MAY 22, 1980

VOICE IS THE TALK OF THE INDUSTRY/95

32-bit minicomputer adopts a mainframe look / 130

What designers should know about power MOS FETs / 143

50 YEARS

Electronics

FOUR DOLLARS A McGRAW-HILL PUBLICATION

SPECIAL REPORT

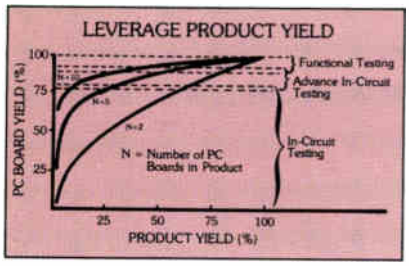
DIVERSITY IN DESIGN

5. Circuit Board Testing Update/No. 5 in a series from Hewlett-Packard.

JUSTIFYING THE PURCHASE OF AN AUTOMATIC BOARD TEST SYSTEM IN LIGHT OF TODAY'S HIGH COST OF CAPITAL.

Today, an automatic board test system can easily cost $100,000 or more. Given the current high cost of money, can a purchase of this size be financially justified? If you choose the right kind of test system it can be. In fact, the right automatic test system will not only pay for itself — including interest costs — but will actually save your company additional money.

The secret! Leveraging.
There are any number of testing alternatives now available. However, HP's 3060A Board Test System combines the latest in-circuit testing technology with board level functional testing. The addition of functional testing to in-circuit testing provides a relatively small increase in board yield. But as you can see from the accompanying diagram, this small increase can mean a large improvement in product yield. For example, in a 5 PC board product, an increase in board yield of only 8% (from 90% to 98%) will leverage product turn-on rate from about 59% to 90%.

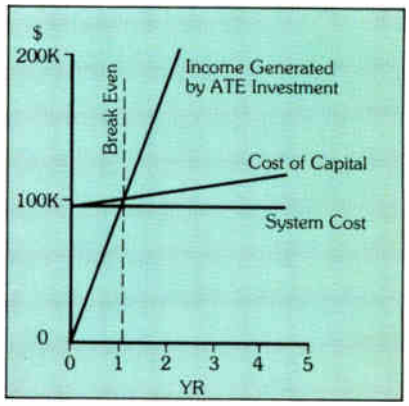


The impact of leveraging on production test costs.
As you may have already discovered, production testing costs increase exponentially. In other words, a fault that costs 18¢ to find during in-circuit testing can easily cost $20 or more if not detected until final product test. Why? Because of the additional time — and increased labor costs — associated with fault diagnosis and repair at this level.

By helping leverage product yield through in-circuit plus functional testing, the HP 3060A can help decrease production test costs. For example, in a five PC board product, with a product volume of 12,000 per year, the 3060A can slash production test costs as much as $19.94 per unit. And that's a total of nearly $250,000 per year.

Will it work for you?
As you can see from the graph, today's increasing cost of capital means the savings to be generated by an investment such as the HP 3060A must be substantial in order to produce a reasonable break-even point. How can you determine whether or not the 3060A would deliver a large enough reduction in production test costs — to justify its purchase?

To help you determine this for yourself, HP now offers a very helpful brochure titled "Financial Justification — Circuit Test Systems." It includes a production test model worksheet, and has guidelines for calculating the 3060A Automatic Board Test System's payback period, average return on investment and/or discounted cash flow. You can use this information to determine the rate of return offered by the HP 3060A in your facility, even in light of today's high-interest economy. For your free copy of "Financial Justification — Circuit Test Systems," or for more information on the HP 3060A, (Priced at $85,000* for standard operational system) write to Hewlett-Packard, 1507 Page Mill Road, Palo Alto, CA 94304. Or call the HP regional office nearest you: East (201) 265-5000, West (213) 970-7500, Midwest (312) 255-9800, South (404) 955-1500, Canada (416) 678-9430.



*Domestic USA price only.

090 58

HP Circuit Testers — The Right Decision

HEWLETT PACKARD

Circle 900 on reader service card

SURPRISE!

HP's New Fiber Optic System is Guaranteed to 1 km.

HP's new 1 km fiber optic system is a complete, point-to-point data link, capable of transmitting any pattern of digital information, from dc to 10 Mbaud, up to 1000 metres. At the heart of this new system is our HFBR-1002 Transmitter. It can directly replace the currently used HFBR-1001 (100-metre) Transmitter to give you full 1 km capability.

In addition, "Cable by the Metre" is available to meet your special requirements. Now you can order cable in one-metre increments, at $2*/metre plus connector installation.

HP's fully specified and guaranteed systems are the result of extensive testing totalling over 1.6 million hours. We also give you applications assistance.

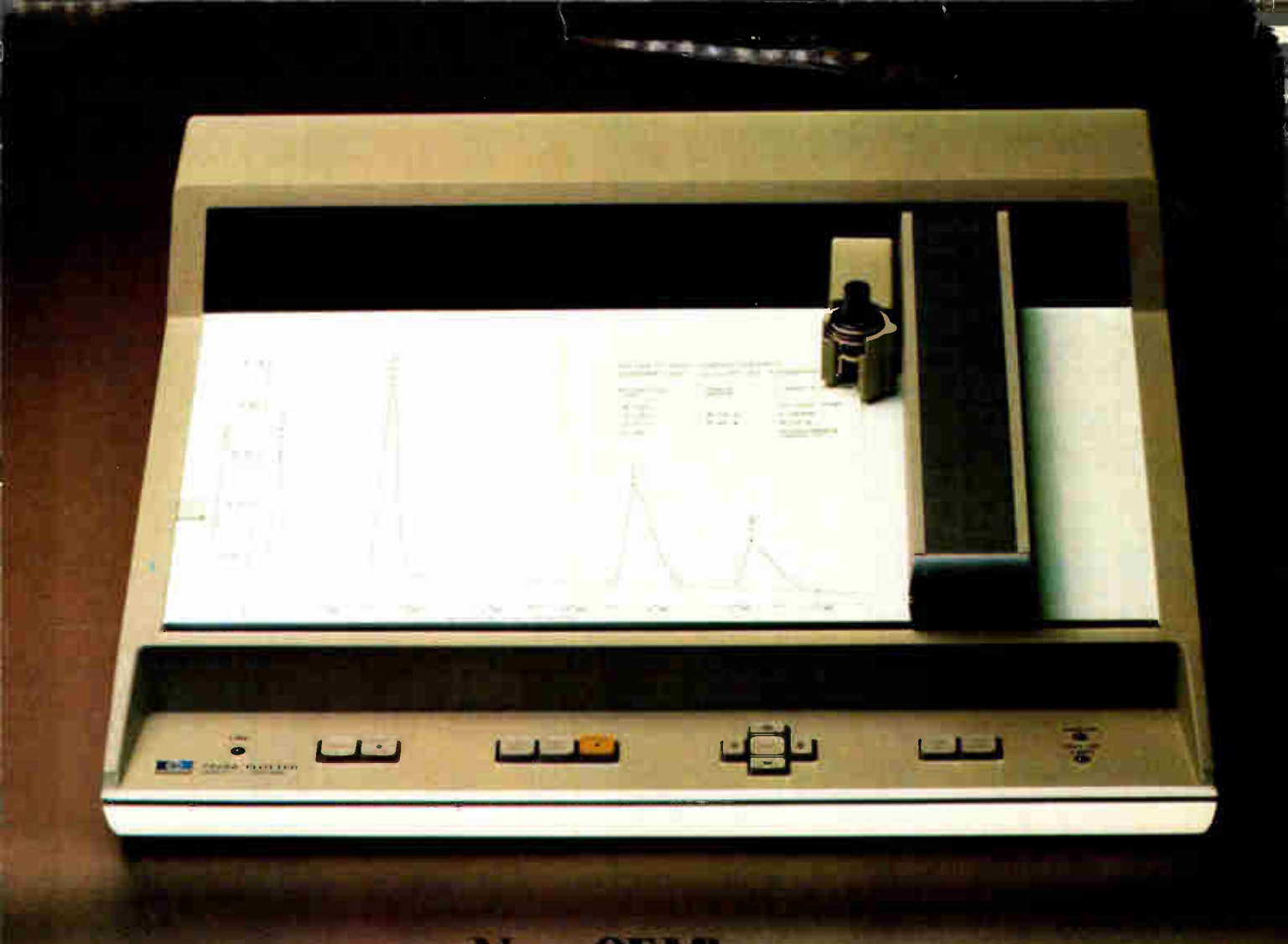
In quantities of 100, the HFBR-1002 Transmitter sells for $235* and the HFBR-2001 receiver sells for $150*. For off-the-shelf delivery, or for more information about HP's fiber optic capability, contact your nearest HP components franchised distributor. In the U.S. contact Hall-Mark, Hamilton/Avnet, Pioneer Standard, Schweber, Wilshire or the Wyle Distribution Group (Liberty/Elmar). In Canada, call Hamilton/Avnet or Zentronics, Ltd.

01907

*U.S. Domestic Price Only.

HEWLETT PACKARD

Circle 1 on reader service card



Now OEM's can draw high quality graphics even when the bottom line is price.

Graphics gives you the best way to analyze and communicate data. But cost has been keeping it out of the picture for many OEM systems. That's why Hewlett-Packard is offering the new Model 7225A Graphics Plotter.

The price: $1913 (domestic USA price with 17602A general purpose "personality" module), in quantities of five. With further OEM discounts from there.

Plug-in "personality modules" customize the plotter for you.

HP's versatile 7225A converts the output of processor based systems into high quality charts and graphs in any size up to 8½ x 11" (A4). A wide selection of plug-in "personality modules" lets you adapt the plotter to suit your needs. Different modules determine interface hardware, language, and capabilities such as internal character sets, axis generation, labeling and scaling.

Simple linear stepping motors eliminate many moving parts to assure reliability. Visually smooth, high resolution ink lines of any length and angle are generated, requiring only end point data.

And you give your customers the confidence of Hewlett-Packard's worldwide service network.

So if you want high quality graphics but you draw the line at price, look into the Model 7225A Graphics Plotter. For a detailed 24-page OEM brochure, contact Greg Diehl at Hewlett-Packard 16399 West Bernardo Drive, San Diego, CA 92127; (714) 487-4100. 11901

HEWLETT PACKARD

Circle 2 on reader service card

Electronics
The International Magazine of Electronic Technology
Vol. 53, No. 12 • May 22, 1980

Electronics

EDITOR-IN-CHIEF: Samuel Weber

MANAGING EDITORS
Technical: Raymond P. Capece, Alfred Rosenblatt
News: Gerald M. Walker
International: Arthur Erikson

ASSISTANT MANAGING EDITORS: Howard Wolff, Margaret Eastman

SENIOR EDITOR: Ray Connolly

ART DIRECTOR: Fred Sklenar

ASSOCIATE EDITOR: Benjamin A. Mason

DEPARTMENT EDITORS
Aerospace/Military: Ray Connolly
Circuit Design: Vincent Biancomano
Communications & Microwave: Harvey J. Hindin
Components: Roger Allan
Computers & Peripherals: Anthony Durniak
Industrial/Consumer: Gil Bassak
Test, Measurement & Control: Richard W. Comerford
New Products: Alan Serchuk, Ana Bishop
Packaging & Production: Jerry Lyman
Solid State: John G. Posa

CHIEF COPY EDITOR: Margaret Eastman

COPY EDITORS: Mike Robinson, Charlotte Wiggers, Jeremy Young

ART: Charles D. Ciatto, *Associate Director*
Paula Piazza, *Assistant Director*

EDITORIAL SECRETARIES: Maryann Tusa, Alan Kleinberger

EDITORIAL ASSISTANT: Marilyn B. Steinberg

REGIONAL EDITORS
New York: Pamela Hamilton (212) 997-2666
Boston: James B. Brinton, Linda Lowe (617) 262-1160
Chicago: Larry Marion (312) 751-3805
Dallas: Wesley R. Iversen (214) 742-1747
Los Angeles: Larry Waller (213) 487-1160
Palo Alto: Bruce LeBoss, *Manager* Martin Marshall, *Computers & Instruments* (415) 968-2712
Washington: Ray Connolly (202) 624-7592
Frankfurt: John Gosch 72-5566
London: Kevin Smith 493-1451
Paris: Arthur Erikson, Kenneth Dreyfack 720-20-70
Tokyo: Charles Cohen 581-9816

McGRAW-HILL WORLD NEWS
Editor: Michael Johnson
Brussels: James Smith
Milan: Jeff Ryser
Moscow: Peter Hann
Stockholm: Robert Skole
Tokyo: Robert Neff

PUBLISHER: Paul W. Reiss

GENERAL MANAGER, DIRECT MARKETING OPERATIONS: Horace T. Howland

CIRCULATION MANAGER: Herbert A. Hunter

RESEARCH MANAGER: Margery D. Sholes

MARKETING ADMINISTRATION MANAGER: Frances M. Vallone

BOOKS & SPECIAL PROJECTS MANAGER: Janet Eyler

SERVICE REVENUE SPECIALIST: Penny Reitman

Highlights

Cover: 64-K RAMs trudge many rocky paths to production, 119

Picking their way among alpha-particle, lithographic, material, pinout, and power-supply obstacles, manufacturers of the coming generation of 64-K (and larger) dynamic random-access memories expect to have the big chips in volume production by 1983. A special report looks at the wide variety of cell and sense-amplifier designs, chip layouts, and alpha-proofing techniques being explored by the score of companies in serious contention for slices of this potentially huge market.

Cover illustration is by Sean Daly.

Speech technology spurred by consumer products, 95

Fledgling technologies for speech synthesis and recognition are due to see steep market-growth curves, according to observers. A comprehensive review of the field underlines the importance of large-scale ICs in bringing speech synthesis to the commercial sector—and speech recognition is not far behind.

When does a minicomputer become a mainframe? 130

A 32-bit computer designed for full compatibility with the Eclipse family of 16-bit minicomputers and existing software defies neat classification. Data General may view itself as a minicomputer maker, but the MV/8000's 4.3-gigabyte virtual memory space puts it in the big leagues, as does its hardware architecture: multiple buses and separate instruction and data caches serve a pipelined, microprogrammed central processor.

Power MOS FETs are taking over more bipolar turf, 143

MOS FETs made for power-switching jobs, which compare favorably with established bipolar parts in terms of switching speed, drive needs, multiple-device operation, and cost, are moving into higher-power areas. Designers used to working with bipolar devices should familiarize themselves with the techniques and tradeoffs involved in applying the three basic power FET structures currently built.

Japanese make serial communications chip for Intel line, 167

Nippon Electric Co. is marketing in the U.S. an MOS chip designed specifically as a two-channel serial communications controller for use with 8080s, 8085s, and 8086s—plugging a hole in the line. It supports bit- and byte-oriented protocols at programmable transmission rates.

. . . and in the next issue

A special report on LSI in communications . . . a chip pair for rf remote control of toys and models . . . changing manufacturer-customer relationships in the era of very large-scale integrated circuits . . . a two-chip 18-bit digital-to-analog converter with 16-bit linearity.

May 22, 1980 Volume 53, Number 12 102,435 copies of this issue printed

Electronics (ISSN 0013-5070). Published every other Thursday with an additional issue this April by McGraw-Hill, Inc. Founder: James H. McGraw 1860-1948. Publication office 1221 Avenue of the Americas, N.Y., N.Y. 10020; second class postage paid at New York, N.Y. and additional mailing offices.

Executive, editorial, circulation and advertising addresses: Electronics, McGraw-Hill Building, 1221 Avenue of the Americas, New York, N.Y. 10020. Telephone (212) 997-1221. Teletype 12-7960 TWX 710-581-4879. Cable address: MCGRAWHILL NEWYORK.

Subscriptions limited to professional persons with active responsibility in electronics technology. No subscriptions accepted without complete identification of subscriber name, title or job function, company or organization, and product manufactured or services performed. Based on information supplied, the publisher reserves the right to reject non-qualified requests. Subscription rates: in the United States and possessions $18 one year, $31 two years, $46 three years; company addressed and company libraries $23 one year, $41 two years, $58 three years; APO/FPO addressed $35 one year only; Canada and Mexico $19 one year, $32 two years, $47 three years; Europe $50 one year, $85 two years, $115 three years; Japan, Israel and Brazil $70 one year, $115 two years, $165 three years; Australia and New Zealand $95 one year, $170 two years, $240 three years, including air freight; all other countries $50 one year, $85 two years, $125 three years. Limited quota of subscriptions available at higher-than-basic rate for persons allied to field served. Check with publisher for these rates. Single copies: $4.00; special Anniversary issue: $9.00 each. Please allow four to eight weeks for shipment.

Officers of McGraw-Hill Publications Company: Paul F. McPherson, President; Executive Vice Presidents: James E. Boddorf, Gene W. Simpson; Group Vice President: Daniel A. McMillan; Senior Vice President-Editorial: Ralph R. Schulz; Vice Presidents: Kemp Anderson, Business Systems Development; Stephen C. Croft, Manufacturing; Robert B. Doll, Circulation; James E. Hackett, Controller; William H. Hammond, Communications; Eric B. Herr, Planning and and Development; John W. Patten, Sales; Edward E. Schirmer, International.

Officers of the Corporation: Harold W. McGraw, Jr., President, Chief Executive Officer, and Chairman of the Board; Robert N. Landes, Senior Vice President and Secretary; Ralph J. Webb, Treasurer.

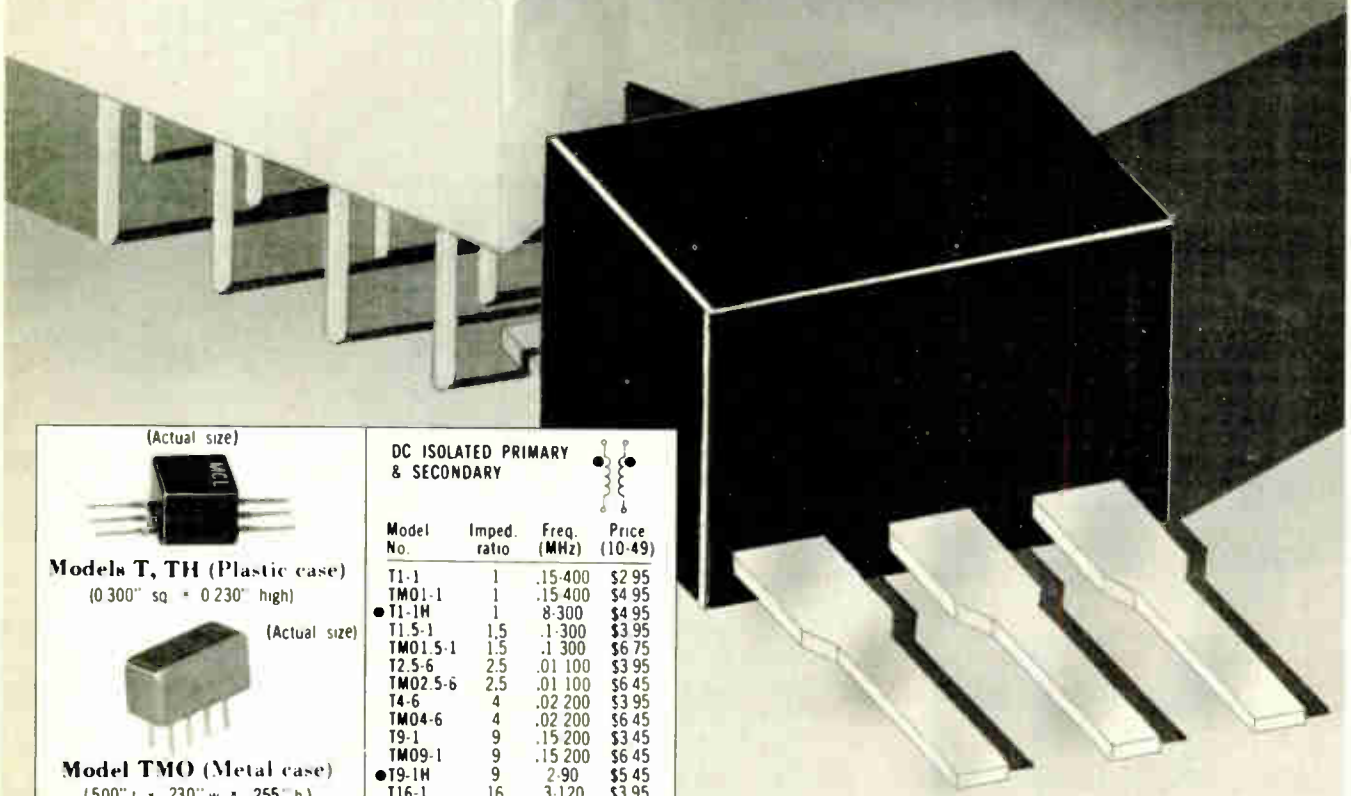
Subscribers: The publisher, upon written request to our New York office from any subscriber, agrees to refund that part of the subscription price applying to copies not yet mailed. Please send change-of-address notices or complaints to Fulfillment Manager, subscription orders to Circulation Manager, Electronics, at address below. Change-of-address notices should provide old as well as new address, including zip codes. Attach address label from recent issue. Allow one month for change to become effective. Subscriber Service: call (609) 448-8110, 9 a.m. to 4 p.m. EST.

Postmaster: Please send form 3579 to Fulfillment Manager, Electronics, P.O. Box 430, Hightstown, N.J. 08520.

Let Mini-Circuits' RF TRANSFORMERS Do Your Matching!

10kHz—800 MHz

...from $2.95



(Actual size)

Models T, TH (Plastic case)

(0.300" sq. × 0.230" high)

(Actual size)

Model TMO (Metal case)

(.500" L × .230" W × .255" H)

DC ISOLATED PRIMARY & SECONDARY

Model No.	Imped. ratio	Freq. (MHz)	Price (10-49)
T1-1	1	.15-400	$2.95
TMO1-1	1	.15-400	$4.95
●T1-1H	1	8-300	$4.95
T1.5-1	1.5	.1-300	$3.95
TMO1.5-1	1.5	.1 300	$6.75
T2.5-6	2.5	.01 100	$3.95
TMO2.5-6	2.5	.01 100	$6.45
T4-6	4	.02 200	$3.95
TMO4-6	4	.02 200	$6.45
T9-1	9	.15 200	$3.45
TMO9-1	9	.15 200	$6.45
●T9-1H	9	2-90	$5.45
T16-1	16	.3-120	$3.95
TMO16-1	16	.3-120	$6.45
●T16-1H	16	7-85	$5.95

● Up to 100mA DC without saturation

CENTER-TAPPED DC ISOLATED PRIMARY & SECONDARY

Model No.	Imped. ratio	Freq. (MHz)	Price (10-49)
T1-1T	1	.05-200	$3.95
TMO1-1T	1	.05-200	$6.45
T2-1T	2	.07-200	$4.25
TMO2-1T	2	.07 200	$6.75
T2.5-6T	2.5	.01-100	$4.25
TMO2.5-6T	2.5	.01 100	$6.75
T3-1T	3	.05-250	$3.95
TMO3-1T	3	.05-250	$6.45
T4-1	4	.2 350	$2.95
TMO4-1	4	.2 350	$4.95
●T4-1H	4	8-350	$4.95
T5-1T	5	.3-300	$4.25
TMO5-1T	5	.3-300	$6.75
T13-1T	13	.3-120	$4.25
TMO13-1T	13	.3-120	$6.75

UNBALANCED PRIMARY & SECONDARY

Model No.	Imped. ratio	Freq. (MHz)	Price (10-49)
T2-1	2	.025-600	$3.45
TMO2-1	2	.025-600	$5.95
T3-1	3	.5-800	$4.25
TMO3-1	3	.5-800	$6.95
T4-2	4	.2-600	$3.45
TMO4-2	4	.2-600	$5.95
T8-1	8	.15-250	$3.45
TMO8-1	3	.15 250	$5.95
T14-1	14	.2 150	$4.25
TMO14-1	14	.2-150	$6.75

FOR ADDITIONAL INFORMATION, COMPLETE SPECIFICATIONS, AND PERFORMANCE CURVES, REFER TO 1979-80 MICROWAVES' PRODUCT DATA DIRECTORY pgs. 161 to 368 or 1979 EEM 2770 to 2974.

It's easy to transform impedance and reduce VSWR.

Chose from 40 models, 12.5 to 800 ohms, 10 kHz to 800 MHz, ultra- low distortion (H models) balanced, unbalanced and center-tapped . . . immediate delivery . . . at prices that can't be matched, starting at $2.95

World's largest manufacturer of Double-Balanced Mixers

Mini-Circuits

MINI-CIRCUITS LABORATORY

A Division of Scientific Components Corp

2625 East 14th Street Bklyn, New York 11235 (212) 769-0200

Domestic and International Telex 125460 International Telex 620156

42/Rev.B

Publisher's letter

Affordable speech-synthesis and -recognition capability is just over the horizon. And as Bruce LeBoss, San Francisco regional bureau manager, points out in the Inside the News feature on this subject (p. 95), people will soon be surrounded by the chatter of hardware conversing in many languages.

Companies are already demonstrating equipment that converse audibly with other equipment. In one setup two terminals are able to tell those old "knock-knock" jokes and may soon be ready to deliver the famous Abbott and Costello "Who's on first?" routine.

In a more serious vein, Bruce reports that to some the arrival of speech input/output capability today is much like the development of the first microprocessors almost a decade ago. There is that same intense effort to find ways to exploit speech capability in products ranging from dolls to industrial process control systems. Also, as in the early days of microprocessors, many users will depend on advice and guidance from suppliers.

Still another aspect of speech I/O that impressed Bruce was the feeling of being on the brink of a new technology explosion—again quite like the early days of the microprocessor. This feeling was dramatized at a one-day seminar on speech synthesis and recognition sponsored by the Institute of Electrical and Electronics Engineers' Computer Society in the Bay Area. The meeting took place on a sunny Saturday, the kind of day most residents would be out playing golf or tennis.

"They expected about 75 to turn up, but I counted over 200," Bruce reports. "People were there not just out of curiosity, but in a serious effort to exchange information."

The crowd was too big to have lunch in the cafeteria at Hewlett-Packard where the sessions were held. Instead, everyone took to the outdoors and ate box lunches picnic-style. "I got the impression that sitting on the lawn in the warm sun was the core of people involved in the hottest technology for the next decade," Bruce observes.

It was not quite the case, since speech technology has quickly become an international bandwagon. As usual the Japanese appear to be a major factor in both synthesis and recognition, especially for consumer applications. In software, however, the U. S. has the edge, Bruce notes.

As for Europe, a large part of the speech effort is coming from government research. The British Post Office has a telephone directory service project and two French labs are working on communications applications.

This is a good time to take a look at dynamic random-access memories, especially 64-K RAMs. That's what solid state editor John Posa reasoned as he set out to prepare the special report on page 119.

"A lot of promises were made, but actual deliveries have been delayed," John points out. "Nevertheless, the 64-K RAMs will be produced and delivered."

More impressive still will be the 256-K RAMs, he adds. Building these will require real processing tricks. "The stored charge in the memory cell is diminishing, so it is harder to sense and store. And alpha particles are likely to create more and more problems."

But John stresses that, as for the 64-K memories, these problems will be overcome and the 256-K RAMs will be developed and produced. "Such devices are incredible, when you think about it," he says. "Four of them will equal a megabit of memory in a 2-square-inch space."

What's next? Dynamic RAMs are said to be composed of single cells but in fact each cell contains a storage capacitor and a switching transistor. According to John, down the road is a new class of cells that will combine the storage capacitor and the switching transistor. These will be truly single cells.

LOW DISTORTION TEST OSCILLATOR

The Ultra In Sine Wave Purity

Krohn-Hite, the leader in oscillator technology for more than thirty years, now brings you *The Ultra* in sine wave purity — the Model 4400. These features are the result of our years of experience:

- Frequency range 1 Hz to 110 kHz
- Sine distortion < 0.001% (−100 dB)
- Amplitude flatness 0.05 dB
- 7 V RMS maximum output
- 3 outputs (sine, quad, and inverted)
- Calibrated attenuator

Because the 4400 has the purest sine waves possible, it can form the heart of an audio test set; when you combine it with a distortion analyzer (our 6800 or any other model) you will achieve the most accurate measurement available. And we've priced the 4400 at a low $550. (U.S. price only.)

The Model 4400 — The Ultra in oscillator excellence. Call Krohn-Hite today for further information and look up our complete product listings in EEM and Gold Book.

KH KROHN-HITE CORPORATION
Avon Industrial Park, Avon, MA 02322 • (617) 580-1660 TWX 710 345 0831

Krohn-Hite . . . Benchmark of Value in Oscillators

AL, Huntsville (205)534-9771; **AZ**, Phoenix (602)279-1531; **CA**, Inglewood (213)674-6850, San Jose (408)292-3220; **CO**, Denver (303)773-1218; **CT**, Canton Center (203)693-0719; **FL**, Orlando (305)859-7450, Sunrise (305)742-2115; **GA**, Atlanta (404)455-1206; **HI**, Honolulu (808)941-1574; **IL**, Chicago (312)283-0713; **IN**, Carmel (317)844-0114; **KS**, Overland Park (913)649-6996; **LA**, Gretna (504)367-3975; **MD**, Towson (301)321-1411; **MA**, Chelmsford (617)256-9061; **MI**, Detroit (313)961-3042; **MN**, Minneapolis (612)835-4818; **MO**, St. Louis (314)569-1406; **NM**, Albuquerque (505)255-2330; **NJ**, Cherry Hill (609)482-0059, Englewood (201)871-3916; **NY**, Rochester (716)473-5720, Saratoga Springs (518)584-6519, Syracuse (315)437-6666; **NC**, Burlington (919)227-3639; **OH**, Chesterland (216)729-2222, Dayton (513)294-2476; **OK**, Jenks (918)299-2636; **OR**, Portland (503)297-2248; **PA**, Pittsburgh (412)261-2604; **SC**, Greenville (803)271-8543; **TX**, Dallas (214)661-0400, Houston (713)688-1431; **UT**, Salt Lake City (801)466-8729; **VA**, Falls Church (703)573-8787; **WA**, Bellevue (206)454-3400; **WI**, Milwaukee (414)545-8400; **CANADA**, Montreal, Quebec (514)744-5829, Ottowa, Ontario (613)725-1931, Toronto, Ontario (416)625-0600, Calgary, Alberta (403)276-7567.

Circle 7 on reader service card

Readers' comments

No more expansion

To the Editor: The editorial "Looking beyond the EE boom" [Feb. 14, p. 28] presented a needed reminder of the painful consequences of a boom-and-bust employment situation for electronics engineers. In contrast with the National Science Foundation's rationale for new spending programs described in the same issue ["Budget opens seller's market for EEs," p. 95] is the Cassandra-like warning of an economist who predicts that "there's a serious recession coming." Some comments:

- The National Science Foundation exists to serve the academic community, not the nation. By law, fully 99% of its research and development funds are reserved for the universities. The NSF has always predicted a shortage of engineers. Now its cry is "We need a broader national base for engineering education." Thus, with this single unproven allegation, the NSF has pulled off a remarkable feat. It has succeeded in obtaining a huge funding increase for its clients, the universities, and all this despite the sharp decrease in student enrollments.
- In contrast, the (also unproven) allegation of a serious recession to come is made by those who have no axes to grind.

In view of these points, what strategy should the American EE community adopt? To me, the answer is clear. Given the experiences of EEs who are now skilled taxicab drivers, employees of fast-food outlets, and gardeners; given the fact that, despite the alleged shortage, the real income of an EE is now less than it was in 1972 (the Institute of Electrical and Electronics Engineers' own figures); and given the self-serving nature of the academics and the corporate executives (both of whom benefit from an oversupply of EEs), the American EE cannot permit any expansion in the output from the engineering colleges. Nor can we permit any additional aliens to be trained or to work in the United States.

Irwin Feerst
Committee of Concerned EEs
Massapequa Park, N. Y.

Make quality impressions with OEM band printers from Control Data

If you're an OEM, you already know what Control Data has done for disk technology. Now we're determined to earn the same reputation for excellence in band printer technology. By giving *you* versatility and maintainability. By giving *your customer* reliability, superior print quality and economical operation.

Engineered for component commonality

All four members of our 9380 family of band printers look pretty much alike. Inside and outside. So your servicing, training and inventory requirements are simplified. Yet you can choose from four print speeds, 69 print bands and lots of other options.

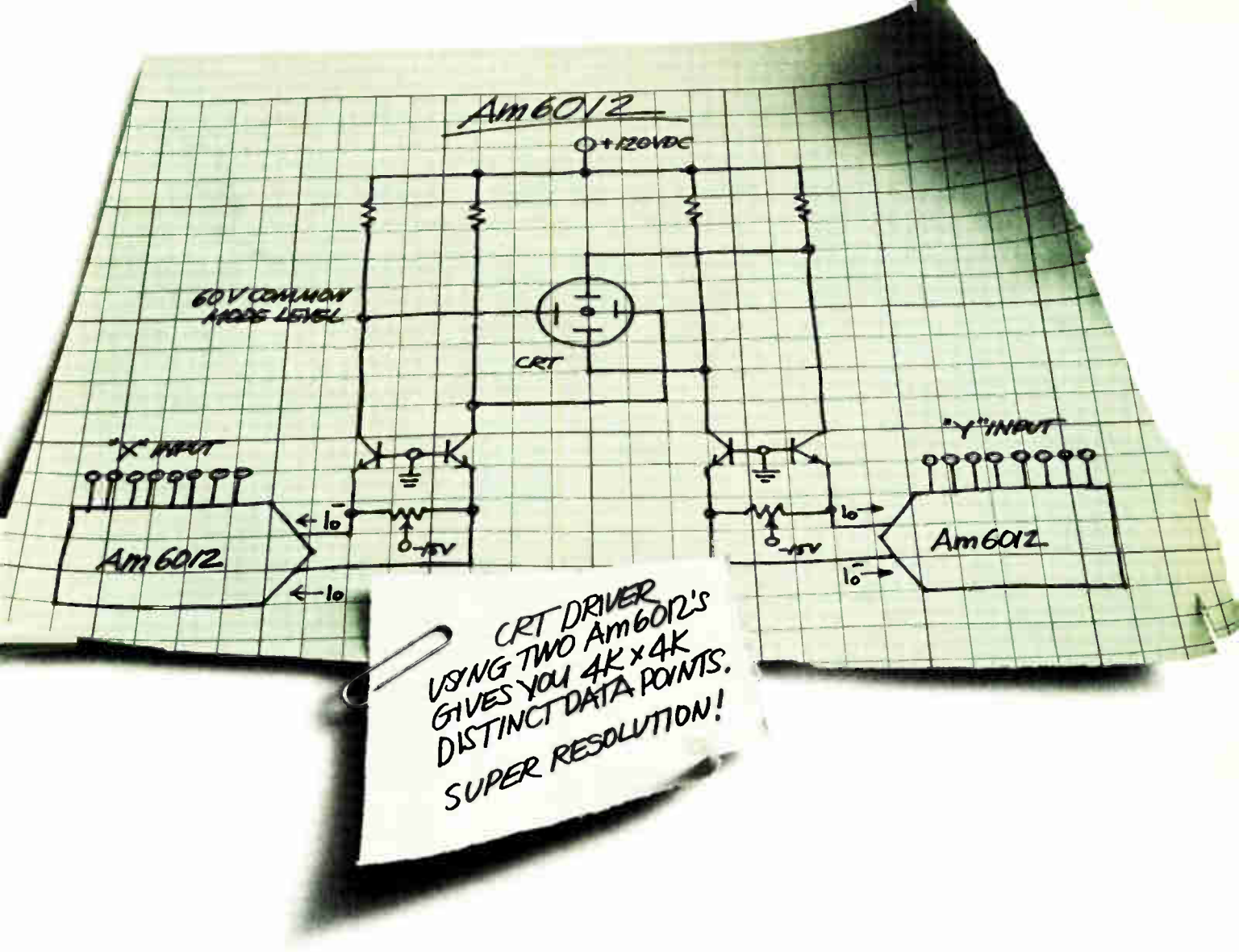
Built with the features and economy to attract end-users

Our 360/720 lpm models offer a compressed pitch option. That saves your customer paper. And gives him the capability to print 132 columns on standard 8½ by 11 inch paper. Bands switch in seconds. Paper loading is easier. Operator controls and adjustments are minimal. And your customer will like the clean, crisp impressions delivered by our proven hammer technology.

Put quality behind your nameplate. Let us send you data sheets and print samples. Call us at 313/651-8810 or if in Europe, contact one of our European representatives. Or write OEM Product Sales Manager, Control Data Corporation, 1480 N. Rochester Road, Rochester, MI 48063.

CONTROL DATA CORPORATION

Addressing society's major needs



We trimmed the price, not the DAC.

Announcing the Am6012. The lowest priced 12-bit DAC you can buy.

Advanced Micro Devices' new Am6012 12-bit monolithic DAC is only $9.95 in 100-up quantities.

But if you think it's just a stripped down DAC, think again. The only thing we trimmed on the Am6012 was the price. And we mean that literally.

The Am6012 is the world's first monolithic DAC produced with diffused, rather than thin-film, resistors. It requires no active trimming of individual devices.

It's the only 12-bit monolithic DAC to spec ±½ LSB (13-bit) differential nonlinearity over the entire temperature range. The only one to spec NL and DNL at both +5V and +15V supplies. It even offers high-output impedance plus high-voltage compliance: −5V to +10V.

Thanks to the Am6012's innovative design, it is inherently monotonic and fast. It has a 250ns typical settling time.

Thanks to Advanced Micro Devices, you get MIL-STD-883 for free.

If you're looking for the best 12-bit DAC at the best price in town, call or write Advanced Micro Devices. And ask for the Am6012.

The only thing we trimmed was the price.

Advanced Micro Devices

901 Thompson Place, Sunnyvale, CA 94086, Telephone: (408) 732-2400

Circle 11 on reader service card

News update

■ Competition is heating up in high-speed 4-K static random-access memories now that Hitachi Ltd.'s 6147 is available in quantity. The Japanese RAM is aimed straight at Intel Corp.'s pioneering 2147 fast static device.

The two parts have the same speed, with access times between 55 and 70 nanoseconds, and the same price range of $30 to $35, depending upon speed selection. However, the 6147 [*Electronics*, Dec. 20, 1979, p. 81] has complementary-MOS peripheral circuitry combined with an n-channel MOS storage array using doped polysilicon loads, whereas the Intel 2147 is strictly n-channel with depletion loads.

Power. As a result, Hitachi's part has an active power dissipation said to be five times better than the low-power 2147L's maximum of 700 milliwatts. It does not fare as well on standby dissipation because the chip-enable line does not shut down the input address buffers upon deselection. Thus, if the address lines are allowed to toggle, power-down consumption shoots from a best case of 10 microwatts to a worst case of 60 mW, which the 2147L beats with 50 mW.

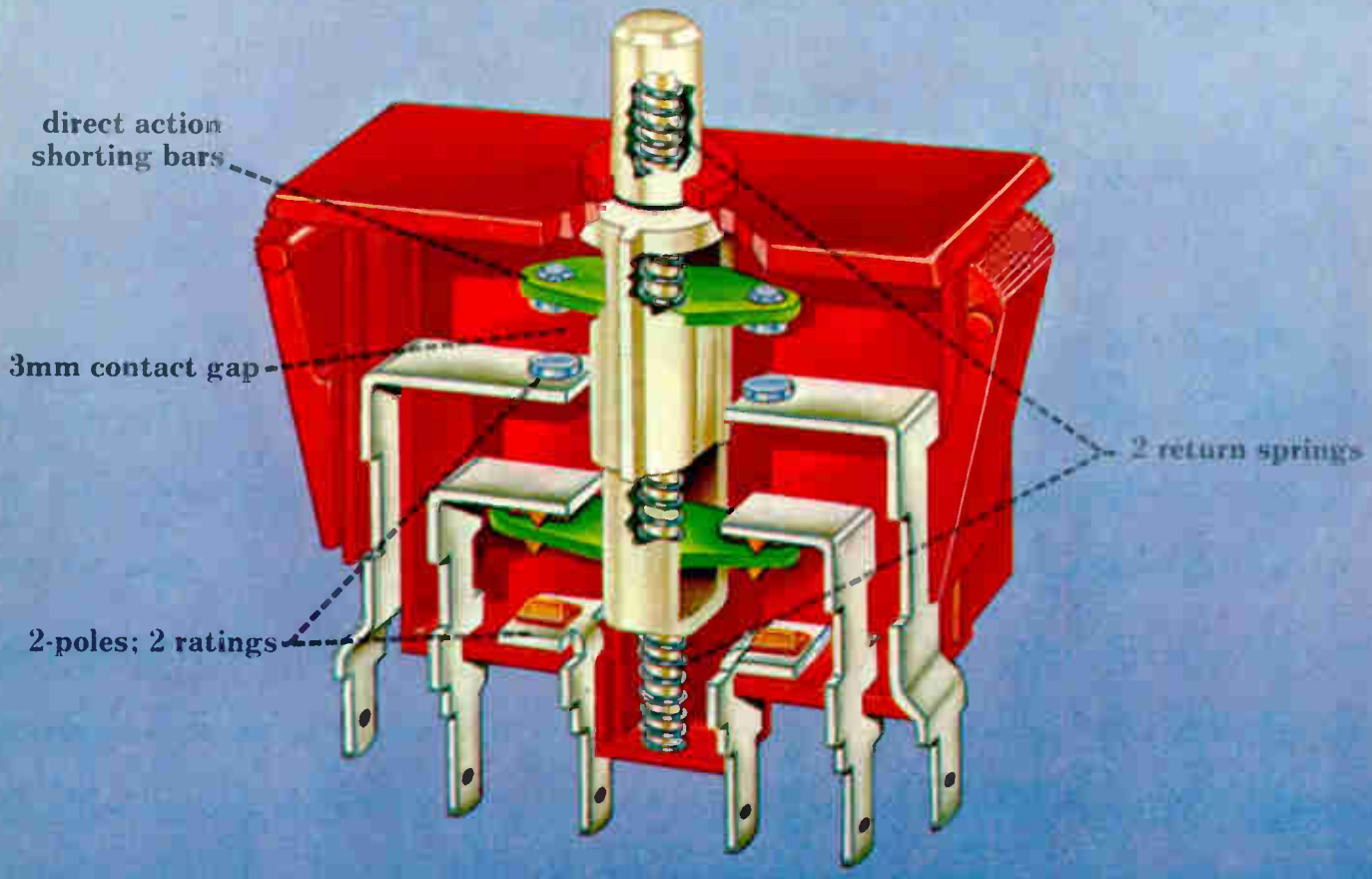
The price comparability staggers U.S. chip makers, for the 6147 requires 13 or 14 masking steps where Intel is said to get by with as few as 8. However, the much smaller cells and die size of the Hitachi part could improve its yield.

Also, Hitachi surrounds the memory matrix with an ubiquitous p well. The junction formed just below the storage nodes sweeps away carriers generated by an invading alpha particle, so that more parts may pass reliability tests.

Fighting back, Intel is using its leading-edge HMOS-II technology to produce the 2147H with 35-to-45-ns access times. Hitachi customers find that 6147s specified at 55 ns invariably perform at 45 ns, but some 2147H users find that their part can dip below 25 ns.

This gives Intel a clear-cut speed advantage because 25 ns is not just 20 ns faster than 45—it is 55% quicker. **-John G. Posa**

LINE-INTERRUPT switch meets latest specs... WORLDWIDE



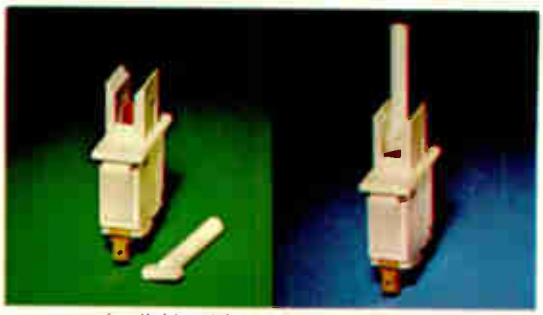
This new safety interlock switch was designed to meet specs of such international agencies as VDE, BSI and others. U.L. listed and CSA approved.

A redundant switch is a safe switch. Cherry builds double protection into this 3mm contact gap line interrupt switch.

Four contacts on each pole, parallel return springs and direct action shorting bars provide an extra margin of safety.

Many of todays products require two voltage levels; one for power and one for control functions. So Cherry offers two different electrical ratings in the same switch. Choose from 10 amp, 16 amp and 0.1 amp combinations. Also available in single pole versions.

All this and Cherry dependability, too!



Available with housing that allows qualified servicemen to test "hot" circuit.

CHERRY LINE-INTERRUPT **SWITCHES**

CHERRY ELECTRICAL PRODUCTS CORP. 3608 Sunset Avenue Waukegan IL 60085—312/689-7700—TWX 910/235-1572

Our worldwide affiliates and phone numbers: Cherry Semiconductor Corp., Cranston, RI U.S.A. 401 463 6000 • Cherry Mikroschalter GmbH, Auerbach, Germany 09 643 181 • Cherry Electrical Products Ltd., Sandridge (Herts) England, 44 727 32231 • Cherco Brasil Industria E Comercio Ltda., Sao Paulo, Brazil 011 246 4343 • Hirose Cherry Precision Co., Ltd., Kawasaki, Japan 044 933 3511

People

Wendt wants to place Sperry on technology's leading edge

Moving up. If Sperry's Wendt has his way, the firm will do more prime contracting.

Robert L. Wendt, the new president of the Sperry division of Sperry Corp., is going to push his military-oriented company to the technological edge. "I'm going to take a hard look at our technological position," he says, adding, "We've been doing state-of-the-art work in a limited number of areas; I'd like our reputation to be more noteworthy. We have a strong technical base for growth over the next 5 to 10 years. In five years, I want to double our present revenue size." That revenue was $486.1 million in 1979.

Wendt, 59, is a 40-year veteran with Sperry. He joined the Great Neck, N. Y., division in 1940 after graduating from Harvard University with a bachelor's degree in physics and electrical engineering. He has held several engineering and managerial positions since then, including manager of the Polaris/Poseidon navigation subsystem program from 1964 to 1969; vice president and general manager of Sperry division's systems management unit from 1971 to 1975; and most recently, vice president and general manager of the Sperry Gyroscope unit from 1975 until his appointment as division president. Wendt succeeded the late Salvatore A. Conigliaro [*Electronics*, April 10, p. 46].

Wendt would like to see the Sperry division become more of a prime contractor and less of a subcontractor on military systems. "We've been moving toward the position of prime contractor in the last few years. We've been in the forefront among electronics—as opposed to aerospace—companies in taking responsibility," he says. "There are a couple of advantages to being the prime contractor. It enables us to tap our skills while providing a better product. In major program management we're able to capitalize on our strengths. I'd rather do the overall job than part of that job," he observes. Sperry is currently bidding on a Canadian patrol frigate contract, where it would be the contractor for the complete weapons systems and for the vessel itself.

Specifically, Wendt sees Sperry expanding into, among other areas, millimeter-wave devices, laser gyro field equipment, simulators and trainers for aircraft and ships, and software. "I want us to be better balanced as a military systems house," he sums up. "One of the thrusts I'll be pursuing is more Army, Air Force, and overseas business to balance our long-standing business with the Navy."

List sees close relations with buyers of speech chips

The ability to produce low-cost synthesized speech using semiconductor components will lead to new generations of talking products and equipment. But first there will be a great deal of talk between the chip vendors and their customers.

That's the opinion of Bernard H. List, vice president and corporate speech strategy manager for Texas Instruments Inc.'s new Speech Technology Center in Midland, Texas [*Electronics*, May 8, p. 33]. The 52-year-old List believes that selling speech chips will require much closer relationships with the original-equipment manufacturers that are the customers that semiconductor makers have been used to. Customers, of course, will be concerned with

PDP11/03® PDP11/23®
MICROCOMPUTER SYSTEMS

FIRSTMICRO™ PDP11®

FIRST COMPUTER CORPORATION NOW OFFERS MICROCOMPUTER DEVELOPMENT SYSTEMS IN BOTH 11/03 AND 11/23 CONFIGURATIONS.

The Basic PDP-11/03 systems offer the designer a low cost compatible alternative to the larger members of the PDP-11 family. The larger faster PDP-11/23 systems offer the power, expandability and operating systems of the larger members of the PDP-11 family while retaining the proven cost effective Q-Bus architecture. These systems save you money, improve programming efficiency, and boost productivity.

	11T03-L	11V03-L	11T23-L	11V23-L
PART #	SRVXLLB	SRVXSSB	SRWXLLA	SRWXSSA
BACKPLANE	KD11-HA CPU 11/03	KD11-HA CPU 11/03	KDF11 CPU 11/23	KDF11 CPU 11/23
	MSV11-DD 32KW Memory	MSV11-DD 32KW Memory	MSV11-DD 32KW Memory	MSV11-DD 32KW Memory
	RL01 Controller	RX02 Controller	MSV11-DD 32KW Memory	MSV11-DD 32KW Memory
	RL01 Controller	DLV11-J Serial (4)	RL01 Controller	RX02 Controller
	DLV11-J Serial (4)	OPEN	RL01 Controller	DLV11-J Serial (4)
	OPEN	OPEN	DLV11-J Serial (4)	OPEN
	OPEN	OPEN	OPEN	OPEN
	OPEN	OPEN	OPEN	OPEN
	BDV11-AA Bootstrap	BDV11-AA Bootstrap	BDV11-AA Bootstrap	BDV11-AA Bootstrap

Serving the world with cost effective computer systems.

TWX NUMBER 910-651-1916

First™ computer corporation

corporate square / 825 north cass avenue / westmont, illinois 60559 / (312) 920-1050

™Trademark First Computer Corporation ®Registered trademark of Digital Equipment Corporation SS-0

Circle 15 on reader service card

People

Linguist. TI's List believes establishment of regional centers is key to speech sales.

speech quality. As List puts it: "That's a very subjective and intangible kind of thing. Everybody hears sounds and interprets them differently. We've found that out just within TI."

As a result, the new speech chief feels that his company's commitment to establishing geographically dispersed regional technology centers "will be key in bringing speech technology to large numbers of customers." TI currently has centers open in Chicago and Boston that will provide a range of vocabulary development services to customers. List says that TI will aid customers in developing "personalized" voices for their products.

List has a background well suited to guiding an emerging technology such as speech synthesis. After receiving bachelor's and Ph.D. degrees from Johns Hopkins University in his native Baltimore, he worked in research and development at the Battelle Memorial Institute in Columbus, Ohio, before joining TI's research laboratories in 1957.

In 1970, he took a leave of absence to work at the Wright-Patterson Air Force Avionics laboratory as chief scientist. He eventually became lab director there and then returned to TI in 1976. Before being named last month to head the newly established speech organization, List was vice president for the firm's U. S. MOS operations in Houston. □

Ohio Scientific: The leader in Winchester based micro-computers.

Ohio Scientific produced the first Winchester based microcomputer in 1977. Since then, we have shipped more of these systems than the rest of the industry combined. Among them are our C3-B and our C3-C microcomputers.

The C3-C.
23 Megabytes. Under $10,000.

The C3-C computer has been designed and engineered to fill the void that existed between floppy disk systems and larger hard disk systems.

In its normal configuration, the C3-C includes the Challenger III processors, 52K RAM, the 23 Megabyte Winchester drive and dual floppy drives for file system back up. And the cost is less than $10,000.

The CPU employs three micro-processors, the 6502, the Z-80 and the 6800. And the processor bus has been designed so new, more powerful micros (like 16 bit CPU's) can be added to the system later on.

There are also 10 open slots in the basic C3-C. The system supports up to 768K bytes of memory, in a multi user configuration.

The C3-B.
74 Megabytes. Under $13,000.

For those who require even more hard disk storage, Ohio Scientific offers another microcomputer in the C3 Series, the C3-B. Its specifications are the same as those of the C3-C. However, the C3-B offers a 74 Megabyte Winchester drive.

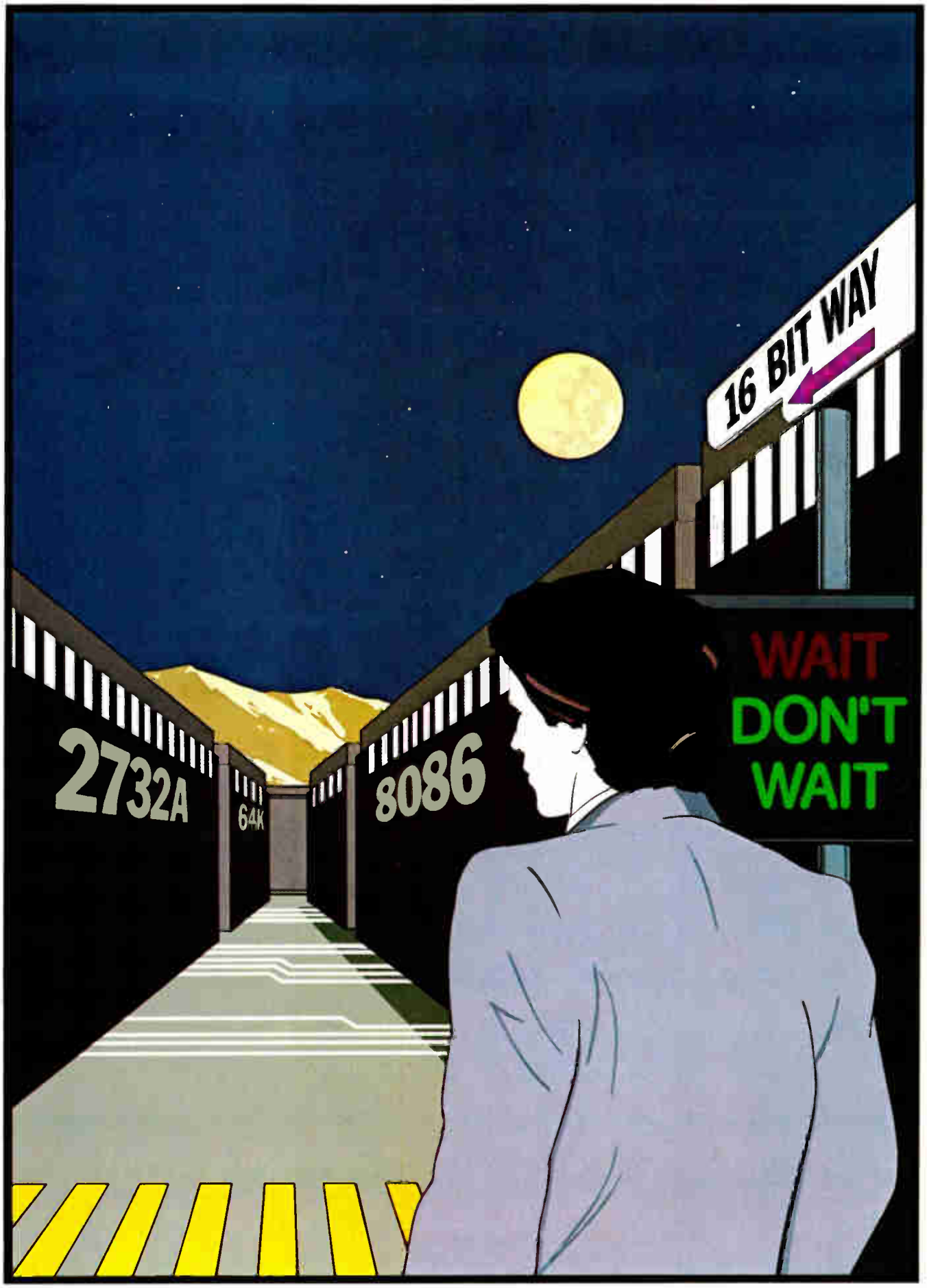
For those who do not need hard disk capacity now, but in all probability will need it in the future, Ohio Scientific offers the C3-A. It is like the C3-B and the C3-C in all respects but two. 48K RAM is standard in the C3-A, and it offers 12 open slots. When more storage is needed, the C3-A is easily expandable to either a 23 Megabyte or 74 Megabyte hard disk system. The C3-A is priced at less than $6,000.

For literature and the name of your local dealer, CALL 1-800-321-6850 TOLL FREE.

OHIO SCIENTIFIC

1333 SOUTH CHILLICOTHE ROAD
AURORA, OH 44202 • (216) 831-5600

Circle 17 on reader service card


16 BIT WAY
WAIT
DON'T
WAIT
2732A
64K
8086

No Waiting

Introducing the Intel® 2732A EPROM. Now you can design 16-bit microcomputer systems without delays.

Now get all the performance you're paying for from your microprocessor designs with Intel's new 2732A EPROM. For 16-bit microprocessor systems, 2732A EPROMs deliver both the high speed (250ns) and high density (32K) solution. No other 32K EPROM on the market comes close.

No speed limit

Other EPROMs require one, two, even three wait states to work with today's high speed microprocessors. Not Intel's 2732A EPROM. It's fast enough to keep up with any of them.

So now, at last, you can utilize the full potential of your microprocessor. In fact, when you use 2732As, you're designing a system that can run 25% faster.

And with a 32K bit density, you're not losing valuable board space to memory chips.

The HMOS*-E generation

By designing with the 2732A today, you're actually designing with the standard of tomorrow. The 2732A is a product of Intel's proven, reliable fourth generation EPROM technology, HMOS-E, and the first to come in a family of dense, high speed EPROMs.

HMOS-E technology means that we'll be able to incorporate high performance features, like increased density, into future EPROMs, without affecting their speed or power characteristics. The 2732A is your first step towards a degree of flexibility in memory design never before available.

JEDEC approved pinout

You can start designing for tomorrow now because the 2732A's pinout conforms to the approved JEDEC committee standard for byte-wide memories from 16K bits to 256K bits. So you can upgrade from a 2732A without changing your design or board layout. And you won't have to sacrifice features like 2-line control—a must in high-speed memories for avoiding bus contention problems.

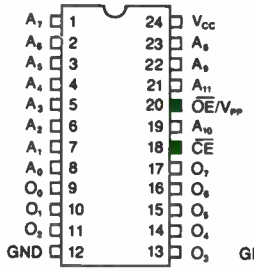
Proven Intel reliability

Like all our EPROMs, your 2732As are put through rigid quality control tests to insure they'll retain their programs and programmability for years to come.

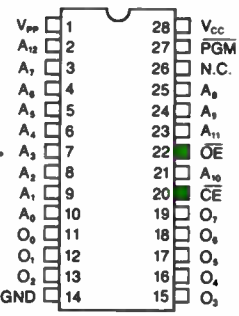
And like all Intel products, the 2732A is backed with our traditional field support and technical documentation. Which means, if needed, you always have a source for technical information and design help to speed development along.

So whether you're designing a system around one of the new 16-bit microprocessors, like our 8086, designing in a high performance 8-bit processor, or upgrading an existing design, *don't wait.* For a cost effective, reliable, and total EPROM solution, with a no-compromise growth path, your best choice is the 2732A.

2732A Pin Configuration



64K Pin Configuration



The 24-pin 2732A pinout conforms to the 28-pin JEDEC committee approved design for byte-wide memories. By using 28-pin sockets, there's no need for delays in upgrading to the 64K, 128K, or 256K EPROMS of the future.

Why add any unnecessary delays? To order now, or for more information—contact your local Intel distributor or sales office. Or, write Intel Corporation, Literature Department, 3065 Bowers Avenue, Santa Clara, California 95051. Or call (408) 987-8080.

*HMOS is a patented Intel process.

intel® delivers solutions.

Europe: Intel International, Brussels, Belgium. Japan: Intel Japan, Tokyo. United States and Canadian distributors: Alliance, Almac/Stroum, Arrow Electronics, Avnet Electronics, Component Specialties, Hamilton/Avnet, Hamilton/Electro Sales, Harvey, Industrial Components, Pioneer, L.A. Varah, Wyle Distribution Group, Zentronics.

SEE OUR BOOTH AT THE NCC SHOW #1354-60

Circle 19 on reader service card

THE NEXT GREAT

Six years ago Biomation brought you the first logic analyzer. Today we bring you the industry's broadest selection. And there's more on the way.

Keeping abreast of the latest technological advances is half the battle these days. If you're designing with digital logic — especially microprocessors — you know how fast things are changing.

The new demands of digital logic are what Bill Moore, Biomation's first chief engineer, had in mind when he developed the logic analyzer, back in '73. He called it a "glitch fixer," designed to track and unravel the mysterious electronic glitches that plague digital logic designs.

Bill Moore was named Man of the Year by Electronics magazine for his invention.

We're proud of that. In fact, pride is a big part of everything we do. It's the secret ingredient in each logic analyzer in our broad line.

Our other "secret ingredient" is good hearing. We listen carefully to our customers. Then design our products to meet your needs. And we keep a finger on the pulse of technology. So we can understand the special demands it puts on you.

As a result, we've been first with each important logic analyzer advance. For example, when we developed "latch mode" we gave you the capabilities to latch onto glitches — random pulses — as narrow as 2 nanoseconds in current models.

GLITCH FIXER.™

Today our K100-D includes latch mode — and much more. It's the premier logic analyzer for the most complex logic problems. It combines built-in display, keyboard input, 16 channels (up to 32 with adapter) and 100 MHz sampling rate.

Not every application requires such a powerful tool. To meet your special needs, we can deliver seven models, with 8, 9, 16, 27 or 32 channels, sampling rates to 200 MHz and memory lengths to 2048 words.

Which glitch fixer is best for your application? Call us at (408) 988-6800 to discuss your needs — or any time you need technical assistance. Our application engineers are here to help. For more information on our complete line of logic analyzers, write for our catalog.

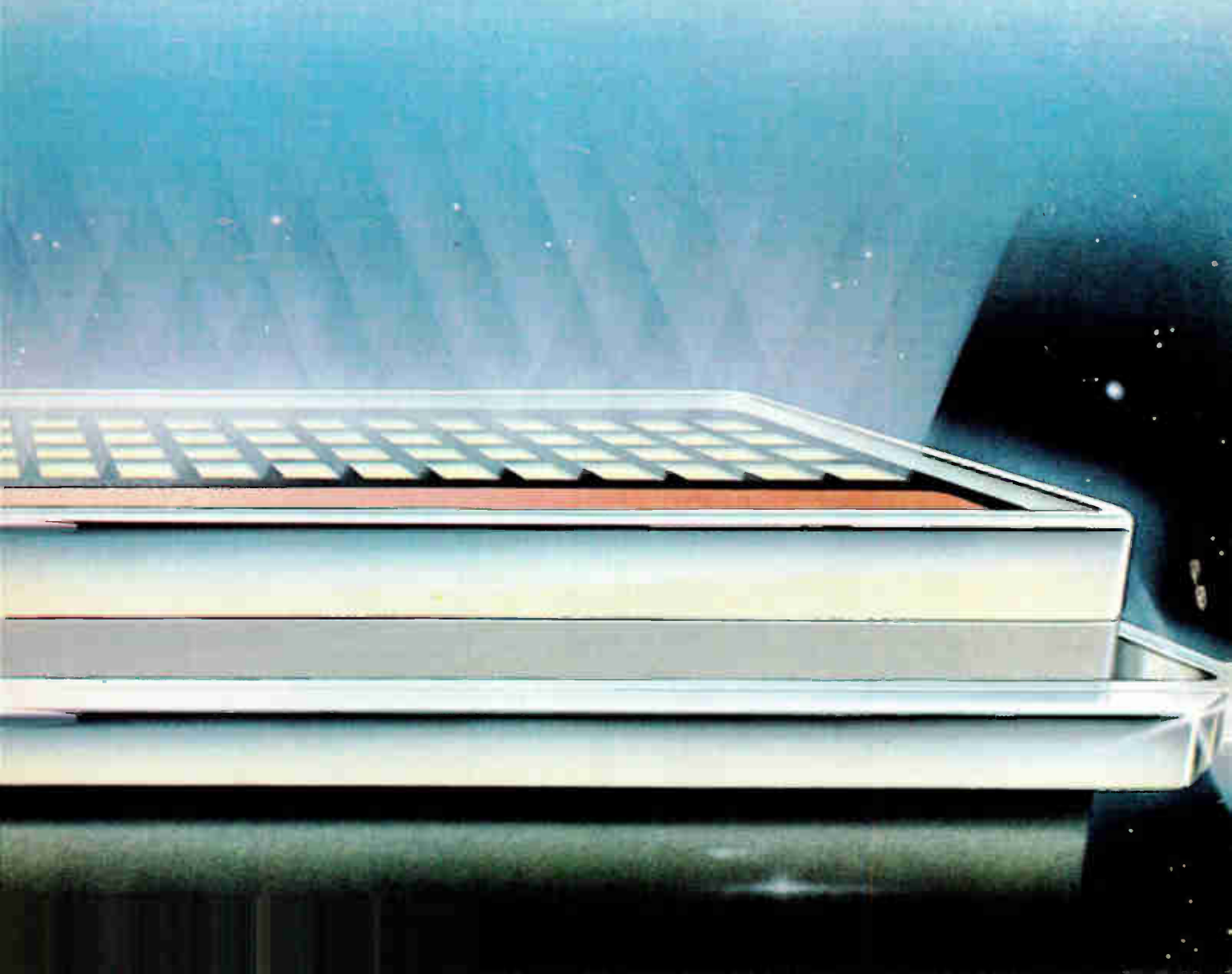
Write Gould Inc., Biomation Division, 4600 Old Ironsides Dr., Santa Clara, CA 95050.

And the next great glitch fixer? One thing you can be sure of. It — and the one after it — will be wearing our name.

GOULD

An Electrical/Electronics Company

Circle #21 for information



Tektronix announces the

next generation of scopes. The 7854.

Solutions at the touch of a button.

Now Tektronix offers a new measurement tool for those who depend on oscilloscope measurements — the 7854. It is designed to improve measurement quality yet simplify measurements. Look at these features to see how you can put its measuring power to work for you.

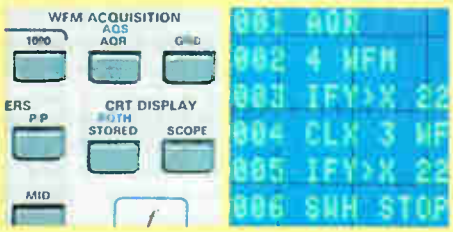
Digital storage.

Digital storage lets you view the same node twice or compare waveforms without bothering with waveform photography or having to move probes and repeat control adjustments. Digital storage improves measurement quality, since resolution is increased to .01 division. Averaging improves measurement accuracy on signals buried in noise. With digital storage, you've got an open door to fast waveform processing and more repeatable measurements.

Waveform processing.

At the touch of a button, waveform processing gives you solutions for common waveform measurements like rise time, period, frequency, RMS, energy, mean, max, and mid. Also, cursors aid in delta time and delta voltage measurements.

Within seconds, you can obtain repeatable answers like rise time without having to adjust position controls or determine the number of divisions between points.



Keystroke programming.

Like a handheld programmable calculator, the 7854 offers keystroke functions for storing, organizing, and reducing data. You can program the scope to acquire and monitor data without an operator's presence. You can even tailormake special functions to avoid manually repeating a series of keystrokes.

GPIB.

The 7854's GPIB interface provides access to processing in external controllers like the Tek 4050 Series. GPIB also allows mass storage and coordination with other instruments.

Part of the Plug-In Family.

The 7854 is the newest member of Tektronix' well-respected 7000-Series family of high performance scopes. Featuring a real time bandwidth of 400 MHz, it's compatible with 7000-Series plug-in units including differential amplifiers, samplers, DVM's, counter/timers, logic and spectrum analyzers, TDR's, and others.

Put the 7854's processing power to work for you. For more information on this new generation of oscilloscope from Tektronix fill out the coupon below or call your Tek Sales Engineer.

For the address of your nearest Tektronix Field Office, contact:

U.S.A.
Tektronix, Inc.
P.O. Box 1700
Beaverton, OR 97075
Phone: 503/644-0161
Telex: 910-467-8708
Cable: TEKTRONIX

Africa, Europe Middle East
Tektronix Int'l, Inc.
European Marketing Center
Postbox 827
1180 AV Amstelveen
The Netherlands
Telex: 18312

Asia, Australia, Canada, Central & South America, Japan
Tektronix, Inc.
America's/Pacific
P.O. Box 500
Beaverton, OR 97077
Telex: 910-467-8708
Cable: TEKTRONIX

Tektronix®
COMMITTED TO EXCELLENCE

Yes, I'm interested in the new 7854.

Name _____

Company's name _____

Title _____

Address _____

_____

Phone (____) _____ ext ____

___ I'd like information on GPIB systems applications

___ Please send me additional information

___ Please contact me for a demonstration

The 7854 Oscilloscope brochure and accompanying specifications folder provide full details on this new instrument.

Editorial

A good place to start the counterattack

The drumbeat grows louder: the U. S. is in danger of losing its preeminence as the world's leader in electronic technology and productivity. There is no doubt that there is a growing problem, but thus far solutions have been mostly of the shoot-from-the-hip variety generated by anger and frustration.

However, Leo Young, president of the Institute of Electrical and Electronics Engineers, has broached a plan that could be the first controlled step toward an orderly countereffort. Speaking last month at the IEEE 1980 Conference on U. S. Technological Policy, a meeting subtitled "Global Competition in the 1980s," Young urged a "holistic, long-term approach," starting with a presidential commission empaneled to study the engineering profession as a whole. Such a study would include the supply of engineers, the "quality and scope" of their education, innovation and productivity in industry, the professional needs of engineers, and, perhaps most important, "the possibility of a focal point for engineering in government—perhaps even a cabinet-level position."

Technology must be recognized as a national priority, says Young, and after that, engineering must receive the kind of special consideration from the Federal government that is accorded medicine, law, science and agriculture. A White House request for an evaluation of engineering and science education, due in July from the Department of Education and the National Science Foundation, is not enough, Young says, for education is only part of the problem. The White House is expected to take no action on Young's program until it receives that evaluation [*Electronics*, May 8, p. 6].

Young's initiative is an idea whose time has come. He is on target when he says that technology too often has been used as a whipping boy, whereas "greatness will be restored to this country only as engineers transform the findings of scientists into technological solutions."

Working on America's weaknesses

At the same meeting, Hans M. Mark, secretary of the Air Force, lamented what he called a general retreat in the U. S. during 1945–1970 from the intensive development and application of new technology that characterized the nation from 1860 through World War II. "We had found a way to pass through the gate to a world where the 'quality of life' would be enshrined as the highest good and no entry fee would be required," he says. In the 1960s, Mark adds, the vogue words were "service economy" and "post-industrial society." The inevitable result was a weakening of America's productive ability. Now, it is time to "reindustrialize" the U. S. or become what Prof. Amitai Etzioni of Columbia University characterizes as a "siesta society"—one in which basic productive industry gets short shrift, with the result that nothing works very well.

What must be done? Mark maintains that, to make a conscious national effort at technology development aimed at reindustrialization and modernization of the industrial plant, we first must start with people: make it attractive for young Americans to go into technical and engineering fields. Then, we must lead with our traditional technological strengths—aviation, electronics, synthetics, and so on—while striving to develop new ones where we have serious problems. Young's plan offers a good way.

Now you can avoid the added costs and delays associated with the purchase of "selected" Schottky Rectifiers . . .

THE FIRST 'FULL SPECTRUM' STANDARD SCHOTTKY LINE!

The chart below tells the whole story: a standard "off-the-shelf" Schottky for virtually every need in the 1 to 150 Amp, 20 to 60 Volt range . . . from one source!

To create this definitive "Full Spectrum" Line we developed 7 new series, each characterized to effectively cover a specific area of common usage.

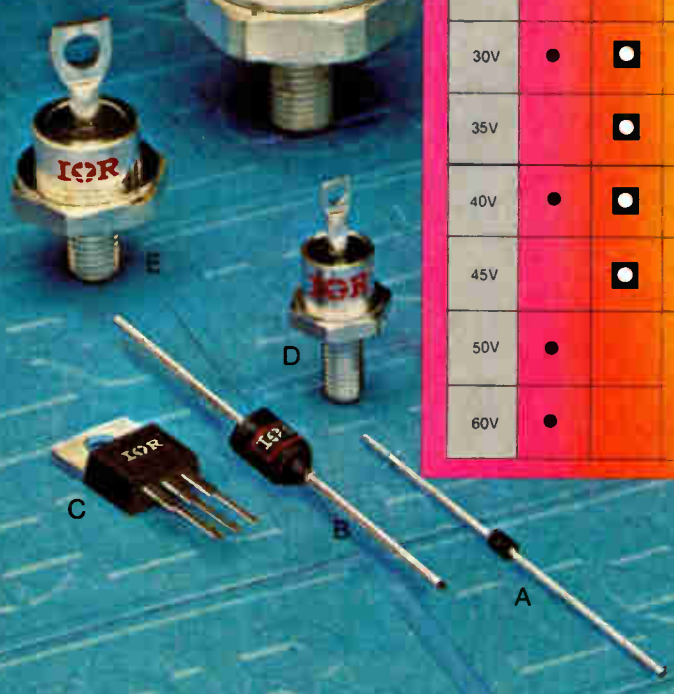
You'll find state-of-the-art low forward voltage devices for operation to 150° C (TJ) and our proprietary "830" Process types for operation to 175° C (TJ) with greater current capability at high temperatures, one-fifth the reverse leakage current, and no voltage derating or thermal runaway.

We've put the whole story with specs and part numbers into a new brochure. Send for it or ask your IR Sales Office, Rep or Distributor for a copy. "Full Spectrum" Schottkys are available through an IR Distributor near you . . . NOW!

Includes 12 new 12, 20 and 30 Amp Dual Schottkys in the TO-220 package!

CASE	A	B	C	C	C	D	D	E	E	E	F
AMPS / VOLTS	1A	8A	12A DUAL	20A DUAL	30A DUAL	30A	30A	60A	75A	85A	150A
20V						●		●			
30V	●	◘	◘	◘	◘	●	◘	●	◘	◘	◘
35V		◘	◘	◘	◘	●	◘	●	◘	◘	◘
40V	●	◘	◘	◘	◘	●	◘	●	◘	◘	◘
45V		◘	◘	◘	◘	●	◘	●	◘	◘	◘
50V	●										
60V	●										

LEGEND: ● LOW FORWARD VOLTAGE 150° C T_J PROCESS
◘ 175° C T_J OPERATION-"830" PROCESS
◘ DUAL CHIP- 175° C T_J "830" PROCESS



INTERNATIONAL RECTIFIER

WORLD HEADQUARTERS: 233 KANSAS ST., EL SEGUNDO, CA 90245, U.S.A. PHONE: (213) 772-2000 TELEX: 66-4484
EUROPEAN HEADQUARTERS: HURST GREEN, OXTED, SURREY, ENGLAND. PHONE: 8833-3215. TELEX: 95219
Manufacturing Subsidiaries, Sales Offices, Representatives, Agents and Distributors Throughout the World.

Circle 25 on reader service card

Meetings

IEEE Computer Conference, NBS and IEEE (Frances Nielsen, B-212 Technology Building, National Bureau of Standards, Washington, D. C. 20234), NBS, Gaithersburg, Md., May 29.

North American Radio Science Meeting and Antenna International Symposium, IEEE *et al.* (1980 URSI/AP-S Meeting, Department of Electrical Engineering, Laval University, Quebec City, Quebec, Canada G1K 7P4), Laval University, June 2–6.

14th Pulse Power Modulator Symposium, IEEE *et al.* (Palisades Institute for Research Services, 201 Varick St., New York, N. Y. 10014), Orlando Marriott Inn, Orlando, Fla., June 3–5.

Eradcom Hybrid Microcircuit Symposium, U. S. Army Electronics Research and Development Command (Fort Monmouth, N. J. 07703), Fort Monmouth, June 4–6.

29th Power Sources Conference, U. S. Army Electronics Research and Development Command (Fort Monmouth, N. J. 07703) *et al.*, Deauville Hotel, Atlantic City, N. J., June 9–12.

Automated Testing for Electronics Manufacturing Seminar/Exhibit, Benwill Publishing Corp. (1050 Commonwealth Ave., Boston, Mass. 02215), John B. Hynes Veterans Auditorium, Boston, June 16–18.

Automation for Safety International Symposium, International Federation for Information Processing *et al.* (ASSOPO '80, Studieadministrasjonen, The Norwegian Institute of Technology, N-7034 Trondheim-NTH, Norway), Norwegian Institute of Technology, Trondheim, Norway, June 16–18.

First Annual Conference of the National Computer Graphics Association Inc. (1129 20th St. N. W., Suite 512, Washington, D. C. 20036), Sheraton National Hotel, Arlington, Va., June 16–19.

1980 Power Electronics Specialists Conference, IEEE, Dunfey Atlanta Hotel, Atlanta, June 16–20.

International Microcomputers Minicomputers Microprocessors/DATACOMM '80 Conference, Industrial and Scientific Conference Management Inc. (222 W. Adams St., Chicago, Ill. 60606), Palais des Expositions, Geneva, June 17–19.

