this is an emitter-coupled structure. The photomicrograph (b) is of a cell that is 10 square mils in area and typical of the cells used in all production RAMs.

converters are located near the bonding pads.

This last concept is further illustrated in the 93415 block diagram in Fig. 4a. The TTL/ECL input buffers provide the noninverted output as well as the inverted output with no additional delay or power overhead, whereas in the normal TTL circuit, the additional inversion required costs, both delay and power. The ECL/TTL output is more complicated, but only one such buffer is required per chip.

In the 93415, the array of 1,024 memory cells occupies 10,000 mil^2 out of a total die area of 19,000 mil^2. This represents a layout efficiency of 53%. In the comparable 256-bit device, the 93410, the respective areas of the cell array and entire die are 2,560 and 7,500 mil^2, representing 34% efficiency. The improved efficiency of the 1,024-bit die is a result of amortizing the overhead of the peripheral electronics over many more bits.

The new 128-bit ECL RAM is also very graceful in utilizing chip area—it has the same layout efficiency (53%) as the 93415. More significant, this latest of Isoplanar devices to go into production has an array 26% smaller than older designs, the array shrinkage resulting from improved circuit designs that require only minor changes in layout rules.

A most important feature of the new ECL RAM is the fact that it is built with a voltage-compensated 10,000-type ECL design—which means that this product represents the first time a voltage-compensated RAM has become available. Clearly, this simplifies systems using it, because now looser specifications can be made on the power-supply tolerances with corresponding savings in power-supply costs. With its access time of only 11 ns typical, 4-mW/bit power dissipation, and delay power product of 44 pJ, this device should prove a valuable asset for high-speed memory applications.

The key performance parameters of the four Isoplanar memories currently in production are listed in Table 3. (Note that a design limit of approximately 500 mW has been set for the 16-lead package.) The advantages of combining Isoplanar techniques with ECL circuitry are shown in the 2-mW/bit power dissipation coupled with the typical access time of 35 ns of the 256-bit 93410 TTL memory. The power per bit of the 93415 is reduced by a factor of 4 to 0.5 mW/bit, but the delay is less than double. The result is a doubling of the speed-power product, again because the peripheral circuit delay and power overhead has been amortized over a greater number of bits.

The ECL devices show even better performance, with typical read access delays of 25 and 45 ns for the 256-bit and 1,024-bit devices respectively. The best speed-power product of 23 picojoules belongs to the 1,024-bit ECL device, further proof of ECL's advantage in memory systems.

TABLE 3: COMPARISON OF KEY DEVICE PARAMETERS

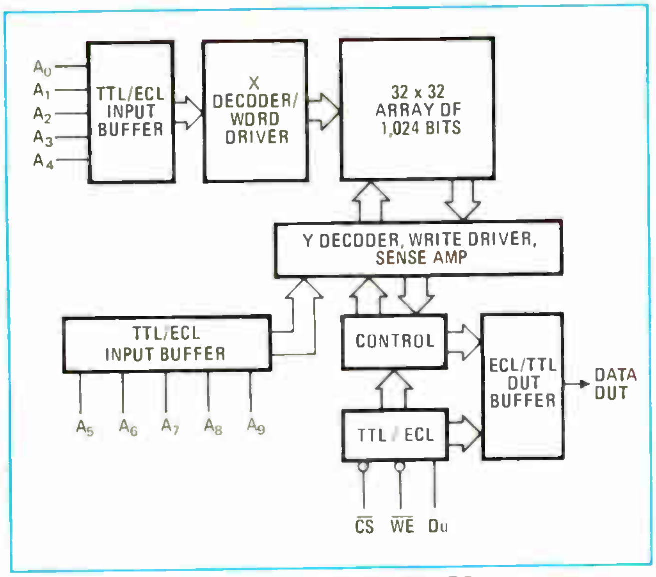
Parameter	TTL		ECL	
	256	1024	256	1024
Power, total	500 mW	500 mW	500 mW	500 mW
Power / bit	2 mW	0.5 mW	2 mW	0.5 mW
Read access time	35 ns (typ)	60 ns (typ)	25 ns (typ)	45 ns (typ)
Delay x power	70 pJ	30 pJ	50 pJ	23 pJ
Chip select access time	20 ns (typ)	30 ns (typ)	7 ns (typ)	20 ns (typ)
Cell size	10 mil^2	10 mil^2	14 mil^2	10 mil^2
Die area/bit	29.2 mil^2/bit	19 mil^2/bit	45 mil^2/bit	19 mil^2/bit

How a system can use them

A major application area for the big bipolar RAMs is main memory, where fast access times are needed. High-performance main memories built from plated wire and specialized core stacks have been available for some time. But the relatively high cost and complexity of such devices have severely limited their usefulness. High-density Isoplanar bipolar memories now offer a far more attractive means of achieving machine cycle times in the 100- to 200-ns range. Figures 5a and 5b chart the read-modify-write cycles of the 93410 (256-bit TTL) and 95410 (256-bit ECL) memories when coupled with the appropriate register and arithmetic unit. The 220- and 90-ns machine cycle times illustrated include address and data register delays as well as arithmetic unit delays.

Bipolar memories, of course, are static (require no refresh), are self-contained (all decoding and sense amplifiers are included on the chip), and require no special clocks or power supplies. Thus they resemble standard logic elements and can be distributed throughout the logic of a given system as required. The 1,024-bit devices represent the break-even point at which bipolar main memories become feasible from a cost/density viewpoint for a wide range of systems.

Conventional 256-bit bipolar devices have long been



4. Something for practically nothing. The ECL design gets two memory types almost for the price of one: as the block diagram shows, the same internal array can be used for both TTL and ECL designs—only the input/output buffers need be changed.

used in cache or buffer stores, because a high-speed buffer between the processor and a slow, large, core or MOS memory enhances the memory's performance at relatively low cost. Higher-density, 1,024-bit bipolar devices, however, can increase the capacity of the cache with no power or size penalty over earlier 256-bit designs. For example, with an Isoplanar 1,024-bit device, a 1,024-by-16 bit buffer can be realized with 16 dual in-line packages, which would occupy a sixth the area of a typical printed-circuit board. One entire board devoted to memory could hold 100 kilobits of memory. Improving the bit ratio will further improve the apparent speed of the main memory. These buffers could also be used as temporary stores for large blocks of data being transferred from a high-speed disk file.

Another opportunity for the big RAMs is in multiprocessing systems, which offer many advantages in complex computing applications. The availability of large high-speed scratch pads will simplify many of the problems previously encountered in implementing this approach. Large scratch pads made with the RAMs are also useful for simulating long shift registers. A high-speed counter linked to the address inputs of the memory array will allow serial data storage at speeds greater than 15–20 MHz.

An important development in digital computer design in recent years has been the transition from an instruction program residing in the bulk memory to a microprogram stored near the logic. This simplifies software and permits very much higher operating speed. The technique has been used both for the control function and for frequently repeated program routines.

The microprograms have usually been held in braided-wire or semiconductor read-only memories, but in many applications high-density, low-power read/write (random-access) memories can now be used in their place. This eliminates the manufacturing and inventory of large numbers of fixed codes, which present a serious logistical problem. Writeable control

Applying Isoplanar to MOS

Although all the bally-hoo about Isoplanar has been directed at bipolar memories, the fact remains that the oxide-isolation process as first described by F. Marandi of SGS-ATES in Milan, Italy, was an MOS process that results in planar structures.

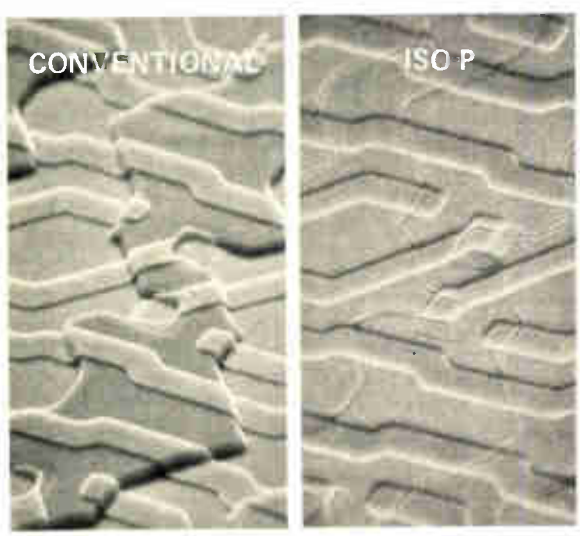
At Fairchild, the first MOS application of the Isoplanar process will be to p-channel devices (to be called ISO-p) and will revise their structure so as to create higher-density circuits. Yields and reliability are also better than with standard silicon-gate methods. These characteristics are obtained at no sacrifice in circuit performance, and in fact, better performance is anticipated since parasitics will be reduced.

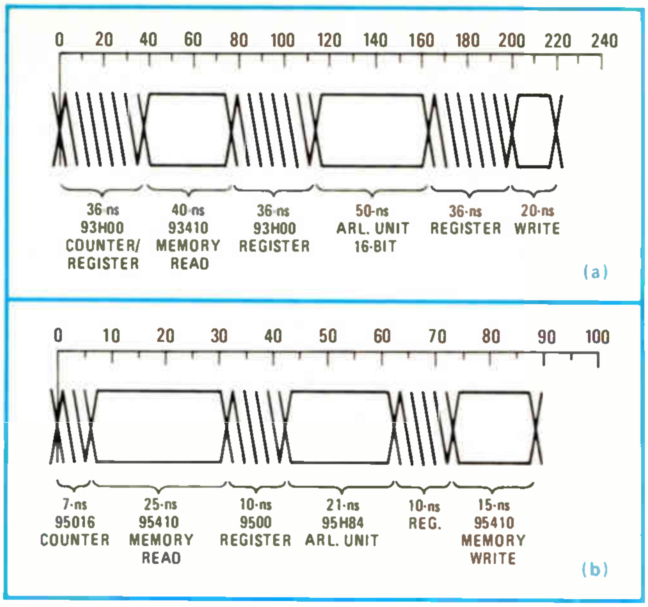
Key to the development of this higher-density MOS LSI is an Isoplanar isolation of the active components. The selective oxidation of the field oxide through appropriate silicon nitride masking, characteristic of Isoplanar processing, results in a flat surface. This flatness permits closer contact with the photomask, improving image transfer because optical scattering, diffraction, and reflection during pattern exposure are reduced. And sharper image transfer means that it is possible to lay out the circuit line elements more densely.

In the accompanying figures, the standard silicon-gate topography is compared to the flatter surface of the Isoplanar device. These scanning electron micrographs encompass a single bit of a 1,024-bit, four-transistor-per-cell, dynamic RAM.

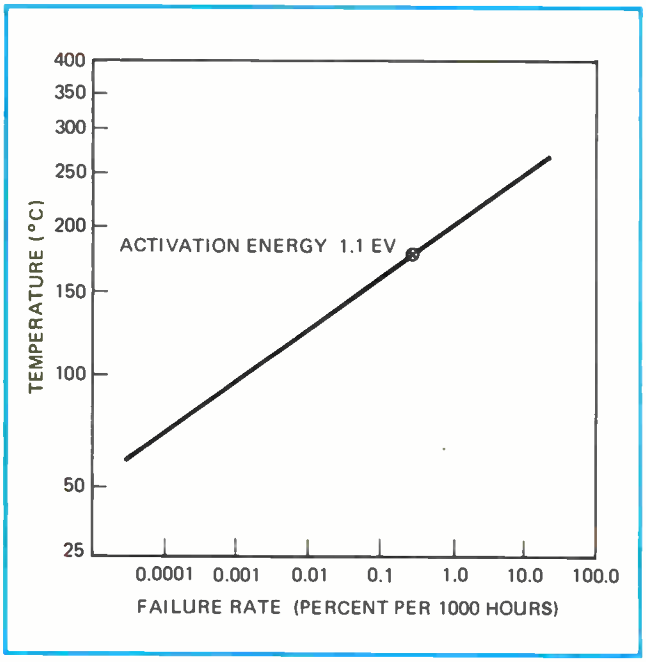
Another significant improvement in density is obtained through the use of a nonaligned contact to the diffused source and drain regions with the polysilicon and metal layers. A 60% area savings results because no allowance need be made for alignment tolerances, pattern size variation, and the unnecessarily large source-drain dimensions these produce.

A third space-saving feature of the ISO-p process is its use of ion-implanted depletion-mode transistors, which have a relatively high effective impedance per unit area and a functional utility that offer higher density circuits. Yields are also enhanced by the increased uniformity of photoresist coverage over the gradual transition from the field oxide to gate oxide and source-drain regions.

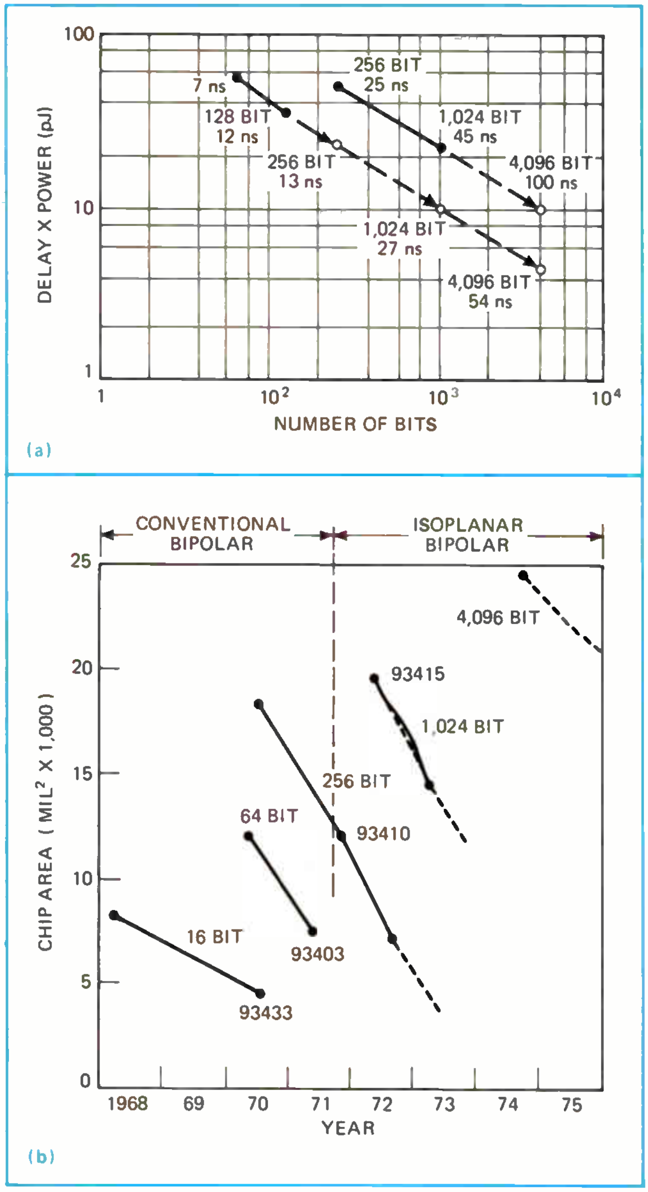




5. Reading and writing. The fast read/write times of the new RAMs enhance the already attractive machine cycle times: 220 ns for the TTL system (a), and 90 ns for the ECL system (b).



6. Almost no failure. Based on the Arrhenius model, Isoplanar failure rate is 0.0015%/1,000 hours at 100°C junction temperature.



7. As time goes on. The next few years will see bigger memories operating faster and more efficiently. Extrapolating to the 1,024-bit level (a), for example, indicates an access time of 27 ns, or 54 ns for a 4,096-bit device. Chip size (and price) is also coming down. This year a 1-kilobit RAM will drop below the 15,000-square-mil die size.

stores also permit easy corrections of errors in the microprogram and allow frequent changes of the "instruction set" to match different applications. The low address access delay of the bipolar RAMs, coupled with substantially faster chip select delays, add to their attractiveness for these applications. Moreover, they are reliable. Accelerated stress tests using an industry standard reliability model can be extrapolated (Fig. 6) to a failure rate of only 0.0015% per 1,000 hours at a junction temperature of 100°C.

And coming

The memories previously described are the first generation of Isoplanar products (see Fig. 7a). Generally speaking, for a given circuit and transistor technology, the memory speed-power product is proportional to the square root of the number of bits. Generally, too, advancements in circuit and processing technology are first applied to smaller memories. Consequently, if the performance of existing Isoplanar 64- and 128-bit memories is extrapolated to the 256-bit and 1,024-bit level, it's possible to expect 256-bit and 1,024-bit memories with 13-ns and 27-ns speeds respectively. A 4,096-bit RAM would have an access time of 54 ns.

Indeed, the chart of chip area for a given memory size as a function of development time (Fig. 76) indicates growing popularity for bipolar devices. And the rapidity with which high-performance Isoplanar read/write memories are improving in speed, power, reliability, and cost virtually mandates their use in new system architecture. □

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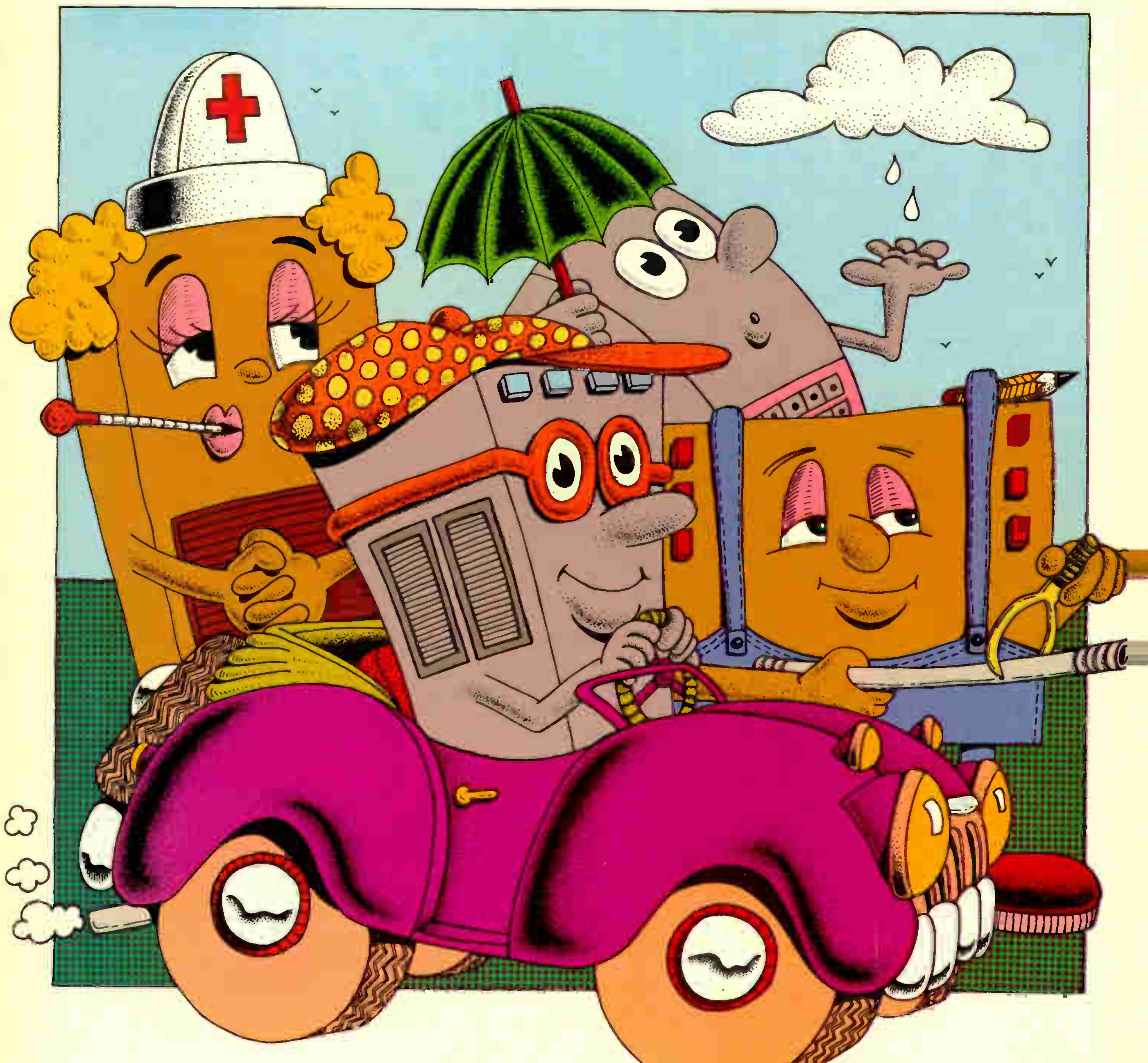
Part I of a series

MINICOMPUTERS GO INTO ACTION IN A MYRIAD OF APPLICATIONS

Increasing numbers of users are exploiting the low-cost versatility and reliability of these small machines to control various types of production and often to serve as the "brains" of larger systems

By Wallace B. Riley, Computer Editor



☐ In less than a decade, minicomputers have exploded in every direction—worldwide. For just about every endeavor—scientific, technical, and commercial—the age of the minicomputer has arrived. This year, U.S. sales should be approximately $6.3 million for minicomputer-based data-processing systems priced under $50,000, compared with $5.4 million the year before. Though the rate of growth will taper off, it's estimated that sales of minis priced under $50,000 will approach $8 million a year by 1976. In Western Europe, mini sales have been leaping ahead at something like 30% a year. And the same sales rate has been set in Japan.

Except for the recession year of 1971, minicomputer systems have enjoyed explosive growth in dollars—up 55% in 1968, 55% in 1969, 30% in 1970, and 55% in 1972. Even in the worst year, 1971, the increase was 13% higher than the level of the previous sales period. All of this occurred during a time of rapidly declining prices, which in part accounts for the phenomenal acceptance of the minis because of their low cost.

The climate hasn't generated unmitigated success, however. A few years ago the glowing prospects of the minicomputer takeover led to the formation of dozens of new companies anxious to get in on the action—with processors, peripherals, software, or systems engineering. Despite the rapidly growing acceptance by users, many of these firms have fallen by the wayside because of poor financial management and/or products that could not live up to advance promotions.

Today, the companies that remain have settled down for the long pull and are producing minicomputers at a rate limited only by their manufacturing capacities. The reasons involve economics as much as technical developments.

A minicomputer offers many advantages over traditional or manual methods—primarily reliability, cost reduction, and savings in space and weight. But right out in front is the machine's effect on productivity. The old ways of controlling machines, analyzing complex mixtures, and collecting and processing data are growing linearly more and more expensive.

But minicomputers, thanks to advances in technology, have been dropping steadily in price, along an almost hyperbolic curve. Geometrically, an upward-sloping straight line and a downward-sloping hyperbola must intersect somewhere—sooner or later, for almost any application, the minicomputer becomes distinctly more economical than manual procedures. Realization of the cost trends by more and more enterprises has created the boom for minis. Today, firms, laboratories, and consumer-service organizations that would never have thought of using a computer only five years ago are routinely employing minicomputers because of the cost savings. In addition, minis, almost by definition, are easy to set up and run, another important attraction to the growing family of new users.

The variegated market

Total shipments of dedicated computers in 1972 amounted to 18,805 machines worth $560 million, according to market researcher International Data Corp., Newtonville, Mass. Many of these minis were components in much larger systems for various applications. Half of this number and 24% of the dollars consisted of minis selling for less than $25,000. Another 42% of the total, priced at $50,000, accounting for almost 50% of the dollar value. IDC predicts that there will be about 24,300 computers sold worldwide in 1973 for dedicated applications.

A principal market for minicomputers has been the customer who buys in large quantities and resells the computer as part of a larger system assembled from various sources. This user may physically build the computer into his own product or simply trans-ship it, along with other component assemblies, also supplying his own marketing distribution or programing expertise.

To satisfy this market, some manufacturers have offered minicomputers that are not expected to run by themselves—they depend on the customer to supply, in his own product, the power supply, external controls, and cabinet. Sometimes even the memory is considered external in this context. Computer Automation Inc., Irvine, Calif., has taken this concept to an extreme with what the company calls the Naked Mini, offered to those customers whose applications provide the power and physical apparatus that the computer requires.

The other major minicomputer market is the end-user—often thought of as a buyer of only a few units. There have been a lot of one- and two-machine buyers; but more significantly of late, many end-users, such as telephone companies and automobile manufacturers, have been purchasing in large quantities. In fact, IDC predicts that the small-business configuration—for applications from retail stores to doctors' offices—will dominate the dedicated-computer field by 1975, passing both the control and monitoring sectors now so closely associated with these machines.

But pitfalls remain for the unwary. No computer, mini or maxi, should be installed on the basis of technical excellence alone, without a careful consideration of other aspects of the application. The buyer's own experts may be familiar with the specific application, and the computer manufacturer's experts may know the machine inside out. The skills of these two sources of help must be properly combined, perhaps with the added skill of an independent outside consultant.

Beware of bargain hunting

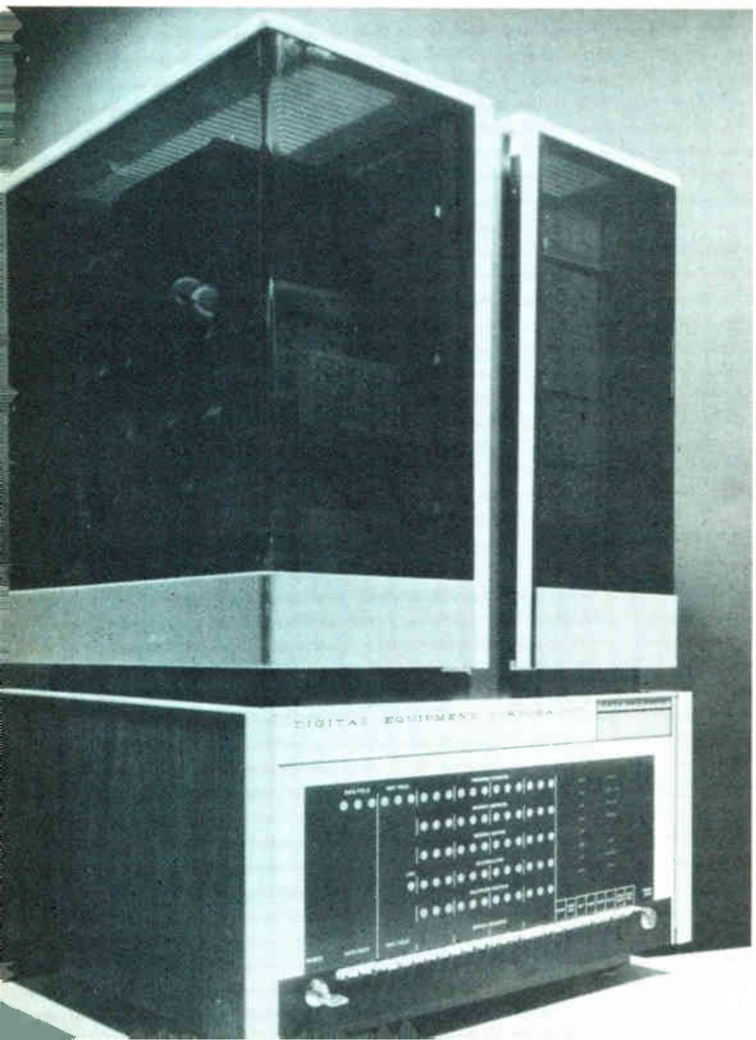
One easy mistake is to buy a minicomputer on the basis of price alone for the central-processing unit. This price probably will include a small assortment of basic peripheral equipment and some barebones software, but the equipment needed for a particular application will cost extra, and it may not be offered by the CPU-maker. A better deal may involve paying more for the basics and less for options and additional equipment.

Only a few years ago, time-sharing was the most exciting new trend in computer capability [*Electronics,* Nov. 29, 1965, p. 72]. It was described then in glowing terms as "the wave of the future." Today time-sharing is a commonly accepted fact of life, and computer networks seem likely to replace the single larger processor with many remote terminals, the usual time-sharing configuration [*Electronics*, Nov. 6, 1972, p. 34].

Yet minicomputers—in networks or standing alone—promise to take the place of some time-sharing systems. Because they are inexpensive, they require little of the complex software that large centralized time-shared computers need, and they avoid common-carrier line charges—which sometimes can exceed the rental of the computer. While standard time-sharing retains its advantage principally where many users must share a single large data base, the flexibility of the mini has brought it into many more diverse applications today.

For example, the police department of Oakland, Calif., has a Hewlett-Packard Co. minicomputer to analyze, correlate and sort crime-related information, and thus to help overtake "perpetrators" more quickly. The Penn Central Railroad's Alfred Perlman yard at Selkirk, N.Y., near Albany, uses a Data General Corp. computer to help classify freight cars and make up trains for different destinations.

The Ferrari racing establishment employs a Digital Equipment Corp. computer to assist in timing and record keeping during automobile races. General Motors Corp., a large user of computers for many applications, has installed at one plant a General Automation computer to regulate carburetors on the production line. And the North Atlantic Treaty Organization has a Varian ruggedized minicomputer to monitor airborne photographic and electronic intelligence-gathering equipment.



The list could go on and on. At airline baggage counters, in department stores, and even in Disney World and behind baseball scoreboards, minicomputers are in action. If any one thing characterizes the minicomputer market, it's the impossibility of neatly pigeonholing it into three or four application categories. Minicomputers are everywhere.

Architecture increases power

From these examples, it is obvious that the minicomputer no longer conforms to the earlier concept of a machine with a limited instruction set, a small memory, slow speed, and small size—consequently selling at a low price. However, in any computer, a single word must encode both an instruction and enough of an address to start execution of that instruction. If the word is short, neither of these essential parts of an instruction has much leeway.

But even though word lengths are still only eight, 12, 16, or occasionally 18 bits, sophisticated architectural schemes have extended the power of instruction contained in such short words. The basic memory that accompanies the processor is still likely to be small, but it is readily extended to quite large capacities, while the necessary addressing structure for the larger sizes is obtained through architectural niceties. The size is still small, but the speed is often quite respectable. The Data General Supernova, for example, when fitted with a semiconductor memory, runs at a 300-ns-cycle clip—and even with a core memory it still stays well under a microsecond per cycle. And the price has plummeted as the cost of semiconductor components has dropped. As recently as 1965, DEC, of Maynard, Mass., electrified the industry with the announcement of a machine selling for less than $20,000. However, today, a very substantial system can be acquired for that price, and a basic mainframe is offered for a price as low as $1,000 to $2,000.

Although the DEC PDP-8 is generally considered the earliest minicomputer, Kenneth H. Olson, founder and president of DEC, claims that the PDP-8 was not the first. However he concedes that it probably started the minicomputer as a major force in the computer industry. "Rather," says Olson, "The PDP-8 was a milestone in a continuous development that began with the Whirlwind computer at the Massachusetts Institute of Technology in the early 1950s." Olson left MIT to form DEC in 1957.

Whirlwind was not a small machine, Olson continues; it was packaged in several rows of huge racks 10 feet high and 26 inches wide. But Whirlwind was a true minicomputer in the sense that it had a relatively short word length (16 bits). It also had a cathode-ray-tube display unit and light pen, half-inch magnetic tape, a magnetic-drum storage unit, high-speed multiply and divide instructions, and other equipment similar—in concept, anyhow—to that in today's machines.

1. Progenitor. The Digital Equipment Corp. PDP-8 was the first in the wave of minicomputers, although it was preceded by such machines as the PDP-5 and Whirlwind. The key idea in its design was approachability—ease of use, not mystery.

"The main contribution of Whirlwind," says Olson, "and the key idea of the PDP-8 and today's minicomputer is that they are approachable—they promote the feeling of being easy to understand and use. In the early days of computers, a lot of people tried to maintain an air of mystery about the new machines. We at MIT took the opposite view."

Olson and his brother, Stanley, established DEC as a supplier of logic modules from which, originally, others could build computers, digital controllers, and the like. Later DEC began to build its own computers, which it called Programed Data Processors—hence the initials PDP, which are still in use. The first of the series to have a short word length, 12 bits, was the PDP-5, and the PDP-8 was its successor.

The PDP-5 grew out of a request to build a special-purpose controller for an atomic pile, to be used at the Chalk River Nuclear Laboratories, Chalk River, Ont., Canada. DEC engineers decided that the special-purpose controller that Chalk River had asked for was too complex to be practical, and in its place substituted a bare-bones general-purpose processor. Chalk River accepted the design, says Olson, and DEC continued to build more of the processors, which were sold as PDP-5s. Later, after studying the production-simplification techniques of appliance manufacturers, DEC streamlined the design of the PDP-5 by using, for example, switches such as those used on clothes dryers—and called the result the PDP-8.

"We visualized a need for these computers," says Olson, "but we never thought then that the need would mushroom the way it has. We knew we could build a machine that children could learn to operate, but we didn't think then that society would reach the level of confidence in the machines that it has." Society's confidence brought DEC $187 million in gross sales last year.

"One of the ideas we took from appliance people was the jazzy appearance of the PDP-8," says Olson. "We did it with Plexiglass and redwood, in lieu of a plain gray metal box. The appearance definitely helped sell the machine. It turned people on."

Another pioneer becomes a competitor

A second name sometimes associated with the PDP-8 is Edson D. deCastro, who left DEC to help found Data General Corp. at Southboro, Mass., only five years ago and became its first and only president. When Data General, now DEC's biggest competitor, was getting started, deCastro billed himself as "father of the PDP-8." He still claims credit for his role on that project, although Olson plays it down.

Today deCastro, discussing the growth of the minicomputer business, credits integrated circuits with providing most of the impetus. "When ICs made it possible to cut the cost of a computer radically, the effect on the market was obvious," says deCastro. "But they also cut the size of the package, reduced the power supply, and showed how to build the machine in a good, logical way. All these changes, put together, turned the minicomputer into a component that could be marketed as such." DeCastro cites the practice of component-marketing for the success of Data General, which grossed about $30 million in 1972. He credits Herbert J. Richman, formerly of Fairchild Semiconductor, one of the four cofounders of Data General, and now the company's marketing vice president, for recognizing that minis are components and for selling them that way. Both of the other cofounders, Richard G. Sogge, engineering vice president, and Henry Burkhardt III, programing vice president, came from DEC.

While both Data General and DEC have provided important milestones in the growth of the minicomputer industry, the growth in mini applications has been spurred by many contributions. DEC, for example, built two new lines around the unified bus, which hangs every major part of a computer system—the processor, memory modules, input-output controllers, and peripherals—on a single group of parallel conductors. However, the unified-bus concept can be traced back to the earliest days of computer technology. A Florida company, Modular Computer Systems Inc., of Fort Lauderdale, Fla., used the bus idea for some years before DEC picked it up in a big way. Other companies have also used it in one way or another.

Another important idea is the homogeneous read-only memory, first used extensively in the Nova computer, Data General's first product. The Nova also used multiple accumulators for the first time in a small computer. Now both ideas are quite common in minicomputers from many manufacturers.

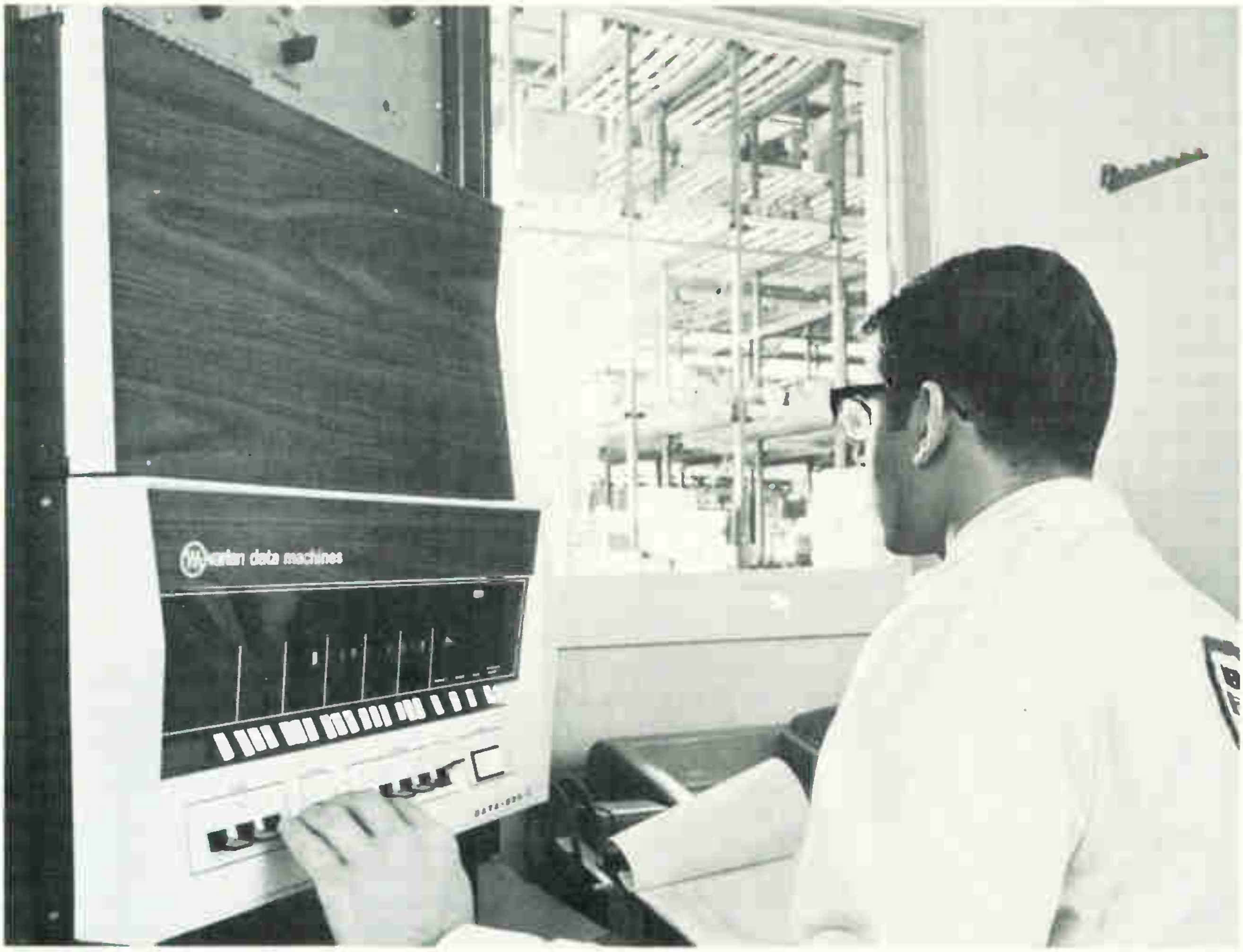
And only last year, Interdata Inc., Oceanport, N.J.,

Minicomputers: more to follow

To document some of the varied applications of minicomputers and to show the wide range of applications, *Electronics* will publish in forthcoming issues a series of articles entitled "Minicomputers in action." One article will discuss the numerical control of machine tools, and another will describe minicomputer simulation of sonar systems, including one computer that models the ocean.

Other installments will tell how minicomputers control epitaxial deposition in semiconductor manufacture; how a major metropolis designs a more effective drainage system, using the results of monitoring rainfall with a minicomputer; and how an airplane manufacturer uses a minicomputer to simulate and test various systems in large commercial aircraft. As the series continues, reports will explore ways minicomputers improve operations in industrial and civil engineering, medicine, and government.

Each article, in general, will cover four topics, beginning with a description of the application. Second, the story will describe how the application was handled before the computer was attached, and in some cases, why the application was impossible without the computer. Third, it will show how the requirements of the application determined or influenced the computer's specifications. Finally, it will reflect on the lessons learned from experience—how the computer installation might be improved or expanded, including what the author might require from the manufacturer.



2. Automated warehousing. Among the thousands of applications in which minicomputers have been installed is the control of automatic materials-handling machinery. Here a technician oversees the operation of a Varian Data Machines 620/i minicomputer in a warehouse.

announced a marketing milestone with a new pricing schedule. Under this plan, a buyer can get a discount as high as 40% for a large-quantity order, but he does not have to buy all of one kind of machine to get it. The move put minicomputers into a kind of a supermarket shopping-cart business so that buyers can pick and choose, and yet get the discount price.

How to use a minicomputer

In general, a minicomputer can be used in two ways—in a new application, or in reworking an existing application—that is, in upgrading it by applying a computer. Either way, the alternatives are manual controls, with accompanying limitations of speed and accuracy, or hard-wired automatic controls, which are expensive and which, once installed, are essentially unalterable so that they can't be modified for minor changes in the application.

But the decision to install a minicomputer isn't simple. There are many important tradeoffs to consider—perhaps nearly as many as there are varieties of minicomputers. A particularly comprehensive list of 10 considerations, published by Texas Instruments, Houston, Texas, to help sell its minicomputers, can guide a would-be purchaser in evaluating the suitability of any machine or of any proposed list of specifications.

1. *The machine's procedure*—the sequence of events that occurs under computer control. It is effectively a program, a piece of software. But, unlike the software found in general-purpose data-processing applications, a minicomputer procedure may include commands such as TURN ON MOTOR or OPEN VALVE, but not necessarily events such as FIND SUM or FILE RECORDS. In evaluating a machine, the purchaser must ask if it can execute the procedures his application needs. Then if the mini is perhaps more suitable for one of two sets of requirements in the given application, does its suitability match the priorities of the application at reasonable cost?

2. *Data*—the information that the machine works on. Data is characteristic of the particular application—for example, speed 5,000 rpm, delay 25 seconds, or limit 1,000°C—and it characterizes the machine that works on it.

3. *The hardware instruction set*, the design, in hardware, of the instructions that will support the desired procedures, with few or no instructions that aren't used in the application. These instructions are likely to be

different from those in a data-processing computer. An exactly suitable instruction set for a given application is not likely to be found, except in a custom-designed computer; but a close approximation to custom design can be obtained, in some cases, by microprograming, which provides the particular instruction set required. A microprogram differs from software simulation, which is discussed later in this article.

How it juggles data

4. *Can the machine perform the same procedures on different blocks of data,* that is, on different controlled devices, at the same time? This highly important consideration is known as hardware re-entrant operation. For example, a group of chromatographs all share the same procedure, but when they analyze different materials, their data differs. Furthermore, the analysis cycles may have started at different times. Or a network of data-logging stations may have a common procedure, but users may enter different data at different times.

Duplicating the procedure for each of these data blocks would be a brute-force way of running the chromatographs and waste memory capacity. But re-entrancy permits different data blocks to pass through the procedure at the same time, possibly out of step with one another, while no one block affects the procedure's operation on any other.

5. *Communication between successive controlled devices.* This is desirable when they execute different procedures sequentially on the same block of data. The devices may be physically, or only logically, adjacent, or they may be widely separated, even though they are in the same process stream. For example, in the data-logging network, a user starting work on an assembly may require information logged previously through another station by another employee who also worked on the assembly. To achieve this form of communication, one procedure must set status bits that another procedure can test, and data blocks must be accessible to different procedures.

Supervision without interference

6. *Separate environments for procedures and for supervision.* This ensures that supervisory routines properly control the execution of the procedures, yet do not interfere with them. At the very least, this implies separate areas in a computer memory—primarily a software distinction. It could mean different hardware implementations of the supervisory and procedural routines—putting one in a read-write memory and the other in a read-only memory, for example. Or it could mean completely separate minicomputers forming a multiprocessor or a network.

7. *Multiprograming capability.* This permits several different procedures to have access to a limited hardware resource in rotation or in accordance with some other protocol. Even a dedicated application can benefit from multiprograming. A procedure that is used only rarely, but is highly important when it is used, need not take up space in the memory when it is idle.

In a way, multiprograming capability is related to re-entrancy, but, whereas re-entrancy is necessary to execute the same procedure on different data blocks simultaneously, multiprograming is the execution of different procedures nearly simultaneously. Neither allows the different events to be processed exactly simultaneously, but both procedures permit partial results obtained from one event to be temporarily stored while the computer briefly attacks another event, perhaps using previously obtained partial results. Re-entrancy prevents one set of partial results from wiping out another, while multiprograming keeps the computer busy after it ini-

The new evolves from the old

The principal specifications of Digital Equipment Corp.'s PDP-8 of 1965, sometimes said to be the first minicomputer, and its descendants through today's PDP-8/F, indicate how far minicomputers have come in less than 10 years. Even though the PDP-8 was the first computer to sell for less than $20,000, the sharp drop in price for its successors is the most noticeable feature of the table at right. After only a year, the 8/S broke the $10,000 barrier at the cost of substantially degraded performance—slow memory and serial arithmetic. When the 8/I introduced integrated circuits to the family, it offered no improvement in performance over the original PDP-8, but there was a small decrease in price and a reduction in size. The 8/L extended the same benefits to the 8/I that the 8/S did to the 8, but without as severe an impact on performance. Finally came the 8/E, a bus-oriented machine with one or two buses and a 32,000-word memory; the 8/F, with only one bus and a 16,000-word memory; and the 8/M, intended for use as a subassembly in larger products and thus characterized by limited external access via switches and indicator lights.

CHANGES THROUGH THE YEARS

Year of first delivery	Model	Price (in thousands of dollars)	Storage cycle, μs	Add time, μs	Physical size, inches W x H x D
1965	PDP-8	18	1.5	3.0	21½ x 34 x 20½
1966	PDP-8/S	10	8	33.0	19 x 10½ x 27½ ½
1968	PDP-8/I	16	1.5	3.0	19 x 25⅛ x 23¼*
1968	PDP-8/L	8	1.6	3.2	19 x 8¾ x 20¾
1971	PDP-8/E	5	1.2	2.6	19 x 10½ x 24
1971	PDP-8/M	3.7	1.2	2.6	19 x 10½ x 15
1972	PDP-8/F	4	1.2	2.6	19 x 10½ x 24

*In rack; other dimensions are table-top measurements.

tiates an external process, so that it doesn't stand idle, pending the completion of the initial task.

8. *Relocatability.* This capability permits a program to be properly executed, regardless of its location in the memory or of the location of its data block. This characteristic is available in many computers, whether designed for control applications or general-purpose data processing. Procedures and data blocks can be moved from place to place in the memory as their sizes change, and the sizes, in turn, may depend on design improvements or on operational changes.

9. *Flexibility in the input/output apparatus.* This capability permits different kinds of peripheral equipment to be connected conveniently without reference to one another—either in hardware or software. In particular, the different equipment should not be restricted to any particular word length; the computer should be able to control devices that communicate with one or two bits at a time, as well as those that need 16 or 24 bits. This is important because the interconnecting network should not be scrambled when a particular piece of peripheral gear is improved or the system configuration is changed.

10. *Finally, simple program language.* The language used to program the computer should be that of the people using the computer. They are not likely to be computer experts or even to understand the well-known scientific or commercial programing languages.

Are all 10 really necessary?

Tradeoffs are possible within each of these 10 considerations, as indicated in the examples given. Tradeoffs among them are also possible in some cases. Some minicomputers qualify under all 10 considerations. Another machine may be deficient in some of the requirements, but be very highly developed in others so that poor relocatability can be traded for good re-entrancy. For that matter, TI's minicomputers are good examples. Built particularly for manufacturing applications, they are therefore well equipped with an instruction set suitable for factory automation, but they are not microprogramed.

If a particular machine lacks one of these 10 characteristics, it may often be programed to make up for the deficiency—at a price. The trouble is that the program takes up space in the memory, and the software simulation, which involves several steps executed in sequence, is necessarily slower in execution than its hardware implementation, which requires only one or a few steps executed more quickly. The extra programing also adds to the integration, documentation, and debugging headaches of the rest of the system software. But programing can also be readily altered, which is good, if the need for occasional changes can be foreseen, or bad, if the effects of accidental alteration would be catastrophic.

Software simulation is not the same as microprograming. A microporgram generally resides in its own memory, so that it doesn't interfere with procedures and data, and because it defines the machine's operation at a lower level than software, it doesn't impact the execution time.

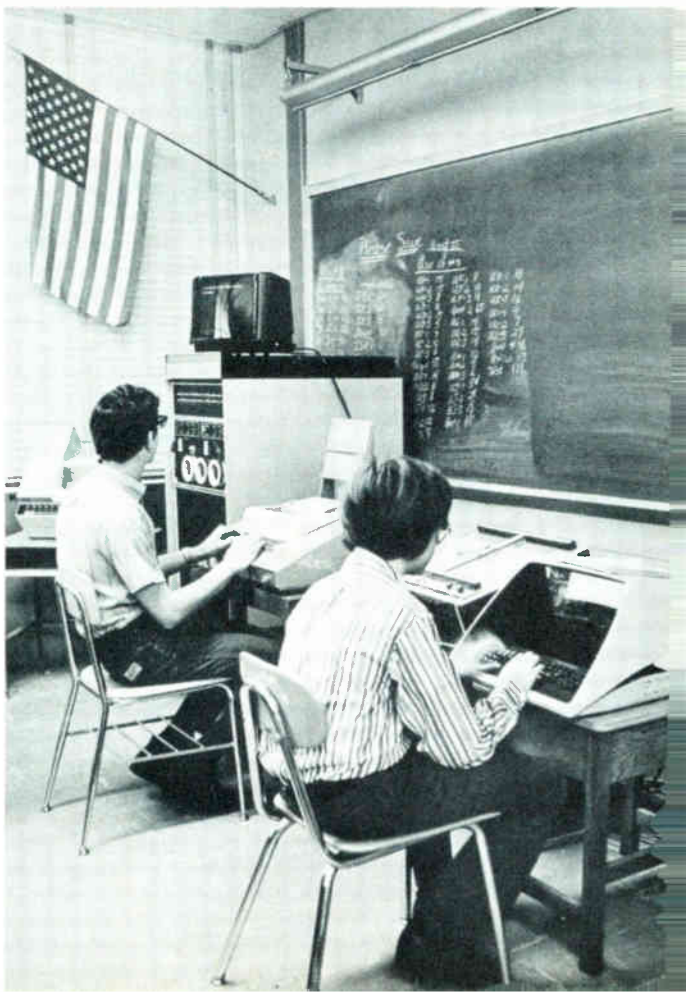
In contrast, if used at all, the microprogram controls execution of every procedure-level instruction at an optimum speed. Additional procedure-level instructions are available at minimum cost, subject only to the capacity of the microprogram memory and to the means of altering its contents. Traditionally the microprogram has been alterable only by the computer manufacturer.

And even though advances in technology are making field-alterable microprograms more and more common, alterations are intended to be left to the computer experts. Microprograming, first proposed in 1951, and first used commercially in 1964, eventually made its way into minicomputers. Both Microdata Corp., Santa Ana, Calif., founded in 1968, and Interdata, founded in 1966, have applied microprograming to minis from the start.