19th Annual Technical Symposium, Association for Computing Machinery (1133 Avenue of the Americas, New York, N. Y. 10036) and National Bureau of Standards, NBS, Gaithersburg, Md., June 19.

17th Design Automation Conference, IEEE Computer Society *et al.*, Radisson Hotel Downtown, Minneapolis, Minn. June 23–25

38th Annual Device Research Conference, IEEE *et al.*, Cornell University, Ithaca, N. Y., June 23–25.

11th International Quantum Electronics Conference 1980, IEEE *et al.*, Sheraton-Boston Hotel, Boston, June 23–26.

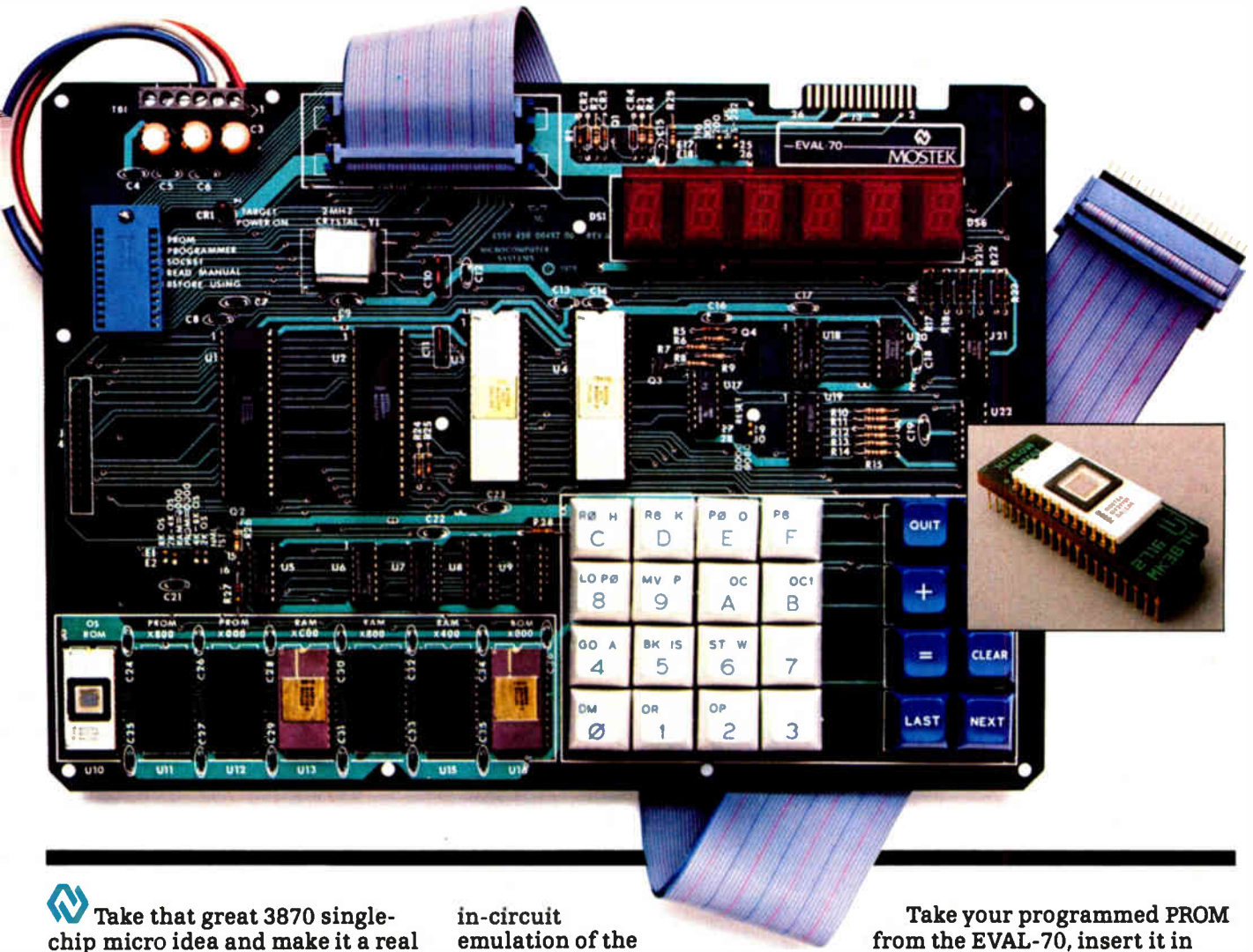
Conference on Precision Electromagnetic Measurements—CPEM 1980, IEEE *et al.*, Stadthalle, Braunschweig, West Germany, June 23–27.

IBI World Conference on Transborder Data Flow Policies, Intergovernmental Bureau for Informatics (P. O. Box 10253, 00144 Rome, Italy), Auditorium della Tecnica, EUR, Rome, June 23–27.

Short courses

Gordon Research Conferences (Alexander M. Cruickshank, director, University of Rhode Island, Kingston, R. I. 02881), Chemistry and Physics of Microstructure Fabrication, Colby-Sawyer College, S. New London, N. H., June 23–27, and Metal-Insulator-Semiconductor Systems, Tilton School, Tilton, N. H. July 21–25.

Field test your 3870 design for under $600.



Take that great 3870 single-chip micro idea and make it a real application. Or set up a one-shot test quickly and economically. The tools for this easy, fast, reliable and easily duplicated design solution: Mostek's EVAL-70™ and the MK3874™.

EVAL-70 is our new single-board microcomputer for program development, debugging and emulation of Mostek's entire 3870 family of single-chip microcomputers.

Write and debug your program in RAM using the powerful DDT-70 operating system. Use the 40-pin emulator cable for real-time, in-circuit emulation of the 3870, 3872 or 3876. Software single step your program for errors. To finish, load the program into a 2716 EPROM using the EVAL-70's on-board PROM programmer.

MK3874 is our piggyback EPROM single-chip microcomputer with the same architectural features, pinouts and I/O lines as other 3870 family members. Using 24-pin EPROMs, the 3874 can address 1K, 2K or 4K bytes of memory, for ideal 3870 family prototyping, testing or low volume production.

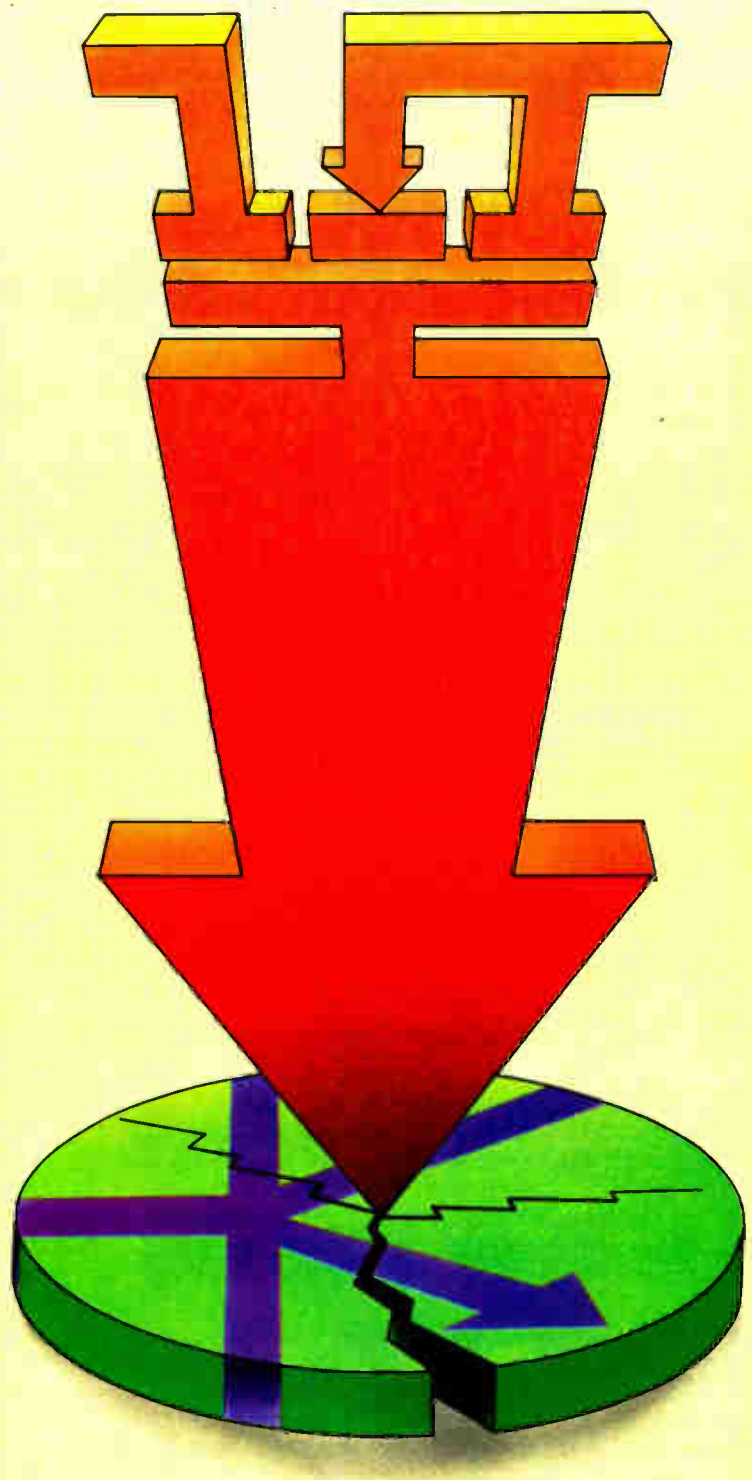
Take your programmed PROM from the EVAL-70, insert it in the 3874, put the 3874 in the target socket and field test your idea.

An inexpensive yet powerful combination: the EVAL-70 is $499; an MK3874 without PROM is $92.

See both at your Mostek distributor. Or contact Mostek, 1215 West Crosby Road, Carrollton, Texas 75006; phone 214/323-6000. In Europe, Mostek Brussels; phone 660.69.24.

MOSTEK.

Siliconix VMOS ends



The Quad breakthrough

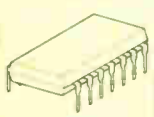
bipolar dominance

VMOS Quads are here with volume economy.

Siliconix was first with Vertical MOS FETs back in 1976. Ever since we introduced VMOS, we've been providing designers with advanced ways to control power. Today we're bringing you a new way to control multiple currents—economically. Introducing Siliconix VMOS Quad power FETs. Our Quads are in volume production, selling at volume prices and on distributor shelves today.

This is the news you've been waiting for if you're still using bipolar drivers. Our new VMOS Quads are ideally suited for the demands of printer, line and memory drivers, lamp and relay drives, in fact, most peripheral drive applications. Packing the performance of four VMOS power FETs into one package, Quads provide you with all the traditional VMOS benefits: faster switching, high gain, high input impedance, linear operation, a wide safe-operating-area, paralleling without current hogging, and freedom from secondary breakdown and thermal runaway. In short, our new VMOS Quads provide everything you expect from VMOS with some important new advantages.

VQ1000 Specifications

14 PIN DIP 	BV_{DDS}	60 volts
	$I_{D(on)}$	0.3 amps
	$I_{D(on)}$ pulsed	1.0 amps
	$R_{DS(on)}$	5.5 ohms
	$t_{(on)}$ $t_{(off)}$	10 ns
	$P_{D(max.\ total)}$	1.2 watts
	Input Zener	yes

Quads make production economy automatic.

Because they are packaged in a standard 14-pin DIP, VMOS Quads can be stuffed onto p.c. boards using automatic insertion equipment. This allows you to substantially reduce handling costs.

VMOS Quads multiply your savings.

When you use Siliconix VMOS Quads in place of bipolars, you can eliminate predrivers and the protective circuitry bipolars require. Your designs become smaller, more economical and space efficient. You use fewer parts so reliability is higher. Moreover, since VMOS Quads are simple one-stage power drivers, they're ideal for boosting the low current output of microprocessors to higher voltages and currents.

Put VMOS Quad economy to work for you.

For more information on VMOS Quads or any of the Siliconix family of VMOS power FETs, dial the Siliconix Hotline: (408) 496-6660. Or just write "VMOS Quads" on one of your business cards and send it to: Siliconix Inc., P.O. Box 4777, Dept. A, Santa Clara, CA 95054.

Siliconix
VMOS power FETs

in power economy

Circle 29 on reader service card

PMI Creates a Rosy New Variety of Analog Switches

In the Linear Wonderland garden, one coat of BIFET covers a lot of CMOS whitewash

In Lewis Carroll's Wonderland, no one was more dreaded than the Queen. She dealt with anyone who crossed her path by ordering their beheading. The gardeners on her croquet court (the Two, Five and Seven from a deck of playing cards) were well aware of the risks.

"Would you tell me please," said Alice, a little timidly, "why you are painting those roses?"

Two began, in a low voice, "The fact is, Miss, this here ought to have been a red rose tree and we put a white one in by mistake. If the Queen was to find out, we should all have our heads cut off."

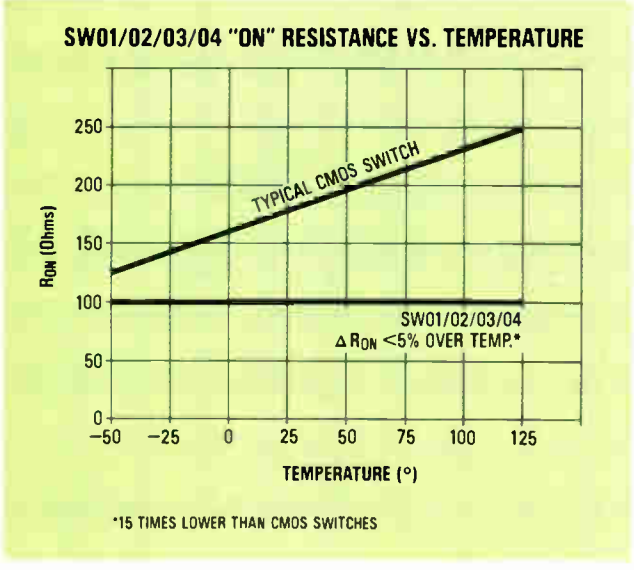
In Linear Wonderland, engineers who pick their analog switches from the CMOS tree are often tempted to yell, "Off with their heads!," just as the Queen did when she found out her red roses weren't really red. What brings out the executioner instinct in every engineer are the thorny problems with "ON" resistance and voltage overload typical of CMOS analog switches.

When PMI decided to get into the analog switch

market, we were determined not to lose our heads. So we looked at the best species of analog switches on the market and decided engineers would find them more attractive if they were grafted with PMI's proven BIFET technology, the same process used in our prized Multiplexer variety of circuits. It wasn't just a cover-up paint job, though; we started at the beginning and created something new: a family of Quad BIFET analog switches that fit the most popular CMOS pinouts but are more rugged electronically than CMOS can ever be.

Consider PMI's SW01/02/03/04. They're Quad BIFET analog switches with temperature-compensated R_{ON} coefficient (0.03%/°C), low R_{ON} vs. voltage (~4%) *and* a low absolute R_{ON} (100Ω maximum at 25°C). That's better performance than you get from CMOS, or even from the other BIFET switches on the market. In addition, you get low leakage (~0.2nA) and the protection against blowout that is inherent with PMI's BIFET technology.

ATTENTION DG201 USERS!



We didn't stop there, however. We know that most engineers are as forward-thinking as the White Queen in *Through the Looking Glass,* who told Alice her favorite things are those that happened the week after next. We kept going and developed the 7510/7511 analog switches which were designed to be pin-compatible with the well-known CMOS AD7510/11. These also eliminate the static discharge sensitivity in CMOS devices, improve leakage currents over temperature by two to five times, and there's no need for pull-up resistors to maintain TTL logic thresholds.

All in all, we think we've got the most beautiful Analog Switch Tree anywhere in Linear Wonderland. To prove it, we'd like you to use the coupon for your "BLOOMIN' SWITCH SAMPLE."

You'll find out that those CMOS guys don't have enough paint in their buckets to gloss over the advantages of PMI's Quad BIFET analog switches. The next time they try, you'll know what to say.

"Off with their heads!"

If someone beat you to the coupon, write to us for your sample. Or circle #199 for literature.

SW01	—Normally ON, no disable. (Pin compatible to both DG201 and LF11201.)
SW02	—Normally OFF, no disable. (Pin compatible to the LF11202.)
SW03	—Normally ON, with disable.
SW04	—Normally OFF, with disable.
SW7510	—Normally OFF. (Pin compatible with the AD7510.)
SW7511	—Normally ON. (Pin compatible with the AD7511.)

Precision Monolithics, Incorporated
1500 Space Park Drive
Santa Clara, California 95050
(408) 246-9222 TWX: 910-338-0528 Cable: MONO

In Europe contact:
Precision Monolithics, Incorporated
c/o Bourns Ag
ZUGERSTRASSE 74, 6340 Baar, Switzerland
Phone: 042/33 33 33 Telex: 78722

Check the box for the "BLOOMIN' SWITCH SAMPLE" you'd like to have.

☐ SW01 – Normally ON, no disable. ☐ SW02 – Normally OFF, no disable.
☐ SW03 – Normally ON, with disable. ☐ SW04 – Normally OFF, with disable.
☐ SW7510 – Normally OFF. ☐ SW7511 – Normally ON.

I am now using: ☐ DG201 ☐ HI201 ☐ LF11201 ☐ LF11202

Mail to: **Precision Monolithics, Inc.,** 1500 Space Park Drive, Santa Clara, CA 95050

or: **Precision Monolithics, Inc.,** c/o Bourns Ag Zugerstrasse 74, 6340 Baar, Switzerland

My name_____

Title_____

Company_____

Dept._____

Address_____

_____

Phone (_____) _____

Our production LSI tester won't put the squeeze on your profits.

The cost of testing seems to be skyrocketing. Benchtops look cheap enough until you start adding up their program development and hardware interface costs. And systems designed for both production testing and engineering characterization force you to buy more than you need. So already narrow profits are squeezed even more.

Take heart. Because we've got a system specifically designed for high volume, high throughput production testing. It's called Sentinel™ and it comes complete with a surprisingly low hardware cost and virtually no software cost.

Sentinel is software-compatible with our Sentry® systems. So you can avoid high program development costs by using your Sentry programs for production testing on Sentinel. Which means you can get on line fast and for less money.

Unlike hardware based benchtops, Sentinel's general purpose architecture lets you test a wide variety of devices and technologies. Simple peripheral chips. Complex micro-processors. And just about anything up to 64 pins.

For production throughput, Sentinel is tough to beat. Its production-oriented operating system minimizes test plan execution time. And its dual-level comparators eliminate the need for multiple passes on functional tests.

So relieve your profit squeeze. Look into Sentinel. Low cost hardware. Proven software. And the same worldwide field service team that gives Sentry the highest uptime record in the industry. Call us at (408) 998-0123. Or write Fairchild Test Systems Group, 1725 Technology Drive, San Jose, California 95110.

FAIRCHILD

A Schlumberger Company

The First Family of ATE.

Circle 32 on reader service card

Electronics newsletter

New conversion method ups speed at which DVM reads accurately

Hewlett-Packard Co.'s Loveland (Colo.) Instrument division is set to introduce a new data-acquisition and -control unit that blankets applications from research to steel production. Called the 3497A, it features an optional high-speed digital voltmeter. The meter uses a new multiple-slope conversion technique that **combines the speed of successive approximation with the accuracy of dual-slope integration;** the new technique will also be used in other HP system DVMs. Adjustable for different integration times, the 3497A's DVM gives 50 readings per second with 5½-digit resolution and 300 with 3½-digit resolution.

Programming aid displays 'keyboards' for each decision

An aid to programmer productivity, in the form of a dedicated cathode-ray-tube terminal system called Proteus, will debut soon. Developed by Solid State Technology Inc. in Woburn, Mass., and the Massachusetts Institute of Technology in Cambridge, Mass., Proteus can generate and show on its screen specialized keyboardlike displays offering only the inputs necessary for each operator decision. **Programmers can design their own keyboards on the screen,** making individual symbols stand for whole subroutines or programs.

Automated tester sets speed mark

Researchers at Lockheed Missile and Space Co.'s Microelectronics Center in Sunnyvale, Calif., have put together an automated system for testing large-scale integrated wafers with signals in the gigahertz range, an order of magnitude above today's commercial systems. **Almost the entire system has been built with off-the-shelf instruments.**

Executives at Electro see strong 1980 and healthy 1981

A panel of industry chief executives and analysts predicts little important deterioration in electronics industry sales through year-end and sees a fairly healthy 1981—though its members agree that hard forecasting beyond about six months is risky. **Such optimism runs counter to the opinions of some analysts who predict a slowdown in the third or fourth quarter of 1980.** Meeting at Electro/80 in Boston, the group pointed to a number of positive signs: strong overseas sales and markets opening or expanding in digital communications, cable TV, automotive electronics, and automatic test and military equipment.

Signetics makes ECL move with Fairchild 100-K

Signetics Corp.'s Logic division, which has quietly built a multimillion-dollar business by second-sourcing Motorola Semiconductor's 10,000-gate (10-K) MECL devices, **is about to launch a new offensive into the emitter-coupled-logic marketplace.** Not only does the Sunnyvale, Calif., division plan to expand its 10-K emitter-coupled-logic offerings significantly, but it will soon make its move into the 100,000-gate (100-K) ECL arena by second-sourcing a majority of 100-K ECL parts offered by Fairchild Camera and Instrument Corp.

Nixdorf buys software firm, unveils computers

Smaller computers with bigger software capabilities will be the key to most user markets in the 1980s, according to Nixdorf Computer Corp. The Burlington, Mass., firm hopes to strengthen its hand in these areas with its acquisition of The Computer Software Co., a Richmond, Va., firm whose billings hit $5 million in 1979, **and with a spate of product introductions**

aimed at personal-computer users and small to medium-sized corporate customers. Meanwhile, the parent firm, Nixdorf Computer AG of Paderborn, West Germany, is making its long-expected entrance into the mainframe business.

Slump causes Motorola to sell car radio lines

The auto and housing sales slumps are cutting into related electronics industries in the Midwest, and the first sell-offs and layoffs have begun. Motorola Inc. has sold most of its line of auto radios geared to the retail aftermarket. The reasons: **car sales are sharply lower and an expensive retail inventory buildup stalled on high costs** [*Electronics*, June 7, 1979, p. 48]. The ARA Manufacturing Co., Dallas, bought the operation.

Meanwhile, the precipitous increase in mortgage rates has led to a near halt in new-home sales, and Honeywell Inc.'s Residential Control Center has laid off more than 100 workers in its various lines. Competitor Pittway Corp. says that first-quarter revenues from its line of First Alert smoke detectors and burglar alarms were down 26%, with profits off 52%.

Converter boards offered by TRW for evaluation

TRW Inc.'s LSI Products division in El Segundo, Calif., is making available evaluation boards of its popular monolithic 6-bit 30-MHz flash-type analog-to-digital converter. By redesigning the TDC1007PCB evaluation board for its high-speed 8-bit digital-to-analog converter, the division has produced the TDC1014PCB 6-bit a-d converter evaluation board, which will sell for $168 in 100-piece prices. **The company also says that it could conceivably have a 10-bit 10-MHz a-d flash converter within a year** and that the price of 6-bit 15-MHz a-d converters could drop to the $20 level within three to four years. Meanwhile, TRW's Defense and Space Systems group is building a monolithic bipolar 10-bit 40-MHz a-d converter under a defense contract.

Systron-Donner and English firm offer response analyzer

SE Labs Ltd.'s Instrumentation division of Feltham, Middlesex, England, and Systron-Donner Corp. of Concord, Calif., are bringing to market their first joint product, the model 2450 frequency response analyzer. The under-$20,000 unit provides **virtually noise-free dynamic measurements of a system's transfer function in virtually any environment,** performing with a precision approaching that of $100,000 minicomputer-based systems.

Addenda

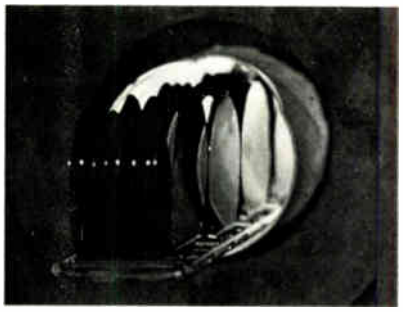
Look for Texas Instruments Inc. to announce a version of its TMS 1000 4-bit single-chip microcomputer **housing an 8-bit digital-to-analog converter.** . . . Beckman Instruments Inc. of Fullerton, Calif., will soon start selling its hybrid 12-bit complementary-MOS digital-to-analog converters through its distributors, **the first time hybrid converters will be sold this way.** . . . Precision Monolithics Inc. of Santa Clara, Calif., has set up a unit **to custom-fabricate IC wafers.** . . . TRW Electronics has formed a division called TRW Array Processors in Sunnyvale, Calif., **to make high-speed digital array processing systems for commercial markets.** . . . Digital Equipment Corp. and Intel Corp. will join Xerox Corp. to develop Xerox's Ethernet internal data-communications system for business offices. DEC **will provide transceivers, Intel the interface circuitry, and Xerox the overall network design.**

Bipolar is our business.

And our future.

MMI is committed to designing and delivering the bipolar product you want. In volume. On time.

Continued leadership in bipolar technology.
MMI has grown to become a $65 million company by consistently designing and delivering state-of-the-art bipolar LSI products. And now we're growing faster than ever.



Our tradition of excellence began with the industry's first 1K PROM in 1971. This was followed by the first 2K, 4K and 8K bipolar PROMs, by the first fast 8x8 multiplier, and then the 15 MHz FIFO. Our latest innovation is PAL™ programmable array logic, the LSI circuit which allows you to program your own logic on a chip.

And we'll continue the tradition, working hard in the future to develop products which are denser, faster and more economical . . . the products you want!

Delivery that keeps pace with our designs.

MMI has made a commitment to deliver large volumes of bipolar products. We currently ship—and will continue to ship—more bipolar PROMs than anyone else in the world.

Our annual output has tripled during the last twelve months.

MMI was the first to install a 4-inch bipolar wafer fab line. And we will expand that line's capacity by another 80% before the end of 1980. At the same time, we have begun converting our 3-inch line to 4 inches and will double its output by mid-1981. We have also broken ground on a new assembly facility and expect it to be operational by September of this year. Over the next few years we'll spend 15-20% of every sales dollar on facilities and equipment to assure you volume delivery of MMI's bipolar LSI.

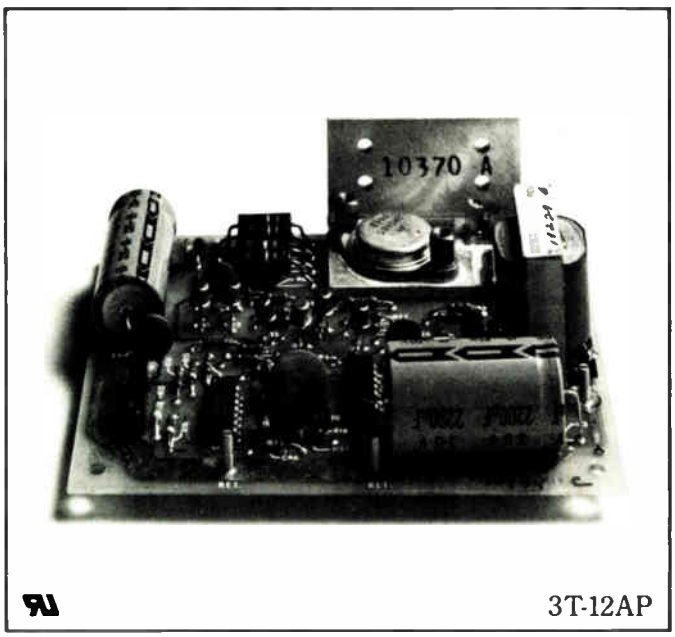
Let us prove it.

Send for a specially prepared report which details MMI's engineering and production capability and outlines our extensive line of digital bipolar LSI products. Please address your requests to Applications Department, Monolithic Memories, Inc., 1165 E. Arques Ave., Sunnyvale, California 94086.

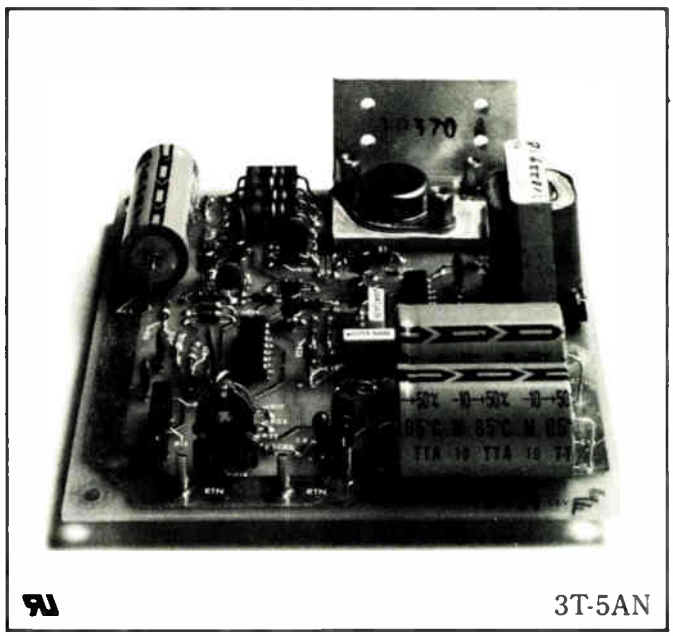
Monolithic Memories MMI

Circle 37 on reader service card

People are switching to Boschert



3T-12AP



3T-5AN

because only Boschert offers a totally new concept in power regulation: 3T switching regulators.

Boschert 3T switching regulators can completely change the way you think about power regulation. See for yourself by answering true or false:

In a switching power regulator, input-output voltage differentials must be kept low.

False. With Boschert 3Ts, you can start with 10 to 40 volts and get 4.5 to 30 volts out, without a power penalty.

To get negative voltage out, you need negative voltage in.

False. Our 3T-5AN lets you take positive dc in and produce negative dc out.

Regulation is inherently inefficient.

False for 3Ts. They offer 70-90% efficiency over the entire operating range.

The magnitude of output voltage must be lower than the input.

False. Our 3T-5AN lets you set the output magnitude less than, equal to or greater than your input voltage.

	3T-12AP	3T-5AN
Input Voltage	+10 to +40	+10 to +40 volts
Output Voltage	+4.5 to +30	−4.5 to −30 volts
Output Current	0 to 12	0 to 5 amperes
Efficiency	70-90%	70-90%
Output voltage and current limits are adjustable.		

Multiple output voltages require multiple tap transformers.

False. All 3T regulators can be powered from the same dc source.

Designing for a wide line voltage range means wasted power at normal line. False. Efficiency is virtually independent of the transformed line voltage input to 3Ts.

Battery backup of multiple voltages requires multiple batteries or a special UPS design.

False. You can backup the input to multiple 3Ts, using one standard battery.

With Boschert 3Ts, you can build better power supplies, build battery backup or single-battery multiple-voltage systems, even add extra voltages to an existing system without redesigning your supply. You see? Boschert 3Ts have already changed your ideas about power regulation. We've got 3Ts in stock, in volume, so you can put your ideas into practice today. For more information, contact your Boschert representative or write us: Boschert Inc., 384 Santa Trinita Ave., Sunnyvale, CA 94086. Or phone (408) 732-2440.

powered by boschert

Circle 38 on reader service card

"SEE OUR BOOTH AT THE NCC SHOW #2659-61"

Three-chip mainframe to accompany other Intel processors

by John G. Posa, Solid State, and Richard Comerford, Measurement Editor

Advance announcements herald 32-bit computer on three chips with object-based architecture

Due for unveiling by Intel Corp., perhaps by year-end, is what amounts to a mainframe computer on silicon. The 32-bit three-chip machine joins a raft of new processors and board-level, development-system, and software-support products that the Santa Clara, Calif., company is announcing well in advance.

The announcements are part of a bold marketing scheme aimed at bolstering Intel's position in the high-performance microprocessor race. They reflect the company's vow to develop software-intensive machines [*Electronics*, Feb. 28, p. 89] to simplify program writing for the complex functions these processors will be called upon to perform.

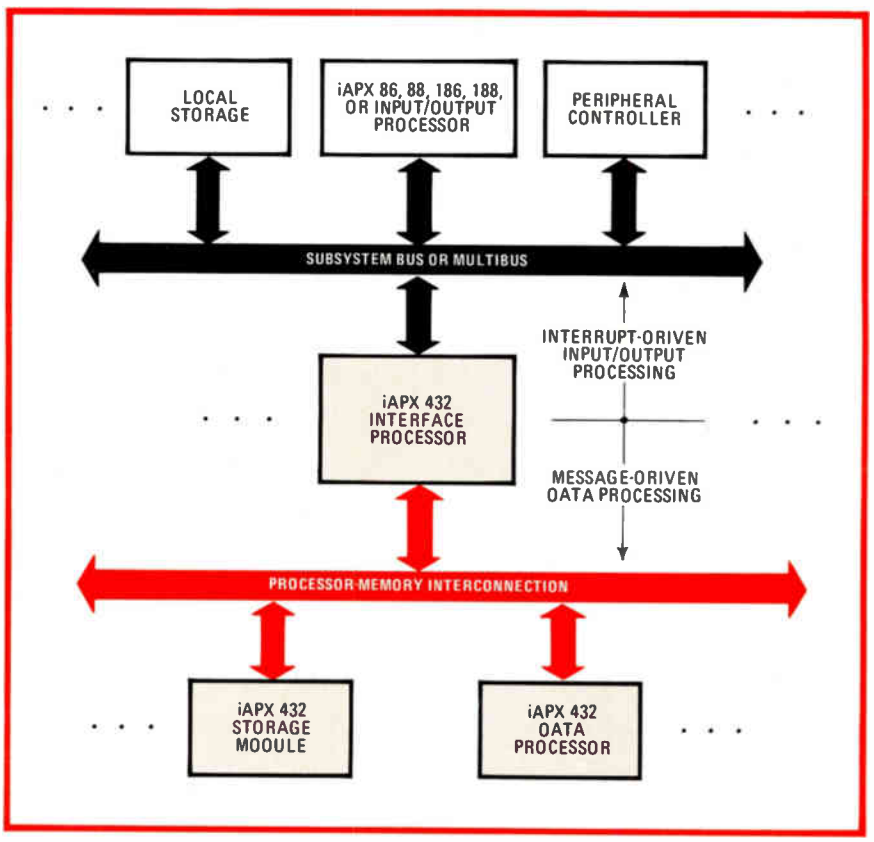
The three chips that will make up the iAPX 432 silicon mainframe will be an interface processor, a data processor, and a storage module (see figure). Housed in 64-pin quad in-line packages, these very large-scale integrated circuits may feature as many as 120,000 transistors per chip and geometries as tiny as 0.5 micrometer.

Architecture. The 432's architectural philosophy, with a computational style markedly different from ordinary microprocessors, was discussed earlier this month at the seventh annual Symposium on Computer Architecture in La Baule, France. "Our structure is based on objects rather than actions—on the 'what' [like an array of data] rather than the 'how' [like move or add operations]," explains Justin R. Rattner, principal engineer for Intel's Special Systems operation in Aloha, Ore.

The approach is somewhat like that of IBM's System/38 [*Electronics*, March 15, 1979 p. 101]. In effect, the hardware embodies an understanding of the types of operations that can be associated with differing data structures (the objects) and thus relieves programmers of spelling out these operations.

To manipulate these objects, Intel has given the machine two instruction sets. Both are based on high-level languages with extensive data structures: one is Pascal, and the other is Pascal-based Ada. The architecture and language combination provides a framework wherein "software design methodology comes along for free," says Rattner.

16-bit arena. By 1981, Intel also will introduce three other new microprocessors: the iAPX 188 and 186 are 16-bit chips and the iAPX 286 has 32-bit attributes. (Also, the 8086 and 8088 microprocessors have



Step up. Intel's three-chip 32-bit microprocessor, the iAPX 432, integrates high-level-language and operating-system functions into a new architecture.

been renamed the iAPX 86 and iAPX 88). Unlike the iAPX 432 chips, these ICs are emerging from Santa Clara—not Aloha—and their instruction sets will be compatible with the iAPX 86's.

The iAPX 286 will offer five times the performance of a standard iAPX 86. Moving into the territory of much larger machines, it will support 10 to 200 tasks in multiprogramming environments and will address a 16-megabyte physical or a 1-gigabyte virtual space through on-chip memory-management and protection logic.

Positions. The iAPX 188 will have a multiplexed 8-bit bus to provide an upgrade path for 8085 and iAPX 88 users. The iAPX 186, with its 16-bit interface, is targeted as a higher-performance iAPX 86 replacement.

Like the 432, these three processors take another bite out of software development costs because they will have access to kernel functions for an integrated operating system. These functions, which will first be offered in firmware for connection to a high-speed local bus, will create tasks, send messages, wait for semaphores, and so on.

Hot on the heels of its 8085A-2–based Intellec series II development system and mainframe link [*Electronics*, April 10, p. 165] comes the unveiling of the speedier 16-bit iAPX 86–based series III, which will support Pascal-86 and Fortran-86, both due later this year. In addition, Intel has opened up plans for a network that will use its present and future development systems in the form of a disk- and file-sharing system, D/FSS, due by year-end.

Network. D/FSS lets several users at different stations gain access to large programs. At the hub of the network is a central node and mass storage facility to which eight stations can be connected.

Any Intel development system—from the model 800 to the series III—may be connected to or disconnected from the network without logically or physically interfering with it. A model 240 or 245 hard-disk unit can be converted to a central node with an upgrade package.

Peripherals

Intelligent office telecommunications switch handles data and voice simultaneously

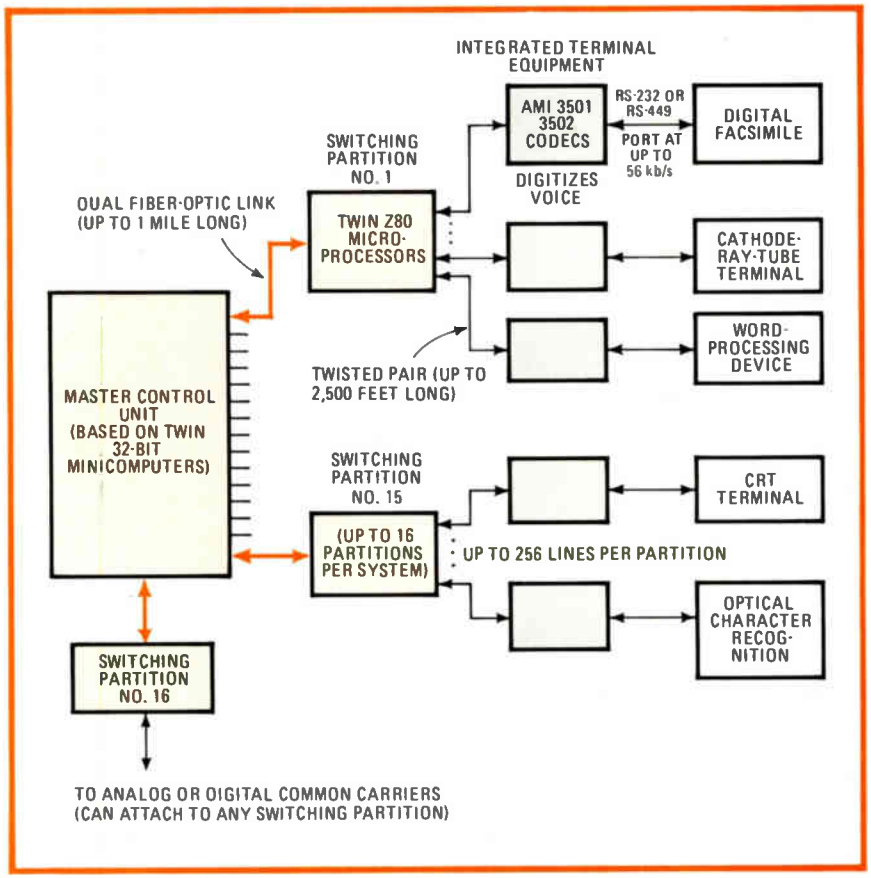
Bringing the fully integrated automated office a step closer, Exxon affiliate InteCom Inc. is unveiling a combined private-automated-branch-exchange telephone switch and a local data network. Its integrated business exchange, or IBX, will handle voice and data communications simultaneously, and it will perform protocol translation between the often incompatible pieces of automated office equipment.

Thus IBX promises to tie together telephones, word-processing units, computers, and facsimile and other office equipment. "We want to be the common intrabuilding channel for all kinds of information," says C. Michael Bowen, president of the Dallas company. "It gets rid of multiple wiring systems."

It is also another approach to the local network concept [*Electronics*, May 8, p. 40]. What's more, IBX will link its network with common carriers—analog or digital—for interfacility communications.

Switch. To accomplish this, InteCom has built a multiprocessor all-digital switch that performs a combination of functions not available in a single system today, Bowen says. Twin 32-bit minicomputers from Perkin-Elmer's Data Systems group equipped with up to 4 megabytes of main memory each and two 10-megabyte disks form its heart.

To this master control unit are



Redundant switching. With redundancy throughout for reliability, the IBX integrated business exchange from Exxon's InteCom simultaneously handles digitized voice and data signals.

connected as many as 16 switching partitions, each of which can handle 256 lines. Each switching partition is built around two Z80 microprocessors from sister affiliate Zilog.

Instead of a conventional analog telephone, InteCom provides what it calls integrated terminal equipment—a tone-dialing phone that includes American Microsystems Inc.'s 3501/2 coder-decoder chips to digitize voice, an RS-232-C or RS-449 port to permit data-terminal attachment, and a controller that multiplexes the two signals onto a twisted-pair wire. The voice becomes a 64-kilobit-per-second signal and the data terminal can simultaneously operate synchronously or asynchronously at rates up to 56 Kb/s, leaving room on the 128-Kb/s line for 8 Kb/s of control signals.

For voice switching, the IBX acts just like a PABX switch, performing intrafacility switching with uniform alternate routing and queueing, call-detail recording, and other sophisticated functions. But its data-switching capabilities set it apart.

Data switch. The master control unit maintains a directory of all the equipment attached to its extensions and their characteristics. For incompatible equipment, IBX uses packet switching techniques and performs protocol and format translation. Bowen will not say what protocols will be handled, however, until first systems are ready for shipping early next year.

The company is the latest of a growing number of firms making electronic office equipment that are financed by Exxon Corp.'s Exxon Enterprises. These companies include facsimile maker Quip System, word-processing company Vydec, electronic typewriter producer Qyx, microprocessor manufacturer Zilog, and a host of others [*Electronics*, April 27, 1978, p. 88]. However, IBX is not limited to linking the products of the coaffiliate firms.

The InteCom offering will face competition from established PABX manufacturers that are adding data-handling capabilities. Rolm Corp. competes with its smaller 500 line Computerized Branch Exchange, and the Business Communications group of Northern Telecom Systems Inc. markets its digital SL-1 that can handle up to several thousand lines. But Bowen is confident that the IBX has a unique combination of features that will make it attractive even at its steep $500,000 to $4 million price range.

InteCom will also get a jump on future competition, says Dale Kutnick, director of research at the Boston-based Yankee group. "AT&T is developing a competitive product code-named Antelope, but that's at least two or three years away, and I suspect it will be at least two years before IBM enters this market," he reports. **-Anthony Durniak**

NCR goes desktop

Shrinking the minimum size and price of its I-8100 line of small-business computers, NCR Corp. is unveiling a new entry-level model, the I-8140. The desktop unit integrates the display with the microprocessor-based central processing unit that includes from 64 to 128 kilobytes of main memory. A separate cabinet holds two floppy-disk drives with as much as 4 megabytes of storage, and a 70-line-per minute matrix printer is also available, according to the company.

The unit is programmable in ANSI-standard Cobol or Basic, and optional software lets the unit simulate the popular NCR 299 accounting computer. Prices for the unit start at $15,255, making it competitive with units like IBM Corp.'s desktop 5100 family. **-Anthony Durniak**

Memories

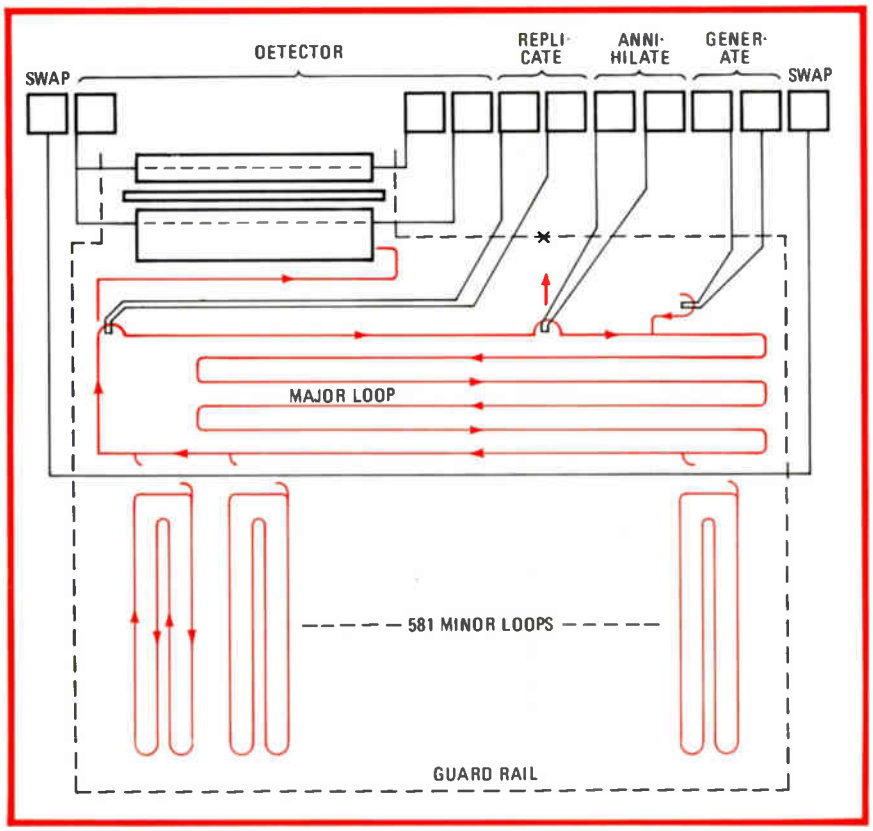
4-Mb bubbles face propagation hurdle

A double-barreled bubble-memory development effort by Rockwell International Corp. aims straight at the major hurdle confronting the next generation of 4-megabit chips: can the familiar chevron-shaped propagation patterns be used, or will it be necessary to go to the more compact contiguous-disk pattern?

Rockwell's Anaheim, Calif., electronics research center is working on 4-Mb bubble chips using both approaches. It has a complete chevron chip, made with conventional lithographic techniques, and it is well on its way to fashioning a part with an ion-implanted contiguous-disk pattern.

Chevron. The 1.5-by-1.5-centimeter completed chip has bubbles 1 micrometer in diameter, so the gap between the Permalloy chevrons—the minimum lithographic feature—must be between 0.5 and 0.67 μm. Rockwell is achieving its submicrometer dimensions with contact lithography.

The chevron chip uses a major/minor loop configuration much like those used in 256-K and 1-Mb bubble chips. The 6-by-6-μm minor loops are C-shaped, rather than simple elipses, facilitating the use of swap gates to move the bubbles from the storage minor loops into the sensing major loop. The design represents Rockwell's incorporation of the swap-gate transfer used by other bubble memory makers; the company has been limited to the block-replicate method. To synchronize



Follow the loop. In its 4-megabit bubble-memory design with Permalloy chevron propagation, Rockwell is using a major/minor loop configuration with C-shaped minor loops.

serial operation, the major loop and the minor loops (see figure) hold identical numbers of bits—8,146—says Isoris S. Gergis, principal designer on the project. Operating at 150 kilohertz at room temperature, it has a performance comparable with that of Rockwell's 1-Mb bubble.

Contiguous disk. However, achieving the required fine features by contact lithography may prove to be a stumbling block in production. So Rockwell and other bubble memory makers are looking at contiguous-disk propagation patterns, even though they are laid down by the much trickier ion implantation.

Because the propagation pattern is one contiguous track, there is no need to achieve the extremely fine minimum dimension that forms the gaps between chevrons. Also, the lack of gaps means that densities can be greater.

Rockwell has completed the minor loops of its contiguous-disk memory and is aiming for a 1.3-by-1.2-cm chip with 8-μm periods (the length of the basic element in the propagation pattern). The minimum feature size is 2 μm, and the minor loops are G-shaped.

The researchers are working on a two-way switch to move bubbles between major and minor loops, since bubbles can move in either direction in contiguous-disk layouts. They also are devising hairpin loop conductors to stretch the bubbles for sensing.

Others. As with 1-Mb bubbles, the company appears well ahead of its competitors on the development trail. But when it came to 1-Mb production, Rockwell was overtaken by its rivals; in fact the company does not sell a part bigger than 256 K.

Other companies acknowledge Rockwell's head start but say they are coming on strong themselves. "I'm sure everybody is working on one," observes James Cunningham, director of National Semiconductor Corp.'s bubble program. His firm is likely to have 4-Mb engineering samples employing chevron propagation later this year, but he is not sure "we will tell the world about them."

At Intel Magnetics Inc., first into 1-Mb production, vice president and general manager Richmond P. Clover would advance no timetable for the next generation. But he did say he sees no trouble in scaling the Intel Corp. subsidiary's 1-Mb part to higher densities, with some changes in loop lengths and dimensions.

The probability of a 4-Mb part "is pretty good . . . in a two-to-three-year time frame," observes H. Dean Toombs, the Texas Instruments vice president for bubble operations. He thinks it may work to build the parts with present technology by going to smaller geometries or by using such density improvements as folded loops—and TI is working on such advances. **-Larry Waller**

Displays

Atoms add luster to electroluminescence

From a small Finnish research laboratory comes a thin-film deposition technique that promises to improve significantly the luminance of electroluminescent displays. Known as atomic-layer epitaxy, it deposits thin-film materials atom by atom, instead of at the coarser nucleated-structure level.

Attendees at the Society for Information Display's recent international symposium in San Diego, Calif., heard the method described by Tuomo Suntola and his associates at Oy Lohja Ab, an Espoo, Finland, research organization. Their approach immediately attracted the attention of leading researchers.

Brighter. The relatively low luminance of electroluminescent materials has restricted their use to some flat-panel displays, but interest persists in them because of their inherently low cost. Suntola reports making a display with a luminance of about 1,500 candelas per square meter when driven at about 85 volts root-mean-square and 10 kilohertz. Under roughly comparable drive

A few of our customers say Abbott MIL Spec power supplies are 99% perfect.

The others say only 98%. For almost fifteen years we have maintained a customer failure rate of 2% for our "C," "S" and "W" MIL Spec power supplies. That's tried and true proof of reliability... in the field.

Our Model "W" family of 400 Hz to DC power supplies is a standard throughout the world for critical military and aerospace applications. They're available with output voltages from 5 to 100 VDC, current levels from 0.3 to 20 amps.

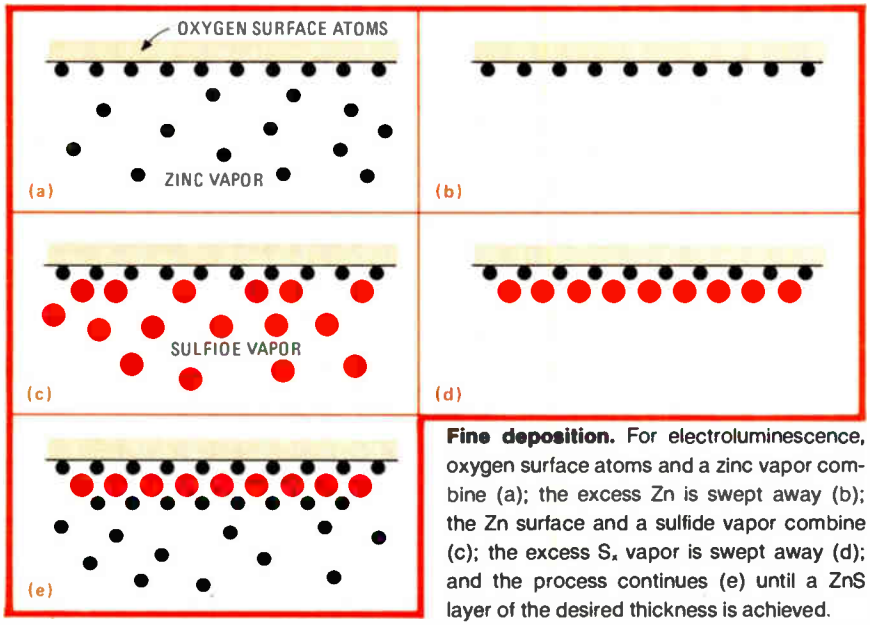
Our "C" family of 28V DC to DC converters and our "S" family of 28V to 400 Hz inverters come in package sizes as small as 2⅛" x 3½" x 3½", and meet the requirements of eleven separate MIL Specs.

For reliability, call Abbott. For delivery, call Abbott. For additional information, write or call Abbott. *See EEM or GOLD BOOK power supply sections*

abbott transistor
MILITARY PRODUCTS DIVISION

Circle 43 on reader service card

Eastern Offices, 1224 Anderson Ave., Fort Lee, New Jersey 07024 (201) 224-6900 TELEX 13-5332
Western Offices, 5200 West Jefferson Blvd., Los Angeles, CA 90016 (213) 936-8185 TELEX 69-1398



Fine deposition. For electroluminescence, oxygen surface atoms and a zinc vapor combine (a); the excess Zn is swept away (b); the Zn surface and a sulfide vapor combine (c); the excess S_x vapor is swept away (d); and the process continues (e) until a ZnS layer of the desired thickness is achieved.

conditions, conventional electroluminescent panels give off about 500 candelas/m², so for adequate brightness they must be driven at much higher voltages or frequencies.

The other major problem with electroluminescent materials is susceptibility to voltage breakdown. Suntola expects that atomic layer epitaxy will reduce this sensitivity because it creates a thin film with fewer pinholes.

As with conventional electroluminescent techniques, the objective is to coat a glass substrate with a thin film of material that emits light when subjected to an electric field. The Finnish technique uses a typical material, zinc sulfide doped with manganese, but deposits it in much finer layers, as the figure shows.

A zinc vapor encounters a glass substrate containing an aluminum-oxide insulating layer, so that oxygen-zinc chemical bonds are formed (a). The substrate's temperature is kept high enough to prevent any zinc from condensing above this monatomic layer (b).

Then a sulfide vapor is applied and another monatomic layer formed by a zinc-sulfide bond is built up (c). Again, the substrate's heat lets only one layer be formed (d). These steps repeat until the desired ZnS layer is formed, typically 3,000 angstroms thick.

Alternatively, the ZnS can be derived from compound vapors laid down in the same manner. For example, zinc-chloride and hydrogen-sulfide vapor layers can be alternated, reacting to produce ZnS.

The secret behind the new process is the deposition equipment, but Suntola refused to release details at the symposium. He did say that, though the equipment is somewhat complex, it works in a low vacuum.

He also said that the equipment for each process step can handle larger substrates than with conventional thin-film deposition. Thus, although total processing time is longer, the throughput is at least as good, he claims. **-Roger Allan**

Personal computers

Apple turns pro to aid professionals

Originally conceived as consumer products, microprocessor-based personal computers are positioning themselves as professional tools serving accountants, stockbrokers, very small businesses, and even engineers. It is not surprising then that the industry leaders are adding sophisticated options to their existing machines or unveiling entirely new models to address these users.

This week's National Computer Conference, for instance, is seeing the unveiling of Apple Computer Inc.'s Apple III, designed around the 2-megahertz 6520A microprocessor, rather than the 1-MHz 6502 in the Apple II. "It is not intended to replace the Apple II, but is the next step in computing power," notes Apple III product marketing manager Don Bryson.

Features. As well as the speed hikes, Apple III also offers 96 kilobytes of random-access memory, with expansion to 128 kilobytes possible, where the Apple II has just 48 kilobytes. The new model adds as standard features a built-in 143-kilobyte mini–floppy-disk drive, a 13-key numeric keypad, and two printer interfaces, and it doubles the display size to 80 characters per line. It can emulate the older unit, however, to preserve the software base.

Along with this hardware, the Cupertino, Calif., company has added a new operating system that handles the memory management for the new larger memory and has file-management capabilities required by the applications' software packages. Also, it is partitioned so that software drivers for the peripherals are separate—a construction that facilitates adding peripherals to the system since the operating system does not have to be changed.

Offerings. Initially, the Apple III will be offered only in two packages. The first is an information analyst package, available in July, that costs $4,400 without a printer and includes Visicalc III, an updated version of the popular Visicalc II chart-based mathematics and analytical mathematics software package written by Personal Software Inc. of Sunnyvale, Calif.

Visicalc III now features a data-interchange format, which can save the user's data on a diskette and then load it back. "A whole family of programs can operate on the same data," says Daniel Flystra, president of Personal Software.

Apple's second package is a word-processing configuration that will include a second floppy disk and

Compatible...Interchangeable...
...the Energy Efficient

CMOS 16k ROM

Please attach this coupon to your company's letterhead with your name, title and mailing address. Send to: Solid State Scientific, Montgomeryville, PA 18936.

☐ Please send more information.

☐ I'd like a free evaluation sample; call me at_____. EI 5/22 mem

But why a CMOS ROM? The SCM5316 from Solid State Scientific is an ideal low power replacement for standard 2316 NMOS ROMs and 2716/2516 EPROMs. It is a 16k static CMOS ROM organized in a 2048x8 configuration.

The SCM5316 can replace the following parts:

EPROMs	CMOS ROMs	NMOS ROMs
2716/27A16	1833 (2)	2316/2616
TMS2516	1834 (2)	MCM68A316
2708 (2)	1835	Am9217/18
IM6653/54 (4)	IM6316	MK31000

Energy Efficient? In your application, the CMOS SCM5316 could mean a power savings of up to 90% or more. This allows for a smaller, less expensive power supply. Since the CMOS SCM5316 is energy efficient, it runs cool and thermal dissipation is negligible. Of course this provides added reliability inherent in energy efficient ICs. The reliability found in our ICs matches Solid State Scientific's commitment to reliable and on time deliveries.

Want to know more? Send in the above coupon or call Solid State Scientific today at **215 855-8400**.

Solid State Scientific
Montgomeryville, PA 18936 / 215 855-8400
TWX 510•661•7267

New pro. The just introduced Apple III is an example of the upscale growth of personal computers into the category of professional tools by the addition of computing power.

either a thermal printer for a $5,400 system price or a letter-quality printer for $7,800 total. First deliveries will be in September.

Packages. Apple's competitors are also closing in on the word-processing and information-analysis market. Commodore Business Machines Inc., which in March unveiled a new business-oriented desktop computer, is announcing its Word-pro-IV word-processing package at NCC. It costs $300 separately and will also come with a 32-kilobyte Pet computer, 250 kilobytes of dual mini-floppy disks, and an impact printer for about $3,500. Commodore's minimum word processing system costs about $2,500.

Earlier this year, Tandy Corp., the volume leader, announced its Scripsit word-processing package for the TRS-80 Model I. The user can buy a word processing package with printer for about $3,300.

Commodore also is announcing a Visicalc package for its Pet computers at NCC. Tandy and Atari will follow suit this quarter.

At stake is a worldwide market estimated by International Data Corp. to be $1.1 billion and growing at a compound annual rate of 30%—enough to make it reach $4.35 billion by 1985. The Waltham, Mass., market research firm notes that business and professional users account for by far the largest portion. They already buy 47% of the units sold in the U. S. and will purchase 67% by 1985. **-Martin Marshall**

Components

New cutting angle keeps crystal calm

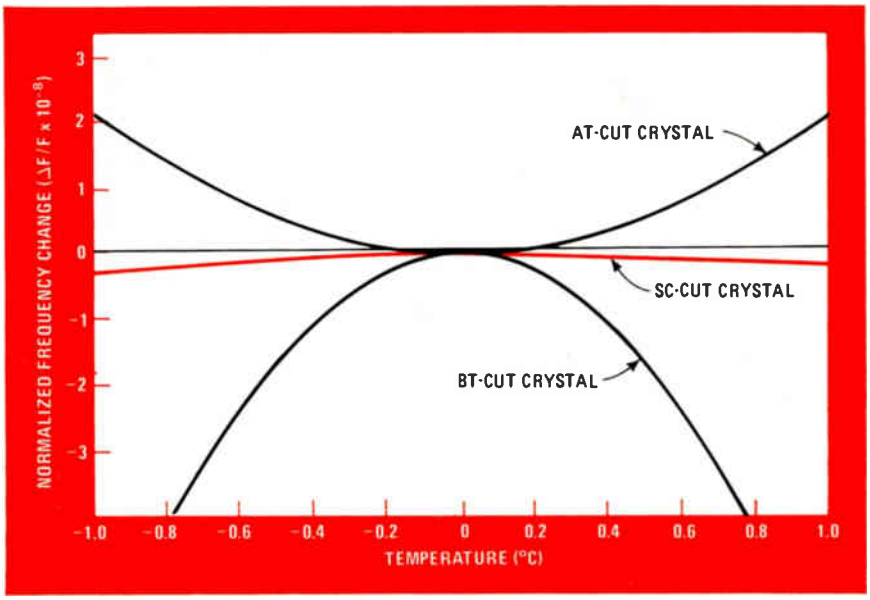
Entering full production at Hewlett-Packard Co. is an oscillator with a doubly rotated, stress-compensated quartz crystal. The new crystal greatly improves the temperature stability and warmup time of such oscillators, which are typically used in test instruments and in communications and navigation gear.

The improved characteristics of the SC-cut crystal come from cutting it at the angle obtained by precisely rotating the master crystal twice, once about its X axis (angle θ) and once about its Z axis (angle ϕ). Single-rotation cuts, such as the familiar AT and BT cuts, are sensitive to small rapid changes in temperature that occur without extremely tight control of oven temperature.

Compensation. These changes set up thermal gradients that stress the crystal, shifting its resonant frequency. Rotating the crystal through a second angle compensates for external stress (hence the SC designation), as well as for rapid temperature changes.

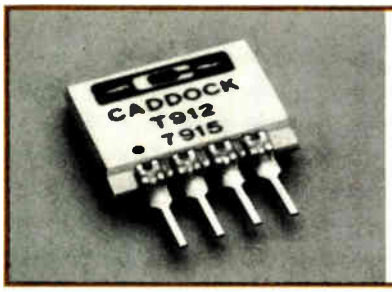
The double rotation means that the cut crystals have a lattice orientation with a zero elastic constant, which internally compensates for any thermal stress. Thus, at 55° ±0.8°C, the frequency shift experienced by SC crystals is less than 1 part in 10^9, an improvement of 10 to 40 times over other crystal cuts (see figure).

Development. About half of the four-year development time was spent in defining the crystal orientation and geometry, says Charles Adams, production engineer for HP's crystal products. "The SC crystal's characteristics are approximately 10 to 20 times more sensitive to angular tolerance than the usual AT or BT cut," he explains. "Then too, getting [the final contour] right moves out the spurious response." The Santa Clara, Calif., company cuts the crystal with typical angles of 34° (θ and



Stable crystal. A double rotation before cutting oscillator crystals gives the SC-cut lattice orientation that compensates for thermal stresses, which can affect frequency stability.

Precision Resistance Ratios from Caddock ..... and more!



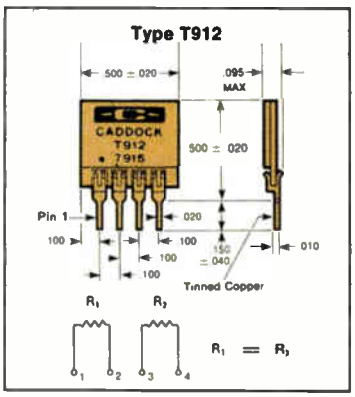
Caddock's Type T912 Precision Resistor Network is the cost-effective replacement for discrete resistor sets.

The ratio characteristics of these high-stability resistor networks make them ideal for applications in precision amplifier circuits, voltage reference circuits and precision bridge circuits.

- **Ratio Tolerances from ±0.1% to ±0.01%.**
- **Ratio Temperature Coefficients of 10 PPM/°C, 5 PPM/°C or 2 PPM/°C.**
- **Ratio Stability of Resistance at Full Load for 2000 Hours within ±0.01%.**

Tetrinox™ — Caddock's unique high-resistance film — provides resistance values from 5 kohm to 2 Megohms in this package size.

Custom models with unequal values can provide resistance ratios as high as 250:1 and values from 1 kohm to 2 Megohms.



Standard Type T912 and T914 Precision Resistor Networks

Standard Resistance Values:

5K	50K	500K
10K	100K	1 Meg.
20K	200K	
25K	250K	
40K	400K	

Special or mixed resistance values are available as custom networks.

Ratio Tolerance:
Maximum ratio difference between any two resistors in the network.

-100 = 0.10%
-050 = 0.05%
-020 = 0.02%
-010 = 0.01%

Ratio Temperature Track:
Ratio Temperature Coefficient between any two resistors in the network from 0°C to +70°C.

-10 = 10 PPM/°C
-05 = 5 PPM/°C
-02 = 2 PPM/°C

Ordering Information:

To specify any of the standard Type T912 and T914 resistor networks, use this model number.

T912 - 500K - 010 - 02

Model No. — Resistance Value* — Ratio Tolerance* — Ratio Temperature Track*

* (This information appears on the back side of the network)

The standard models of Type T912 resistor pairs and Type T914 resistor quads can be delivered in prototype and production quantities from stock to within 6 weeks ARO.

For additional technical information — and immediate confirmation of price and delivery on initial quantities — call or write directly to:

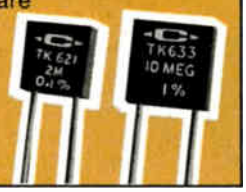
Caddock Electronics, Inc.,
3127 Chicago Ave., Riverside, Calif. 92507
Tel: (714) 683-5361

CADDOCK
HIGH PERFORMANCE FILM RESISTORS

In addition to the Type T912 and Type T914 Precision Resistor Networks shown here, Caddock Electronics is in volume production on many other types of precision discrete resistors and resistor networks:

Type TK Temp-Stable Precision Film Resistors

These .250" and .300" square discrete resistors are rated at .3 and .4 watts, and deliver TCs better than 10 PPM/°C from -55°C to +125°C.



Type TF Low TC Ultra-Precision Film Resistors

Tolerances as tight as ±0.01%, values from 1 kohm to 10 Megohms and a TC better than 15 PPM/°C make the Type TF resistors the ideal replacement for expensive wire-wound resistors.

Type 1776 Precision Decade Resistor Voltage Dividers

25 standard models of these three-, four- and five-decade resistor networks provide values up to 10 Megohms and ratio tolerances as tight as ±0.05%.

Type 1787 Current Shunt Resistor Networks

For accurate current sensing in multi-range instruments, there are 16 standard models of the Type 1787 resistor networks with values between 1 ohm and 1000 ohms and tolerances as tight as ±0.02%.

To receive complete technical information on all of these high stability precision resistors, call or write directly to the applications engineering group at Caddock Electronics, Inc.

CADDOCK
HIGH PERFORMANCE FILM RESISTORS

For type T912 and T914 data circle 46

For Caddocks General Catalog circle 47

22° (ϕ), finishing it to a planoconvex contour.

The remainder of the development time went to devising and perfecting special production equipment. HP uses the crystals in its new 10811 plug-in oscillator that can be substituted for the earlier 10544, which employed a single-rotation crystal.

Warmup. In addition to reducing the temperature sensitivity of the new oscillator, the crystal's thermal transient characteristics reduce its warmup time. Whereas the 10544's crystal oscillates about a nominal frequency during warmup and takes about 20 minutes to settle to within specification, the new oscillator approaches the nominal frequency asymptotically, thereby taking only 10 minutes to stabilize in spec.

The improvement in temperature performance is not due to the crystal alone; HP has also redesigned the oven that keeps the crystal at its 55°C operating temperature. The oven's gain—or change in ambient temperature versus change in crystal temperature—has been increased from about 300 to over 1,000 by switching to aluminum from copper for the oven cavity and lid for the former's lower thermal capacitance.

In addition, changes in oven design cut the overall power consumption of the new unit by more than half, from 4.5 to about 2 watts. The earlier unit used a resistive heater controlled by an external transistor in which almost half the consumed power was wasted. In the 10811, two Darlington transistors serve both to heat and control the oven, more than doubling its efficiency, the firm says. **-Richard W. Comerford**

Communications

Codec filter chip jumps ahead of pack

As integrated-circuit makers push into telecommunications applications, they are finding new ways to exercise their expertise at putting systems on chip. A case in point is Motorola's new 14413 switched-

News briefs

Shockley receives IEEE award
William Shockley, coinventor of the transistor with John Bardeen and Walter H. Brattain, received the Institute of Electrical and Electronics Engineers medal of honor in a ceremony preceding Electro/80 last week in Boston. Bardeen received the IEEE's medal of honor in 1971. Other 1980 awards included: the Alexander Graham Bell medal to Richard R. Hough, executive vice president of American Telephone and Telegraph Co.; the Edison medal to Robert Adler, director of research for Extel Corp.; the founders' medal to Simon Ramo, vice chairman of the board of TRW Inc.; the Frederik Philips award to William M. Webster, vice president of RCA Laboratories; and the education medal to Aldert van der Ziel, electrical engineering professor at the University of Minnesota.

IBM expands entry-level 4331 mainframe
Neatly filling the gap between its latest entry-level model 4331 and medium-scale 4341 mainframes introduced over a year ago, IBM Corp. has introduced a new group of 4331 machines. Labeled the 4331 model Group 2 by the corporation's White Plains, N. Y., Data Processing group, the new units are technically similar to the 4331 model Group 1 machines [*Electronics*, Feb. 15, 1979, p. 85] but now include an 8-kilobyte cache memory and operate 1.8 to 2.3 times faster. The user pays about double the price of equivalent Group 1 machines—the Group 2 processor with 1 megabyte of memory sells for $150,000. The Group 2 units are available with as much as 4 megabytes of memory—the previous limit was a single megabyte—with the biggest configuration selling for $197,000.

Mohawk Data Sciences comes on strong
Bouncing back from financial reverses, Mohawk Data Sciences Corp., Parsippany, N. J., has introduced a communications service in conjunction with Wiltek Corp., Norwalk, Conn. Called WINC, for worldwide integrated communications, the electronic mail service will make use of Mohawk's series 21 family of microprocessor-based data terminals. It will also provide data-entry, distributed-processing, word-processing, and network-management capabilities. Earlier this month, the terminal manufacturer announced the imminent acquisition of Qantel Corp., the Hayward, Calif., small-computer maker for about $36 million.

TRW, Fujitsu operations merge
TRW Inc.'s retail and financial systems business has been combined with computer offerings of Japan's Fujitsu Ltd. to establish a new joint venture that will market information-processing systems in the U. S. TRW-Fujitsu Co. will be based in Los Angeles. Except for manufacturing facilities, most of TRW's 450-strong communications systems and services division will be transferred to the joint venture, whose president will be TRW's vice chairman, J. S. Webb. Eventually the product lineup is likely to be all Fujitsu, with the same product lines the separate companies offer: retail systems, banking systems, small-business systems (Fujitsu's V-830 line), and general-purpose systems (Fujitsu's M-F mainframes).

Fire-control award goes to Norden
Norden Systems has won a $97 million five-year contract for production of the U. S. Army's battery computer system. The Norwalk, Conn., subsidiary of United Technologies Corp. is scheduled to manufacture 687 systems for the Army Communications Research and Development Command, Fort Monmouth, N. J. The Army has options to buy some 2,000 systems worth more than $250 million to Norden. The BCS, built around a military emulation of the Marconi Elliott 1800 computer, provides automated assistance in aiming and firing as many as 12 guns at the field-artillery battery level. It receives target information via a digital wire or radio link from forward observers, automatically computes firing data, and displays firing commands at each howitzer.

NO. 12

NATIONAL ANTHEM

SEMICONDUCTOR NEWS FROM THE PRACTICAL WIZARDS OF SILICON VALLEY.

National emerges as the logical choice for memory.

HIGH QUALITY RAMs NOW AVAILABLE IN ALL SPEED RANGES.

Data acquisition rethought

The best choice in Custom MOS/LSI

Introducing STARPLEX™ with ISE™

National and Widlar do it again

Universal active filters cut costs

Highly versatile fiber optic interface

Practical Wizardry for tomorrow

Free literature from the National archives

Linear bestsellers for 1980

The ultimate CRT controller

Data Acquisition Logic Transistors Hybrids Linear Interface Bubble Memory
RAMs/ROMs/PROMs Transducers Displays Custom Circuits Optoelectronics
Memory Boards Microprocessors Development Systems Microcomputers Modules

NATIONAL ANTHEM

STARPLEX™ aids μP system development.

STARPLEX with ISE,™ the fully developed development system.

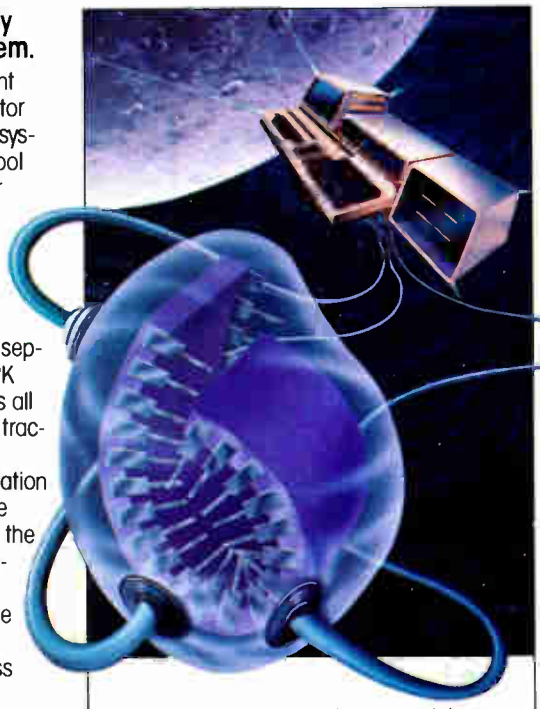
Using the STARPLEX development system with National's 8048 Emulator Package, designers of 8048 Family systems get the kind of sophisticated tool needed for efficient microcomputer development.

And with 8048 ISE (In-System Emulator), they get capabilities that up to now simply haven't been available in this type of instrument.

What is ISE? National's ISE is a separate STARPLEX module housing 32K bytes of real-time map memory, plus all the necessary logic for breakpoints, tracing, and memory mapping. These resources are available for the emulation of several different μPs. Because the individual emulator target cards are the only components dedicated to particular processors.

And since ISE doesn't share the STARPLEX BUS, the system doesn't have to compete for memory access with its STARPLEX host.

ROM display and disassembling. The 8048 emulator package provides capabilities which zero in on the problems of designing with single-chip microcomputers. The target card has its own 4K of RAM dedicated to the real-time emulation of the processor's program



ROM. So the designer has complete access to this memory throughout emulation.

He may examine and disassemble existing ROM contents, make changes, and execute the altered code. This gives him considerable flexibility in new product design, as well as previously masked 8048.

Look into our ISE. National's easily-learned ISE software comes completely integrated into the STARPLEX system, including an "In-File" mode that will implement a predefined sequence of commands. And ISE can also record those results, so you can see exactly how each part of the system operated during the emulation sequence.

ISE's program control capability provides not only the usual breakpoint conditions, but also a "coast" command which allows you to continue executing a program after the breakpoint combination has been satisfied.