Prospects for microcomputers

Minicomputer technology and minicomputer markets will probably experience some shakeup in the wake of new designs for microprocessors, which have been announced by several sources during the past year or so [*Electronics,* March 1, p. 63.]. Microcomputers are complete arithmetic-processing units, built as units on single large-scale integrated-circuit chips, that work on four to 16 bits at a time. Already they're being used in applications ranging from a controller for a "smart" terminal to a preprocessor for a minicomputer, and dozens of others between.

By one estimate, as many as 30 companies have been formed to offer design services and consultations for microcomputer-based systems. As for hardware, so far Intel Corp., Santa Clara, Calif., has announced the 4004,



part of the MCS-4 chip set [*Electronics*, April 24, 1972, p. 112], and the 8008 [*Electronics*, March 13, 1972, p. 143]. National Semiconductor Corp., also in Santa Clara, has brought out its MAPS (microprogramable arithmetic-processor system), a seven-chip set [*Electronics*, April 10, 1972, p. 121]. Both companies are said to be working on 16-bit versions.

Meanwhile Fairchild Semiconductor, Mountain View, Calif., and Rockwell Microelectronics, Anaheim, Calif., have started producing their own microcomputers. Additional entries are being planned by American Micro-systems Inc., still another Santa Clara outfit, Microsystems International Ltd., Ottawa, Ont., Canada, and Western Digital Corp., Santa Ana, Calif.

These devices usually come in sets that include, along with the processor, some read-write and read-only memory chips, circuits for interfacing with peripheral equipment, and other accessories—without which the processor wouldn't be worth much.

What's ahead?

Where will the minicomputer industry go from here? Data General's deCastro thinks the component market will continue to be important, as builders of other equipment incorporate minicomputers into their own more complex systems. This is particularly true, as user sophistication continues to increase. He says the new microcomputers are interesting, but not an important factor in the market for some time to come. "Although microcomputers are inexpensive," says deCastro, "their real contribution will be in conjunction with external logic where raw speed isn't important."

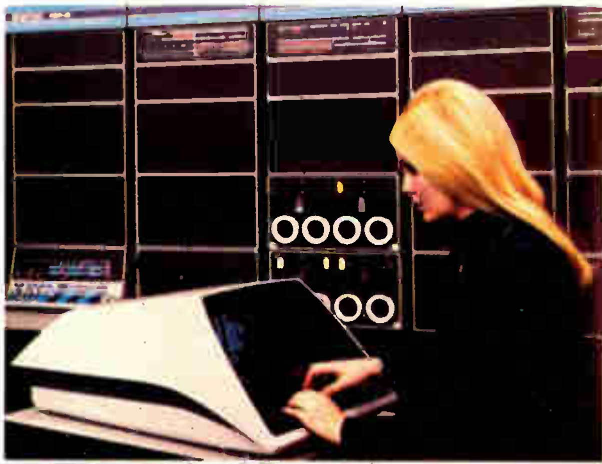
Olson, on the other hand, sees the "component" business as something yet to come—a future part of the minicomputer business. Obviously DEC is selling many of its minicomputers into applications similar to those of Data General customers, but DEC takes a slightly different approach to marketing. It views the computer and the related peripherals and software as tools that the sophisticated customer uses in an application that he understands thoroughly and that DEC doesn't claim to understand.

The semiconductor manufacturers will sell microcomputers as components for use in high-volume consumer goods and thereby will open up some new markets for conventional minicomputers. Minicomputer manufacturers are now an important source of supply for makers of more complex gear, but they'll become less important for some companies that can benefit from the availability of microcomputers.

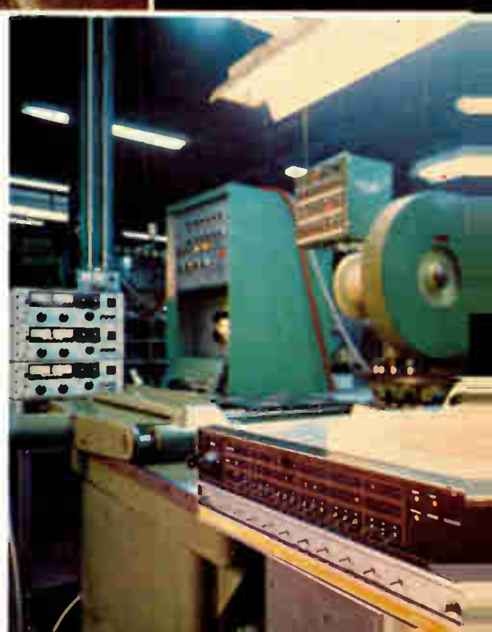
Meanwhile the minicomputer makers will continue to develop more and more complex machines—Olson cites DEC's PDP-11/45 as an example [*Electronics*, Oct. 11, 1971, p. 62] where cost-effective design philosophy is combined with improved performance and added features for higher speed and greater capacity. In parallel, the minicomputer makers will also build systems containing many peripheral devices and "conglomerates" of processors, well beyond the capabilities of the semiconductor manufacturers. It's clear that, starting from today's base, minicomputers will become a virtually ubiquitous consumer product.

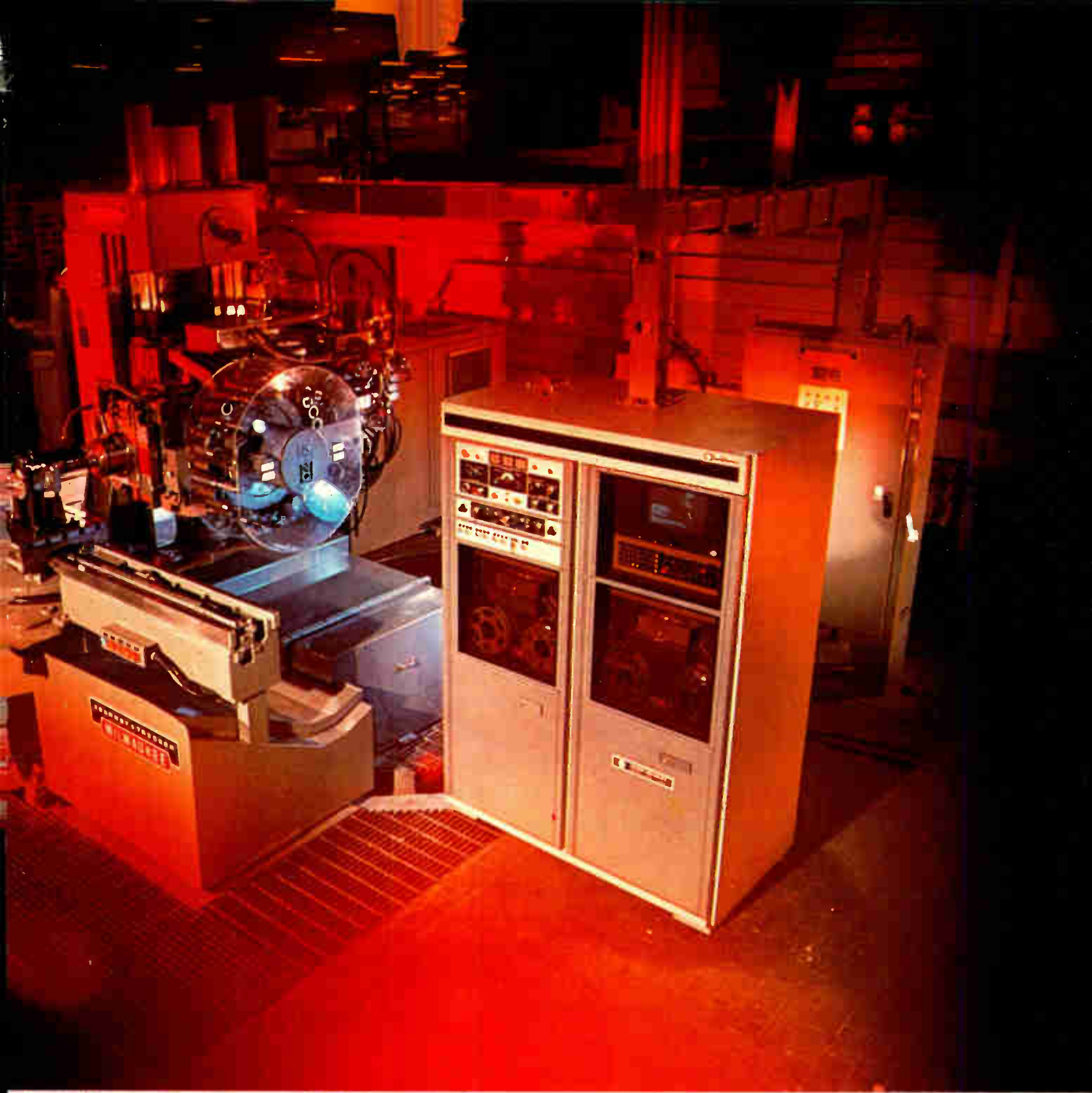
3. Teach. Minicomputers are in wide use in classrooms (left), as exemplified by Digital Equipment Corp.'s EduSystem 25, a time-shared minicomputer that accommodates up to eight users simultaneously. The computer is a PDP-8/E.

4. Portent. Prized by Data General Corp. is this network of eight Nova minicomputers, part of a General Electric Co. simulation system for training Navy pilots. The minicomputer network is an increasingly important way to get high performance at low cost.



Diversity is characteristic of minicomputer applications. In communications systems (top), they serve as "front ends" for larger systems, taking much of the housekeeping load off the central system. Here a blonde operator uses a DEC terminal. In the Penn Central Railroad's Selkirk yards, near Albany, N.Y. (directly above), a Data General computer controls the switching of freight cars in making up trains. The computer is in a small shed in the middle of the yard, indistinguishable from the freight cars surrounding it. Machine tools are increasingly controlled by minicomputers (right); here another Data General Nova is hard at work in a machine shop, controlling such tools as lathes and milling machines.





Numerically controlled machine-tool system (above), more sophisticated than the one on the opposite page, is a Kearney & Trecker system run by an Allen-Bradley controller. Software structure of the Allen-Bradley system permits changes to be made in its functions quickly and on short notice; details on this system will appear in the next issue of *Electronics*. Meanwhile, another minicomputer monitors an automobile assembly line (left)—one of many hundreds of minicomputer applications in the automobile industry. □

Extending time delay with an emitter-follower

by Victor Hatch
Peripheral Power Systems, San Jose, Calif.

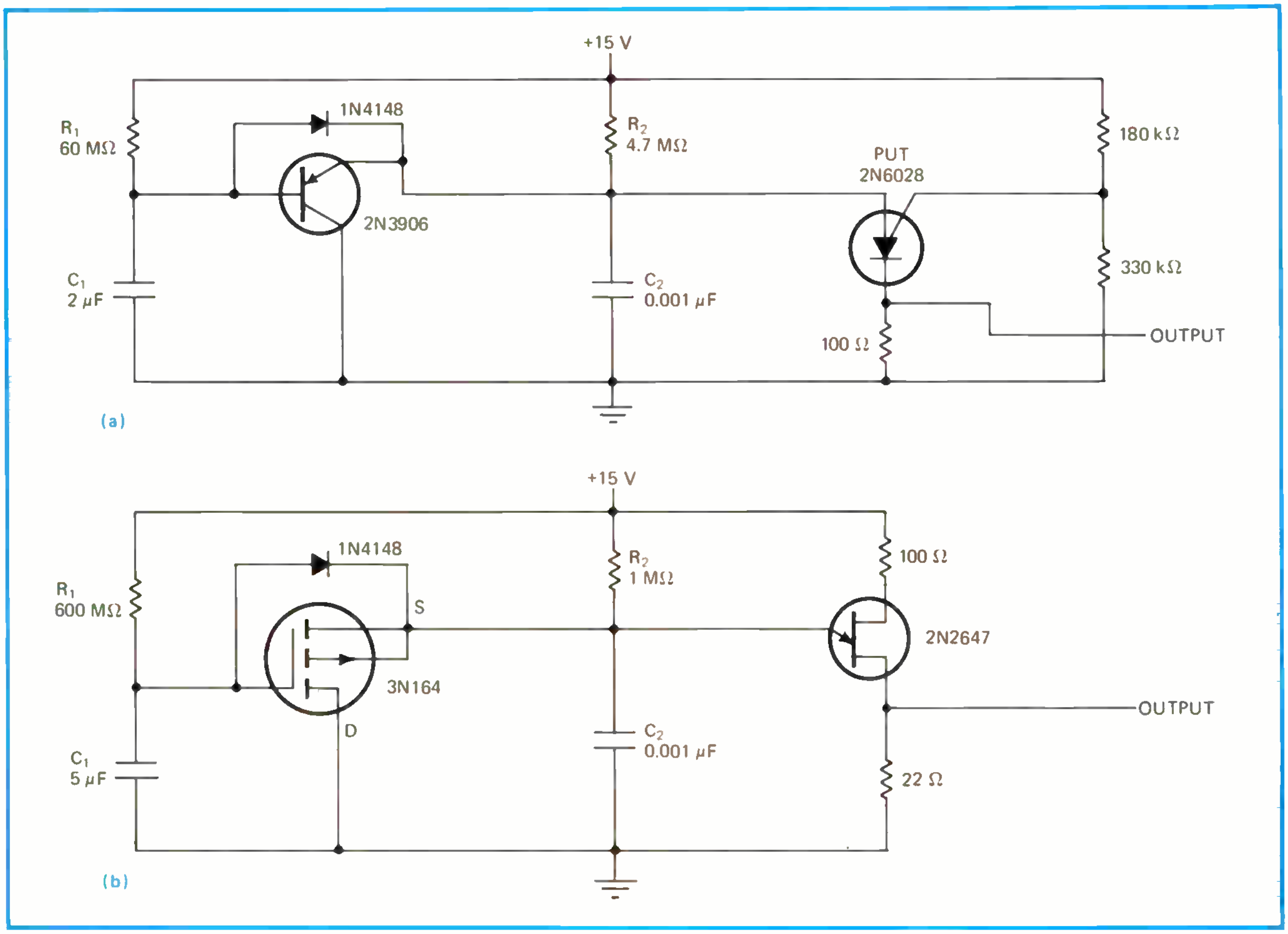
When a long delay is needed between pulses, two unijunction transistors are frequently tied together so that one of them periodically changes the triggering point of the other. A better approach—one that permits very large time constants to be realized—is to use a programable unijunction transistor (PUT) and an emitter-follower. In this way, the peak point current needed to fire the PUT can be obtained when a high value of resistance is used in the timing network.

The circuit shown in (a) produces an output pulse every 2½ minutes. Resistor R_1 and capacitor C_1 are the timing components that set the circuit's operating frequency. Resistor R_2 assures that circuit oscillation will be sustained by providing a bias current that is greater than the PUT's peak point current (0.15 microampere in this case) for turning the PUT on and less than the PUT's valley current (25 μA in this case) for turning the PUT off. Capacitor C_2 biases the PUT until the diode conducts and capacitor C_1 begins to discharge.

Even longer time delays can be realized by using the circuit shown in (b)—a unijunction transistor (UJT) and a p-channel enhancement-mode MOSFET that is connected as a source-follower. This particular configuration produces one pulse an hour. Timing resistor R_1 can have a higher value here because the gate current of the MOSFET source-follower is lower than the base current of the transistor emitter-follower.

Again, the value of resistor R_2 determines the proper bias currents. It must supply the UJT with a turn-on bias current that is larger than the sum of the device's peak point current and emitter leakage current, and a turn-off bias current that is smaller than the device's valley current, which is usually several milliamperes. □

Stretching the off time. Emitter-follower (a) allows high values of resistance to be used in timing circuit of programable unijunction transistor. The resulting large time constant extends the time between output pulses to 2½ minutes for the components shown. With conventional UJT and a source-follower (b), the delay can be made even longer. Here it's one pulse an hour.



Current-sharing design boosts regulator output

by Marvin Vander Kooi
National Semiconductor Corp., Santa Clara, Calif.

When a higher-than-rated current must be supplied by a monolithic voltage regulator, an external boost transistor is usually employed. Most normal current-boosting schemes, however, require additional active devices to duplicate some of the worthwhile safety features of the integrated regulator—for instance, short-circuit current limiting, safe-operating-area protection, and thermal shutdown.

The regulator circuit in the figure retains these safety features by extending them to the external pass transistor through a current-sharing design. This regulator, which is intended for transistor-transistor-logic circuits, has an output voltage of 5 volts at 5 amperes and a typical load regulation of 1.4%.

Resistors R_1 and R_2 provide the necessary current division, assuming that the transistor's base-emitter voltage equals the diode drop. Then the voltage drops across resistors R_1 and R_2 are equal, and the currents through R_1 and R_2 are inversely proportional to their resistances. With the resistance values shown, resistor R_1 has four times the current flow of resistor R_2.

For reasonable values of transistor beta, the transistor's emitter current (from resistor R_1) will approximately equal its collector current, while the current through resistor R_2 will equal the current flowing through the monolithic regulator. Under overload or short-circuit conditions, therefore, the protection circuitry of the packaged regulator not only limits its output current, but also limits the output current of the pass transistor to a safe value, thereby preventing device damage.

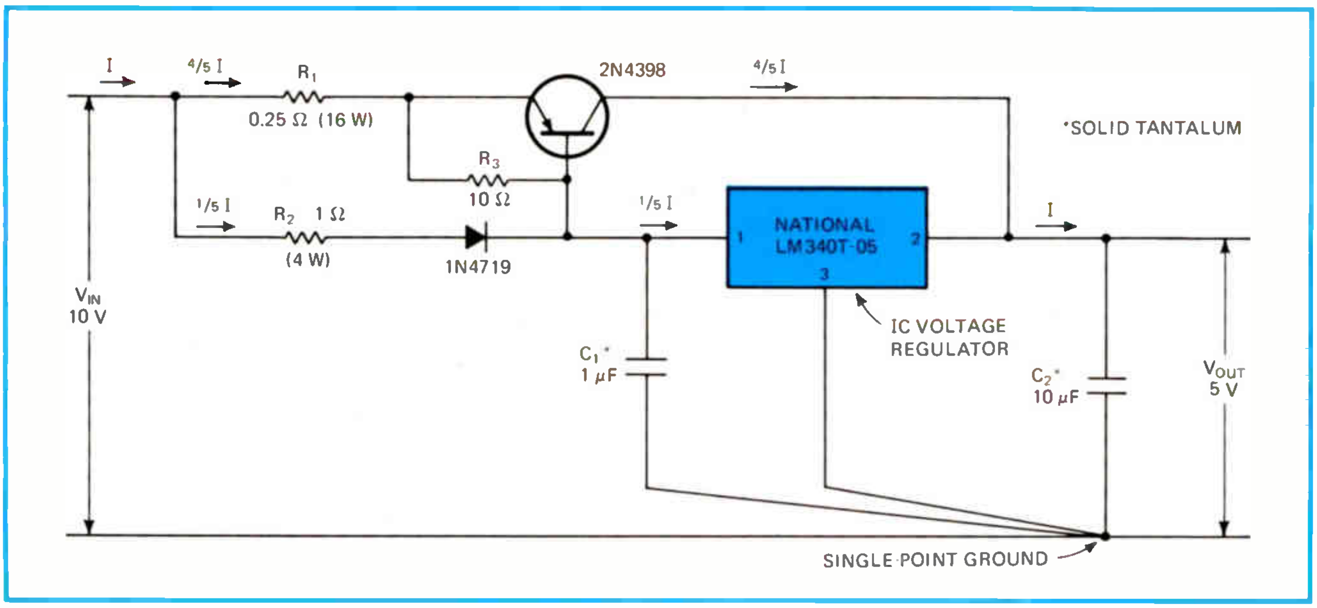
Thermal-overload protection is also extended to the external pass transistor when its heat sink is designed to have at least four times the capacity of the regulator's heat sink. This is because both devices have almost the same input and output voltages and share load current in a 4:1 ratio. During normal operation, up to 1 A of current flows through the regulator, while up to 4 A flow through the outboarded pass transistor.

Under instantaneous overload conditions, the over-all circuit will supply approximately 9 A of output current (for junction temperatures varying from 0°C to 70°C). This reflects the 1.8-A current limit of National's LM340T regulator, causing the times-four current limit for the pass transistor to be 7.2 A. If the short-circuit condition is continuous, the regulator heats up and limits the total steady-state current to about 7.5 A.

For optimum current-sharing between the regulator and the pass transistor as the temperature changes, the diode should be located physically near the pass transistor. Also, the diode's heat-sinking arrangement should keep it at the same temperature as the pass transistor. If the LM340T is used and mounted on the same heat sink as the pass transistor, the regulator should be electrically isolated from the heat sink, since its case (pin 3) is at ground potential, but the case (collector) of the pass transistor is at the regulator's output potential.

Capacitor C_1 prevents unwanted oscillations, while capacitor C_2 improves the output impedance of the over-all circuit. Resistor R_3 provides a path to unload the excessive charge that develops in the base region of the pass transistor when the regulator suddenly goes from full load to no load. The circuit's single-point ground system allows the regulator's sense terminals (pins 2 and 3) to monitor load voltage directly, rather than at some point along a possibly resistive ground-return line carrying up to 5 A of load current. □

Sharing the load for TTL. Current-boosting scheme for IC regulator divides input current in 4:1 ratio between the regulator and an external pass transistor. This current-sharing preserves the IC's short-circuit, overload, and thermal-shutdown safety features. The circuit provides an output of 5 volts at 5 amperes, regulated to 1.4%. The protection diode and the transistor should be kept at the same temperature.



Up/down synchronous counter takes just four MSI packages

by Richard J. Bouchard
Sanders Associates Inc., Nashua, N.H.

An 8-bit synchronous up/down counter with programable increment-decrement values and a look-ahead overflow-underflow line can be implemented with only four medium-scale integrated circuits. An up/down control line allows the counter to increment either up or down on each clock input pulse by any number from 1 to 7. This type of counter is used in such applications as differential analyzers and X-Y deflection circuits for random-plot cathode-ray-tube displays.

The counter contains an 8-bit latch that is driven by two 4-bit adders. The output of these adders is the sum of the existing latch (counter) output, plus or minus the existing value of the 3-bit increment-decrement control signal. Therefore, at any given time, the input to the latch represents the next counter state, which is synchronously entered into the latch upon receipt of a clock input pulse.

In the count-up mode, the three-bit increment-decrement value is added directly to the existing counter output to provide the next-count input for the latch. In the count-down mode, however, the inputs to the (left) adder from the output lines of the quad exclusive-OR gate represent the 1's complement of the 3-bit increment-decrement value.

The carry input of the least-significant adder stage is activated simultaneously via the count-down control line, and the 2's complement of the existing decrement value is added to the counter output. For the count-down mode, then, the input to the 8-bit latch is less than the existing counter output by the value of the 3-bit increment-decrement control.

One of the stages of the quad exclusive-OR gate is used to generate a positive output signal whenever the next count to be entered into the latch will cause either an overflow or underflow in the counter output. This is accomplished by simply gating the up/down control line with the carry output of the last adder stage. In a vector display, the look-ahead overflow-underflow signal can be used to inhibit the clock input so that vector wrap-around does not occur.