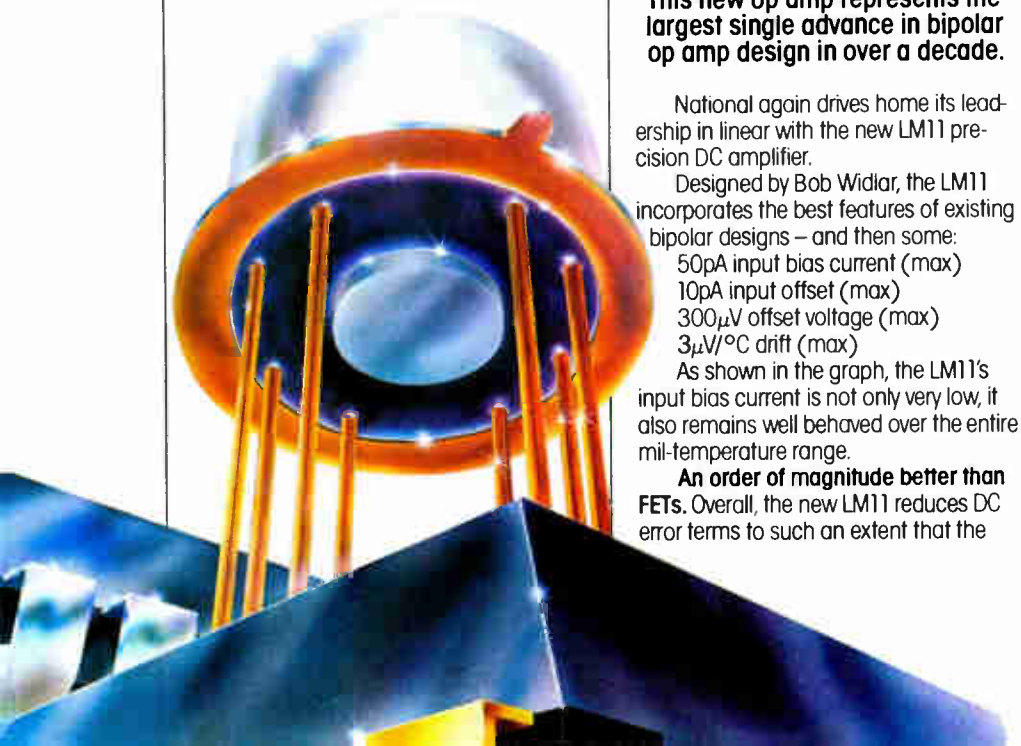
STARPLEX can not only develop and debug software for the 8048 Family, but also for 8080 and Z-80® microprocessors plus BLC/SBC Series 80 boards. NSC800, 8070 and other ISE packages will of course become available as these new processors are introduced.

When you get right down to it, National's STARPLEX with ISE offers features not available in any other development system on the market today. Yet it costs substantially less to own and operate than any system currently being sold.

Practical Wizardry strikes again.

STARPLEX and ISE are trademarks of National Semiconductor Corporation. Z-80 is a registered trademark of Zilog Corporation.

The LM11. A dramatic advance in op amps.



This new op amp represents the largest single advance in bipolar op amp design in over a decade.

National again drives home its leadership in linear with the new LM11 precision DC amplifier.

Designed by Bob Widlar, the LM11 incorporates the best features of existing bipolar designs – and then some:

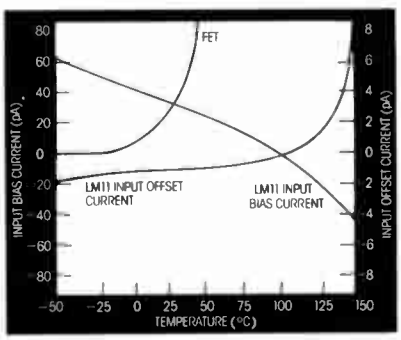
50pA input bias current (max)
10pA input offset (max)
300μV offset voltage (max)
3μV/°C drift (max)

As shown in the graph, the LM11's input bias current is not only very low, it also remains well behaved over the entire mil-temperature range.

An order of magnitude better than FETs. Overall, the new LM11 reduces DC error terms to such an extent that the op amp is no longer the limiting factor in many practical designs. Especially over the mil-temp range.

Further, its offset voltage, drift and long-term stability are an order of magnitude better than FETs.

Although internally compensated with provision for offset balance, the new LM11 is pin-compatible with, and quite similar to, the well-known LM108A amplifier.



Leakage current only affects input current of the LM11 above +125°C

National's new BLC-8715 — a more intelligent approach to data acquisition.

High-speed intelligent I/O board offloads analog pre-processing functions from the data acquisition system CPU.

National announces a bright new addition to its family of Series 80 Board Level Computers: the BLC-8715 Intelligent Analog Input Board.

The BLC-8715 was specifically designed for industrial data acquisition and process control systems. This new microprocessor-based interface offloads all of the analog data pre-processing functions normally performed by the host CPU.

And in doing so, the CPU may then devote more of its valuable resources to the rest of the control system.

Faster than a speeding digit. Besides freeing up host system resources for more demanding tasks, there are many reasons why the rugged BLC-8715 smooths out process control.

One of the most dramatic is its A/D conversion speed. Based on National's proven BIFET™ technology, the 8-bit BLC-8715 Analog Input Board performs the A-to-D conversion in a scant 8μsec.

More versatility than ever before. The BLC-8715 performs "front end" measurement and control functions for 16 analog processes. But that's not all.

It also features 22 digital (TTL-compatible) lines for controlling simple on/off equipment functions, digital read-outs, and even manual keyboard override systems.

And to further increase the board's versatility, the Practical Wizards at National designed it so that it may be configured in either of two ways.

By using its standard RS232C interface, the BLC-8715 becomes a remote "slave" to the CPU host.

However, the intelligent I/O board can also interface directly with the host system bus. One of the many benefits of this approach is the BLC-8715's Mailbox memory: 265 bytes of RAM that are directly addressable by any intelligent device on the bus.

It certainly comes as no surprise that National should be the first to take a more intelligent approach to data acquisition and process control.

After all, that's what Practical Wizardry is all about.

BIFET is a trademark of National Semiconductor Corporation

What's new from the National Archives?

005 ☐ Additional Custom MOS/LSI Information
006 ☐ Special Functions Data Book ($6.00 ea.)
015 ☐ MST Program Brochure
024 ☐ DP8350 Series Data Sheet and Application Notes
026 ☐ AF100 Data Sheet
031 ☐ LH0082 Data Sheet
034 ☐ LM11 Data Sheet and Application Note
035 ☐ Additional Series/80 Information
036 ☐ Optoelectronics Handbook ($3.00 ea.)
037 ☐ Additional STARPLEX and ISE Information
038 ☐ MM5290 Data Sheet and Additional Information
039 ☐ BLC-8715 Data Sheet
044 ☐ 1980 Linear Data Book only ($6.00 ea.)* qty____
046 ☐ 1980 Data Book Package (3 books; $15)* qty____
TOTAL $____

*Prices effective until September 1, 1980

Enclose check or money order based upon appropriate currency. Make checks payable to National Semiconductor. Allow 4-6 weeks for delivery.

NAME_____

TITLE_____ PHONE_____

COMPANY_____

ADDRESS_____

CITY_____ STATE_____ ZIP_____

For desired information, mail coupon to:
National Semiconductor Corporation
2900 Semiconductor Drive
Mail Stop 16250
Santa Clara, California 95051

In Europe, mail coupon to:
National Semiconductor GmbH
Industriestrasse 10
D-8080 Fürstenfeldbruck
West Germany

National Semiconductor
The Practical Wizards of Silicon Valley.

NA 12

Printed in USA

LH0082 fiber optic receiver amp lightens the load.

National now in fiber optics with versatile high-speed interface.

National has good news for anyone designing commercial fiber optic applications. Their new LH0082 general purpose receiver amp eliminates the cost and hassle of building your own high-speed amplifier. But there's more. The LH0082 not only expedites development, it also improves performance while allowing an unprecedented degree of design flexibility.

All you need, all in one. The self-contained LH0082 requires only a single 5V to 12V power supply. So it can act as the interface between all of the most popular photodetectors and any standard logic family or any analog circuit.

The LH0082 transimpedance amp also features a 2GHz gain bandwidth, excellent sensitivity (to 30nW), data rates up to 50Mbps, and high immunity to noise in a fiber optic environment. All hermetically sealed for reliability in a standard 14-pin DIP.

The possibilities are endless. National's new LH0082 lends itself perfectly to fiber optic communications both guided and broadcast. It can, for example, be used for computer interfaces with peripheral devices, word processing systems, remote graphic terminal data links, and point-of-sale data links.

The LH0082 is also ideal for industrial control devices, robotics, telecommunications on T1, T2, or T3 carriers, as well as airborne and shipboard multiplex communication and control systems.

And to top it off, all of this performance is now available at a surprisingly low cost.

When you come right down to it, it's no surprise that National would be the first to offer a truly versatile necessity to the fiber optic designers. After all, that's what Practical Wizardry is all about.

AF100 active filters–a universal solution to cost problems.

In the past, the easiest and least expensive means of active filtering was with discretes. But this is no longer the case thanks to National's new AF100 universal active filters.

The AF100s are internally adjusted to provide center frequency accuracies of ±2.5% (for the AF100-1CN model) and ±1% (for the AF100-2CN model).

And because of their small size and low external parts count, the AF100 active filters lend themselves perfectly for use in MODEMs and many other telecommunications applications that require lowpass, highpass, or bandpass filter configurations.

But there's more to the price/performance story than just design versatility and decreased manufacturing costs. The AF100 universal active filters are attractively priced as well.

Just another example of Practical Wizardry cutting your costs to the bone.

"National is your best choice for Custom MOS/LSI because we planned it that way."

"What does it take to become the best? At National Custom MOS/LSI, it took good planning – and the solid resources of a billion-dollar company to back it up.

"We're certainly proud of being the best and we have every intention of staying that way. Because we've got something that no other single supplier can offer: the bigness of a Fortune 500 corporation and the smallness of a personal staff of design wizards dedicated to your application.

"On one hand, we're large enough to find the best solution to your particular needs in the shortest amount of time. Even if the answer lies in standard component designs, National's broad-based product line has you covered.

William Sanderson, Group Marketing Manager, Custom MOS/LSI.

"Yet on the other hand, we're small enough that we can work in close technical partnership with your own engineering staff to develop an exciting new and exclusive product. Whether it stems from a list of specs or an existing standard component design.

"It takes good, sound business practices to develop a high-quality operation like this.

"From design and development, all the way through fabrication and assembly, and on to delivery, you're assured of getting the best there is in Custom MOS/LSI.

"Because at National, planning for your success is a never-ending process."

Practical Wizardry – a means toward new beginnings.

Practical Wizardry.

A catchy phrase, but what does it really mean? Is it an end in itself? Or is it a beginning?

To answer these questions, consider some of the most outstanding personal examples of practical wizardry – the works of Sir Isaac Newton.

Newton's brilliance came from his uncanny insight into common, everyday phenomena. The swinging of a pendulum. Gravitational attraction. Terrestrial mechanics. The spectral properties of sunlight.

And when he needed to go further than simple algebra could take him, he opened up a whole new realm of mathematics called calculus – one of the most fundamental beginnings of modern technology.

In fact, if it wasn't for Newton, today's technological renaissance may never have happened.

And when you think about it, today's practical wizards really aren't very different. Although their efforts are more specialized, their contributions to today's society are every bit as useful and significant as Newton's were to his.

At National Semiconductor, practical wizardry is much more than just a catchy phrase – it's our lifes' work. A means toward new beginnings.

By following the examples set by Newton and dozens of other practical wizards of the past, we're finding the most useful and workable solutions for today's needs.

Major CRT makers demand ultimate controller.

National's DP8350 Series of single-chip CRT controllers form the heart of over 60 terminal designs worldwide.

Over 50 major CRT terminal manufacturers from around the world have discovered the industry's only complete, single-chip CRT controllers.

National Semiconductor's powerful line of CRT controllers – the DP8350 Series – requires considerably less support circuitry than any other controller on the market.

Due in part to their bipolar (I^2L) circuitry, the DP8350 Series is widely regarded as the ultimate in CRT display refresh circuits.

Single-chip versatility. The 40-pin DP8350 Series – which includes the DP8350, DP8352 and DP8353 controllers – offers a full range of features using internal mask programmable ROM.

Since the need for a microprocessor interface has been eliminated, overall system design is greatly simplified.

The versatility inherent in the DP8350 Series cannot be understated. In the character field, for example, both the total number of dots per character field and the number of scan lines per character may be specified (up to a 16 x 16 dot matrix). The number of characters per row (from 5 to 110) and character rows per video frame (from 1 to 64) may be specified as well.

Doing more for less. The popular DP8350 Series does more to lower your system costs than any other single component. And since it requires so little in the way of support circuits, the engineer can spend much more time (and board space) on the more demanding aspects of the product design.

It's no wonder that the DP8350 is at the heart of the best designs. The industry certainly knows a winner when it sees one.

Linear Data Book tops National bestseller list.

National announces the new 1980 Linear, Voltage Regulator and Audio data books. And until Labor Day, they're all yours for $15* complete.

National, the long-time Linear leader, is also known for their clear, concise and comprehensive data books. And the 1980 books are certainly no exception to the rule.

Their 1980 Linear Data Book, the analog designer's "right-hand man," gives you over 1200 pages packed with useful, up-to-date information on National's broad line of Linear components. (The broadest line in the industry.)

And until Labor Day, you can add this perennial bestseller to your reference library for only $6.00 ($3.00 off the regular price).

The package deal. National is also offering a special package deal on a set of three valuable references. No technical library would be complete without them.

And between now and Labor Day, National will sell you three of their best-selling 1980 books – Linear, Voltage Regulator and Audio – for only $15.00 complete. That's a full $6.00 off the regular selling price.

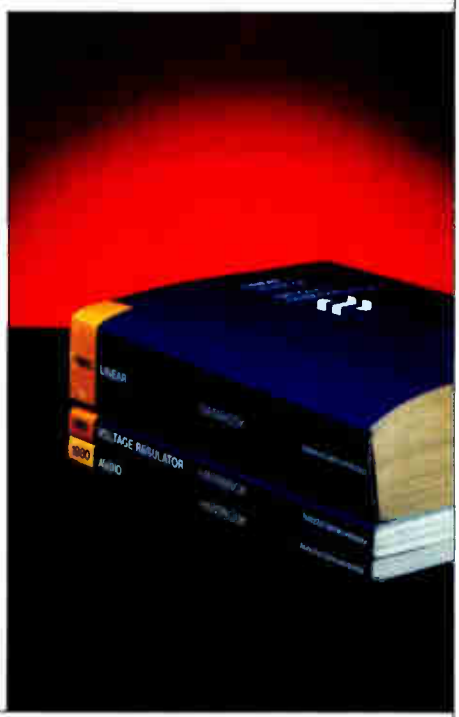
The 1980 Voltage Regulator Handbook covers power supply and regulator design all the way from the transformer to the heat sinks.

The 1980 Audio Handbook presents – in a single volume – real-world design approaches plus the more exotic audio subjects (such as pickups, phase splitters, fuzz, reverb, etc.).

To get your copies, simply fill out and send in this issue's National Archives coupon. Please indicate the quantities desired and include a check or money order for the appropriate amount.

All orders postmarked by Labor Day – September 1 – will qualify for this special offer, so don't delay.

*Prices shown are U.S. prices only



Nationally improved memories.

By substantially increasing their production capacity, National is meeting the demand for high-quality 16K dynamic RAMs.

National Semiconductor has made a major commitment to the high-density RAM marketplace by significantly stepping up their production capacity.

As a result, their competitively priced MM5290 16K dynamic RAMs are available in production quantities right now through your National distributor or sales representative. (Call for pricing information.)

And with their exclusive combination of design and manufacturing procedures, the MM5290s are setting new industry standards for quality and reliability.

For example, the popular MM5290 Family is designed so that soft errors induced by stray alpha particles are virtually eliminated.

This, combined with National's extensive component test procedures, assure unsurpassed operational integrity and dependability in every high-speed, high-density RAM application.

← Don't miss the important news inside.

The first and only MST.™ In addition to National's use of conventional final testing and QA component level processing, many customers request National's unique MST (Memory Systems Test) program.* MST eliminates or greatly reduces the customer's own requirements for internal testing. So their incoming test, board test and system rework costs are substantially reduced.

For more detailed information about MST and the MM5290 Family – plus a Reliability News Brief on alpha particle test results – be sure to check the National archives coupon below.

Quality RAMs from a quality source. National has, of course, been known as a quality production house for a long time.

And now they've made an unprecedented full-force commitment to the RAM marketplace. A commitment proven by the industry's most advanced design, fabrication and testing techniques.

And thanks to their unmatched production capacity, this kind of quality in every kind of RAM is now even easier to get than you ever thought possible.

From start to finish, the Practical Wizards from National are doing more and more to meet all your memory needs.

*Patent pending
MST is a trademark of National Semiconductor Corporation

capacitor filter IC for coder-decoder chips: it adds an on-board high-pass filter to take care of both 20- and 60-hertz noise rejection.

The Austin, Texas, MOS Integrated Circuits division recently started production on a predecessor chip with two low-pass filters that meet most telephone-industry specifications for codec filters. The problem is that "systems using filters with different architectures [than the new 413] have to take care of the 20 Hz in the system, and that costs money," notes Steve Kelley, engineering manager for telecommunications products.

Others. Motorola is not alone in adding these new filtering functions, although it may be furthest along since it is at the sample stage. Mostek is working on a similar chip, which will also take care of the 20-Hz induced noise from ring signals on other lines and of the 60-Hz line noise. Intel has available a codec filter chip that uses a notch filter for 60-Hz rejection.

The complementary-MOS metal-gate 4113 packs other added functions into its 175-by-113-mil area. To boost weak signals, the amps may be used to drive "any kind of a subscriber-line interface circuit, including hybrids," Kelley says.

What's more, the 413 can handle two codec signals at once, making conference calls possible. This feature is available with other codec filter approaches, but at the cost of adding some auxiliary circuitry.

Motorola has a patent on the 413's frequency compensation. Known as the (sine x)/x correction, its version is unusual in that "it does not increase the delay distortion that the filter introduces into the codec signal path," Kelley says.

Less crosstalk. The new filter IC has a typical 80-decibel crosstalk isolation, at least 20 dB better than some existing chips. The next step for Motorola is to integrate the IC with its codec chip, giving a system highly resistant to crosstalk.

"It is just bizarre how some people justify separate transmit and receive codecs because of the crosstalk problem," Kelley says. "Crosstalk should

Electronics review

not be a problem for either codecs or filters."

The chip draws but 25 milliwatts in the active mode. When it is used with the Motorola codec, it automatically powers itself down under the appropriate conditions. "That's the proper system concept—designing parts that work together," Kelley boasts.

The North American standard governing filter specifications does not call for the 20- and 60-Hz rejection. But, as Kelley notes, the problem has to be solved somewhere in the system, and doing it on chip is an elegant solution. **-Harvey J. Hindin**

Consumer

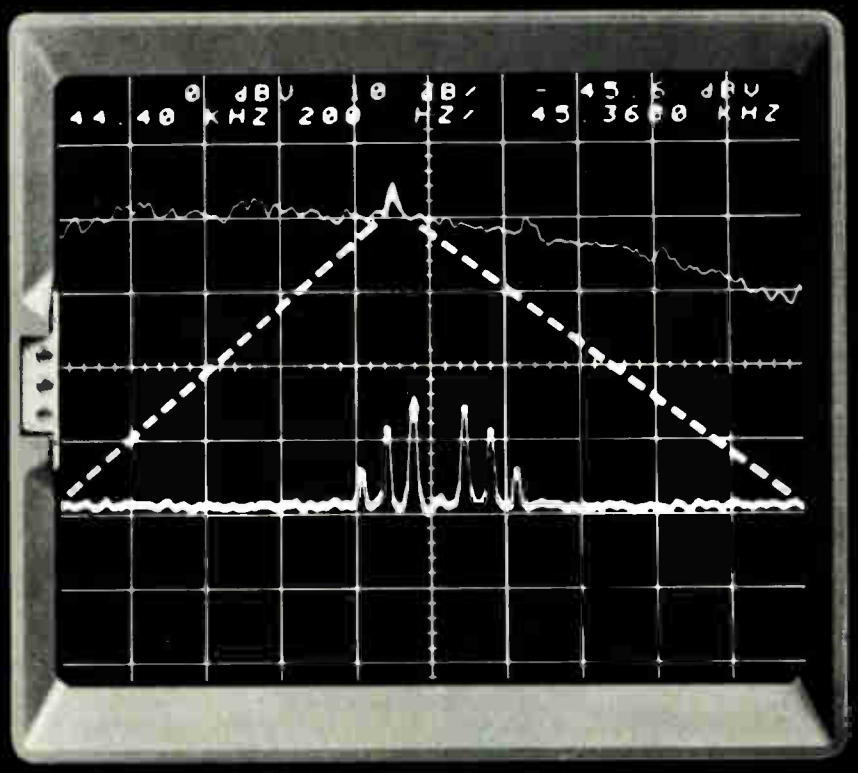
A-m stereo chips getting ready to play

Hard on the heels of the Federal Communications Commission's selection of the Magnavox a-m stereophonic broadcast system, Sprague Electric Co. and Signetics Corp. have disclosed a joint development program for a-m stereo decoder chips. Christened the ULN-3800, the integrated circuit is well into the breadboard stage and should be introduced later this year.

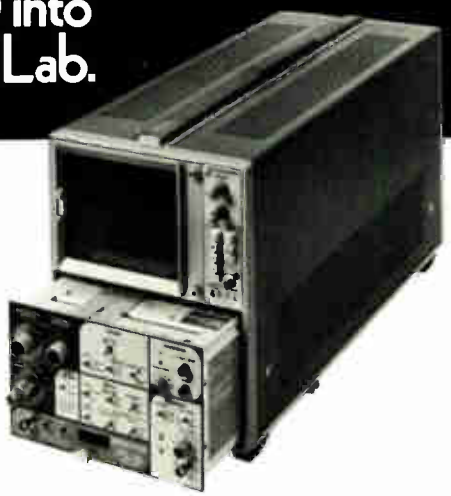
"We may have to go through one or two more design refinements, but essentially we're there," says Oliver L. Richards, design engineer at Sprague's Semiconductor division in Worcester, Mass. Because the design is compatible with both firms' semiconductor processes, it will be available simultaneously from both and will mate with each firm's front-end ICs for a two-chip a-m stereo radio.

Architecture. Though the decoder IC still needs work on its noise-detection and -processing sections, much of the design is firm. It will use a standard peak detector to demodulate the left-plus-right, or monaural, signal and a low-frequency phase-locked loop to acquire the interchannel-difference, or left-minus-right, signal. Algebraic addition of the two signals would take place in a matrix much like that used in pres-

Increase the scope of your 'scope.



Our 7530A converts your Tektronix® 7000 into a Spectrum Analysis Lab.



Stuck in the time domain? No need to be when we've made it so easy for you to get into the frequency domain of FFT spectrum analysis. Just plug our high speed 7530A into your Tektronix mainframe and you have a complete signal analysis lab for measuring noise, harmonics, power, spectral density, voltage, phase noise, spurious signals... you name it.

With simple, friendly, three-knob control, you'll be able to analyze signals from dc to 100 kHz with ultra-sharp resolution of 1 Hz across the entire band. For a real close look at a segment, just zoom in and magnify that part of the spectrum. You'll get an enlarged image in the foreground and simultaneously a display of the entire spectrum, in the background.

The high performance 7530A has a dynamic range of up to 90dB and a very low noise floor. And thanks to FFT and the use of a microcomputer the 7530A gives you superb accuracy and processing speed 200 times faster than conventional swept-filter analyzers.

If you thought FFT spectrum analysis was too expensive, think again: The 7530A and the scope together cost less than a comparable stand-alone analyzer.

We'd like to tell you more about FFT spectrum analysis and our easy-to-use 7530A. For complete data or a demo, contact us or our rep.

Rockland Systems Corporation.
Rockleigh Industrial Park
Rockleigh, NJ 07647
(201) 767-7900

® Registered Trademark, Tektronix Inc.

Circle 57 on reader service card

ROCKLAND

ent-day fm stereo decoders.

"The design is compatible enough with existing systems that you could almost substitute it for the detector diode in the intermediate-frequency strips of existing a-m radios," says Richards. The ULN-3800 will fit an 18- or 20-pin dual-in-line package and will take up less than 10,000 square mils of silicon.

Pricing plans. "We want samples in the marketplace in the fourth quarter of 1980," says Peter R. Loconto, who is director of product development and marketing for the division. The price should be $1.50 to $2 in large quantities, dropping to less than $1 by 1982 or 1983.

Loconto says the semiconductor division and Signetics, across the continent in Sunnyvale, Calif., began investigating each proposed a-m stereo system several years ago, so when the FCC decision was announced [*Electronics*, April 24, p. 48], they were ready to move. At stake is what is viewed as a major consumer market, mostly for automobile radios.

The attraction over fm stereo is expected to lie in the greater long-distance range and tolerance to urban interference inherent in a-m broadcast. "The U. S. soaks up eight million auto radios a year," says Robert F. Milewski, product manager for custom ICs. "By 1985, I expect that 50% to 70% of all auto radios will have a-m stero decoders, and by 1982, up to 90% of [other] fm/a-m radios will include a-m stereo."

Target areas. "The market we see includes the whole U. S., outside the heavily urbanized areas where there is almost a saturation level of fm stations," says marketing director Loconto. "And even in urban areas, a-m stereo's operating advantages should make it a strong competitor to fm."

Fm stereo is prone to interference from image frequencies and multipath; a-m stereo will not be. Also, a-m stereo should offer longer-range reception than fm; a-m stations already reach out 150 miles or more routinely, whereas some fm stations are difficult to receive in suburban locations. **-James B. Brinton**

Which Schottky do you need?

0.75A BRIDGE VSB51 Series: 10/20/30/40 V_{RRM} 0.65 V_F @ 0.75 mA I_F

1A VSK 1 Series: 20/30/40 V_{RRM} 0.55 V_F @ 1.0 A I_F

3A VSK 3 Series: 20/30/40 V_{RRM} 0.475 V_F @ 3.0 A I_F

5A VSK 5 Series: 20/30/40 V_{RRM} 0.450 V_F @ A I_F

15A VSK15 Series: 20/30/40 V_{RRM} 0.60 V_F @15.0 A I_F

30A VSK30T Series: 20/30/40 V_{RRM} 0.64 V_F @ 15.0 A I_F

30A VSK30S Series: 20/45 V_{RRM} 0.64 V_F @ 30 A I_F

40A VSK40 Series: 20/30/40 V_{RRM} 0.62 V_F @ 40.0 A I_F

60A VSK51 Series: 45 V_{RRM} 0.60 V_F @ 60 A I_F

60A VSK51B Series: 45 V_{RRM} 0.63 V_F @ 60 A I_F

Look to Varo for the widest choice of Schottky devices for power supplies.

Efficiency is today's basic design criteria, and energy-saving begins in the power supply. That's why Varo has developed the most comprehensive line of Schottky devices around today. From a practical, dual in-line bridge family to a tough, 60 amp braided lead rectifier, we've got your requirements covered. Devices are available now; ready to meet your prototype or production schedules.

For application info, specs or a sample device, call: (214) 271-8511. Varo Semiconductor, Inc. Box 40676 Garland, Texas 75040.

VARO

The world's leading rectifier company

Customer Service
Varo Semiconductor, Inc.
Box 40676; Garland, Texas 75040
Please send me:

☐ Specs and pricing on: _____

_____

My application is: _____

_____

Name _____

Company _____

Address _____

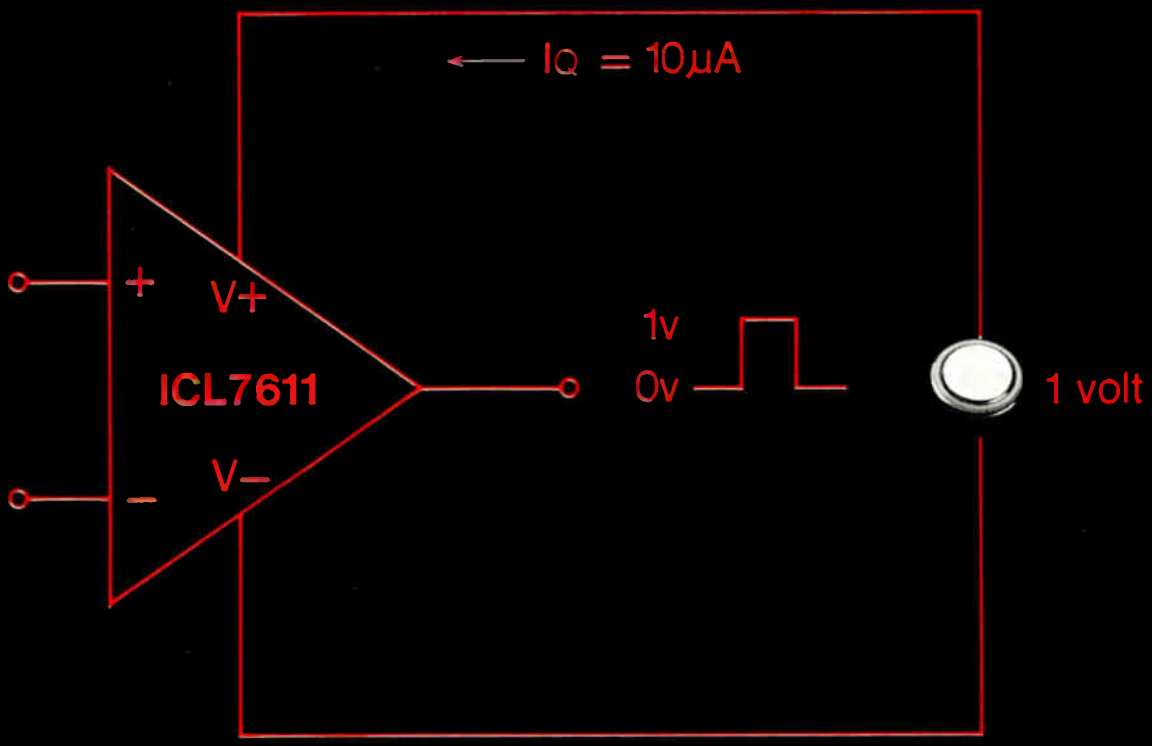
City _____

State _____ Zip _____

Phone _____

MICROPOWER CMOS OP

PICK YOUR POWER SUPPLY
±½v to ±8v



V_S = 1 volt
V_{out} = 1v PK-PK
P_C = 10µW

AMPS. FROM INTERSIL.

RAIL-TO-RAIL.

The ICL7611 family of ultra-low power CMOS operational amplifiers operates perfectly on a 1V supply. A single battery for instance. They require a fraction of the voltage of the bipolar OP AMPs you're using now. Yet, output swing is within millivolts of the supply rails. And they operate from ±½V to ±8V. Or, from a single +5V logic supply. What you get is low voltage operation with usable output swing.

LOW POWER.

If you're looking for low power, Intersil's delivering. In CMOS OP AMPs. In fact a whole family. Many with a unique quiescent current programming pin which can be set for standby currents of 10μA, 100μA or 1mA...with no external components. What you get is ultra-low power consumption: Down to 10μW. That means reduced power supply and cooling requirements.

LOWEST INPUT CURRENT OP AMPs.

1pA (Typ.). That's it. Compare that to the Industry Standard BiFET's 30pA requirement. High accuracy performance in high impedance applications. $10^{12}\Omega$ input impedance plus ultra-low noise current.

SINGLES. DUALS. TRIPLES. QUADS.

Right now, there are 11 versions in the ICL7611 family of CMOS operational amplifiers, including types with extended input common mode voltage ranges that go beyond both supply rails and others with input voltage protection of up to ±200V. Internally and externally compensated versions are also available. All have input currents of 1pA (Typ.).

TYPICAL PERFORMANCE.

@V_s = ±5V, 25°C

V_{os}	3mV
I_{os}	0.5pA
I_b	1pA
A_{vo}	100 db
CMRR	90 db
PSRR	88 db

I_Q — Programmable	10μA	100μA	1mA	(per channel)
Slew Rate	.016	.16	1.6	V/μs
Bandwidth	.044	.48	1.4	MHz

PICK YOUR SPECS.

V_{os} specifications down to 2mV MAX. Full military temperature devices available (−55°C to +125°C). Pinouts compatible with Industry Standard OP AMPs. And, prices that start at 75¢ @100 pieces for singles...$2.55 for quads.

MORE THAN CMOS: MAXCMOS.™

The ICL7611 family of OP AMPS are manufactured using Intersil's proven MAXCMOS™ process. A process that delivers ultra-low power operation. That means ultra-cool performance that allows high density packaging. You get maximum reliability...from a proven process. And, you get to pick your power supply.

INFORMATION FAST.

Proof not claims. From your Intersil Sales Office or Franchised Distributor. Or, send us the coupon below. We'll send you back complete information on the MAXCMOS™ OP AMPs that operate on ±½V to ±8V supply...a single cell battery, for instance.

TM–MAXCMOS is a trademark of Intersil, Inc.

INTERSIL SALES OFFICES:

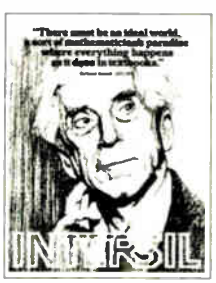
CALIFORNIA: Sunnyvale (408) 744-0618, Long Beach (213) 436-9261 • COLORADO: Aurora (303) 750-7004 • FLORIDA: Fort Lauderdale (305) 772-4122 • ILLINOIS: Hinsdale (312) 986-5303 • MASSACHUSETTS: Lexington (617) 861-6220 • MINNESOTA: Minneapolis (612) 925-1844 • NEW JERSEY: Englewood Cliffs (201) 567-5585 • OHIO: Dayton (513) 866-7328 • TEXAS: Dallas (214) 387-0539 • CANADA: Brampton, Ontario (416) 457-1014

INTERSIL FRANCHISED DISTRIBUTORS:

Advent (IND, IA) • Alliance • Anthem • Arrow • Bell Industries • Cardinal • CESCO • Component Specialties • Components Plus • Diplomat (FLA, MD, NJ, UT) • Harvey (upstate NY) • Kierulff • LCOMP • Panda • Parrott • R.A.E. Ind. Elect. Ltd. • RESCO/Raleigh • Schweber • Summitt • Western Microtechnology Sales • Wyle • Zentronics Ltd.

INTERSIL

Analog Products—Linear Circuits
10710 No. Tantau Ave., Cupertino, CA 95014
(408) 996-5000 TWX: 910-338-0171
(800) 538-7930 (Outside California)



Gentlemen,

____Send me complete information on your ICL7611 Family MAXCMOS™ OP AMPs.

____While you're at it, send me your 20 x 24" Bertrand Russell poster.

Name _____

Company _____

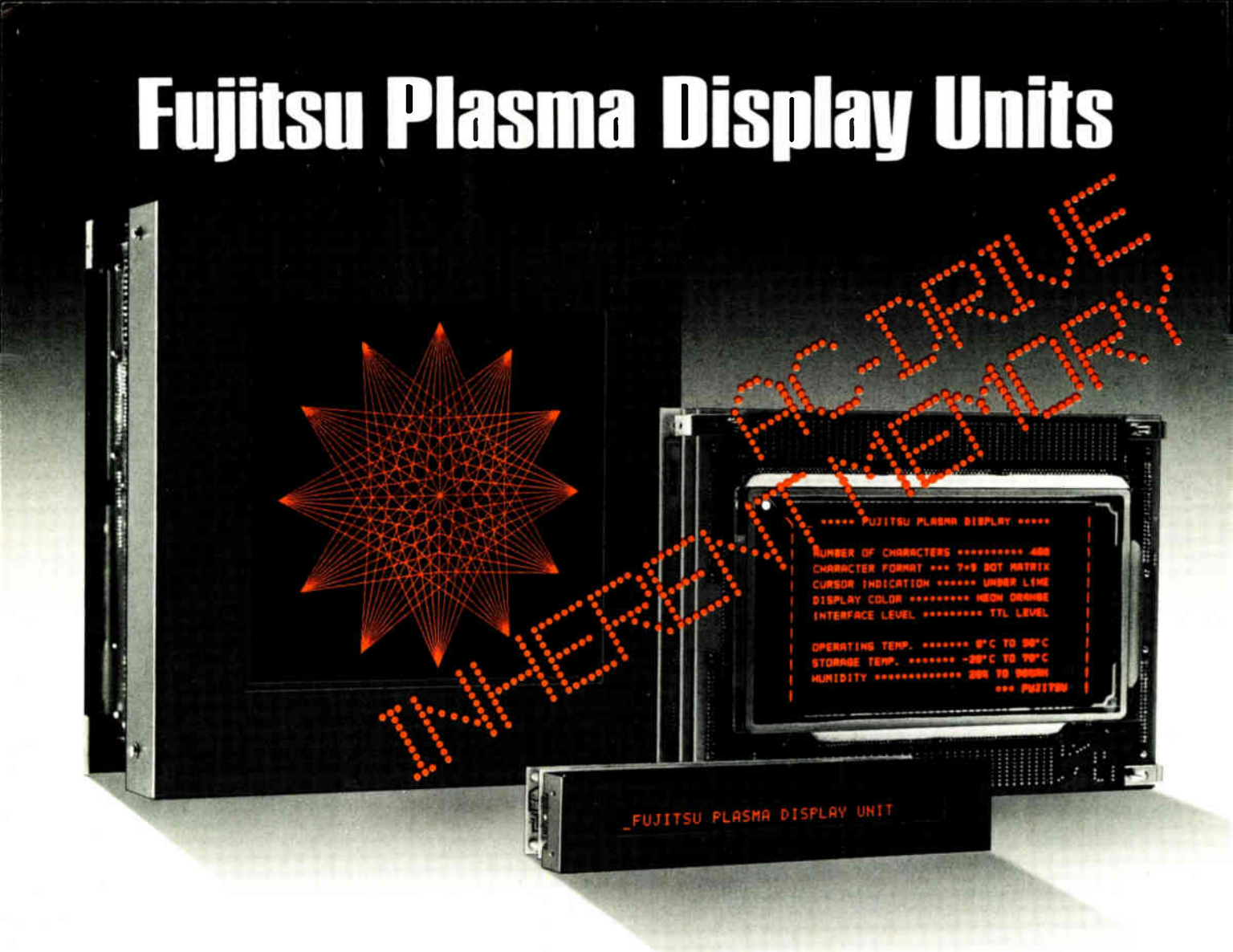
Address _____

City _____

State _____ Zip _____

E52280

Fujitsu Plasma Display Units



Fujitsu AC-drive plasma display units bring quality and reliability to display technology. Compact size. Long-term display stability. High image resolution without flicker, sway or distortion. And the largest effective display area available — an expansive 512 x 512 dot field. Their unique AC-driven inherent memory eliminates the time-consuming chore of refreshing display data. Thus it brings an easier controller circuit and even further reduction in size. And due to meticulous testing and strict quality control every unit brings a guarantee of reliability and long service life.

Fujitsu offers both graphic and character plasma displays with AC-drive and inherent memory. They come in a wide variety of designs to suit the full range of display applications, including measuring instruments, computer peripheral and terminal equipment and graphic design units. Contact the Fujitsu distributor nearest you today.

CHARACTER UNITS (For units with character generator control)

Model	No. of Characters	Character Format	Character Size (mm)
FPC1601NRCA	16 (16 chars. x 1 row)	5 x 7 dot matrix	8.0 x 11.2
FPC2004NRCA	80 (20 chars. x 4 rows)		4.0 x 5.6
FPC3201NRCE	32 (32 chars. x 1 row)		
FPC3208HRCD	256 (32 chars. x 8 rows)	7 x 9 dot matrix	3.5 x 4.5
FPC4002NRCD	80 (40 chars. x 2 rows)	5 x 7 dot matrix	3.1 x 4.4
FPC4012HRCB	480 (40 chars. x 12 rows)	7 x 9 dot matrix	3.5 x 4.5
FPC8001HRCB	80 (80 chars. x 1 row)		3.15 x 4.5
FPC8002HRCB	160 (80 chars. x 2 rows)		
FPC8006HRCA	480 (80 chars. x 6 rows)		2.8 x 4.5
FPC8012HRCA	960 (80 chars. x 12 rows)		
FPC8025HRCA	2,000 (80 chars. x 25 rows)		

Character color: neon orange

GRAPHIC UNITS

Model	Effective Display Area		No. of Effective Lines		Dot Pitch (mm)
	D (mm)	W (mm)	D	W	
FPG7NRUC	78	78	128	128	0.6
FPG9HRUD	217	217	512	512	0.42
FPG0805NRUA	153	18.6	256	32	0.6

Character color: neon orange

FUJITSU

Fujitsu America Inc. Chicago Office:
910 Sherwood Drive 23, Lake Bluff, Illinois 60044 Phone: 312-295-2610 Telex: 20-6196 TWX: 910-651-2259

Circle 62 on reader service card

Washington newsletter

SBS sees high-speed electronic mail by end of 1981 . . .

Satellite Business Systems expects to have high-speed electronic mail customers operating with its first domestic satellite by the end of 1981 **using new AM International Inc. automatic digital copiers able to reproduce 70 pages per minute**—more than 100 times faster than conventional facsimile devices. Where conventional fax costs now run to several dollars per page, an SBS official says the AM International prototypes developed for SBS show costs will be "substantially under $1 a page," depending on a user's volume and if it employs simultaneous transmissions to multiple terminals. The first SBS satellite is to be launched in October, with operations to begin in January 1981.

. . . as AM International unveils 70-page/min fax prototypes

The AM International prototypes developed by its Multigraphics division at Mount Prospect, Ill., achieve document resolution of 300 lines per inch, compared to 96 lines for a 6-minute facsimile machine, using a helium-neon laser under computer control for a 2-second page scan. Data is then condensed in the computer—by the elimination of white space between lines, for example—**and digitized for transmission at rates up to 448 kb/s, almost 100 times the data-carrying capacity of a telephone line.** Laser imaging is used for data reproduction in the system, which is linked to a document generator that electronically prints pages in sequence, and collates and staples them into sets automatically. The number of copies and addresses are specified by the sender, although SBS says each copy will show only the name and address of one recipient. AM International retains rights to manufacture and market the new system since SBS contracted only for prototype development and delivery of two systems.

Threat of changes in VHSIC timetable troubles contractors

Whether the military very high-speed integrated circuits program can maintain its tight timetable, plus the threat that some segments of the effort may be broken off and assigned to a single contractor, concerns some of the nine industry contractors. Timetable watchers are waiting to see if the Department of Defense's program office meets its Sept. 7 deadline **for getting a VHSIC Phase One proposal instruction package to interested companies.** The contractors are anxious to submit proposals by the end of December, when the ongoing Phase Zero nine-month studies are scheduled to be completed [*Electronics*, March 27, p. 41]. Contractors will need the proposal instruction package if the program is to stay on schedule with Phase One awards in June 1981. The possibility of breaking off segments of the program such as computer-aided design—instead of letting each competitor mount its own effort as part of a vertically integrated program—is reportedly being reviewed following receipt of a separate proposal from Sandia National Laboratories, Albuquerque, N. M., seeking to lead the CAD aspect of the program.

Carter pressured to extend controls on TV imports . . .

Unless President Carter extends color TV receiver import controls that expire June 30, a U. S. labor-industry coalition predicts, the remaining 65,000 American jobs in the industry will disappear. **The group foresees a new invasion of the U. S. market led by South Korea, along with Taiwan and Japan.** Carter received a mid-May recommendation from the International Trade Commission to continue import controls on Korea and Taiwan that went into effect last year, but to end the 1977 Orderly Marketing Agreement with Japan, which now has eight color TV manufac-

turing operations in the U. S. The President can accept, reject, or modify the ITC recommendation. Compact—the Committee to Preserve American Color Television, made up of four companies and 11 unions—cites a recent Korean prediction that it expects to boost its color TV exports to the U. S. by 400% to 800,000 sets this year if import controls are lifted. If that occurs, Compact contends, "color TV manufacturing will simply follow all the other [domestic consumer electronics] procedures into the increasingly crowded graveyard of domestic industries."

. . . as court puts a hold on Commerce dumping settlement

Compact and the Electronic Industries Association's tube division got some good news this month when the U. S. Court of Appeals in Washington, D. C., granted their request for an injunction against implementation, by the Department of Commerce and the Customs Service, of the controversial settlement of television dumping claims against Japan [*Electronics*, May 8, p. 61]. But Compact and the EIA still have a long struggle ahead after winning that first battle in the dumping duty struggle that began in 1968. **At issue is the amount of dumping duties that can be assessed against Japan for selling TVs to the U. S. below its home market price**—Compact says $700 million compared to the Commerce Department's estimate of $128.7 million—and the department's negotiation to settle for about $75 million, an action the petitioners claim is illegal. The appeals court must now rule on the validity of the claims.

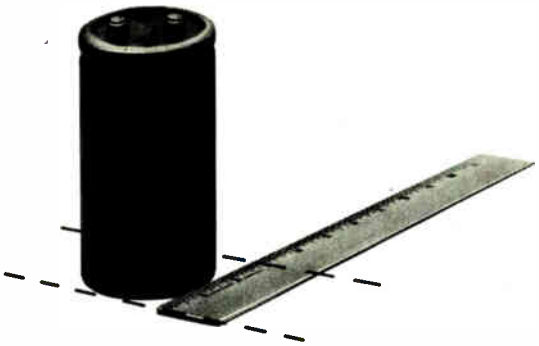
April TV sales show sharp drop as recession deepens

Sharp declines of more than 17% in April sales of both color and monochrome television receivers are convincing Washington economic observers that the domestic recession is likely to be deeper than earlier Federal forecasts. The April drop in total TV sales to less than 835,000 sets is well under the 1 million-plus sold by manufacturers to dealers of a year earlier and 44% below the nearly 1.5 million sets sold in March. The April figures put sales for 1980's first four months at 4.4 million units, down 8.2% from last year—a significant increase from the 5.8% decline posted for the first quarter. **The recession has yet to cut into spending for high-priced video cassette recorders, however.** The Electronic Industries Association figures show that April VCR sales of 3,400 units were 47% higher than last year, putting volume for the first four months 57% ahead of the 1979 level. Nevertheless, analysts note the growth rate for VCR sales is also slowing.

New hearings urged by Datapoint for 1934 Act rewrite

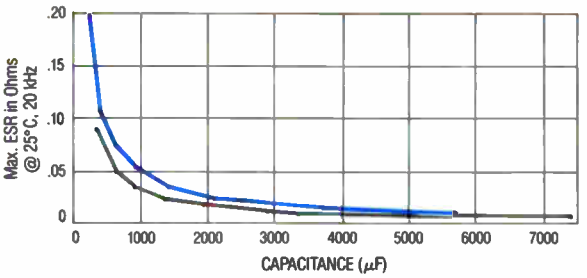
A new call for full public hearings on H. R. 6121—the congressional rewrite of the 1934 Communications Act—has come from Datapoint Corp. of San Antonio, Texas, which believes **competitive telecommunications could be threatened by American Telephone & Telegraph Co.'s market dominance resulting from a hastily drafted, compromise bill.** H. R. 6121 is still bogged down in the House Commerce subcommittee on communications, and observers doubt whether an acceptable compromise can be passed and coordinated with a Senate version before adjournment for the elections. "The present third-generation bill has never been the subject of hearings," says Datapoint chairman and chief executive Harold O'Kelley in his call on Capitol Hill for hearings on both House and Senate versions. Datapoint manufactures computers, electronic office products, and telephone management systems.

HIGH CAPACITANCE PER CASE SIZE



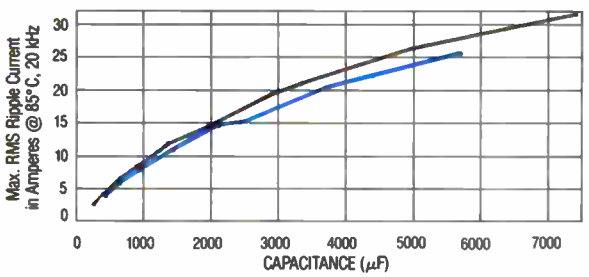
Values as high as 7,400 μF @ 200 VDC in a 3" x 5.625" case.

LOW ESR



Curve plotted in gray represents capacitors rated at 200 VDC. Curve plotted in blue represents capacitors rated at 250 VDC.

HIGH RIPPLE CURRENT CAPABILITY



Curve plotted in gray shows ripple current capability for capacitors rated at 200 VDC while curve plotted in blue shows ripple current limits for capacitors rated at 250 VDC.

A RATING TO MEET YOUR NEEDS

Sprague Type 623D Extralytic® Input Filter Capacitors are available in 20 standard ratings ranging from 260 μF to 7400 μF.

New Sprague Type 623D Input Filter Capacitors for switched-mode power supplies

Sprague's new Type 623D Extralytic® Capacitors have been expressly designed to provide superior performance in off-line switching-type applications . . . and they meet tight space and tight budget requirements.

A few of the prime advantages of these new capacitors are highlighted above. Most important, though, is the fact that you can select from standard ratings to zero-in on your power supply requirements without paying for costly specials that necessitate slower deliveries.

For detailed technical data, write for Engineering Bulletin 3461 to: Technical Literature Service, Sprague Electric Company, 35 ***Marshall St., North Adams, Mass. 01247.***

4SE 91158R1

THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS

SPRAGUE®
THE MARK OF RELIABILITY

a subsidiary of GK Technologies Incorporated

Circle 65 on reader service card

Announcing...

instant access to the most important recent advances in data communications technology.

Practical Applications of Data Communications
A User's Guide
edited by Harry R. Karp
Founding Editor, *Data Communications*

Catch up fast with the most significant and helpful breakthroughs in data communications technology with this invaluable briefing compiled from recent issues of *Data Communications* magazine.

You'll find a vast range of the most needed information and guidelines on such vital topics as...

- architectures and protocols
- data-link performance
- testing and diagnostics
- distributed data processing
- communications processors
- data security
- software
- digitized-voice and data-plus-voice

Page after page is packed with the realistic—not theoretical—insights you need for top on-the-job performance. All presented in straightforward terms you'll relate instantly to your projects in hand.

Network Designers will find an invaluable storehouse of the most needed information on architecture, protocols, and communications processors all focused on what it takes to meet your organization's data communications needs.

Corporate and Division Managers will gain indispensible insight into network complexities and come away better prepared to communicate objectives and assist in achieving goals.

Network Operators will benefit from clearcut presentation of the underlying theory and practice of network performance... *plus* timesaving descriptions of available equipment and techniques.

60 invaluable articles, including...

- Inside IBM's Systems Network Architecture
- Making SNA work on existing on-line networks
- AT&T answers 15 questions about its planned (ACS) service
- How to anticipate performance of multipoint lines
- How to determine message response time for satellites
- Relating networks to three kinds of distributed function
- The micro, mini, and mainframe in a DDP network
- Distributed data processing—the key is software
- An introduction to what makes the hardware run
- The NCP atlas: roadmap to IBM's net control
- The TP monitor: know what's important to ask before buying
- Network security in distributed data processing
- An orderly routine eases diagnostics on multipoint lines
- Spotting trouble on high-speed digital data links
- Network control: managing the data environment
- Seven steps to picking the best communications processor
- How concentrators can be message switchers as well
- Digitized voice comes of age: trade-offs and techniques
- and much more!

Order your copy today using the coupon below.

Electronics Magazine Books
P.O. Box 669
Hightstown, NJ 08520
(609) 448-1700, x5494

Send me the book (s) indicated to examine without obligation for 15 full days. At the end of that time, I will either remit in full plus local tax, postage and handling, or return the book (s) postpaid to Electronics Magazine Books.

☐ Practical Applications of Data Communications 424 pages, paperback, $13.95

☐ Basics of Data Communications 303 pages, paperback, $12.95

☐ McGraw-Hill's Compilation of Data Communications Standards, 1133 pages $165.00

☐ Data Communications Procurement Manual, 150 pages $24.50

Name _____

Company _____

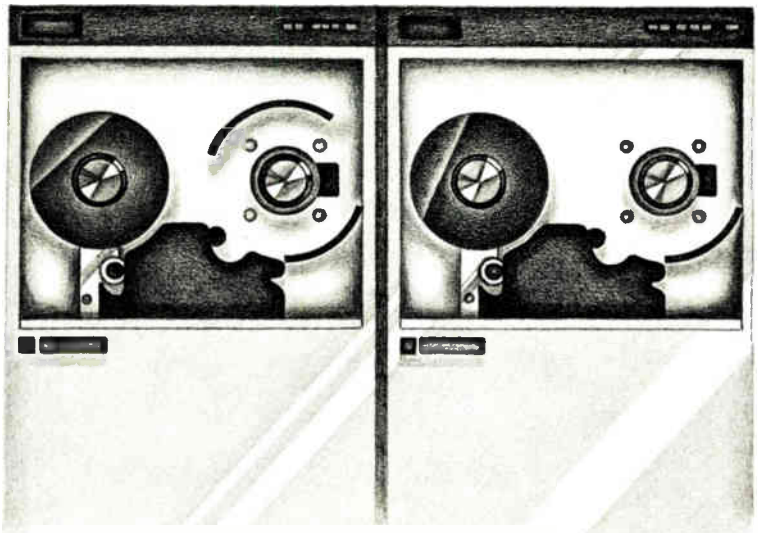
Address _____

City _____ State _____ Zip _____

SAVE MONEY! Remit in full with this order, plus local tax, and Electronics Magazine Books pays all regular postage and handling charges. Full return privileges still apply. Please allow 4-6 weeks for delivery.

☐ Payment enclosed (payment must accompany orders under $25) ☐ Bill my company ☐ Bill me EL

Super computer...



...or diminutive diode, the key to successful sales in Japan lies here:

Whether you are hoping to sell a multimillion-dollar computer system or a new line of components in Japan, you need to make your name known to the right people there.

And the perfect medium for getting your message across is Nikkei Electronics, Japan's leading electronics magazine.

Published bi-weekly, Nikkei Electronics is distributed on subscriber basis to more than 40,000 key decision makers in the electronics industry.

Nikkei Electronics. Success comes easier through us.

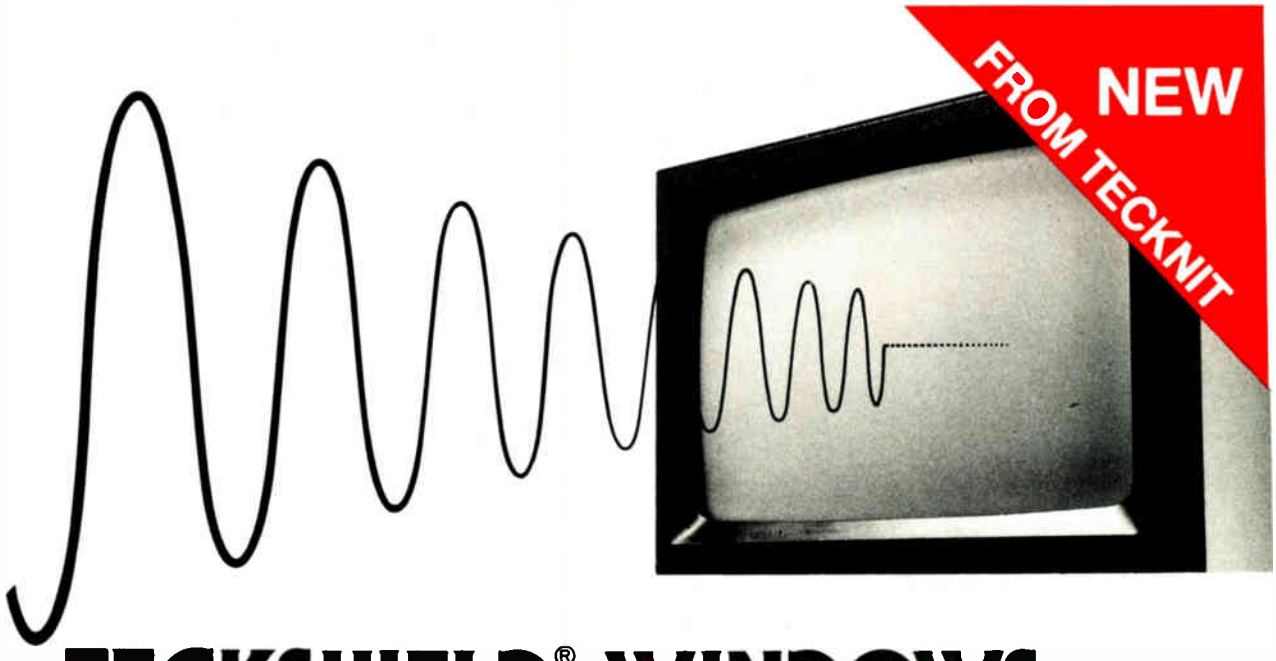
Japan's foremost electronics publication

Nikkei Electronics

NIKKEI-McGRAW-HILL, INC.
The Publisher of Nikkei Electronics
Wataru Makishima, Manager, Advertising.
Nikkei Annex Bldg. 2-1-2, Uchi-Kanda, Chiyoda-ku,
Tokyo, Japan. Telex: J26296 NKMCGRAW

Subscriptions: 42,866 (Feb.18, 1980 issue)
Circulation: 39,625 (Jan.–June 1979)
Japan ABC
Regularly audited by the Japan ABC

For further information, write to:
H.T. Howland, Marketing Services Manager,
Electronics, McGraw-Hill Publications Co.,
1221 Avenue of the Americas, New York,
N.Y. 10020, U.S.A. Tel: (212) 997-6642



TECKSHIELD® WINDOWS CUT EMI MORE THAN ~~50~~ 60 dB AT 1GHz

WITHSTANDS RIGOROUS MILITARY TEMPEST TESTING!

TECKNIT'S TECKSHIELD High Performance Windows combine optimum EMI shielding with excellent optical characteristics. **TECKSHIELD** windows perform dependably even in severe interference environments.

Design Features

- Special low-resistance mesh fully laminated between two layers of glass, acrylic, polycarbonate, or combinations of these materials.
- Curved windows for CRT computer terminals, word processors, and other CRT-based displays.
- Flat windows for maximum protection of teleprinters, LED, Nixie tube, and other flat displays.
- Color filters and polarizers for contrast enhancement.
- Uniform mesh-to-enclosure continuity around the entire perimeter of the shielded aperture.
- Good viewing screen image with minimum distortion.

TECKSHIELD High Performance Windows are specially designed to solve tough viewing aperture shielding problems. For further information contact the **TECKNIT** representative nearest you.

U.S. Sales Offices: ☐ **Cranford, NJ:** (201) 272-5500. ☐ **Santa Barbara, CA:** (805) 963-5811.

International Representatives: ☐ **England:** Dricom Ltd. (Woking, Surrey), Tel: WOKING 62465. ☐ **France:** Altoflex (Paris), Tel: 372-81-88. ☐ **Israel:** Mechatronics Engineering, Tel: 03-761927. ☐ **Japan:** Industrial Suppliers Co., Ltd. S.A. (Tokyo), Tel: 403-0471.

TECKNIT®

EMI Shielding Division **320 North Nopal Street • Santa Barbara, CA 93103 • (805)963-5811**

Matsushita microprocessor clocks at 13.3 MHz

Three companies in Japan's Osaka-based Matsushita group have announced the development of the fastest 16-bit n-MOS microprocessor yet. **To be available in sample quantities next spring,** it has a clock frequency of 13.3 MHz. The fastest execution time of any of the device's 100 different instructions—for addition and subtraction and logical operation—is 300 ns. Floating-point multiplication instructions can be executed in 58 ms. Known as the MN 1613, the new processor can address 512 kilobytes of main memory.

West Germans build small green-light laser

Using a proprietary design, researchers at the Ruhr University in Bochum, West Germany, have developed a helium-selenium green-light laser whose power output is comparable to that of a helium-neon laser but that is considerably smaller. The air-cooled laser, which emits its light at wavelengths between 497 and 530 nm, **has an output of 3 mW in multimode operation and 0.8 mW in single-mode operation.** Its active length is 10 cm, about one third that of a helium-neon version. The small size and green light should make it a handy device as an adjustment tool and for providing a pilot light in laser surgery. Since green light is three times more perceptible than red light, laser outputs of about 1 mW are clearly discernible even in broad daylight.

Mullard gives viewdata terminal intelligence

With its third-generation viewdata chip set, code-named Lucy, Mullard Ltd., the London-based Philips subsidiary, is transforming the basically dumb viewdata terminal, which links television sets to a remote computer by telephone, into an intelligent terminal system with powerful message-handling capabilities. The system **builds from a basic terminal for home applications to one addressing the professional market** with interfaces for a full alphanumeric keyboard, data cassette storage, and data transfer between terminals. It incorporates a modem, a universal asynchronous receiver-transmitter, and an autodialer that interfaces via the telephone line with other terminals and with a keyboard. There are also interfaces for a teletext display and for a remote control. **The heart of the system is a new custom large-scale integrated interface chip,** designated the SAA 5010, that works with an Intel 8048 microcomputer. Mullard is supplying customers with developmental printed-circuit–board systems expandable from one to three boards. A production version would fit on one board.

France wants major increase in domestic ICs

The French government wants French-controlled semiconductor firms to boost their output of integrated circuits enough over the next five years **to equal the country's needs by 1985.** Last year, production was less than 20%, nearly all of it in bipolar circuits. Jean-Claude Pelissolo, who heads the government's Direction des Industries Electroniques et de l'Informatique, disclosed the goal at an electronics markets strategies conference held in Monte Carlo by London's Financial Times and the UK consultant firm, Mackintosh International Ltd., in early May. Pelissolo estimates that foreign firms will still have half of the French IC market in 1985, meaning the French semiconductor houses will have to export half the chips they turn out.

International newsletter

Semiconductor moves made by GEC

Britain's General Electric Co. Ltd. is looking at ways of sharpening its semiconductor capability. For starters, it is bringing its microcircuit, hybrid, and power semiconductor activities together into one group with a $40 million turnover. Future development will be concentrated at a new plant in Lincoln, headquarters for the power semiconductor group. The company is also negotiating with the Canadian company, Mitel Corp., for manufacturing rights to its high-density dielectrically isolated complementary-MOS process. More speculatively, **the firm is interested in a stake in Inmos Ltd.** and is awaiting a reply from the government's National Enterprise Board. A joint manufacturing operation with Fairchild Camera and Instrument Corp. [*Electronics*, Aug. 17, 1978, p. 63] is going ahead at the engineering level at least, despite rumors to the contrary, but the long-term intent of both companies—since Schlumberger Ltd.'s acquisition of Fairchild—will not be fully tested till a scheduled board meeting to finalize equipment investment for the jointly owned fabrication unit at Neston, Cheshire.

Cambridge Scientific Instruments boosts E-beam unit's speed

One of the first products to benefit from the United Kingdom's joint electron-beam program embracing industry, government, and university research establishments is Cambridge Scientific Instruments Ltd.'s EBMF-6 electron-beam microfabricator. The vector-scanning machine is 10 times faster than its predecessor, thanks to **an increase in the writing rate from 1 to 6 MHz and and increase in resolution from 13 to 15 bits.** The latter allows the writing-beam diameter to be matched to the size of features within an individual frame that can be set from 0.5 to 3.2 mm on a side. Features down to $1/32$ μm have been produced. The writing speed is 6.4×10^6 picture elements per second. That means that a 4-inch wafer could be exposed in two hours using 1-μm design rules.

Philips' West German microcomputer plant now in full swing

The first European-made 8048 and 8021 single-chip microcomputers are now in full production at NV Philips Gloeilampenfabrieken's plant in Hamburg, West Germany. The new production facility, Philips says, should **help alleviate the supply shortages in some areas that have resulted from the enormous worldwide demand for microcomputer products.** "The facility will be a welcome additional source for such devices for many users," a company spokesman declares. The Dutch firm's 8048 family is fully interchangeable with that manufactured by Intel Corp. The production of other microcomputers of strictly European design is being planned.

Addenda

Hitachi Ltd. will start volume production of its 16-K electrically erasable programmable read-only memory, the world's first [*Electronics*, Feb. 15, 1979, p. 39], this fall in Japan and the U. S. Samples of the device, designated HN48016, are now available in the U. S. . . . Nippon Electric Co. has introduced **Japan's first office computer with Japanese-language input/output that combines data and word processing.** The N6300 model 50N will sell for about $35,600, and deliveries will start in October. On another front, NEC has opened a 37,000-ft^2 plant in Ireland's County Meath to increase its production of integrated circuits for the European market. Sales of the company's Irish operations rose from about $5 million in 1978 to more than $11 million in 1979, with another doubling expected for 1980.

Xicor, Inc. and MEM-EBAUCHES announce a joint international effort in semiconductor products.

X2201 FABRICATION FACILITIES

Xicor, Inc., a new California semiconductor firm and MEM-Ebauches Electroniques SA of Switzerland, the world leader in electronic time pieces, are engaged in a joint effort producing microprocessor-related products.

The initial products are nonvolatile semiconductor memories with unprecedented ease-of-use features.

(continued on next page)

Xicor™ announces a breakthrough

NONVOLATILE 5V STATIC RAMS

Xicor's X2201 and X2202 are the first easy-to-use nonvolatile 5V only static RAMs. They open up exciting new product opportunities.

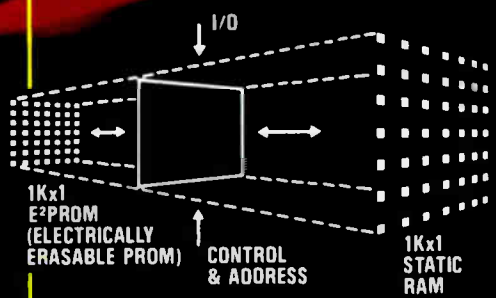
POWER-FAILURE PROTECTION: One simple TTL signal saves your entire RAM database! A snapshot nonvolatile copy of all RAM data is internally stored safe without power and will reappear automatically in the RAM when power returns—ready to use. No battery backup needed!

NONVOLATILE PROGRAM STORE: The X2201 and X2202 each contain 2K bits of memory organized as a conventional 1K static RAM overlaid bit-for-bit with a nonvolatile 1K Electrically Erasable PROM (E^2PROM). You can store a nonvolatile bootstrap program in the E^2PROM and at the same time access an independent program in the RAM memory. At any time, data can be transferred back and forth between the RAM and E^2PROM by simple store and recall signals.

5V ONLY: You will never need high voltage pulses or supplies. A single 5V supply is the only power source ever required for any function!

EASE-OF-USE: Unprecedented simplicity. All inputs and outputs are directly TTL compatible. Fully static timing.

PERFORMANCE: RAM cycle time is less than 250ns. During operation, data can be recalled from the E^2PROM an unlimited number of times.

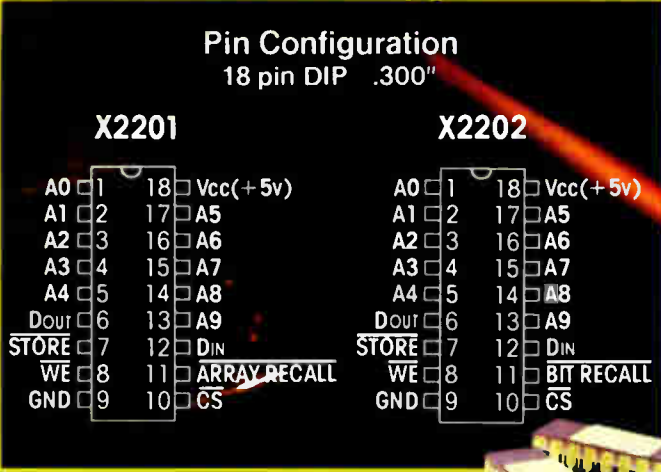


Xicor's X2201 and X2202 are fabricated with reliable n-channel floating gate MOS technology. For systems where RAM nonvolatility or *in-the-circuit* ROM changes by TTL signals are important, the Xicor X2201 *(array recall)* and X2202 *(bit recall)* are the only choice!

Applications

- Power-failure and crash protection
- Microprocessor systems
- Field-programmable control modules
- Instruments
- Nonvolatile electrical meters
- Cash registers and smart terminals
- Portable nonvolatile electronic databases
- Remotely codable security systems
- Electronic office equipment
- Consumer products
- Replacement of EPROM in applications where unsocketing, uv light data erasure and high-voltage programming are undesirable.

Pin Configuration
18 pin DIP .300"

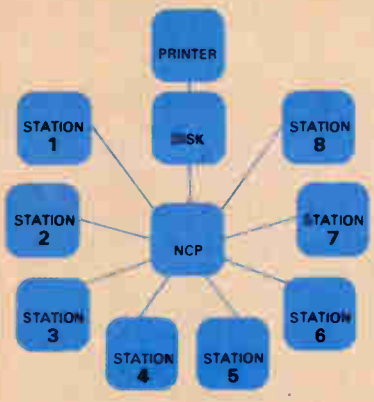


XICOR product is available now. For sales and information write or call:
XICOR, Inc., 1221 Innsbruck Dr., Sunnyvale, CA 94086, (408) 734-3041, TWX: 910-379-0033
Nationwide distributor: Marshall, Headquarters: El Monte, CA, (213) 686-0141

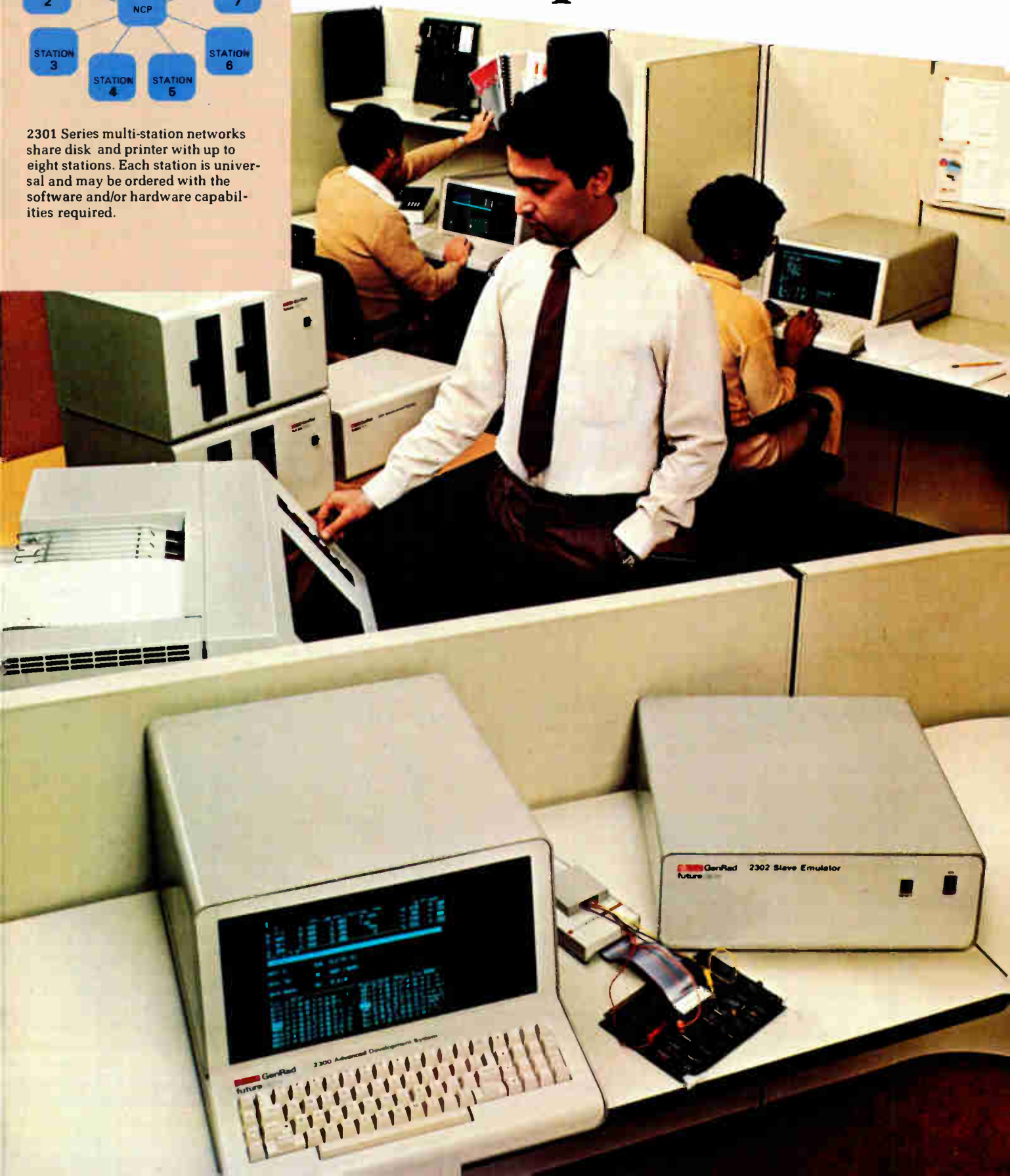
When the power goes out, Xicor remembers.

Circle 73 on reader service card

Multiply your micro capabilities with



2301 Series multi-station networks share disk and printer with up to eight stations. Each station is universal and may be ordered with the software and/or hardware capabilities required.



processor based design our universal network

ADVANCE YOUR SMART-PRODUCT DEVELOPMENT PROGRAMS—Our universal, multi-user development system network is the most cost-effective means of implementing a multi-station, microprocessor-based design facility. It's also the most versatile and productive solution to smart-product design.

MORE SUPPORT FOR MORE CHIPS FOR MANY USERS—Our network stations already support all of the most popular microprocessors. Our unique slave emulation system permits us to add support for new chips faster than anyone else. With eight stations tied into our network you can stop paying designers to wait in line. All eight can be developing products simultaneously with different chips.

MULTI-PROCESSOR EMULATION—Our slave emulation system provides transparent, non-stop, full-speed emulation to 10 MHz. And, it's the only system that allows simultaneous emulation of many different processors. Up to eight emulators can be tied into one network station. Our transparent in-circuit emulation and logic analysis take all the guesswork out of processor evaluation and design, even for products using several different chips.

SHARE AND SAVE—By sharing costly and under-utilized resources (disks, printers, slave emulators, design aids and software), a network system lowers your cost-per-station dramatically. Without trade-offs! Each user has his own CPU, CRT and keyboard. The same powerful software supplied with our stand-alone development systems is provided to each network station. Each station can be equipped with any combination of software and/or hardware capabilities you require, including local disk storage.

SPEED UP YOUR PROGRAMMING—With our interactive, high-speed CRT, complete operating system software, and assembly and high-level language programming capabilities, things happen fast—sometimes instantaneously. Now available with highly block-structured PASCAL compilers, our system can cut your programming time by 50% or more.

RELY ON THE LEADER—We started delivering network systems over one year ago. For a complete understanding of how these cost-effective systems can multiply your capabilities, contact one of our worldwide sales and service offices today.

8086
8085
8080
z8000
z80
68000
6809
6802
6801
6800
6502
1802
3870

GenRad
futuredata

GenRad/Futuredata
5730 Buckingham Parkway
Culver City, CA 90230
(213) 641-7200. TWX: 910-328-7202.

GenRad/Futuredata universal development systems – expanding your world of microprocessor-based design.

Circle 75 on reader service card


Are they
investing enough
to keep up with our
future plans?

When it's TRW, the answer is yes.

TRW has been in business for a long time and we're continually expanding to be sure we'll be in business tomorrow.

New plants are under construction, world-wide. Major capital equipment purchases have recently been made or are authorized for every division, to increase existing product capacity and to build state-of-the-art products.

We're investing in people, not only to fill new positions, but also in a special way to provide special attention to our customers. Full-time engineering/marketing teams, with specific account responsibility are now functioning, and additional teams are being added, to work on long-range programs and to assist in day-to-day operations.

If you want a supplier that is willing to invest in your company's future, call your nearest TRW/ECG sales office or Renfrew Electronics in Canada. You'll find them listed in EEM, Gold Book, Electronics Buyer's Guide, Who's Who in Electronics, the Electronic Industry Telephone Directory and the Electronic Buyer's Handbook.

TRW CAPACITORS
TRW CINCH CONNECTORS
TRW CINCH-GRAPHIK
TRW GLOBE MOTORS
TRW INDUCTIVE PRODUCTS
TRW IRC NETWORKS
TRW IRC RESISTORS
TRW LSI PRODUCTS
TRW OPTRON
TRW POWER SEMICONDUCTORS
TRW RF SEMICONDUCTORS

TRW ELECTRONIC COMPONENTS GROUP

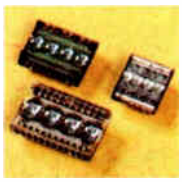
DIVISIONS OF TRW INC.

5725 East River Road • Chicago, Illinois 60631

THE LITRONIX SAMPLER.

Here's a tiny part of the broadest line in optoelectronics.

INTELLIGENT DISPLAYS™



Four character, 17 segment LED alphanumeric display with on-board memory, character generator ROM, and LED multiplex and drive circuitry. Product available with .112", .160" and .225" characters. Interfaces just like a RAM.

LED DISPLAYS.

Red, orange, green and yellow digits. Numeric, alphanumeric and bar graph styles. Eight sizes from .1" to .8" high. In DIPs of one to four digits. Light pipes with wide viewing angles, air gap reflectors and filled reflector displays.

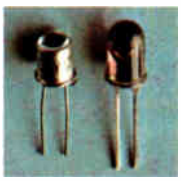
LED LAMPS.

Red, orange, yellow and green lamps. T-1, T-1¾ and miniature axial lead packages. Arrays of two to ten lamps. Lamps that flash on/off. Constant current lamps.

OPTO-ISOLATORS.

One, two and four-channel opto-isolators. Current transfer ratios up to 450%. Isolation voltages up to 5000v. Nine JEDEC types.

IR EMITTING DIODES.

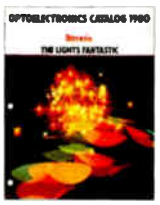


Lowest degradation available from any source. From medium to very high power. Beam widths from 6° to 60°. Hermetic and low cost non-hermetic TO-18 packages. Axial or radial leads. Arrays of two to ten diodes.

PHOTO-DETECTORS.

Photo-transistors and photo-diodes with acceptance angles from 6° to 73°. Hermetic and low-cost non-hermetic. TO-18 packages, ceramic packages and miniature radial lead configurations. Arrays of two to ten detectors.

ASK FOR YOUR COPY OF LITRONIX 1980 CATALOG THROUGH YOUR LOCAL DISTRIBUTOR:



U.S. Distributors: Advent, Almac-Stroum, Arrow, Component Specialties, Gerber, Hamilton Avnet, Harvey, Kirkman, Lionex, Marshall, Moltronics, Pioneer, Summit and Zeus.
Canadian Distributors: C.M. Peterson, Electro Sonic, Future, Hamilton Avnet and L.A. Varah.

Litronix, 19000 Homestead Road, Cupertino, California 95014.
Phone (408) 257-7910.

Circle 78 on reader service card

litronix
AN AFFILIATE OF SIEMENS

THE LIGHTS FANTASTIC

Electret microphone's output is quiet and highly linear

by Kevin Smith, London bureau manager

One of three types to be evaluated by the BPO, it performs better than carbon-granule microphones

A thin electrically polarized plastic membrane vibrating in sympathy with the speaker's voice will soon replace the carbon-granule microphone in large-scale trials by the British Post Office. The new electret microphone is one of three technologies—the others are piezoelectric film and moving coil—to be evaluated in a first bulk purchase of high-quality linear microphones.

The speech quality of the electret microphone is far superior to that of the carbon-granule microphone, but it does need an amplifier, and this pushes the cost to $6 for initial pilot production versus $1 for its predecessor. In compensation, BPO researchers argue, the electret microphone's inherent reliability will cut service calls, lowering overall costs. Further out, future telephone generations performing many other functions and containing several integrated circuits could incorporate the amplifier as part of an existing chip at little or no extra cost.

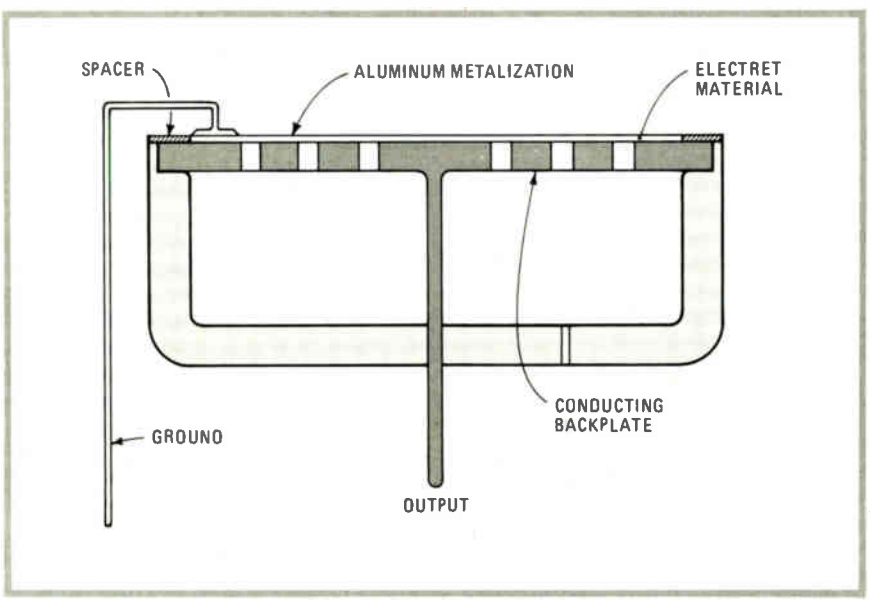
Committed. The post office has now made a commitment in principle to high-speech-quality linear microphone designs. As one part of a $110 million program to replace existing phones with more modern versions, it has placed a first, 150,000-piece order with five suppliers for telephones incorporating a variety of linear electronic amplifier designs. The bulk of these purchases is for electret microphones to be supplied by A. P. Bessons Ltd., GEC Telecommunications Ltd., Pye-TMC Ltd., and Standard Telephones & Cables Ltd. Plessey Telecommunications Ltd. and STC are also supplying piezoelectric-film versions.

Electrets—a term coined by Oliver Heaviside to describe materials that permanently retain an electric charge—can now be made using polymer films such as fluorinated ethylene polymer Teflon aluminized on one surface and only 13 micrometers thick. A charge of up to 100 volts is imparted to the membrane during manufacture by one of four basic techniques—electron-beam, corona-discharge, thermocharging, or knife-edge.

Diaphragm. In a design originating at the BPO's Martlesham, Ipswich, research center, a metalized film diaphragm is placed 70 μm in front of a conducting back plate. It closely resembles a capacitive microphone in action but without the need for a polarizing voltage. Flexure of the diaphragm changes the microphone's capacitance and with it the charge-induced voltage. A back volume of air is also included to provide compliance, against which the diaphragm acts under the influence of a sound wave.

The resulting microphone structure provides a highly linear low-noise output. This performance is reliable, predictable, and stable with age, and the output is unvarying with line length. In all respects except cost, it is thus superior to the carbon-granule microphone.

Because of the electret microphone's low output, some 20 decibels below that of a typical carbon-gran-



On trial. The electret microphone above, one of three high-quality linear types the BPO is to evaluate, uses a metalized film diaphragm and acts much like a capacitive microphone.

ule microphone, a compensating amplifier with a high input impedance (10 megohms) must be provided. It is most readily achieved using a field-effect transistor in a hybrid configuration and could eventually be integrated. But for stand-alone applications, the research center has commissioned Ferranti Semiconductors Ltd. to develop a one-chip solution using its high-density collector-diffused-isolation, or CDI, process.

Integrated amplifier. The circuit, to be evaluated in the Besson transducer, incorporates a high-impedance Darlington front end together with a high-dissipation bridge used to rectify the supply. Designated the ZN470, the 72-by-75-mil chip is housed in a 14-pin dual in-line plastic package. To enable it to handle up to 2 watts at line currents of up to 100 milliamperes (or 200 mA for a 20-second overload), Ferranti uses a copper-alloy lead frame with the unused pins shorted together. The amplifier's operating temperature range is from $-20°$ to $+80°$C.

Since electrets have an extremely high impedance, the amplifier has to match into it. To achieve this in bipolar technology, Ferranti engineers adopted a Darlington input configuration with its input impedance determined off chip by high-impedance biasing resistors. As a result, the chip can handle the electret's input current of 2 to 5 nanoamperes, providing a 20-dB current gain. Thus the resulting output is comparable to that of the carbon-granule microphone, for which it is a drop-in replacement.

But whereas the carbon-granule microphone's output varies with line length and hence current, the output voltage variation of Ferranti's chip is less than 1 dB for line currents of from 10 to 100 mA. In fact, the amplifier will operate down to a line current of 1 mA. Further, to match the chip to the transducer, the gain can be set during manufacture from 20 to 26 dB in 2-dB steps.

West Germany

Focusing system emulates human eye to yield clear, high-contrast pictures

A research team at the Technical University of Berlin has developed a system that focuses a video camera or other photographic device fully automatically. Called Biofocus, it allows clear, high-contrast pictures to be made that compare in quality with those taken by a professional photographer with a manually focused video camera.

The result of a five-year development effort by Ingo Rechenberg, Hans-Eberhard Koralewski, and Peter Bienert of the university's Institute for Measuring and Control Engineering, the new system is based on a phenomenon encountered in real life: the focusing mechanism of the human eye. Hence the name "Biofocus."

According to the researchers, who consider their system a milestone in photographic techniques, many others around the world are also working on self-focusing, but their efforts have thus far led to systems that provide only inadequate pictures. The reason, the team believes, is that others are approaching the problem from the wrong end. They all try to perfect highly precise distance-measuring devices based on either ultrasound or triangulation techniques and use the measured results as criteria for controlling the camera lens. The upshot: generally sharp objects in the near field, but poorly focused objects further away.

Instead, Koralewski says, "we set out to emulate the eye." He explains that, to focus, the eye evaluates contrast levels. In this process, the eye muscles are always in motion, shaping the eye's lens such that the sharpest light-dark contrast, and thus an image of the highest possible sharpness, is projected onto the retina.

At the retina, nerve cells collect and sort the light information and convert it into electrical pulses. The latter are sent to the vision center in the brain. If the nerve cells transmit pulses denoting a poor-contrast, unsharp image, the brain tells the muscles to adjust the eye's lens for greater sharpness.

That, in principle, is what the Biofocus system does electronically. But of course the system is a far less sophisticated device than the human eye with its millions of nerve cells.

Implementation. In implementing their scheme, the team uses the photoconductive layer on the camera's vidicon tube to represent the eye's nerve cells. Taking the place of the eye muscles is an electric motor that continually adjusts the camera lens for optimum sharpness in accordance with the vidicon output.

The vidicon output, which consists of a stream of signals each representing the brightness of a picture dot, is evaluated signal by signal. Three signals are handled at a time. The first one is delayed by a certain period, typically 200 nanoseconds, the second one by half that time, and the third is undelayed, so that the three signals are simultaneous.

Next, half of the first and third signals is subtracted from the second signal, so that the result represents a brightness-difference signal of a certain level. The delay and subtraction process, taking place behind the vidicon tube, is a continuous one, with the last two signals of one three-signal combination constituting the first two signals of the succeeding combination.

In this manner, the brightness-difference signals for a whole "measuring window"—that is, the marked-off portion of the camera field in which the object to be photographed lies—are obtained. The difference signals are subsequently summed and integrated and the resulting difference signal represents the degree of image sharpness. Maximum sharpness is obtained when the lens is adjusted to its optimum position. As an aid, the degree of sharpness can be read off a meter calibrated in volts.

The difference signals from the

4K CMOS RAMs.

New page

To: C. Keith, Components Engineering

From: B. Jones, Design Engineering

Hey, have you guys seen and/or followed up on this OKI ad? Let's get crackin'. These 4K CMOS RAMs are more than just replacements for good old standby 6504, 6514 and 2114L. They're REAL IMPROVEMENTS in memory technology. With low power requirements. Plus battery backup...this alone oughta turn customers on (blackout protection)!

And never underestimate the selling power of low-power RAMs. Less draw, less heat—no need to wire in a cooling fan. Said customer not only saves bulk and bucks on power...he can also add memory later without hassling heat build-up. A big deal for super-compact system expansion or upgrade.

Better yet, OKI's not talking some "pie in the sky" CMOS RAM family. They've got specific product. Available now. In volume.

* Ask OKI to ship MSM 5104, to replace 4Kx1 6504.
* Design in MSM 5115 with on-chip registers, to replace 1Kx4 6514.
* Plug MSM 5114 right into N-Channel 2114L sockets. A pin-for-pin replacement: snap out, snap in...and system keeps running, but now with OKI CMOS RAM low power and battery backup!

For complete data, use the ad coupon. But I wish you'd take a shortcut and call OKI today. (408) 984-4842. Ask for Ron Engelbrecht, Sales Director.

B. Jones

P.S. They seem to volume-stock Rex the Wonder Dog tales... be sure to pass the new one along.

Hig
rep

OKI
sock
prote
Our
regist
socke

Demo leadership in CMOS technology.

OKI's CMOS quality story began 10 years and 20 million chips ago. Now the same dedication to quality which built our broad line of low power and CMUX multiplexed consumer watch/clock circuits is apparent in circuit designs for the electronic OEM market. Our future as a broad-line supplier of RAM, EPROM, and microprocessors for minicomputer, computer mainframe and telecommunications systems designers is beginning now.

Please rush data sheets on OKI 4K CMOS RAMs:

- ☐ MSM 5104—4Kx1, 6504 replacement
- ☐ MSM 5115—1Kx4, 6514 replacement
- ☐ MSM 5114—1Kx4, plug-in 2114L replacement

And:

- ☐ data sheets for all OKI memory product
- ☐ add me to your mailing list

Name_____ Title_____

Attach coupon to company letterhead (jot down your RAM application for a special deal), and send to: OKI Semiconductor, 1333 Lawrence Expressway, Santa Clara, CA 95051. (408) 984-4842.

OKI

Circle 81 on reader service card

summing and integrating circuits are fed to the camera-control unit, where they are temporarily stored in a sample-and-hold circuit. A comparator then compares each incoming signal with the previously stored one, determining whether the new value is bigger or smaller than the previous one. Depending on the result of this comparison, the motor is signaled to turn the camera lens in either the same or the opposite direction. If the new value is bigger than the old, the direction changes. Thus, the position of the lens is continually changed in search of the optimum sharpness of the image.

Koralewski sees a host of applications for the Biofocus system. Besides in video cameras, it could be used in slide projectors; there, an array of photocells would sense the brightness and sharpness level of the projected slide. The Berlin team has, in fact, already built an experimental model of a Biofocus-based slide projector. Other applications are in movie cameras, electron microscopes, and night-vision cameras. In amateur-type still cameras, however, the system will not be used soon because of its initial high cost.

Both industry and the military, Koralewski says, are already showing much interest. Negotiations with some firms wanting to commercially exploit the system are already under way. **-John Gosch**

France

Thomson-CSF going after market for broadcast-satellite TWTs

Like death and taxes, more television seems inevitable, and with terrestrial channel allocations already hard to come by, countries from Australia to Zaïre expect they will one day beam TV programs into their territories from geostationary satellites. That points to a solid market on the way for space-qualified broadcast tubes, and Thomson-CSF, the leading French firm in space electronics, has positioned itself for a solid share.

Flight models. Roger Agniel, marketing manager for Thomson's Electron Tube division, headquartered in the Paris suburb of Boulogne-Billancourt, says the company's effort to develop high-power traveling-wave tubes for TV broadcast satellites involves an outlay of about $12 million. The firm already has a return in sight: it is producing 30 flight models of a 230-watt version of the tube, a dozen of which will power the preoperational satellite that France plans to launch early in 1984 as part of the Franco–West German direct-broadcast satellite project [*Electronics*, Dec. 6, 1979, p. 66]. The order for the tubes, which operate in the 12-gigahertz region, is expected toward the end of this year.

Agniel is convinced this first batch will be just the beginning. Although AEG-Telefunken has a TWT in the works that will power the preoperational satellite that the West Germans have scheduled for a late 1983 launching, French tubes could possibly get the pick for follow-on satellites as the four main contractors—AEG-Telefunken and Messerschmitt-Bölkow-Blohm GmbH of West Germany and Société Nationale Industrielle Aérospatiale (SNIAS) and Thomson for France—apportion the procurement to get the near 50-50 balance the two governments have agreed on. Above all, Thomson is counting on the upcoming world market for TV broadcast satellites to make its investment a profitable one.

The tube that the firm is readying for this market is the TH 3619. It was first breadboarded last summer, and the engineering model should be ready by the end of the year, Agniel says. Despite its power rating of 200 to 230 W at 11.7 to 12.5 GHz, the tube all by itself cannot power a satellite-TV channel, so Thomson has worked out a way to operate two 3619s in parallel and thus get the 350 W or so necessary for the French satellite. Jean Boulange, export manager for microwave tubes and devices, says that the company's engineers think TWTs with a 400-W output could be designed. But he points out that it would be difficult at that power to get the reliability that is a must for space applications, where tubes must last for seven years or more.

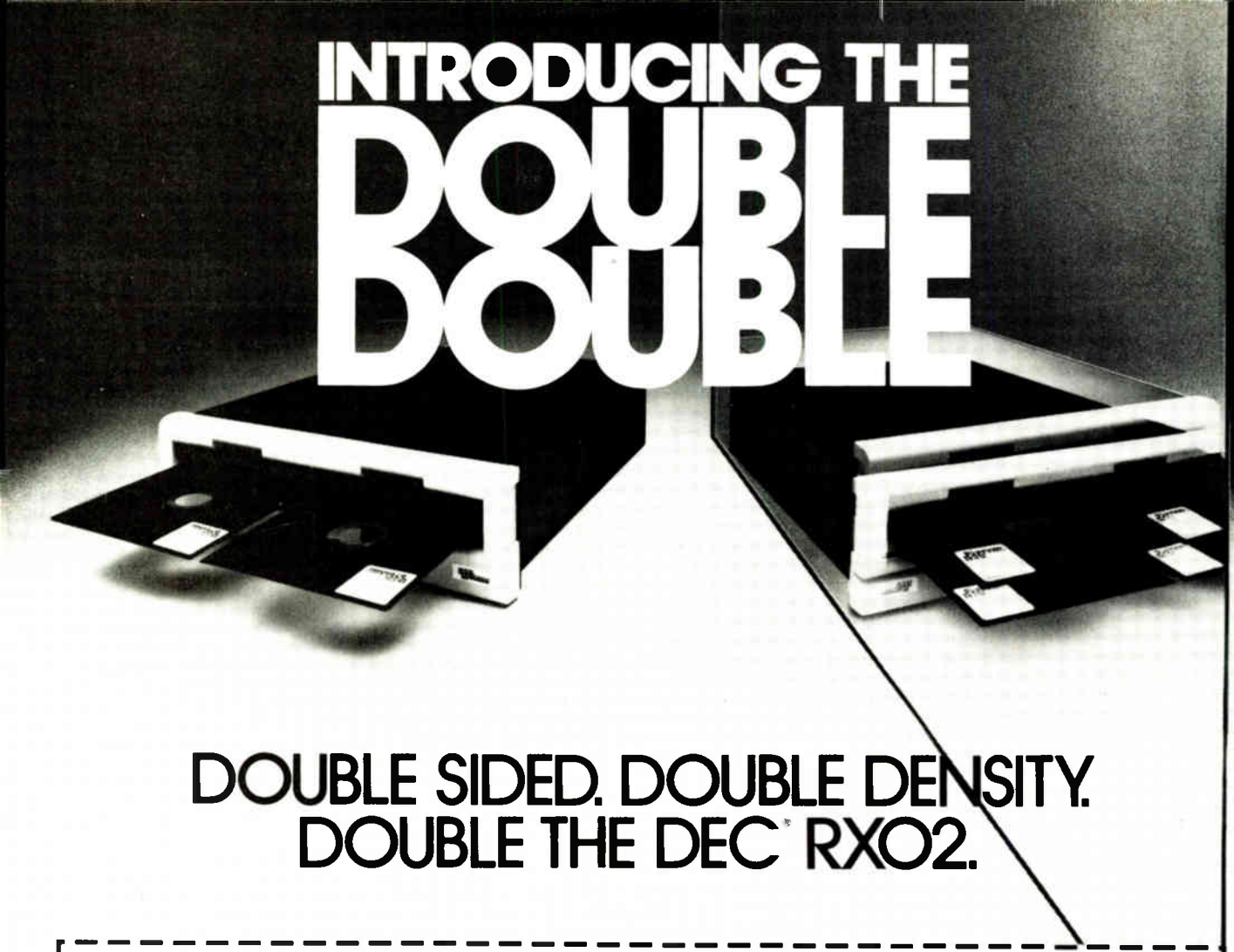
Actually, the 3619 is the high-power version of a line of TWTs for TV satellites that Thomson started developing some four years ago. The amplifying technique is conventional—a microwave signal traveling along a helix interacts with an electron beam. Traveling-wave amplification can also be achieved using coupled cavities instead of a helix, but this makes for a much heavier tube. The 3619 weighs in at just over 3 kilograms; a coupled-cavity tube with the same output power would weigh 7 to 8 kg, says Boulange.

Although the amplification scheme is conventional, Thomson has its particular technology for building TWTs. For one thing, it brazes the copper helix to its beryllium oxide supports and the supports to the copper envelope of the tube as well. This structure boosts the thermal transfer to the outside by a factor of 10 or more compared with a mechanically fixed helix, Agniel maintains, adding that no other tube maker has mastered the Cu-BeO brazing technique. And, he insists, this will be the first time direct thermal radiation will be used in a satellite tube.

Impregnated. For another, the tube's collector, with electrodes of pyrolytic graphite, radiates directly into space, so that heat levels inside a satellite will remain reasonable even at high power. Like other tube makers, Thomson uses porous tungsten cathodes impregnated with calcium and barium aluminates; they have longer life than cathodes coated simply with oxides.

Despite its many merits, a single 3619 cannot provide the power needed for good reception all over France. Therefore the company, which is responsible for the electron-

INTRODUCING THE DOUBLE DOUBLE



DOUBLE SIDED. DOUBLE DENSITY. DOUBLE THE DEC® RX02.

FULL RX02 COMPATIBILITY—HARDWARE, SOFTWARE, AND MEDIA.
DOUBLE THE CAPACITY—ONE MEGABYTE ON EACH DISKETTE.
BUILT-IN BOOTSTRAP—CONFIGURE AN ENTIRE LSI SYSTEM IN A FOUR-SLOT BACKPLANE.

THE DSD 480

- FOR PDP®-11 OR LSI-11 SYSTEMS.
- ALL IBM AND DEC DISKETTE FORMATS—convenient data exchange between DEC and IBM systems.
- EXCLUSIVE "HYPERDIAGNOSTICS"—Built-in intelligence for switch-selectable self-testing and display.

THE DSD 470

- FOR LSI-11 SYSTEMS.
- LSI-11/23 FOUR-LEVEL INTERRUPT ACKNOWLEDGEMENT—DEC standard for all future peripherals.
- ON-BOARD DIAGNOSTICS FROM ODT—Simplified incoming inspection or system analysis.

LOW PROFILE, MODULAR PACKAGE—ONE HALF THE SIZE OF THE RX02.
HIGHER PERFORMANCE—34% FASTER AVERAGE ACCESS THAN THE RX02.

Advanced technology and innovative engineering deliver DEC-compatible flexible disk systems with added capabilities and superior performance. When you need increased storage capacity and proven reliability for your DEC computer, look to the leader—DATA SYSTEMS DESIGN.

☐ Please call me. ☐ Please send me more information.
My system: ☐ LSI-11, PDP-11/03, LSI-11/2, ☐ LSI-11/23, ☐ PDP-11/____

Name_____ Title_____ Company_____
Address_____ City_____ State_____ Zip_____
Telephone_____

E 4/10/80

Data Systems

Data Systems Design, Inc.
3130 Coronado Drive
Santa Clara, CA 95051
(408) 249-9353
TWX 910-338-0249

Eastern Regional Sales
990 Washington Street, Suite 101
Dedham, MA 02026
(617) 329-5730
TWX 710-348-0563

® Registered trademark of Digital Equipment Corporation

Electronics International

ics package, will operate them in parallel to get the necessary 350 W per channel. TWTs have been paralleled before for satellite operation, but at much lower power and frequency levels.

The idea is to group the tubes by threes and run two of them at a time. To do this, the input signal is split into three approximately equal signals, each of which drives a TWT amplifier. Associated with the amplifiers are three remote-control switches. One selects single-tube or double-tube operation (a single tube will work for degraded reception), and the other two select the operating tubes.

When two are working, the output signals are recombined by a hybrid coupler. The phase difference between the outputs of these TWTs usually runs no more than 30°, and the power loss is therefore not crucial. If closer matching is desired, it can be had by attenuating the input signals or by adjusting the helix operating voltages of the tube.

Twos and threes. For the preoperational satellite, Thomson now plans to use two groups of three tubes and three groups of two in parallel for a total of 12. Although the satellite will have only three broadcast channels, this setup will make it possible to try out a five-input multiplexer for the antenna.

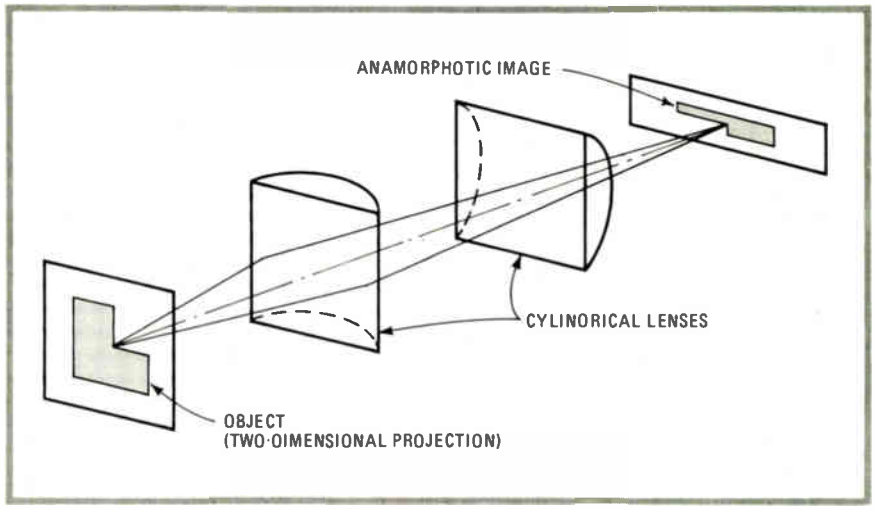
The company says that the change was made to make the French and West German satellites more like each other. Thomson switched to a five-input multiplexer because the operational satellites will have five channels. **-Arthur Erikson**

West Germany

Optoelectronic sensor makes images quasi–one-dimensional for fast processing

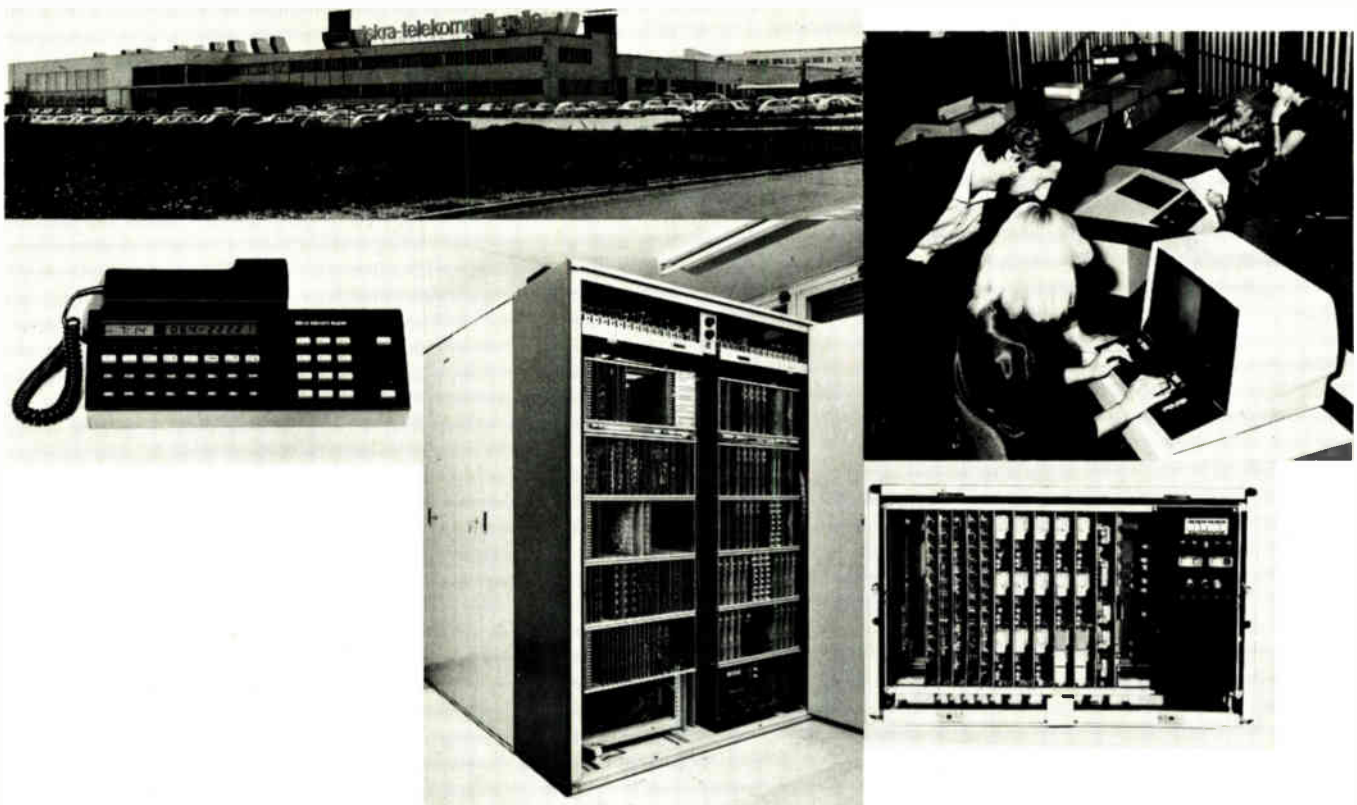
With automated production processes in mind, engineers at Siemens AG in Munich have perfected a fast, low-cost optoelectronic sensor that reduces a normal two-dimensional image of an object to a quasi–one-dimensional image. This considerably reduces the amount of data that pattern evaluation circuits must subsequently cope with, thus allowing more patterns to be handled in a given time.

Called Optomat and developed by Norbert Roth and his associates, the sensor could be part of an industrial robot for recognizing the shapes of workpieces or part of a sorting system. In the latter application, the



Done with lenses. Optomat sensor converts two-dimensional image into quasi–one-dimensional, or anamorphotic, one detected by just one row of photodiodes.

YOU KNOW THE LARGEST ELECTRONIC COMPANIES IN THE WORLD. DO YOU KNOW ISKRA?



Iskra group has some 29,000 employees including 2,000 research and development engineers in 81 factories, research, marketing and other organizations, and the most up-to-date technologies to work with. With a total turnover of 1.294 billion dollars last year, it has been classified among 16 largest manufacturers of electronic products in Europe.

In its development, Iskra is oriented towards tomorrow's activities which go far beyond the traditional limits of electromechanics and extend to the widest application of electronics with priority being given to the promotion of the development of computers, communications, automation, microelectronics, optoelectronics and engineering activities. All to ensure that every project we handle comes within schedule and budget requirements and meets performance and client expectations.

Iskra has 24 trading companies, representative offices and production plants in 18 countries all over the world. In the period 1974-1979, Iskra's exports increased by 153% reaching 120 million dollars in 1979. In 1980, the total turnover is expected to be 1.486 billions of dollars and the export figure approximately 145 million dollars.

For more information call or write:

Iskra Commerce, Trg revolucije 3, 61001 Ljubljana, Yugoslavia, Telephone-international: + 38 61 324 261; Telex: 31 356 yu iskexp

USA: Iskra Electronics Inc., 8 Greenfield Road, Syosset, N.Y. 11791, Tel.: (516) 364 2616—*Germany:* Iskra Elektronik, GmbH, Furtbachstrasse 2b, 7000 Stuttgart 1, Tel.: (711) 60 30 61—CEFRA, GmbH, Ungererstrasse 40, 8000 München 40, Tel.: 39 20 61—*Italy:* Iskra Elettronica Italiana, S.r.l., Piazza de Angeli 3, 20 146 Milano, Tel.: 49 80 036—*France:* Iskra France, 354, rue Lecourbe, 75015 Paris, Tel.: 554 04 27—*United Kingdom:* Iskra Limited, Surrey CR 3 2 HT, Redlands, Coulsdon, Tel.: 66 87 141—*Switzerland:* Iskra Electronics AG, Stalden 11, CH 4500 Solothurn, Tel.: (065) 22 81 22—*Czechoslovakia:* Iskra, Lazarska 5, 11000 Prague, Tel.: 20 27 71—*Poland:* Iskra, Swietokrzyska 36 m 15, Warsaw, Tel.: 20 12 53—*Germany DR:* Iskra, Hermann-Maternstrasse 46, 104 Berlin, Tel.: 28 28 322—*Rumania:* Iskra, Str. Visarion nr. 6, Bucharest, Tel.: 50 26 75—*U.S.S.R.*: Iskra, Mosfilmovskaja 42, Moscow, Tel.: 147 84 03—*Egypt:* Iskra, 34 Adly Street, Cairo, Tel.: 74 76 95—*Iran:* Iskra Teheran, 9th Street No. 6, Maydan Sanai, Teheran, Tel.: 82 67 65—*Turkey:* Iskra Istanbul, Yenicarsi Biltez Han No. 40, Galatasaray, Tel.: 44 75 00—*Venezuela:* Eurocommerce S.A., Apartado 68901, Altamira, Caracas, Tel.: 72 88 21.

Iskra

Circle 85 on reader service card

See page 205

Electronics international

device could be programmed to respond only to certain object patterns moving past it and to disregard all other shapes.

Lenses. The key to the sensor's operation, Roth explains, is a lens system consisting essentially of two half-cylinder lenses (see figure). From a normal two-dimensional image of an object, the lenses produce a laterally stretched and vertically highly compressed version, called quasi-one-dimensional, or anamorphotic. Because of the narrowness of that image, it can be projected onto just one row of photodiodes.

The Optomat uses 128 such diodes in a row. Their output is a video signal proportional to the brightness levels of the original object. An evaluation circuit external to the sensor digitizes the signal and compares it with the previously stored data of a reference image. A Siemens SKC85 microcomputer, which is built around an 8085 microprocessor, checks whether or not the signal and the reference image agree. In this way, the sensor detects the patterns of the workpieces that it is programmed to recognize.

Less data, more speed. Since only one row of photodiodes is used, the data to be handled is much less than would be involved if a two-dimensional image were projected onto a two-dimensional diode array. The number of patterns that can be compared in a given time is therefore high: up to 7,000 per second. This speed allows workpieces to be moved quickly past the sensor.

With the present sensor, image fields between 2 by 2.8 millimeters (79 by 110 mils) and 50 by 70 mm (2 by 2.8 inches) in size can be obtained. The workpieces need not move through the image field at a constant rate, so that they may be moved past the sensor along a transport system or down a slide.

The Optomat sensor could also be used to automatically detect flaws—in textiles, for example—to check the position of parts during automated assembly, to read characters and symbols, or to select electronic components according to their size and shape. **-J. G.**

R.OHM THERMAL PRINTHEADS

Integrated Electronics — Drive circuits, shift registers and diode matrix are integrated on the printhead.

High Dot Density — Up to eight dots per millimeter.

Wider Print Widths — Print widths up to 10" from single element.

High Speed — 2 milliseconds per line.

Extended Life — MDLBF = 100×10^6

With R-Ohm printheads, thermal printing becomes a practical, reliable alternative for hundreds of applications, including yours.

Contact us today.

R.ohm

QUALITY · RELIABILITY

R-Ohm Corporation, 16931 Milliken Ave., Irvine, CA 92714
(714) 546-7750. Central Office: (312) 843-0404.
Eastern Office: (215) 337-8877. TWX: 910-595-1721

Vrrroom.

Introducing Series 20: 0-60 pins in 20 MHz.

The faster your LSI devices, the more you need our latest breakthrough. Because our new Sentry® Series 20 is one of the fastest LSI test systems around. It can test a full 60 pins of microprocessor, memory and peripheral chips at an uncompromised 20 MHz. Or 30 pins at 40 MHz.

The Series 20 system uses 10K and 100K ECL throughout all formatters, timing paths, pipeline and local memory sections. You get faster throughput and faster data formatting.

You'll test MOS and bipolar memories, microprocessors and peripheral chips that run above 10 MHz. Static RAMs, bit slice microprocessors and microprogrammable controllers that run above 20 MHz. And you'll be able to characterize these high speed devices as they're designed. In fact, Series 20 is the only commercially available tester that can provide full 60-pin I/O operation at 20 MHz.

Series 20 also features an enhanced timing system that gives you increased accuracy and flexibility at these high speeds. You get 156-picosecond resolution to place edges accurately when testing AC parameters. And 16 timing generators so you can program up to 32 edges independently. You can even change each edge between 16 different values on the fly.

Series 20 gives you expanded memory capacity. Up to 196K 24-bit words give you the program capacity needed to test future high-speed devices. And our new fast, fixed head disk gives you a two-to-one speed advantage in access time while expanding your program capacity even further. Your investment is solid today and protected for years to come.

Series 20 is compatible with all Sentry software. So you don't have to wait for programs to be developed. You can start right up, using existing Sentry programs without incurring heavy retraining and programming costs.

So don't let the new technologies pass you by. Shift into high speed with Series 20. You get the speed, accuracy, flexibility and worldwide support that will keep you ahead of the pack. Call us at (408) 998-0123. Or write Fairchild Test Systems Group, 1725 Technology Drive, San Jose, California 95110.

FAIRCHILD

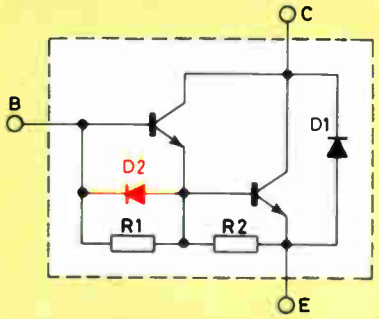
A Schlumberger Company

The First Family of ATE.

SGS-ATES.
Dimensions of perfection in the universe of power.

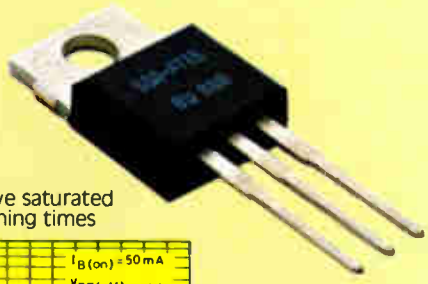
A shining example:

BU806

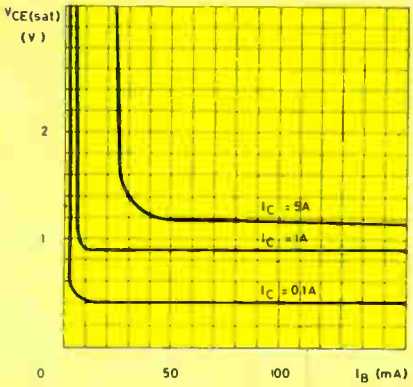


R1 Typ. = 100Ω
R2 Typ. = 3.3kΩ

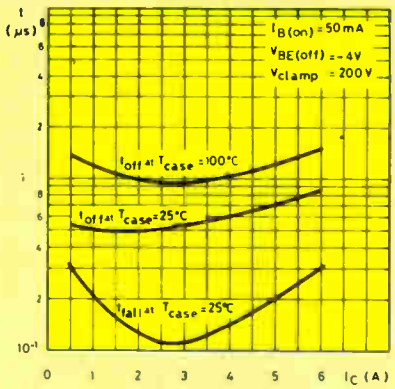
High current, high voltage capability
V_{CEO} — 200 V; V_{CBO} — 400 V
$V_{CE\ (sat)}$ — 1.5 Vmax at I_C — 5A / I_B — 50 mA



Collector-Emitter saturation voltage



Inductive saturated switching times



Low-cost plastic package with power dissipation up to 60W.

An on-chip extraction diode guarantees high switching speed over the whole collector current range.

BU806 - Fast darlington with integrated speed-up diode from a range of power darlingtons for every application.

With several years of production experience behind it, the BU806 fast high-voltage darlington is one of the most advanced devices in the extensive SGS-ATES range.
In the demanding field of power semiconductors SGS-ATES have a market position consolidated by finding the right and competitive balance between performance and price.
The BU806 isn't the only example, there are the complementary BDX53 (NPN) and BDX54 (PNP) series - available in voltage ratings from 45V to 160V, the BU910/12 series - with collector currents up to 10A, $I_{C\ (sat)}$ = 4A, $V_{CEO\ (sus)}$ from 350 to 450V.

SGS ATES **Minute details matter.**

SGS-ATES Semiconductor Corporation - Waltham, MA 02154 - 240 Bear Hill Road - Tel. (617) 890-6688 - Tlx. 923495 • Des Plaines, IL 60018 - 2340 Des Plaines Ave. - Tel. (312) 296-4035 - Tlx. 28247 • Representatives: AL: REP INC - Huntsville (205) 881-9270 • AZ: HECHT, HENSCHEN - Phoenix (602) 275-4411 • CA: KAPLAN - Carlsbad (714) 438-4488 • CA: KOTTMEIER - Cupertino (408) 255-3710 • CA: RICAL - Santa Ana (714) 894-7257 • CO: ELCOM - Englewood (303) 770-4400 • FL: ASI - Orlando (305) 851-7629 • FL: ASI - New Port Richey (813) 848-8578 • FL: ASI - Plantation (305) 583-8895 • GA: REP INC. - Tucker (404) 938-4358 • IL: GOTTLIEB - Chicago (312) 775-1151 • IL: JANUS - Des Plaines (312) 298-9330 • IN: LATTRONICS - Indianapolis (317) 846-5788 • KS: KEBCO - Overland P. (913) 649-1051 • MA: STONE - Waltham (617) 890-1440 • MD: ARBOTEX - Ellicott City (301) 461-1323 • MI: GREINER - Grosse Point (313) 499-0188 • MN: GREEN - Minneapolis (612) 571-6738 • MO: KEBCO - Maryland H. (314) 576-4111 • NY: J-SQUARE - Westbury (516) 997-6210 • NY: EISS - Rochester (716) 328-3000 • NC: REP INC. - Raleigh (919) 851-3007 • OH: KRW - Cleveland (216) 741-4711 • OR: R&R - Portland (503) 292-4406 • PA: NEWSON - Flourtown (215) 248-3377 • IN: REP INC. - Jefferson City (615) 475-4105 • TX: WEST - Dallas (214) 661-9400 • UT: ELCOM - Salt Lake City (801) 532-7940 • WA: R&R - Kent (206) 251-5396 • CANADA: ARMATEL - Toronto (416) 663-6240 • MEXICO: MEXEL - Mexico City (905) 575-7868.

Circle 91 on reader service card

J389

IN RAM TEST ACCURACY, ENTER THE NEXT GENERATION.

The new J389 Memory Test System gives you the narrowest guardbands ever. Plus high-integrity waveforming and test flexibility for next generation devices: the 64k and 16k-5v dynamic RAMs, the high-speed one-wide and bytewide static RAMs.

Quarter-nanosecond timing accuracy and address and data alignment minimize guardbands.

New Remote Test Electronics delivers system accuracy with 10 nanosecond I/O active load switching and half-nanosecond data detector skew.

Flexibility for complex RAMs comes from 16 timing and formatting sets operating at 20MHz.

Automatic Edge Lock continuously self-calibrates clock edges and address and data skew to within a quarter-nanosecond, monitoring voltages for outstanding correlation.

Teradyne's PASCAL-T software minimizes programming time and allows symbolic debugging in the language of the written program.

Real-Time Bit Mapping for state-of-the-art characterization is well-proven. And the J389's new architecture and thermal design keep the whole system Teradyne-reliable.

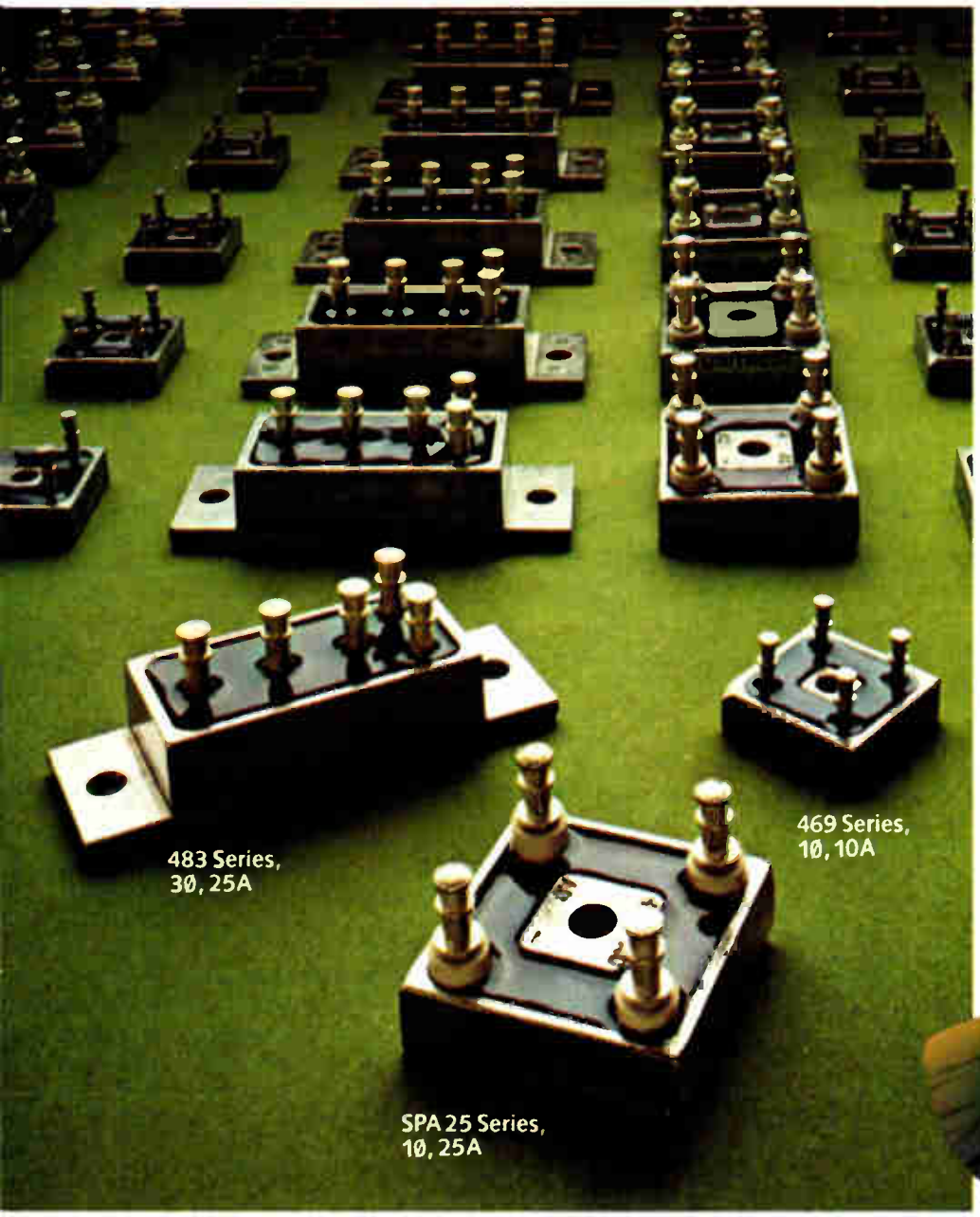
Added to an installed base of several hundred J380-series systems, the J389 continues to give you the Definite Edge in RAM testing.

Contact Teradyne, Inc., 21255 Califa Street, Woodland Hills, California 91367.

TERADYNE

Circle 93 on reader service card

AVOID THE HASSLE. BUY JAN RECTIFIER BRIDGES.



Qualifying your own rectifier bridge isn't worth the trouble anymore.

Because Unitrode now offers you a whole line of JAN and JANTX Rectifier Bridges right off the shelf.

They're already qualified, so you don't have to worry about time-consuming approvals. And you don't have to worry about reliability, either. Our rectifier bridges are assembled from the same Unitrode discrete military rectifiers that have been designed into every major defense project of the last two decades.

Simply choose the JAN or JANTX bridge you need from Unitrode's three families: 3-phase, 25A (MIL-S-19500/483); single-phase, 25A (/446); or single-phase, 10A (/469). Up to 600V.

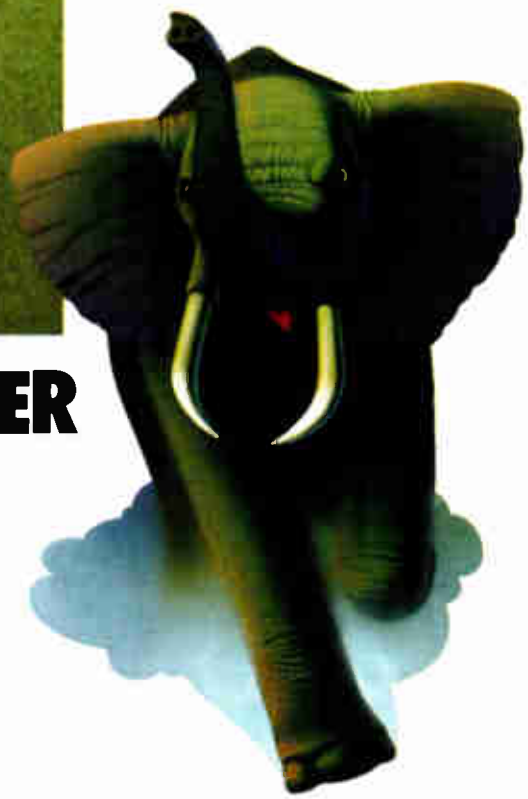
Unitrode's JAN and JANTX Rectifier Bridges. Available now, in high volume.

Without any hassles.

For more information, call or write: Unitrode Corporation, 5 Forbes Road, Lexington, MA 02173.
Tel. 617-861-6540.

UNITRODE

UNITRODE RECTIFIER BRIDGES



Circle 94 on reader service card

Speech I/O is making itself heard

Popularized in recent consumer and commercial products, voice synthesis and recognition are set for a boom

by Bruce LeBoss, San Francisco regional bureau manager

Up to now, anyone listening to or talking to an automobile or a calculator, a microwave range or a television, might have been a candidate for the psychiatrist's couch. But thanks largely to advances in solid-state and computer-software technologies, such behavior seems destined to become commonplace as speech synthesis and voice recognition are perfected and applied in a wide variety of products.

Unquestionably, the latest developments in computer-controlled voice input/output devices herald a new era, when the chatter of hardware will be heard across the land.

Several suppliers and users of I/O devices, subsystems, and systems have embarked on a wide range of applications developments that use speech synthesis or recognition technologies and even a combination of the two. Although a number of voice I/O products have surfaced over the last decade or so, most have been quite cumbersome, extremely costly, and of relatively poor performance.

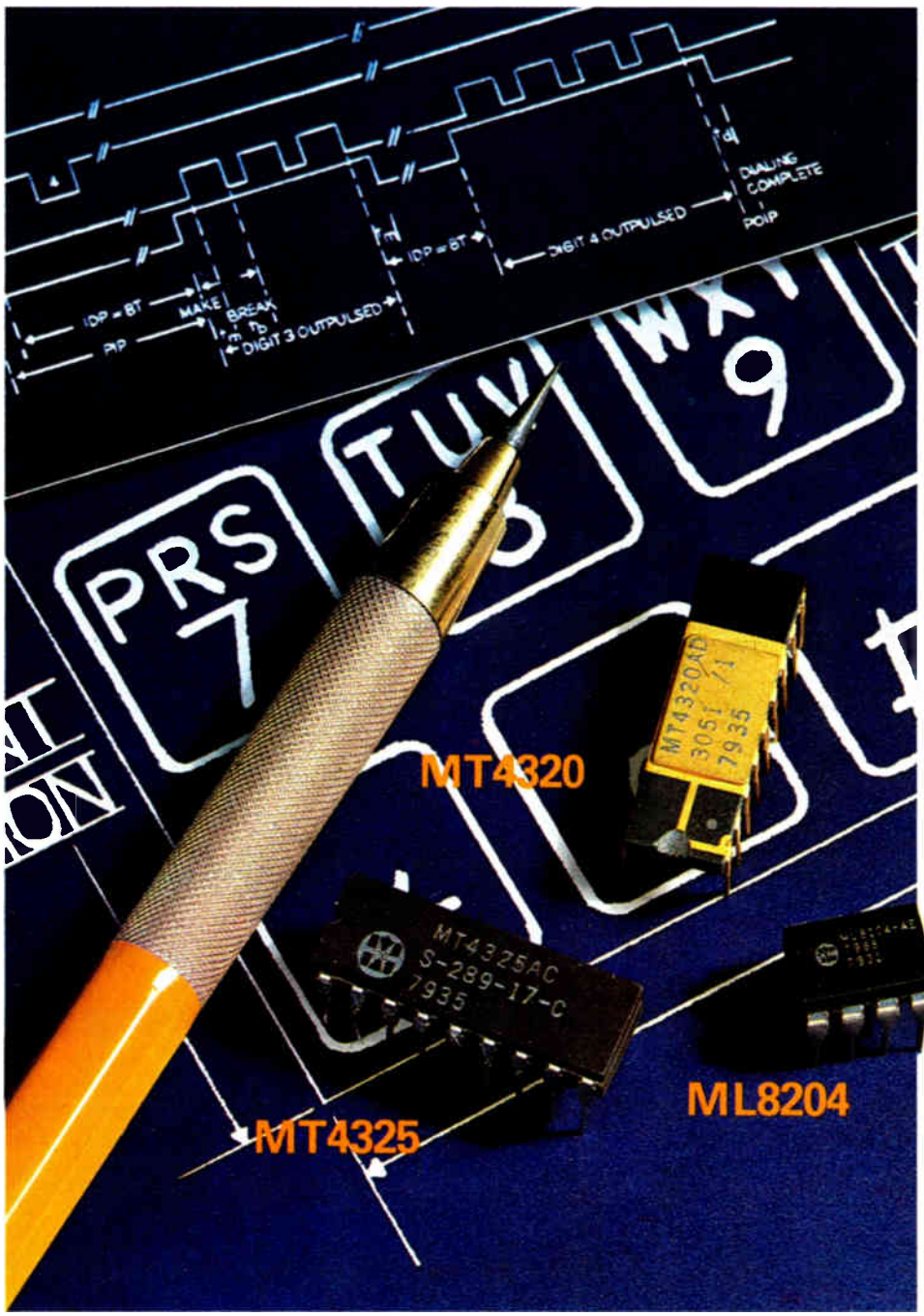
New patterns. However, with the rapid advances of late in large-scale integrated circuits—both analog and digital—and in developing signal-processing and pattern-recognition algorithms, it is now realistic to expect a rapid escalation in the development of speech devices, boards, and modules. These are likely to find their way into a large number of consumer, industrial, and commercial systems, ranging from talking games and appliances to automobile dashboards that deliver warning messages; from voice-actuated patient-support systems to computers, terminals, and dictation machines that recognize speech and respond to the voice input.

Interestingly, the total U. S. market for speech I/O equipment in 1978, according to a recent report by SRI International, Menlo Park, Calif., was estimated to have been less than $20 million. However, high equipment prices and technological constraints that have limited growth are being overcome, SRI points out.

Rapid growth. Today, not only have a number of companies made a strong commitment to the voice I/O

Chatterboxes. Soon homes will be filled with the voices of TV sets such as Toshiba's prototype (below, left), calculators such as Sharp's desktop CS-6500 (below, right), and microwave ovens such as Quasar's (right) dispensing information to the consumer.

THE TELEPHONE DESIGNERS' COLLECTION



3 OF THE MOST INNOVATIVE TELEPHONE COMPONENTS IN THE WORLD

Our designers at Mitel Semiconductor know the telephone. That's because they work side by side with Mitel Telecom engineers. The application of our semiconductor technology to the telephone has produced the most efficiently integrated phone components in the world.

The MT4320 Pulse Dialer

The MT4320 allows the rotary dial to be directly replaced by a push button pad. This pin for pin equivalent to the industry standard DF320 has an operating voltage range of 2 to 7 volts, 250μW operating power dissipation, and a stand-by current consumption of less than 1μA. The MT4320 stores up to 20 digits, has last number redial, pin selectable line break/make ratio and pin selectable impulsing rate of 10, 16 or 20 PPS.

The MT4325 Programmable Dialer

The MT4325 has all of the features of the 4320. In addition it has an audible key tone and access programming for automatic dialing pause in redial mode.

The ML8204 Tone Ringer

This replacement for the telephone bell, with a minimum of external components, provides a pleasant warbling sound, and interfaces to the telephone line. The ML8204 has low power consumption, an on-chip regulator, positive switch-on and is packaged in an 8 pin minidip.

MITEL SEMICONDUCTOR, we've got the goods for you.

MITEL SEMICONDUCTOR

United States: 1735 Jefferson Davis Highway, Suite 1009, Arlington, Virginia, U.S.A. 22202. Telephone (703) 243-1600
1223 Westchester Pike, Havertown, Pennsylvania, U.S.A. 19083. Telephone (215) 449-5556.
2321 Morena Blvd., Suite M, San Diego, California, U.S.A. 92110. Telephone (714) 276-3421.
Canada: P.O. Box 13089, Kanata, Ottawa, Ontario, Canada K2K 1X3. Telephone (613) 592-2122, Telex: 053-4596, TWX: 610-562-8529.
18 Airport Blvd., Bromont, Quebec, Canada J0E 1L0. Telephone (514) 534-2321, Telex: 05-267474.
Europe: Hamilton Road, Slough, Berkshire, England SL1 4QY. Telephone 0753-36137, 0753-36138, Telex: 847730
Fredericiagade 16, Suite 309, 1310 Copenhagen K, Denmark. Telephone (01) 119302, Telex: 27246
Asia: TST P.O. Box 98577, Kowloon, Hong Kong, 3-318256, Telex: 64235-Mitel HX

Circle 96 on reader service card

equipment field, but further, as SRI adds, economic incentives to increase productivity, growing consumer and business acceptance of electronic systems and devices, and dramatic improvements in price, performance, and flexibility "are spurring the interest of potential users and suppliers." In fact, SRI forecasts the market for U. S.-produced voice response and speech recognition "should experience high growth at an average annual rate of over 50%, reaching between $1.265 and $1.81 billion by 1988." What's more, SRI notes that the current aerospace and defense market should add one quarter to one half again to the total for all other markets.

Voice-response systems, subsystems, and components, which by far dominate the total speech communications market at present, accounted for from $14.5 to $19 million in 1978 and will jump to $100 million to $145 million in 1983, SRI estimates. Five years later, voice-response equipment should increase to $270 million to $355 million.

Of particular note in SRI's report is the market growth projected for speech recognition equipment, which accounts for only about 10% ($1.5 million to $3.0 million) of the total speech communications equipment market ($16 million to $22 million) estimated for 1978. SRI's forecast for 1983 puts speech-recognition equipment at $151 million to $192 million. By 1988, this segment is forecast to reach $995 million to $1.455 billion.

Whereas the major applications for speech communications equipment are expected to be in the industrial and commercial markets, it is the consumer market that is initially sparking user interest and paving the way for advances in technology. Texas Instruments Inc.'s Speak & Spell learning aid, introduced by the Dallas-based firm nearly two years ago [*Electronics*, June 22, 1978, p. 39], is largely responsible for consumer

Three ways to design speech synthesis

Each of the three methods of designing speech-synthesis circuits—formant synthesis, linear predictive coding, and waveform digitization with compression—has its supporters. The Votrax division of Federal Screw Works, Troy, Mich., uses formant synthesis; Texas Instruments Inc., Dallas, has been a leading exponent of linear predictive coding; and National Semiconductor Corp., Santa Clara, Calif., has come out for waveform digitization.

In the Votrax system, the process starts by partitioning the text into the basic sound elements, phonemes. But even phonemes are not specific enough for high-quality speech because used in different contexts the same phonemes may sound different. Therefore, the system selects so-called allophones from memory, according to the sound and context of what is to be said. These give the spoken words a lifelike sound.

Votrax machines have 128 allophones to select via either a keyboard or a computer. An advantage of this arrangement is that the vocabulary is unlimited—allophones are simply connected as needed to produce continuous speech. The allophones are generated by 12-bit control words acting on a hardwired phonemic synthesizer developed by Votrax.

The phonemic synthesizer generates speech from the 12-bit control word in two steps. First, the control word is decoded and processed into analog control signals specifying the pitch, duration, timing, amplitude, and overtone quality associated with each allophone. This technique is called synthesis by rule because the rules for extracting the word signals are stored in hardware; the word parameters are not extracted through a computer analysis of actual speech, as with the TI device.

The second step is implemented by a parametric synthesizer, which translates the parametric signals into speech sounds. As with the other techniques, the parametric signals act on an array of sound generators and programmable filters. Voiced sounds are created in the synthesizer by a variable-pitch generator and unvoiced sounds by a white-noise generator.

In the case of Texas Instruments, its trio of chips represents an integrated-circuit model of the vocal tract. Basic to a model is the linear predictive coding technique. LPC provides the feedback values or coefficients for a second-order digital lattice filter on the a synthesizer chip.

This multistage linear filter mimics the major resonant modes of the vocal cavity in the human vocal tract. A TMS 1000 microprocessor performs the calculations to derive the filter coefficients. The third chip is a word-storage read-only memory that holds the speech parts broken into four parameters—voicing, pitch, amplitude, and frequency. A complex software algorithm manipulates the sound parameters to create the speech synthesis.

The benefit of LPC is that it takes advantage of the slow time constants of the human vocal tract. These physiological constraints limit the range of formants (frequency ranges) that can follow a prior set. LPC predicts new filter characteristics based on prior sets. Predicting and generating the formant sets reduces memory requirements, as well as the overall system data rate, which is 1,200 bits per second.

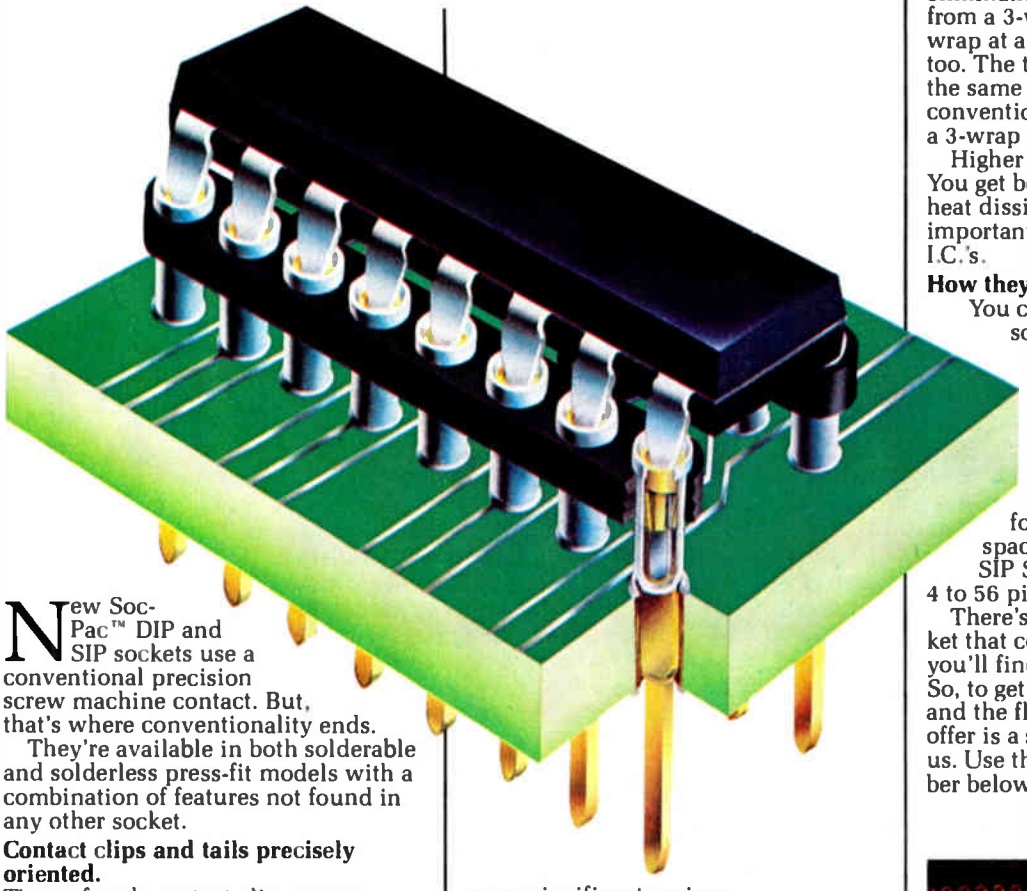
National's synthesizer is based on the ability to perform an analog-to-digital conversion of the speech waveform and store it in memory for subsequent retrieval. That would suggest a tall sampling order and make this technique less appealing.

But National has gotten around the problem by combining data-compression techniques to offer a practical approach to chip-level speech synthesis in the time domain. A minicomputer performs the digitizing and compression on an audio tape recording of the original spoken phrases. The resulting data is stored in a ROM for retrieval by a speech-processor chip. Three compression techniques—phase-angle adjustment, delta modulation, and half-period zeroing—reduce the data rate to about 1,000 bits for one second of speech, so that 10 K of ROM stores about 10 words.

Compression is begun by digitizing the analog speech wave and forming the data into groups of 128 samples, called pitch periods. The phase angles are adjusted to produce a set of digitized samples analogous to the spoken phrase. Further compression is achieved by delta modulation, so that instead of digitizing and storing the absolute amplitude of each sample, only the amount of change from the last value is stored. **-Gil Bassak**

A major improvement over traditional I.C. packaging methods.

How a simple socket can mean greater reliability, greater design flexibility at a lower cost.



New Soc-Pac™ DIP and SIP sockets use a conventional precision screw machine contact. But, that's where conventionality ends.

They're available in both solderable and solderless press-fit models with a combination of features not found in any other socket.

Contact clips and tails precisely oriented.
Tines of each contact clip are precisely oriented for perfect alignment with I.C. leads. The result — four contact points at every lead every time, a redundancy that costs you no more than conventional designs.

Also, each tail is oriented square and parallel with the others to easily accept mating connectors.

Selective gold plating.
The contact clip is plated with 30μ in. gold over nickel. The screw machine contact can be selectively plated starting from the tip of the tail (.250" minimum) — with the exact gold thickness you need. That can mean significant savings.

Solderless press-fit advantages.
With solderless press-fit Soc-Pac sockets, you get the savings that eliminating the soldering step make possible. And, you get a gas-tight mechanical and electrical interface with the plated-thru hole in the PCB. There are still more advantages to the Soc-Pac design.

Get higher density, more flexibility.
Contrary to the trend to low profile sockets, Soc-Pac sockets stand relatively high on the PCB. There are very good reasons for that.

It allows us to reduce pad size to 0.055" on press-fit and 0.050" on solderable sockets. Which means you can run a trace between contacts for greater printed circuit density. And greater design flexibility. Additional printed circuitry translates to eliminating at least one tail wrap — from a 3-wrap tail to a 2-wrap, or no wrap at all. You keep compactness, too. The two-wrap tail allows about the same board to board spacing as conventional low profile sockets with a 3-wrap tail.

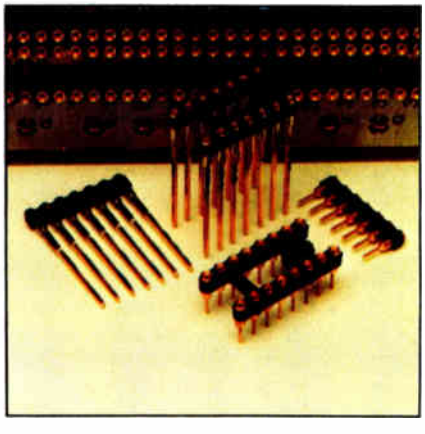
Higher sockets also add reliability. You get better air flow, thus better heat dissipation. That's particularly important with higher pin count I.C.'s.

How they come.
You can select either solderable or solderless press-fit Soc-Pac sockets in selective gold over nickel, tin, or nickel finishes.

DIP sockets come in 8, 14 and 16 pin counts for a 0.100" x 0.300" grid spacing and 24 and 40 pin counts for 0.100" x 0.600" grid spacing.

SIP Sockets come in strips from 4 to 56 pin counts.

There's no other socket on the market that combines all the features you'll find in the Soc-Pac™ socket. So, to get the savings, the reliability, and the flexibility Soc-Pac™ sockets offer is a simple matter of contacting us. Use the address and phone number below.



ELFAB
The Leader in Press-fit Technology
P. O. Box 34555, Dallas, Texas 75234. 214-233-3033

Circle 98 on reader service card

awareness and interest in speech communications equipment. And, as evidenced at the Consumer Electronics Show in Las Vegas, Nev., earlier this year [*Electronics*, Jan. 17, p. 39], speech-synthesis and speech-recognition capabilities are proliferating in a variety of products.

Three ways. Thus far, most if not all of the voice-response products introduced or in development use one of three main techniques—formant synthesis, linear predictive coding (LPC), or waveform digitization with compression—to synthesize human speech (see "Three ways to design speech synthesis," p. 97). There are tradeoffs to be considered in the use of each of these techniques, for they vary considerably in the quality of speech provided, the data rate required to achieve acceptable quality, and the cost of the memory for storing speech data, among other factors. Usually, the technique chosen depends upon the application and the size of the vocabulary required for the application.

When TI's Central Research Laboratories first became involved with the development of Speak & Spell in 1976, both the LPC and formant synthesis techniques were considered, says George R. Doddington, manager of speech synthesis research in the Systems and Information Laboratory. Major consideration was given to producing good-quality speech while keeping the data rate low to hold down storage cost, he notes.

According to Doddington, TI eventually settled on LPC despite the fact that the 1,200-bit-per-second data rate achieved with the technique was not sufficient to meet TI's original goal of at least a 500-word vocabulary. Thus, the original device has about a 230-word vocabulary, which was later expanded with the availability of read-only memory modules.

The 500–600-b/s data rate needed to achieve the original goal could have been accomplished with formant synthesis. But the architecture of such a chip, Doddington says, would have been "substantially more complicated" than that required for the LPC chip. "We were not convinced that the [voice] quality [of formant synthesis] would be sufficient," he says.

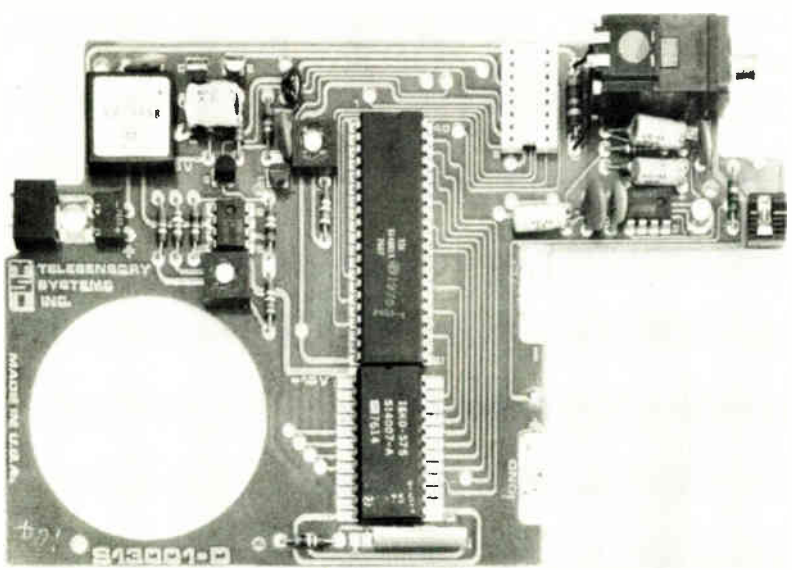
Talkies. Also enjoying a measure of success in the speech-synthesis arena is Federal Screw Works' Votrax division, Troy, Mich. Its phoneme-based speech-synthesis system has been incorporated into hobbyist computers, among them Radio Shack's TRS-80 and Commodore Business Machines' PET, as well as in many medical and business applications. IBM Corp.'s Office Products division, Franklin Lakes, N. J., for example, has introduced an audio typing unit for the blind based on the Votrax voice synthesizer. The unit translates each type character into a stored phoneme that, on playback, is linked with other phonemes according to programmed rules of pronunciation. The audio typing unit verbalizes punctuation in addition to text and prompts the user through various typewriter functions.

A somewhat similar aid for the handicapped has been developed by Kurzweil Computer Products Inc., Cambridge, Mass. The firm's Reading Machine for the blind uses computer software to convert ASCII-print images into synthesized speech. Conversion is done using a complex set of programming instructions that string phonemes together into whole words and sentences. It relies on Kurzweil's own specially designed analog formant synthesizer, said to be capable of speech rates faster than human speech.

Other aids for the handicapped developed or in various stages of design take advantage of speech-processing technology. For example, Telesensory Systems Inc. of Palo Alto, Calif., developed a talking calculator in 1976 and, more recently, a portable Braille and audio information center. These products and other modules use the LPC technique.

According to Barbara R. Glavish, the company's speech components manager, the LPC approach was chosen because "it is the most useful for the most number of applications." Although the LPC technique consumes more memory than other approaches, it provides an extremely high quality of natural-sounding speech, she states.

The science of speech interfacing



Speaking board. One of two speech-synthesis modules from Telesensory Systems Inc., this calculator unit has a 24-word vocabulary in English, German, or Arabic. It contains a voltage converter, audio filter, amplifier, volume control, and 2-in. speaker.

extends even to pinball machines. Williams Electronics Inc., a Chicago-based subsidiary of Xcor Corp., last year introduced Gorgar, a talking pinball machine that has a 15-word vocabulary compressed in a 12-K n-channel MOS ROM.

According to Ward Ellis, engineering vice president, a continuously variable-slope delta-modulation (CVSD) detector chip from Harris Semiconductor, Melbourne, Fla., takes the ROM code and creates a facsimile of a sound waveform under the direction of an 8-bit Motorola 6808 microprocessor.

Harris Semiconductor backed into speech processing with its CVSD chip, introduced about five years ago and originally aimed at telecommunications speech and signal-processing applications [*Electronics*, Oct. 13, 1977, p. 91]. Harris uses self-aligned silicon-gate complementary-MOS circuitry (for its low-power, high-speed advantages), along with dielectric isolation and on-chip resistors. Ordinarily no microprocessor control or external components are required for recovery of digitized speech; the chip does all its own data conversion and processing, says Harris senior scientist Norman C. Seiler.

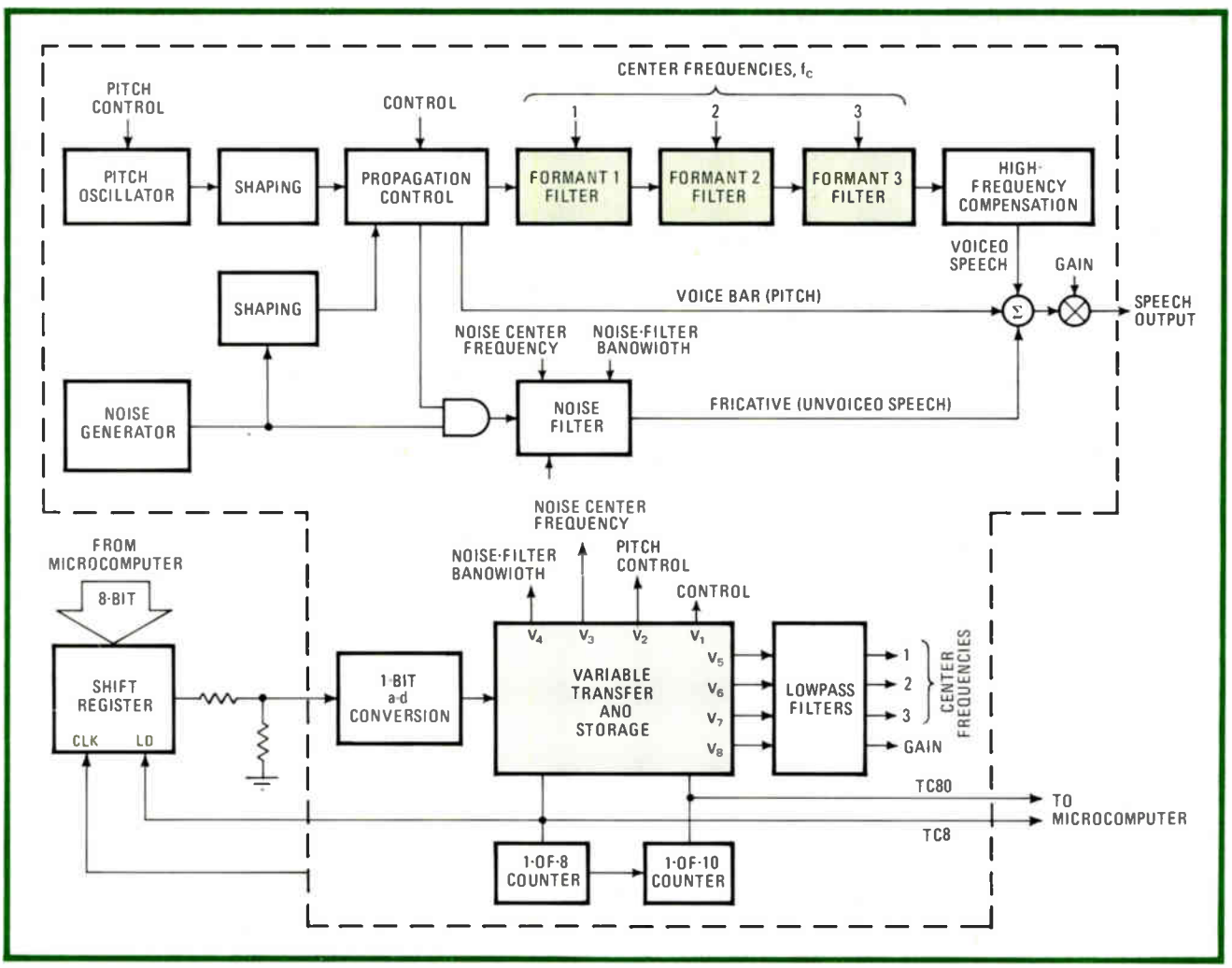
In Gorgar, the 15-word vocabulary in ROM can be arranged into eight different phrases. "Substantially all our future machines will have speech," notes Ellis of Williams Electronics.