The range of programable increment-decrement values may be readily extended from the 1-to-7 one shown here to a 1-to-127 one by adding a second quad exclusive-OR element. □

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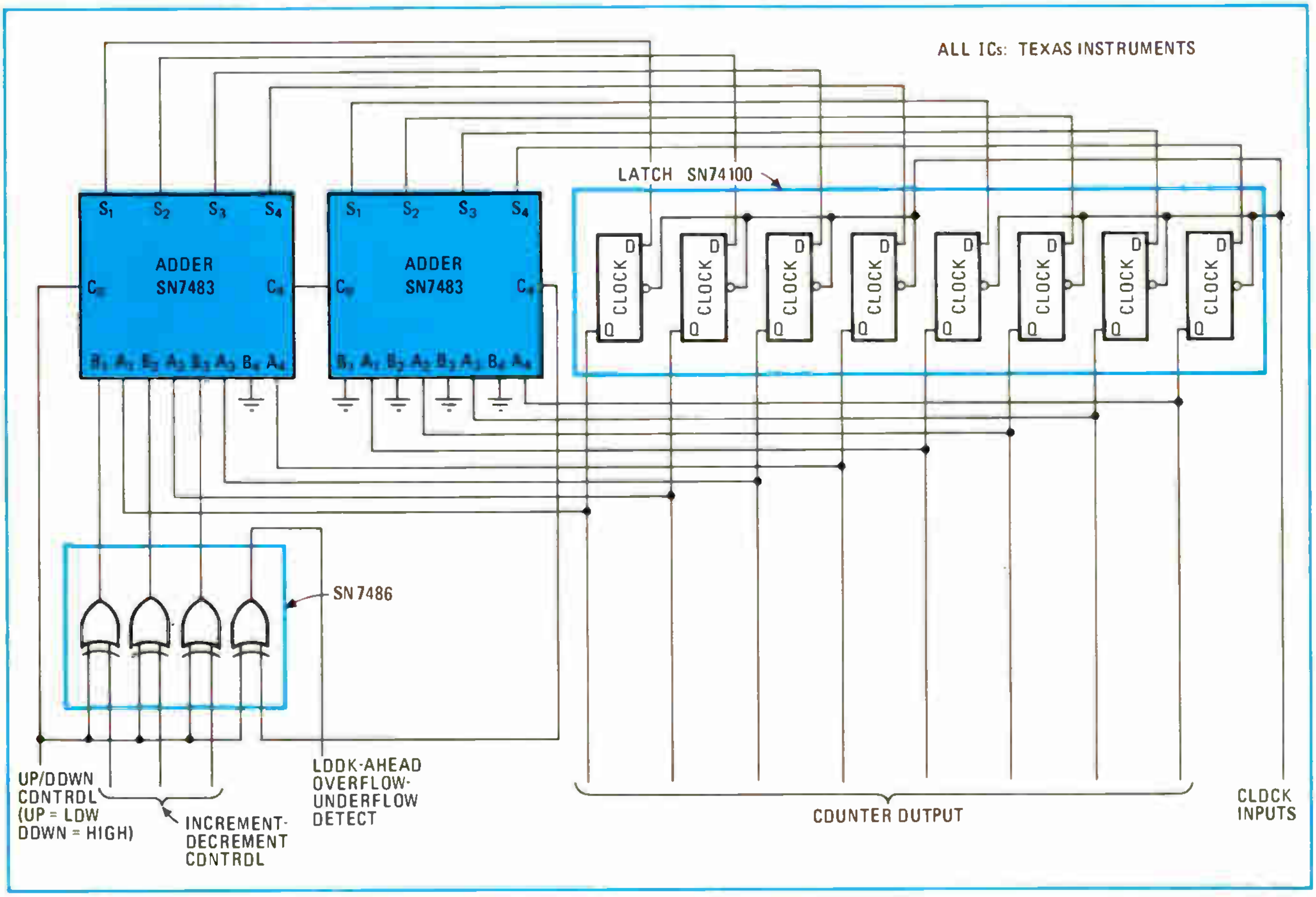
Space-saving counter. Four MSI circuits make up complete 8-bit synchronous up/down counter that includes look-ahead overflow-underflow detection. Output count can be dynamically varied by 3-bit increment-decrement control. For count-up, the value of this signal is added to the existing counter output; for count-down, it is subtracted. The latch input always represents the next counter state.



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Flat, flexible cable makes excellent IC interface

When flat cable is fabricated with printed-circuit techniques, conductors can be made narrow enough to align with the pads on tiny IC packages; then it's simple to wire-bond them

by M.A. Berger and E.G. Bylander,
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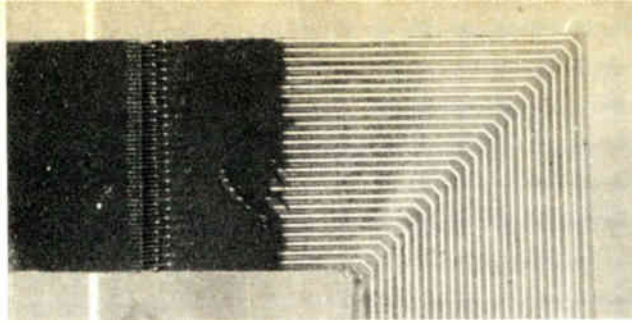
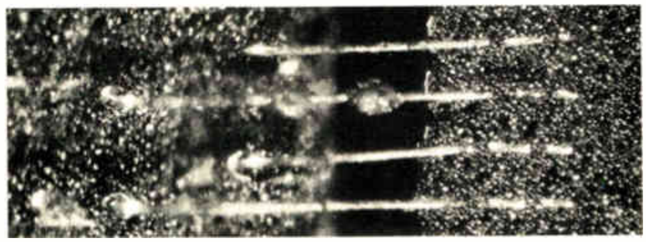




Dense interface. One-mil wires connect multilayer flexible circuit with infrared device; the wires are ball-bonded to the device pads on the left and stitch-bonded to the cable on the right. In the magnified view, droplets on wires are paint, which is applied to the assembly to prevent unwanted incident light from reaching the light detectors.

□ Flat, flexible cable, familiar in military and aerospace hardware, is finding new applications in commercial equipment as an interface with densely packed microelectronic devices. Connecting a 50-terminal integrated-circuit device to a 50-lead cable just can't be done with the cables found in wire catalogs—the wires are too large, and they are spaced too far apart. But even if a cable could be found, there is almost no hope for soldering the leads to a microelectronic device, because it is almost certain that the solder would bridge the 8-mil gaps between the connection pads on the device.

So flexible circuitry is the answer. The reason is that printed-circuit techniques enable reliable, flexible, printed wiring to be fabricated with conductors as narrow as 3 mils and center-to-center conductor spacings as narrow as 6 mils.

For short production runs the expenses of fabricating the flat cable may prove to be prohibitive. But when quantities are high, so that design costs per unit fall, then economies of wiring devices with flat cable enhance the technical virtues of the technique. Assembly is more economical than for conventional round cable because the planar cross-section forces those doing the wiring to wire each conductor in sequence and so frees them from the need to keep track of the wires. In effect, the geometry is a constraint on the address of each lead to its termination, so the work will proceed rapidly with little chance of an address error.

The single-layer flexible cable is composed of a base layer, copper foil, and often a cover sheet (Fig. 1a). The cover sheet protects the copper from abrasion and accidental short circuits and adds both strength and thermal conductivity. On the other hand, it also increases the design and fabrication costs. Multilayer flexible circuits can be made by stacking single-layer circuits.

The fabrication sequence begins with the generation of artwork, which is usually four times actual size. Then a copper foil that has been laminated to a polyimide sheet is treated with a photoresist and exposed photographically to the image of the required conductor pattern. Finally, the unwanted copper is etched away (Fig. 1b), yielding a single-layer flexible circuit to which a cover sheet of plastic can be added.

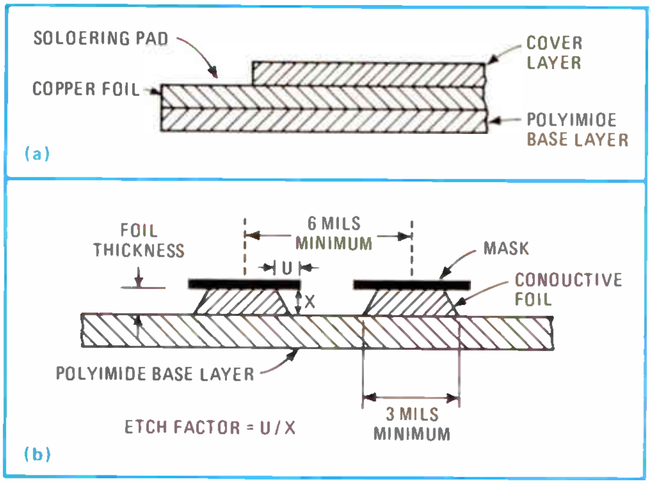
When it comes to connecting the flexible cable to IC terminals, the thermocompression bonding tip—a common tool for wire-bonding IC devices—does a fine job. It is capable of stepping the small increments between leads (approximately 8 mils) and thus can wire-bond each flexible circuit lead to each terminal pad.

In Fig. 2, a single-layer flexible cable is shown that was designed to connect a magnetic-disk read-write head to a connector on a pc board. The connector fans out the densely spaced, magnetic-head conductor spacing to the relatively broad conductor spacing commonly used on pc boards. Also shown in Fig. 2 is a multilayer circuit. Here the fanout from the device at the lower left to the terminals at the upper right is two-dimensional. Other applications of flat flexible cables include light emitters, and cryogenic computers.

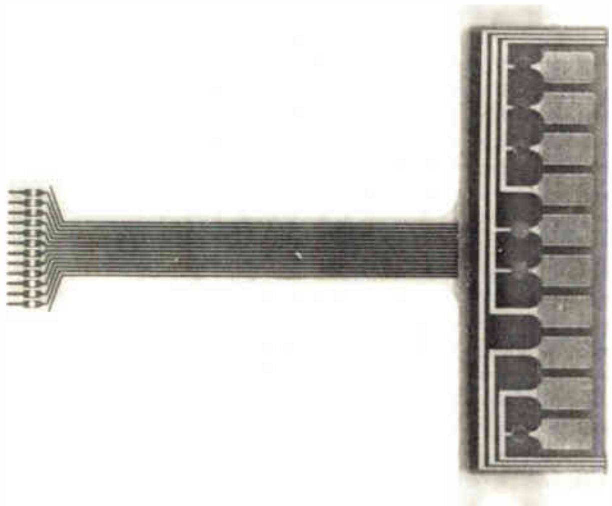
The proper use of copper

It's easy enough to talk of copper foil laminated to a polyimide base. But the key question is: will the conductive foil stay put on the plastic base? There are several ways of forming the laminate, such as cementing the copper down with an adhesive or sputtering the copper, ion by ion, onto the base with sophisticated sputtering equipment. But the best method for fastening the copper to plastic sheeting, such as the polyimide, is thermocompression bonding because the laminate formed by this technique will not develop lift-off or swim when subjected to soldering and plating. The thermocompression-bonding process employs heat and pressure to fuse the copper and polyimide base layer (the process values are usually proprietary). The method is also satisfactory for attaching the cover layer.

Another important consideration in building a flexible circuit—single-layer or multilayer—is thermal conductivity. The designer must know the ambient temperature in which the cable will operate, and he must also have information on heating which may arise due



1. Sandwich. A typical flexible circuit consists of 1-oz electroplated copper foil bonded to a 1-mil-thick polyimide base layer and protected by a cover layer (a). Because etch back occurs under the mask, vertical walls cannot be fabricated (b), and conductor widths are limited to a minimum of about four times the foil thickness. Etch factor refers to the ratio of the horizontal to the vertical cut.



2. Single-layer and multilayer interface. Closely spaced conductors at the left end of single-layer flexible circuit are connected to a disk read-write head on a ceramic package; right end is a rigid circuit board that plugs into connector mounted on a circuit board.

to ohmic loss in the conductor, if he is to select the proper base material and conductor cross-section.

Tests of mechanically strong films indicate that they are the poorer thermal conductors. So in those cases where large current flow is anticipated, the conductors must be large enough in cross-section to carry the current without undue heating. As for thickness, polyimide 0.5 mil thick tears easily, so sheeting at least 1 mil thick is preferred. Mechanical, environmental and economic factors are important.

The most common conductors are 0.5-ounce (per square foot) and 1-oz annealed electroplated copper. Rolled copper should be avoided since it is more likely to be plagued with pinholes. Such holes, which may be 1 to 2 mils in diameter, are serious flaws in a conductor that may be no more than 3 mils wide—though they have been successfully combatted by plating the foil with a malleable plating such as 50 to 100 microinches of gold.

Conductor widths are limited to about four times the metal thickness because the etching process cannot develop a vertical wall but cuts the trapezoidal cross-section shown in Fig. 1—a phenomenon known as etch back. The upper width of the top of the trapezoid is the limiting dimension. For ½-oz copper (0.7 mil thick), 3-mil conductors on 6-mil centers are about the highest density that can be realized. Denser spacing would mean a higher likelihood of circuit failure due either to broken conductors or to lack of conductor separation. Attempts to use ¼-oz copper have not succeeded because this material is extremely fragile. Properties of common conductors are given in Table 2.

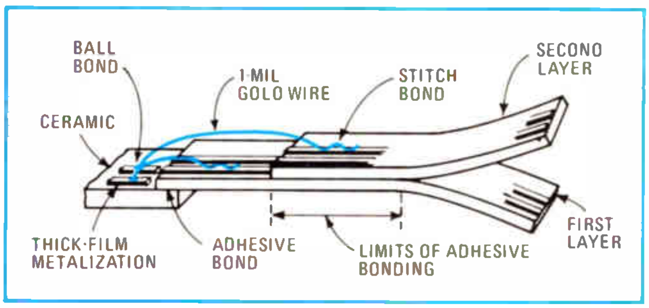
More than a single layer

To accommodate a really large number of interconnections and crossovers, multilayer-circuit construction can be used, but it should be remembered that its design and fabrication are quite costly. An important reason for selecting multilayer cables is to establish ground planes to reduce noise pick-up. Ground-plane foils may be interleaved between signal planes and will be effective for signal lines spaced 6 to 8 mils apart or less. These foils may also serve as attachment points for securing the cable along its path. (Of course, ground planes may also be added to a single-layer signal plane.)

There are several ways to bond multilayer cable together. The right choice will be dictated by cable thickness, required flexibility, and the interconnection geometry.

One way is to laminate two single-layer cables along their entire length, but this imposes severe demands on those assembling such a cable. A second technique is to attach conductors to two sides of a laminate. This transfers the accuracy demands back to the artwork phase, where it is more easily handled.

The need for a third technique arises where multilayer is required only at the interface, as shown in Fig. 3. Here a flexible circuit is connected to a flatpack integrated-circuit package, and bonding of the layers is con-



3. Multilayer interface. Flat two-layer flexible cable is laminated for a short distance immediately adjacent to the interface with the thick-film device. Then each layer breaks away as a single-layer circuit.

Wire-bonding flexible circuits

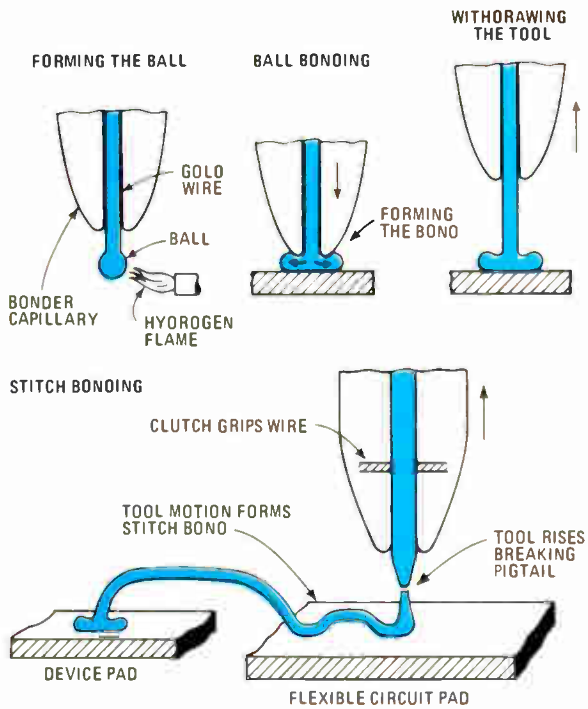
Thermocompression bonding, long used to bond IC chips to their packages, is also well suited to welding the short lengths of gold wire to the device lead at one end and the flexible circuit conductor at the other end. The tool that does the job is called a bonder capillary and is shaped in the form of a tapered nozzle. The wire is fed through the opening in the tip, and the tip walls deliver the force required to bond the wire to the mating surface or pad. The bonder capillary, which is heated to 250° to 350° C, applies a force of approximately 25 grams to the wire at the device end. However, at the flexible circuit end, about four times this force is required to achieve a satisfactory bond. As the wire deforms, spreading laterally, and the surface oxides break up, what were two separate metals weld together.

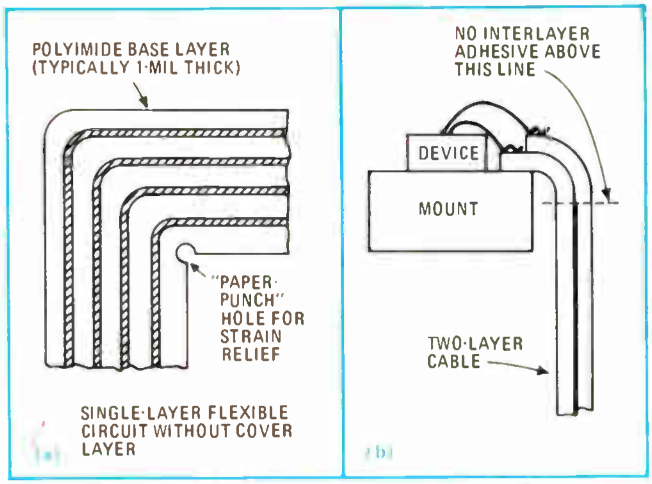
The steps in the bonding process are:

- A hydrogen flame sweeps through the end of the gold wire, and surface tension causes the molten metal to form a ball.
- The heated bonder capillary descends, bonds the ball to the device pad, and rises to its previous position, still feeding out gold wire.
- The bonder capillary, with a lateral sweep, is next positioned over the flexible-cable conductor pad, descends, and stitch-bonds the wire to the pad.
- A clutch grips the wire above the bonder capillary so that, when the bonding tip rises, it breaks off the pigtail.

The pressures required to ball-bond device leads to a flexible circuit are higher than are required to bond IC chips to their packages. For example, a 1-mil gold wire with a 3-mil ball requires about 100 grams. Pull strengths compare favorably to those obtained in IC device wire bonding.

For a discussion of wire-bonding techniques, refer to "Thick Film Hybrid Microcircuit Technology" by D. Hamer and J. Biggers, Wiley-Interscience, New York, 1972, pp. 202–222.





4. Corners. "Paper punch" holes in 1-mil polyimide film stress-relieve the corners so that tearing is prevented (a). If the multilayer laminates are left free of adhesive at the bend (b), layers can slide along their interface and thus bend without setting up high stresses ih either the adhesive or the fragile copper foil.

fined to the region where the interface occurs. Beyond this region the layers might run free from each other or at most be laminated with a more relaxed tolerance for the rest of the run.

A fourth way to make a multilayer cable is to use an adhesive to bond a second foil to the back of a single-layer circuit. The original thermocompression-bonded foil would be suitable for ball bonding, whereas the new foil would be suitable for soldering. The problem here is that when each side of a film is laminated, the final yield for the cable is the product of the yields of either side. So if the yield on each side is 10%, the yield for a complete two-side metalized flexible circuit is only 1%. However, if two single-layer circuits are processed independently and then laminated, the composite yield is an average (rather than a product) of the individual yields and hence is higher.

Rounding the bend

When a single-layer flexible circuit is installed, bending presents a problem, particularly when thin, 1-mil films are used, because the high, localized stress concentrations that develop at the corners are likely to cause the film to tear. It has been learned that punching out the corners—as can be done with a paper punch—relieves the stress concentration (Fig. 4a).

A comparable problem occurs in multilayer cables when a cable is bent as shown in Fig. 4b. If cement is applied to laminations and the cable is flexed, the cement is subjected to shear and the adhesion is often destroyed. Therefore, it's important to avoid applying adhesive in the region subjected to a bend.

Making the connection

Soldering and thermocompression bonding are two common techniques used to hard-wire the flexible circuits in place.

Soldering is eased if the foil is gold-plated, since gold plating does away with any need to flux the copper. (The drawback with flux is that connections must be cleaned carefully after being soldered to ensure that all

Property / Plastic film	Useful upper temperature and time	Melting point or zero strength temperature (°C)	Moisture absorption (%)	Tensile strength (psi)	Ultimate elongation (%)	Coefficient of thermal expansion (in./in./°F x 10^{-5})	Dissipation factor (1 kHz)	Dielectric constant (1 kHz)	Dielectric strength (V/mil @ 1 mil)	Yield (ft²/lb/mil)	Cost factor
Polyimide (Kapton)	450°C 5–30 min	800	4.0	25,000	70	2.0	0.003	3.5	7,000	136	17.0
Polyester (Mylar, Celanar)	Not available	250	<0.8	25,000	120	1.7	0.005	3.25	7,500	140	1.0
TFE (Teflon)	200°C 5–30 min	330	<0.01	4,000	350	6.8	0.0002	2.0	430	84	9.2
FEP (Teflon)	Not available	270	<0.01	3,000	300	5.4	0.0002	2.0	6,500	90	16.0
Polyamide (Nomex)	Not available	500	3.0	11,000	10	2.1 – 8.6	0.007	2.0	450	240	1.9
Polyvinyl fluoride (Tedlar)	Not available	300	<0.05	10,000 to 19,000	110 to 300	2.8	0.02	8.5 to 10.5	3,500	140	3.5

TABLE 1: PLASTICS FOR FLEXIBLE CIRCUITS

flux traces are removed.) A room-temperature plating solution that is slightly acid is most satisfactory for flexible circuits. An ac plating current, in the form of a nonsymmetrical square wave, is applied, and the cycling is set for a two-thirds throw (or plate) cycle and a one-third de-ionization cycle (which knocks off the bubbles). The plating rate is set at about 2 mils per hour. The adjustment procedure has been to advance the plating current until bubbles appear and then reduce the current to the point just below where bubbles disappear.

In thermocompression bonding, gold wire is used to bond the device leads to the flexible circuits. Both stitch bonds and ball bonds are used (see "Wire-bonding flexible circuits," p. 88).

As for the other end of the flexible circuit, both single- and multilayer types required a new connector pin because there was none to be had that would mate satisfactorily with the small and dense conductor geometry. So a pin was designed (Fig. 5a) that could connect a flexible-circuit conductor to a mating receptacle. Note the round head, which is 17 miles in diameter, and the shoulder. The rounding prevents the pin from piercing the thin polyimide film inadvertently. To accommodate the pin, a hole is made through the circuit and the pin is passed up through the polyimide base material so the film rests on the pin's shoulder. The hole in the cover layer is 35 mils in diameter, to provide adequate area for a solder fillet to form a sound connection, both mechanically and electrically.

When a multilayer flexible cable is to be terminated to connector pins, the end of the cable is formed in a staircase fashion (Fig. 5b). A soldered connection is made to the topmost foil on each step. The lower layers are drilled with oversize holes so that no electrical contact occurs. An alternate approach is to use plated-through holes to connect one or more layers at a time to a connector; but plating increases the likelihood of delamination and should be used only in those cases where the staircase technique cannot be employed.

To pass circuit connections through a hermetically sealed wall, hermetic feedthrough headers are often employed. If soldering is employed to connect flat flexible circuits to both sides of a header, then precautions should be taken so that soldering to one side does not loosen connections on the opposite side. A 50° C soldering temperature differential has proved workable, and the solder with the higher melting point should be employed on the side that is required to be the most permanent. A heat gun is a good way to desolder when design changes or repairs are required.

Laying out the circuit

The narrowness of both conductors and the spacings between conductors on flexible cable makes greater demands on the preparation of artwork than do the specifications for conventional printed circuits. Still, as with conventional printed circuits, flexible-circuit design begins with a layout of over-all geometry and lead place-

TABLE 2: METAL FOILS FOR FLEXIBLE CIRCUITS

Property / Metal foil	Specific gravity	Resistance (ohm/cm x 10^{-6})	Temperature coefficient of resistance (ohm/cm/°C)	Coefficient of thermal expansion (in./in./°F x 10^{-6})	Thermal conductivity (Btu/in./ft²/hr/°F)	Tensile strength (psi)	Elongation (%)	Modulus of elasticity (psi x 10^{6})	Thickness range (mil)	Yield (ft²/lb/mil)
Copper (rolled, annealed)	8.89	1.72	0.00393	9.2	2,720.0	34,000	20.0	17.0	0.7 – 14	22.0
Copper (electrodeposited)	8.94	1.77	0.00382	9.2	2,720.0	45,000	12.0	16.0	0.7 – 14	22.0
Aluminum	2.70	2.83	0.00390	13.1	1,080.0	12,000	18.0	10.6	1.0 – 20	71.2
Nickel (rolled)	8.90	9.50	0.00470	7.4	865.0	72,000	40.0	29.6	0.5 – 15	21.7
Steel	7.8	13 – 22	0.00160	8.4	324.0	44,000	36.0	29.0	1.5 – 10	25.0
Stainless steel	7.9	74	–	9.6	87.0	90,000	50.0	28.0	0.5 – 10	25.0

Design history of flexible circuit

Consider a design requirement for a cryogenically cooled sensor which will mount 100 silicon phototransistors in an array. Each device is 4 mils square, the array is to form a matrix on 6-mil centers, and the entire chip will measure 0.8 inch by 0.1 inch. To ensure low noise, the assembly must operate at −100° C and so it will be evacuated to avoid frost formation and to prevent heat loss due to convection.

To accommodate the system requirements, the image plane must be located at one end of a tube 4 inches long and 1 in. in diameter. A hermetic header is built at the opposite end with a 100-pin feedthrough, which serves as the interface to two 50-pin connectors mounted on an adjoining plate.

Once the rough package outlines are established, the termination techniques for connecting flexible cable to the header can be selected, and the over-all dimensions of the flexible circuit can be laid out. The feedthrough end of the flex circuit is called "the foot." The other end is bonded to a gold-plated Kovar mount to which the phototransistor chip has been attached with conductive epoxy.

A 0.25-in.-wide pad provides an adhesive seat on either side of the chip mount for attaching the flexible circuit. Since two rows of 50 devices, each requiring 50 emitter and 50 base leads on 3-mil centers are planned, two sets of three-layer circuits are assigned to either side of the mount.

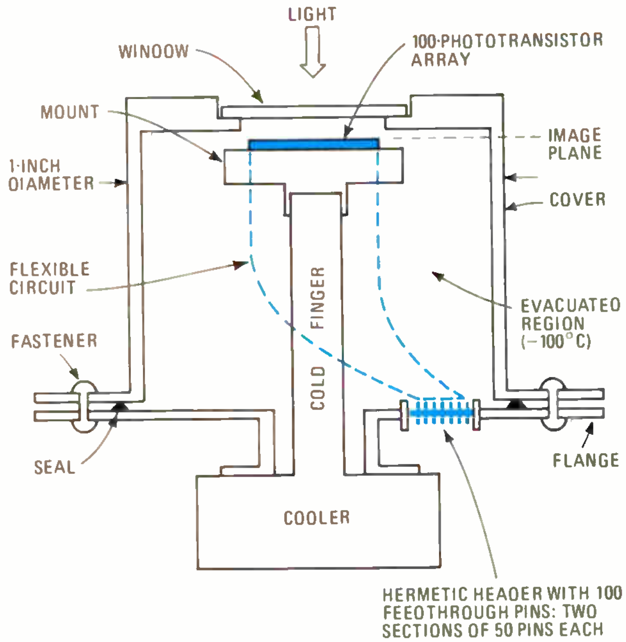
One layer is a solid ground plane for connecting the collector leads; it will be soldered face down at the mount and foot. The second and third layers comprise 3-mil-wide conductors on 6-mil centers for the emitter and base leads; these leads will be wire-bonded at the mount and soldered at the foot.

At this point the design should be far enough along for a wooden or aluminum dowel model to be constructed. This will aid design of the complex device and usefully supplement the more conventional engineering drawing techniques.

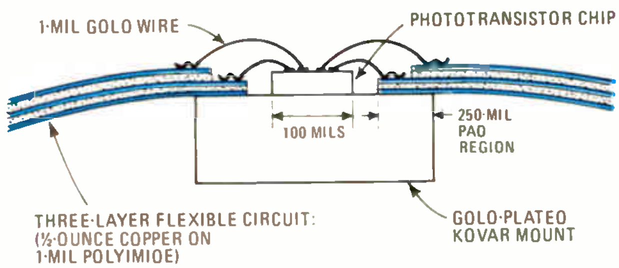
Thermal loads are apportioned to a 1-watt cryogenic cooler. The polyimide film is allotted 300 milliwatts. The system designer has established 5 ohms as the upper limit for lead resistance. Based on past experience, it is estimated that 0.5-oz/ft^2 copper (that is, 0.7-mil-thick copper) on 1-mil polyimide falls well within design requirements.

A conductor routing to the 100-pin feedthrough is then established for the two 50-pin sections, each of which comprises 10 rows and five columns of terminals spaced on 80-mil centers. The leads are made to enter the feedthrough tangent to the flange face, so that nine sets of five leads snake between the pins; the other set of five leads is attached from outside the pins. To fit the feedthrough, the cable leads have to converge and narrow. The ground foil is terminated short of the feedthrough on a stand-off and is soldered to a much smaller, eight-pin feedthrough.

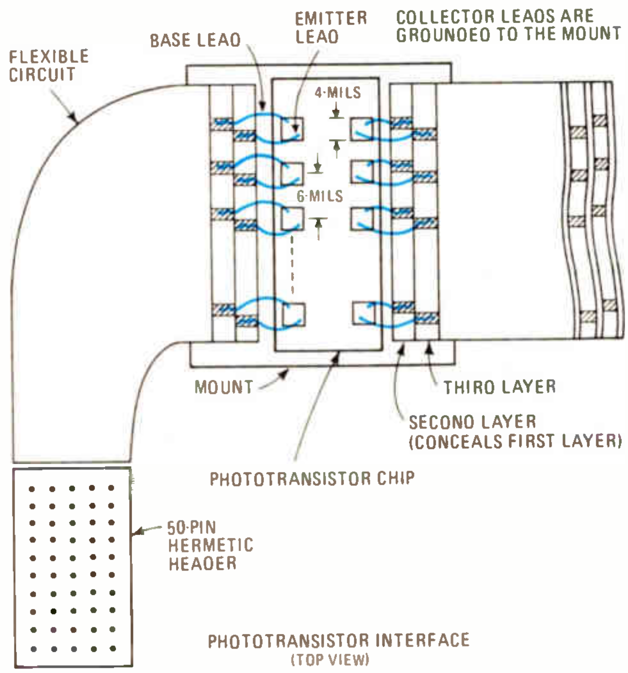
The cable patterns are programed for a photoplotter, but the program is test-run on a paper plotter. Once correct master artwork has been prepared, film base artwork is developed using the photoplotter. Sepias are generated and are submitted to the vendor. Samples are then purchased, and design deficiencies corrected. At the same time, prototype phototransistor arrays are being fabricated and tested in house.



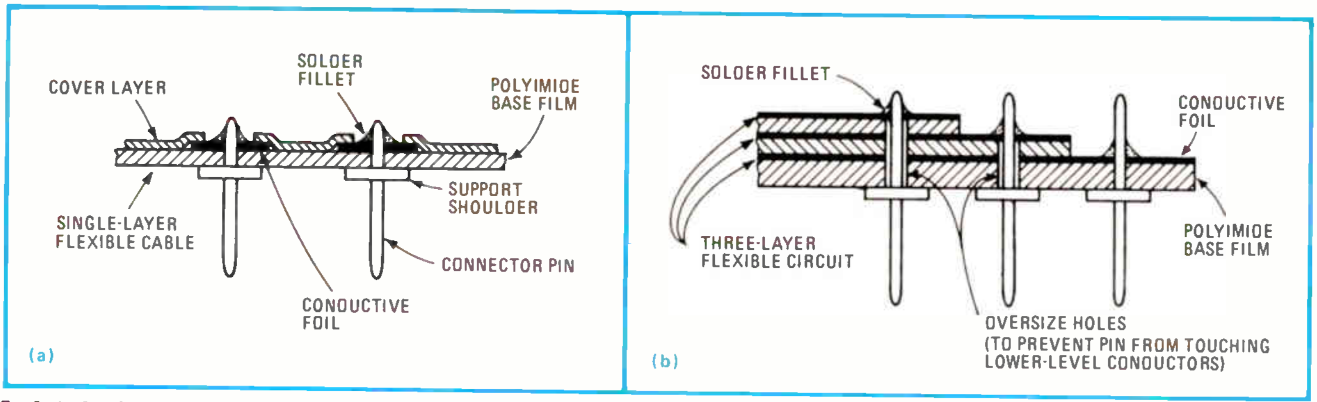
(SIDE VIEW)



PHOTOTRANSISTOR CHIP INTERFACE
(PROFILE VIEW)



PHOTOTRANSISTOR INTERFACE
(TOP VIEW)



5. Ant-sized connector. A round head on the pin prevents it from puncturing the flexible cable (a), and the shoulder provides a seat for the polyimide film (b). Pins pass through over-sized clearance holes in any lower layers, are soldered to the topmost foil.

ment. Masks may be created on vellum with black drawing ink, or a knife and a ruler may be used to cut away the red peelcoat film which is then removed from the clear film.

Alternately, a coordinatograph may be employed. This machine is designed for guiding a tool to cut along coordinate axes with a high degree of precision. The drawback with this machine is that numerical calculations for coordinates of all the turns must be determined. And any error on the peelcoat is intolerable because it is difficult or impossible to correct a peelcoat.

Computer-controlled pattern generators are the next best bet. They develop patterns using a building block approach, superimposing images photographically. However, although precision is 1 mil or better, the equipment is able to generate only right angles and sharp corners. This deficiency would be a severe limitation in artwork were it not taken up by photoplotters.

Photoplotters can step in increments as small as 1 mil and so can sweep an arc with any required radius of curvature. Also, a check plot may be made to verify the design prior to making the mask. A Gerber photoplotter is shown in Fig. 6. This machine employs a light pen to sweep circuit patterns from one point to another on a 48-by-60-inch bed on photographic plates as large as 30 by 40 inches. The drawings are generally four times actual size. Various apertures for frequently employed termination patterns may be selected by the user and exposed in a single-step fashion to generate required patterns on the photographic plate. □

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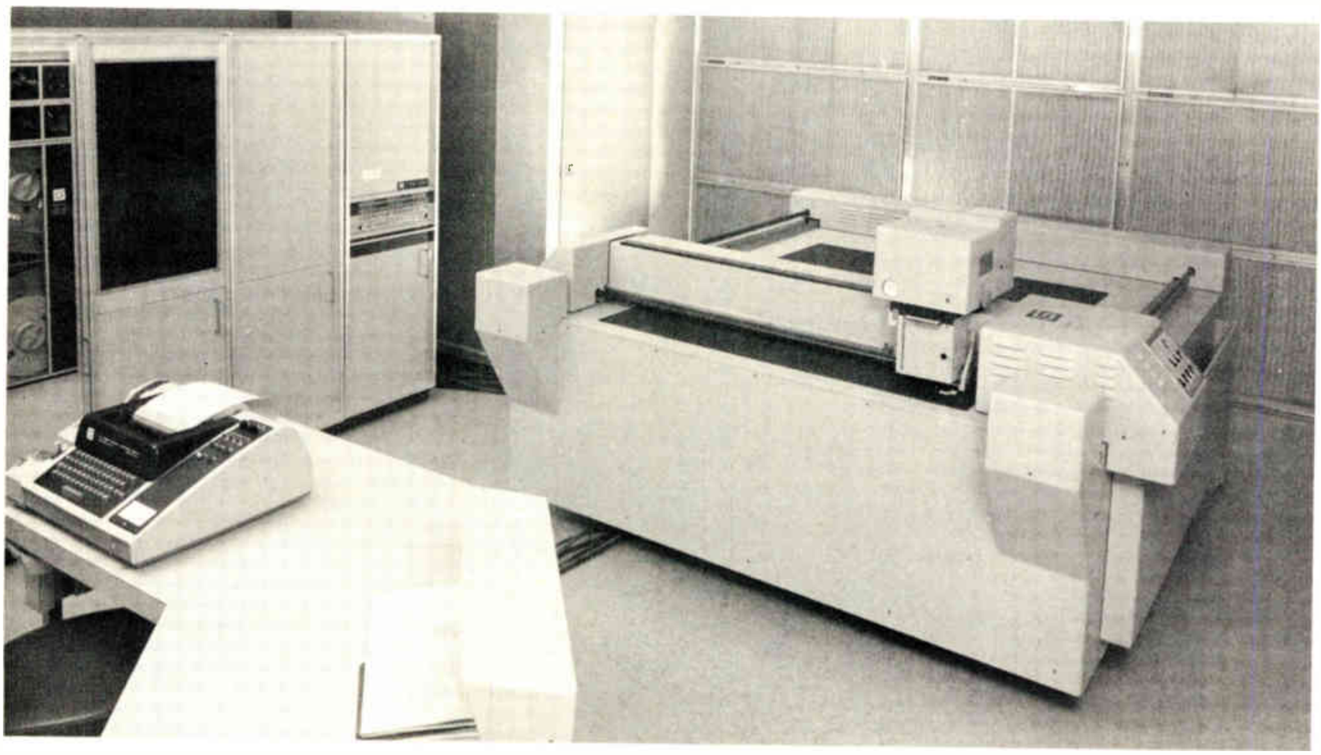
J.R. Perkins, "Selection of Materials for Use as Electrical Insulation," IEEE Trans. Elect. Ins., E16, 1971, pp. 106–110.

6. Photoplotter. A photoplotter, a familiar instrument in automated printed-circuit design, also fills the bill for flat, flexible circuitry. It is temperature-stabilized and kept meticulously clean. Teletype, paper tape, or magnetic tape may be used to control the sweep of the light pen.



More computation shortcuts with pocket calculators

by Lucinda Mattera
Circuit Design Editor

By the looks of our bulging mail sack, techniques for getting the most out of the four-function pocket calculator are now in vogue. We have received numerous letters proposing new ideas, as well as letters commenting on the calculator shortcuts we recently published in Engineer's notebook. We welcome this response and invite you to send us more suggestions for simplifying an engineering computation on the four-function calculator. If your idea is selected for publication, we'll pay you $50.

A better way to find square roots

The design idea that generated the most letters was "Three-step shortcut for finding square roots" by James R. Whitmore in our Feb. 15 issue. Each of Whitmore's steps consists of four mathematical operations: division, subtraction, division again, and addition. Many readers wrote to tell us the subtraction operation can be eliminated by simplifying the algorithm that Whitmore uses.

Let N represent the squared number and X_0 the initial estimate for the square root. The first approximation for the root, X_1, can then be written as:

$$X_1 = (N/X_0 - X_0)/2 + X_0$$

This is the algorithm used by Whitmore. It is "nothing more than a longer version of the old Newton approximation method for finding square roots," says one reader, Stephen B. Gray of Darien, Conn. The equation easily reduces to:

$$X_1 = (N/X_0 + X_0)/2$$

With this algorithm, only three mathematical operations—division, addition, and division again—are required to arrive at the first approximation. Additional approximations are just as easy to find:

$$X_2 = (N/X_1 + X_1)/2$$

where X_2 is the second approximation. In general, the technique can be summed up as:

- Divide N by approximation X_i to get number A.
- Add approximation X_i to number A to get number B.
- Divide number B by 2 get approximation X_{i+1}.

Since the three-operation method and the four-operation method are essentially the same, "the results will be the same," explains William W. Pfeifer from the Data Processing division of The National Cash Register Co., San Diego, Calif., "except perhaps a one-digit difference in the least significant digit, because a different number is truncated in the calculator."

Another reader, H. Orlo Hoadley of Rochester, N.Y., notes: "Many of the small four-function calculators store a constant that can be used only as a multiplier or as a divisor, depending on how the number is put into the machine. This makes it necessary to write down each successive value of the approximate root and then reenter it twice through the keyboard at each step after reentering the value of N."

However, if the calculator permits the use of the constant feature with all four functions, square roots can be extracted "to any degree of accuracy without having to write down any intermediate results," observes Thomas D. Price, Jr. of Saunderstown, R.I. "As each approximation is found, it can be stored in the constant register for use in the next approximation, and only the value of N need be reentered for each step."

Other readers that had similar comments include Ralph V. Anderson, Holton, Kans.; O.C. Barr, Naval Research Laboratory, Washington, D.C.; P. Chapouille, Honeywell Bull, Saint-Ouen, France; Fred F. Chellis, Cryogenic Technology, Inc., Waltham, Mass.; Mrs. C. Groenenboom-Eijgelaar, University of Nijmegen, Grave, Netherlands; Larry Hutchinson, Oregon State University, Corvallis, Ore.; R.H. Kaufmann, Kaufmann Engineering, Schenectady, N.Y.; Wayne L. Martin, Longmont, Colo.; William J. Travis, Sprague World Trade Corp., Ronse, Belgium; A. Weerheim, University of Waterloo, Waterloo, Ontario, Canada; Robert L. Zuelsdorf, WKOW-TV, Madison, Wis.

Extending the technique to nth roots

Several readers pointed out that the square-root algorithm is just a special case of Newton's general formula for any root:

$$N^{1/n} = [N/X^{n-1} + (n-1)X]/n$$

where N is the number, n is the root number, and X is the nth root. Daniel Chin of Cambridge Memories Inc., Newton, Mass., outlines a general procedure for solving this equation with successive approximations:

- Divide N by estimated X, (n – 1) times.
- Add X, (n – 1) times.
- Divide by n; result is new estimated root.
- Repeat for convergence of initial and final X values.

As an example, Chin solves for the cube root of 8, beginning with an estimated root value of 1.8. Only nine operations are needed:

1. 8/(1.8)(1.8) = 2.4691357
2. 2.4691357 + 2(1.8) = 6.0691357
3. 6.0691357/3 = 2.0230452 (first approximation)
4. 8/(2.0230452)(2.0230452) = 1.9546941
5. 1.9546941 + 2(2.0230452) = 6.0007845
6. 6.0007845/3 = 2.0002615 (second approximation)
7. 8/(2.0002615)(2.0002615) = 1.9994770
8. 1.9994770 + 2(2.0002615) = 6.0000000
9. 6.0000000/3 = 2.0000000 (answer)

Other readers that proposed variations of this technique include E.G. Burges, United States Air Force, San Antonio, Texas; Herbert Galman, Arga Controls, Pasadena, Calif.; Robert Grundalski, Bowmar/ALI Inc., Acton, Mass.; J.C. Kaelin, Zurich, Switzerland; Dick Sabroff, Sabroff Engineering Co., Greendale, Wis.; Philip E. Ziegler, Medford, Mass.

A different approach to solving the nth-root algorithm is suggested by Ralph A. Evans of Evans Associates, Durham, N.C. With his technique, the initial estimate can be even more arbitrary than it is with the previous method.

A slight change in notation is necessary. Let the first estimate be:

$X_{i+1} = N/X_i^{n-1}$

where X_i is the initial guess. Let the new estimate be:

$X_{i+2} = [(n-1)X_i + X_{i+1}]/n$

To use the algorithm, move the decimal point n places at a time until number N is between 1 and 10^n. Keep track of how many times this is done, and move the decimal point back that many times, one place at a time, for the final answer. For any value of number N, the number 10 can be used as an initial guess.

The algorithm for X_{i+2} always approaches a solution from above, while the one for X_{i+1} approaches from below. Until X_{i+1} is more than X_i, use X_{i+2} as the approximate average of X_i and X_{i+1}, regardless of the value of root n. The convergence will be much faster, even though averaging departs from the actual algorithm.

Evans illustrates his technique by finding the 5th root of 243. The answer can be computed to the eighth decimal place in eleven operations:

1. Try $X_i = 10$, since N is between 1 and 10^5
   $X_{i+1} = 243/10^4$, which is much too small
2. Try $X_i = 10/2 = 5$
3. $X_{i+1} = 243/(5)^4 = 0.4$, which is still less than X_i
4. Try $X_i = 5.4/2 = 2.7$
5. $X_{i+1} = 243/(2.7)^4 = 4.6$, which is larger than X_i
6. Now use the algorithm for X_{i+2}
   $X_{i+2} = [4(2.7) + 4.6]/5 = 3.16$
   which becomes the new X_i
7. $X_{i+1} = 243/(3.16)^4 = 2.43701$
8. $X_{i+2} = [4(3.16) + 2.43701]/5 = 3.0154$
   which becomes the new X_i
9. $X_{i+1} = 243/(3.0154)^4 = 2.9392$
10. $X_{i+2} = [4(3.0154) + 2.9392]/5 = 3.00016$
    which becomes the new X_i
11. $X_{i+1} = 243/(3.00016)^4 = 2.9993601 1$

The other calculator item in our Feb. 15 issue, "Using pocket calculators to square numbers directly" by Paul B. Wesling, also produced some suggestions for shortening squaring and power operations.

Squaring and finding powers

One reader, H. Peter Clamann, Harvard Medical School, Boston, Mass., shows how to square a number without using the constant key:

- Enter number to be squared.
- Press and release multiply key.
- Press and release add/equal key.

"The second and third steps," Clamann says, "will produce the square of whatever number happens to be on display. Thus, squaring can be an operation in a chain calculation. Repeating the second and third steps will generate, in order, the 4th, 8th, 16th, . . . power of the original number."

Peter M. Talbot, Kelvin Hughes, Division of Smiths Industries Inc., Woburn, Mass., proposes a way to raise a number to a power without unweildy manipulation of the constant key. "In most calculators," he notes, "the constant key is either self-locking when depressed, or it is a slide switch." To raise a number to a power:

- Press (activate) constant key.
- Enter number to be raised to power.
- Press multiply key.
- Press add/equal key once for each integer power above 1.

"The power to which the entered number is raised is (n + 1), where n is the number of times the add/equal key is depressed," says Talbot.

A word of caution

The number of steps required for calculator operations like squaring or taking the reciprocal depends to some extent on the brand of calculator being used. For instance, the constant register may not be available for all four functions, and the way to activate the constant register varies from make to make. If you send us any suggestions, please remember that there are many calculator brands, and to be useful, a good computation shortcut should be applicable to a number of them. □

COMPUTING ROOTS WITH SUCCESSIVE APPROXIMATIONS

SQUARE ROOT	n th ROOT
$X = N^{1/2}$	$X = N^{1/n}$
First approximation:	First approximation:
• $N / X_0 = A_0$ (Divide by initial guess)	• $N / (X_0)(X_0)(X_0)\ldots = A_0$ (Divide by initial guess, (n−1) times)
• $A_0 + X_0 = B_0$ (Add initial guess)	• $A_0 + (n-1)X_0 = B_0$ (Add initial guess, (n−1) times)
• $B_0 / 2 = \boxed{X_1}$ (Divide by 2)	• $B_0 / n = \boxed{X_1}$ (Divide by root number)
Second approximation:	Second approximation:
• $N / X_1 = A_1$ (Divide by first approximation)	• $N / (X_1)(X_1)(X_1)\ldots = A_1$ (Divide by first approximation, (n−1) times)
• $A_1 + X_1 = B_1$ (Add first approximation)	• $A_1 + (n-1)X_1 = B_1$ (Add first approximation, (n−1) times)
• $B_1 / 2 = \boxed{X_2}$ (Divide by 2)	• $B_1 / n = \boxed{X_2}$ (Divide by root number)

Versatile breadboard checks out designs quickly

by M.J. Salvati
Sony Corp. of America, Long Island City, N.Y.

At a cost of only around $25, a breadboard system can be put together that is both versatile and convenient to use. Nearly any type of component, including integrated circuits and discrete semiconductors, can be interconnected rapidly with ordinary hookup wire. And since the parts are not soldered and need no special adaptors, they remain undamaged and can be used again. The breadboard, of course, can be tailored to suit specific needs or outfitted with an adjustable power supply and different connectors for added flexibility.

The heart of the breadboard is its socket, which is manufactured by El Instruments, Inc. of Derby, Conn. (A similar socket, which is known as Superstrip, is available from AP Instruments in Painesville, Ohio.) Although relatively expensive—approximately $17 when ordered singly—the socket is well worth the investment.

It has 64 rows of plug-in contacts along its length. Each row contains two groups of contacts, one on either side of the socket's midpoint. There are five tie points for each contact group. Component leads, input and output wires, and test probes can be simply inserted into the desired tie point.

Dual in-line packages snap right into the socket because the contact spacing is the same as the pin spacing of the standard DIPs. Along its lengthwise edges, the socket has groups of parallel-connected contacts that serve as power and ground buses. Hookup wire and component leads can range from AWG #22 to #26.

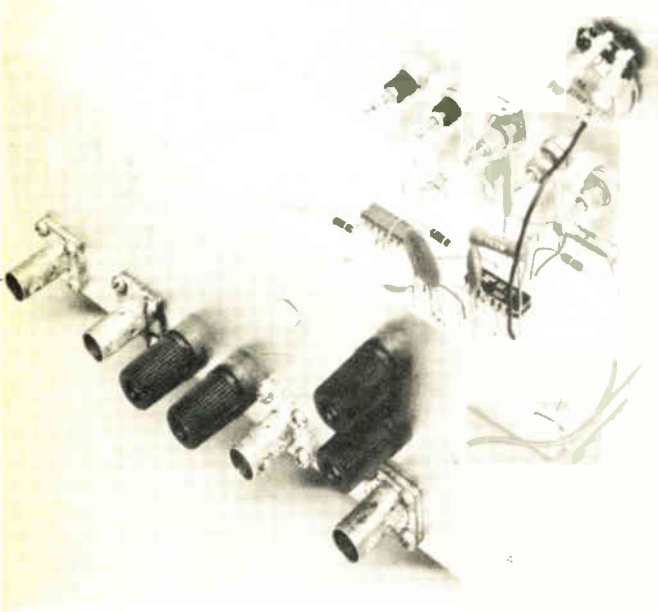
A basic version of the breadboard is depicted in Fig. 1, with a design for an oscilloscope sweep circuit already laid out. The socket is mounted in a minibox on a 3/32-inch-thick Lucite sheet. This increases the separation between the socket's contacts and the minibox so that the breadboard's capacitance to ground is reduced.

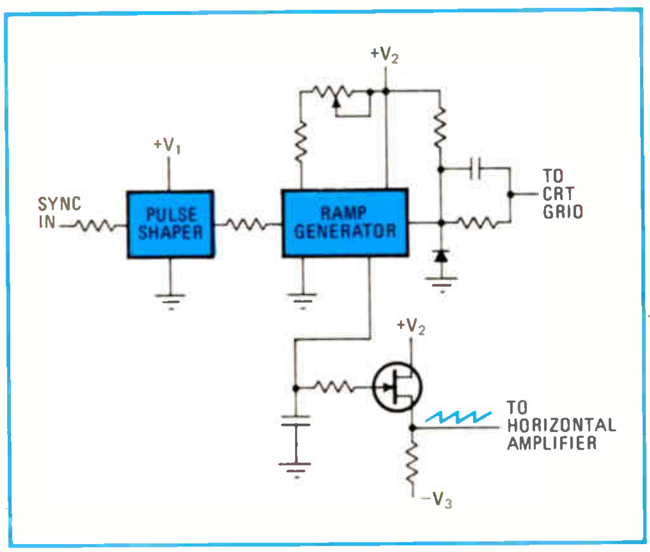
Since the minibox is made of two U-shaped pieces of aluminum that fit together as a closed box, it completely shields the circuit being checked and makes it easy to mount potentiometers, coils, and other components that are too large to be plugged directly into the socket. Connections to these components are made with 3-inch lengths of #22 wire having miniature alligator clips attached at one end.

Five binding posts on the back panel are provided for power input, and several sets of suitable input and output signal connectors are located on the front panel. Short lengths (2 to 3 inches) of #22 wire are soldered to the connectors for carrying the signal to and from the socket. With this arrangement, even many lead changes or jiggling will not upset the breadboarded circuit.