Voicing approval. Others are headed that way. At the recent consumer show, for example, TI introduced a speech synthesizer for its 99/4 home computer, while Atari Inc., Sunnyvale, Calif., showed the prototype of a new video game, Home Run, with limited speech capability.

Also ready to plunge into the speech-game waters is Mattel Inc.'s Electronics division, Hawthorne, Calif., which unveiled its first voice-actuated game at the consumer show and plans to introduce several products with voice-synthesis capabilities.

Mattel is currently working with suppliers of several kinds of speech-synthesis techniques. Director of product engineering David Chandler believes that there is room for each of the different approaches and that the choice of which one to use for a particular application is based on performance and cost tradeoffs, among other factors.

Already enjoying a measure of success with its voice-response games is Fidelity Electronics Ltd., a



Talkative. Intel's 2920 general-purpose signal-processing single chip microcomputer lends itself to speech-synthesis chores. The device is organized to handle format synthesis to lower the memory bit rate. Data rates as low as 100 to 150 b/s are possible.

Miami, Fla.–based firm that has introduced several chess and bridge games that communicate orally with the player. Fidelity's initial voice Chess Challenger, introduced last year, tells the player all its moves, repeats the player's moves, suggests moves and announces mate-in-two for the player to solve.

According to design engineer Robert N. Nelson, the basic chess game has a 50-word vocabulary housed in 8 K of ROM and is controlled by a Z80 8-bit microprocessor.

Attention. Voice response and recognition are also making a lot of noise in the military/aerospace market. One such system, developed by Sperry Univac's Defense Systems division, St. Paul, Minn., instead of creating speech by synthesis methods, prerecords voice responses that are first spoken by a trained announcer, then digitizes the words and phrases and stores them in memory. "We use some speech compression with adaptive differential pulse-code modulation," explains Timothy C. Diller, principal research engineer for speech communications technology. Using ADPCM, he notes, "the net result is much better than can be achieved with synthesis. It turns out just like a tape recording, only the signal hasn't been broken up into its parameters."

To produce speech output, a host computer first specifies the sequences of words and phrases that form the desired output message. A voice-response controller next retrieves the digitized speech from the Sperry Univac–developed VRU-401 voice-response unit. The controller is implemented with a programmable microprocessor, which provides "a great deal of flexibility and internal processing capability," Diller says.

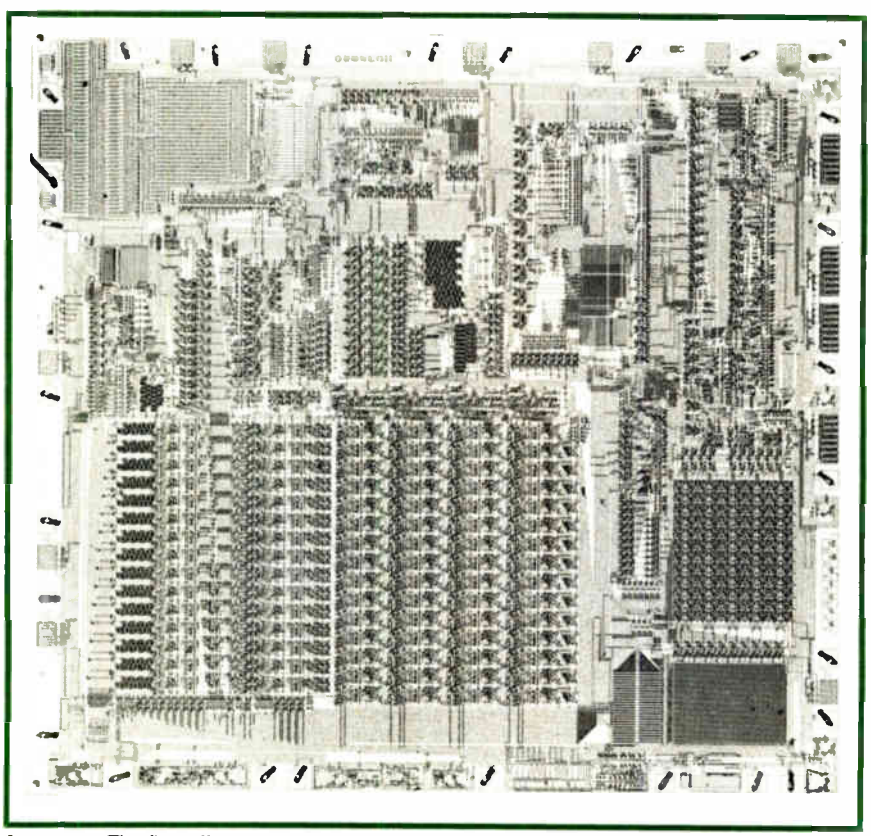
Talk is chip. Perhaps the foremost reason for the acceptance of speech-response technology today is the general availability of speech-synthesizing components. Based on recently announced and ongoing developments from major U. S. and foreign semiconductor producers, it appears the several-hundred-million-dollar market forecast for the late 1980s is within reach. Until recently, TI's speech-synthesis chip set was not sold to outside manufacturers. But now that other major semiconductor houses are selling—or plan to make available—their LSI implementations of speech synthesis, TI will make its chip set available from a new facility in Midland, Texas [*Electronics*, May 8, p. 33].

Most likely, a factor in TI's decision to go to the original-equipment-manufacturer market was the announcement by National Semiconductor Corp., Santa Clara, Calif., of plans to begin offering evaluation quantities in June of its speech-processor chip (SPC) and a 16-K clocked or static ROM that contains both compressed word patterns and the frequency and amplitude information necessary for speech [*Electronics*, March 27, p. 39]. Rather than adopting LPC or formant synthesis techniques, National opted for waveform digitization, sampling at twice the highest frequency of interest, a technique used for pulse-code modulation. However, because standard PCM would produce far too many bits in proportion to the amount of talking, the firm uses a comprehensive data-compression scheme to condense the speech data.

Also about to be heard in the market is General Instrument Corp.'s Microelectronics division, Hicksville, N. Y., which is developing a single-chip speech processor, to be available in December. Designated the LISP-0256, the n-MOS chip draws on two techniques for encoding speech—synthesis by analysis like TI's LPC approach and synthesis by rule like Votrax' phoneme-based approach.

GI stores data in ROM on board the 0256 in two forms. One form is the parametric data needed to adjust filter and sound-generator characteristics. The other is the speech phoneme, called up as needed, to form words. Generally speaking, the LPC technique requires relatively large amounts of data, processed at a high rate, and simple hardware, says a GI spokesman. In contrast, speech generation using phonemes needs less data processed at a lower rate. However, he adds, the processing hardware is more complicated.

Equally interested in the prospects for speech-synthesis ICs is Harris Semiconductor's Seiler. He notes that Harris' R&D budget commit-



Japanese. The first effort to use LSI for speech synthesis in Japan used the Parcor (for partial correlation) technique developed by Nippon Telegraph and Telephone Public Corp.

ment to these areas is growing fast and that the firm is developing new products for both speech synthesis and recognition.

Higher calling. Certainly one development that highlights the importance of speech-generating algorithms, when coupled with advanced LSI devices, is the model 2920 general-purpose signal processor from Intel Corp., Santa Clara, Calif. Because of its analog input and output, plus high speed, this single-chip analog microcomputer readily lends itself to speech synthesis. By using appropriate software algorithms, it can implement a variety of speech-synthesis techniques. What's more, the 2920 also is being considered for use as a front end in a voice-recognition system, notes M. E. Hoff Jr., Intel's manager of applications research.

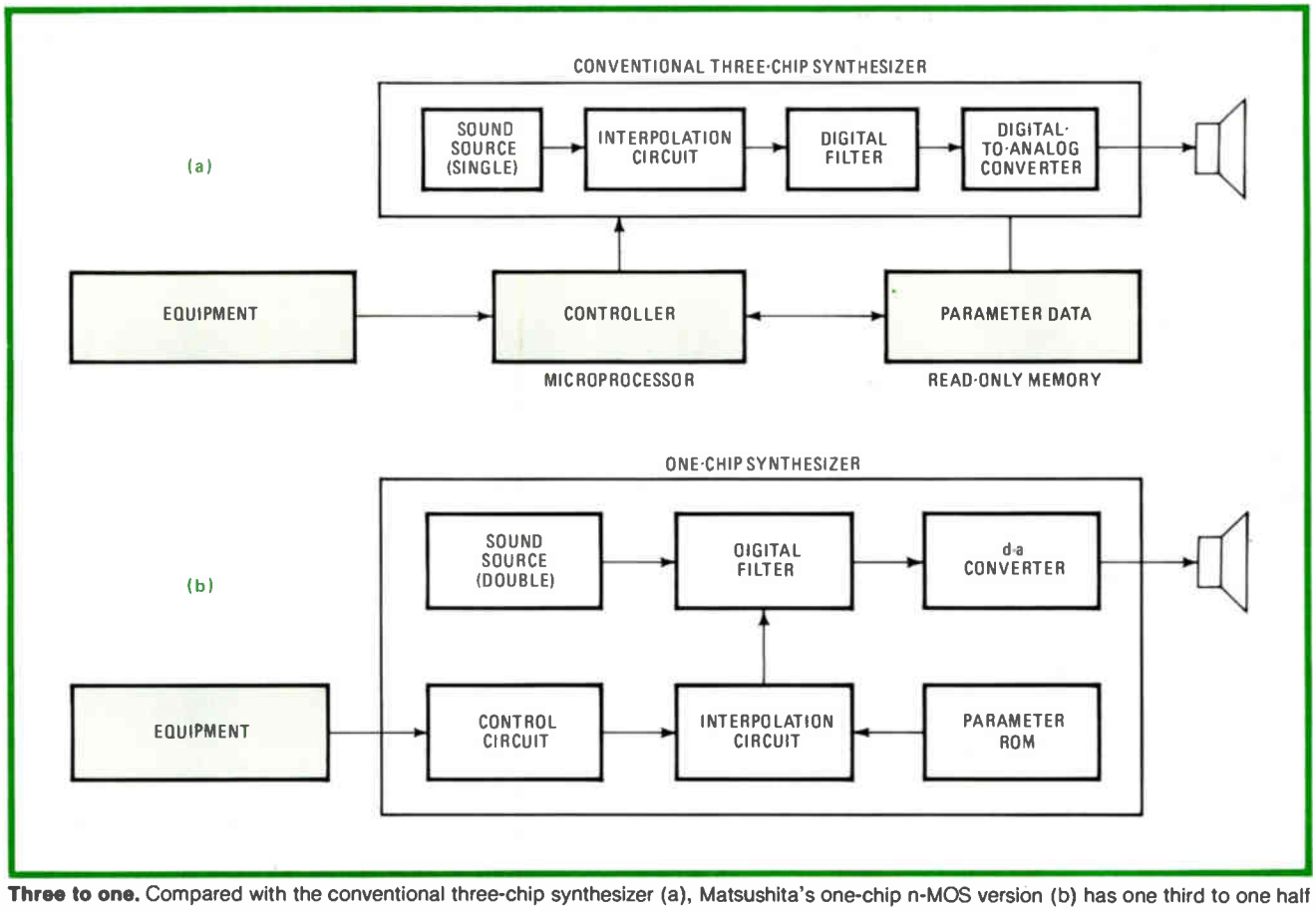
Among several signal-processing applications, Intel engineers have developed a formant speech synthesizer based on the 2920. Although the chip can implement LPC and other speech-synthesizing techniques, Intel is concentrating its efforts on formant synthesis because this method has the potential for using the lowest memory bit rate.

Undoubtedly, one company that is committed to getting speech synthesis off the ground even more than it already has, is Texas Instruments. In the wake of its plans to sell speech chips to outside manufacturers, TI is establishing a new organization within the company devoted primarily to speech and headed by Bernard H. List (see p. 14).

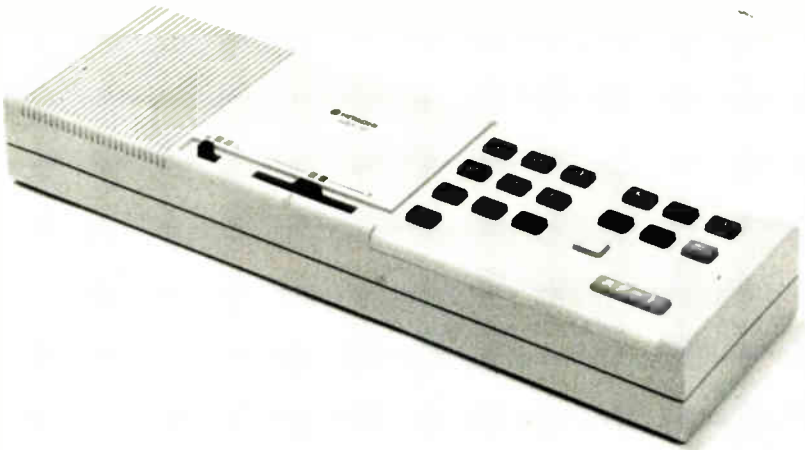
Although he will not talk specifics, List says TI plans to come out with a whole new line of speech chips, which are set to appear over the next 12 months. The first such addition was seen at Electro in Boston last week, where TI unveiled a new LPC synthesizer chip known as the TMS5200. Like the 5100, the new chip is fabricated in p-channel MOS metal-gate technology. Unlike the earlier device, however, the 5200 contains a 128-bit first in, first out buffer and other circuitry on board that will enable it to interface with any standard microprocessor having an 8-bit data bus. Speech code for the 5200 can also be stored in any type of standard memory, including n-channel ROMs, erasable programmable ROMs, random-access memories, or bubbles.

Speaking Japanese. As is true of many burgeoning market opportunities, where advanced technologies are making cost-effective and practical applications a reality, U. S. companies are by no means alone in their intensive development efforts. As demonstrated by the spectrum of speech communications equipment previewed this year, the Japanese are on the heels of U. S. speech-synthesis and -recognition developments and may even have taken the lead in some segments of the technology.

Japan's pioneering work in speech synthesis was done by Nippon Telegraph and Telephone Public Corp., which in 1968 announced development of its Parcor (partial correla-



Three to one. Compared with the conventional three-chip synthesizer (a), Matsushita's one-chip n-MOS version (b) has one third to one half the size, power consumption, and cost. It is headed for vending machines, facsimile equipment, calculators, and appliances.



Teaching and telling. Hitachi has put its three-chip speech synthesizer into a $95 learning aid to teach students the use of the abacus, or soroban (left). Sharp's digital pocket watch (right) uses a C-MOS synthesizer IC that lacks only a 6-bit d-a converter.

tion) coefficients for speech analysis and synthesis. Parcor is a form of LPC, similar to TI's approach, and one that most Japanese companies are using.

NTT built its first experimental speech synthesizer—a large computer—in 1971. Two years ago, it finished a six-year effort to achieve acceptable sound quality at a 2.4 kb/s-to-9.6 kb/s data rate. NTT is synthesizing speech from phonemes stored in memory.

Meanwhile, Hitachi Ltd. has flexed its muscles in the speech communications arena by implementing Parcor on a three-chip set that is Japan's first commercial voice-synthesis LSI device [*Electronics*, Oct. 25, 1979, p. 63]. Since early February, the firm's Musashi plant has been producing about 1,000 sets daily for in-house use, with outside sales not expected to start for another two or three years. Hitachi's first speech-synthesis product, introduced last month, is an abacus (soroban) trainer that sells for about $95 and is being produced at the rate of 5,000 monthly. The unit calls out digits and answers for students practicing on the abacus. This month, Hitachi took the wraps off a talking elevator that will go on sale next month. And in August, it will begin selling a talking clock.

The Hitachi chip set uses Parcor, which is a "very stable" form of LPC, says Kazuo Nakata, director of engineering and chief researcher at Hitachi's Central Research Laboratories in Kokubunji. The speech-processing chip operates at a data rate of 2.4 kb/s and, when coupled with the set's 128-K ROM that stores whole words, can synthesize speech for 50 to 100 seconds. What's more, the set operates with a 4-bit single-chip microcomputer that can control up to 16 128-K ROMs.

Matsushita Electric Industrial Co.'s recent unveiling of a one-chip LSI synthesizer, generated considerable interest in voice communications equipment circles. The first voice-synthesis device from Japan that combines the synthesizer, d-a converter, ROM, and controller on one chip, the n-MOS device is expected to enter production next month and reach large-volume production by August, mainly for use in Matsushita products at first. The chip's 32-K ROM can hold up to 63 words, but external ROM coupled with an external controller can boost capacity. Speech length ranges from 10 seconds for high quality to 30 seconds for low quality. The firm expects to boost vocabulary eightfold within five years by quadrupling its memory and halving its bit rate.

Savings. Using Parcor, the Matsushita chip has a data rate of about 1.6 kb/s. Parcor was chosen because its analysis of sound can be easily processed mechanically and because it offers a low bit rate, explains Shinichi Yagi, assistant planning counselor in Matsushita's R&D center, engineering division.

On the heels of Matsushita's announcement of a single-chip synthesizer, designed for consumer applications where very high quality is not necessary, Sharp Corp. of Osaka disclosed development of a similar C-MOS speech synthesizer, only without the d-a converter [*Electronics*, April 10, p. 64]. A new "talking time" pocket-sized digital watch whose components, except for an external 6-bit d-a converter, are contained on a 5.3-by-5.3-millimeter chip announces the time at the press of a key or automatically each half hour. It also makes elapsed time announcements as programmed and 5- and 10-minute audible warnings after its chime and melody alarm have sounded. The Japanese-language model contains 39 words spoken by a female voice, whereas the English-language version holds 43 words spoken by a male voice.

With a bit rate as low as 1.3 kb/s but averaging 2.4 kb/s, the Sharp chip can synthesize 13 to 22 seconds of speech. Capacity can be expanded by adding up to 10 100-K C-MOS ROMs.

Triple play. Just now being heard from in the voice-synthesis field is Nippon Electric Co., which has established itself in the voice-recognition segment of the industry. NEC's IC division is working simultaneously on three groups of synthesizers, the first of which uses ADPCM waveform coding. NEC has a prototype of its n-MOS synthesizer, which offers 10 seconds at 10 kb/s. The multichip device will be converted to C-MOS

next year, according to the company.

The second group of synthesizers NEC is developing include two basic products that use LPC techniques, among them Parcor. One product is a 10-to-12-chip n-MOS signal processor having a data rate of 1.4 kb/s and offering up to 90 seconds (60 to 120 words) of speech. It will be used internally for computer terminals.

The third group of synthesizers will use waveform phoneme synthesis, which Suzuki calls "the perfect one-chip system." It will contain a 32-bit ROM and have a data rate of 800 b/s to 2 kb/s. The device will not be available for several years, the major hurdle being voice analysis.

European tongue. Meanwhile, voice-synthesis developments are being pushed on the European front as well. For example, when Britain's System X made its debut at the Geneva Telecommunications Exhibition last year, one of its crowd-pulling features was a voice that talked to the user and helped him to make use of available services. The voice-response system caters to each individual's requirements by acknowledging his push-button actions, offering guidance, and then confirming the actions taken.

Like many stored-program-control exchanges, System X provides more than a dozen services, among them repeat last call, bar incoming calls, and alarm call. British Post Office researchers determined that instruction books were inadequate and that a means was needed of guiding the caller through the control procedures and informing him how the exchange responded. In the production version, this is achieved by a microprocessor-controlled voice-response system with individual words and word segments stored in 64-millisecond speech segments housed in RAM. For the highest voice fidelity, BPO engineers use PCM techniques to compress digitized speech from 64 kb/s to 48 kb/s. The processor pulls out the needed words from the stored vocabulary and assembles them according to an announcement assembly table, interspersing periods of silence as needed.

France is also working on speech synthesis, but most of the buzzing is coming from two government laboratories. Using LPC techniques, researchers at the Centre National d'Etudes des Télécommunications in Lannion, Brittany, have designed a single-chip synthesizer very similar to that of TI. Corrected prototypes of the chip are expected by year-end, says Jacques Majos, a researcher in CNET's Microelectronics Laboratory. The chip is fabricated in the multidrain MOS process developed by CNET, although actual production will be handled elsewhere.

Like the TI synthesizer, the CNET chip uses a 10-step lattice filter, but its data-compression scheme requires 6 kb/s of control input, 150% more than the TI device. The CNET chip is optimized for telecommunications applications and, as such, has two different digital outputs. Synthesis experiments at CNET are based on a library of all possible combinations of phonemes that are stored in 600,000 bits of ROM. Though CNET researchers have thus far used a minicomputer to process their data, they are confident a 16-bit microprocessor can do the job.

Meanwhile, researchers in the electronics laboratories of the French atomic energy agency—the Commissariat à l'Energie Atomique (CEA)—in Saclay have developed a system based on a wave-function approach to synthesis [*Electronics*, Aug. 31, 1978, p. 71]. The system currently uses a d-a converter, with the synthesis performed through software, explains Benoit Dupeyrat, a CEA research engineer.

Hearing. As designers drive toward the next generation of synthesis systems, advancing the state of the art of speech recognition appears to be a much tougher task at present. Despite all the advances in LSI technology that make it possible to perform complex signal-processing functions on a single IC, researchers in the Department of Electrical Engineering and Computer Sciences and the Electronics Research Laboratory at the University of California at Berkeley suggest that much work has yet to be done on speech-recognition algorithms.

According to the university's Hy Murveit, "The most difficult problem is to understand a large vocabulary [greater than 1,000 words] of normally spoken, connected speech, without any special knowledge of the speaker. This task has proven to be extremely difficult, and," he adds, "the algorithms which would allow greater than 90% accuracy are not yet developed."

Words, words, words. One of IBM's speech-recognition projects emphasizes programmability so that users can maintain their own software. The intended use is for office equipment.

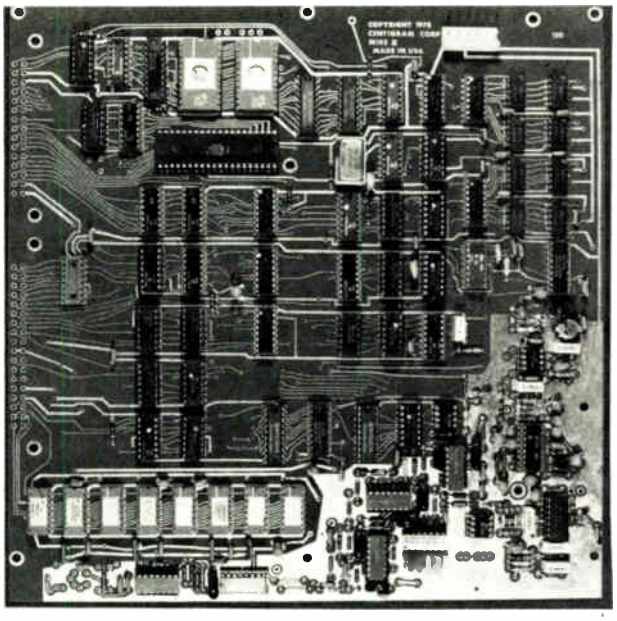
In contrast, for small vocabularies (less than 100 words), with each word spoken in isolation by a given speaker, Murveit notes, "it has been possible to obtain extremely high accuracy [greater than 99%] with a relatively straightforward feature-extraction approach."

"Speech recognition is a funny kind of business. People paint a very rosy picture for the distant future. It's generally accepted that in 1990, in the data entry room of the office of the future, speech recognition will be an important, economically feasible technology," states Joel S. Birnbaum, director of computer sciences at IBM's Thomas J. Watson Research Center, Yorktown Heights, N. Y. The key question in pattern-recognition systems, he says, is that it is hard to set price-performance goals. "Right now we have good ways of getting information into a computer using a keyboard."

Researchers at Bell Laboratories in Murray Hill, N. J., also have made significant strides toward enabling a large population of people to speak directly with a computer. One of the experimental systems they have devised can automatically provide directory assistance in response to a spoken request, rather than push-button entry, like the British Post Office's System X.

Capable of comprehending most American dialects and some foreign accents, the system's "ear" is based on an automatic word recognizer that was developed at Bell Labs several years ago and refined by researchers Larry Rabiner and Aaron Rosenberg to suit the directory assistance application.

A user-independent system for airline reservation and other applications is already available from Dialog Systems Inc., an Exxon Enterprises affiliate located in Belmont, Mass. The major application to date for the firm's model 1800 is for large-company telephone network access by employees in remote locations. They can dial the network-access line and give an identification number and the number they wish to call, explains chief engineer R. Robert Osborn, who says the system processes the verbal commands with better than 95% accuracy.



Analyzer. Voice-recognition board made by Centigram for its Mike terminal learns and recognizes patterns derived from spectrum analysis data. When learning a word, the system stores patterns in memory and then compares the incoming pattern with each reference to make a match.

Although technical and market limitations remain a problem, there are signs that major high-volume applications for voice recognition are beginning to materialize, particularly in computers and terminals. For example, Control Data Corp., Minneapolis, says it is examining the option of adding speech recognition to its Plato computer-aided instruction system. Lear Siegler Inc.'s Data Products division in Anaheim, Calif., has gone a step further by contracting with an outside supplier to provide a speech-recognition system for its ADM-3A, a cathode-ray-tube terminal that has an installed base of about 100,000 units.

Supplied by Heuristics Corp., Sunnyvale, Calif., the speech-recognition module will add $2,000 to the price tag of the $895 terminal. However, Philip W. Shires, marketing and sales vice president at the Data Products division, says the disproportionate price for voice "doesn't bother me a bit. It's a matter of total price for the function."

Sharing the enthusiasm for potential applications is Carl L. Berney, engineering vice president at Centigram Corp. The firm, also based in Sunnyvale, has developed a combined voice-recognition and -response system, called Mike. The system learns and subsequently recognizes 16 isolated words or short phrases in any language. Its vocabulary can be segmented into two sets of 16 words in the internal memory, and with the addition of an expansion module having 16 K of RAM, another 10 sets of 16 words can be added. The system responds with up to 8 seconds of speech recorded by the user.

Interstate Electronics Corp. in Anaheim, Calif., sees almost endless potential applications, such as in word-processing control, computer-added design of ICs, and telecommunications. Its voice-recognition offerings currently require 256 bits of memory for each reference pattern, with a 1.5-to-2-second delay in response time. Like Heuristics and Centigram, Interstate makes speech-recognition products available both as single-board modules and as self-contained units. They are capable of recognizing up to 100 discrete words or phrases spoken by a trained user.

Getting speech-recognition systems to recognize more than isolated words or phrases has indeed proved to be a challenge for most firms in the business. In fact, Japan's NEC appears to be the only supplier that has built and is selling such systems. NEC's DP-100, developed more than two years ago, is capable of recognizing up to five words spoken continuously out of a basic 120-word vocabulary. □

Reporting for this article was provided by James Brinton, Linda Lowe, Pamela Hamilton, Wesley Iversen, Larry Waller, Larry Marion, Kenneth Dreyfack, Kevin Smith, Robert Neff, and Charles Cohen.

Mainframe builders making more ICs

More turning to captive lines as semiconductor suppliers turn into competitors with VLSI-based systems

by Larry Marion, Chicago bureau manager

Pragmatic business practices and advancing technology are pulling mainframe makers and their semiconductor vendors away from the close collaborations of the past. A result of the new, more cautious arm's-length relationship is a crop of in-house IC production facilities started up by the computer firms.

One of the biggest stimulants is the introduction by traditional vendors such as Intel Corp. and Texas Instruments Inc. of very large-scale integrated-circuit components and systems that compete with mainframe product lines. Computer designers therefore feel constrained to protect distinctive product concepts by burying them in silicon that they turn out themselves. "We see more and more vertical integration of the semiconductor industry, and we have to be careful about what we tell our vendors," explains Wallace W. Lindemann, vice president of the Computer Components division of Control Data Corp., Minneapolis. At the same time, IC makers are loathe to talk about their new competitors.

Meanwhile, the increasing expense of IC mass production forces the component vendors to abandon obsolete low-volume parts designed into ongoing peripheral product lines. One result is that the computer makers now find themselves in the expensive and awkward position of producing chips at the high and low ends of the spectrum.

Thus, the recent announcements that Sperry Univac and IBM are building dedicated VLSI production facilities are only the tip of the growing captive-IC production iceberg—each mainframe maker in the U. S. now can or is gearing up to produce in house at least 20% of its needs. Though no manufacturer is ready to declare complete independence from the semiconductor vendors, NCR Corp. in Dayton, Ohio, is typical in expecting eventually to produce 60% of its component needs, including logic and memory (see chart).

Sperry Univac is the last of the computer firms to begin IC production. Explains Robert A. Erickson, recently appointed vice president and general manager of Sperry Univac's new Semiconductor division in St. Paul, Minn.: "We've observed that vendors are less and less interested in special work for the computers. We've had suppliers say no to requests to continue producing second-generation parts. They say, 'Using [scarce] silicon to make chips with six to eight gates is damned inefficient.' "

New needs. Erickson explains Sperry Univac's late entrance into the captive production parade by noting that until now it could get what it needed and that bipolar transistor-transistor logic, emitter-coupled logic, and gate-array production technologies had matured enough to avoid startup cost overruns. On the other hand, if the company had waited longer, the cost would have been prohibitive—beyond the $50 million already committed.

Honeywell Inc.'s future investments are even bigger—a $100 mil-

CAPTIVE INTEGRATED-CIRCUIT PRODUCTION: COMPANY PROFILES

	Number of employees	Number of ICs produced (millions)	Product value ($ million)	Percent of need	Technology
IBM Corp.	30,000	–	1,600	80	Large- and medium-scale integrated bipolar logic and memory
Honeywell Inc.	875	80 (1979)	55	10 – 20	80-90% bipolar: integrated injection logic, direct-coupled logic, and low-power Schottky in MSI and LSI
NCR Corp.	800	50 (1980)	60	40	LS microprocessors, p-MOS and n-MOS memory
Burroughs Corp.	800	–	50	–	MOS, current-mode, complementary-transistor logic and memory in MSI and LSI
Sperry Corp. (1982 projection)	less than 800	–	50	20	Very large-scale integrated TTL and emitter-coupled logic, perhaps also complementary-MOS and metal-nitride-oxide-semiconductor logic and memory
Control Data Corp.	500	50 – 60	30	20 – 25	n-MOS memory, I^2L and ECL in MSI and LSI

SOURCES: INTEGRATED CIRCUITS ENGINEERING CORP., STATEMENTS TO *ELECTRONICS*, ESTIMATES

Spender. Honeywell, under Carl Nomura, will spend $100 million for ICs over five years.

Gearing up. Sperry Univac is launching its IC division under Robert Erickson.

lion, five-year capital spending program begun this year strictly for IC design and production, says K. C. (Carl) Nomura, vice president and general manager of the company's Solid State Electronics Center in Plymouth, Minn.

IBM, always a heavy producer of semiconductors, plans to add to its capacity with a 13,000-square-foot IC plant in Manassas, Va., about 60 miles from Washington, D. C. Part of IBM's Federal Systems division facility, the IC plant is keyed to the Defense Department's very high-speed integrated circuit (VHSIC) design competition. It already has 100 workers.

The operation initially will produce silicon-gate n-channel MOS chips with 2-μm features. Advanced bipolar and complementary-MOS technologies are being evaluated, says Ed Spall, manager of the division's advanced development program. Electron-beam direct-writing systems will be installed later as the program becomes operational this summer. Gallium arsenide technology will also be explored for use in VHSIC, in rf amplifiers and analog-to-digital converters for radar, but the new operation will not produce standard components, such as random-access and read-only memories.

While VLSI and vertical integration of the vendors are the twin pistons behind the plunge into IC production, each firm has adopted a unique approach. Captive suppliers are usually the component source of last resort, but many are used as the focal point of new end-product development. Explains Erich Bloch, general manager of IBM's East Fishkill, N. Y., logic facility, "Close coupling between semiconductor development and manufacturing results in better end products."

The contribution to the overall success or failure of the parent company is measured in a variety of ways. The performance of Honeywell's Solid State Electronics Center is measured by the value of the final products containing its components; the center's payback has been 300 to 1 from research through five years of system production, Nomura says. In contrast, James Van Tassel, NCR's new Component division vice president and former MOS product line manager at TI, and Lindemann of CDC both are responsible for a separate profit and loss center—components must meet internal and marketplace cost and price targets.

Other examples of the nature of the captive supplier are:

- Honeywell produces far more ICs for its Industrial Control division than for its computers. Currently it is a 2-to-1 ratio, but that will rapidly change as the Solid State Electronics Center becomes a key source of VLSI components, says Nomura.
- Most of the in-house production of NCR, Burroughs, and CDC are for peripherals, not mainframes, because of the price-performance premium at the printer, tape driver, and terminal level. Sperry Univac will focus on mainframes, though.
- Single-device production at the typical captive operation ranges from 1,000 to less than 10,000 parts per year, except for NCR, which has a 5,000-to-250,000 range.
- Better quality and reliability than are available from the vendors are required to be a successful captive supplier. "It's up to us to convince the purchasing agents in the divisions that we can do as well as or better than the vendors," says CDC's Lindemann. Van Tassel of NCR says, "Our goal is to be considered the most cooperative vendor of specialty devices, with quality and reliability above the merchant market at an acceptable price."

Fine geometries. In addition to the low profile and "source of last resort" humility at the captive houses, there is expertise. For example, development chips at CDC and Sperry Univac feature 2-micrometer geometry. CDC has achieved 50,000 gates on a chip, and NCR has reached the 100,000-component level with 3-μm geometry. Sperry Univac, Honeywell, and Burroughs each have an electron-beam machine, and Honeywell has two more on order. "We're making 500- to 600-picosecond devices and have already reached 250 ps," claims Nomura.

In fact, Nomura is currently pondering whether Honeywell should reenter the merchant market with homegrown special-purpose "nuisance" devices that other companies have requested after failing to find vendors willing to provide the chips. "Two questions have to be answered first, though: which chips do we sell, and can we do it at a profit?"

Underneath the bravura of achievement, captive production also can leave the parent company vulnerable to production glitches that can disrupt the entire corporation—like last year's shortfall of MOS memory chips at NCR, due to a variety of yield problems.

But now production is under control, says Van Tassel, who adds that he is spending a significant amount of time on yield improvement. And several unnamed "weak areas" of NCR's Components division will be bolstered with an infusion of outside people, he says. Like their semiconductor brothers, the mainframe makers are scrambling to hire additional specialists. □

The first functional PCB tester good enough to be called Fairchild.

It's the company behind Series 70 that puts it a generation ahead.

In the world of ATE, no name has so consistently been synonymous with innovative technology, dependable quality, and total systems support as the name Fairchild.

With the introduction of Series 70, Fairchild brings that long tradition of excellence to the functional board tester.

Series 70 offers true state-of-the-art hardware and software, developed for efficient and accurate board test and program simulation. It is modular in design for off-the-shelf economy and cost-effective expansion. It has a computer specifically designed for functional testing. It has a high-speed memory bus and a separate high-speed I/O bus. It can diagnose faults down to the component level with logic clip and probe capability. And it can test all of today's most advanced LSI devices —high-speed digital, analog and hybrid.

Without a doubt, Series 70 is the most complete, comprehensive and capable functional tester available today. And with the increasing complexity of today's PC boards, you can't afford a system that offers less.

And Series 70 is faster, smarter and easier.

While other testers operate at a leisurely 1.8 MHz, Series 70 gives you data rates to 5 MHz across all digital pins in parallel and collects probe data at full test speed. It offers faster, more accurate fault isolation, and it lets you program timing increments with 20 ns resolution. You can even track bus-related faults at full speed with Series 70.

Thanks to MEDIATOR, Series 70 gives you a high-level conversational test program language instead of low-level code. And MEDIATOR is an English-like, multi-level language so you can write your own hybrid board programs easily and economically.

More accurate, more flexible, and more adaptable.

Compared to today's best known functional tester, Series 70 offers specifications that are truly impressive:

	Series 70	An older tester
SPEED	5 MHz	1.8 MHz
PROGRAMMABLE PULLUP RESISTORS	Yes	No
COMPUTER	Specially designed dual bus architecture 16 bits 64 K words memory (128 K bytes)	PDP-8 12 bits 32 K words memory (48 K bytes)
SIMULATOR	High accuracy Can be run on tester	Longer debug time Have to add memory
MASS STORAGE	12 or 24 MB disk	2.4 MB or 4.8 MB disk
SOFTWARE	Virtual memory	Overlay & linking
EDITOR	Continuous on-line operation	Call-up mode
SYSTEM INITIALIZATION	Totally automatic	Boot from TTY
DIAGNOSTIC CAPABILITY	Fault tracing to the component level with FLO-TRACER	No equivalent
ADVANCED LSI TECHNIQUES	Live data compression	No equivalent
HIGH-SPEED CLOCKS	8 phase with OR capability	No equivalent
HYBRID CAPABILITY	6 bus dual-pole throughout	Limited scanner

The world's first true hybrid tester.

Unlike other functional testers, Series 70 covers all types of boards—bus oriented microprocessors, dense dynamic memories, fast static memories, complex linear circuits and discrete devices. And it can handle boards from MOS and CMOS to TTL and advanced bipolar.

With Series 70, you also get a wide choice of fixturing systems—universal, edge connector, or optional Thinline® bed-of-nails interface.

And it's from the first family of ATE.

Like all Fairchild test systems, the Series 70 is backed by the largest support network in the industry. Training, applications software, special hardware configurations and maintenance are all part of the Fairchild support package. Together they provide a comprehensive, proven and state-of-the-art solution to your functional PCB testing needs today and tomorrow.

For more information on the new Series 70 Functional Board Tester from Fairchild, call or write for our new brochure:

Fairchild Test Systems Group
Fairchild Technical Center
Billerica, MA 01821
(617) 663-6562

FAIRCHILD

A Schlumberger Company

The First Family of ATE.

Circle 109 on reader service card


High accuracy simulator
Computer: 16 bits. 64 K words memory
6 bus dual-pole matrix
Fault tracing to the component level
12 or 24 MB disk
Dual IEEE bus
Live data compression
5 MHz data rate
Virtual memory
SERIES

Commercial electronics

Supermarket scanners start to move

Point-of-sale systems make headway as customer resistance lessens and food chains complete equipment evaluations

by Wesley R. Iversen, Dallas bureau manager

The long-simmering market for supermarket point-of-sale scanning equipment may finally be heating up. Despite the looming recession, scanning-system suppliers are adding factory capacity aimed at keeping up with recent mounting backlogs for the laser-based equipment. And point-of-sale vendors at the annual Food Marketing Institute (FMI) convention this month in Dallas were touting new scanners and related hardware among their new product offerings as well as software packages for better utilization of scanner-captured data.

Despite the availability of the technology since 1973, when the retail food industry adopted the Universal Product Code of vertical bars and spaces for marking grocery products, supermarket scanning has been slow to catch on. Only about 2,000, or 6%, of the nation's 33,000 food stores have scanning equipment in place, says Timothy M. Hammonds, FMI senior vice president. But that figure is about four times the 562 scanning installations reported by FMI at the end of 1978, and grocers now are adding scanners at a rate of about 100 installations per month.

Point-of-sale system vendors attribute the surge in scanner order rates during the past two years to several factors. Early consumer resistance related to the removal of prices from products on the shelf has softened, they say, and most large food chains have now had time to complete evaluation testing of the scanner equipment. An additional barrier fell during 1978, when the portion of products actually marked with the price symbol reached 75% to 80%, the level that industry sources say is necessary to make scanning cost-effective.

Figures for scanner-related savings vary widely by store. But many agree that improved checkstand productivity coupled with the so-called "soft" benefits that come with better inventory and labor management due to availability of scanner data in a variety of report forms can add 1% to a store's profit margin. In an industry that works with notoriously low margins to begin with, vendors are counting on this factor too.

Light reading. IBM's 3663 supermarket point-of-sale terminal shown in use. The laser-based system has helped IBM sell 35.3% of such installations, just behind leader NCR's 36.1%.

NCR is leader. According to FMI figures, NCR Corp. of Dayton, Ohio, led the industry with 36.1% of the installed scanner base as of March this year, followed closely by IBM Corp. Armonk, N. Y., with 35.3% and National Semiconductor Corp. of Santa Clara, Calif., with 19%. Other vendors with smaller market shares include Sweda International Inc. of Pine Brook, N. J., a division of Litton Industries; Data Terminal Systems Inc. of Maynard, Mass.; and DataCash Systems Inc. of Clearwater, Fla.

As the supermarket-scanner business matures, production capacity of the respective competitors could play a role in ultimate market share. While IBM and National both manufacture their own scanners, several

In Europe, nobody offers a single package CEPT compatible DTMF receiver, 'cept us.

If you are a design engineer of telephone switching systems, we have some small news for you.

Tone receivers that meet the full range of your design needs.

The 88205-5NC is the only single package DTMF receiver available today that meets both CEPT and Bell specifications. A simple external adjustment is all that is necessary to meet individual gain requirements.

The 3000 Series tone receivers are based on a unique modular design for applications in DTMF (Bell specification only) as well as MF signalling applications including R1, CCITT#5, R2 Forward and R2 Backward. These tone receivers are field proven (in use for nearly 4 years) and the modules form a complete receiver function.

Both provide an unparalleled combination of size, cost and performance. You will find these components to be of high quality and packaged with hybrid reliability that will meet your most stringent demands. Specify them for your next Central Office, PABX, Key System, Mobile Page System or end-to-end signalling application.

For more information, contact: ITT North Microsystems Division, 700 Hillsboro Plaza, Deerfield Beach, FL 33441. Phone (305) 421-8450, TLX: 51-2329 & TWX: 510-953-7523.

ITT

ITT North Microsystems Division

Circle 111 on reader service card

other vendors purchase the helium-neon gas laser-based systems on an original-equipment-manufacturer basis from Spectra Physics Inc. of Mountain View, Calif. That firm began shipments early this year on a fourth-generation scanner known as the model F, which is being produced exclusively in a new Spectra Physics factory in Eugene, Ore.

The model F uses a design that takes advantage of a recent easing of Federal regulations governing allowable laser radiation output to reduce system component count by 66%, says Alfred P. Hildebrand, general manager of the company's Laser System division. Schottky TTL devices were notable among circuit types eliminated, he indicates.

As noted by Ralph E. Canada, food and drug systems marketing manager for NCR's Dayton, Ohio, Retail Systems division, the model F is "more manufacturable" than Spectra Physics' previous model E scanner. But officials from more than one vendor at the Dallas show—including Data Terminal Systems and DataCash—complained that slower-than-expected startup deliveries of the model F have contributed to growing backlogs.

Top speed. NCR's Canada reckons that his company's 2552 POS system is currently in place in some 6,000 supermarkets, each of which can be upgraded to scanning. NCR is now "installing scanners as fast as we can" at the rate of about 20 to 30 per month, says Canada. In addition to purchasing Spectra Physics scanner systems, he adds, NCR has recently begun making its own and hopes to boost installation rates to 60 to 70 per month by summer.

National also recently increased its scanner manufacturing capability almost twofold, reports Systems division marketing director John Humphreys. This has enabled the Sunnyvale, Calif., division to cut scanner lead times for its Datachecker POS equipment line from about nine months last November to about four months currently, Humphreys says.

Checking out. The Bar Double X scanner from National Semiconductor reads product codes at better than 100 inches per second. National ranks third with 19% of installed POS base.

As the scanner technology catches on, more standard software can be expected from vendors that will enable grocers to take advantage of scanner-captured data. Illustrative of this trend are two new software packages from IBM called Merchandise Management and Resource Management. Designed for use on the IBM 3650 programmable store system, these programs are capable of providing more than 50 standard format reports to aid a store manager in controlling merchandise flow and labor and equipment scheduling.

Among new hardware at the Dallas show was the Eagle 1 scanner from DataCash. Pegged for availability in June, the Eagle 1 uses a 2900-type bit-slice processor that is 12 bits wide. The firm says it will significantly increase "first pass" reads of irregularly printed price symbols. Also new was the model 6100 scanner from Sweda, which is said to provide a 50% depth-of-field improvement over previous Sweda units.

Out back. Most vendors of POS systems offer the supermarket scanning option within an architecture that includes checkstand terminals with limited intelligence that are tied into a backroom disk-based processor holding the store's inventory file. For an eight-lane store, the total cost of such a system—which sometimes includes dual, redundant processors—was typically quoted at the Dallas show between $90,000 and $120,000.

A maverick among vendors is Data Terminal Systems, which has configured its system using no central processor. Rather, the company has chosen to hold down system cost by employing semiconductor chip intelligence at each checkstand. William T. Emberton, food industry systems development manager, says this enables Data Terminal to offer systems at about 40% less than competitors. There are, however, disadvantages. One is that inventory files must be duplicated for each checkstand. No more than four terminals can work from the same file without degrading response time, and the 384-kilobyte capacity currently offered can handle only 15,000 items, which is not big enough for the largest stores. □

Get meaningful signal analysis through complete annotation of accurate data. Introducing the Gould ES 1000.

The new Gould ES 1000 electrostatic analog recorder automatically makes the exact chart notations you require for determining the nature of your signals. Chart speeds, amplifier sensitivity settings, units of measurement, real time, and test identification are all printed exactly according to your preprogrammed instructions. Even when you make additional, immediate notations through the auxiliary keyboard, there's no need to touch the chart or stop the recorder.

You'll also find the rugged, dependable Gould ES 1000 is a versatile performer whatever your application. Plug-in signal conditioners provide accurate monitoring of a wide range of input functions. There's even an optional plug-in digital converter. You get a peak capture capability of 40 microseconds and flat frequency response from DC to at least 10 kHz across all 16 channels.

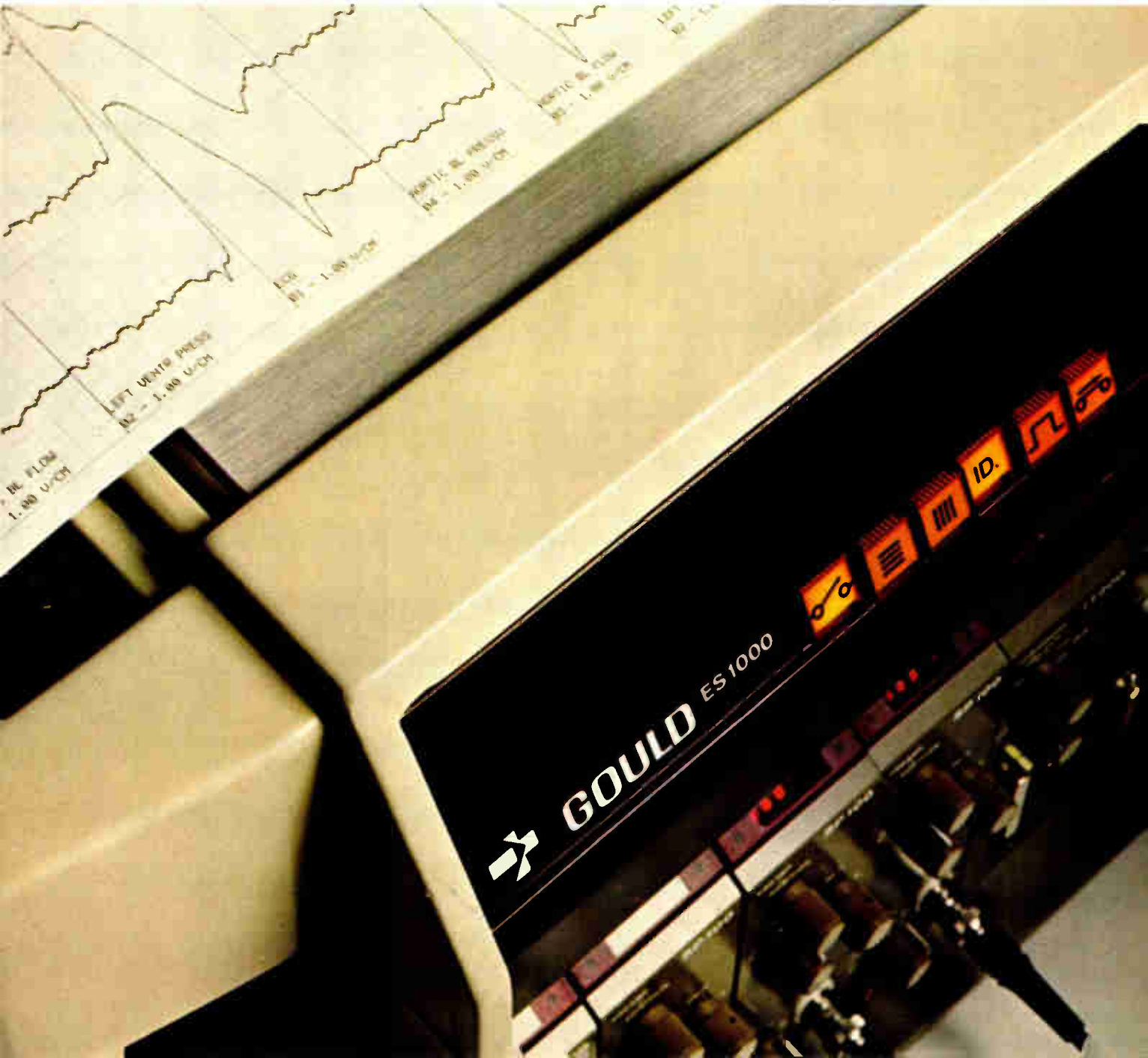
For accuracy, the fixed electrostatic linear array of the ES 1000 generates its own grid pattern at the same time it is producing the high resolution 100 dots per inch trace. Traces overlap allowing all channels to record full scale across the 10" wide writing area. The unique 1000 electrode head eliminates pens, ink, and other moving parts that might have the potential for trouble.

Find out more about how meaningful your signal analysis can be with the new Gould ES 1000. Write Gould Inc., Instruments Division, 3631 Perkins Avenue, Cleveland, Ohio 44114. Or Gould Instruments S.A.F., 57 rue St. Sauveur, 91160 Ballainvilliers, France.

GOULD

An Electrical/Electronics Company

Circle 113 on reader service card



Displays

World of displays is a wide one

Flat panels especially show the multiplicity of technologies and design talents that are needed to surmount barriers

by Roger Allan, Components Editor

It wasn't too long ago that information display meant cathode-ray tubes. Now, though CRTs are still a dominant force, the world of displays has become an interdisciplinary, multifaceted one involving specialists in a variety of technologies teaming up to solve problems.

Nowhere has this been brought home more clearly than at the Society for Information Display Seminar/Symposium/Exhibition earlier this month in San Diego, Calif. (see "The SID: many disciplines, more members," at bottom). There, circuit designers, software engineers, materials researchers, and interface specialists placed one another's achievements and problems under a magnifying glass, coming away with the impression that flat panels are making the kind of progress that will enable them to complement CRTs in the next decade. Born of a need to fulfill special form-factor requirements that the CRT cannot, these new technologies are now poised for market acceptance.

Make no mistake: the CRT will still be around long after other display technologies have matured. However, most display experts queried at the San Diego show, including some CRT stalwarts, felt that, given the rate of information-processing advancements and the greater pervasiveness of computer technology in everyday life, information-display requirements will dictate more and more the use of new technologies compatible with future needs. These technologies will inevitably be non-CRT flat-panel displays.

Drivers needed. An example of how interdependent different disciplines are in information-display technology—and of a technological weak point that is holding it back—is the critical need for more breakthroughs in flat-panel-display drive electronics. At a discussion on such displays, the call went out to semiconductor manufacturers to accelerate their development of driver chips for panels. It was pointed out that plasma, vacuum-fluorescent, and electroluminescent panel displays have reached the point where the remaining stumbling block is the availability of low-cost, high-voltage driver integrated circuits.

Confirming this, representatives of Texas Instruments Inc., Dallas, reported that demand for the company's 512-line plasma-panel driver chips that were on display was beyond expectations [*Electronics*, May 8, p. 33]. Yet as Laurence Tannas of Aerojet Electro-Systems, Azusa, Calif., a participant in the discussion and a well-known flat-panel display expert, points out, it is difficult to interest a semiconductor manufacturer selling millions of microprocessors and memories in producing more driver ICs with greater voltage and line-driving capabilities for flat-panel displays that are not even in production.

Still, someone has to have the courage to do it first, maintains Elliot Schlam of the U. S. Army Electronics Research and Development Command, Ft. Monmouth,

The SID: many disciplines, more members

The recent Society of Information Display Seminar/Symposium/Exhibition was the most successful in its history. Over 1,000 individuals attended, compared with some 700 last year in Chicago, with most of the technical presentations, panel sessions, and seminars drawing standing-room-only audiences. "Interest in the SID meeting has gone up dramatically, from 46 technical presentations last year to 89 this year," says Ifay Chang of IBM Corp.'s Thomas Watson Research Center, Yorktown Heights, N. Y., program chairman.

The large number of technical presentations reflects the multidisciplinary aspects of the conference, where physicists, electronics engineers, glass manufacturers, avionics experts, and TV broadcast engineers, among others all had something to say. In fact, it is also a reflection of the SID itself, a body that was founded in 1962.

"One of our society's successes has been its interdisciplinary broadness," explains Bernard Lechner of RCA Corp.'s David Sarnoff Laboratories, Princeton, N. J., who is the outgoing SID president. The next president is Tarricia DuPuis of Hughes Aircraft Co., El Segundo, Calif. Ms. DuPuis feels that the SID, with close to 2,000 members worldwide, has become large and well established enough to warrant greater attention from the electrical-electronics engineering communities at large. "We would like to grow at a reasonable rate, but we'd also like to keep the small-community feeling we now have," she says. "Because of the society's relative smallness, you'll find many renaissance SID individuals who are forced to deal with several aspects of information display," she adds. -R. A.

Superior X-Y value.

Now, a high performance X-Y recorder without a high price. Introducing the Gould 3054, the X-Y recorder with value superior to any other analog recorder in its price or performance ranges. It's the first of an all-new series of high performance X-Y recorders designed to handle a broad range of applications in industrial, scientific, and biophysical measurement. For a much lower cost than you'd expect, the new Gould 3054 gives you the fast, sensitive response needed to provide precise, permanent records of the relationships between two analog variables.

The new Gould 3054 offers performance and features normally found only in much more expensive, less flexible instruments. The high speed drive system provides for high system fidelity with a minimum slewing speed of 85 cm/sec and accelerations of 7700 cm/sec^2 in the Y-axis and 5100 cm/sec^2 in the X-axis. Advanced X- and Y-axis preamps with sensitivities down to 200μ V/cm ensure recorder flexibility.

In use, a simple, disposable fiber-tip pen system provides a high quality fine line trace. Improved electronics servo protection ensures instrument reliability. Also included are calibrated zero offset, a switchable low pass filter, and switchable input polarity reversal. Plus, an optional time base is available.

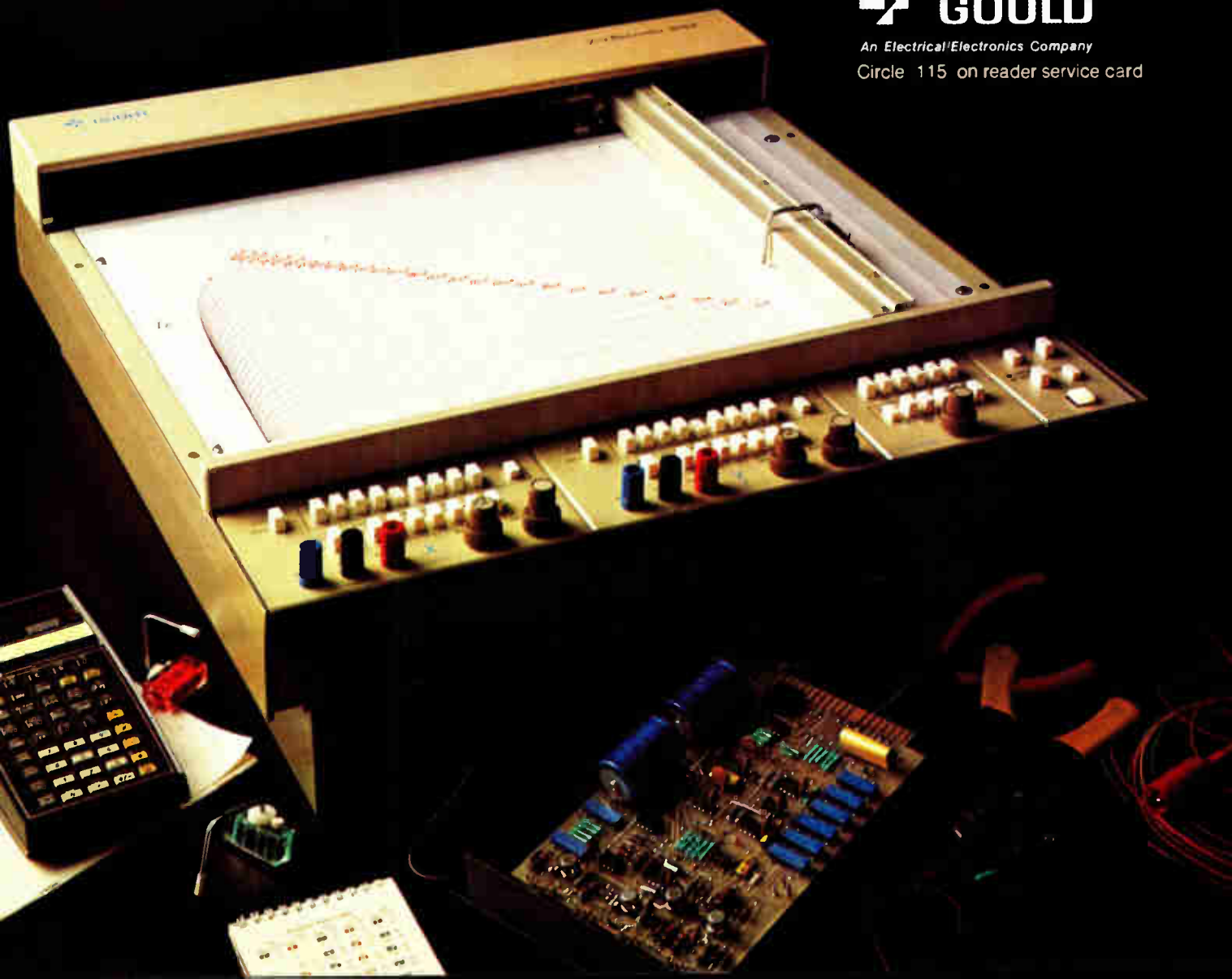
Find out more today about what makes the new Gould 3054 superior to anything in its price or performance ranges by writing Gould Inc., Instruments Division, 3631 Perkins Avenue, Cleveland, OH 44114.

For brochure call toll-free: 800-331-1000. In Oklahoma, call collect: 918-664-8300.

GOULD

An Electrical/Electronics Company

Circle 115 on reader service card



Probing the news

N. J. Schlam, also a participant in the session on flat-panel displays, says there is great demand for high-voltage driver ICs for flat panels.

Complicating things is a debate raging among flat-panel experts about the feasibility of flat-panel technology with the use of high-voltage driver ICs. One school feels that flat-panel displays, to be successful, must be compatible with lower-voltage ICs like those made of TTL and emitter-coupled logic. Liquid-crystal and light-emitting diode displays are thus looked upon as more promising, since it may be possibile to integrate the display material and driver electronics on the same chip. On the other hand, LCDs and LEDs cannot compete with plasma, electroluminescent, and vacuum-fluorescent displays for large-screen and graphic applications even though the latter require higher-voltage driver ICs. There is also hope that further research into display materials could reduce the drive voltage needed.

Using the future. As though technology and circuit design were not providing enough barriers that must be surmounted, display experts also find themselves worrying about the human-machine interface. This is particularly true when they discuss the office of the future.

Thus, instead of discussing technologies, a group of experts at San Diego found itself embroiled with questions of how to get people in the office setting to accept the next generation of electronic aids. An emerging consensus is that a definition is needed of what those products will be and what they can do, shaped mainly by how they interact with the office worker.

Panelist Christopher Stockbridge of Bell Laboratories in Holmdel, N. J., summarized the participants' feelings by urging product designers to spell out more clearly what their designs hope to achieve and how these designs will stimulate office workers into accepting them. Such equipment must meet the needs of individuals to maintain or improve their perception of themselves and of others, he said. □

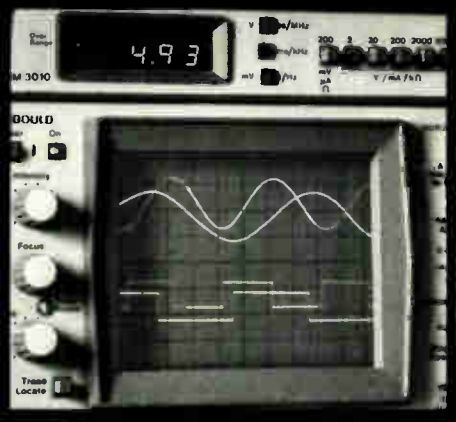
Now—Gould quality in a 100 MHz oscilloscope.

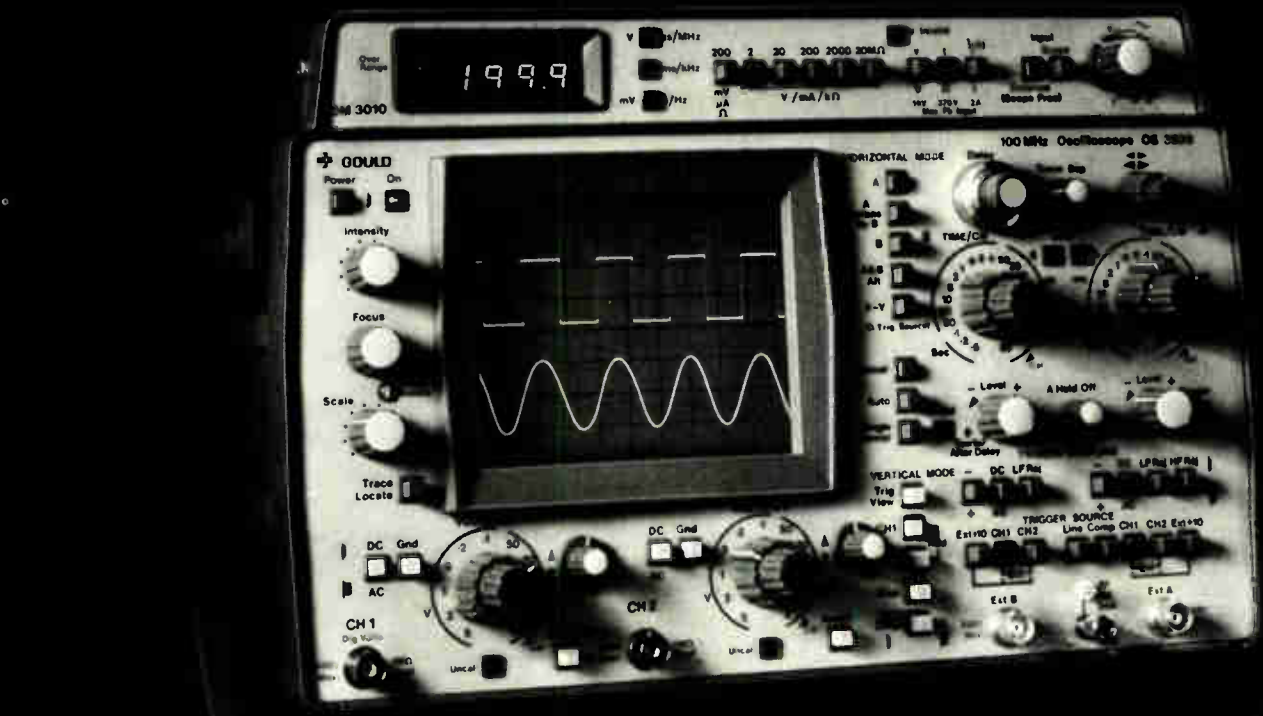
No scope on the market has more of the features you need than the new Gould OS3600 with optional DMM. You can use the OS3600 on any electrical/electronic circuit from digital to conventional with exceptional results.

With vertical sensitivity of 2mV/cm up to 85 MHz, the OS3600 can examine extremely low level signals. The 4-trace capability allows comparison of original and delayed sweeps.

The bright, flicker-free CRT displays even narrow pulses with low repetition rates. The optional 3½ digit DMM is available as a factory fit or retrofit. Plus, the OS3600 is backed by a worldwide service network and a unique 2-year warranty that covers all parts and labor (exclusive of fuses, calibration, or minor maintenance).

Write Gould Inc., Instruments Division, 3631 Perkins Avenue, Cleveland, OH 44114. Call toll free 800-331-1000 (in Oklahoma, call collect 918-664-8300).





GOULD

An Electrical/Electronics Company

Circle 117 on reader service card

THINK BAUSCH & LOMB VALUE

For more than twenty years, StereoZoom® Microscopes have been the first choice of electronics assembly, packaging, and inspection operations.

The reasons all relate to Bausch & Lomb value. Like a dedicated effort to respond to your constantly increasing performance requirements. Persistent attention to quality to help you improve your product reliability. And versatile, high performance features that reduce operator fatigue and increase productivity.

This attention to your requirements has made StereoZoom Microscopes your best value year after year. Call or write today for a detailed catalog, applications assistance, or a personal demonstration.

Performance. Quality. Reliability.
Three good reasons to...
THINK BAUSCH & LOMB VALUE

BAUSCH & LOMB
Scientific Optical Products Division
ROCHESTER NEW YORK 14602

Consult Yellow Pages under "Microscopes"

Circle #118 for more information

CAMBION IC SOCKETRY.

Now as a boon to design engineers, production and QC specialists—and everyone else concerned with loaded PC board performances—Cambion offers TWO great series of LOW PROFILE solder-tab IC sockets: the *new* nylon body *703-53XX* Series and the *newest* polyester body *703-42XX* Series (UL 94V-0 rated).

Both super-dependable series feature an inverted contact design for excellent lead-in and secure gripping of the flat sides of delicate DIP leads (face-wipe). *Both* series offer anti-moisture bosses and Kapton® anti-wicking sealing strips. Cambion helps—all across the (PC) board—check out the chart for fast, easy reference, and keep your PO's handy!

CLIP AND SAVE

CAMBION LOW-PROFILE IC SOCKETS

Solder-Tab[1], Electrotin Finish[2], Kapton® seal

Total No. Pins	Centers	Body Length	Series 703-53XX Red Nylon Body Cambion Part No.	Series 703-42XX* Black Polyester Body For Automatic IC Insertion Cambion Part No.
8	.300	.396	703-5308-01-04-12	703-4208-01-04-10
14	.300	.696	703-5314-01-04-12	703-4214-01-04-10
16	.300	.796	703-5316-01-04-12	703-4216-01-04-10
18	.300	.896	703-5318-01-04-12	703-4218-01-04-10
20	.300	.996	—	703-4220-01-04-10
22	.400	1.096	703-5322-01-04-12	703-4222-01-04-10
24	.600	1.196	703-5324-01-04-12	703-4224-01-04-10
28	.600	1.396	703-5328-01-04-12	703-4228-01-04-10
40	.600	1.996	703-5340-01-04-12	703-4240-01-04-10
64	.900	3.196	703-5364-01-04-12	—

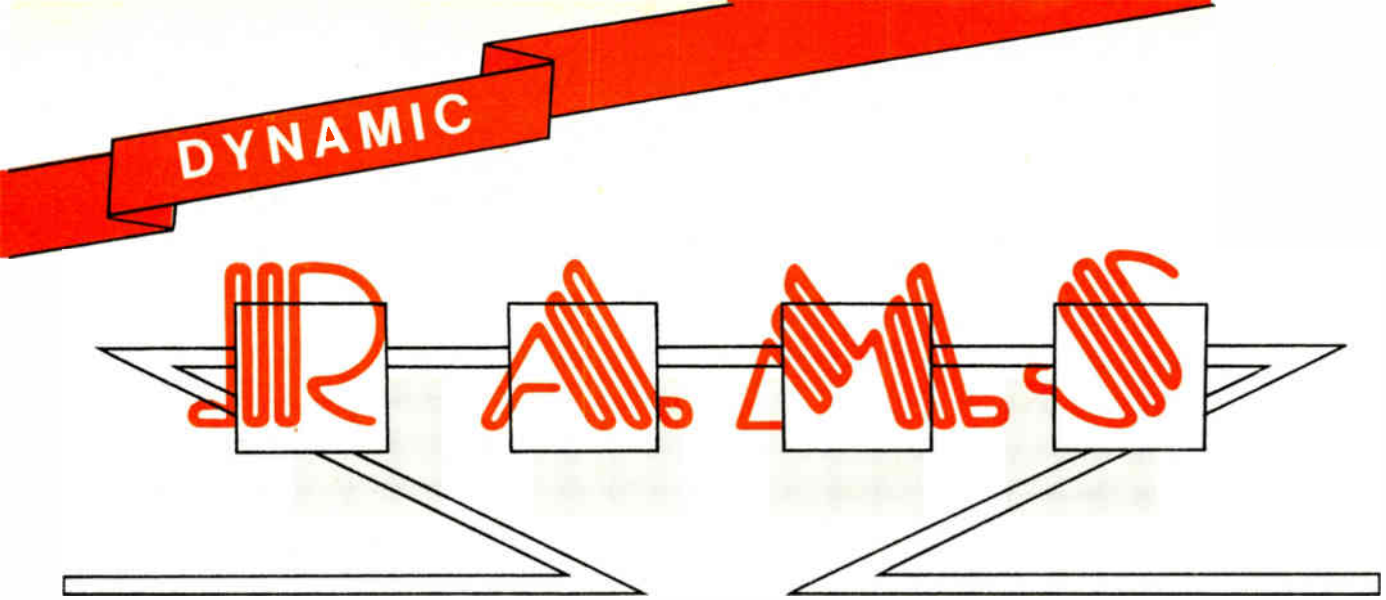
Get our new IC Socket Catalog!

[1]*Mounting Data:* Drill no. 67, mtg. hole dia is .032"
[2]For gold finish, specify -03 instead of -04
*Open ended for air circulation and easy access for removal of DIP.

CAMBION®
The Right Connection.

Cambridge Thermionic Corporation, 445 Concord Avenue, Cambridge, MA 02238
Tel: (617) 491-5400, Telex: 92-1480, TWX: (710) 320-6399

Circle 235 on reader service card



What to expect next: a special report

64-K and larger dynamic memories struggle toward the market, trusting in a variety of technologies

by John G. Posa, *Solid State Editor*

☐ Early cost-per-bit studies projected that 64-K random-access memories would be competitive with 16-K RAMs in 1981. However, this prediction was predicated on a bad assumption: that semiconductor manufacturers possessed the resources and technical prowess necessary to mass-produce the parts. For this reason and others, that crossover point has been pushed back two years. While memory users will be denied their bits, this lull in volume production affords an excellent opportunity to compare and contrast 64-K and bigger dynamic RAMs in the offing.

Although the 16-K RAM demanded a second level of polysilicon, its device geometries were not significantly reduced from 5 micrometers, so in-place projection lithography equipment that exposed 4-K RAMs could be used for the new generation. In contrast, the 64-K RAM needs linewidths of 3.5 μm or less, so the contestants must all learn the art of scaling. This minimum feature also taxes present lithography machines, yet the alternatives—deep-ultraviolet and direct-step-on-wafer exposure systems—are back-ordered.

To make matters worse, it was established that 64-K RAMs should generate their substrate bias internally for operation from a single 5-volt supply. This, in conjunction with roughly half-sized cells, lowered internal operating margins while at the same time increasing susceptibility to alpha radiation. Undeterred, at least 18 U. S., Japanese, and European chip makers say they will make 64-K RAMs (see table). The carrot being held in front of them is a market exceeding $1 billion by 1983, according to some market research firms (see "A $1 billion 64-K market by 1983," p. 121).

Many choices

With so many manufacturers poised to crowd the market, it is reasonable to expect that some or most of the chip designs will be identical or at least similar. Nothing could be further from the truth, however; indeed, the most fascinating aspect of the upcoming dynamic RAMs is the variation in their design. These differences—some subtle, others striking—are no longer just being debated at circuits conferences, but are being put into silicon. And each manufacturer feels strongly justified in choosing the architecture and manufacturing process that it will put into practice.

RAM storage areas are being partitioned into two, four, and eight array sections. Open and folded bit-sense lines will both be used, as will a unique sense amplifier

fed by four bit-sense lines—double the usual number. The chips will be refreshed in 2 milliseconds with 128 cycles or in 4 ms with 256 cycles, and at least three 64-K memories have or will be given counting circuitry for automatic refreshing, done on chip.

Redundancy will be used in some cases to improve yield, while new materials and implants are being tried to up the capacitance of the storage cells. Refractory silicides and laser annealing are being experimented with to lower the resistance of polysilicon wiring, and various coatings are being prepared as shields against ionizing alpha radiation. As a result of this diversity, access times and power dissipations for the latest generation of dynamic RAMs, too, will span a wide range.

A bit of history

The design of 64-K dynamic RAMs got off to an early start in Japan through an adjunct program of its recently concluded four-year, government-sponsored program for research and development of very large-scale integration. But at present the Japanese appear no closer than U. S. chip makers to volume production of 64-K RAMs, although they are regarded as the ultimate threat in the domestic and world dynamic RAM markets—Nippon Electric Corp. was second only to Mostek Corp. in global 16-K RAM shipments for 1979.

Specifically, Japan's initial 64-K RAM designs were targeted for Nippon Telegraph and Telephone Public Corp. equipment. NTT has a research arm—its Musashino Electrical Communication Laboratory—but no real production facilities. At the 1978 International Solid State Circuits Conference, NTT described a 64-K RAM that was partitioned into 16 4-K arrays; later, in a paper coauthored by Nippon Electric Co., a 16-K-by-4-bit dynamic RAM was presented. Last year, it reported a 64-K chip with a 1-μm molybdenum gates. None of these designs were slated for production.

Some more recent 64-K RAMs originally intended for NTT were, however, manufactured by NEC, Fujitsu Ltd., and Hitachi Ltd. All were two-supply parts. Between shipments to NTT, Fujitsu and NEC stock their own computers with these devices. Fujitsu also offers its part, the MB8164, commercially; if fact, the company claims to be the only company that can, today, supply 64-K RAMs "by the thousands per month." In the light of the single-supply precedent set by the U. S., Fujitsu plans to introduce a 5-V-only device this month, the MB8264. The fate of its older +7- and −2.5-V RAM depends on demand, says Fujitsu.

Fujitsu's 8164, considered by some to be the first 64-K RAM, was announced in 1978 along with devices from Texas Instruments Inc., International Business Machines Corp., and Motorola Inc., in that order. In 1979, Bell Laboratories and Mitsubishi Electric Corp. followed suit, as did Hitachi, now with a 5-V-only device. Since then, a great many other chip makers have promised 64-K RAMs. Also, 256-K memories have been described by NEC and the Musashino Lab. And the now defunct Kawasaki Cooperative Laboratories of Japan's VLSI Technology Research Association has laid the groundwork for half-megabit and even larger monolithic dynamic RAMs [*Electronics*, Feb. 14, p. 138].