For the ultimate in breadboarding convenience, two miniboxes can be fastened together, and the lower minibox used to house one or more regulated power supplies, as shown in Fig. 2. This deluxe version, which costs about $75 to build, offers two sockets, a choice of supply voltage, and a meter for reading out the level of the supply voltage. It is built with a pair of miniboxes measuring 8 by 6 by 3½ inches and outfitted front and back with BNC connectors.

The breadboard has fixed positive and negative 5-volt supplies, as well as variable positive and negative supplies that can be adjusted from 9 to 18 v. (The schematic for these supplies is also shown in Fig. 2.) The terminals for the regulated voltages are located between the two sockets, and the meter can be switched between the two variable supplies. A slide switch at the bottom of the front panel allows the supplies to be set before they are applied to the breadboarded circuit.



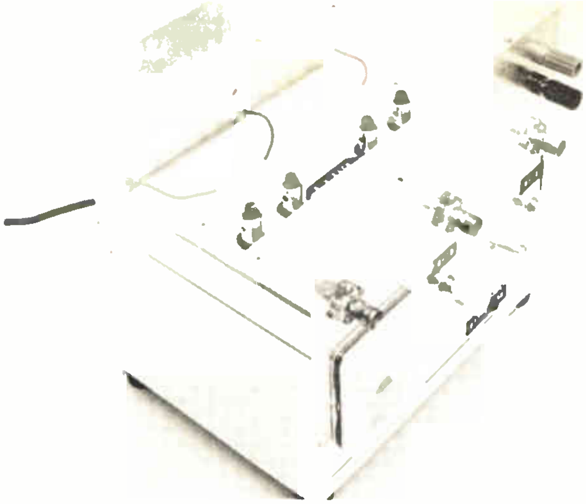


1. Basic breadboard. Oscilloscope sweep circuit (on right) can be rapidly laid out and tested with easy-to-use breadboard. Because components are plugged in, they can be used again. A circuit can be breadboarded almost as quickly as it can be drawn.

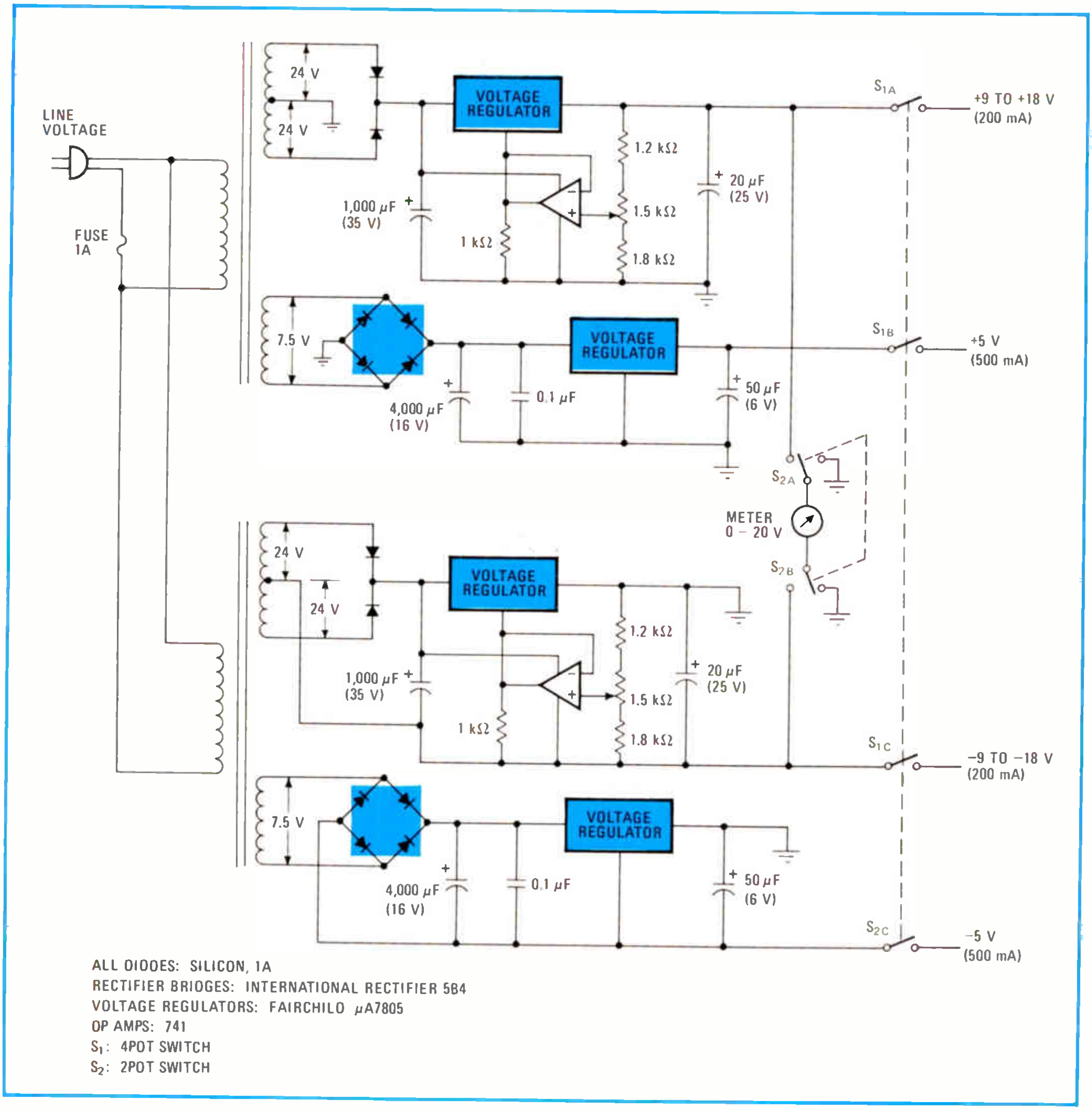
Fairchild's 7800-series voltage regulators are recommended for this application because they are compact, easy to use, and can handle almost all the power requirements needed by this type of breadboard. Moreover, the internal overload protection of the regulators is excellent for breadboard purposes.

Naturally, the number and nature of the regulated voltages should satisfy the user's most frequent requirements. Similarly, the type of input and output connectors, the size and location of the panel holes, and the number of sockets depend on specific needs. □

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.



2. Super breadboard. A choice of regulated supply voltages gives the breadboard additional flexibility. Here the supply circuit shown is housed in the bottom minibox. The supply provides fixed ±5-volt outputs and variable (from ±9 to ±18 v) outputs with a meter readout.



A FET can also serve as a resistor

If you've been thinking of field-effect transistors as useful only for amplifiers and switches, remember **they can make great voltage-controlled resistors as well.** This property stems from the fact that a FET's conductance in the active region is a linear function of the gate voltage, and it allows you to get, among other things, **a simple but effective potentiometer or voltage-divider attenuator.** Hook a protected FET across the input voltage to be divided; the gate voltage controls the FET's resistance, which like any potentiometer divides the voltage proportionally. Tougher applications can be gotten from Siliconix, Santa Clara, Calif., which produces 20-ohm to 4,000-ohm FETs.

Making the most of some delays . . .

Most of the time, the propagation delay and inherent capacitance of IC gates are working against you, but it's sometimes possible to make them work for you. For example, the time delays of up to several nanoseconds built into any TTL gate **could be used in certain equalizing networks or for pulse shaping or stretching.** And for some circuits, gate capacitance is large enough to be coupled with an external resistor to set a time constant for integrating or delaying a signal.

. . . and making the least of others

Working on a circuit design that requires a lot of passive components? Watch out, those ordinary **resistors, capacitors, inductors, and connectors seem to be getting scarce.** Some delivery times on big orders are reported at many months or more.

Getting the copper out

Here's an ecology tip that's also an economy tip. Some suppliers of etching material will **recycle the spent etchant to extract the copper** that's in it. At the going market rate of 1 cent an ounce for used copper, production managers can get **about $11 a drum** for the stuff. Some suppliers will even come and get it—for instance, MacDermid Inc., Waterbury, Conn., will, if you call Dick Wickat (203) 754-6161.

More displays to the rescue

If, like everybody else in the calculator business, you're having trouble getting hold of numeric panel displays in quantity, there's relief on the way. Sperry Information Displays, Scottsdale, Ariz. is about to introduce **an alternate to the popular Panaplex panels** made famous by Burroughs. Sperry's new display, a nine-digit unit with ¼-inch-high characters, has a decimal with each digit. Like all gas-discharge panels, it comes in natural, or in red with filters. Price will be $15.70 in 1,000-lots.

That data bank on power transistors

Motorola has expanded its computerized data bank service on power transistors [*Electronics*, Jan. 4, p. 110]. List your transistor requirements on your terminal, and you'll get a list of parts meeting your specs. **Or supply any silicon 2N part number, and you'll get a standard replacement.** Or write in COST, and they'll relay the price of any standard Motorola power transistor. CHAIN gets a sequence of rf power transistors for building an amplifier specified to frequency, supply voltage, modulation, and output power. Mel Kowal, at (602) 273-6508, has all the codes.

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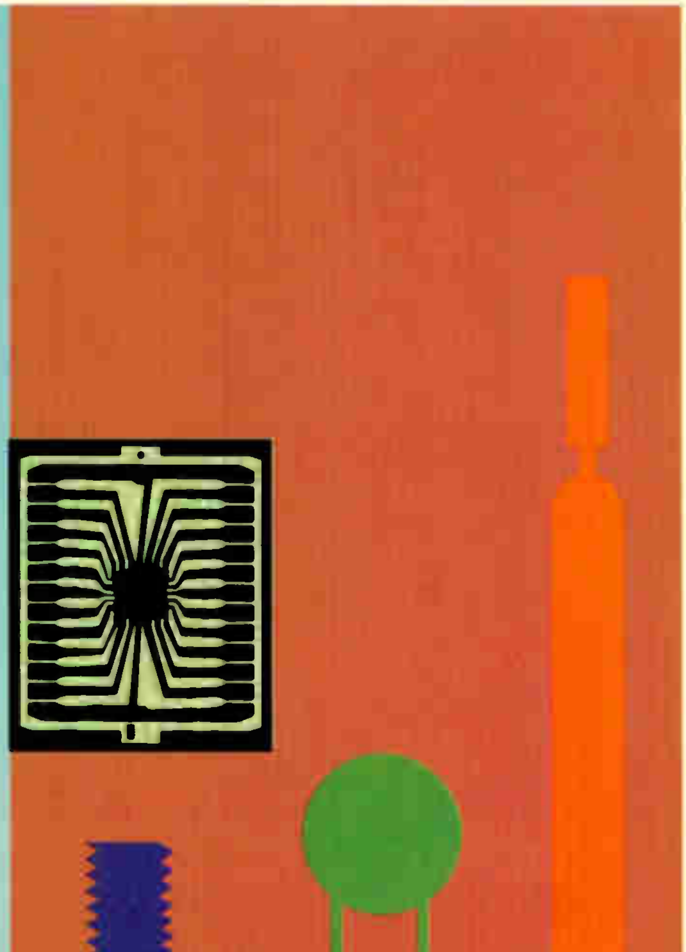
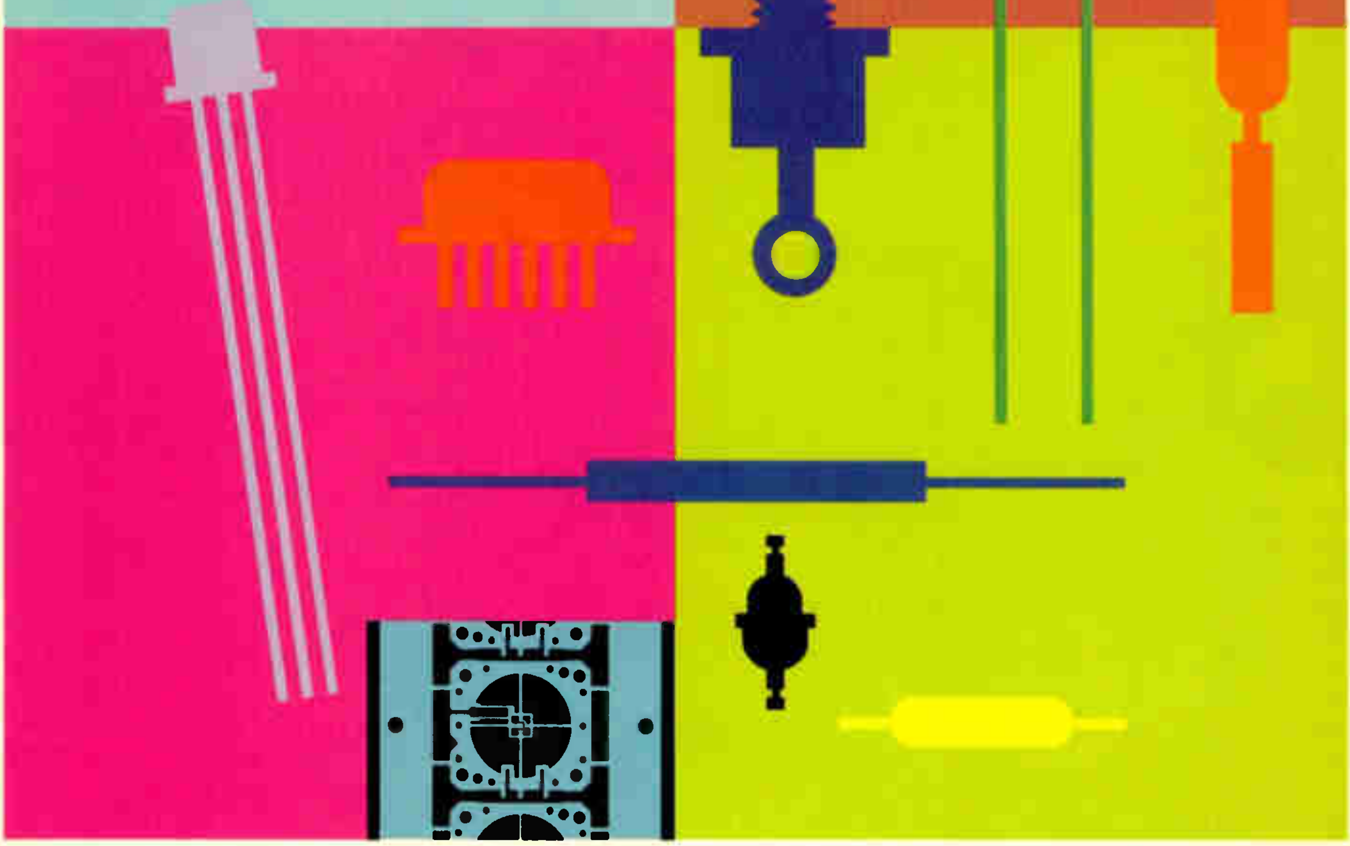




Phase-angle voltmeter is digital

Programable instrument does away with slow, manual nulling techniques; it permits measurements by unskilled personnel or by a computer

by Michael J. Riezenman, Instrumentation Editor

Phase-angle voltmeters have clearly established their value in the design and testing of components, instruments, and systems that handle or operate on ac signals. Avionics and naval navigation systems, precision transformers, ac amplifiers, and resolver/synchro-control systems are just a few areas in which the PAV's ability to make precise measurements of phase angle, in-phase voltage, quadrature voltage, fundamental voltage, and total voltage have made it a standard tool for both production and field use.

Until now, however, the phase-angle voltmeter has suffered from a drawback whose seriousness depends upon the application of the instrument. The manually operated analog instrument uses a nulling technique to measure phase angle, and the implications of this are threefold: making a measurement is a time-consuming chore that requires the attention of a fairly knowledgeable technician, automated testing is impossible, and accuracy is limited by nonlinearities in the calibrated phase-shifter used for phase-angle measurements.

Variable control. Now, North Atlantic Industries has developed a digital phase-angle voltmeter—a fully programable instrument that shows all four voltages and phase angle on a 4½-digit display. With the exception of a variable control for dialing in an arbitrary offset-phase angle, the instrument's controls consist of push buttons.

Called the Model 225, the digital meter will have a single-unit price in the range of $3,450 to $4,500, depending upon options. The options include autoranging, front-panel offset control, up to four switch-selectable frequencies (each with a bandwidth of 5%), and fixed-frequency (transformer) or wideband (active) input-isolating circuits.

A lower-cost unit, the model 220, is also being introduced at IEEE Intercon 73. This unit, a stripped-down 225, will sell for from $2,950 to $3,500, depending on options. It is not programable, does not provide BCD outputs, and does not measure phase angle.

Both units can handle a maximum voltage input of 500 v rms and have five additional ranges down to 10 mv full-scale. Maximum voltage-measuring error is 0.1% of full scale on any range. Resolution on the 10-mv scale is 10μv, making the meters useful as phase-sensitive null detectors.

In measuring phase angle, the instrument has a maximum error of 0.2° ± half a least significant digit. This figure can be reduced to 0.13° by measuring the in-phase and quadrature voltages, computing the tangent of the phase angle, and looking up the angle in a trig table. The angle-measuring resolution is 0.1°. Both voltmeters will be ready for delivery in June.

North Atlantic Industries Inc., 200 Terminal Dr., Plainview, N.Y. 11803 [338]

Programable. Phase-angle voltmeter's controls consists almost entirely of push buttons. Only exception is a reference-angle offset dial.

Components

Touch switch works remotely

Module can be actuated over long cables by touching any conductive object

Touch-operable switches are not new—they are in elevator banks in many buildings. But Magic Dot's new solid-state switch modules can be actuated by touching any remotely located conductive object. The switches can control signals over long cables because they include input-noise-rejection circuitry.

Designed for specialized applications such as talk-listen bars on intercoms, enlarged panic switchplates for machine control of photo labs, and hand-held medical and dental probes, the 300 series can also function in extremely hostile environments because the electronic part of the switches can be remotely located, says Magic Dot vice president Willis A. Larson.

Packaged in an eight-pin DIP, the switch module can be mounted on a printed-circuit board in the chassis or elsewhere, and connection is made to the remote object—a brass plate, metal ring, or conductive plastic or foam—through a pair of twisted wires, one of which connects to the conductive object, while the other goes to ground. Circuit closure is made when a person touches the conductive object. Since the switch's output is a bipolar transistor, the switch is directly compatible with TTL circuits.

Unlike the company's recently introduced 200 series of touch-operable switches, which can be removed 6 to 8 inches from the activating plate, "the new line has the ability to reject noise and therefore can operate up to 1,000 feet away," Larson says. "We sense the amount of noise in reference to the input signal and cancel that noise. Input-current levels are down in the 20- to 50-nanoampere range."

There are six leads on the 300-series switch—one for the positive dc supply voltage, another for the negative dc supply, a third for 3-to-150-volts ac at 1 microampere, the two input twisted-pair wires, and the output lead. With the dc supply secondary grounded, the input sensitivity of the switch can be varied by increasing or decreasing the ac voltage, or by changing the value of an external resistor. With the dc supply secondary floating with respect to ground, no ac voltage is required—and that lead can be connected to either the positive or negative side of the dc supply.

Price of the switch is $15.

Magic Dot Inc., 40 Washington Ave. So., Minneapolis, Minn. 55401 [341]

Flame-proof resistor also withstands 1,000 V

Ruggedness is a key feature of a new flame-proof resistor introduced this week by the Sprague Electric Co. at the IEEE Intercon show. A Sprague spokesman says the wire-wound resistors have to be built for ruggedness because they are being aimed at applications where reliability cannot be sacrificed, particularly where flameouts can occur.

The units are being aimed principally at the electronic data-processing market, but there are applications also in the telecommunications industry. The resistors can be helpful anywhere that a user can't afford a burnout, and according to Sprague, standard silicone-coated resistors, which they can replace, may occasionally flame out, especially if the resistor outgases.

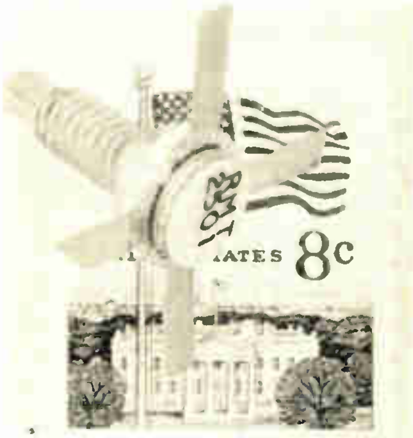
The resistors are ceramic-insulated, and the company claims that they will not ignite, even in the flame of an oxyacetelyne torch. Covered by a proprietary coating, the units will withstand 1,000 volts ac on voltage-block tests. The devices are also resistant to standard industrial cleaning solvents and fungus. In addition, they meet humidity and other specifications of MIL-R-26.

The resistors are available for 1 to 10 watts of power, and maximum resistance at 10 w is from 1 to 60,000 ohms. Size ranges from 1/8-inch diameter by 3/8 in. at 1 w to 5/16-in. diameter by 1¾ in. at 10 w. Standard resistance is 5%, but units are available with this specification as close as 1%. Two models are available, the 330E with standard wiring, and the model 400E, which has noninductive wiring. Price has not yet been determined, but quantity figures are expected to be issued by the company in the near future.

Sprague Electric Co., 35 Marshal St., North Adams, Mass. [342]

Ceramic thermoelectric module heats and cools

A ceramic thermoelectric module that both heats and cools also uses metalized plates to provide good



thermal transfer with maximum electrical isolation. Operating characteristics include a maximum current of 8.5 amperes, a nominal voltage of 3.5 v dc, a maximum operating temperature of 100°C, and maximum temperature change of 60°C.

Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. 02138 [343]

Resistors have temperature coefficient to 7,000 ppm/°C

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Circle 101 on reader service card

538°C. The units can be furnished to any coefficient of temperature sensitivity from -0.01%/°C to 0.7%/°C, the last spec being offered by chemically pure nickel resistors. The units are available with over 50 different alloys, including platinum. Price is from 29 cents to $2.

Arcidy Associates, 370 Commercial St., Manchester, N.H. 03101 [344]

Two miniature rotary switches are combined on one shaft

To satisfy requirements of manufacturers who find panel space at a minimum, two miniature rotary switches are combined into a single concentric shaft switch. A 1-3/8-inch-diameter switch with 12 or 24 positions is combined with a ½-inch-

diameter switch of six, 10, or 12 positions.

RCL Electronics Inc., 700 South 21st St., Irvington, N.J. 07111 [345]

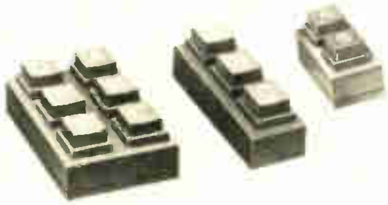
Switch operates sequentially over three positions

The model B5300 push-button switch has three positions in a single housing and operates sequentially. The first or normal position is available as a NO or NC contact. Depressing the push button makes the second position after 0.070-inch travel. Continuation of the push-button travel for 0.060 inch breaks the second circuit and makes the third circuit. Both positions provide operation via positive detents. The second and third switch positions are available with NO or NC contacts. Quantity price is about $3.

Control Switch Inc., 1420 Delmar Dr., Folcroft, Pa. 19032 [346]

Push-button switch inserts directly into pc board

Miniature one-, two-, three- or six-button switches can be combined in an array that maintains the same distance between the button centers. The modules can be inserted directly into a pc board, and size approximates the standard push-but-

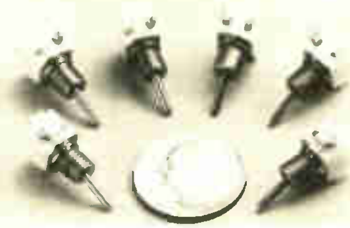


ton telephone configuration. Anything from a single-pole single-throw to a four-pole single-throw configuration is available under each button. Circuitry can be the same throughout the module or different for each button, and custom legends are offered. A 1-button, single-pole, single-throw switch is priced at 75 cents in lots of 100.

Grayhill Inc., Box 373, 561 Hillgrove Ave., LaGrange, Ill. 60525 [347]

Toggle switch provides wide frequency range

The Giga-Switch is a subminiature toggle switch offered in two models: the 254TXM, a double-pole double-throw unit, and the 254TM, a modified double-pole double-throw type with a shorting strap across two terminals. The units measure 0.400 by 0.325 by 0.350 inch. Frequency



range of the Teflon body and actuator unit is dc to 1 GHz and above. Life is 100,000 cycles. Price ranges from $3 to $5.50 depending on quantity.

Kay Elemetrics Corp., 12 Maple Ave., Pine Brook, N.J. 07058 [348]

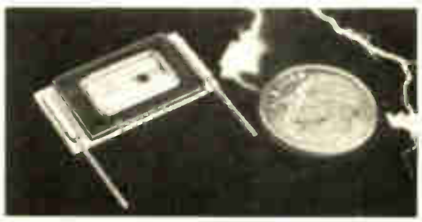
Capacitors have coefficient of +25(±10) ppm/°C

A silicon-dioxide chip capacitor offers a positive temperature coefficient of +25(±10) ppm/°C over the range of -55° to +125°C. Dissipation factor is 0.2% at 1 kHz, and rated working voltage is 20 V dc. Two geometries are available: single electrode and five electrodes. Single-electrode models have values from 15 pF to 180 pF with tolerances of 10% and 20%. The five-electrode model provides five binarily weighted values of capacitance from 1 pF to 64 pF with a tolerance of 20%. Price in 100-lots ranges from 64 to 72 cents.

Hybrex, a division of Burr-Brown, International Airport Industrial Park, Tucson, Ariz. 85706 [349]

Micro-arrester protects high-frequency circuits

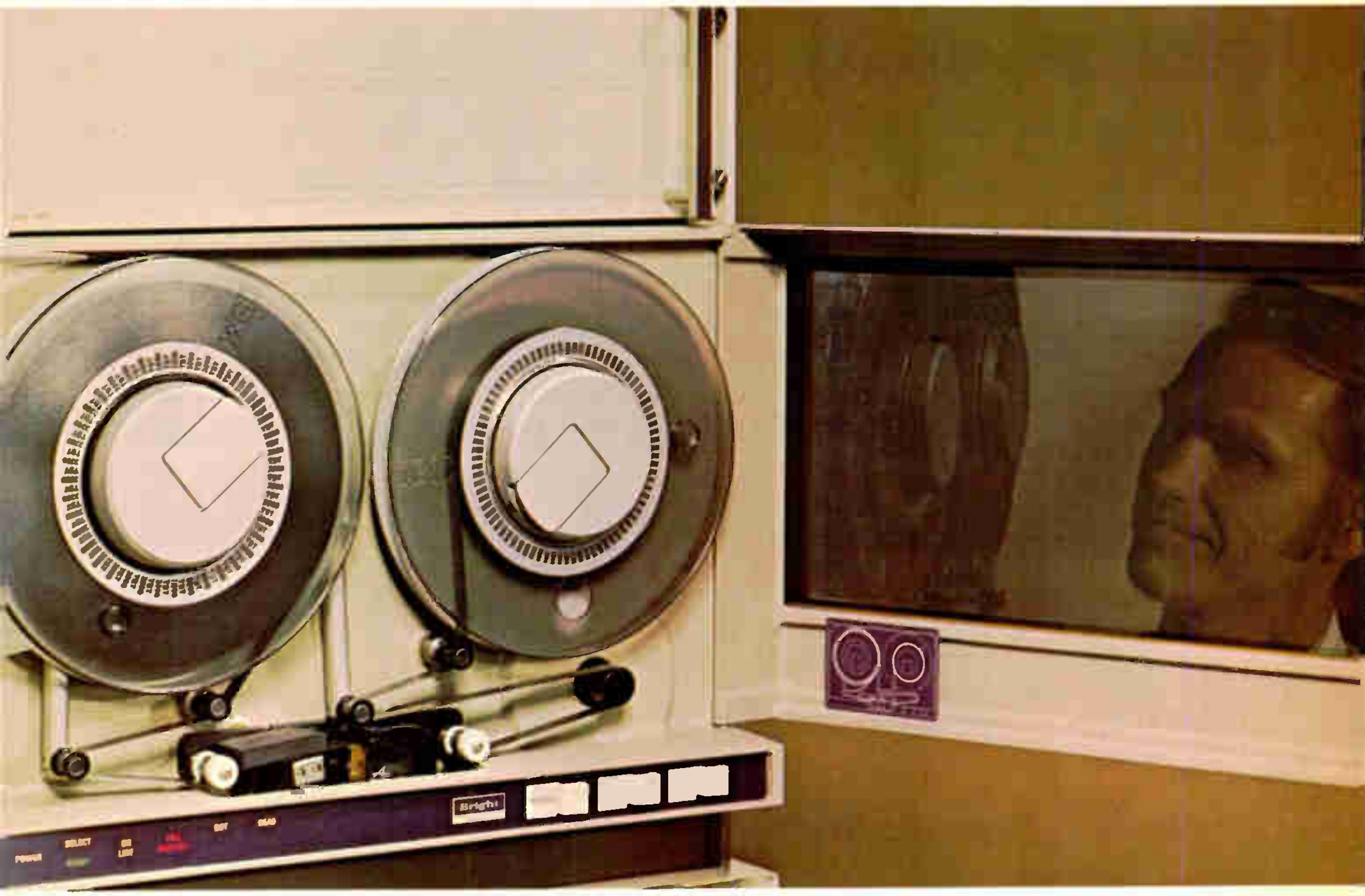
A micro-arrester, which protects high-frequency circuits from damage by high-voltage pulses caused by transients and lightning, is de-



signed to edge-mount on a minimum of board area. The units use cermet construction, and a sealed glass cover permits periodic inspection of the spark gap. The arrester is capable of withstanding 20 pulses of 1,000 amperes peak. Price in 100-lots is $1.99.

Dale Electronics Inc., Box 609, Columbus, Neb. 68601 [350]

The moment you open the dust cover, you sense it.



Look closer. The cover frame is cast of solid aluminum. So is the deck panel.

No wonder they fit together perfectly—like the door of a well-made car.

Bright tape decks may be the most solidly built tape decks in the world.

The use of cast aluminum is not frivolous. It provides a perfectly rigid base for the tape guides and the capstan motor. A base that is mounted at only three points so it can't be stressed.

Construction like this means that the tape drive can't come out of alignment—the tape always runs true, and tedious adjustments are simply not necessary.

You can buy Bright tape decks in either 8½ or 10½ inch models configured to suit your needs. Anything from the bare necessities to fully buffered electronics and internal formatting. You can even get an interface.

Tape speed is 12 to 45 ips, bi-directional. Packing density is 200, 556, or 800 bpi on 7 tracks or 800 or 1600 bpi on 9 tracks. Interface is by TTL/DTL logic.

For a tape deck like this, you would expect to pay a premium. And you do, about 10%. But you get what you pay for—a tape deck that is truly impressive in your system.

More information is available. Contact Bright Industries, 686 West Maude Avenue, Sunnyvale, California 94086. (408) 735-9868.

Bright INDUSTRIES INC.
A Subsidiary of Data Disc, Inc.

Circle 103 on reader service card

Instruments

Plug-in analyzer easy to operate

Spectrum unit spans 100 kHz to 1.5 GHz, has over 70-dB dynamic range

The virtues of spectrum analyzers are many and well known. What is also well known is that they can be tricky instruments to operate. Pick the wrong combination of i-f bandwidth and sweep speed, for example, and much of the resolution that the instrument is capable of is thrown away. Overload the input, and the display screen may show a lot more frequency components than are present at the input port.

Hewlett-Packard's latest answer to this problem is its model 8558B spectrum analyzer plug-in module for the company's 180-series of oscilloscopes. For most measurements, only three controls on the instrument need to be used. This not only speeds and simplifies the measurement procedure, but it also greatly reduces the probability of making an erroneous measurement by missetting the analyzer's controls.

The three key controls used for most measurements are: tuning, frequency span, and reference level. The tuning control sets either the start- or center-frequency of the display and causes it to be indicated on a 3½-digit LED readout. The frequency span control sets the width of the frequency aperture to be viewed. In the automatic mode of operation, setting the frequency span also results in the selection of the optimum combination of resolution bandwidth and sweep time. The reference level control directly calibrates the display in absolute power units in the range of −115 dBm to +30 dBm.

To minimize the probability of false readings or damage from overloading the analyzer's front end, the instrument indicates both optimum and maximum input levels for any chosen amplitude control setting.

While ease of operation was emphasized in the analyzer's design, it is definitely a laboratory-quality instrument. It has a ±1-dB frequency response over its full operating range of 0.1 to 1,500 MHz, and a dynamic range in excess of 70 dB.

Cost is another plus factor. The 8558B carries a price tag of $3,350 by itself, and the desirable model 182A large-screen oscilloscope mainframe costs $950. So a complete analyzer is priced at $4,300.

Initial deliveries to customers are expected to begin in April.

Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif. 94304 [351]

Five-digit voltmeter costs less than $1,000

The model 5000 voltmeter is a five-digit instrument priced at $995. Two features of the unit are: delayed dual-slope integration and internal auto-zero without kickback. The former feature reduces noise and increases linearity, making 100% overrange possible, as well as the reduction of bouncing digits. There are five dc ranges covering from 1 microvolt through 1,000 V, and autoranging is offered on all functions. Better than 1,000 V dc and 1,000 V rms can be applied to all dc and ac ranges without damage.

Dana Laboratories, 2401 Campus Dr., Irvine, Calif. 92664 [352]

Equivalent series resistance meter resolves to 1 milliohm

The model 273 meter is an instrument that reads the equivalent series resistance of capacitors and resistors at 100 kHz. The unit can resolve down to 1 milliohm for capacitors greater than 0.5 μF. Two other ranges allow higher resistance measurements on smaller capacitors. The model 2743 is self-balancing and operates on a four-wire principle so that it may be used with up to 25 feet of cable between the instrument and the test jig. The 2½-digit decimal display has BCD output available to drive printers or external circuitry. Accuracy is to within ±2% of the reading, ±3 digits, within 0.5 seconds of applying the capacitor or resistor to the instrument's terminals. Price is $735.

Clarke-Hess Communications Research Corp., 43 W. 16th St., New York, N.Y. [353]

Sweeper plug-ins cover 0.5 to 18.5 GHz

The series 6200 rf plug-ins are dual-band, sequentially swept units. They eliminate switching between drawers or manual switching of oscillators in a drawer to obtain two-band

coverage. Three plug-ins cover the frequency range from 0.5 to 18.5 gigahertz, and three plug-ins cover from 2 to 18.5 GHz. The model 6211 covers 500 MHz to 2 GHz, the model 6219 covers 2 to 8 GHz and the model 6229 covers 8 to 18.5 GHz. Price ranges from $2,250 to $4,950 depending on model.

Wiltron Co., 930 E. Meadow Dr., Palo Alto, Calif. 94303 [354]

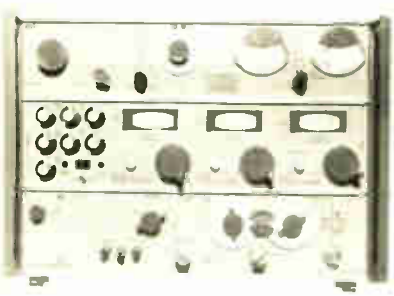
Instrumentation amplifier combines three modes

A triple-mode instrumentation amplifier is a combination differential dc amplifier, isolated-charge amplifier, and ac-voltage amplifier in one package. The dc mode features a gain of 1 to 3,300, and gain error is held to 0.1%. The model 7350 incorporates ±10 V at ±100 mA output with output-level controls. Price is from $665.

Dynamics Electronic Products, 12117 E. Slauson Ave., Santa Fe Springs, Calif. 90670 [357]

Signal generator includes digital synchronizer

A high-stability variant of the fm-signal generator 2006, called the 2006/1, incorporates a digital synchronizer to provide a frequency stability of two parts in 10^7. The



technique, combined with the generation of the carrier signal at a fundamental frequency produces stable test signals of high spectral purity. Using a separate or built-in counter for accurate frequency setting is eliminated because frequency readout is displayed in seven digits on the synchronizer module. The carrier frequency range covers from 10 to 500 megahertz. Price is $6,590.

Marconi Instruments, 111 Cedar Lane, Englewood, N.J. 07631 [355]

Converter allows dc meter to measure true rms

In addition to allowing any dc meter to measure true rms, a converter can increase the sensitivity, frequency response, and accuracy of any multimeter or digital voltmeter. The

unit features error of 0.3%, a bandwidth to 500 KHz, and its own input ranging amplifier of 1 mV to 140 mV. Price is $198.

UFAD Corp., Box 96, Ada, Michigan 49301 [359]

Power-line-disturbance monitors operate remotely

A family of three power-line-disturbance monitors simultaneously detect, count, categorize, time, and record overvoltages, undervoltages, fast transients, and frequency variations on single-phase or three-phase power lines. Designated the 3200 series, the instruments provide audio/visual alarms and hard-copy printout that indicates day, hour and minute, plus a code digit correlated with the specific power anomaly noted. This permits unattended

remote applications.

Programed Power Inc., 141 Jefferson Dr., Menlo Park, Calif. 94025 [358]

Digital multimeter offers 90-day accuracy to 0.01% dc

Providing a four-digit readout, the model 4700A digital multimeter offers five dc ranges, four ac ranges, and six ohm ranges, with isolated BCD output, and remote programing. The unit maintains accuracy to 0.01% dc accuracy for 90 days. The choice of autoranging or manual selection of range is provided in every function. Price is $1,095.

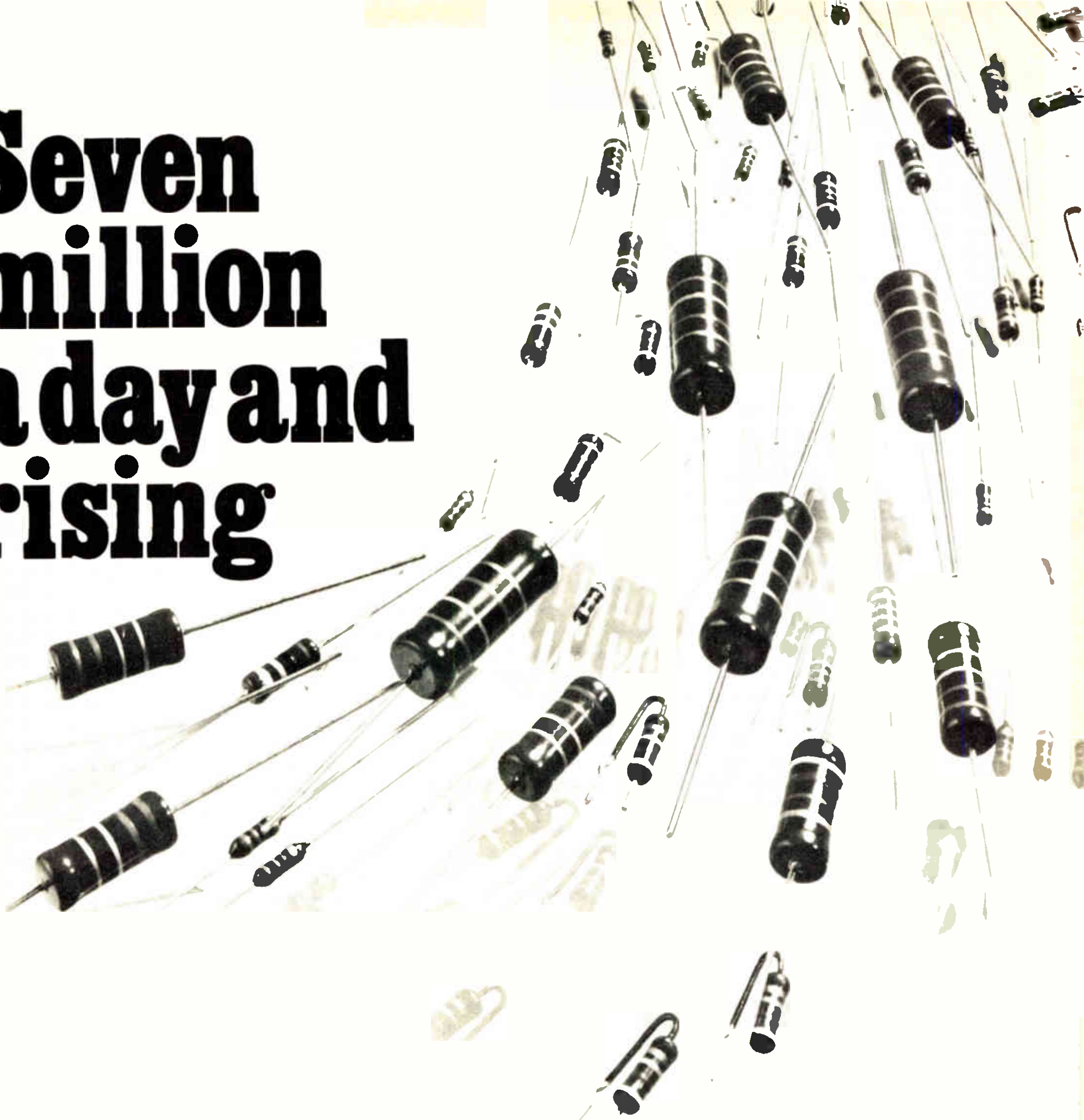
Dana Laboratories Inc., 2401 Campus Dr., Irvine, Calif. 92664 [356]

Printer plugs into digital multimeters

A printer is designed to plug into and print out the digital measurements of most 4½-digit multimeters. The DMMP-7be prints on two successive lines: on the first line a three-digit index automatically sequences every print command, and on the second line the unit of measurement is printed according to the setting of the coupled digital multimeter, together with the actual measurement made and displayed. Price is $645.

Practical Automation Inc., Trap Falls Rd., Shelton, Conn. 06484 [360]

Seven million a day and rising



Which is why Piher is a giant in the field of carbon film resistors. That's the company's *daily* production figure to meet world demand.
Our work in ceramics has taken us to the forefront of this high technology field – a prerequisite in carbon film resistor manufacture. When added to Piher design capability this helps explain why users can now have the benefits of *quality* carbon film *at low cost*.
Piher have the largest variety of quality preformed components available anywhere.
We manufacture a full range of wattages, from ⅛ to 2 watts, and they are available in every type of packaging configuration – including bandeliers and reeled. The resistors are ideal for high density packaging and every one is coated with 5 layers of specially formulated lacquer to ensure maximum environmental protection.
Where close tolerances, long term drift, shelf life and minimum noise parameters are critical, you need Piher carbon film resistors.
Use the magazine's reader card – or contact Piher – for detailed technical data.

Find out more about us, it pays.

U.S.A. – Piher International Corp. 1239 Rand Road, Des Plaines, Illinois 60016, U.S.A. Tel: 312-297 1560 Telex 282154

Germany – Piher International GmbH, 85 Nuremberg, Westtor graben, 5. Germany. Tel: 0911 260 469 Telex 623354

U.K. – Piher International Ltd., Romar House, The Causeway, Staines, Middlesex, England. Tel: Staines 56157. Telex 934167

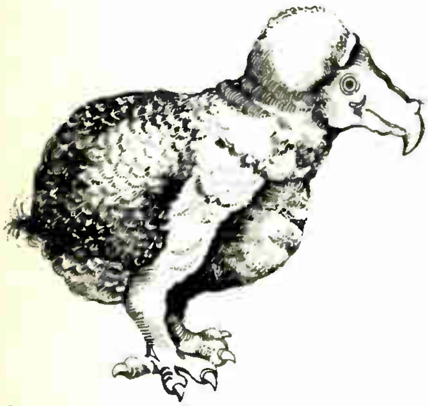
France – Piher International SARL, 83 Rue Etienne Dolet, 94230 Cachan, France. Tel: 656 26 07. Telex 27107

Italy – Piher International S.P.A. Via Cenisio 34, 20154 Milan, Italy. Tel: 314532/316213.

Head Office – Spain – Riere Cañado, s/n. Apartado de Correos 53 Badalona (Barcelona), Spain. Tel: 389 03 00. Telex 59521

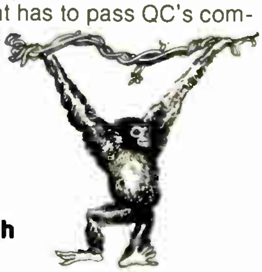
PIHER

Evolution and the function generator



Lessons from the Dodo
IEC, in building its high-quality, low-cost Series 30 Function Generator, learned from the mistakes of others. (Yes, the industry has had its Dodos.) We knew that only a strong, highly reliable unit would survive, so we developed our compact, hard-working 0.3Hz-3Mhz Series 30 accordingly.

Performance and quality are built into the unit right from the beginning. Interstate Electronics Corporation's independent QC lab puts every Series 30 semiconductor through a rigorous performance test before production acceptance. Then, after Unit Testing, Calibration, Burn-In, and Stress Cycling, each instrument ticketed for shipment has to pass QC's computerized Assurance Test before it goes to our customer.

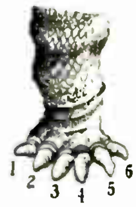


Monkeying with Ontogeny
The Unit Test is the first evaluation to identify and correct operative problems in the working instrument. Each of Series 30's versatile outputs, including variable Width Pulse, Sweep Sawtooth, Adjustable D-C Level, and Sine, Square, and Triangle waveforms are scrutinized for pure, consistent performance up to 20V p-p. In addition, our direct-reading Sweep Limit, 40-db Calibrated Attenuator, and other controls are handled for "feel" as well as accuracy.

During Calibration, Trigger, Gate, Burst, and Sweep Modes are given full play. By such critical inspections, we learn more about the instruments we make, and the product species as a whole is improved.

IEC actually over-calibrates to reach an exceptional quality of performance. While we spec a respectable 0.3% sine distortion, our generators typically achieve 0.18%.

Loss of the Sixth Toe
As part of the stress Cycle, we developed a "Shake 'n Bake" test that jolted and jarred Series 30 prototypes, then operated them in a 70°C. heat chamber. We still burn-in each Series 30 generator, but after extensive Unit Tests without a vibration failure, the "shake" cycle was declared obsolete.

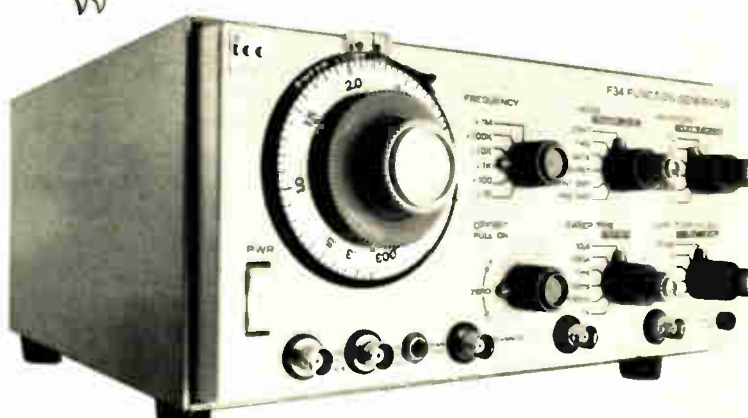


Mutation Elimination
We don't produce to MIL-SPECS, but our procedures are amazingly close to it. During four in-process inspections, a QC team checks everything from each solder joint to screw mounts, rejecting the slightest imperfections. We expect each Series 30 unit to evolve exactly as specified, with absolutely no mutations.

Survival of the Fittest
After calibration, the Series 30 generator undergoes a minimum 120-hour "mileage" test. We turn each instrument on and off at irregular intervals during this stress cycling to simulate real-world strain, and our exclusive Output Limit Indicator glows to confirm that the Generator is operating under stress.

Following this, all instruments are processed by a final automated lab system. At this point the Function Generator *must* continue to perform precisely, with an exacting degree of conformity and predictability. Only by surpassing the highest standards of the species does the Series 30 survive in the field, and enjoy the lowest return in the industry.

We're ready to back up our claims. Go ahead . . . call John Norburg, collect, at (714) 772-2811, and ask for a demo!



F34 . . . $495

5 Other Models available in Series 30 From $295 to $695

IEC INTERSTATE ELECTRONICS CORPORATION
a subsidiary of A-T-O Inc.
Dept. 7000, Box 3117, Anaheim, Calif. 92803.
TWX 714-776-0280 TELEX 655443 & 655419

Circle 108 on reader service card

Communications

Video corrector is automated

On-line instrument for TV broadcasters processes color signal

One of the key products that Tektronix Inc., Beaverton, Ore. introduced this week at the National Association of Broadcasters Conference in Washington, D.C., was a video processing unit that automatically corrects color television signals for anomalies produced when recording or transmitting the signals. According to Bill Kelly, chief engineer at New York station WNEW, this is the first automatic corrector and should prove to be an important instrument in television stations.

The model 1440 automatic video corrector operates on-line, making use of vertical interval reference signals (VIRS) which are encoded and attached to color video signals when they are produced. The unit automatically corrects for video gain, chrominance-to-luminance-gain ratio, setup level, burst phase relative to chroma (hue), burst gain, and sync gain.

Video gain is controlled by the 50 IRE level of the VIRS. Chrominance-to-luminance-gain ratio and burst phase are controlled by the amplitude and phase of the VIRS chrominance, respectively. Setup level is controlled by the 7.5 IRE level of the VIRS. Sync and burst gains are controlled respective to their standard amplitudes.

The 1440 may be remotely set to a manual operating mode, with all corrections remotely controlled. If a VIRS is not present, the 1440 will automatically switch to manual operation. If burst is not present, but a VIRS is, the burst phase and burst gain will automatically go to preset operation.

Outputs are provided so that the amount of correction may be monitored. The instrument is intended for rackmount installation and, in the event of power failure, or the actuation of a remote bypass switch, or the removal of the 1440 from the rack, a relay routes the program signal in such a way that program line continuity is maintained.

Price of the video corrector is $2,450. It will be available in the third quarter of 1973.

Tektronix Inc., P.O. Box 500, Beaverton, Ore. 97005 [401]

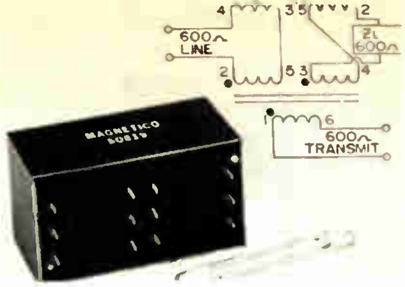
Facsimile recorder, scanner is modular, handles 10 grays

The model 731 facsimile recorder and the model 741 scanner can handle 10 shades of gray and is said to be eight times faster than otherwise comparable units from other manufacturers. The unit is modular and can be used with most fast communications systems and document transmitters, such as cable, microwave or laser, to permit graphic communications within and between plants, infrared and ultrasonic scan systems, TV monitoring and copying, and police identification by photo, fingerprint and voice-print transmission. Paper supply in a single loading is 8½ in. by up to 500 feet.