It is interesting to note that two big names in the memory business—Intel Corp. and NEC—have so far been very close-mouthed about their 64-K devices. NEC will introduce a single-supply device this summer; Intel will do so shortly thereafter. In previous generations, NEC took pride in being the last to announce a device,

A SURVEY OF 64-K DYNAMIC RANDOM-ACCESS MEMORIES

Manufacturer	Part number	Die size[1] (mil^2)	Access time[1] (ns)	Power dissipation[1] (mW)	Voltages (V)	Refresh (cycles/ period)	B[2]	W[2]	32-K partial[7]	5-V 16-K[7]
Fujitsu, Tokyo, Japan	MB8164[3]	34,250	150/200	385/n.a.	+7[3], −2.5	128/2	FM	P	N	M
Texas Instruments, Dallas, Texas	TMS4164	33,000	150/200	125/17.5	+5	256/4	D	M	N	Y
IBM, Essex Junction, Vt.	internal	62,500	330–440	360/20	+8.5, +4.25, −2.2	256/2-3	D	M	Y[4]	N
Motorola, Phoenix, Ariz.	MCM6664[5]	39,000	150/200	275/30	+5	128/2	FM	P	Y	Y
Bells Labs, Murray Hill, N.J.	internal	61,800	170	440/n.a.	+8, −5	128/4	P	M	N	N
Hitachi, Tokyo, Japan	HM4864	45,460	150/200	330/20	+5	128/2	FM	P	M	Y
Mostek, Carrollton, Texas	MK4164	40,750	100/120	300/20	+5	128/2	P	M	Y[6]	Y
Mitsubishi, Tokyo, Japan	M58764S	41,750	150/200	250/27.5	+5	256/4	D	M	N	Y
National, Santa Clara, Calif.	NMC4164	31,000	120/150/200	200/20	+5	256/4	M	P	Y	Y
Toshiba, Tokyo, Japan	TMM4164C	38,600	120/150	250/20	+5	128/2	D	M	M	N
NEC, Tokyo, Japan	μPD4164	50,650	200	250/28	+5	128/2	D	M	N	Y
Intel, Santa Clara, Calif.	2164	n.a.	100/150/200	n.a.	+5	128/2	n.a.	n.a.	Y	Y
Siemens, Munich, West Germany	HYB4164	39,000	150	250/n.a.	+5	256/4	n.a.	M	n.a.	n.a.
ITT, Freiburg, West Germany	ITT4564	36,000	150	250/25	+5	128/2	D	M	Y	n.a.
AMD, Sunnyvale, Calif.	Am9064	< 40,000	100/150/200	200/20	+5	128/2	n.a.	n.a.	M	Y
Fairchild, Mountain View, Calif.	F64K	36,450	120	< 200	+5	256/4	M	P	n.a.	n.a.
Inmos, Colorado Springs, Colo.	n.a.	< 40,000	n.a.	n.a.	+5	256/4	n.a.	n.a.	N	Y
Signetics, Sunnyvale, Calif.	2164	40,700	60/80/120	300/15	+5	256/4	n.a.	n.a.	Y	n.a.

1. Actual and speculative values are intermixed. 2. B = bit-line material, W = word-line material, M = metal, D = diffused (ion-implanted), P = polysilicon, F = folded bit line.
3. Newer 8246 is 5-V-only. 4. Not a partial. 5. Newer 6665 has no pin-1 refresh. 6. 4332 contains 2 16-K RAMS; 4532 is a 64-K partial. 7. Y = yes, N = no, M = maybe.

A $1 billion 64-K market by 1983

Updating its outlook for the dynamic RAM marketplace, Dataquest Inc. now foresees 64-K RAMs crossing the $1 billion threshold by 1983. As shown in the graph on the left, the Cupertino, Calif., research firm expects the market for 64-K chips to start a steep upward climb in 1981, gaining nearly $4.5 million in market size per year at least to 1984, leaving the other device types in the dust just after 1982's onset.

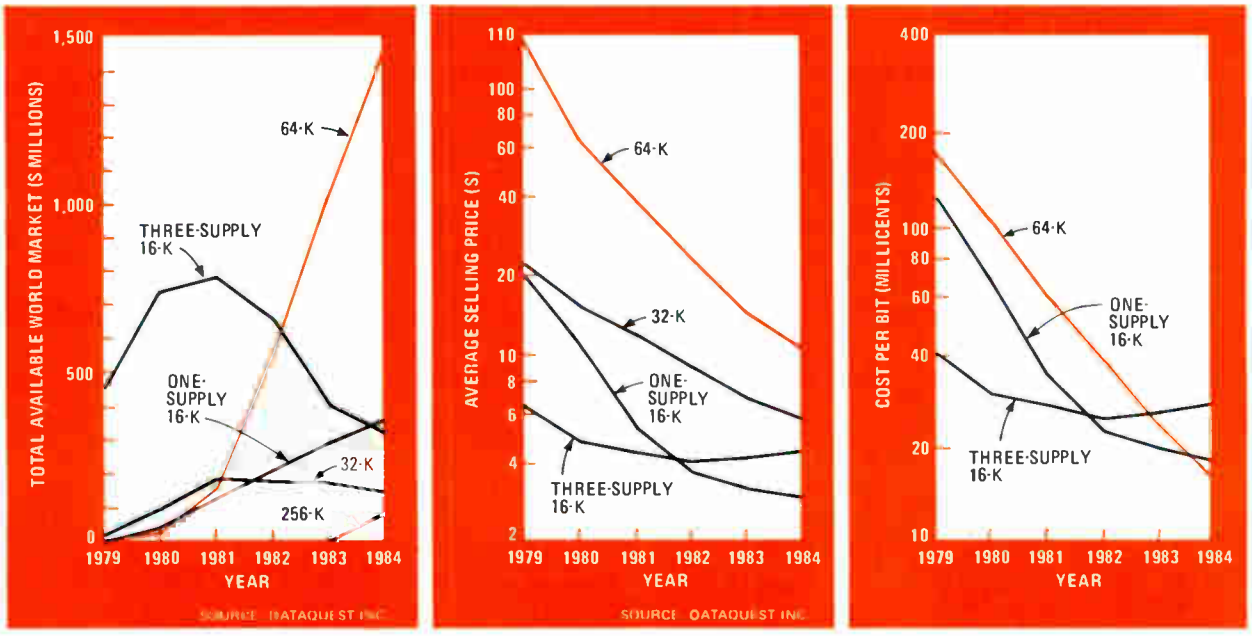
The data it has compiled on the single-supply 16-K RAM, too, is optimistic, indicating that a linear upward ramping has already commenced, shooting to hit $400 million by 1984. But, as underscored by current fluctuations in the cost of triple-supply RAMs due to a softening in demand, RAM pricing and market size are particularly sensitive to industry capacity and day-to-day economics. "If the market goes soft for the 16-K, it will provide the incentive to push wafer starts," states Dataquest's Daniel Klesken. This may close the window on the single-supply 16-K RAM, he cautions.

Based on Dataquest's average selling price curves (center graph), the single- and triple-supply 16-K RAMs will not compete on a cost-per-bit basis until the second half of 1981. The curve for the 64-K RAM crosses that for the three-supply 16-K in the second half of 1982 and that for the one-supply 16-K RAM in mid-1983 (right graph).

In a market study done by Hitachi Ltd., growth curves for the 16- and 64-K parts are more conservative; but for the 256-K RAM, it forecasts a $0.5 billion market by 1985. Hitachi sees the same peak year for the 16-K RAM—1983—and although its curves resemble those of Dataquest's, Hitachi's combined total for both 16-K device types comes within only 60% of Dataquest's, on the average. With the 64-K RAM, Hitachi closely tracks Dataquest until 1983, at which point it predicts a market of only $700 million, followed by a wait until 1985 to reach $1 billion from a more moderate slope.

These market estimates are for worldwide consumption in noninflated, or constant, dollars. Dataquest's Klesken adds that of the total, the U. S. consumes about 55%, Europe about 25%, and Japan, about 20%. He feels that Japan might pick up 5 to 8 percentage points in the next five years for its own computers, subtracting from both European and U. S. shares. But much of this equipment will "get purchased in Europe and the U. S. anyway."

In terms of production, Dataquest says that about 16,000 64-RAMs were shipped in 1979, of which about 10,000 came from Motorola, about 2,400 from TI, and the rest from Fujitsu. Motorola does not repudiate these estimates; in fact it adds that though Dataquest quotes Hitachi as merely supplying samples of its 64-K RAM in 1979, it has "heard rumors that Hitachi may have shipped as many as 1,000 64-Ks last year." IBM and Western Electric (for Bell Labs) both claim to be in volume production of their devices, albeit for captive consumption.



but afterwards began production with a vengeance and quickly forged its way to the top of the pack. With the materialization of the market so distant, these two companies feel no compulsion to rush. After all, each is profiting from 16-K dynamic RAM sales—NEC from its three-supply device and Intel from its new, expensive, but fast single-supply 2118.

As the table shows, more than half of the companies planning 64-K RAMs are also considering single-supply 16-K memories. There will be diversity in these designs too. Some of the manufacturers will first build 64-K RAMs, then offer tiny 16-K chips incorporating the same scaled-down design rules. Others, like Intel, to beat the competition to the market, will first introduce 5-V-only 16-K parts with relaxed geometries. Single-supply 16-K RAMs will not be competitive with three-supply devices for at least another year, especially when 64-K RAM features are used. The parts therefore must—and do—

have something else to offer: speed. Intel's 2118 is twice as fast as the slower versions of its 64-K RAM.

The single-device cell used in modern dynamic RAMs actually contains a MOS FET in series with a storage capacitor. The drain of the transistor connects to a bit line that in turn feeds a sense amplifier for that column of cells. The gate of the transistor connects to a word (or row) line. The bit lines are perpendicular to the sense amplifiers. The word lines are parallel; thus, their number settles how many cells will hang on a sense amp, as well as the number of refreshing cycles.

Dynamic organizations

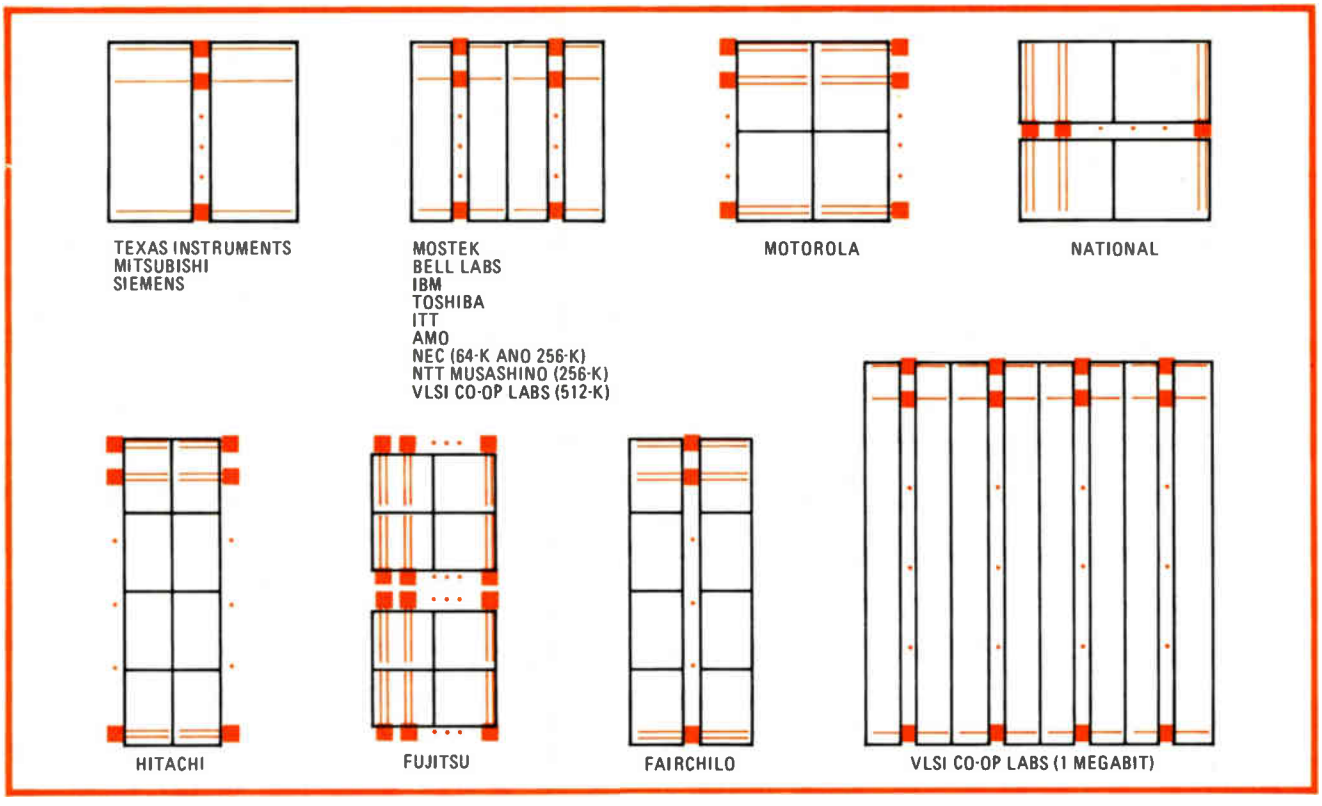
The most daring way to organize a dynamic RAM is to divide up the array the fewest number of times consonant with the requirements of such peripheral circuits as the sense amps and decoders. Large, solid arrays mean long, unbroken bit and column lines, and since metal is rarely used for both, the nonmetallic set of interconnections may exhibit long RC time delays and bog down access time. In addition, if large numbers of cells are attached to the bit lines, more sense amp sensitivity might be required or operating margins may suffer. Also, partitioned arrays may be more conducive to use as partial devices, and it is possible to shut down unused array sections to conserve active power.

No manufacturer has so far been bold enough to build a high-density dynamic RAM and not split up the array at least once. The degree to which 64-K and denser parts are divided is shown in Fig. 1. At the 64-K level, Texas Instruments, Mitsubishi Electric Corp., and Siemens AG begin with a 256-by-256-bit matrix and split it down the middle into two 32-K arrays. It is believed that Signetics Corp. is adopting the same plan for its 64-K chip.

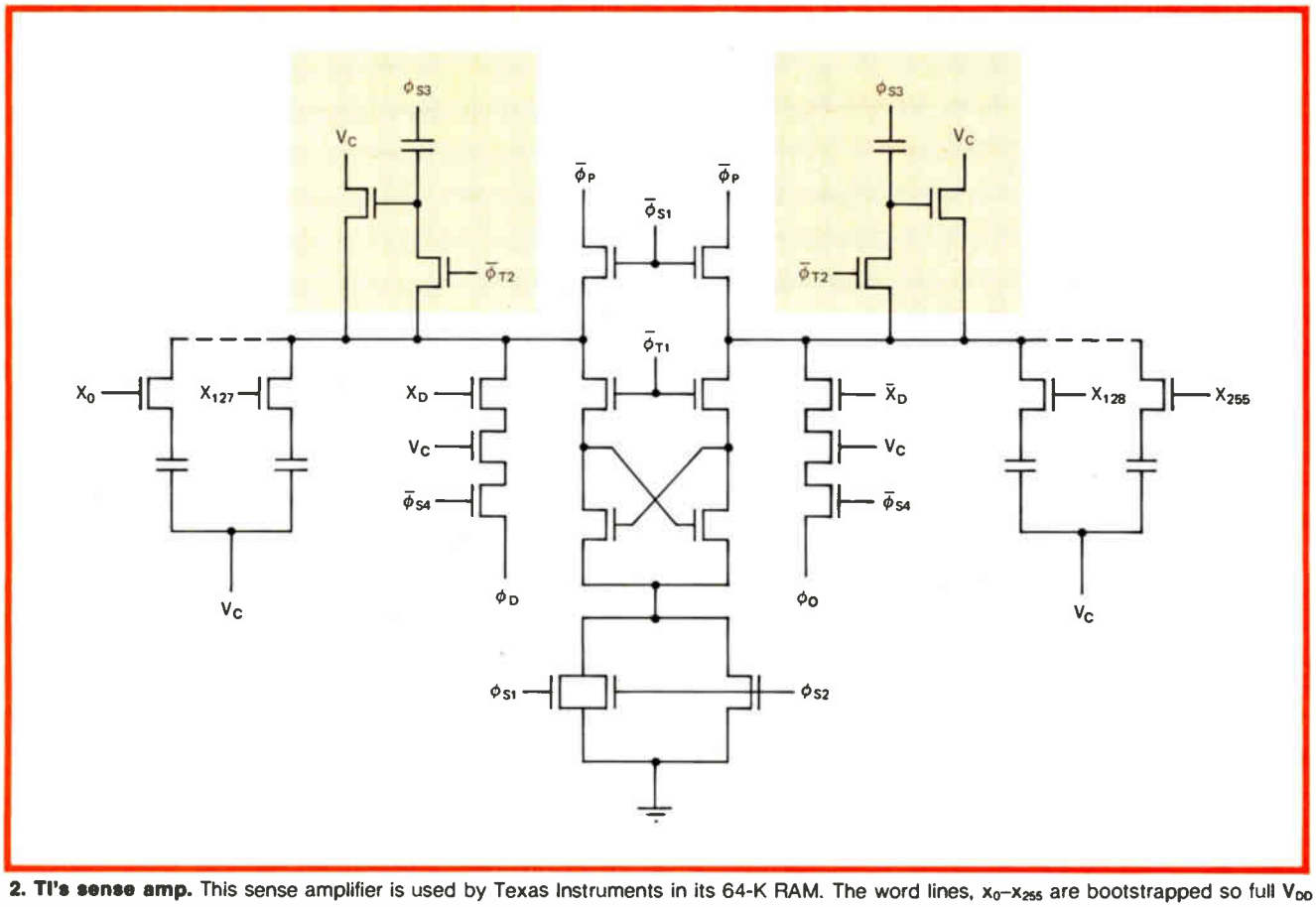
With two 128-by-256-bit arrays, there are 256 sense amps that connect to 256 cells each—128 on either of the two arms that emanate from every amplifier. Since in general the number of cycles required to refresh the array equals the number of cells serviced by each sense amp, TI, Mitsubishi, Siemens, and Signetics all specify a 256-cycle refresh.

Although every 16-K RAM is refreshed with 128 cycles, this 64-K departure from precedent has become a non-issue. As the 128 cycles must be supplied in 2 ms, 256-cycle RAM makers simply specify a 4-ms period. This means that the overhead—the percentage of time wasted on refreshing—is the same in both instances. A common method of refreshing 128-cycle devices is with 7 bits from an external binary counter. But counters have 8 bits if they have 7, so the previously unconnected line is simply brought over to the eighth address line—A_7—of a 256-cycle RAM.

However, with 256 cells attached to each sense amp and with 4 ms elapsing between refreshes, companies like Texas Instruments must take added precautions against leakage or the charge stored on the cells will fade away. Data loss is caused by a buildup of minority carriers underneath and around the storage region, degrading a stored 1 to a 0. Expressing minority carrier buildup mathematically, TI found that leakage currents



1. Array of arrays. Dynamic RAMs are partitioned into two, four, or eight subsections in accordance with sense amplifier and cell design. The sense amps (the small tinted boxes) usually have two bit-sense lines emanating from them. Folded bit-sense lines are adjacent.



2. TI's sense amp. This sense amplifier is used by Texas Instruments in its 64-K RAM. The word lines, x_0–x_{255} are bootstrapped so full V_{DD} potentials are written into the cells. The active load devices (shown tinted) restore this level after reading and refreshing.

are aggravated by increasing the negative substrate voltage, V_{BB}, so the Dallas, Texas, company straps the substrate of its 64-K RAM to the cold-water pipe—in other words, to ground, V_{SS}.

However, all other domestic 64-K RAM suppliers generate a negative substrate bias on chip—with the exception of IBM and Bell Labs, which forgo 5-V-only operation and bias the substrate externally. So TI's practice of making V_{BB} equal to 0 V certainly has given the rest of the industry something to talk about. For instance, the competition cannot fathom how TI achieves workable operating margins since the loss of V_{BB} truncates internal signal swings by at least 2 V.

Enough margin

To keep margins up in the 64-K RAM, most chip makers—TI included—bootstrap their word lines to a high voltage so that a full V_{DD} logical 1 level can be written into the cells. This bootstrapping offsets the threshold voltage of the cell's selection transistor, which must otherwise be subtracted from the potential stored on the cell. In addition, after a cell is written, state-of-the-art sense amps keep it at full V_{DD} level after read and refresh operations.

TI's sense amp is shown in Fig. 2. V_C is a regulated version of V_{DD}. The active loads (shown tinted) keep 0s equal to V_{SS} and 1s equal to V_{DD}. Until those pull-ups are clocked, however, operation is more or less as in 16-K parts. With a high-going row-address strobe, $\overline{RAS}$, indicating a precharge mode, precharge clock ϕ_P is set to V_{DD} and sense amp clock $\overline{\phi}_{S4}$ is pulsed to establish a dummy-cell reference between V_{SS} and V_{DD}.

Whether to read it or refresh it, the desired cell is selected with an appropriate word line (x_0 through x_{255}) and, simultaneously, a dummy cell is selected on the opposite side of the sense amp. At this point the cross-couple flip-flop in the sense amp goes through its decision-making process on the basis of signals presented to it by the dummy cell and the memory cell. With clock $\overline{\phi}_{T1}$ high, ϕ_{S1} and ϕ_{S2} are sequenced to amplify these voltages, now latched on opposite sides of the flip-flop.

Those active loads now swing into play. First, $\overline{\phi}_{T2}$ is raised; on the side of the sense amp that reads 0, this discharges the gate of the load transistor (the device across V_{DD} and the bit-sense line). On the high side of the sense amp, though, raising $\overline{\phi}_{T2}$ charges up the gate of that load device. Now ϕ_{S3} is brought higher than V_{DD}—this time to avoid the threshold of the load device—and a full V_{DD} level is restored to the cell. Had a cell been selected on the other side of the sense amp—the zero side—current would have been unable to flow between V_{DD} and the bit-sense line so that the cell would remain near ground.

Active loads and extra clock lines, in addition to bootstrapped lines—are they worth it? TI gives an unequivocal "yes." With the exception of National and Fairchild, for a reason that will be explained shortly, all of the designs with 128-cycle, 2-ms refreshing need

double TI's number of sense amplifiers, or 512. "About 80% of the power dissipation is in the sense amps," explains Dick Gossen, manager of MOS memory development at TI. He and A. C. D'Augustine, dynamic-RAM marketing manager, feel that the schemes using 512 sense amps "are going to have a tough time matching the TMS 4164's 200-mW specification" and parts now coming off the assembly line consume even less, they claim. The TI officials also like to observe that "every successful dynamic RAM to date—including the 1-K 1103, 4-K 4060, 4-K 4027, and 16-K 4116—has had a square organization with a single rail of sense amps running down the middle."

Double strength

In all other 64-K dynamic RAMs, the sense amps are loaded down with only 128 cells, essentially doubling the signal strength riding on the bit lines. This camp of manufacturers believes their almost doubled margins yield a more mass-producible part; after all, if the 64-K RAM cannot be manufactured, who cares about the 256-K RAM anyway? The only drawback with the 128-cycle refresh is that a slightly larger die area is required.

Mostek, Bell Labs, Toshiba, and the others listed in Fig. 1 divvy up the main array lengthwise into a pair of 128-by-256-bit subarrays, each with a row of sense amps running up the middle. They get 128-cycle refreshing, but with the extra row of sense amps. Toshiba feels that two 32-K arrays are just right in light of package restraints and 16-K compatability. It says that "further division [into more arrays] would only increase the amount of on-chip wiring." Also, while TI makes claims about low power consumption, Bell Labs interjects that with two arrays, active power and peak current are both minimized because only one of the arrays need be selected at a time—in the other block, only row decoding and refreshing occur.

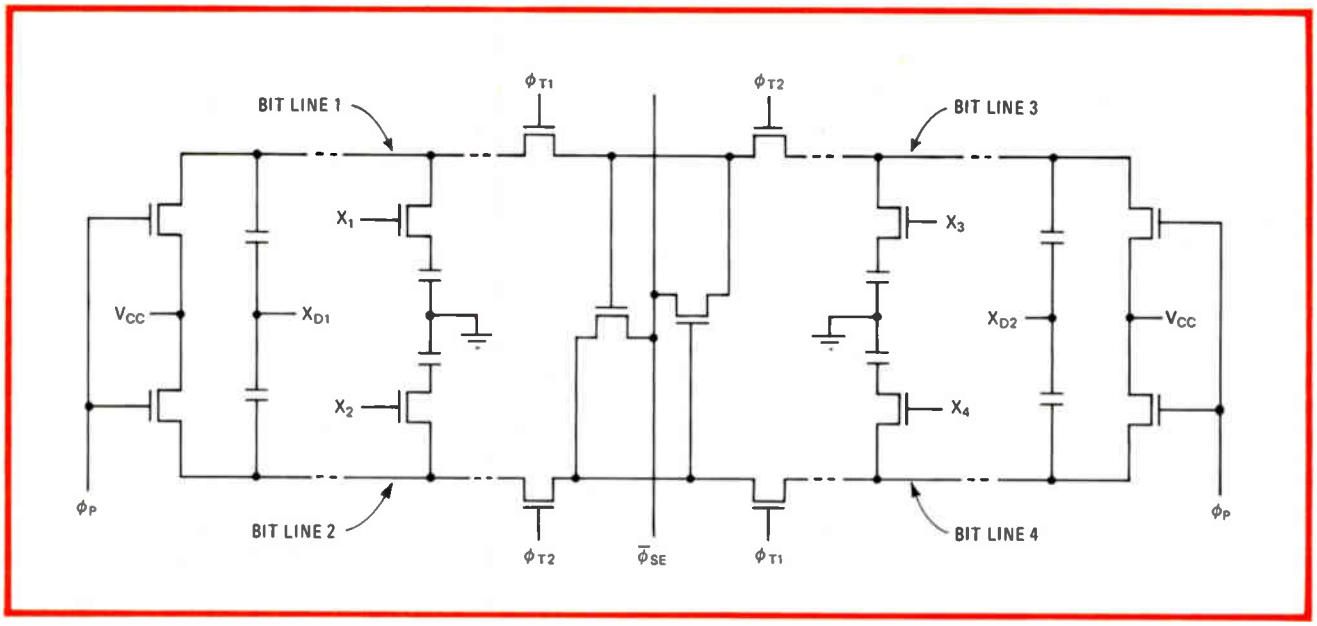
As mentioned briefly already, National and Fairchild use sense amps with double the refreshing power. In their 64-K RAMs, each sense amp is shared between two pairs of bit lines. Both chips use a 256-cycle, 4-ms refresh, need only 128 sense amps, and connect each bit line to only 64 cells.

National's sense amp is shown in Fig. 3 (Fairchild's is similar in principle). Note that it is symmetrical about the sense amp enable line, $\overline{\phi}_{SE}$. Bit lines 1 and 4 are balanced, as are bit lines 2 and 3. Clocks ϕ_{T1} and ϕ_{T2} select one of these pairs, while a memory cell is singled out with the appropriate word line, say X_1. A dummy cell is also selected, but on the same side of the sense amp as the chosen memory cell.

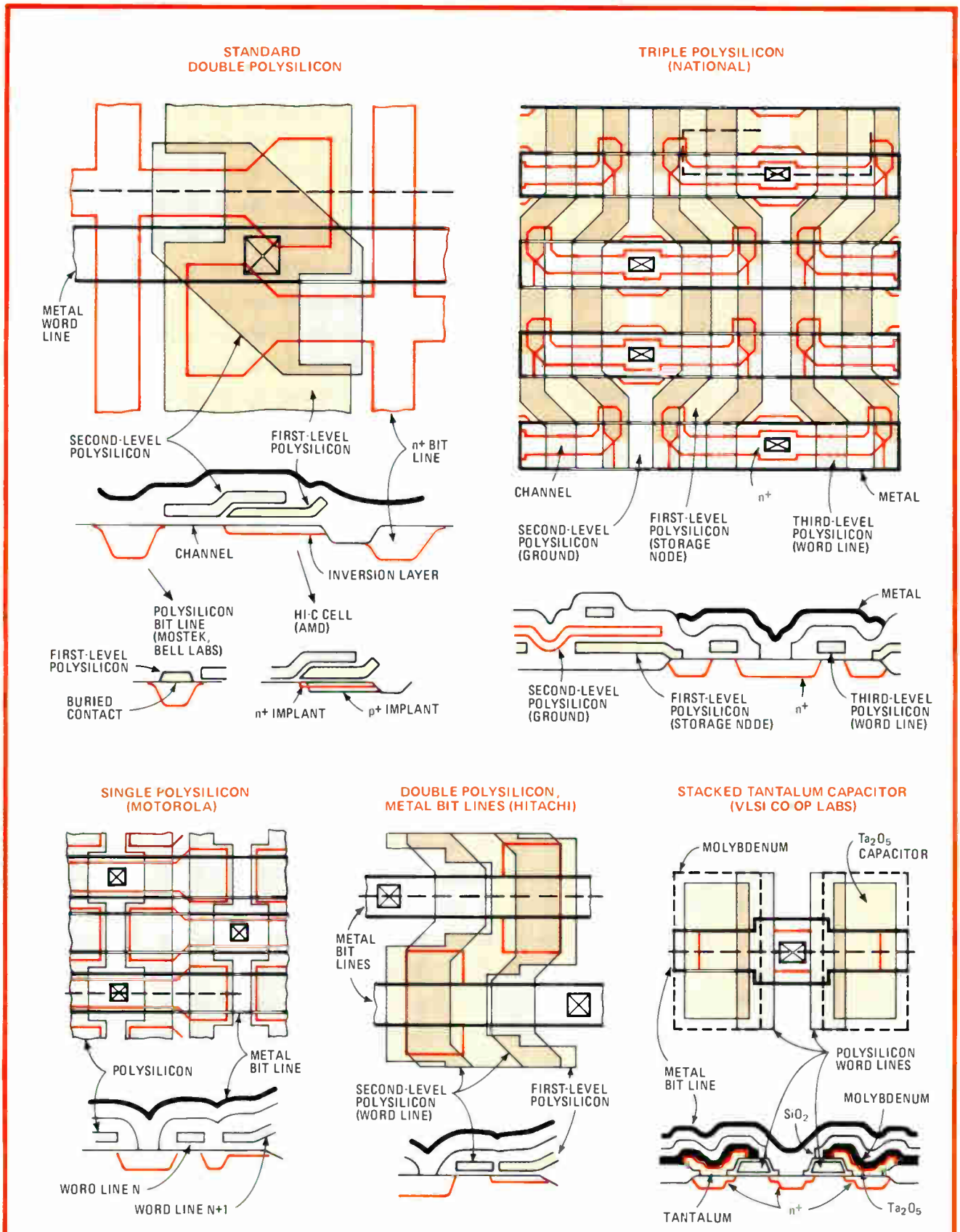
If the memory capacitor is charged to store a 1, the added charge from the dummy cell causes bit line 1 to be slightly more positive than bit line 4. If a zero is stored, the imbalance will go the other way. The difference is sensed and amplified as $\overline{\phi}_{SE}$ is lowered.

John Barnes, a senior staff member in Fairchild's dynamic-memory department, points to another distinct advantage of this scheme: "It allows a full-sized dummy-cell capacitor." The charge on such a capacitor can be divided between two bit lines, presenting each with a midpoint reference; this is exactly what a sense amp wants to see for its comparison. Older dynamic RAMs allowed half-sized dummy capacitors to be fashioned for this purpose, but new RAMs practically forbid it. "How can you make something with half the minimum feature?" asks Barnes.

The sense amps of National and Fairchild are optimally laid out with metal bit (not word) lines. This makes polysilicon the logical choice for the word lines, though now a greater distance must be traversed, forcing a further division of the array to circumvent the speed



3. Four for one. National uses this sense amp in its 64-K RAM and Fairchild will use a similar version. Each amplifier is responsible for four bit lines—twice the usual number—so these two companies are able to achieve 256-cycle refreshing with only 256 sense amps.



4. Cells for sale. Mostek and Bell Labs give polysilicon bit lines to the standard double-polysilicon cell. AMD is giving it high-capacity storage; Motorola has a single-poly process; National's cells have three; Hitachi folds its bit lines; and the VLSI Co-op Labs use tantalum.

problems inherent in polysilicon's high sheet resistance.

Metal bit lines are also helpful against alpha radiation, since diffused bit lines appear even better than the storage nodes at collecting the excess charge generated by the alpha particles. Further shielding is realized by folding the bit lines, which is what Motorola, Hitachi, and Fujitsu have done in their 64-K RAMs.

A twofold plus

Folded bit lines are nothing magical. Each sense amp is still connected to only one pair of bit lines, but instead of being aimed in opposite directions, the lines are laid out right next to each other. The rationale is that the carriers created from the alpha particle will now be coupled to both sides of the sense amp. Since the sense amp is designed to amplify a difference signal, the chance of alpha-generated soft errors will be significantly diminished.

At least one company says that folded bit lines also give layout advantages. Says Bill Martino, a Motorola circuit designer who helped on its 64-K RAM, "You can put the sense amps on one end of the pair of bit lines and you can put a decoder with an I/O section on the other. It saves running the bit lines across the decoder," which can foul up the signal. But, as with the designs of National and Fairchild, metal bit lines strongly suggest polysilicon word lines. As a result, Motorola, Hitachi, and Fujitsu were similarly forced to divide their array and place column decoders within it to decrease word-line propagation delay.

In sum, then, for the same performance that metal word lines provide, polysilicon word lines ask for a somewhat larger die. In addition, Mostek claims that folded bit lines do not permit bootstrapping of the word lines. But there is reason to believe that metal bit lines are a winning choice. Aside from some thick, organic coatings, folded metal bit lines seem to be the best protection against alpha particles. No U. S. 16-K RAMs feature folded bit lines, but Fujitsu's 16-K RAM does. "Ask any user, and he'll tell you that the most reliable 16-K RAM is Fujitsu's. Its alpha particle error rate is practically three orders of magnitude less than Mostek's device's," says a senior memory designer at Inmos. "Folded bit lines are the only way to go."

It is no secret that the smart RAM makers are investigating methods to lower polysilicon's sheet resistance. This, in the industry, is referred to as "the low sheet rho problem," the Greek letter ρ symbolizing resistivity. Whereas some IC manufacturers think that the problem can be put off until the 256-K level, Mosaid Inc., the MOS memory analysts in Ottawa, Canada, maintain that low sheet ρ will be needed for the 64-K RAM.

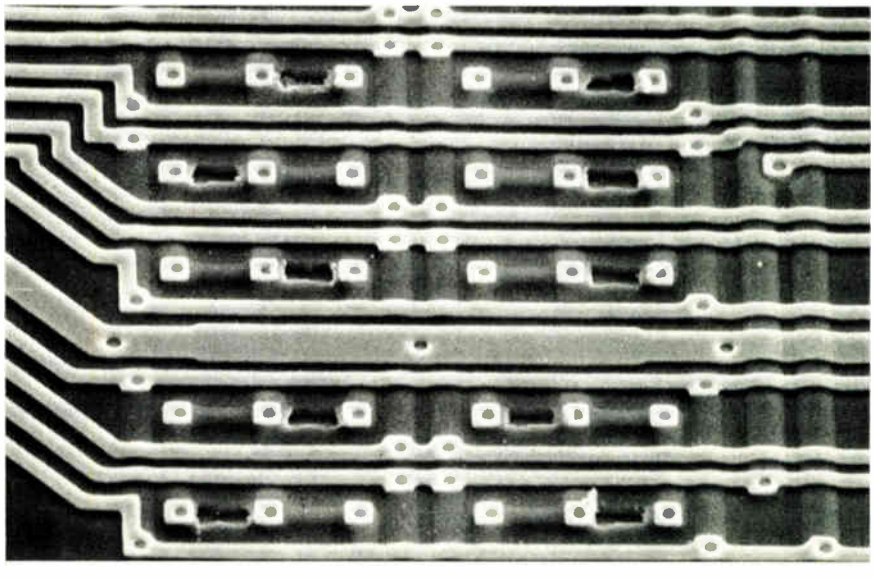
At the present time there are three techniques to heighten polysilicon's conductivity. These include the use of a second metal layer, refractory metal silicides, and laser annealing of the polysilicon itself. All three schemes are being tried. IBM uses two levels of metal in its 64-K RAM, NTT uses molybdenum disilicide word lines in its 256-K device, and memory makers are buying up laser annealing equipment at a fast pace.

As yet, no manufacturer will admit that it is using laser annealing, but there is reason to believe that at least one company—NEC—is using it in its 64-K RAM. Mosaid recently observed NEC's polysilicon interconnections and found them to exhibit large grains and a sheet resistance of about 22 ohms per square. Heavily doped polysilicon has a resistance of over double that. It has also been rumored that Intel Corp. intends to solve the low sheet ρ problem on its 64-K RAM; this decision may have contributed to the tardiness of its chip.

Cells on offer

Besides the variety of architectures and interconnection schemes in the new dynamic RAMs, there is variety in their cell designs. These are based on compact layout, to be sure, but because of the reduced stored charge resulting from scaled geometries, the primary focus is how to achieve more capacitance for the micrometer.

Commercial 16-K RAMs and some 64-K chips use the standard double-polysilicon cell (see Fig. 4). Bit lines are



5. Burned out. IBM, Bell Labs, and the Musashino Lab of NTT have designed dynamic RAMs with redundant elements to improve yield. Each concern has a unique method of swapping in the extra circuitry. In Bell Labs' 64-K RAM, spare rows and columns are inserted with a laser at the time of wafer probing.

diffused and staggered so that their hammerhead-shaped appendages, sometimes referred to as spades, interlock. Cell capacitors reside at the tips of these spades. First-level polysilicon field-plate lines meander between each bit line, forming the top capacitor plates and connecting them to V_{DD}. Upper-level polysilicon is used as gate material, controlling current between bit lines and storage capacitors. To save room, this second polysilicon layer with its single contact via is shared between two cells from adjacent bit lines. Although two layers will be most common, dynamic RAM cells have been also given one or three layers of polysilicon.

Inversion layers

Actually the bit lines of modern RAMs are ion-implanted and not diffused, but the terminology has held on from the old days. Also, the polysilicon field-plate line has another role. Besides connecting upper capacitor plates to V_{DD}, it also inverts the surface of the silicon underneath it, and the resulting collection of charge becomes the bottom plate of a capacitor.

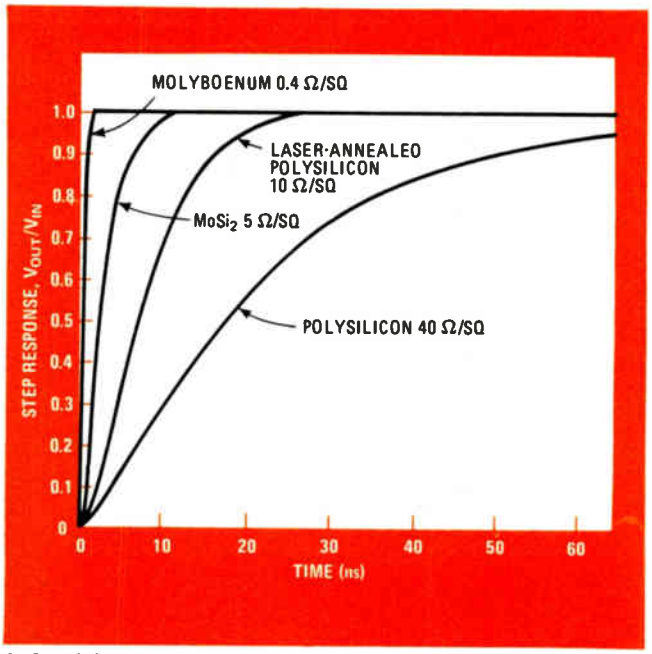
A logical 0 is represented by the electrons trapped in this inversion layer, and a 1 is established through the removal of some of these electrons via the MOS FET switch. The inversion layer can be augmented with a diffusion or implant and, if p-type, the field-plate line can be grounded yet retain electrons.

Evidently Mostek added such a p-type ion implantation (and its mask step) because the capacitors in its 64-K RAM are grounded and not attached to the supply. Sam Young, Mostek's strategic marketing manager of memory products, points out that this configuration eliminates the signal loss due to power supply excursions, commonly known as voltage bumps. Other companies, like TI, circumvent this problem by regulating V_{DD} right on the chip.

Mostek also switched from diffused to polysilicon bit lines for its 64-K RAM. This adds a mask for the buried contact between the diffused and polysilicon regions, but Young explains why the tradeoff is worthwhile: "It allows a larger cell without enlarging the die size. Diffused bit lines sit on the same physical plane as the capacitor, which means that a 4-μm-wide bit line has to be 7 μm away from the capacitor on each side.

"With the polysilicon bit line," Young continues, "the entire distance between both capacitors—with the 4-μm-wide bit line in between—can be reduced to 7 μm, thus saving 11 μm" between the two capacitors. According to Bell Labs, which also chose polysilicon bit lines, the resulting ratio of storage cell to bit-line capacitance is 0.08 compared with 0.05 for diffused bit lines and the same layout rules.

To up the capacitance in their 64-K RAMs, Advanced Micro Devices Inc. and a major Japanese chip maker are going to use the high-capacity or Hi-C RAM cell. In this cell, first described by TI in late 1977, a deep p-type implant dramatically increases the otherwise negligible depletion-region component of the storage cell capacitance. Unfortunately the implant also raises the threshold necessary to form the inversion layer, so a second, shallow n-type implant is used to counteract this unwanted side-effect. Aside from the two implants and their associated masking steps, the Hi-C cell need not be different from a standard double-polysilicon cell.



6. Good, better, best. If polysilicon is to be used for long, unbroken interconnection paths in dynamic RAMs, its resistance will have to be lowered. This graph, from TI, shows the combined effects of laser annealing, molybdenum disilicide, and pure molybdenum.

It takes guts to use the Hi-C cell, though, because alignment is of the essence. If the shallow n implant encroaches too far into the MOS FET's channel region, undesirable short-channel effects may occur. Worse still, if the p implant is allowed to completely engulf the n implant, a potential barrier might arise and prevent reading of the cell capacitor. Nonetheless, "we have taken care of that with our cell structure," boasts Jeff Schlageter, product manager of MOS dynamic RAMs at AMD. "Alignment [of the implants] is no more critical than anything else in the circuit." TI originally predicted that the storage capacity per unit area could be 50% to 100% greater with the Hi-C cell; in practice, AMD expects a 30% increase.

Motorola is the company that gets by with a single level of polysilicon in its 64-K RAM cells; the resulting six-mask process probably did not adversely affect the chip's manufacturability. Using a cell first discussed by Teletype Corp., it also makes every word line double as a field plate line for an adjacent row, as shown in the bottom-left drawing in Fig. 4. This space-saving trick has, however, been criticized from a reliability standpoint. Under certain test procedures and operating conditions such as refreshing, a capacitor's field plate line, being a word line, may be rapidly pulsed. This, say some, may induce built-in voltage-bump problems.

National's 64-K RAM cell adds a third level of polysilicon, allowing both capacitor plates to be made of polysilicon. This layering "allows us to double the amount of charge that can be stored," according to Gene Miles, director of memory components marketing for National. The capacitor is also of higher quality, with only one fifth of the storage node's total area subject to substrate

leakage. Although the third polysilicon level is said to be second in complexity only to epitaxy and the formation of buried n^+ regions, Miles contends that National's 64-K RAM will use eight or fewer mask steps.

A better dielectric

All of the increases in cell capacitance described thus far have been achieved with silicon dioxide as the dielectric material. But capacitance is directly proportional to the dielectric constant of the insulator, so a change in this material provides another degree of freedom. At last February's ISSCC, Japan's Cooperative Laboratories presented experimental 512-K and 1-megabit dynamic RAMs that exploit tantalum oxide (Ta_2O_5).

Combining the stacked-capacitor RAM cells first described by Hitachi in 1978 with their own quadruply self-aligned MOS process, the lab members refer to their creation as the stacked-high capacitor RAM. With a basic design rule of 2 μm, the team's 512-K RAM—at about 71,000 square mils—is roughly twice the size of an ordinary 64-K RAM. To build a megabit RAM, it essentially puts two 512-K RAMs onto a single 140,000-mil^2 die. The designers also state that with a 1-μm process, chips of "several megabits" are possible.

If the area of the storage capacitor in a standard double-polysilicon cell were to be reduced to the dimensions of the ones in the Co-op Labs' megabit RAM, stored charge would drop from about 250 femtocoulombs to below 30 fC, assuming that cell voltages are restored to full V_{DD} levels. This works out to fewer than 200,000 electrons. Such a minute charge packet would demand almost constant replenishing, and an alpha particle would wreak havoc.

So the researchers opted for tantalum oxide, which has a dielectric constant of 22; SiO_2's value, at 3.9, is less than a fifth of that. As shown in the cross section in Fig. 4, the tantalum makes direct contact to diffused regions. Next, to form Ta_2O_5, the tantalum is anodically oxidized, then covered with molybdenum.

The process requires 10 masks, but the reward is twofold. One benefit is more stored charge than in conventional double-polysilicon 64-K RAM cells. The second boon is low leakage through the Ta_2O_5: it takes 3.7×10^4 seconds for a 5-V stored level to decay to 4 V—if the Ta_2O_5 plate is the only escape path, that is.

Adding extras

Tough as it is to squeeze thousands of cells and hundreds of sense amps and decoders onto one substrate, some companies are adding extra circuitry. Bell Labs, IBM, and the Musashino Lab of NTT add redundant cells to improve yield. Motorola and Mostek add to their 64-K RAMs self-refreshing logic, activated with a low signal applied to pin 1. AMD is studying the approaches taken by these two companies as it prepares to pick one of the techniques for a version of its upcoming 64-K RAM. And up Inmos' sleeve is a way to get refreshing without dedicating a pin to the function.

As the logistics of on-chip refreshing are ironed out, there will be a fusion of static and dynamic RAM technology. This will not really affect by-1-bit memory organizations, but it will have a profound impact on byte-organized pseudostatic RAMs, as they are often called. A majority of the 64-K RAM makers also have a self-refreshing 8-K by 8 bit version in the works. If on-chip refreshing can be perfected to the point where dynamic RAMs appear to be truly static—and many feel this probable—it may signal the demise of fully static RAMs beyond the 16-K level, says one TI memory designer.

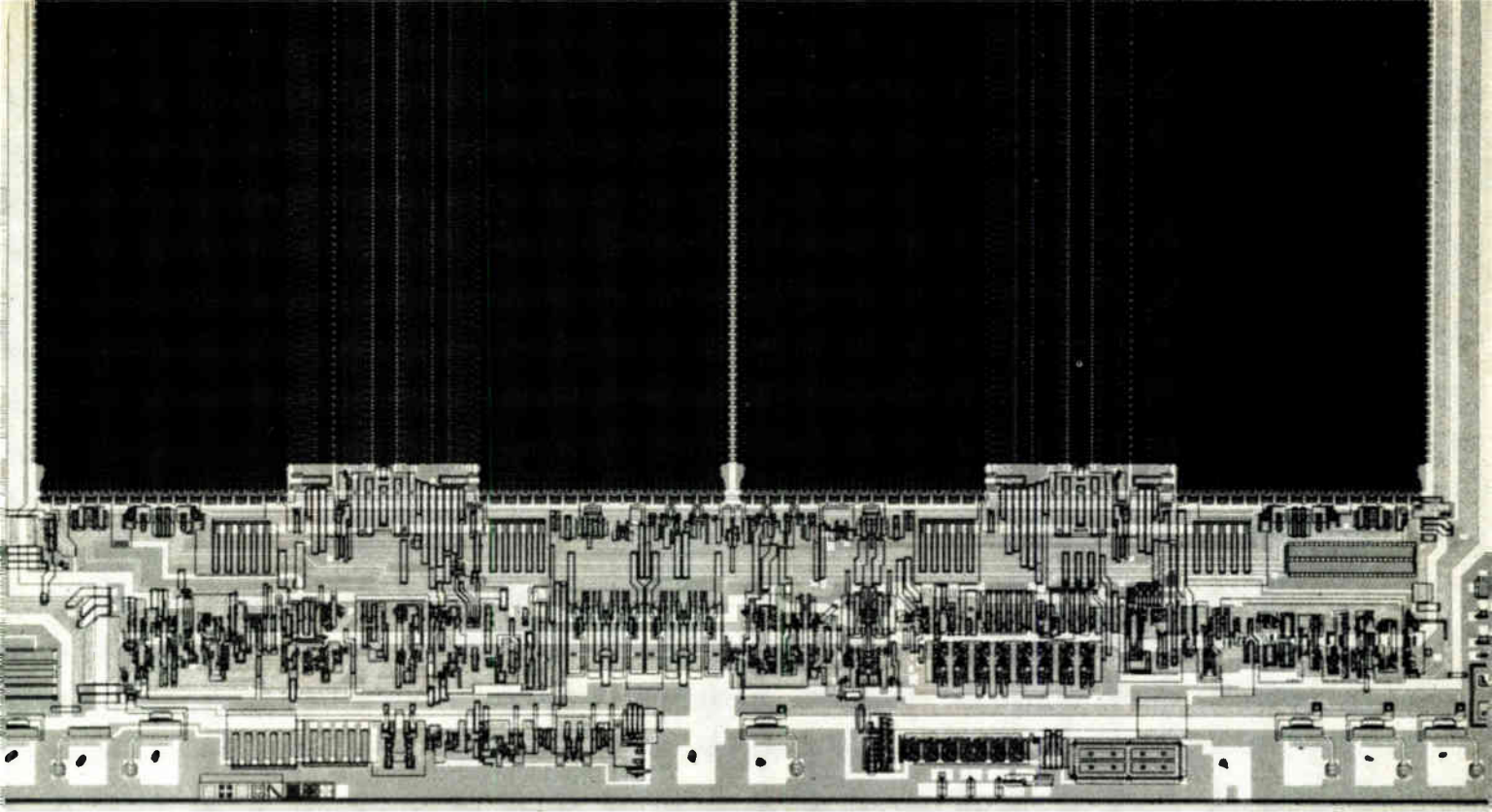
Interestingly, the three approaches to fault-tolerant yield are unique. NTT's 256-K RAM (probably another research vehicle) has four 128-by-512-bit sections, each with one spare word line and four spare bit lines, for a total of 4,096 spare bits; the superfluous cells are substituted with 15-V programming pulses applied at wafer probing. Bell Labs provides two spare rows and two spare columns for each of the four 64-by-256-bit arrays in its 64-K RAM, for a total of over 2,560 bits. Programming here, however, is done by opening 3-μm-wide polysilicon links with a laser (see Fig. 5).

On IBM's 64-K chip, another device intended just for in-house use, redundant lines pinch-hit for cells, rows or columns that fail functional testing. Bad addresses are stored in an on-chip ROM programmed with the second metalization level; incoming addresses are compared and routed accordingly. IBM's chip contains over 2,000 bits of built-in redundancy, says Nicholas M. Donofrio, manager of systems and test at IBM's General Technology division's development laboratory in Essex Junction, Vt.

In these three examples, neither the percentage of redundant storage nor the method of swapping the extra circuitry is the same. Obviously, a standard form for dynamic RAM redundancy does not exist. Although opinions vary, the consensus is that spare circuitry will not be put into commercially available RAMs, even at the 256-K level. Even though Bell claims that a fault-tolerant memory occupying 62,000 mil^2 (the size of its chip) will yield better than a memory half that size (slightly smaller than all the others), semiconductor manufacturers are still too proud to anticipate imperfection. And besides, the sale of partially good devices is going well.

Even though on-chip refreshing techniques have been endorsed by some major chip manufacturers, it is the important users that have given the concept a lukewarm welcome. David Ford, Motorola's strategic marketing manager of MOS memories, estimates that "about 50% of our customers want it," but concedes that those customers are in the minority when it comes to sales. "The mainframe guys don't want to refresh," he admits. "That's why we're offering a part [the 6665] that doesn't have it."

Motorola's 6664, the version with refresh, features two internal modes initiated with a low-going signal applied to pin 1. These are self-refresh and automatic refresh. Mostek's pin-1 refresh cycle is a perfect subset of the latter, though there are two minor differences. One is that Mostek specifies that the refresh line be inactive (brought high) for a minimum of 125 nanoseconds within the refreshing cycle. And Motorola puts an upper bound of 2 microseconds on pin 1's low state.



7. New kid in town. It is nowhere near volume production, but the Nippon Electric Co. is actually fabricating this 256-K RAM with wafer steppers from GCA Corp. The chip is only about twice the size of 64-K devices; NEC fit it into a standard 16-pin DIP.

Motorola limits how long pin 1 can be low because after about 13 μs the chip enters the self-refresh mode, a condition unique to Motorola's 64-K RAM. In this state, a new row is refreshed every 12 to 14 μs; thus, even in the worst case, the entire memory will be refreshed in less than the 2 ms specified. Motorola says this mode is mainly intended for battery-backup applications.

Packaging problems

There is reason to believe that pin 1 will be used for the ninth address line, A_8, for the 256-K RAM. Such a decision would forgo pin-1 refreshing. This has not yet been standardized by the Joint Electron Device Engineering Council's JC-42 committee, but Intel for one has already announced that it will use this pin for that purpose.

One solution to this dilemma is being proposed by Inmos. When the column address strobe, $\overline{CAS}$, is pulled low before $\overline{RAS}$, the row address strobe, an internal refreshing sequence will be activated in its 64-K design. This should not conflict with normal read and write operations since all manufacturers specify that the row address be latched before the column address.

Another solution, being looked at by both Motorola and Mostek, is a package with more pins. Mostek, for example, through a so-called bit-wide concept, will use the same 18-pin package for its 32- and 128-K products. The pin designations have actually been established already with the MK4332, a 32-K RAM built with two 16-K chips. Next, when the 32-K partial of the 64-K RAM becomes available, it too will be put in this package, as will two fully functional 64-K chips for a 128-K device. One reason why Motorola and Mostek want to salvage dedicated-pin refreshing is that the newer microprocessors have refresh pins that, in cases, can be directly interfaced to pin 1 on their parts.

More pins are only one of the bitter pills that will be swallowed as higher-density random-access memories draw near; the medicine is being tasted already at the 64-K level. To make the 256-K RAM, IC manufacturers will want to increase sense amplifier sensitivity. For optimum performance and alpha particle hardening, respectively, capacitance will have to be stolen from on-chip wiring and given to the storage nodes while decreasing cell size. A routine method of lowering polysilicon's resistance is anxiously awaited—perhaps only perfection (see Fig. 6). Cells exploiting Hi-C-like concepts will tend to prevail; maybe the use of a higher-dielectric material such as tantalum oxide is the answer.

Alphas revisited

Many of these problems will have to be solved to confound alpha particles. Hitachi has been coating its chips with a proprietary version of the organic material polymide it calls PIQ. A thickness of 40 to 55 μm diminishes soft errors by a factor of 1,000. Although invisible, alpha particles will still be heard from. But chip coatings, cells with high capacitance, and folded metal bit lines will sufficiently frustrate them.

There exists an entire other class of dynamic RAM cells that combine transfer and storage functions into a single unit. The taper-isolated cell and the stratified-charge memory are 2 of the 10 or so approaches that come to mind. Maybe the next generation of dynamic RAMs will be graced with the enormous density advantages that such concepts have the potential of offering. □

Minicomputer fills mainframe's shoes

Fully compatible with its 16-bit family, this 32-bit minicomputer has mainframe features: multiple-bus hardware with separate instruction and data caches, and a 4.3-gigabyte virtual memory

by Carl J. Alsing, Kenneth D. Holberger, Charles J. Holland, Edward J. Rasala, and Steven J. Wallach, *Data General Corp., Westboro, Mass.*

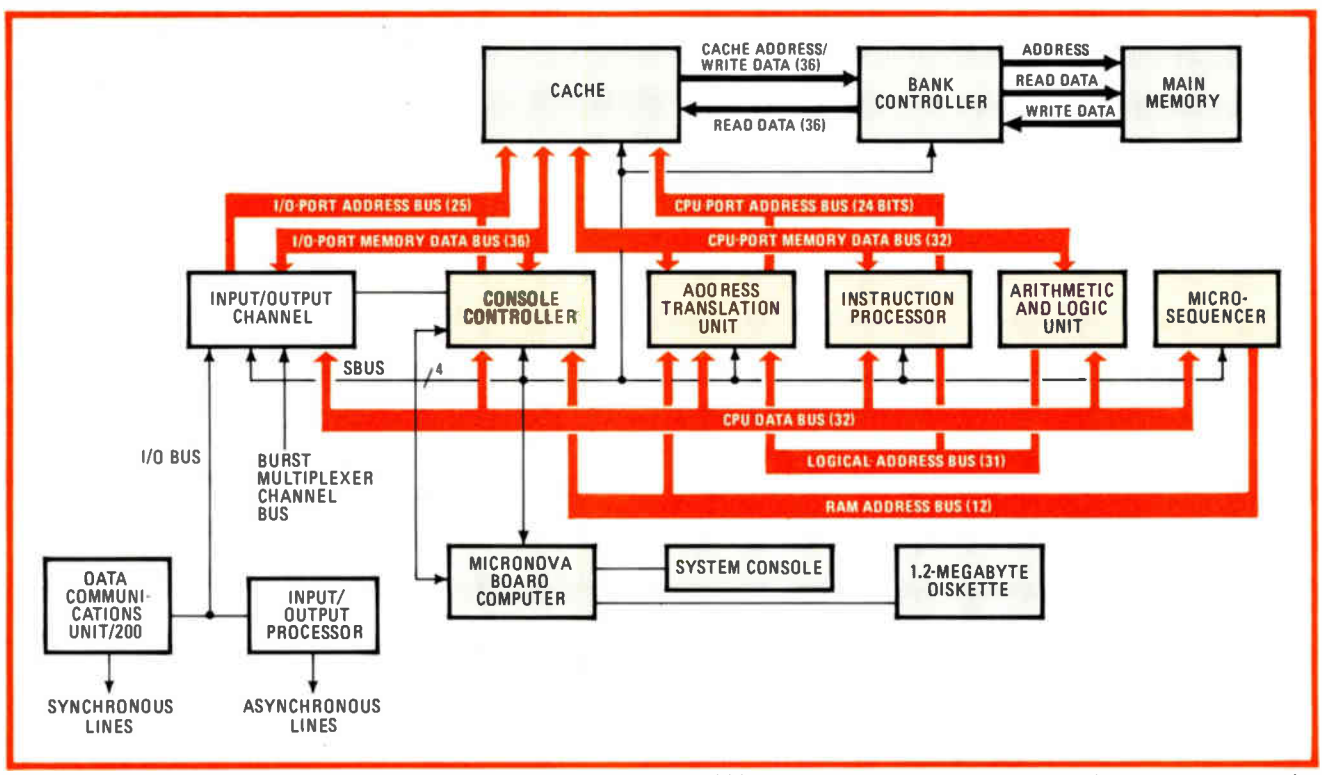
☐ The new head of the Eclipse minicomputer family, the fully compatible 32-bit MV/8000, has a hardware organization that is hard to distinguish from those used in mainframes. It also supports a mainframe-size virtual memory.

The MV/8000 can address a main store of 2 megabytes—as much as IBM's medium-scale 4341 mainframe—and a virtual memory space of 4.3 gigabytes—250 times that of the IBM machine. The new Advanced Operating System/Virtual Storage (AOS/VS) written for the MV/8000 lets users write programs up to 512 megabytes long—32 times the maximum program length for Digital Equipment Corp.'s 32-bit VAX-11/780.

The new Eclipse hardware features a novel cache memory arrangement that uses separate buffers for data and instructions; a pipelined, microprogrammed central processing unit; a separate system-control processor; a high-speed input/output subsystem that can transfer data at rates as high as 16 megabytes/second; and an independent I/O processor that can support up to 128 terminals. An eight-level hierarchical-ring protection scheme is also provided by the hardware.

The MV/8000 is unique in its complete compatibility with the existing 16-bit members of the Eclipse family. Whereas most other machines to date have accomplished this with dual operating modes—a native mode and one compatible with the existing machines—the MV/8000 has only one manner of operation.

To achieve compatibility without adding an operating mode, the MV/8000's instruction set was designed as a superset of the Eclipse instruction set—it includes all the 16-bit instructions as well as 250 new 32-bit instructions. There is no mode bit to distinguish them. This provides total binary compatibility with existing 16-bit Eclipse



1. Subdivisions. Multiple high-speed buses interconnect the Eclipse MV/8000 central processing unit (color tint), the memory system, the system-control processor, and the input/output system. The S bus has only four lines and handles diagnostic functions exclusively.

programs written under the current Advanced Operating System (AOS). They will not have to be recompiled or reassembled to run on the new machine.

In addition, the MV/8000 can concurrently execute existing 16-bit programs with new 32-bit programs and handle an intermingling of both 16- and 32-bit instructions in the same program with no loss in performance. The input/output system is both hardware- and software-compatible with that of the 16-bit Eclipse, as well.

State-of-the-art design concepts implemented in the MV/8000's hardware organization support these architectural features. The computer is divided into four functional portions: the memory system, the central processing unit, an input/output system, and the system-control processor (Fig. 1). Unlike traditional single-bus minicomputer designs, these subsystems are interconnected by several high-speed buses.

Loads of buses

The 36-line I/O-port memory data bus (IPM) carries 4 bytes with 1 bit each for parity checking between memory and the I/O system and the system-control processor. The 32-line CPU-port memory data bus (CPM) connects the CPU and the memory system; due to their physical proximity and the bus protocol, no error checking is used. Two buses for physical addresses, called the I/O-port address bus (IPA) and CPU-port address bus (CPA), connect the I/O system and system console to the memory and the CPU to the memory, respectively. A third data bus, the CPU data bus (CPD), connects the CPU, the system console, and the I/O system. These buses operate at a data-transfer rate of 18.2 megabytes per second.

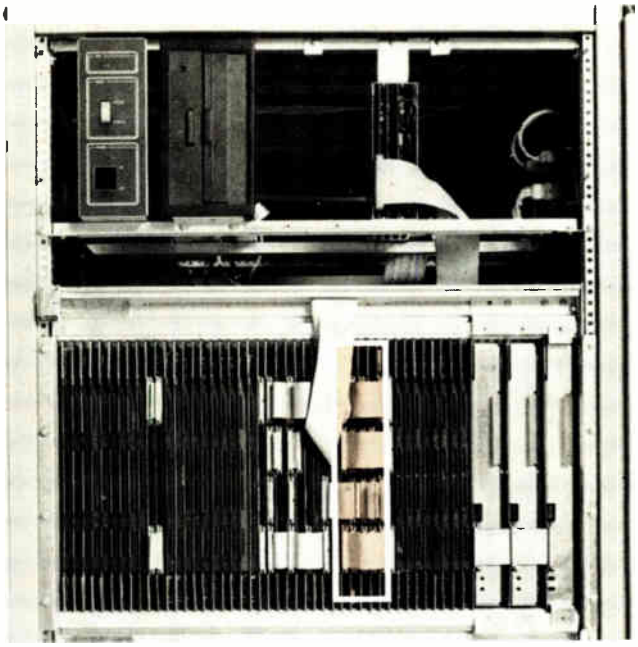
The four-line diagnostic-scan bus (S bus) is connected to all major elements of the computer to allow the system-control processor to perform its diagnostic functions.

The highly pipelined 32-bit central processing unit is built on five standard Data General 15-by-15-inch printed-circuit boards. Because of its compact size, this CPU and up to 2 megabytes of main memory, the I/O system and the system-control processor (SCP) can fit into a single cabinet that measures 34.5 inches wide, 30.75 inches deep, and 60 inches high and includes the necessary front panel and power supplies (Fig. 2). Each board performs one major function. These boards are the arithmetic and logic unit, microsequencer, address translation unit, instruction processor, and console controller. The CPU has a minor cycle time of 110 nanoseconds and a major cycle time of 220 ns. Instructions typically execute in one or two 220-ns cycles.

The National Semiconductor 2901A-1 4-bit-slice processor is the basic building block for the ALU. This particular version of the 2901 was chosen primarily for its fast arithmetic times.

The ALU is divided into two separate sections, an 8-bit section that performs operations on floating-point exponents, and the 32-bit section that manipulates floating-point mantissas, fixed-point quantities, and 32-bit logical addresses (Fig. 3).

Like the previous top-of-the-line 16-bit Eclipse M/600, the MV/8000 contains four fixed-point accumulators, but in the MV/8000 these accumulators are 32 bits wide. Four 32-bit stack registers aid in the management of stacks in main memory and four floating-point accumulators, each 64 bits wide, contain single- or double-precision floating-point operands.



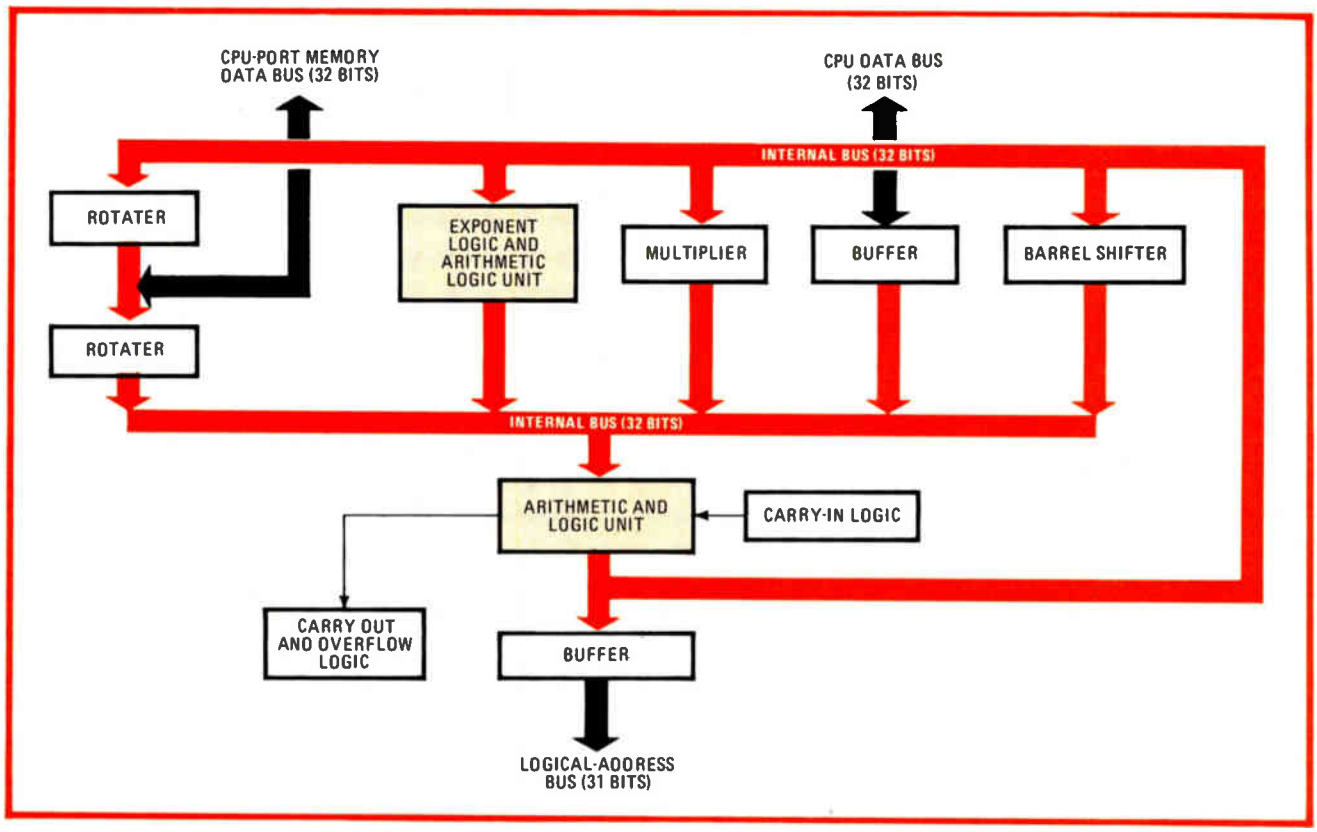
2. Squeeze play. The 34-inch-wide, 56-slot card cage holds the five 15-by-15-inch CPU boards (tint), along with eight memory boards holding 2 megabytes of memory, the I/O system, the system-control processor, and power supplies. The front panel is at upper left.

To direct this ALU, the microsequencer chips available in the 2900 family were considered too slow and lacking in flexibility in the generation of the next microinstruction address. But more importantly, the inability to easily dump the contents of the microsubroutine stack maintained within the chip encouraged a custom microsequencer design.

Using programmable-array logic (see "Logic arrays dominate design," p. 133) and a static-RAM control store with a fast (55-ns) access time, the microsequencer contains 4 kilowords of microcode that interpret the MV/8000's instruction set. Each microcode word is 74 bits long plus 1 bit for parity and generates the control signals required by the other processor elements. Because the control store is constructed from random-access memories, unlike previous Eclipse machines, the microcode is loaded from the SCP's diskette.

Feeding the microsequencer

Providing the input to the microsequencer is the instruction processor, which decodes instructions for subsequent execution. Unique among 32-bit minicomputers is the instruction processor's 1-kilobyte direct-mapped instruction cache. It is organized as a 64-block memory with 16 bytes per block and operates on a 110-ns cycle time. During program execution, the instruction cache provides a speed increase because of its look-ahead and look-behind potential. Program loops or backward jumps, in particular, can be executed faster because of this feature. Totally separate from the system cache, the instruction cache allows instructions to be fetched con-



3. Team effort. In addition to the 32-bit arithmetic and logic unit that performs the bulk of the data and address calculations, a second 8-bit ALU is included to handle the exponents of floating-point operands. These ALUs are built with 2901 4-bit-slice processors.

currently with data without interference.

The instruction cache provides the input for the pipelined instruction decoder (Fig. 4). The first stage of this process fetches an instruction from the cache. Then the op code of the instruction is decoded to obtain the starting microcode address (stage 2). In stage 3 the first microinstruction of the microcode program that interprets the instruction is read. In stage 4 the first microinstruction is executed. This four-stage pipeline makes it possible to fetch and decode the next instruction (stages 1 and 2) while the present instruction is executed (stages 3 and 4), increasing performance significantly.

Key to the MV/8000's virtual memory capabilities is the address translation unit (ATU) that converts the logical addresses used in the programs and by the ALU into the physical addresses needed by the main memory system. The ATU performs all the hardware checking required by the protection scheme described later.

To support compatibility with the 16-bit Eclipse, the ATU can also emulate the Eclipse memory management and protection unit, to handle the memory-mapping techniques used in the current systems.

Memory blocks

One of the keys to the high performance of the MV/8000 is its block-oriented memory system. Designed to provide optimum throughput with minimum cost, this block orientation extends throughout the entire MV/8000 and minimizes bus demand and cache fault resolution time. All processor and I/O transfers to main memory go through the cache in 16-byte blocks.

The block-oriented memory system is made up of three major elements. The system cache acts as a high-speed buffer between main memory and the rest of the system to significantly reduce effective memory-access time. The bank controller is the interface between the system cache and third system component, the memory modules themselves.

Between four and eight memory modules are supported by the MV/8000. Because each module stores 256 kilobytes of data, the maximum physical memory is 2 megabytes. A module is organized as 64-K double words of 4 bytes each (a single word being 2 bytes); a 7-bit modified Hamming code is appended to each double word. Each memory module is interleaved four ways, resulting in an extremely high data-transfer rate of 36.4 megabytes per second.

Selecting these memory modules is done by the bank controller when it receives a physical address from the system cache. This controller also performs complete error checking and single-bit error correction on transfers between itself and the memory modules. Byte parity checking is done between the system cache and controller. To further increase reliability the bank controller performs a novel "sniffing" operation. Each time a refresh operation begins, the bank controller reads one block from the memory row being refreshed. This block goes through a complete error check and correction and is written back to the memory module.

Because this operation occurs on a different block during each refresh operation, the entire contents of main memory are checked and, if need be, corrected

Logic arrays dominate design

The hardware design of the new Eclipse MV/8000 is as much a departure from previous designs as the 32-bit architecture is from the existing 16-bit processors.

Most obvious is the widespread use of fast static random-access memories in the various caches and the system's control store. But programmable-array logic chips (PALs), more than any other component, affected the design, performance, and personality of the MV/8000.

A PAL (manufactured by Monolithic Memories Inc. and National Semiconductor) is a programmable AND array providing inputs to a fixed NOR array. Three versions of the PAL family of devices (16R8, 16R4, and 16L8) were used, all of which were packaged in 20-pin, 0.3-inch dual in-line packages.

The use of PALs in the design began slowly, but when it started reducing parts count by a factor of 3 to 5 compared with off-the-shelf medium-scale integration, their use accelerated. Ultimately over 10% of all components used in the central processor were PALs.

Why use so many PALs? They are packaged in 20-pin DIPs, providing good board density; they offer the right functionality while reducing parts count; they permit design changes to be limited to fuse changes in PALs, avoiding board changes; and they are easy to use.

Software design tools developed under Data General's AOS operating system on an internal engineering time-sharing system permitted each logic designer to enter the PAL equations interactively. Then this system is used to create a file containing the fuse characteristics of the desired PAL. The logic designer then inserts a PAL into a Prolog M900 programmable read-only memory programmer connected to the engineering time-sharing system via a RS-232 adapter and personalizes the part. All these actions are done on line.

PALs were not used when an off-the-shelf MSI chip could do the job at a lower price or when a PAL was too slow. About 30% of the PALs used were 16L8s, which have a propagation delay of 40 nanoseconds. In many cases this was not sufficient to handle the worst-case circuit delay. If a PAL with a propagation delay of 20 ns had been available it would have been used.

Of course the decision to use PALs is not easy to make. In all cases, prudent use of PALs and its reduction in parts count must be balanced against their availability in volume and the cost of an equivalent MSI implementation. In some cases the tradeoffs are straightforward. In other cases, where board count, connectors, and system reliability are considered, the tradeoffs become more complicated.

every 4 seconds. Thus, single-bit memory errors do not accumulate undetected over time, which can result in their becoming uncorrectable double-bit errors.

A 16-kilobyte system-wide cache operates with a 110-ns cycle time and is dual-ported so that the CPU and I/O system each have their own access path. The cache devotes alternate cycles to memory requests from the CPU and the I/O system, thus reducing the time needed by each to access main memory and minimizing contention between the two ports. The system cache functions as both a look-ahead and look-behind buffer for the system. It contains 1,024 16-byte blocks, which are directly mapped to main memory locations. Simply, every block of main memory always maps into the same cache block. This saves retrieval time to the cache. Stores into the cache utilize the write-back instead of the less efficient write-through technique.

Moving data into and out of the CPU and memory system is the I/O system. It comprises three levels: a high-speed burst multiplexer channel (BMC), a data channel, and programmed I/O. All three are under control of the I/O channel board.

Access to cache

Both the BMC and the data channel transfer data to and from the system cache directly; data need not pass through the CPU. The BMC transfers a 16-byte block at a rate up to 16.16 megabytes per second. Even at this rate, the 32-bit central processing unit can continue unabated. Only when there is conflict over the system cache/bank controller bus does the processor pause.

As previously mentioned, a 16-bit Eclipse minicomputer functions as the I/O processor (IOP) that, connected to the data-channel bus, controls all asynchronous communications for up to 128 user terminals.

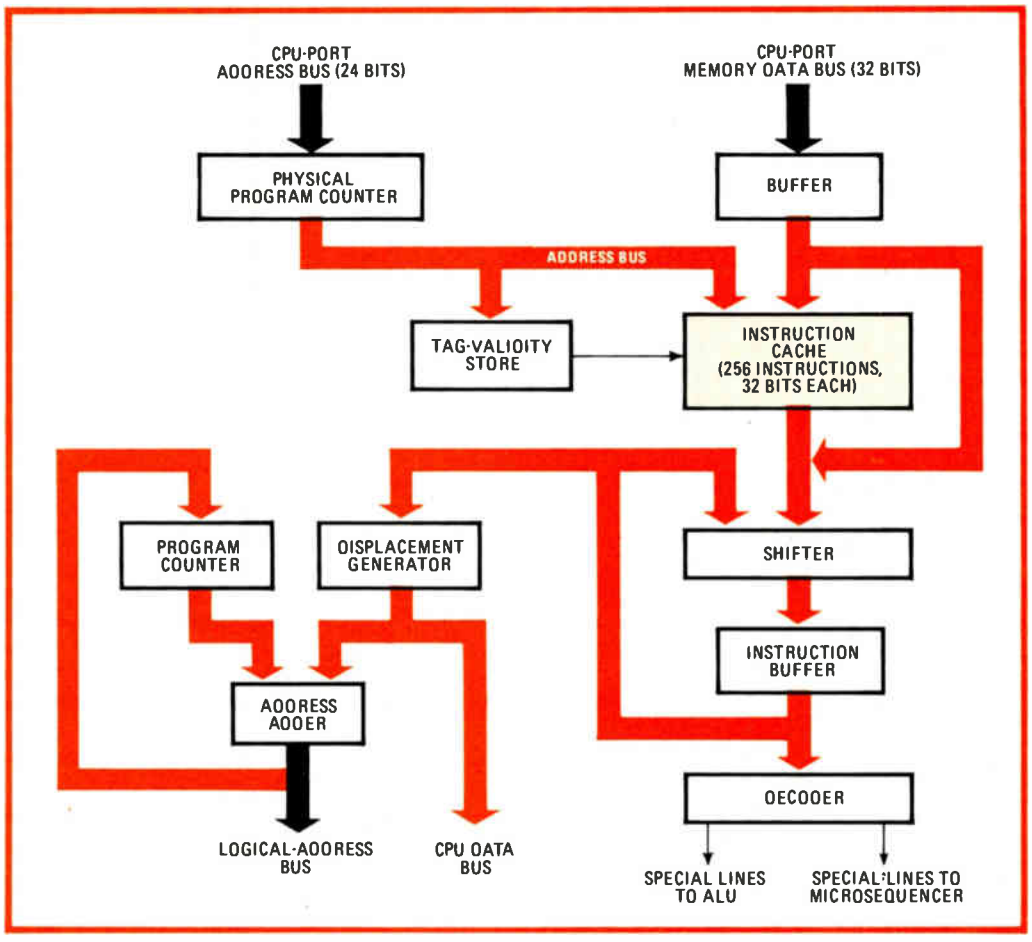
A second front-end communications processor, the Nova-based Data Communications Unit/200, is available for handling synchronous line protocols such as IBM's binary synchronous protocol. Using its 8 kilobytes of local memory, it provides extensive communications handling capability in distributed processing environments. Each DCU/200 can support up to 8 synchronous lines with an aggregate data rate up to 38,400 bits per second or a single 56,000-b/s line. Up to four DCU/200s can be attached to an MV/8000, but the number of synchronous lines on a system is limited to 16.

Managerial processor

Overseeing the operation of the other three elements is the system-control processor (SCP), a diagnostic and console-control monitor. Included in the SCP is the console controller board that provides all the system timing for the MV/8000 including the real-time clock and programmable interval timer. Based on a microNova with 32 kilobytes of RAM, 4 kilobytes of programmable read-only memory, and a 1.2-megabye diskette, the SCP connects to all the other elements of the computer through a diagnostic bus (S bus) driven by a universal asynchronous receiver/transmitter.

Besides providing the operator's console interface into the system, the SCP runs microdiagnostics that isolates faults to a logic board in minutes. Also under control of the SCP is the ability to logically disconnect the instruction cache, system cache, and the ATU address cache. Thus, processing can continue in a degraded mode of operation should one of these units fail.

A significant architectural feature supported by the MV/8000 hardware is its 4.3-gigabyte virtual memory. The MV/8000 operating system, called AOS/VS, provides the mechanisms that allow the virtual-memory



4. Unique cache. The instruction processor contains a 256-instruction cache—a unique feature among 32-bit minicomputers—that speeds instruction fetching. In addition, the decoding of the instruction is pipelined with the execution of the previous instructions.

hierarchy to be totally transparent to the computer's user.

The benefits of virtual memory in general are well established. To these the MV/8000's virtual memory system adds several architectural advantages including a large user-program size of 512 megabytes. Both one- and two-level page-table structures are available to optimize the logical-to-physical address translation for the size of the program being run.

In addition, it lets the operating system be imbedded in the user-addressable space. This significantly decreases processor and software overhead for operating-system call processing. These features make MV/8000's virtual memory system the most advanced virtual memory structure available on 32-bit minicomputers.

Efficient virtual addressing

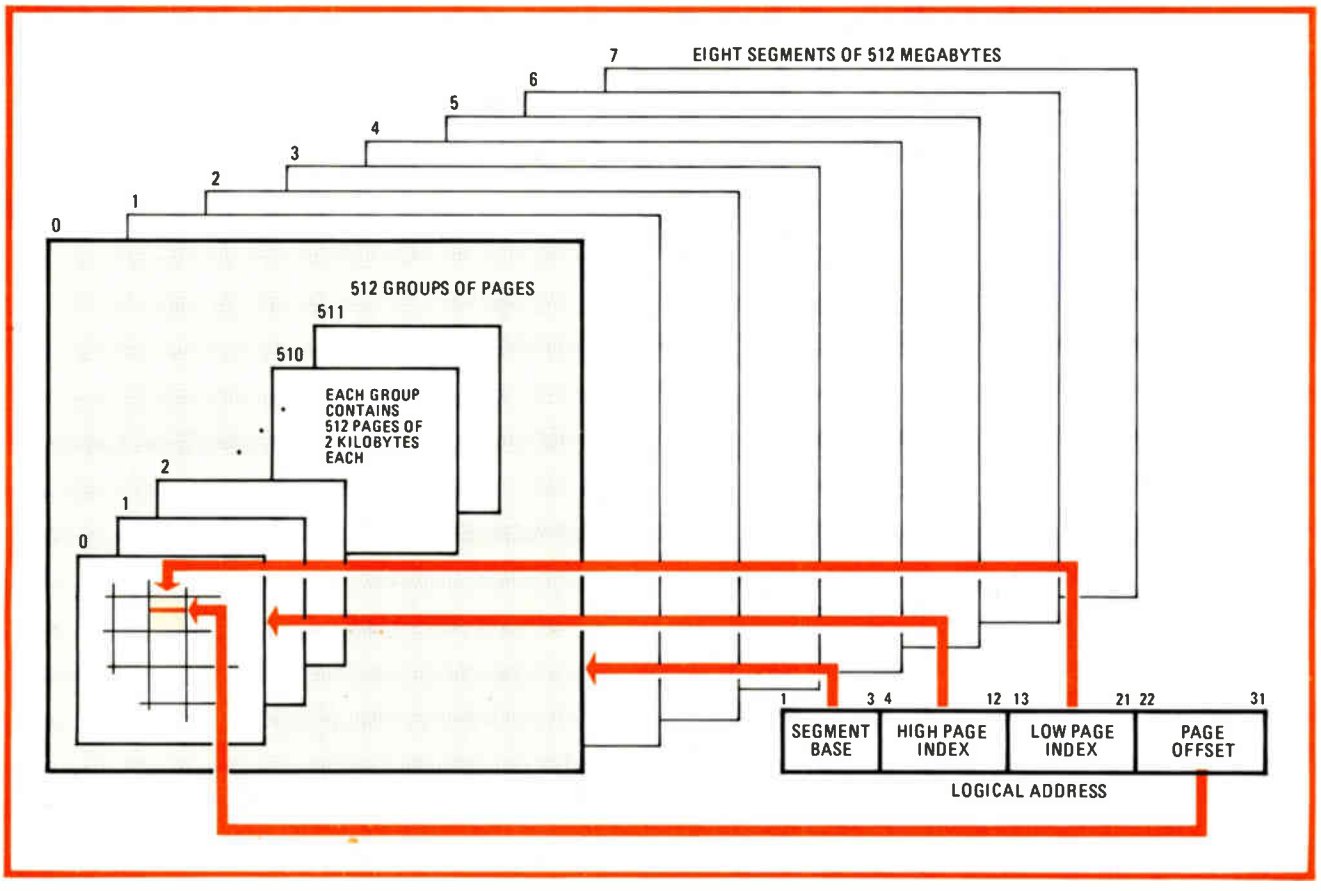
As in any virtual memory system, data and instructions are moved between main memory and disk in pages. The size of MV/8000 page is 2 kilobytes. The area in main memory that a page occupies is called a page frame. An important characteristic of this memory management scheme is that the largest unit of continuous physical memory is the 2-kilobyte page frame. This makes the AOS/VS memory-management algorithms perform more efficiently.

Managing the 4.3 gigabytes of virtual memory simply as 2-kilobyte pages would be a bit unwieldy, however, so the MV/8000 virtual address space is further partitioned into eight segments. Each segment contains 512 megabytes of memory, or 256,000 pages. The pages within a segment are then divided into 512 groups, each of which contains 512 pages.

This division of the logical address space also reduces the amount of main memory needed to hold shared programs. The shared program is bound into one segment. This segment is used only for these features and the user programs occupy different segments. Then, all users have different user segments but the same run-time segment, only one copy of which need be kept in main memory. This decreases main memory requirements and, more importantly, virtual memory management. That is, only one copy of the shared program per system is managed, rather than one per user.

As shown in Fig. 5, the 31-bit virtual address is subdivided in a similar manner. The first 3 bits denote which of the eight segments are in use. The next 9 bits, called the high page index, indicate which group of pages is being referenced, and the next 9 bits, called the low page index, choose one of the 512 pages in the group. The final 10 bits, called the page offset, locate a 16-bit word within that page. Should the programmer use instructions that generate 32-bit virtual byte addresses, an extra bit is added to the logical word address. The address translation then proceeds as outlined below except that the last bit is saved by the ATU and appended to the final physical address.

The address translation unit hardware transforms this



5. Virtual segments. The 4.3-gigabyte virtual memory is divided into eight 512-megabyte segments, each containing 512 groups of 512 2-kilobyte pages. The 31-bit logical word address is similarly divided to facilitate the address-translation process.

logical address into the 29-bit physical address. It should be noted that while this 29-bit address provides for 536 million words or 1 gigabyte of physical main memory, only a 24-bit physical address is currently implemented in the hardware. And of these 24 bits only the least significant 20 are currently used by the MV/8000 to address its 2-megabyte main memory. The ATU uses page tables stored in main memory to provide the cross-references necessary to derive the physical address.

As shown in Fig. 6, the first 3 bits of the logical address are used by the ATU to pick one of eight segment base registers. These registers contain various flags associated with the security system and the starting address of the appropriate page table in main memory.

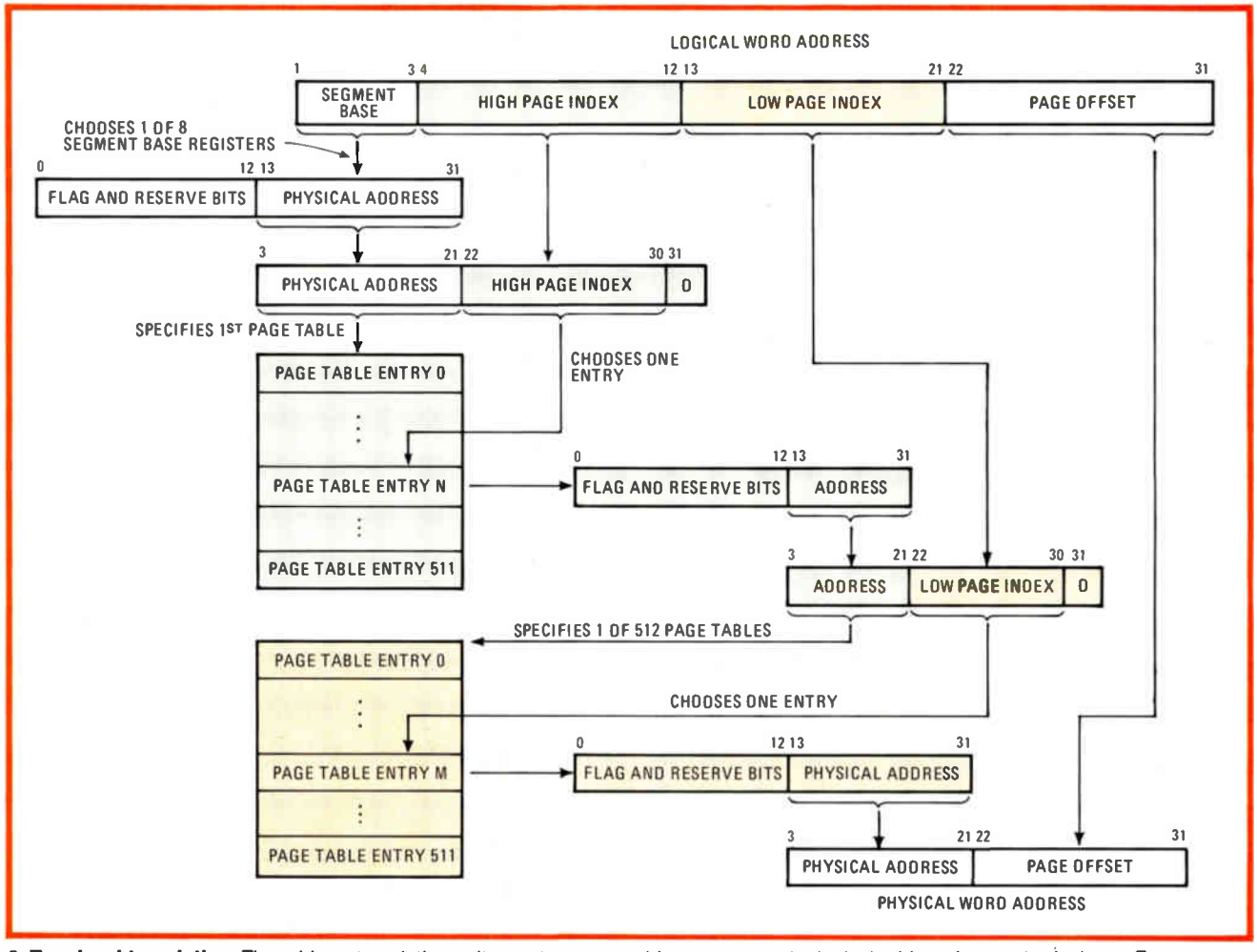
The high page index portion of the logical address (bits 4 to 12) is used to index one entry of that table. The contents of this page table entry are used by the ATU to point to 1 of the 512 page tables. Then, together with the low page index of the logical address (bits 13 to 21), it locates an entry in that table. This latter page entry includes flags for the security system, as well as a bit that tells the ATU if the next needed page table is resident in main memory. If not, the ATU signals the operating system to begin the page swap to bring the needed information from disk into main memory. The last 19 bits of the page table entry are appended to the page-offset portion of the logical address (bits 22 to 31) to create the 29-bit physical word address.

This novel two-level page table scheme provides the operating system with a great deal of flexibility in managing virtual memory. For programs taking up to 1 megabyte, the operating system can use a single level of page tables, saving translation time. All the high page index bits must be zero in this case.

Dealing with 16-bit addresses

The MV/8000's ability to handle 16-bit direct memory references is crucial to its compatibility with its 16-bit predecessors. It converts the 16-bit byte address into a 32-bit logical byte address by placing it into the 16 low-order bits of the logical address, appending 3 bits from the program counter register, and filling the remaining bits with 0s. This logical address is of course only capable of addressing the first 64 kilobytes of the 512-megabyte segment. But the AOS/VS creates a single-level page table for the segment containing this 16-bit program, thereby minimizing the time for translating the logical address into the physical address and ensuring that existing 16-bit programs can be run without degradation of their memory-reference time.

Once an address translation is made, it is desirable that the association between the logical and physical address be remembered, since programs often reference the same memory locations more than once while executing. Thus the ATU includes a 256-entry direct-mapped address cache that operates with an access time of 45 ns. Because of the design of the translation mechanism, it is expected that more than 98% of the time the needed



6. Two-level translation. The address translation unit uses two page tables to convert the logical address into a physical one. For programs up to 1 megabyte in size, only the second page table (tinted) is used, and the high page index in the logical address (gray) is all 0s.

address translation will already be available in the cache memory, thus speeding memory access.

In addition to partitioning the virtual address space into pages and segments, the virtual address space is duplicated many times over. Each duplicate of the address space is called a process and contains the 8 segments of 512 megabytes each for a total of 4.3 gigabytes. The hardware does not limit the number of processes on the MV/8000 but the current version of the AOS/VS operating system limits it to 255 processes. Various portions of the logical address space of the segments can be shared between different processes, reducing the overall amount of main memory required to support the on-line interactive, multiprogrammed computational environment the MV/8000 is designed for.

Of the eight segments, segment 0 is system-wide—that is, all the processes have the same segment 0. This segment is reserved for the basic kernel of the AOS/VS.

This is one of the most important features of the MV/8000 because it integrates AOS/VS into the user's logical address space. Imbedding the operating system in the user's address context allows the user to view the operating system as a set of system-provided subroutines. The same MV/8000 instruction (CALL) that is used to invoke a user subroutine is also used to make an operating-system call. This totally hardware-supported structure results in more reliable, structured, and distributed software systems. Reduced hardware and software overhead for servicing operating-system calls is also a byproduct of this sophisticated structure, since a complete context switch does not have to be performed.

Additionally, the user address space is viewed by the operating system as an extension of its own address context. Thus data movement by the operating system between user and system data bases is direct, requires no remapping, and is very efficient.

But imbedding the operating system in the user's address space requires some form of protection against malicious or accidental encroachment by an user on operating-system data bases and programs. The basis of this protection is an eight-level hardware mechanism based on the concept of rings.

Ring around the memory

There are eight hardware-supported protection rings, that correspond to the eight segments of the virtual address space and are numbered 0 to 7 (Fig. 7). Ring 0 is the most privileged and so is where the AOS/VS kernel (the most secure and privileged segment of the operating system) executes. A special class of privileged instruc-

tions can only be executed in ring 0. Instructions which manipulate referenced bits and that perform context switching are examples of the privileged actions that can only be executed in ring 0.

The amount of privilege decreases as the ring number gets higher. Rings 1–3 typically contain outer layers of the operating system. These outer layers, though part of AOS/VS, do not have the same privileges of ring 0. The layering of the operating system in this manner, coupled with the hardware-supported ring structure, results in a highly maintainable and reliable software system.

Rings 4–7 have less privilege than rings 0–3; ring 7 has the least privilege. User programs are executed with the ring 7 privilege.

Hardware within the MV/8000 processor mediates all logical address references with respect to proper ring ordering. The eight-ring structure is tightly coupled with the eight-segment structure of the virtual memory mechanism. Segment 0 always executes with ring 0 privileges. Segment 1 executes with ring 1 privileges, and so on.

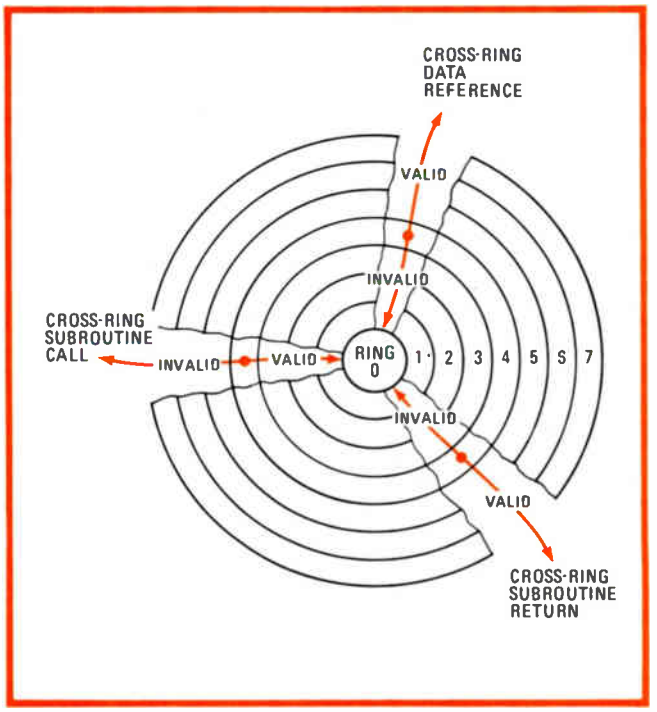
Completing the protection structure two are additional mechanisms: gates and access privileges for a page. Each page table entry contains three access privileges: read, write, and execute. As was mentioned earlier, upon every memory reference, the ATU validates that the correct page-access privileges are being used.

Gates are portals that mediate normally prohibited accesses from higher rings to lower-numbered rings. Gates force all system calls to branch to a known starting instruction location in the called program. If this hardware-enforced protocol were not present, the potential would exist for operating-system–call processing to initiate at an unknown instruction. This would result in unknown side effects, potentially leading to abnormal program or system termination.

The gates' function is analogous to a military security system's. If a person with only confidential clearance needs to have access to a confidential section of a top-secret document, it is clear that a security violation could occur if the entire top-secret document was made available. This problem is solved by requiring a person with the necessary top-secret clearance to screen the document and provide only the requested confidential information. A security violation is avoided and the appropriate information is transmitted.

The hardware-enforced screening is a two-step mechanism. The first step requires that the caller possess a minimum ring number. This is an example of the military principle of "need to know." The second step is the direct vectoring to a known starting instruction within the inner (callee's) ring. Then the inner-ring program beginning with this instruction provides the proper data-extraction service and returns the requested operands to the caller.

As previously described, all valid data references must be to the same or to an outer ring. All subroutine calls must be to the same or to inward rings (that is, toward ring 0). Inward calls to rings 0–3 are operating system calls. Inward calls to rings 4, 5, and 6 by the user are typically to common run-time support or to proprietary software packages provided by a system house. Subroutine returns are the inverse of subroutine calls. Valid returns are either to the same or to outward rings.



7. Ring around the memory. Each of the eight memory segments is associated with one of the eight protection rings. Ring 0 is the most secure and privileged and ring 7 is the least privileged. Accesses across ring boundaries are permitted only in certain directions.

The MV/8000 protection mechanisms serve to enhance the reliability of the user and system software systems. Program debugging is made easier and runaway user programs are kept isolated to their own process. High-level operating-system services can be made available to the user without concern for system integrity.

Room to grow

As in other aspects, the MV/8000 leaves room for growth. In the initial releases of AOS/VS, certain rings are reserved for future system-software expansion. As these operating system functions are added, they can reliably be incorporated in the reserved rings.

With the exception of this virtual memory and protection mechanisms, the architecture of the MV/8000 is basically an extension of the 16-bit Eclipse machines.

The instruction set of the MV/8000 comprises 437 instructions of which over 250 are new. The rest are the same as the instructions of the 16-bit Eclipse processors. This comprehensive instruction set can manipulate several types of data, including fixed point bytes, 16-bit words, and 32-bit double words, single- and double-precision floating-point operands, byte strings, and bit strings. Furthermore, eight types of commercial variable-length byte strings and stacks are supported. New instructions handle 32-bit integers for the first time in an Eclipse, plus linked structures that can be manipulated as double-threaded queues or single-threaded linked lists. These instructions can be used with three types of addressing: absolute, program-counter–relative, and accumulator-relative, which can be performed with 16- or 32-bit displacement. □

Fm decoder improves SCA subcarrier detection

by Robert F. Woody
Christiansburg, Va.

The 67.5-kilohertz subcarrier required for subsidiary communications authorization (SCA) service in the fm band can be recovered by a decoder that needs only two chips and one discrete amplifier. And it can be built for less than $10. Besides using fewer parts than existing designs, this circuit provides higher output and offers greater versatility.

As an illustration of its advantages, the 4046 phase-locked loop in the decoder provides an output level approximately equal to the fm level at its input, thereby generating adequate drive to succeeding stages. In addition, the PLL's filter also serves as the deemphasis filter, thus eliminating the need for a separate network. Finally, upon loss of the subcarrier, the circuit generates a signal that can cue a recorded message to the audience receiving SCA service.

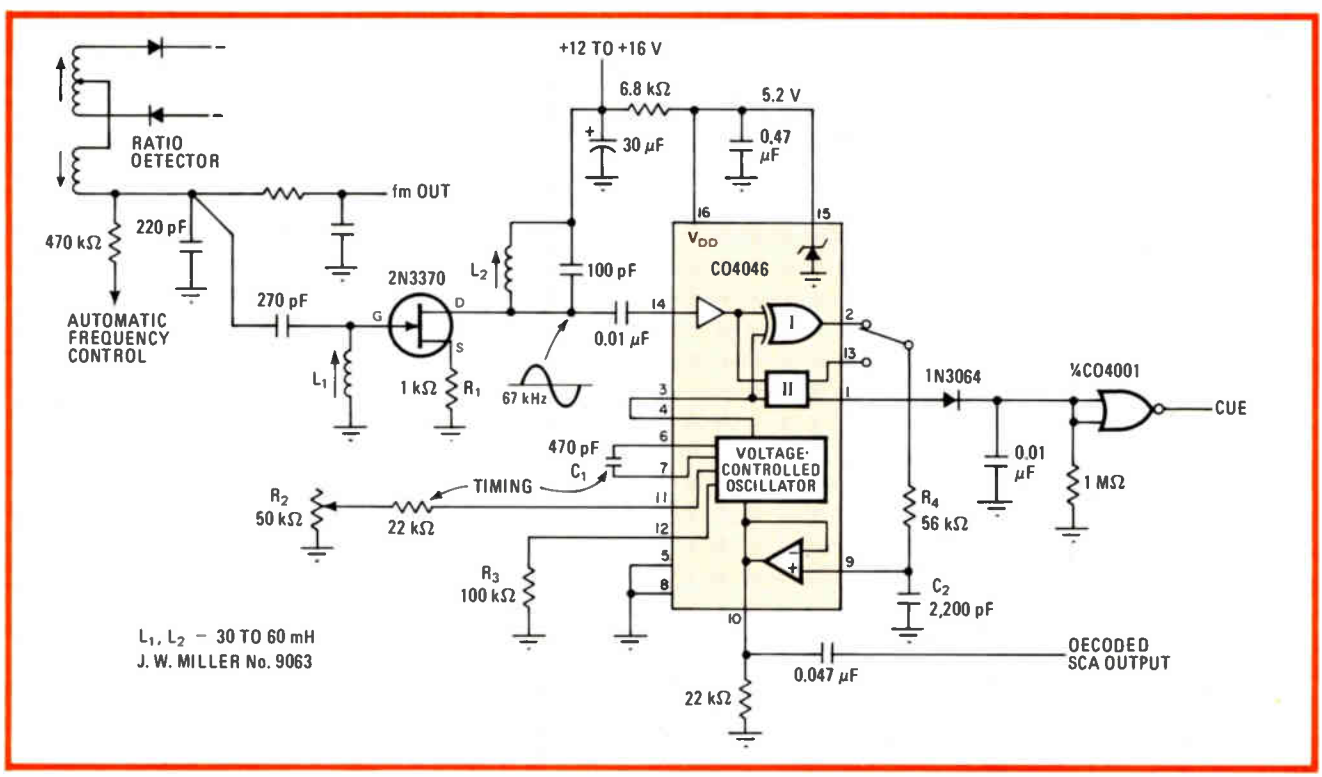
The decoder is attached to an fm receiver at its ratio-detector output, ahead of the deemphasis filter. For best performance, it is recommended that the signal be taken from a stereo receiver because its bandwidth, which is designed to be broad for the stereo carrier, provides good reception of the 67.5-kHz SCA signal.

The 2N3370 tuned field-effect-transistor amplifier separates the low-level subcarrier from the other program material, including the very strong stereo carrier. Resistor R_1 yields maximum amplifier gain at 1 kilohm. This resistance can be increased to reduce the amplifier's gain for fm receivers that deliver high-level output signals. Values to 5 kΩ are within the amp's range.

The CD4046 PLL performs the decoding. C_1 and R_2 set the loop's center frequency. R_3 sets the conversion gain (volts/radian) of the PLL's voltage-controlled oscillator. Increasing R_3 makes the VCO less sensitive to input-voltage changes. Decreasing R_3 reduces the SCA output level.

C_2 and R_4 comprise the low-pass filter. As placed in the circuit, these elements also deemphasize the SCA signal at high frequencies, the amount of deemphasis being about 3 decibels at 1.3 kHz.

A string of pulses is emitted from pin 1 of the 4046 when the PLL is in lock. The pulses are rectified by the 1N3064 diode and filtered by the 0.01-microfarad capacitor. Thus a dc level is derived. Should the subcarrier disappear, however, the level will fall and the CD4001 NOR gate will go high. This signal can be used to cue the playing of recorded messages, such as typical commercial advertisements. □



Simple service. Improved fm decoder for detecting SCA subcarrier yields higher output, uses fewer parts, provides good selectivity and cue option. Requiring only two chips, and one tuned amplifier for separating the stereo from the SCA subcarrier, it costs less than $10.

Low-cost logarithmic amp works over one decade

by Christopher S. Tocci
Becton-Dickinson Medical Systems, Westwood, Mass.

If extremely high precision is unnecessary and if the required dynamic range spans no more than one decade of input voltage, then this logarithmic amplifier will serve the application well. Use of a simple exponential generator, which is ultimately required to convert a voltage into its base-10 logarithmic equivalent, makes it possible to build the amp for a mere $3 to $4.

The overall system is shown in (a), with the schematic of the exponential generator shown in (b). Voltage divider R_1–R_2 applies 0.5 volt to RC combination R_3C_1 through op amp A_2 on power-up in order to initialize the exponential growth process. As C_1 charges, the output of A_2 increases as shown in the curve until the Schmitt trigger, A_3, which has a switching threshold of 10 v, fires, turning on field-effect transistor Q_1 and discharging C_1 to about 1.0 v. The process then repeats, with switching occurring at a rate, τ, determined by C_1 and R_2. The op amp must have a minimum slew rate of:

$$dV_o(t)_{max}/dt = (1/\tau)\, e^{t/\tau}|_{t=\tau} = (10 \log_e 10)/\tau = 23.03\, f_s$$

where f_s is the switching frequency. Thus at a switching frequency of 10 kilohertz ($C_1 = 0.01\ \mu F$, $R_1 = 4.32\ k\Omega$) the slew rate must be at least 0.23 v/microsecond.

During each switching cycle, the exponential output is compared at A_1 to the instantaneous input voltage, V_c, that is to be converted into its corresponding logarithm. A_1's on time, D_{v_p}, is thus related to input voltage V_c by:

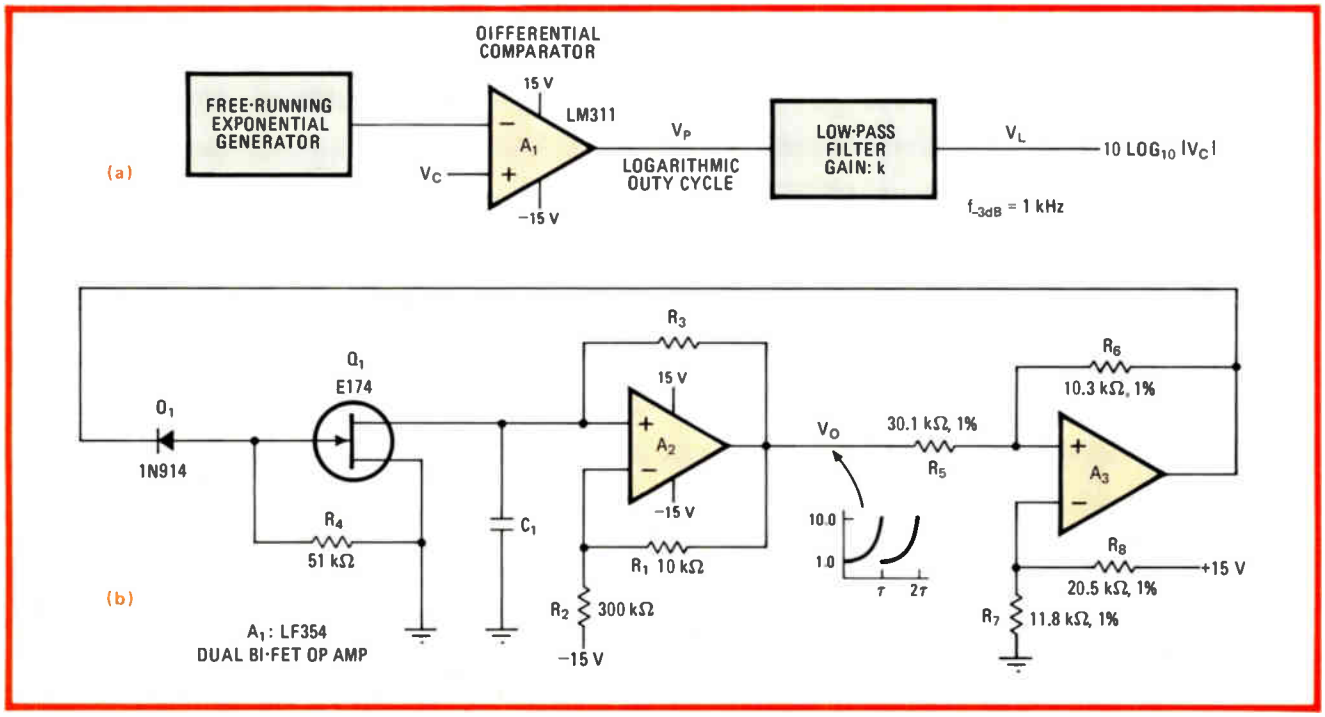
$$D_{v_p} = (t_{on}/\tau)\ 100 = \tau \log_e |V_c|/\tau = 0.434 \log_e |V_c|$$

where output voltage V_p corresponds directly to D_{v_p}, ignoring a scale factor.

The active low-pass filter of gain k that follows, which should be at least a third-order type for the best results, then finds the average value of V_p from:

$$V_L = \overline{V_p} = k(0.434) \log_e |V_c|$$

Choosing k such that $k(0.434) = k(V_{p\,max}/\log_e 10) = 4.34$, it is seen that $V_L = 10 \log_{10} |V_c|$ for $1 \le V_c \le 10$. □



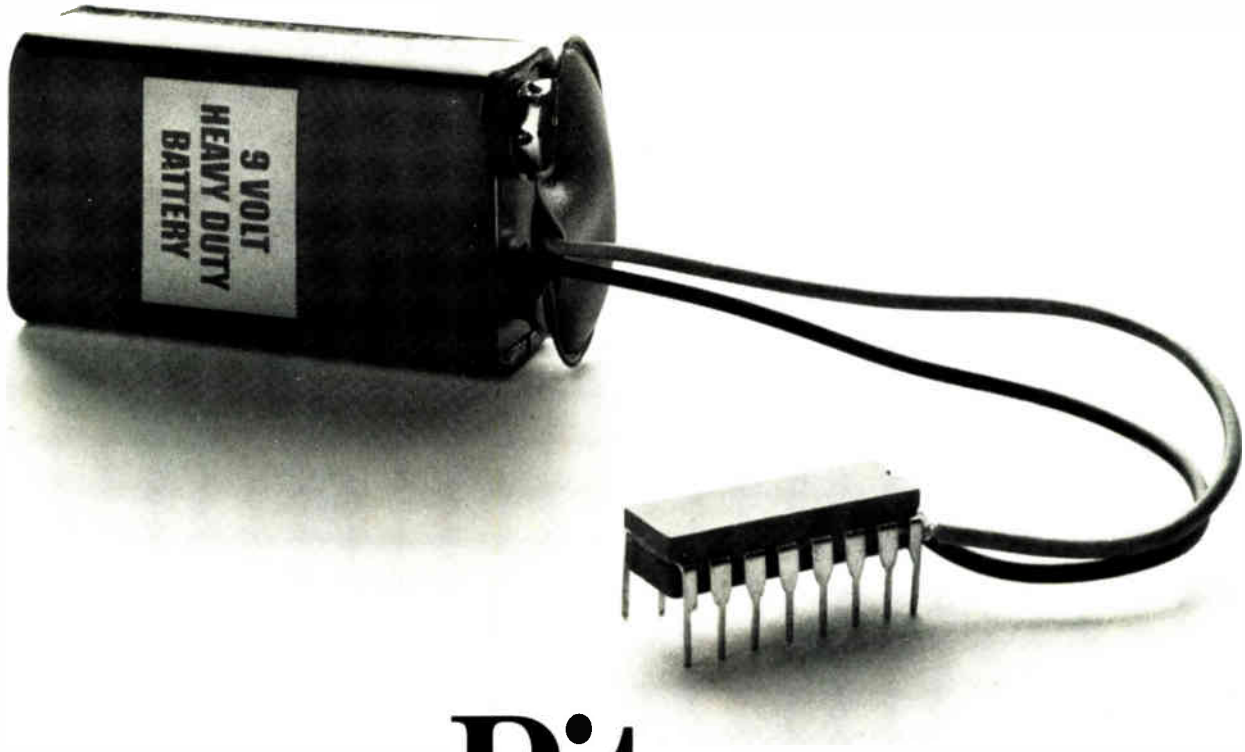
Naturally. Low-cost generator provides exponential waveform of sufficient accuracy in amplifier that takes logarithms over one decade of input voltage. Filter averages pulse-width-modulated equivalent of V_c produced by differential comparator, A_1, for $V_L = 10 \log_{10} V_c$.

Hall sensors and flip-flop sustain pendulum's swing

by John Karasz
Sperry Corp., Great Neck, N. Y.

This circuit offers a simple way to control and sustain oscillatory motion in a simple pendulum and in many other types of mechanical oscillators. Using Hall-effect sensors to detect the instantaneous position of the pendulum and to call for delivery of an energy burst through a flip-flop to keep it swinging, the circuit is a good alternative to the complicated electromechanical arrangements frequently employed. The cost of the entire circuit is also

Still using CMOS?



Pity.

Now you can eliminate the one major failing of CMOS—the battery backup.

By eliminating the CMOS. And using Plessey MNOS instead.

The listing shows the start of the new Plessey family of non-volatile MOS. We call it NOVOL because it is. Devices are *guaranteed* to hold their data for at least one year when the power is removed. They all operate from *standard* MOS supplies and are fully compatible with your TTL/CMOS designs.

With our NOVOL devices, you can eliminate the battery backup, the mechanical relays, the pegboards and thumbwheel switches that you've had to depend on. It's the perfect solution for security code storage, metering, elapsed time indicators and any other application where you need a little storage with a lot going for it.

Plessey NOVOL MNOS

MN9102	4-Bit Dete Letch (+5V, −12V)
MN9105	4-Decede Up/Down Counter (+5V, −12V)
MN9106	6-Decede Up Counter (12V only)
MN9107	100-Hour Timer (12V only)
MN9108	10,000-Hour Timer (12V only)
MN9110	6-Decede Up Counter with Cerry (12V only)
MN9210	64 x 4-Bit Memory
COMING SOON	8 x 4-Bit Memory
COMING SOON	6-Decede Up/Down Counter, BCD Output
COMING SOON	6-Decede Up/Down Counter with Preset, BCD Output

For more data, just contact Plessey Semiconductors, 1641 Kaiser Avenue, Irvine, CA 92714. Telephone (714) 540-9979.

Plessey MNOS doesn't forget.

relatively low, making it especially attractive.

When the small permanent alnico magnet that is part of the pendulum support rod comes into sufficiently close proximity to Hall sensor S_1, the sensor generates a negative-going pulse. This pulse sets the R-S flip-flop formed by two cross-coupled 74LS00 NAND gates, A_1 and A_2. The Q output of the flip-flop, now at logic 1, energizes electromagnet L_1, thereby delivering energy to the pendulum via the field between the steel pendulum bob and L_1.

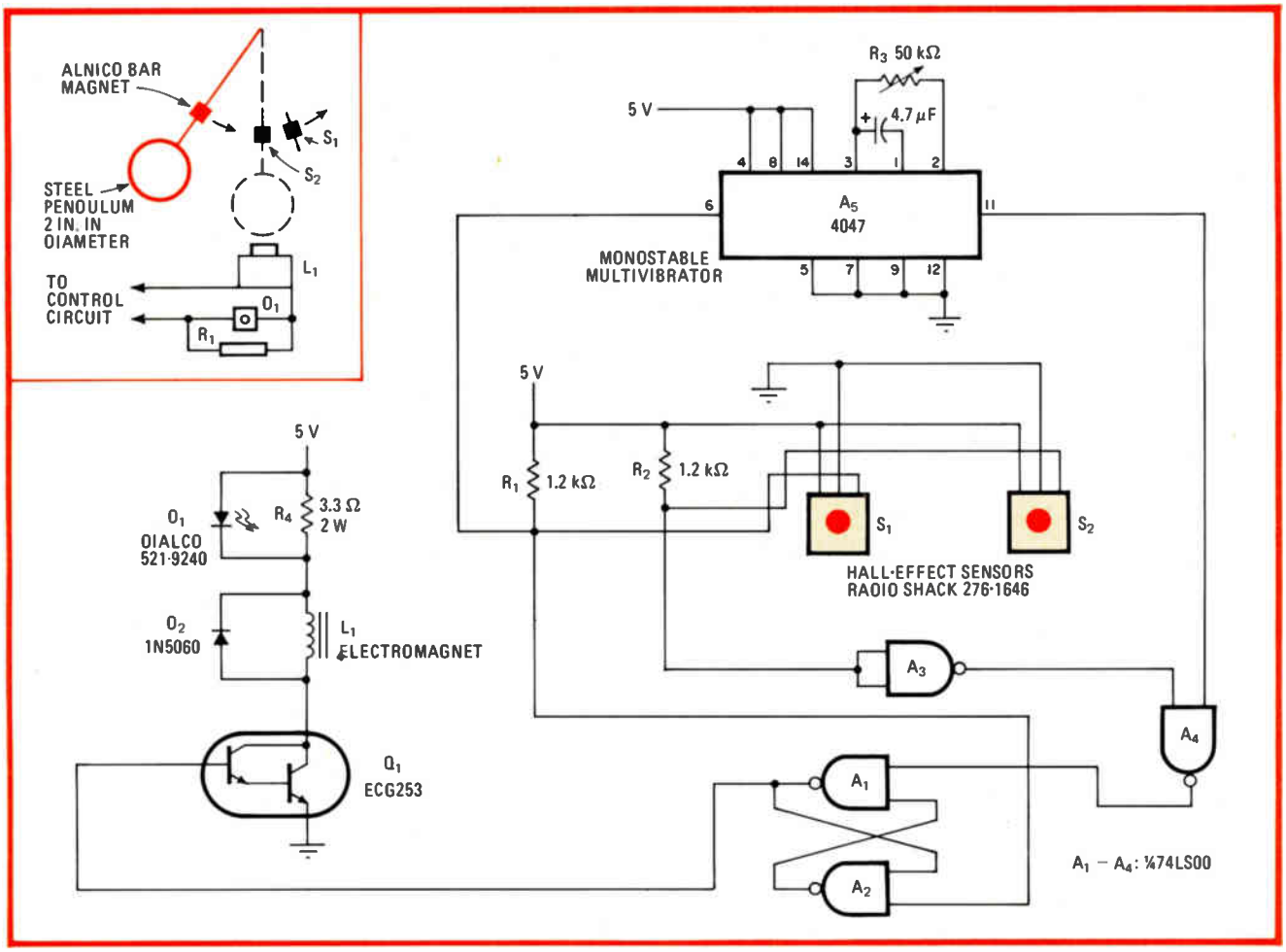
When the pendulum bob reaches the lowest point in its trajectory, L_1 is deenergized by the negative-going pulse generated by sensor S_2, which clears the flip-flop. Simultaneously, one-shot A_5 is triggered. Hence, as long as the Q output of A_5 remains active low, the flip-flop cannot be retriggered because gate A_4 cannot move to logic 0. This action prevents L_1 from energizing and thus creating any drag effect on the pendulum. Also, it conserves power by limiting the time L_1 is on.

In order to initialize the circuit at a relatively small pendulum swing, the period of the one-shot should be set for $t = T/4$, where T is the natural period of the pendulum. Because the oscillation frequency of a simple pendulum is $\omega^2 = g/L$, where $\omega = 2\pi f$, $g = 32.2$ feet per second squared, and L = the distance from the point of support to center of mass of the pendulum bob, it may be seen that $T = 2\pi(L/g)^{1/2}$, and so t should be in the range of 0.32 to 0.36 s in a practical configuration, for T = 1.44 s.

As for component considerations, L_1 is constructed from 100 feet of AWG 24 enameled wire wound on a steel core 1 1/16 inch long and 3/8 in. in diameter. The alnico magnet is situated only about 0.45 in. above the top surface of the pendulum bob—in terms of metric units, approximately 12 millimeters away. The magnet is 3 mm wide, 3 mm high, and 8 mm long. The clearance between the magnet's pole face and the Hall-effect sensor's surface should be between 1/32 in. and 1/16 in. for best results. A small decoupling capacitor (0.033 μF, disk ceramic) is connected between the supply lead and ground of the 74LS00 chip to keep circuit transients caused by S_1 or S_2's firing from inadvertently setting the flip-flop to the wrong state.

Light-emitting diode D_1 serves as a visual monitor, being lit when L_1 is energized. When mounted at the base of the electromagnet, it facilitates a qualitative check on the performance of the system. □

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



Keep swinging. Hall-effect sensors detect instantaneous position of pendulum, direct flip-flops A_1-A_4 to generate energy pulse via field between L_1 and alnico magnet in order to keep pendulum moving. One-shot A_5 prevents flip-flop refiring in any given cycle, thus stops pendulum drag, and conserves energy. Inset illustrates physical relation of bar magnet to pendulum and interface elements.

Announcing an Intel Seminar on Microcomputer Solutions for the '80s.

The 1980s will require total microcomputer system solutions to enable you—the system designer—to keep pace with ever increasing application complexities. To help you plan for the '80s, Intel is sponsoring a series of one-day seminars discussing the directions for future VLSI computer solutions.

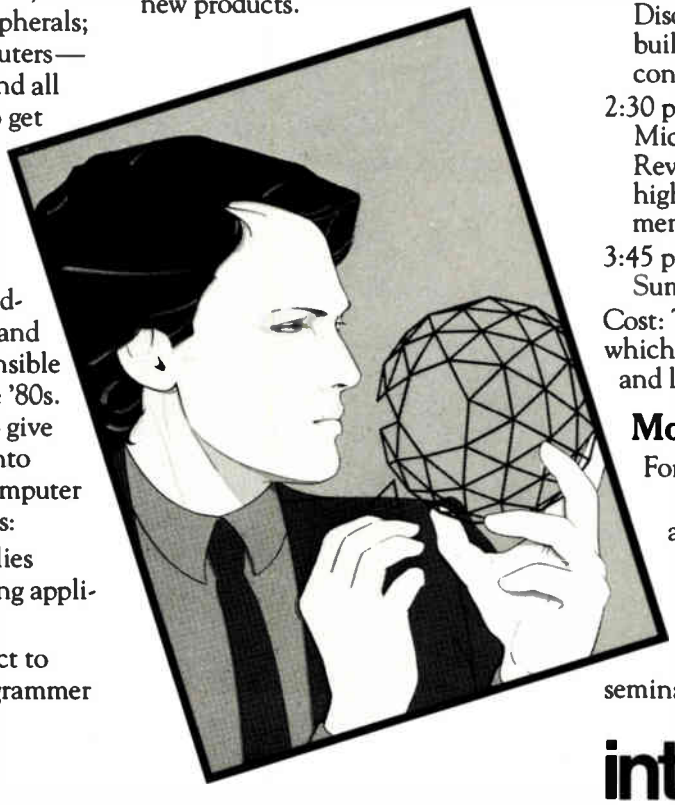
In these seminars, you'll learn how our VLSI solutions uniquely address the needs of the future. Topics discussed will include system-level integration in 16-bit, 16/32-bit, and 32-bit microcomputers; peripherals; software; single board computers—and more. In short, you'll find all the information you need to get a head start on your next generation of products.

Who should attend.

The seminar is intended specifically for software, hardware, and system engineers and managers who will be responsible for designing systems for the '80s. The seminar is structured to give you a comprehensive look into future directions in VLSI computer system development, such as:

- New microprocessor families designed to meet increasing application complexity.
- Tools to speed your product to market by increasing programmer productivity.
- Highest performance microsystem configurations achieved through co-processing and multi-processing.
- Integration of system programming and software functions into silicon.
- Integration of memory management and protection facilities.

Course materials will include a seminar notebook, and an *Advanced Data Catalog* which will outline Intel's comprehensive line of new products.



Agenda

8:00 a.m.
Registration

8:30 a.m.
Introduction of Intel's total solution approach

10:30 a.m.
New Microprocessor Products
Preview of three microprocessors covering 16-bit, 16/32-bit, to 32-bit complexity

12:00 Noon—Lunch

1:00 p.m.
Microsystem architecture
Discussion of new peripheral building blocks and system interconnects

2:30 p.m.
Microsystem software
Review of new operating systems, high level languages and development tools

3:45 p.m.
Summary and questions/answers

Cost: There is a $15.00 registration fee which will cover seminar material and lunch.

More information.

For registration information and to guarantee reserved space at the seminar, please contact your local Intel sales office a minimum of one week prior to the seminar in your area. The person to contact for your seminar is listed below, so call today.

intel® delivers solutions.

Seminar Date	Location	Contact	Phone
May 13	Santa Clara, Ca.	Bob Cifranic	(408) 987-8086
May 16	Seattle, Wa.	Steve Prue	(206) 453-8086
May 20	Baltimore, Md.	Steve Kay	(301) 796-7500
May 21	Cincinnati, Oh.	Dave O'Hanian	(513) 890-5350
May 22	Detroit, Mi.	Stan Korus	(313) 353-0920
May 28	Minneapolis, Mn.	Blain Erskine	(612) 835-6722
May 29	Chicago, Ill.	Tom Alwicker	(312) 981-7200
May 29	Orange County, Ca.	Dave Neubauer	(714) 835-9642
May 30	Cleveland, Oh.	Steve Turcola	(216) 464-2736
June 16	Los Angeles, Ca.	John Affoldy	(213) 986-9510
June 16	Boston, Mass.	Bruce Giron	(617) 667-8126
June 17	Manhattan, N.Y.	Don Buckhout	(516) 231-3300
June 17	Denver, Colo.	Pat Maley	(303) 321-8086
June 18	North New Jersey, N.J.	Tom Trainor	(201) 225-3000

Seminar Date	Location	Contact	Phone
June 19	Houston, Tx.	Larry Gast	(713) 784-3400
June 19	Philadelphia, Pa.	Gene Murphy	(215) 542-9444
June 20	Dallas, Tx.	Dave Takacs	(214) 241-9521
June 24	Toronto, Canada	Franca Martinek	(416) 675-2105
June 25	Montreal, Canada	John Freeman	(613) 829-9714
June 27	Long Island, N.Y.	Don Buckhout	(513) 231-3300
July 10	Phoenix, Az.	Phil Richards	(602) 997-9695
July 15	Portland, Ore.	Steve Dallman	(503) 641-8086
July 16	Salt Lake City, Ut.	Bob Spina	(303) 321-8086
July 22	Milwaukee, Wisc.	Karl von Spreckelsen	(414) 784-9060
July 23	Kansas City, Ks.	Tom Izzo	(913) 642-8080
July 24	San Diego, Ca.	John Linn	(714) 268-3563
August 5	Melbourne, Fla.	Don Dabney	(305) 628-2393
August 6	New Haven, Conn.	Bill D'Eramo	(203) 792-8366
August 7	Rochester, N.Y.	Bill D'Eramo	(716) 254-6120

"SEE OUR BOOTH AT THE NCC SHOW #1354-60"

MOS FETs rise to new levels of power

Boasting exciting performance advantages over bipolar transistors, they are moving into numerous applications and even creating new ones

by Rudy Severns, *Intersil Inc., Cupertino, Calif.*

☐ Advances in the fabrication of MOS field-effect transistors have freed them and their users from their earlier power limitations. Now, designers can exploit to the full their performance and economic advantages over bipolar power transistors.

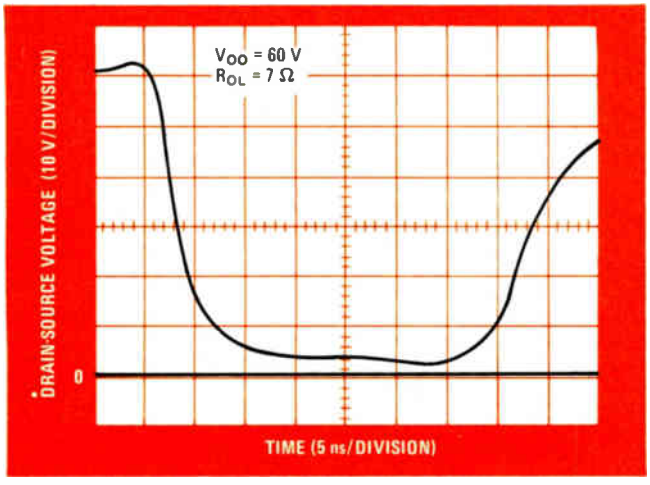
Besides costing less than bipolar types, power MOS FETs switch faster (typically in a few nanoseconds), offer higher input impedances with low drive requirements, simplify multiple-device operation, and greatly extend safe operating areas. Thus it is no surprise that they are beginning to replace bipolar transistors in many power-switching applications. Furthermore, they have created circuit opportunities that did not exist before.

Several different types of power MOS FET are available, each with its own strong and weak points, and all steadily increasing in performance levels. Despite the proliferation of a host of power MOS FET structures with similar-sounding and confusing names—like V-MOS, V-FET, HEX FET, T-MOS, D-MOS, and Z-MOS—they all break down into three basic structures: vertical-junction MOS FETs, V-groove MOS FETs, and vertical D-MOS FETs (see "Examining power FET structures," p. 144).

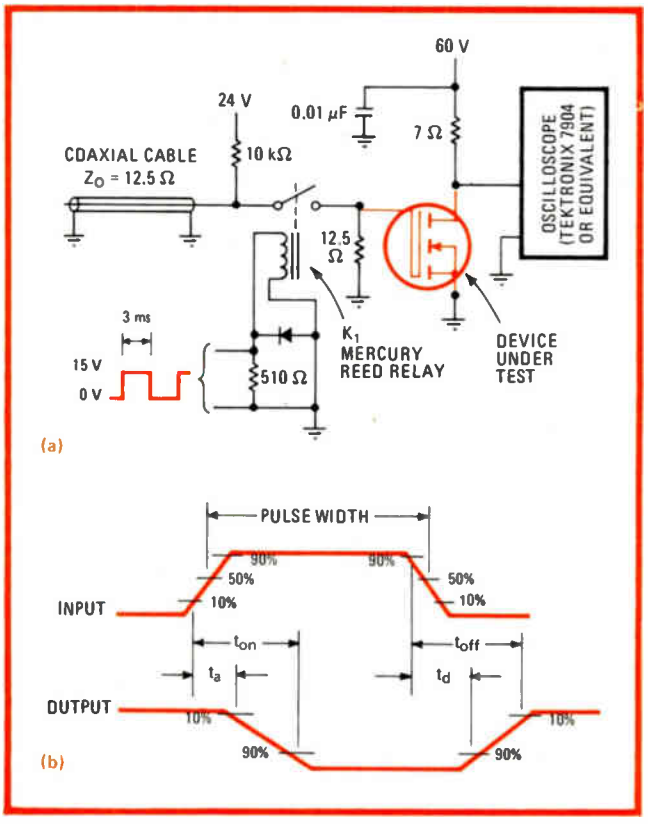
Although power MOS FETs compete favorably with bipolar transistors in performance, the different structures do not yield the same benefits. And beyond a good understanding of how each type behaves lies the need for a basic understanding of how a power MOS FET in general differs in construction, operating characteristics, and application from a bipolar transistor. Such an understanding is a prerequisite for getting the most out of the device.

Breakdown voltage affects on-resistance

As the breakdown voltage rating of either a MOS FET or a bipolar transistor increases, the transistor's on-resistance goes up by an exponential factor of 2.3 to 2.7 for a given die area and process. If the breakdown voltage rating of a 1-ohm, 100-volt device, for example,



1. Switched. A power MOS FET like the Intersil IVN5200 can switch nearly 60 V at 8 A in a little more than 5 ns. The test circuit of Fig. 2 was used for switching. The slight voltage rise at turn on is caused by capacitive coupling of the drive pulse to the output.



2. Test circuit. The test circuit (a) should be used to accurately measure the switching time of a power MOS FET. The resulting switching waveform is shown (b). Note that the actual switching waveform of Fig. 1 is different because of FET capacitance effects.

Examining power FET structures

A host of different structures for power field-effect transistors exist, each with its own advantages and drawbacks.

Planar MOS FET. Figure (a) is a cross section of a conventional planar n-channel enhancement-mode MOS FET. Fabrication begins with a p substrate into which n^+ regions are diffused. A silicon dioxide layer is then grown and etched for later deposition of aluminum. The aluminum forms the source, gate, and drain connections. When no bias voltage is applied to the gate, the device acts as two back-to-back pn diodes and no conduction occurs. When the gate is made positive with respect to the source, an electrostatic field draws electrons near the surface of the p region, inverting it to an n region. A channel is thus formed, allowing conduction between source and drain.

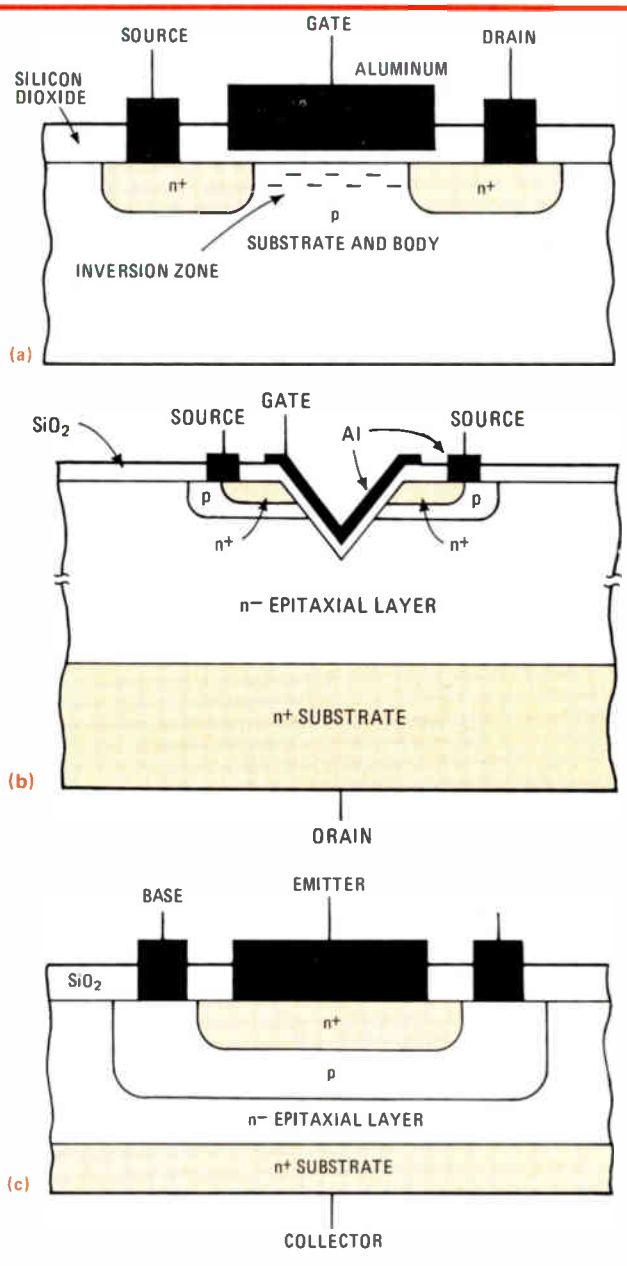
Since the MOS FET is a majority carrier device, it acts as an extremely fast switch with no storage time effects. However, a number of drawbacks eliminate this structure from practical consideration for high-power use. For one, the length of the channel is controlled by the mask spacing of the n^+ regions; because of the degree of accuracy of photomask technology, relatively wide spacing is needed. The wide spacing produces long channel lengths that increase the resistance for a given area of silicon. For another, source, gate, and drain conductors are on the same surface, and their metalizations take up a major portion of the die area, further increasing the on-resistance. Finally, the planar structure has large inherent capacitance, especially between gate and drain. These capacitances reduce the gain-bandwidth product and increase the drive power in repetitive pulse applications.

V-MOS. Most of the deficiences of the planar MOS FET can be overcome by a structure that allows the current to flow vertically and in which the channel length is controlled by diffusion processes rather than by mask spacing. The V-MOS structure shown in (b) is a particularly good solution. The fabrication process starts with an n^+ substrate and an n^- epitaxial layer. A p region is diffused in, followed by an n^+ layer that is diffused within the p region. Up to this point, this process is very similar to that for a double-diffused npn transistor, shown in (c). Instead of applying base and emitter metal layers, a V groove is anisotropically etched in the surface of the device. Then a silicon dioxide insulating layer is grown, and finally source and gate metal is deposited. Note that the source metal overlaps the p and n^+ regions so that the base and emitter of the transistor are connected together.

By applying a positive potential between the gate and source, the p region close to the gate can be electrostatically inverted to n-type material and a conducting channel formed. Thus the source and gate connections are on the upper surface, the drain is on the bottom, and current flow is essentially vertical. In addition, the channel lengths are controlled by the diffusion processes and can be made very short. This structure allows very efficient utilization of the silicon and fabrication of high-power MOS FETs.

The structure in (b) has some drawbacks. The sharp bottom of the V groove produces a strong field concentration between the gate and drain. In addition, a tendency exists for the gate oxide layer to thin down around the tip of the V. The result is limited high-voltage capability because of gate-oxide breakdown, even though the gate does not see the full drain-source voltage.

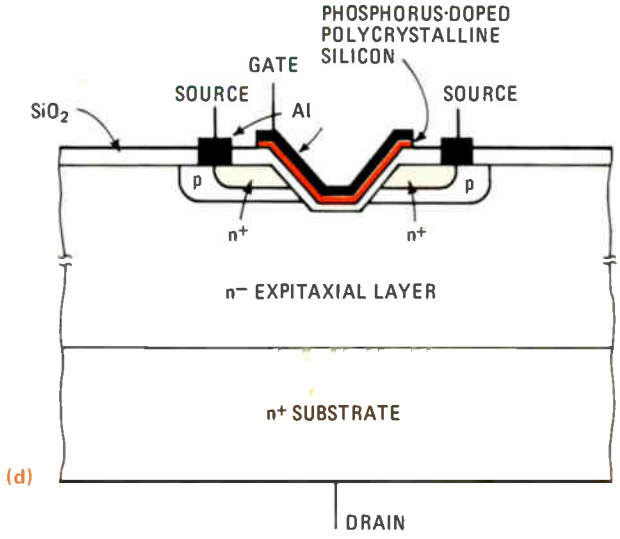
Another problem is the use of an aluminum gate, which can cause long-term reliability problems as a result of ion migration (principally sodium) through the gate oxide. Ion migration leads to variations in the device threshold voltage. Still another drawback is the channel formation. If the channel's groove does not penetrate well past the p region into the epitaxial layer, excessive current densities

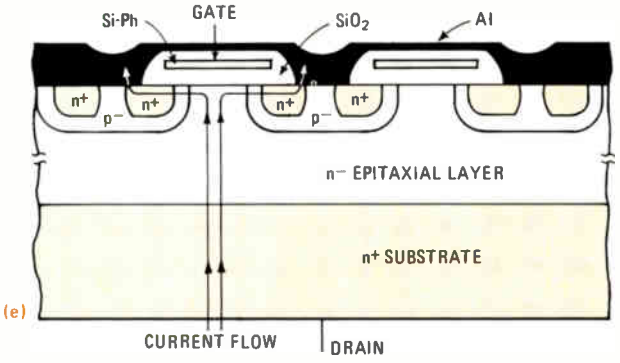


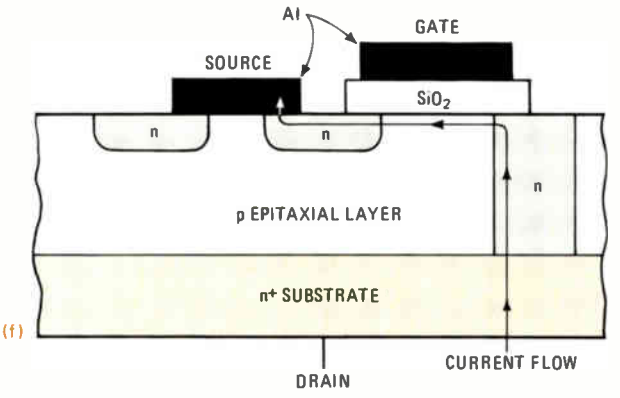
is increased to 200 V, the device's die area would have to be at least five times larger for the transistor to maintain the same on-resistance.

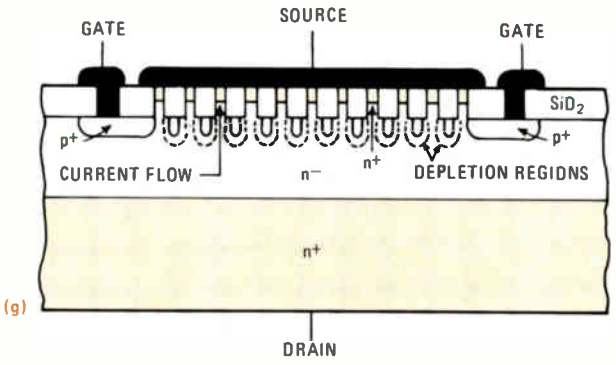
There are two basic reasons for the exponential increase in on-resistance: the resistivity of the transistor's epitaxial layer must be increased for higher avalanche-breakdown capability, and its thickness must be increased to ensure that the transistor's depletion region remains totally within the layer.

In a 400-V transistor, the resistivity of the epitaxial









can cause current-injected avalanche breakdowns.

Most of these problems can be relieved by a structure with a flat-bottomed groove and a combined silicon and aluminum gate structure as shown in (d). Fabrication is very similar to that for V-MOS, except that the etching is halted while the bottom of the groove is relatively wide. A layer of oxide is then grown and overlaid with a layer of polycrystalline silicon doped with phosphorus.

Phosphorus-doped polysilicon is an effective ion-migration barrier but not a particularly good conductor, having a resistance about 3,000 times that of aluminum. In a large device, this resistance could lead to a slow turn-on time and reduced dV/dt capability. Therefore a layer of aluminum is applied over the silicon gate for high conductivity. The silicon-gate process, which Intersil uses for V-MOS, also increases yield, lowering the device cost.

Vertical D-MOS. Although the modified V-MOS process of (d) is very effective for voltages under 150 volts, voltage-gradient problems still exist, and the groove spacing requirements increase the die area. A vertical D-MOS (double-diffused MOS) structure, shown in (e), alleviates these problems. The process begins as for an n-channel device, with an n^- epitaxial layer grown on an n^+ substrate. P^- regions are then diffused; and inside these, n^+ regions. Next, a silicon gate is imbedded in silicon dioxide and the source and gate metalization are then added. The current flow is at first vertical and then horizontal, with the drain on the n^+ substrate.

This structure has a number of different names, among them, D-MOS, T-MOS, Z-MOS, and HEX FET. The processes used to make them are basically the same, the primary differences being in the geometry of the p and n regions and the interconnections. The HEX FET, for example, uses hexagonal p regions, which allow a very low on-resistance by maximizing the channel perimeter. Unfortunately, as currently implemented, the silicon-gate structure has a relatively high series resistance, which increases the switching time significantly. An alternative geometry used in Intersil's power devices retains the low on-resistance but reduces the gate resistance.

Hitachi Ltd. has developed a MOS FET in which the gate structure overlays a checkerboard of n and p regions to form the channels, and the n regions connect to the n^+ substrate so that the drain is on the back side of the die (f). To date, devices using this structure display a restricted gain-bandwidth product of 0.6 to 1.5 megahertz and a relatively high $r_{DS(on)}$ for a given die area.

Sony Corp. makes a vertical depletion-mode junction FET that it calls a V-FET. It has a square-law transfer characteristic (g). Its disadvantages are a relatively low stage gain, substantial gate current if the gate is driven positive, and relatively high gate resistance and input capacitance that reduce the gain-bandwidth product.

layer is typically 1,500 to 2,000 times greater than that of the n^+ substrate. At high voltages, therefore, the transistor's on-resistance is dominated by the resistance of the epitaxial layer. Thus for a given MOS or bipolar transistor die area, an increase in the transistor's breakdown voltage means a decrease in the device's power-handling capability. If the power capability is to be retained for a higher breakdown-voltage rating, a large die area is needed.

The large die area is a double-edged sword. The larger

it is, the lower the on-resistance, since the latter is inversely proportional to the die area. However, that also means fewer dice per wafer. This last fact, combined with dice losses due to inherent wafer defects and an increased scrap zone around the wafer's center and periphery (for a given larger die), means lower wafer yields and therefore higher costs. The yield can typically be represented by the relationship:

$$Y = K(n)\,(1-e^{AD})^2/AD$$

where:

A = the die area

D = the defect density

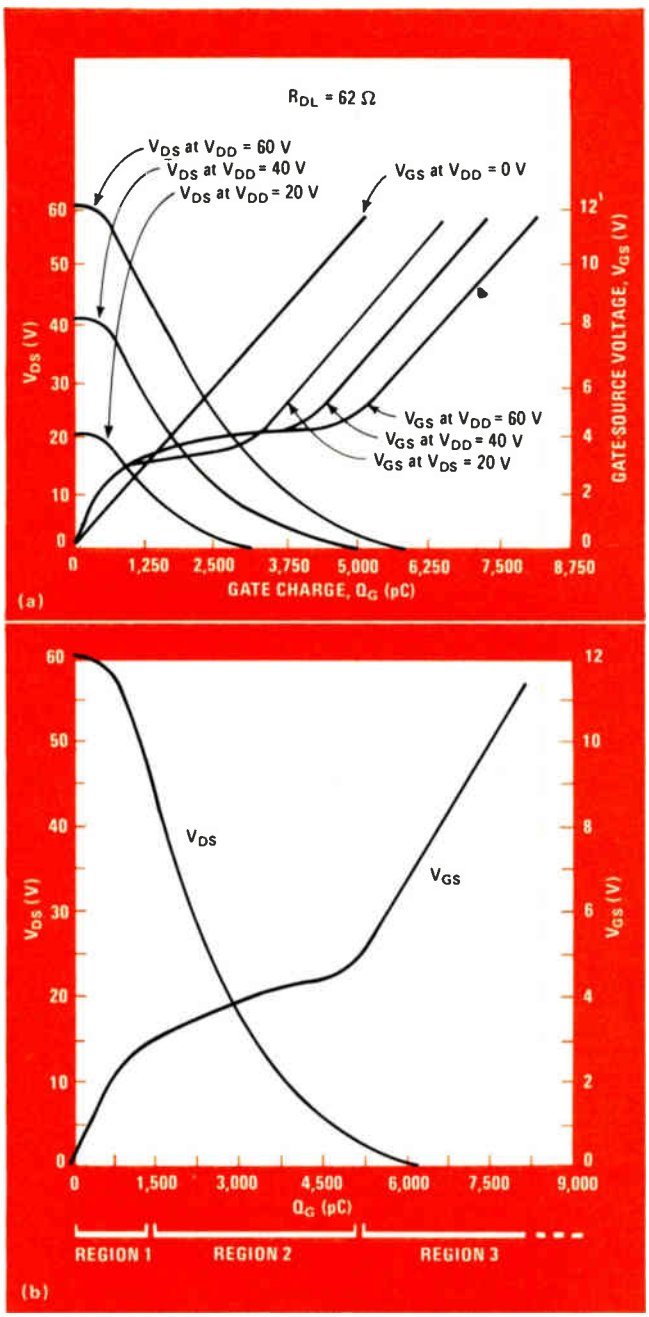
n = the number of process steps

K = an exponential factor that varies inversely with n

For small die dimensions of less than 0.050 by 0.050 inch, yields are usually very high and die costs low. As die dimensions exceed 0.100 by 0.100 in., yields decrease rapidly and die costs escalate. Many power-transistor die dimensions are usually larger than those mentioned, accentuating the yield and subsequent cost problems as devices with a lower on-resistance are made. A 450-v transistor with 1-Ω on-resistance, for example, may cost four to six times as much as a transistor with 2.5-Ω on-resistance and the same breakdown-voltage rating.

Most MOS power transistors are n-channel devices. Although p-channel devices can be built just as easily as n-channel ones by the simple interchanging of n- and p-channel regions, there is a difference in their performance compared with n-channel MOS FETs.

In n-channel MOS FETs, the majority carriers are electrons, while in p-channel devices the majority carriers are holes. Since holes have about one half the mobility of electrons, p-channel on-resistance for a given device is about twice as high as that of an n-channel structure, unless about twice the n-channel's area is used in a p-channel structure. A larger p-channel structure means more capacitance and a higher cost than does an equivalent on-resistance n-channel one.



3. Gate charge. Switching-time and drive-power values for a power MOS FET are accurately calculated from a knowledge of the FET's gate charge as a function of its gate-source voltage (a). For simplicity, the curves for a drain supply of 60 V are reproduced (b).

MOS FETs—ultrafast switches

A major advantage of a power MOS FET over a bipolar power transistor is its ultrafast switching speed. If the gate capacitance of a MOS FET could be charged instantaneously, switching times of 50 to 200 picoseconds would be possible. That is the time it takes for the transistor's majority carriers to travel from the device's source to its drain terminal. In fact, production MOS FETs can be switched in less than 1 nanosecond, provided a suitable pulse source is used to drive the transistor's gate terminal. Such a pulse source can include a mercury-wetted relay and a transmission line.

In practice, switching times of 10 ns or more are fairly easy to accomplish, limited primarily by the source resistance of the drive circuit. For shorter switching times, the transistor's package inductance, the internal gate resistance, and the pulse-generator source's connections become more limiting factors. It is difficult, for example, to attain switching times under 2 to 3 ns for power transistors packaged in commonly used TO-3 cases.

Switching waveforms

Figure 1 shows the switched waveform for an Intersil IVN5200 power MOS FET switching 60 V at 8 amperes and using the test circuit and waveform shown in Fig. 2. The slightly positive voltage rise at turn on is due to the coupling of the drive pulse to the output by the reverse transfer capacitance, C_{rss}, during the turn-on delay time. A similar negative pulse can occur during the turn-off delay time.

The delay at turn on is due to the length of time it takes for the gate voltage to rise to $V_{GS(th)}$, where the device begins to conduct. In most switching applications,

sufficient gate drive will be supplied to obtain the minimum $r_{DS(on)}$. (This corresponds to the area in Fig. (e) ("Linear characteristics—a closer look," p. 151, where r_{DS} changes relatively slowly with V_{GS}.) The result is a turn-off time delay where V_{GS} has to drop significantly before r_{DS} begins to rise.

Gate capacitance is nonlinear

Switching-time and drive-power calculations for power MOS FETs tend to be inaccurate when computed from small-signal input capacitance and source-resistance values. That is because gate input capacitance is highly nonlinear. A more accurate method of calculating a MOS FET's switching-time and drive-power values can be derived from a knowledge of the MOS FET's gate-charge behavior as a function of the transistor's gate-source voltage. Fig. 3 shows this behavior for an IVN5200 MOS FET, which is driven from a current source whose output is integrated to derive the charge.

As can be seen, the MOS FET's dynamic input capacitance is different for three distinct gate-source voltage regions. Take the curve where the drain supply voltage is 60 V. The first region exists between a gate-source voltage of 0 V to a threshold value (a charge of about 1,100 picocoulombs). In this region, the MOS FET is essentially off. The relative linearity of the gate-source voltage's rise indicates that the capacitance is fairly constant.

Regions two and three

As the gate-source voltage is increased, the curve enters the second region, in which a large increase in capacitance occurs. In this region, the drain-source voltage is falling and the Miller effect takes place, being bounded by charge values of approximately 1,100 to 4,800 pC.

In the third region, above 4,800 pC, the slope of the gate-source voltage curve begins to increase again, although not quite as much as in the first region. Again, the slope is relatively linear. In this region, the MOS FET is on and the transistor's drain-source voltage is no longer changing. No Miller effect is present here.

A knowledge of gate-source voltage and capacitance values for each of the MOS FET's three regions allows the circuit designer to calculate the input capacitance for each of these regions.

As for drive-power requirements, the energy, W, needed to turn the MOS FET on is defined as:

$$W = \tfrac{1}{2}V_G Q_G \text{ watt-seconds}$$

where V_G is the gate voltage and Q_G is the gate charge.

If the MOS FET's gate is driven on and off repetitively from a resistance source at a rate f_0, then the drive power is:

$$P = Q_G V_{GS} f_0$$

At a V_{GS} of 10 V and a switching rate of 100 kilohertz, 7.5 milliwatts of drive power would be required for an INV5200. That is a vast improvement over a comparable bipolar transistor.

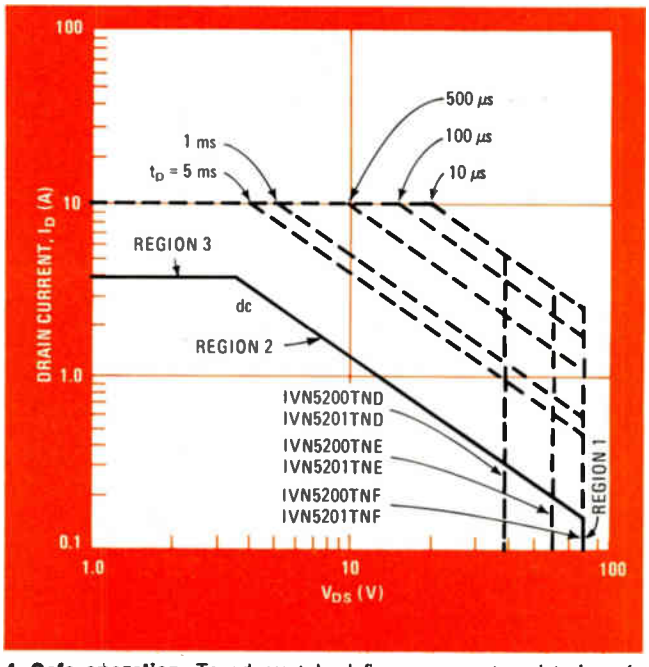
For a power semiconductor device to perform satisfactorily, the circuit designer must make sure that the device is operated within its voltage, current, and thermal ratings. Generally, power-device manufacturers provide the device's maximum ratings, a safe-operating-area rating (SOAR) curve, and a thermal-impedance curve. However, a maximum-rating table of values by itself is insufficient, and unfortunately, that is all that some manufacturers supply.