Hathaway Industries, A Hathaway Instruments Inc., Co., Box 45381, Southeast Sta., Tulsa, Okla. 74145 [405]

Transformers turn four-wire terminal to two-wire path

Designed to meet telephone company requirements for data and voice access, the model 50819 transformer contains a hybrid pair for converting a four-wire terminal into a two-wire voice path or the reverse. Frequency response over the range of 300 to 3,500 Hz is ±½ dB, over levels −45 dBm to +7 dBm. Longitudinal balance is 45 dB minimum and return loss 26 dB minimum. The trans-hybrid loss exceeds 50 dB, and the impedance match is within ±10%. Price is $12 each for orders



exceeding 1,000 units.

Magnetico, 6 Richter Ct., E. Northport, N.Y. 11731 [404]

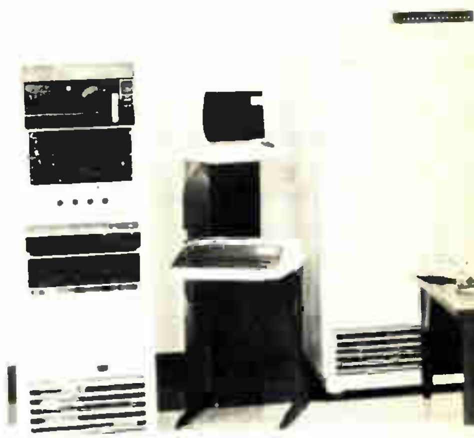
Termination sets connect toll circuits, office trunks

A four-wire termination set for common-carrier telephone companies connects toll circuits with two-wire office trunks and subscriber loops. The set incorporates front-panel and switchable balanced send and receive attenuators. An 11-foot-6-inch rack can hold 360 sets. Diodes on the send side of the four-wire sets provide surge protection, and strappable line build-out networks and front-panel switchable balanced send and receive pads are offered.

Communications Systems Div., General Electric Co., Section P., Box 4197, Lynchburg, Va. 24502 [406]

Communications unit offers direct and remote operation

An audio-data communications system designated ADC1000 provides audio messages in response to input from Touch-Tone telephones or pads and simultaneously handles a number of low-speed teleprinters and high-speed CRT display terminals. The unit operates as a direct replacement for IBM 7770 model 3 audio-response units, as a front-end

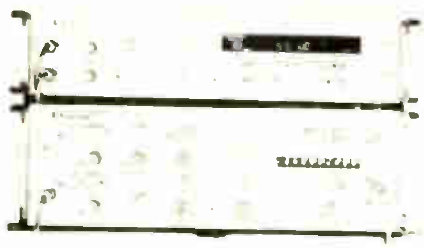


telecommunications subsystem connected to an always-on computer, and as a stand-alone system using magnetic-tape or disk storage for data logging, file inquiry, and other applications. Price starts at $50,000.

Wavetek Data Communications, Box 651, San Diego, Calif. [407]

Test set generates data at rates to 150 megabits/s

A system for measuring bit error rates evaluates the performance of high-speed digital systems. The unit can generate data and detect errors at rates of up to 150 megabits per second and is particularly suited to testing equipment and systems that use pulse-code modulation.



Designated the 3760A/3761A, the test set's range and flexibility allow it to test such items as computer memories, disk stores, digital recorders, and high-speed logic circuits. The bit-error-rate test system costs about $8,100; the data generator alone, $4,295.

Hewlett-Packard Company, 1501 Page Mill Rd., Palo Alto, Calif. 94304 [408]

PCM encoder tester can operate from bit synchronizer

The model ECO-2 checkout unit for pulse-code-modulation encoders is a miniature, stored-format, frame and subframe demultiplexer and word selector that operates directly from a PCM encoder or from a bit synchronizer. The unit offers four switchable formats, data rates from 1 bit to 5 megabits per second, decimal thumbwheel selection of any word from the frame or subframe, and switchable input impedance, TTL or C-MOS, accepting codes compatible with IRIG 106-71. Also featured in the new encoder checkout unit are parity checking and subframe synchronization. Price is under $3,200, with 60 days delivery.

Coded Communications Corp., 1620 Linda Vista Dr., San Marcos, Calif. 92069 [409]

Semiconductors

Quad switches have low drift

High performance credited to novel IC layout, special attention to thermal tail

Built for use in current-summing digital-to-analog converters, the ULS/N-2140 series of quad current switches has about half the temperature drift, double the relative accuracy, half the nonlinearity, and much faster settling time than competing devices, according to its designers at Sprague Electric Co. Much of the claimed improvement is due to novel IC layout, revised thinking about the use of current sources, and special attention to a phenomenon—called thermal tail—that is the curse of monolithic-switch designers.

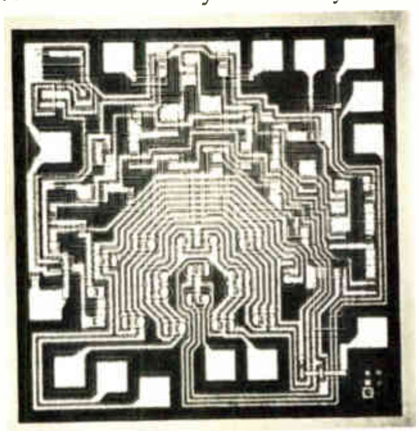
Any time a transistor is turned on or off in response to its digital input, heat is dissipated, or a small heat sink is created. Depending on how the switching transistors are laid out on the chip, the thermal profile of an operating switch can look chaotic, and so can the switch's output. Linearity, absolute error, and monotonicity of the eventual converter all can suffer because of potentially differing electrical characteristics over the chip face, which can take from milliseconds to seconds to settle out.

Sprague IC design engineers have shortened the thermal tail by placing a continually running current source near the transistor switch for the most significant bit. Transistors for bits of lesser significance are arrayed around this center, with those for the least significant bits outermost in a series of rings. Thus, the MSB transistor is in a miniature monolithic oven, and so to a lesser degree are the transistors surrounding it; as the MSB transistor changes state, the thermal effect of this switching radiates outward to affect the other switches, doing this in an evenhanded way.

With such a layout, Sprague lays claim to a 200-nanosecond settling time, indicating a very stubby thermal tail. Maximum nonlinearity is specified at ±0.01% at most; maximum nonlinearity with change in temperature is pegged by the company at one part per million per degree centigrade.

Thus, while aimed at the active 10-bit-DAC market, the 2140 series in many ways could be comfortable in 12-bit applications.

The constantly running current source approach also allows something which may be unique among monolithic switches of this type. The 2140 can work well with the most accurate resistors available—wirewounds. Normally, wirewound resistors can't be placed in the binary scale of R-2R ladder networks used in DACs because of their inductance problems with fluctuating magnetic fields and back emf—each of which destroys accuracy. But



since the current source within the 2140 always is on, there are no magnetic fields to collapse and generate unwanted pulses.

Sprague also has used what may be a novel collector-switching approach. Switching is accomplished at quite uniform bit-to-bit impedances and times, permitting less glitching as the switch transits from one bit state to the next.

Finally, output leakage has been cut by a circuit design that prevents the relatively large leakage of the current-source transistors from appearing at the 2140's output when the switch is in the off state. Typical leakage is about 30–40 picoamperes, a figure said to be about 10 times better than that available from competitors.

Since it takes three such switch chips to build a 12-bit or 10-bit converter, Sprague is pricing the devices by the set. In 100-unit lots, a set costs about $6. Delivery is from stock, and for hybrid manufacturers, Sprague is inviting orders for unpackaged chips. Militarized versions also are available.

The Sprague Electric Co., 114 Northwest Cutoff, Worcester, Mass. 01606 [411]

Linear IC arrays include super betas, npn/pnp units

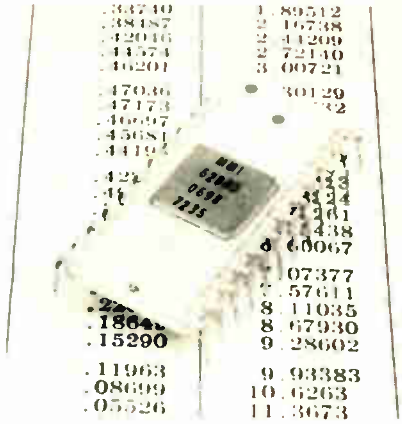
A super beta array and two npn/pnp arrays are designated CA3095E, and CA3096E and CA3096AE respectively. The super beta array, which consists of a super beta differential cascode amplifier and three independent, general-purpose, high-voltage npn transistors, offers operation to 10 MHz. The npn/pnp arrays consist of five independent devices—two pnp and three npn transistors on a common monolithic substrate with separate connections for each transistor. The difference between these types is that the CA3096AE has a matched npn transistor pair. Price ranges from $1 to $3.15 in 100 to 999 lots, depending on type.

RCA Solid State Division, Box 3200, Somerville, N.J. 08876 [414]

Bipolar ROMs offer 8,192 bits of storage

A read-only memory with 8,192-bit storage is designed for applications such as microprograming, arithmetic functions, logic functions, and character generators. Access time for the model MM5280/6280 is 150 nanoseconds maximum, and power dissipation is 50 μW per bit. The unit offers fully decoded on-chip address decoding and is DTL/TTL compatible with 1/10 of standard TTL input load and open collector output. The ROM is organized in a 1,024-by-

New products



eight-bit format. Price is $55 in 100-lots.

Monolithic Memories Inc., 1165 East Arques Ave., Sunnyvale, Calif. 94086 [415]

MOS 2,048-bit shift register provides 10-megahertz rate

A 2,048-bit multiplexed, dynamic shift register is designed to provide a 10-MHz shifting rate over −55° to +125°C. The model HDSR 2048 is structured as a dual 1,024-bit unit but is also available as a single 1,024-bit unit (HDSR 1024), a dual 512-bit unit (HDSR 1025), and a quad 256-bit unit (HDSR 1026). Input can be directly driven by MOS, TTL, or DTL integrated circuits. Both bipolar and MOS circuits can be driven by the output stages. Power dissipation is typically 300 mW at 25°C for 10 MHz with 50% duty cycle clocks per 1,024 bits. Price is $36 in 100-lots.

Hughes Microelectronic Products Division, 500 Superior Ave., Newport Beach, Calif. 92663 [418]

Tuning varactor diodes offer low leakage

A series of glass-packaged silicon tuning varactor diodes offers typical leakage currents of 20 nanoamperes at 25°C and 500 nanoamperes at 150°C. The capacitance/temperature coefficient is as low as 200 ppm/°C. Three reverse voltage breakdown series are available: 45, 60, or 120 V. In the 45-V and 60-V series, diodes have total capacitance ranges at 0 V bias of any value between 2 and 44 picofarads. In the 120-V series they have ranges from 5 to 36 pF.

Varian Solid State East, Salem Rd., Beverly, Mass. [416]

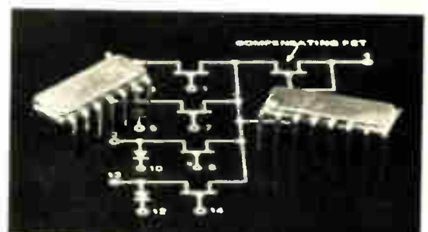
SCRs have built-in gate trigger current amplification

Measuring two inches or 50.8 millimeters in diameter, type T920 thyristors have built-in amplification of the gate trigger current. This simplifies, and in some cases eliminates, drive circuitry used for firing. Di/dt rating is 800 amperes/microsecond. The gate consists of a pilot SCR that is built into the main SCR by photomasking techniques and amplifies the gate trigger current to fire the larger SCR. Prices range from $92 to $400 per 100 pieces depending on current and voltage requirements.

Westinghouse Electric Corp., Semiconductor Division, Youngwood, Pa. 15697 [417]

FET analog gates offer on-resistance under 150 Ω

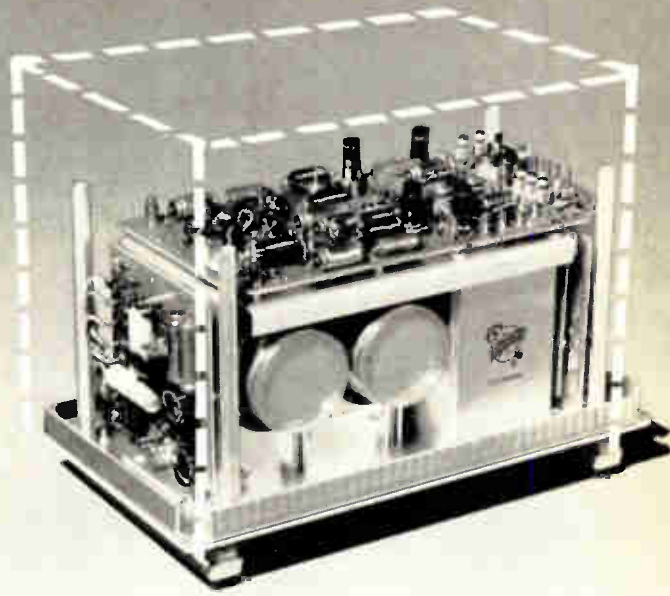
A series of FET analog gates designated the IH5009 series offers on-resistance of less than 150 ohms. The on-resistances are matched to within 5 ohms for critical applications, and the units include an ex-



tra FET for temperature compensation of the feedback resistance. The gates are intended for shunt or summing-point-switching of signals up to ±15 V or for series-switching of signals under 200 millivolts. In 100-lots, the units cost $1 per switch point.

Teledyne Crystalonics, 147 Sherman St., Cambridge, Mass. [419]

Imagination and Stackpole ferrites can cut a power supply down to size



Tektronix, Inc. uses Ceramag® ferrite materials to achieve efficiency and significant savings.

Conventional power supplies are bulky, heavy and inefficient. Tektronix, Inc. changed all that. With ferrites and a fresh idea.

By rectifying line voltage, converting it to 25kHz and rectifying it again, Tektronix, Inc. engineers produced a power supply that was 50% lighter, over 25% smaller and consumed ⅓ less power. And the overall operating efficiency of 70% is a big improvement over the 50% typical of conventional power supplies.

Ferrites can offer the unique advantages, design freedoms and electronic characteristics that produce exciting new ideas. Stackpole Ceramag ferrites were used throughout the power supply design. Because Stackpole has a wide variety of materials and configurations, designers can unleash their imaginations.

Ceramag 24B

Tektronix, Inc. selected 24B for their "U" and "E" cores. This proven material has seen years of service in flybacks for television. Ideal for power applications, it can be operated at higher frequencies than laminated steel. It is cool running, due to low losses under power conditions and controlled power permeability. Tooling is available for a wide range of "U", "E" and "I" configurations.

Ceramag 24

Toroids of Ceramag 24 were used by Tektronix, Inc. for transformer cores. Again, this is a proven material, widely used by the computer industry for pulse transformer cores. It has a tightly controlled initial permeability, and tooling for a variety of sizes is also available.

Ceramag 7D and 27A

Multiple material selection for coil forms allowed Tektronix, Inc. maximum flexibility and design freedom. Proper inductance values could be achieved in the allotted amount of room. In addition, the high resistance of 7D

material prevents accidental shorting on printed circuit boards.

Great new designs happen when you *start* with the idea of ferrites. Particularly Stackpole Ceramag ferrite components. Why? Because Stackpole offers the variety of materials, numerous tooled configurations and the technical back-up you need. Twenty-four years of television and computer experience makes Stackpole one of the largest and most experienced domestic suppliers of quality ferrites.

Consider ferrites on your next prototype or redesign. But give us a call when you start. Perhaps we (and some Ceramag® ferrites) can help you cut a problem down to size. Stackpole Carbon Company, Electronic Components Division, St. Marys, Pa. 15857. Phone: 814-781-8521. TWX: 510-693-4511.

STACKPOLE®
ELECTRONIC COMPONENTS DIVISION

Microwave

Switching diodes are rugged

Small p-i-n types can handle 60 kilowatts peak and 15 watts average power

A new family of p-i-n-type switching diodes from Unitrode is especially suited for cable television, antenna switching, and medium-power applications including microwave phase shifters and attenuators. The Watertown, Mass., firm has designated the diodes the UM-7900 series and claims power-handling capacities of 60 kilowatts peak and 15 watts average for the Micro-pill devices.

The diodes are small, rugged, and designed in a packaging format especially suited to strip-transmission-line applications. The pill-like package—as opposed to the common two-lead diode package or open chips—offers reduced parasitic capacitance and inductance. Total capacitance, for example, is rated at only 0.9 picofarad maximum at 1 GHz; series resistance is 1 ohm maximum. Parasitic inductance is about 0.1 nanohenry.

Strip-line constructions often must handle sizable amounts of power, despite small dimensions. Because the 7900's pill-like package allows equally rapid heat dissipation from both its cathode and anode ends, the package acts like two heat sinks face to face, with the diode chips between them. This makes for low thermal impedance: 10°C per watt. It is this easy transfer of heat to surrounding conductors and/or substrate materials that allows these diodes—some smaller than the head of a pin—to handle the specified microsecond-long, 65-kW peaks. Unitrode spokesmen claim that packages with C-spring or wire-lead anode and cathode connections can't match this thermal performance.

In the target markets for the 7900 diodes, switching speed is traded for other, more desirable, characteristics. Thus, the 7900s have a relatively long carrier lifetime and so at 100 nanoseconds maximum, they switch less quickly than some others. But this feature also reduces distortion—especially important in CATV applications—because the switching speed of the diodes is slow enough to block distortion products. Thus, cross-modulation products are said to be more than 80 dB below carrier levels, and second-order harmonic distortion is reportedly down by 60 dB at 10 mHz and 80 dB at 60 mHz. This means that in many applications, the 7900 can replace the pairs of balanced diodes formerly needed for low distortion—saving the user money on components, and on the bias power supplies needed to make the pairs operate.

Finally, Unitrode spokesmen point out the amount of raw abuse the diodes will take without performance degradation. Engineers regularly drop such diodes into liquid nitrogen, allow time for them to cool to the LN2's approximately 700° absolute, and then remove them immediately to a batch of molten solder. Unitrode uses them to track the current quality of its face-to-face metallurgical bond and fused-in-glass passivation and sealing process—and therefore users can braze, solder, or attach the diodes to their stripline circuits without fear of thermal destruction.

The UM-7900 series diodes are available in five breakdown-voltage ranges from 100 to 1,000 volts. Hundred-volt units are priced at $8 in 100-unit lots, and at $4 in the 1,000-unit lots. For 1,000-V breakdown, the price is $40 in hundreds and $21.60 in lots of 10,000.

The Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172 [430]

Coaxial adapters cover 7.8- to 18-GHz range

Three double-ridge coaxial adapters are available with stainless-steel connectors for broadband operations. The model TDR14C010, which offers a right-angle SMA female connector, covers the range of 7.8 to 16.5 gigahertz. The model TDR14C002, which incorporates an SMA female connector, covers the range of 7.5 to 17.0 GHz. The model TDR14C007, which features a TNC female connector, covers 7.5 to 18 GHz. Maximum insertion losses are 0.15 dB, 0.15 dB, and 0.10 dB, respectively. All three are priced at $260 each.

Technicraft Division, Tech Systems Corp., 401 Watertown Rd., Thomaston, Conn. 06787 [433]

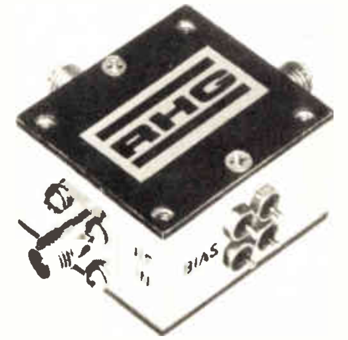
Epitaxial transistors offer 5-W output with 6-dB gain

Planar epitaxial npn silicon transistors, the RMT 1605 and RMT 2501, are designed primarily for classes A, B, and C vhf, uhf, and microwave-amplifier or oscillator applications. The 1605 offers 5-watt output with 6-decibel gain at 1 gigahertz, and the 2501 is rated at 1 W with 5 dB gain at 2 GHz. Total power dissipation is 12 and 5.8 W, respectively. Price of the 1605 in 1 to 9 quantities is $44 each, and the 2501 is $48 in the same quantities.

Raytheon Co., Special Microwave Devices Operation, Wayside Ave., Burlington, Mass. [434]

Double balanced mixer achieves –10-dBm levels

With a local-oscillator injection level as low as –10 decibels referred to 1 milliwatt, a double balanced



mixer in a single unit provides rf coverage of 1 to 12 gigahertz in five ranges. The DMB-series unit uses a split diode and quad arrangement. This configuration allows the application of diode bias, as well as monitoring of diode current. Bias can be positive, negative, or floating. I-f range is from dc to 300 MHz. Price is from $350.

RHG Electronics Laboratory Inc., 162 E. Industry Ct., Deer Park, N.Y. 11729 [435]

Double balanced mixer operates from dc to 4 GHz

The model M1K double balanced mixer, is a high-intercept, wideband unit in a hermetically sealed package. The unit provides two-tone performance over the range of dc to 4 gigahertz. With a local oscillator drive level of +23 dBm, the mixer has a +28 dBM typical input third-order intercept point. With two input tones at 0 dBm, the third-order products will be typically suppressed 56 dB, relative to the desired input. Price is $299 each for one to four units.

Watkins-Johnson Relcom Products, 3333 Hillview Ave., Stanford Industrial Park, Palo Alto, Calif. 94304 [438]

TWT amplifiers cover frequencies in Ku band

Two versions of the model 1277H04 traveling-wave-tube amplifier cover frequencies in the Ku band. The devices are the model 1277H04F-001, operating at 13.2 gigahertz, and the model 1277H04F-002, operating at 17.8 GHz. Minimum rf-power output is 28 watts. The amplifiers consist of TWTs, regulated solid-state

power supplies, and air-cooling systems. Price of the amplifiers is about $7,600 for each.

Hughes Aircraft Co., P.O. Box 90515, Los Angeles, Calif. 90009 [436]

Video detectors cover from 1 to 18 GHz

Three broadband, high-power video detectors provide burnout protection to 100 watts of peak power in crystal video systems by incorporat-

ing limiters with the detectors. The model LD3380 covers from 2 to 18 gigahertz, model LD3381 covers 8 to 18 GHz, and model LD3382 covers 1 to 12.4 GHz. Prices start at $175.

American Electronics Laboratories Inc., MS/1123, Box 552, Lansdale, Pa. 19446 [437]

Traveling-wave tube is for use from 38 to 40 GHz

A traveling-wave tube is designed for use in the range of 38 to 40 GHz with an average gain of 40 dB. Specific uses of the RW4010 include microwave radios in local-distribution systems for transmission of mes-

sages, data, and television. The unit has a guarantee of 10,000 hours and an average life in excess of 5,000 hours, the company says.

Siemens Corp., 186 Wood Ave. South, Iselin, N.J. 08830 [439]

New literature

Data terminal. Pertec Corp., Dept. 736, 10880 Wilshire Blvd., Los Angeles, Calif. A 20-page booklet describing the model DT100 key data terminal system contains specifications and options. Circle 421 on reader service card.

Modem. A 24-page brochure describing a line of digital modem packs for switched-voice networks and leased-line applications is available from the Digital Communications Department, Sanders Associates Inc., Daniel Webster Highway South, Nashua, N.H. 03060 [422]

TTL ICs. Texas Instruments Incorporated, P.O. Box 5012, MS/84, Dallas, Texas 75222. A data book on transistor-transistor logic ICs contains 640 pages of specifications on five families of 54/74 units. [423]

Graphics system. A four-page brochure from Systems Science and Software, Box 1620, La Jolla, Calif., describes an interactive graphic system for NC tape preparation and verification. [430]

Thick-film printing. Industrial Reproductions Inc., 100 Northeastern Blvd, Nashua, N.H. 03060, is offering a brochure describing the company's line of products for thick-film printing. [425]

Wire wrapping. Catalog 350 describes a line of manual wire wrapping and unwrapping tools available from Jonard Industries Corp., 3047 Tibbett Ave., Bronx, N.Y. [426]

Packaging systems. A 16-page brochure from Mupac Corp., 646 Summer St., Brockton, Mass. 02402, covers the company's line of microelectronic packaging systems and hardware. [477]

Matrix selector switches. Cherry Electrical Products Corp., 3600 Sunset Ave., Waukegan, Ill. 60085. A multipage guide details the line of matrix switches for rapid circuit selection and programing, permitting crosspoint selection by means of a selector knob. [428]

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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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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.

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6.3 KV @ 5. 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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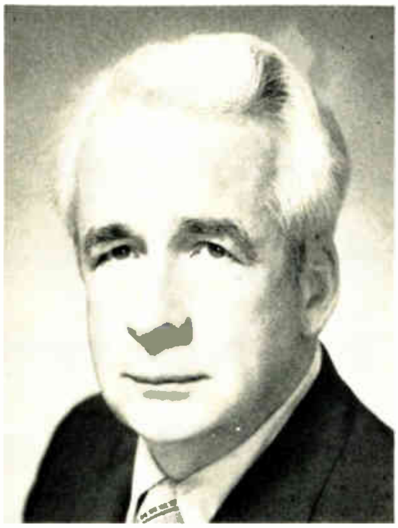

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