More than the ratings

As can be seen in Fig. 4, the SOAR curve for a MOS FET has three boundary regions. Region 1 is defined by the MOS FET's breakdown-voltage capability. Region 2 is defined by the device's thermal capability, where a junction temperature of 150°C maximum is normally specified. This limits the power dissipation to a peak junction temperature of 150°C. Higher peak powers can be defined from a family of thermal curves for shorter pulse widths. Region 3 is defined by the device's current-handling capability.

The current-handling capability of a MOS FET is limited by the diameter of its bond wire, the area of the bonding pad on the die, and the metalization on the die surface. Although breakdown-voltage and junction-temperature limitations for a power transistor can be determined readily by direct measurement, current limitations are derived empirically from life testing. The maximum current is limited to a value that has been found to give an acceptable service life.

In a bipolar transistor, there is a rapid decrease in h_{FE}—the transistor's common-emitter static forward current-transfer ratio—above its current ratings. In a MOS FET, however, the gain is not reduced at high currents. For fast-pulse applications where a high drain-source voltage is acceptable, the temptation may exist to operate the transistor with very short high-current pulses



4. Safe operation. To adequately define a power transistor's safe operation conditions, a safe-operating-area rating (SOAR) curve is necessary. For a MOS FET, this curve has three boundary regions: for breakdown voltage, thermal capability, and current capability.

in excess of the ratings. Doing so is inadvisable for two reasons, even if the device's power dissipation is low. First, the device's reliability or service life is likely to be shortened. Second, for sufficient increases in current densities, it is possible that current-injected avalanche breakdown could occur and cause the destruction of the transistor.

For a bipolar transistor, the SOAR curves include a fourth boundary region, defined by the thermally induced secondary breakdown characteristics of the transistor. There are several ways of inducing secondary breakdown in a bipolar transistor. One way is by lateral thermal instability. When the temperature of a hot spot on the transistor is sufficiently high, the transistor's impedance is reduced drastically, funneling the collector current through a small area. This leads to eventual destruction of the device.

Another way is by avalanching. When the transistor's collector voltage is raised to the breakdown point of the collector-base junction, a very large current flows, causing the device to go into secondary breakdown.

MOS FETs have wider breakdown regions

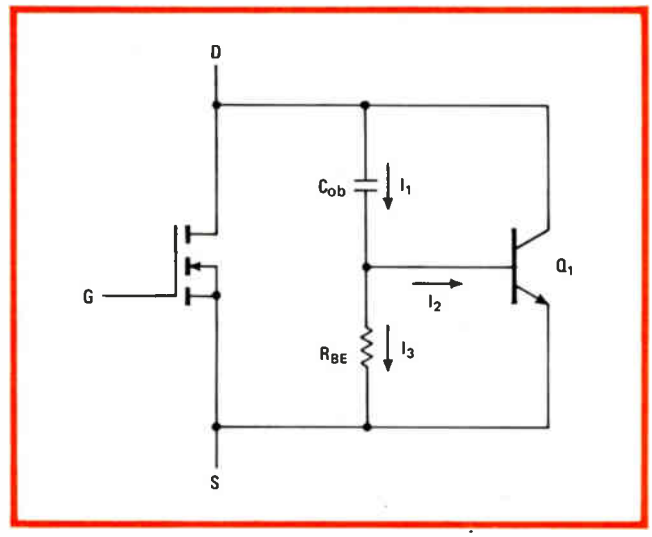
It has been widely advertised that MOS FETs do not exhibit secondary breakdown. This claim is not true. It is true that the thermally induced secondary breakdown phenomena so prevalent in bipolar devices is *not* present in MOS FETs, but avalanche-induced secondary breakdown is.

A MOS FET structure contains an npn transistor. The voltage limit of the this transistor is its base-collector junction breakdown voltage. Its base-emitter resistance, temperature, and h_{FE} all determine the current level at which primary breakdown becomes secondary breakdown.

In a MOS FET, the npn transistor's base and emitter terminals are shorted together on the die, so as to yield the least base-emitter resistance. Minimizing this resistance improves the MOS FET's drain-source dV/dt characteristics. Furthermore, the h_{FE} of a MOS FET's parasitic bipolar transistor is much lower than that of a conventional bipolar transistor. The net result is a higher current level at which secondary breakdown occurs compared with a bipolar transistor.

MOS FETs have maximum drain-source voltage ratings that are well below the actual breakdown point, so that voltage avalanche breakdown is not usually a problem. Theoretically, the current-injected avalanche breakdown present in bipolar transistors during reversed-bias operation can also lead to secondary breakdown in MOS FETs. For a given field gradient within a transistor, a maximum current-density threshold exists above which self-sustaining avalanche breakdown occurs. That threshold is the basic current-handling limitation of any power transistor. For MOS FETs, internal current densities are limited by design, so that the junction-temperature thermal limit is reached well before any current-injected avalanching is present. Since the thermally induced and avalanche-induced breakdown limits lie well outside the published SOAR curves, neither one is of direct interest to a user.

Typically, the SOAR curve for a bipolar transistor or a MOS FET is plotted for a transistor case temperature of 25°C, for either dc or single-pulse operation. In reality, case temperatures often exceed 25°C and operation is often by repetitive pulsing. Therefore a user must modify the standard MOS FET SOAR curves to conform to the application at hand. Modification can be done by using the transient thermal-impedance, or $Z_{(th)}$, curve normally supplied by the MOS FET manufacturer.



5. Equivalent. A MOS FET contains an inherent bipolar transistor whose equivalent circuit and switching performance are shown above. This parasitic structure can impose a limit, through switchback effects, on the rate of rise of the FET's drain-source voltage.

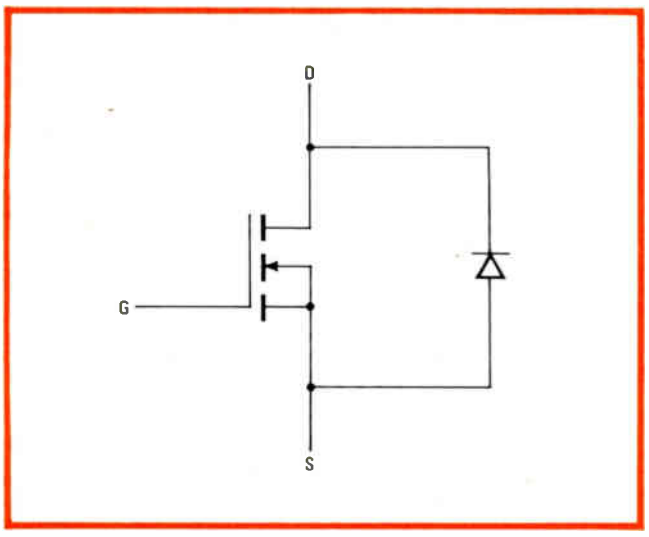
Bipolar structure limits MOS FETs

The bipolar transistor structure within a MOS FET can impose a limit on the rate of rise of the MOS FET's drain-source voltage, V_{DS}. Figure 5 shows an equivalent circuit of a parasitic bipolar transistor, Q_1, in parallel with a MOS FET. Even though the MOS FET's source metalization connects the n^+ and the base p regions at the die's surface, a significant amount of base-emitter resistance, R_{BE}, exists due to the bulk resistance of the n and p regions. Furthermore, there is capacitance C_{ob} caused by the collector-base junction.

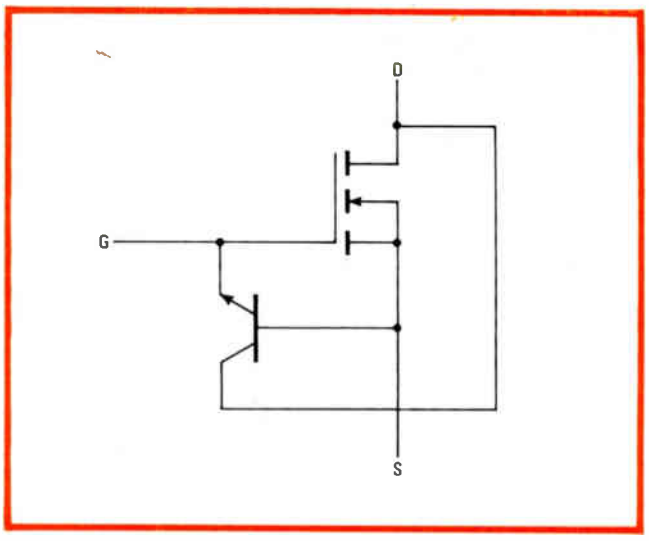
When the drain-source voltage undergoes a positive transition, a current flows through C_{ob} equal to $C_{ob}(dV_{DS}/dt)$. As V_{DS} rises more rapidly, more current flows through C_{ob} until a point is reached where the voltage across R_{BE} is sufficient to turn on Q_1. This undesirable turn on, or switchback, interferes with the normal circuit operation of a MOS FET and can possibly destroy it.

The threshold for switchback varies from one MOS FET device type and manufacturer to another. Maximum dV_{DS}/dt information is not yet a standard item of information on most MOS FET data sheets. Thus a user must consult with the device's manufacturer or test the device to determine his parameter. For Intersil's IVN5000 and 5200 MOS FETs, dV_{DS}/dt ratings are at least 20 V/ns.

The dV_{DS}/dt rating for a MOS FET can be improved by designing the FET's die layout for minimum R_{BE} and by controlling the doping of the p region to produce a bipolar transistor with low h_{FE}. In any parasitic bipolar



6. Internal diode. Below a MOS FET's dV/dt triggering threshold level, the internal bipolar npn structure is inactive and acts as a device with shorted emitter and base terminals—an equivalent circuit is shown above—allowing an FET to be used as a diode.



7. Protection. The first V-MOS power devices on the market included an on-chip zener diode from gate to source terminals, to prevent gate breakdowns caused by static charging. Newer MOS FET power devices are more rugged and do not require this on-chip diode.

structure, h_{FE} is a function of the transistor's temperature. The dV_{DS}/dt switchback threshold decreases with increasing temperatures.

Using the internal diode

When the MOS FET's V_{DS} rise time is below the threshold of the switchback level, the internal parasitic npn bipolar transistor is inactive and acts as a transistor whose base is shorted to its emitter. The equivalent circuit shown in Fig. 6 is that of a diode in parallel with an ideal MOS FET. If V_{DS} is reversed, the diode conducts and can thus be used as a rectifier or as an inductive energy clamp in switching circuits. The diode's forward-current and breakdown-voltage ratings are equal to those of its parent MOS FET.

Reverse-recovery time for the diode can be very fast. For example, in the IVN5000 and the 5200 MOS FETs, it is typically 60 to 70 ns. This rapid reverse-recovery time is a function of the MOS FET's fabrication process and can vary widely from manufacturer to manufacturer. During fabrication, lightly doped epitaxial diodes with sharply defined doping gradients are produced. In addition, when a p region is formed by ion implantation, dislocations are caused in the semiconductor's crystal structure. These dislocations act as recombination centers for the stored junction charge and speed up reverse-recovery time.

Like maximum dV_{DS}/dt values, reverse-recovery time data is not normally found on MOS FET data sheets. Again, users are advised to seek this information from the device's manufacturer.

Synchronous rectification

A MOS FET can also be used as a synchronous rectifier. When the gate-source voltage, V_{GS}, is positive, current will flow through the FET in either direction with equal facility. For synchronous rectifier operation, V_{GS} is zero when the drain is positive with respect to the source. When V_{DS} reverses, the FET's gate is energized and current flows through it in the reverse direction. The forward voltage drop is proportional to the FET's $r_{DS(on)}$ and the current flowing. When the threshold level of the parallel diode is reached, current bypasses the FET channel and the rectifier acts like a conventional pn junction diode.

For currents that keep V_{DS} under the 0.6-V diode threshold, the FET acts as an ultrafast high-voltage and low-capacitance rectifier with no minimum offset voltage. Such behavior is useful for employing the device as a power rectifier up to 15 megahertz. Currently available MOS FETs can be used in this manner, with the only drawback being a relatively high $r_{DS(on)}$ value that restricts the amount of useful current. Future MOS FETs are likely with low-voltage and low-$r_{DS(on)}$ characteristics, specifically designed for this type of service. Such characteristics will make possible the switching of large amounts of power efficiently for 2- to 5-V loads.

Internal zeners are no longer needed

The first MOS FETs on the market using V-groove structures included on-chip zener diodes connected from gate to source terminals. The diodes prevented gate breakdowns due to static charging. Each diode was formed by diffusing in an additional npn transistor, with the zener action being accomplished by the reverse breakdown of the npn bipolar transistor's base-emitter junction (Fig. 6).

The on-chip diode has a number of drawbacks. For one thing, its ability to handle no more typically than 2 milliamperes severely limits the FET's power dissipation. In addition, when the FET's gate is pulled negative to −0.6 V or more, the npn transistor turns on and draws current from the drain circuit, which can destroy the transistor. The result is poor device reliability.

On the other hand, experience has shown that the gate structure of a discrete power MOS FET is much more rugged than that of a small-signal MOS integrated circuit. Given reasonable care in packaging, handling,

Linear characteristics—a closer look

The output characteristics of MOS field-effect transistors differ from those of bipolar power devices. For a given die area, the total power loss of a MOS FET is greater than that of a bipolar transistor at frequencies below 20 kilohertz. Above 20 kHz, the power loss of the latter becomes much greater than that of the former. The differences can be seen, for example, from the behavior of an Intersil IVN5200 power MOS FET, where the on drain current, I_o, is shown as a function of the drain-source voltage, V_{DS}, in (a) and (b).

Two distinct regions of operation are apparent, a linear region and a saturated one (for bipolar devices, the definitions of these regions are almost exactly opposite). In the linear region (where V_{DS} is approximately equal to 0 to 5 volts), the voltage across a MOS FET's channel is not sufficient for the carriers to reach their maximum drift velocity or their maximum current density. In this region, the FET operates as a square-law device; the static drain-source resistance, $r_{DS(on)}$, is equal to V_{DS}/I_o at each point, and the small-signal drain-source resistance, $r_{ds(on)}$, is the slope of the transfer curve.

As V_{DS} is increased, the carriers reach their maximum drift velocity and the device enters the saturation region, where the output impedance is high (the curves are relatively flat) and the equal spacing between the curves for the gate-source voltage, V_{GS}, is an indication of constant transconductance, g_m. In this region, the transfer function is linear.

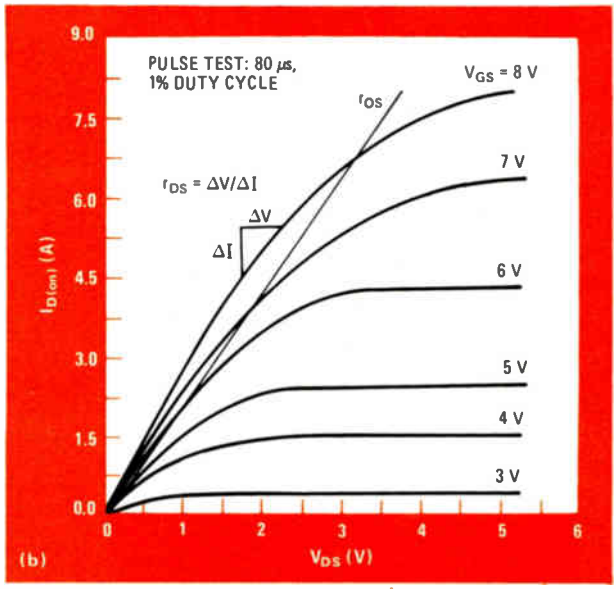
The output conductance, g_{os}, of an INV5200 is relatively independent of temperature. Its transfer characteristic is shown in (c).

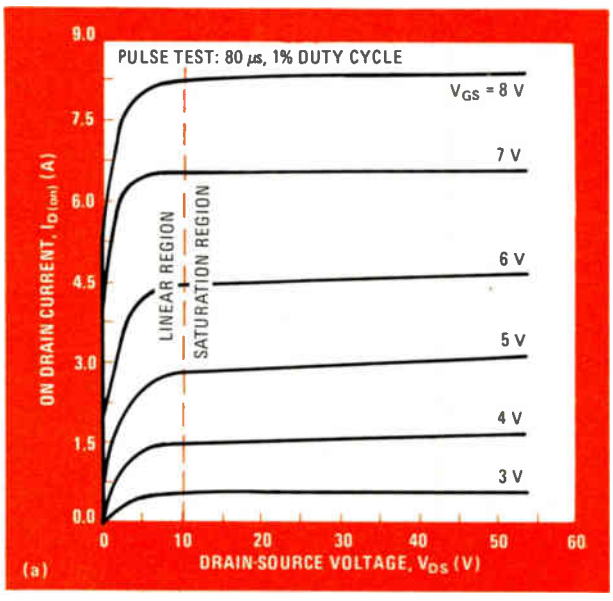
$V_{GS(th)}$ is defined as the gate voltage at which some small current, usually 1 to 10 milliamperes, depending on device size, begins to flow. It varies as a function of temperature. Typically, an IVN5200 exhibits a temperature coefficient of 6 millivolts/°C.

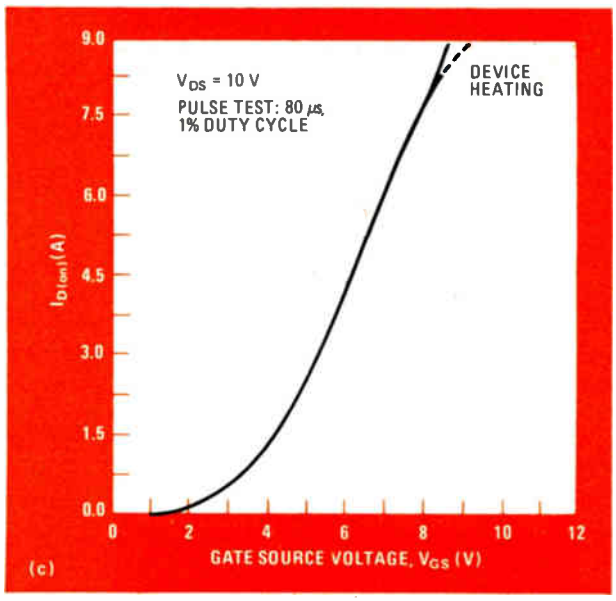
For switching applications, the temperature dependence of $V_{GS(th)}$ is not very significant. However, for linear applications, the MOS FET's bias point may need to be stabilized by the use of a source resistance or other negative-feedback scheme in order to keep this temperature dependence at a minimum.

A characteristic of short-channel MOS FETs is that, for a given V_{DS}, transconductance increases with I_{DS} until a point is reached where it becomes constant.

Drain-source on-resistance. A MOS FET's $r_{DS(on)}$ is made up of two components: the channel on-resistance and the bulk device resistance. In low-voltage devices (less than 100 V), $r_{DS(on)}$ is primarily caused by the channel





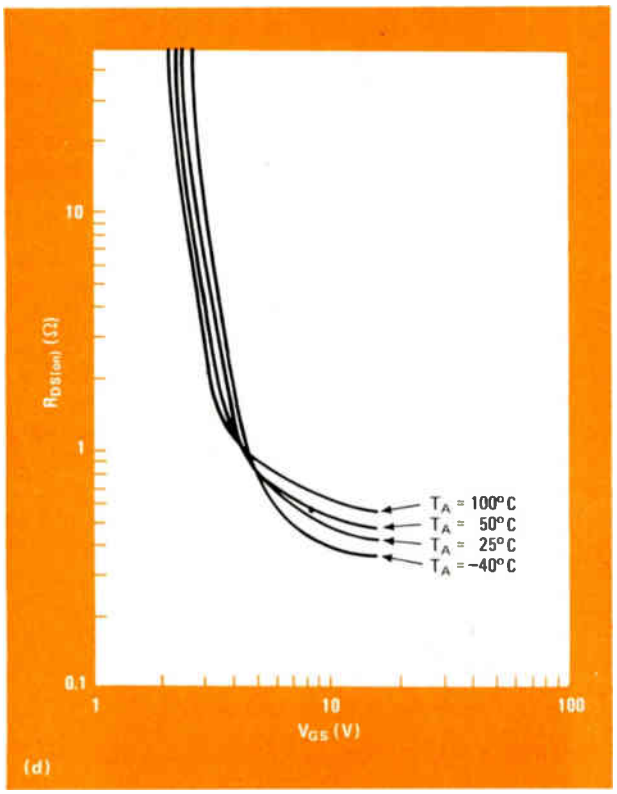


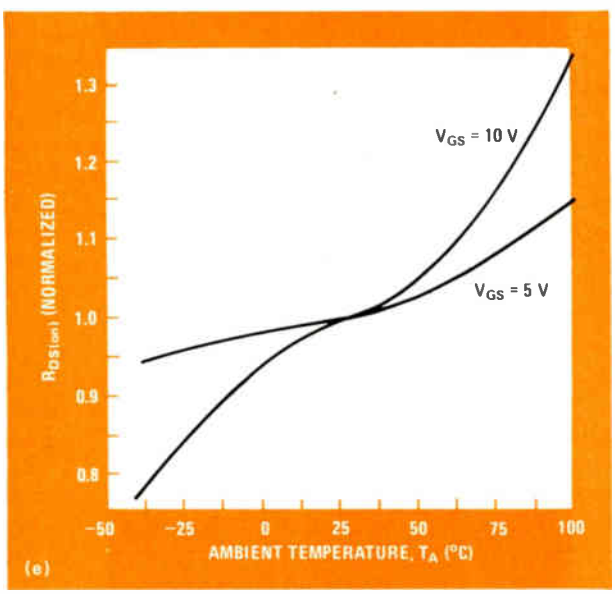
and installation, there is no need for an internal zener diode in most applications.

The positive temperature coefficient of a MOS FET's $r_{DS(on)}$ is useful when these devices are operated in parallel with each other. It is possible to parallel MOS FETs, without any matching, in dc applications; the device that

resistance. In higher-voltage devices, however, the minimum $r_{DS(on)}$ value is domimated by the resistance of the epitaxial layer.

Figure (d) shows how channel resistance is controlled by the degree of device gate enhancement. On-resistance can be decreased by increasing V_{GS} to about 15 V.





A point of diminishing returns, however, sets in, so that little is gained by increasing the gate-source voltage much above 15 V. It is also important not to approach the gate breakdown voltage in the quest for a low $r_{DS(on)}$. For MOS devices with higher $V_{GS(th)}$ levels, the curve in (d) will be displaced to the right, but the shape remains essentially the same.

The effect of temperature on $r_{DS(on)}$ at different values of V_{GS} is shown in (e). Note that the temperature coefficient of $r_{DS(on)}$ is positive, which is a major reason why a power MOS FET has an improved safe operating area over bipolar power transistors and can be easily paralleled. This positive coefficient, which is caused by the competitive effects of a positive temperature coefficient of silicon and a negative temperature coefficient of $V_{GS(th)}$, varies in value between +0.2% and +0.7%.

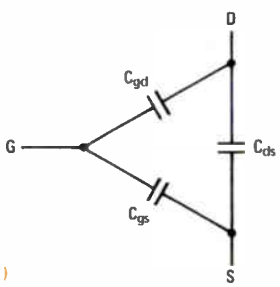
As shown for V_{GS} = 5 V, when V_{GS} is close to $V_{GS(th)}$, threshold effects predominate. As V_{GS} is increased, the temperature coefficient begins to take on the positive characteristics of silicon. In devices with voltages of more than 80 V, r_{DS} is dominated by the device's bulk resistance and the temperature coefficient is more nearly linear, with typical values being +0.6% to +0.9%.

Capacitance effects. Like the bipolar power transistor, the power MOS FET has significant input, output, and transfer capacitances that vary with voltage. For example, capacitances exist between the gate structure and both the source and drain structures, known as C_{gs} and C_{gd}.

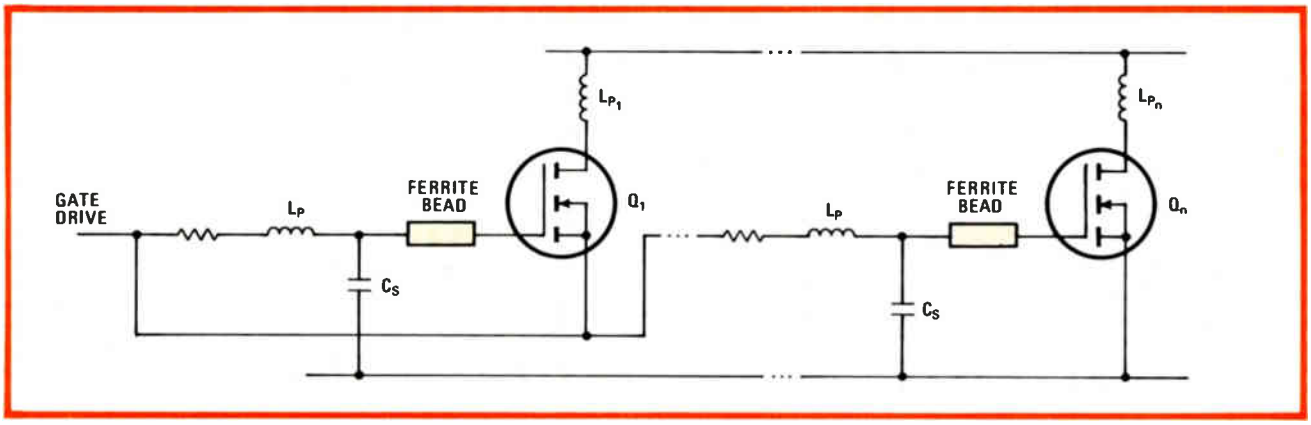
Also, the base-collector junction of the inherent npn transistor in the MOS device, a reverse-biased pn junction, contributes capacitance between the drain and source structures (C_{ds}). C_{ds} shunts the series combination of C_{gd} and C_{gs} as shown in (f).

These three capacitances in turn result in C_{iss}, C_{rss}, and C_{oss} capacitances. C_{iss} is the parallel combination of C_{gd} and C_{gs}, C_{oss} is the parallel combination of C_{ds} and C_{gd}, and C_{rss} is the same as C_{gd}. Each of these varies with changing V_{DS} for a MOS FET, increasing very rapidly for V_{DS} under 10 V. For V_{DS} greater than 10 V, each of these capacitances decreases slowly at a nearly constant rate.

Since a MOS FET uses an insulated gate structure, its input current, I_{GSS}, is normally very small—on the order of a few picoamperes—at room temperature. This current is made up of the leakage current through the gate structure and surface leakage current between the package terminals. Like any leakage current, I_{GSS} increases exponentially with increasing temperatures.



initially draws the most current and consequently heats up shifts the current to other FETs, thereby distributing the current among the paralleled devices more equally. Unmatched paralleling of MOS FETs is not recommended for dc applications, however, because a higher than necessary power dissipation level may occur. Mismatch-



8. In parallel. When power MOS FETs are operated in parallel, they tend to oscillate at very high frequencies, particularly if large numbers of them are paralleled. This tendency can be greatly reduced by inserting ferrite beads or resistors in series with the gate leads.

ing will also cause one FET to turn on or off before or after the other parallel FETs in switching applications and consequently one device may have to accept the full-load current. The FET may therefore function outside its SOAR and fail.

MOS FETs can operate in parallel

By matching the $V_{GS(th)}$ levels of MOS FETs to within 5% of each other, paralleled operation is much more effective. This matching ensures that the turn-on and turn-off delays, due to the gate-voltage rise and fall time relative to $V_{GS(th)}$, are nearly equal. This will also ensure the matching of each FET's $r_{DS(on)}$, eliminating excessive differential heating of the FETs. By providing a higher V_{GS} drive potential so that all of the paralleled FETs operate at their minimum $r_{DS(on)}$ values, the effects of mismatching are further reduced.

Keep in mind that many MOS FETs have gain-bandwidth products in excess of 500 MHz and therefore can oscillate at very high frequencies, particularly when many of them are paralleled. Such oscillations are often unsuspected causes of device failures. These oscillations can be reduced significantly by the insertion of low-value resistors (50 to 100 Ω) or ferrite beads in series with the gate leads of the FETs as shown in Fig. 8.

Symmetry needed for fast pulses

For MOS FET applications in fast-pulse circuitry, simply matching the transistors for parallel operation is inadequate. The circuit must also be reasonably symmetrical, so that identical drive voltages are applied to each FET gate. At high speeds, inductive as well as resistive effects of circuit components must be considered. For example, for proper circuit operation, the drain leads of FETs Q_1 and Q_n in Fig. 8 must have parasitic inductance values that are close to each other. If the parasitic inductance value for Q_1 is much smaller than that of Q_n, then most of the current will flow through Q_1 when the FETs are first turned on, even though the gate drive and threshold voltages of both may be identical.

Variations in the gate-circuit stray capacitance and the FET's input capacitance can also cause uneven FET turn on in this type of application. For switching times of less than 10 ns, it may be necessary to match FET capacitances. Nevertheless, in most applications, switching occurs well above 10 ns, where simple matching of FET threshold voltages is all that is needed for proper parallel operation.

For bipolar transistors, paralleling more than two devices can become a complex and expensive affair. It is for this reason that manufacturers are developing single-device bipolar transistors (as well as silicon controlled rectifiers) that handle more power. Obviously, making a device larger means increasing its die size. And as the die size increases, a point is reached where either the thermal capabilities of the case or the available mounting area for the die become limiting factors, so that a more expensive package may be necessary. These combined effects result in very expensive high-power bipolar devices.

Multiple power devices or just one?

There are well-founded arguments for the use of a single bipolar power transistor instead of a number lower-power bipolar transistors that add up to the same power level. These arguments however, do not necessarily follow for power MOS FETs, since they do not behave as bipolar devices.

The tradeoff for MOS FETs may well be between multiple low-power devices with low die and package, as well as moderate heat-sink, costs and single high-power devices with high die, package, and heat-sink costs. But just where the crossover point between single and multiple devices lies has yet to be determined, and this calculation is complicated by the fact that larger-size MOS FET chips are expected to undergo substantial price reductions.

When using MOS power devices in series, other considerations are important. All power devices operating in series with each other should turn on simultaneously, with $V_{GS(th)}$ and the gate drive for each device being matched closely. For applications where the maximum voltage capability is needed, it may be necesary to match the gate-source voltages closely, to ensure equal voltage distribution during switching transitions. The effect of parasitic capacitances for series-connected power devices is analogous to that of parasitic inductances for paralleled devices. Differential drain-source capacitances, either in a device or in a series of devices, leads to unequal sharing of transient voltages. □

We'll help put the "C" in your CF-18 systems.

At Garrett Manufacturing Limited, you'll find an experienced partner to help meet your Canadian content requirement in electronic sub-systems aboard the new Canadian fighter aircraft.

In fact, with our famous temperature control systems, we're already part of the F-18 aircraft. As well as the overwhelming majority of Western military and commercial aircraft.

For the F-18's sophisticated electronics, GML has the technical base and the facilities needed to handle all of your sub-contract manufacturing and testing needs. From custom thin and thick film hybrid microcircuits, printed circuit board assemblies and black boxes to control display units/consoles for a variety of requirements. Including radar, fire control, navigation, communications, air data computers, missiles, training simulators and ground support equipment.

And when it comes to testing, you'll find that we're up to the job. We have extensive automatic test facilities with complete diagnostic capabilities for both analog and digital systems and RF equipment. Our advanced manufacturing centre also has facilities for production burn-in/environmental testing, and our qualification test labs are fully equipped and MIL approved.

As a military supplier for over 20 years, our expertise in efficient program management ranges from material procurement and subcontractor supervision to complete life cycle support.

Finally, GML is backed up by the vast technical resources of The Garrett Corporation, whose worldwide support network includes 14 sales and service offices in the U.S.

For more information on how GML can play a leading role in your defense sharing plans by offering high technology at a competitive price, contact: Sales Manager, Garrett Manufacturing Limited, 255 Attwell Drive, Rexdale, Ontario, Canada M9W 5B8. Or call: (416) 675-1411.

GARRETT MANUFACTURING LIMITED

GARRETT The Garrett Corporation
One of The Signal Companies

Estimating the power coupled into an optical fiber

Nomograph yields values for butt joint using parameters supplied on data sheet

by Steven L. Storozum, *McDonnell Aircraft Co., St. Louis, Mo.*

☐ Many engineers in communications, industrial control, and computers are thinking of including fiber optics in their designs. Initial evaluation is soon followed by the first attempt at a working system, which is often thrown together as quickly and inexpensively as possible. At this breadboard stage, light is usually fed into a fiber by simply butting the fiber up against a light-emitting or laser diode and clamping it there.

Here is a nomograph (Fig. 1) that provides a quick, easy way to determine graphically the coupling loss in a butt joint, from which the power coupled into the fiber may be calculated. The estimate relies only on specifications commonly made available on manufacturers' data sheets for diodes and fibers.

The data sheet for a given diode lists its light-power output, but the manufacturer cannot specify the power coupled into a fiber because of the wide variety of fibers available. To get the coupled power, designers generally resort to measurements made with an optical power meter. The nomograph, however, can be used before the parts are even in hand.

Safety factor

The engineering assumptions made in the nomograph's derivation lead to conservative estimates of coupled power. These estimates in turn promote conservative preliminary system design. In a final design, techniques more sophisticated than simple butting are used to couple more power into the fiber.

These techniques include the use of lenses, index-matching fluid, and antireflective coatings to enhance coupling efficiency. All are used in the final packaging of light sources and fibers. The nomograph does not take final-design techniques into account: it is meant only for a worst-case analysis.

Using the light-power output figure quoted on the diode manufacturer's data sheet, experience shows, is reasonable in practice—deviations have little effect on the nomograph's accuracy. It is assumed that all the power specified is emitted from the front of the diode where the butt is made. Any other assumption would involve taking into account too many unknown or uncontrollable factors.

It is also assumed that the diode is perfectly butted to the fiber so that the air gap between them is infinitesimal. Again, assuming otherwise is impractical; in any case, a gap variation makes little difference as long as it is small.

It should be noted, however, that the nomograph assumes the use of step-index optical fiber. If dimensionally similar graded-index fiber is used, the power loss will be about 1 decibel greater than the nomograph indicates.

A geometry problem

It is also assumed that the fiber core is centered on the emitting area of the light source. Centering is easy to do in practice. It is then an exercise in plane geometry to calculate the area of overlap between fiber and diode in the three cases of interest.

The first two cases are elementary. If the fiber core area encloses the emitter's active area (A_e), the shape of the emitter is of no consequence and the overlap area (A) is equal to A_e. Conversely, when the emitter's active area encloses the fiber core area (A_f), the emitter's shape is still of no concern, and the overlap area equals A_f.

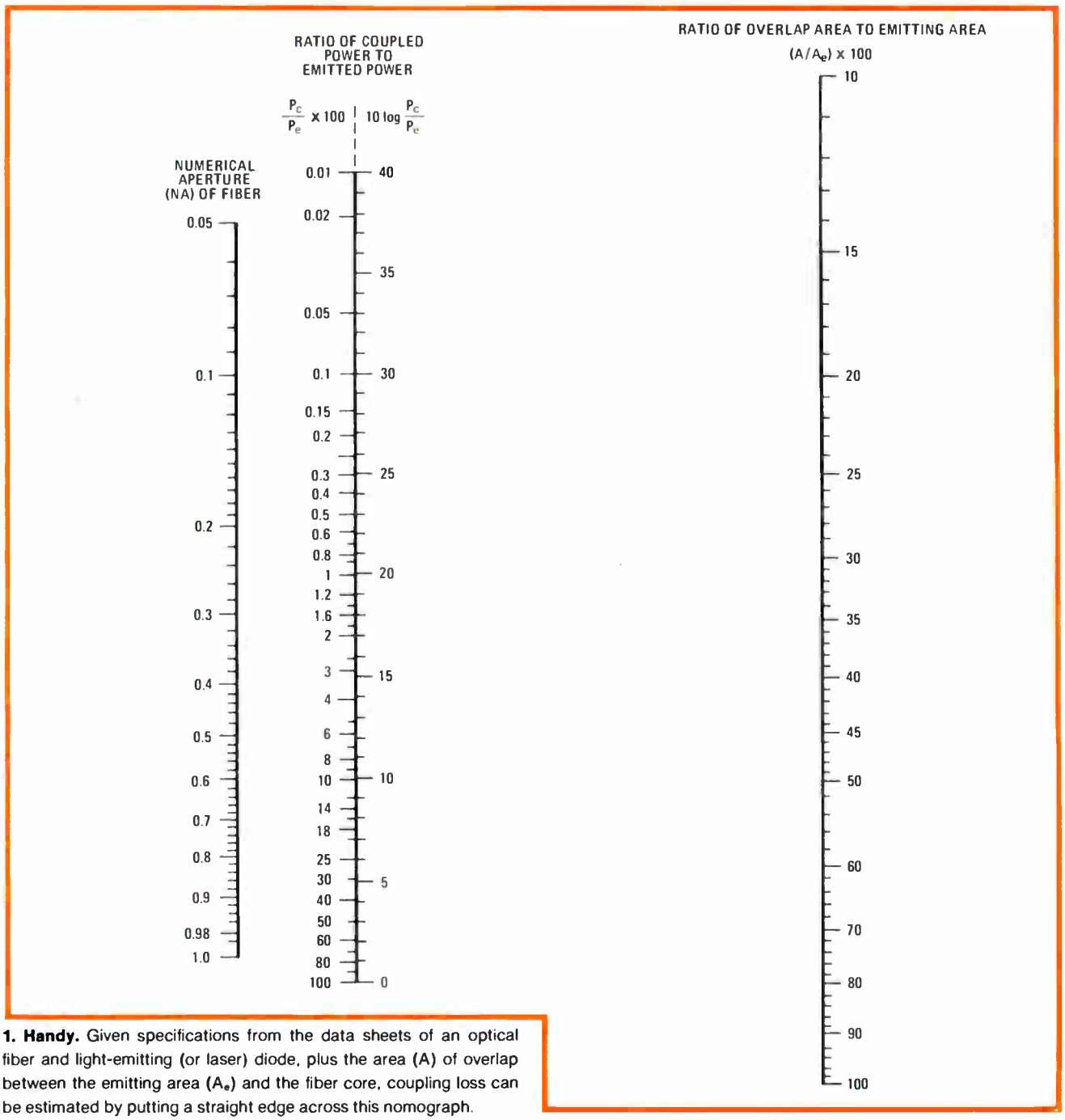
The third case arises with a rectangular emitter area (which most diodes have) that is longer than the fiber's diameter. The overlap area A, in this case, is found by calculating the approximate area of the intersection of the emitting rectangle and the circular cross section of the fiber (Fig. 2):

$$A = (H/2)(4R^2 - H^2)^{1/2} + 2R^2\arcsin[H/(2R)]$$

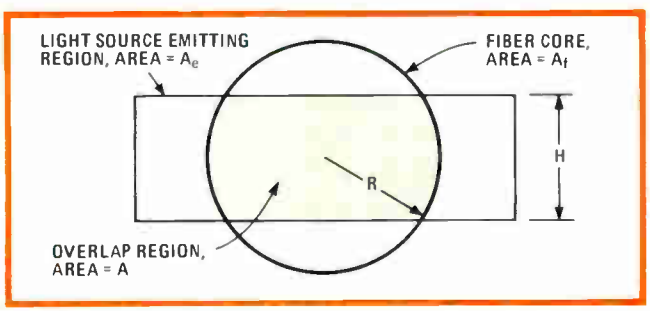
wnere R is the fiber's radius and H is the height of the active emitting area. As the ratio of H to R grows very small, A approaches 2HR.

All of these dimensions are readily available from the manufacturers, as is the numerical aperture (NA) of the fiber used in the nomograph estimation. After overlap area A is calculated, the ratio of A to A_e is determined and the point on the nomograph's right-hand scale found. A straight line through this point and the point on the numerical aperture scale at left crosses the center scale at a point indicating the ratio of coupled power (P_c) to emitted power (P_e).

The results are helpful in computing tradeoffs in an optical fiber system. For example, trading numerical



1. Handy. Given specifications from the data sheets of an optical fiber and light-emitting (or laser) diode, plus the area (A) of overlap between the emitting area (A_e) and the fiber core, coupling loss can be estimated by putting a straight edge across this nomograph.



2. Overlap. The portion of the light source's active emitting area that actually butts up against the fiber must be found to use the nomograph. The emitter is often rectangular; if it is longer than the fiber's diameter, overlap area (A) must be calculated by plane geometry.

aperture for fiber core diameter can be done to find the optimum fiber from the standpoint of coupling loss.

Suppose a step-index fiber with 0.25 NA and an A/A_e ratio of 0.4 is assumed as the first guess for some system. The nomograph indicates that a coupling efficiency of about 1.2% (19 dB loss) can be obtained. This may be satisfactory, but a fiber with a 0.3 NA can achieve the same efficiency with a more practical A/A_e ratio of 0.28.

This example illustrates the usefulness of fibers with large numerical apertures given a specific coupling-efficiency requirement. Of course, the bandwidth of source and fiber must also be considered during preliminary design, but these factors can also be estimated rapidly [*Electronics*, Nov. 23, 1978, p. 135]. □

Micromapped control system jumps on multiple flags

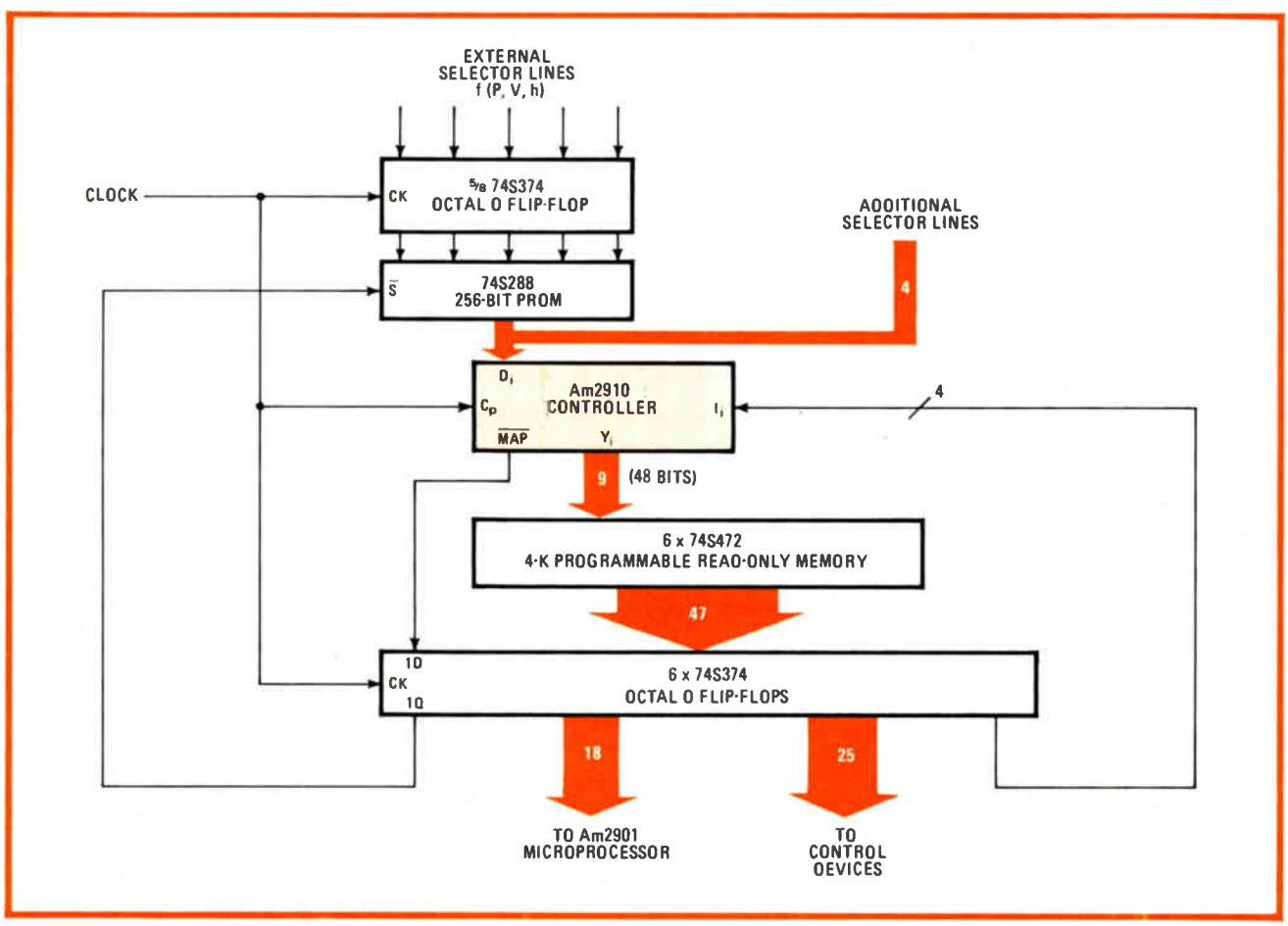
by Sorin Larnescu
Teledyne Systems Co., Northridge, Calif.

Not even the most versatile of controllers, such as Advanced Micro Devices' Am2910, provides a microprogrammed system with the specific ability to select its next microinstruction as a function of more than one input variable. A viable system can be implemented, however, if programmable read-only memories and a few latches are added to the basic configuration, thus making it possible, for example, for the program to jump to any desired location for any given set of input conditions. Utilizing the input variables in this PROM-mapping scheme achieves the objective at minimum cost and without complex circuitry.

The hardware technique is illustrated for a 48-bit thermodynamic control system in which any of 32 combinational conditions of temperature, pressure, and humidity, as detected by the five address (external selector) lines, direct a microprogrammed routine to jump to a corresponding location. Thus the system is a barometer of real-time conditions, determining when the input variables constitute a serious but not hazardous state of affairs or, alternatively, when to shut down.

The states of the five external inputs are periodically latched into the 74S374 octal flip-flop by the system clock. This set of signals makes up the command address for the 74S288 PROM, whose 8-bit output drives the direct inputs of the Am2910 controller. The output of the controller represents the corresponding start address of the microprogram instruction cycle that is executed by the 74S472 operating memories.

If, under program control, any of the aforementioned 32 danger conditions should be detected by the controller, the corresponding microprogram will be run. By using the Am2910's arithmetic capabilities, the pre-



Expansion. PROMs and latches supply controller with the ability to select its next microinstruction as a function of a multiple set of input conditions. Monitored variables map input PROM for controller, whose output represents starting microinstruction address for 74S472 operating memory. Result of computation is passed on to the microprocessor, thus making possible program jumps or transfer of contents.

scribed actions may then be taken immediately.

An 18-line bus for controlling the microprocessor is required between the latches and the microprocessor to transfer 48-bit data. Four lines are dedicated to controlling the Am2910. Twenty-five control lines are made available for closing mechanical relays, activating lamps, and so on. Execution time for each microinstruction is shortened by applying the map line of the controller, which bypasses the Am2910's internal pipeline register, to the 74S288's enable port via one output latch. □

SCR controller keeps motor speed constant

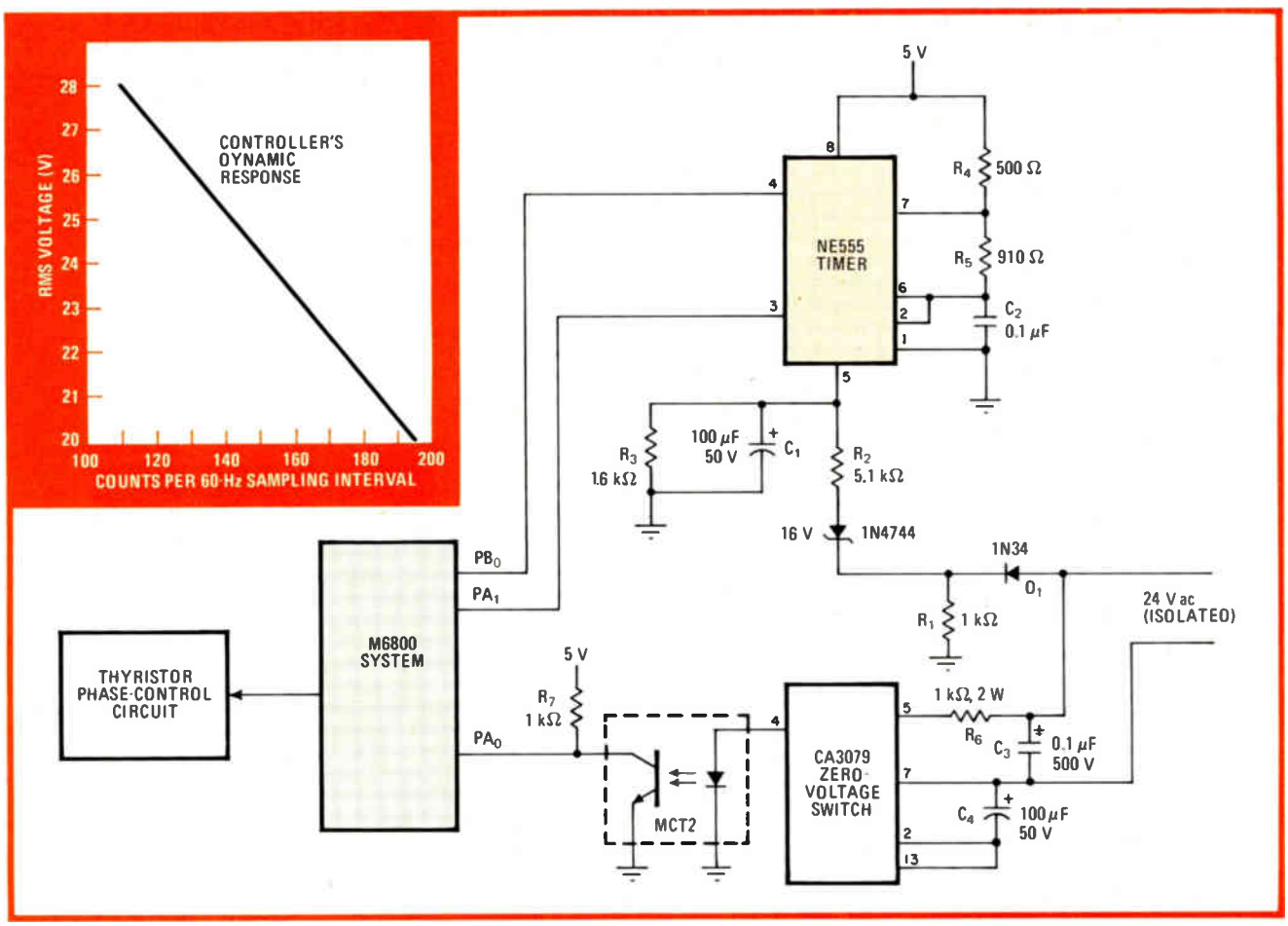
by William Linkowski
Copier Systems Division, Pitney Bowes Inc., Danbury, Conn.

This microprocessor-based controller is a compact and relatively low-cost solution to the problem of adjusting a silicon controlled rectifier's firing angle to conform with variations in rms driving voltage in order to hold motor speed or light intensity constant. Use of an open-loop system also simplifies the circuitry considerably.

The technique is shown implemented in a standard SCR circuit driven with a 24-volt, 60-hertz ac line. Diode D_1 passes each positive half cycle of the line voltage to pin 5 of the 555 timer through the zener, which fires when the incoming signal exceeds 16 V. Low-pass filter R_2–R_3–C_1 thus develops a dc voltage proportional to V_{in} for driving the timer, which operates as a voltage-to-frequency converter running at a center frequency of about 10.8 kilohertz.

Meanwhile, the CA3079 switch delivers a pulse to the PA_0 line of the 6800 microprocessor via the MCT2 optocoupler each time the input voltage passes through zero. This pulse initiates a counting interval of 16.6 milliseconds (one 60-Hz period) during which the 555's transitions at PA_1 are summed. The total count is thus proportional to the actual rms line voltage.

The typical rms voltage-to-count response is shown at the upper left (inset). The software relates this information to an internal look-up table that indicates the time increment correction needed to delay or advance the firing of the SCR to maintain motor speed. □



Invariant. From monitored line voltage, microprocessor-based controller determines delay or advance-triggering time required for firing SCR in order to hold motor speed constant—independent of line variations. Software relates trigger time to a count that is proportional to the rms line voltage. Open-loop system, made possible by processor's look-up tables, simplifies circuitry considerably.

Sampling filters simplify converter's offset measurement

by Dennis Knowlton, *National Center for Atmospheric Research, Research Aviation Facility, Boulder, Colo.*

A microprocessor-based data-acquisition system has difficulty in making corrections for input offset and gain drift when it uses active filters to remove the effects of aliasing, or system noise. In such circumstances, the filters' frequency response and settling time vary as a function of the sampling rate and the magnitude of the input signal. However, the difficulties encountered with these sampled-data systems may be overcome by means of a switched aliasing filter, so that the anomalies in filter response may be virtually neglected and the offset and gain drift may be readily determined under software control.

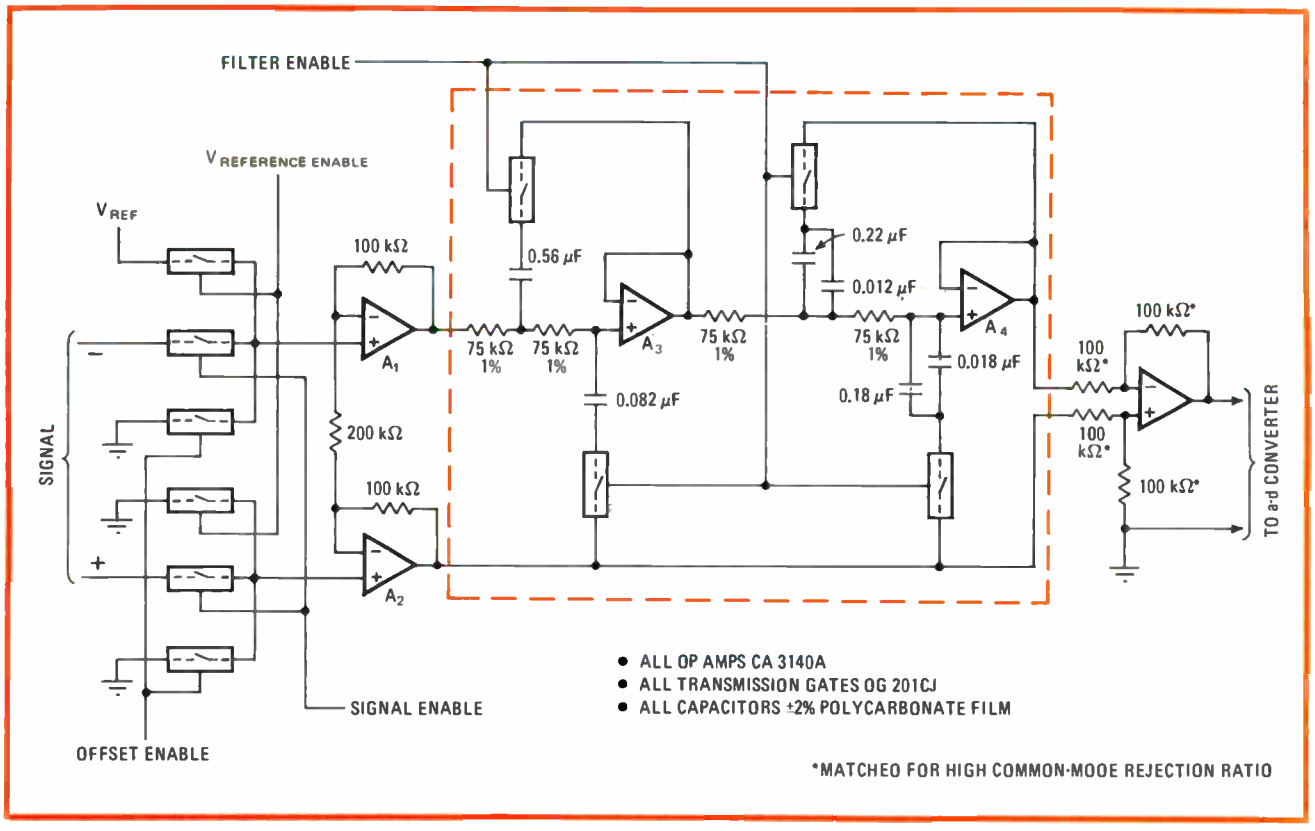
In the typical input stage leading to the system's a-d converter, the noninverting ports of op amps A_1 and A_2 are periodically switched to ground and to a reference voltage so that the circuit can be isolated from all external stimuli and its inherent offset and gain determined. This scheme eliminates potentiometers and the requirement for precision components. It also leaves the measuring task to the software routine, where time and temperature have no effect on system accuracy, and where the data can be corrected for actual gain and offset by means of look-up tables.

Because of sampling, however, the filter's frequency-domain response becomes a factor and thus a significant amount of signal data can be lost during the filter's settling time. Switching the filter out at a very slow rate compared with the signal sampling rate, and doing so at a low duty cycle, eliminates the problem.

The key to the success of the circuit lies in the fact that in the standard active filter, the only energy-storage elements are capacitors. Switching these elements out of the circuit periodically transforms the filter into one that has a very high cutoff frequency; thus the filter is essentially out of the circuit and its op amps' offset and gain drift can be easily measured. When the capacitors, which store the instantaneous value of the driving signal, are switched back into the circuit, they perform their basic filtering function. Thus, assuming the use of fast op amps, a high-speed a-d converter, and low-leakage capacitors in the filter, the signal-path response of the filter is unchanged; yet, offset and gain drift can be determined.

Shown in the circuit example is a simple four-pole filter built around A_3 and A_4 whose components are selected to reject aliasing noise at 10 hertz. Signal-path sampling is done at 50 Hz and capacitor switching at 0.1 Hz for a duration of 12 microseconds. The input and output stages of the circuit all utilize standard differential amplifiers. □

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.



Indeterminate. Aliasing filter A_3–A_4 for data-acquisition system makes it impossible to ascertain input offset and gain drift unless it is itself of the sampling type. Filter's signal-path response will be unchanged, but stages' inherent imperfections can then be measured.

WE TURN OUT MORE LIGHTS THAN ANYBODY ELSE.

We've developed the industry's broadest and most advanced line of infrared LEDs and detectors. We also offer more opto package configurations. And more products available in volume orders.

That's everything you need for precision switching and sensing functions in applications requiring encoding, card and tape sensing, object positioning and detection.

On the emitter side, our LEDs utilize power efficiently to provide reliable and accurate operation in a variety of packages. We match that capability with high performance photodiodes, phototransistors, photodarlingtons and photo ICs. Plus, we manufacture the only opto Schmitt component with internal voltage regulation that's compatible with TTL, CMOS, and other standard logic families.

All Spectronics parts are available in volume from a nationwide network of distributors. And our staff of highly trained engineers is available to answer any questions you may have about the design or implementation of our products.

So, if you've been in the dark about opto design, give us a call. We turn out more lights so you can turn out better designs.

For more information, call us at 214/234-4271. Or write to Spectronics, 830 East Arapaho Road, Richardson, Texas 75081.

Spectronics
A division of Honeywell

Light years ahead.

TYPICAL SPECS FOR SPECTRONICS' EMITTERS AND DETECTORS

LED

Near IR Emitter	935 nM
T_r	0.6 µS
High efficiency solution grown	
P_O	5 mW @ I_F = 100 mA
High pulse current	30 A

PHOTODIODE

T_r	5 nS
I_L	40 µA @ H = 5 mw/cm² V_R = 20V
Application	Linear, analog or hi-frequency

PHOTOTRANSISTOR

T_r	5 µS
I_L	12mA @ H = 5 mw/cm² V_{CE} = 5V
V_{CE} (SAT)	0.2V @ I_C = .4 mA
Application	General Purpose Detectors

PHOTODARLINGTON

I_L	100 µA 6 mA @ H = 0.2 mw/cm² V_{CE} = 5V
V_{CE} (SAT)	1.1V @ I_C = 1 mA
Application	High current or high light sensitivity requirements

PHOTO IC
Schmitt Trigger Output

T_r, T_f	30 nS
Output Sink	10 TTL loads @ V_{CC} = 4V
Propagation Delay	5 µS
T_{op}	-55 to +100°C
Application	Opto Switching

Engineer's newsletter

High-level math software for TRS-80 now available

Microsoft Consumer Products of Bellevue, Wash., has announced the availability of muMATH, a symbolic math package that for the first time enables the popular TRS-80 microcomputer to do sophisticated mathematics. Developed by the Software Warehouse of Honolulu, Hawaii, it gives the TRS-80 the power to perform algebraic, trigonometric, calculus, and other symbolic math operations accurately and efficiently.

muMATH's capabilities include exact rational arithmetic and automatic algebraic simplification. **Other talents include logarithmic simplifications and symbolic differentiation and integration.** All operations are performed with a precision to 611 digits. The package requires a TRS-80 having a minimum of 32 kilobytes of RAM and a single disk drive. To take full advantage of its capabilities a 48-K system is needed. The muMATH package includes the muMATH diskette and complete instruction manual. Suggested retail price is $74.95. For the name of the nearest dealer, contact MCP at 10800 Northeast Eighth, Suite 507, Bellevue, Wash. 98004, or telephone (206) 454-1315.

IEC standardizes more electronic symbols . . .

Keeping engineers all over the world abreast of current electronic symbology, the International Electrotechnical Commission has recently issued Publication 148B, which contains the latest letter symbols agreed to internationally for semiconductor devices and microcircuits. The second supplement to Publication Standard 148, this manual **contains over 100 letter symbols that apply to bipolar transistors, low-power signal diodes, voltage-reference and voltage-regulator diodes, thyristors, digital and analog integrated microcircuits, and current-regulator diodes.**

. . . and receiver measurement methods, too

Also released is Publication 489-5, the fifth supplement to the standard used to specify measurement methods for radio equipment used in the mobile services, IEC Publication 489. IEC 489-5 deals specifically with radio receivers having audio-frequency bandwidths generally not exceeding 10 kHz for the reception of single-sideband signals. **The new standards makes it possible to compare** the measurements made by other observers on other equipment. The cost of Publication 148B is 32 Swiss francs, and that for 489-5 is 70 Swiss francs. Write the Information Officer, Central Office of the IEC, Geneva, Switzerland.

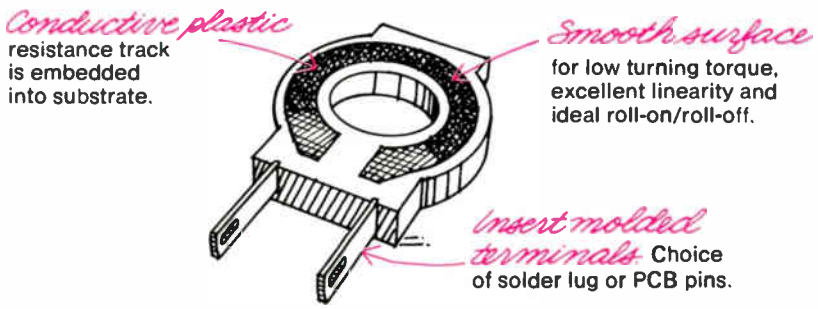
Op amp integrator needs no capacitor

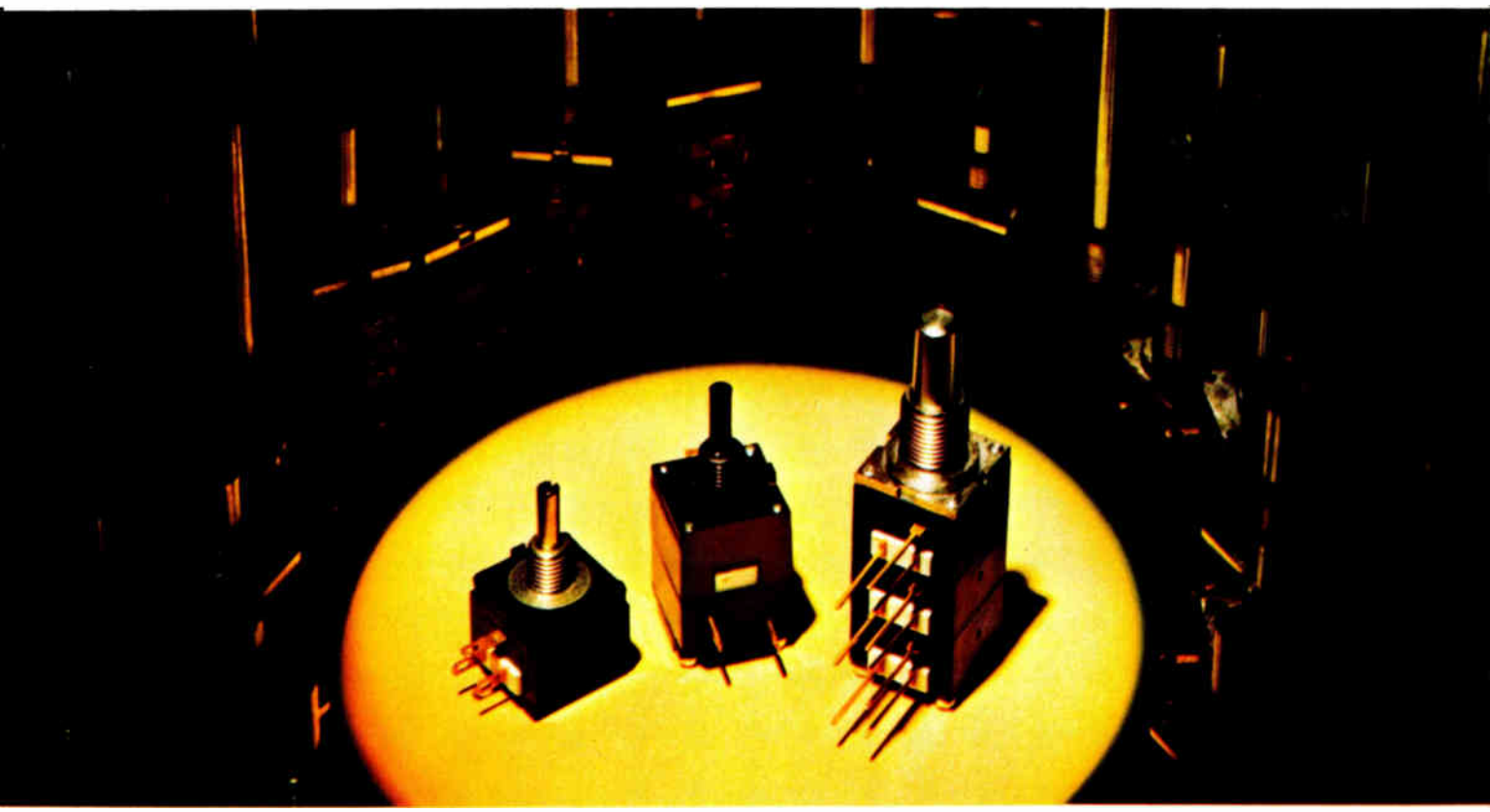
It's easier to utilize the inherent rolloff characteristics of an op amp to make an adjustable integrator than it is to adjust the values of the typical RC integrator's capacitor or to simultaneously vary its feedback and input resistor combination, says Angelo Pariani of Milan, Italy. Besides, he adds, the relatively high cost of the external capacitor can be saved.

The response of the typical inverting op amp integrator is $F(\omega) = (-R_f/R_i)/(1+j\omega CR_f)$, where R_f is the feedback resistor, R_i is the input resistor, and C is the integrating capacitor. But the frequency-dependent gain of the op amp itself is $A(\omega) = K/(1+j\omega/\omega_T)$ where K is a constant and ω_T the inherent cutoff radian frequency. **As a consequence, an integrator can be formed with only R_f and R_i**—no capacitor is needed. For if a potentiometer R_x is placed between the inverting input of the op amp and ground to select the cutoff frequency, the circuit's response will be $F(\omega) = (-R_f/R_i)/\{1+j\omega[(R_i+R_x)R_f+R_iR_x]/(R_iR_xBW)\}$, where the gain-bandwidth product, BW, is equal to $K\omega_T$. **-Vince Biancomano**

New conductive plastic element now available in the MOD POT®... the original modular potentiometer.

Allen-Bradley introduces a new conductive plastic resistance element with low turning torque for velvet smooth rotation. And CRV of typically less than 0.2%. Linear and modified log tapers (CW and CCW) are available from 100 ohms to 1 megohm. All feature smooth characteristics, particularly at resistance roll-on and roll-off positions. Conductive plastic elements are available in Series 70, 72 and 73 versions. Come to the original source for MOD POT potentiometers. We have what you need; our distributors have them when your need is now. Ask for Publication EC5670-1.1.





Quality in the best tradition.

ALLEN-BRADLEY
Milwaukee, Wisconsin 53204

EC214

Circle 161 on reader service card

No one portable everyone's needs.

So we built 21.

Everyone's needs are different. Some want the same versatility in the field they get from a bench model in the lab. Others are more concerned about weight. Some require basic performance models at an economical price. Tektronix offers a selection of 21 portable scopes — 15 real-time and 6 storage models — to satisfy just about everyone.

Take your pick. You can't beat our 400 Series when it comes to high performance. Choose from 9 models ranging in bandwidth from 50 MHz to 350 MHz. All under 26 pounds (11.8 kg). Five with an optional DMM and delta time read out.

If you're looking for a battery-powered model that fits into a briefcase or toolbox, there's our 200 Series. Bandwidths to 5 MHz. Weights less than 3.7 pounds (1.7 kg).

In between, there's the compact 300 Series, with bandwidths to 35 MHz. Each scope weighs less than 11 pounds (5.0 kg). And finally, we offer the low cost T900 Series.

Our worldwide service team goes where you go. We're with you all the way, with more than 500 service personnel at 46 Tektronix centers in the U.S.A. and hundreds of Tektronix-supported service engineers in over 50 other countries to calibrate and maintain your Tektronix scope.

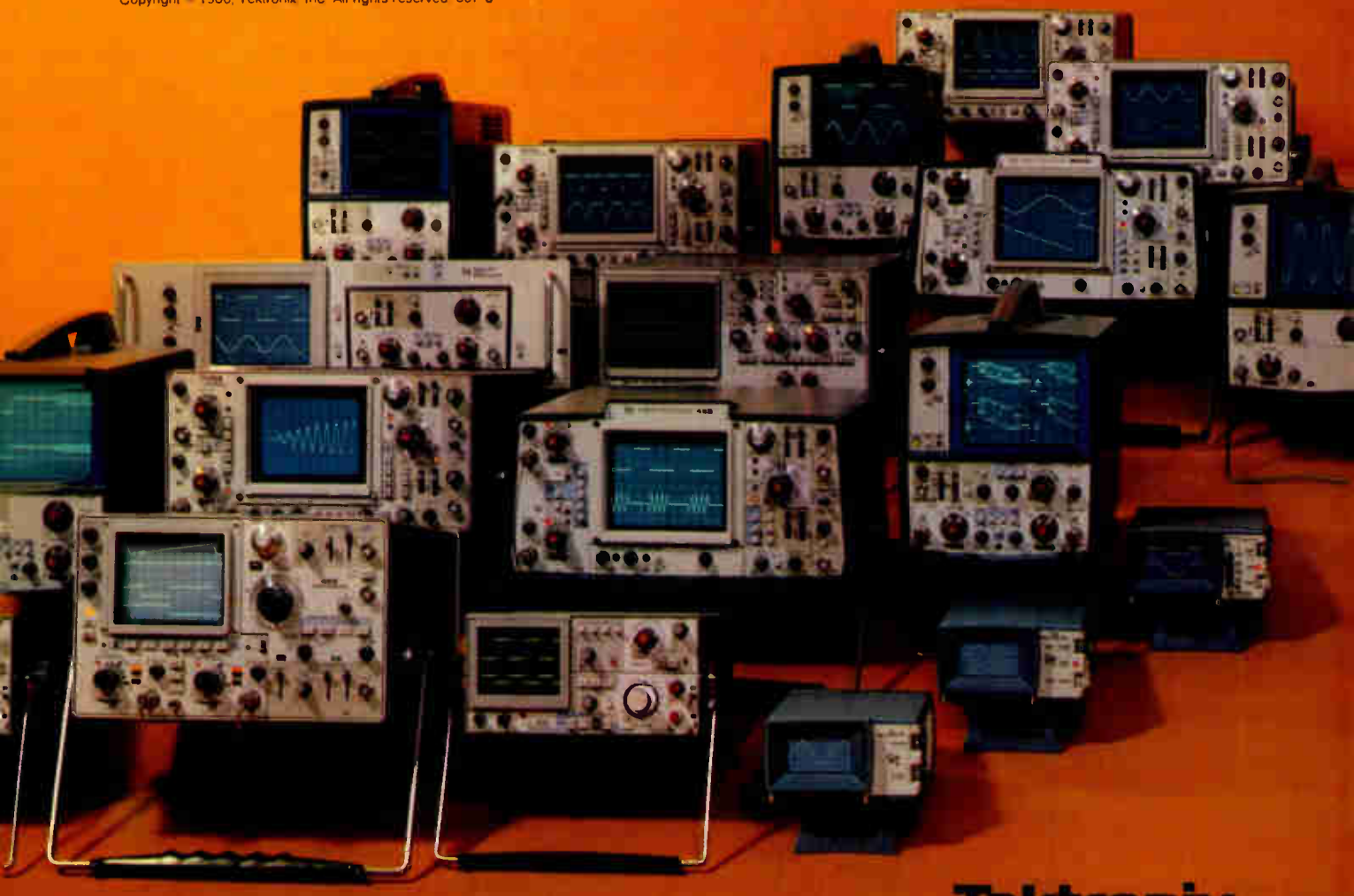
So let us show you the model that's right for you. Simply contact your Tektronix Sales Engineer. He'll arrange for a demonstration of our portable or laboratory oscilloscopes. And for our latest portable oscilloscopes brochure, write: Tektronix, Inc., P.O. Box 1700, Beaverton, OR 97075. In Europe: Tektronix International Inc., European Marketing Centre, Postbox 827, 1180 Av Amstelveen, The Netherlands.

We're going places

scope meets

	Product	Bw	Dual Trace	Delayed Sweep	Fastest Sweep Rate	Other Special Features
Storage Models	466	100 MHz @ 5 mV/div	yes	yes	5 ns/div	3000 div/μs stored writing speed
	464	100 MHz @ 5 mV/div	yes	yes	5 ns/div	110 div/μs stored writing speed
	434	25 MHz @ 10 mV/div	yes		20 ns/div	Split-screen storage
	314	10 MHz @ 1 mV/div	yes		100 ns/div	Only 10.5 lbs (4.8 kg)
	214	500 kHz @ 10 mV/div	yes		1 μs/div	Only 3.5 lbs (1.6 kg)
	T912	10 MHz @ 2 mV/div	yes		50 ns/div	Low-cost bistable storage
Nonstorage Models	485	350 MHz @ 5 mV/div	yes	yes	1 ns/div	Widest bw in a portable
	475A	250 MHz @ 5 mV/div	yes	yes	1 ns/div	High-performance 250-MHz portable
	475	200 MHz @ 2 mV/div	yes	yes	1 ns/div	Highest gain-bw in a portable
	465B	100 MHz @ 5 mV/div	yes	yes	2 ns/div	Cost effective for 100-MHz bw
	465M	100 MHz @ 5 mV/div	yes	yes	5 ns/div	Triservice standard 100-MHz scope
	455	50 MHz @ 5 mV/div	yes	yes	5 ns/div	Cost effective for 50-MHz bw
	335	35 MHz @ 10 mV/div	yes	yes	20 ns/div	Only 10.5 lbs (4.8 kg)
	305	5 MHz @ 5 mV/div	yes		0.1 μs/div	Autoranging DMM
	221	5 MHz @ 5 mV/div			100 ns/div	Only 3.5 lbs (1.6 kg)
	213	1 MHz @ 20 mV/div			400 ns/div	DMM/Oscilloscope @ 3.7 lbs (1.7 kg)
	212	500 kHz @ 10 mV/div	yes		1 μs/div	Low cost for dual trace & battery
	T935A	35 MHz @ 2 mV/div	yes	yes	10 ns/div	Variable trigger-holdoff and differential
	T932A	35 MHz @ 2 mV/div	yes		10 ns/div	Delayed sweep and differential
	T922	15 MHz @ 2mV/div	yes		20 ns/div	Low-cost dual-trace scope
	T922R	15 MHz @ 2mV/div	yes		20 ns/div	Rackmount version of T922
	T921	15 MHz @ 2mV/div			20 ns/div	Lowest-cost TEKTRONIX Portable
Time Interval Readout	DM44	Optional, factory-installed, direct numerical readout of time intervals and DMM functions for the 464, 465B, 466, 475, 475A				

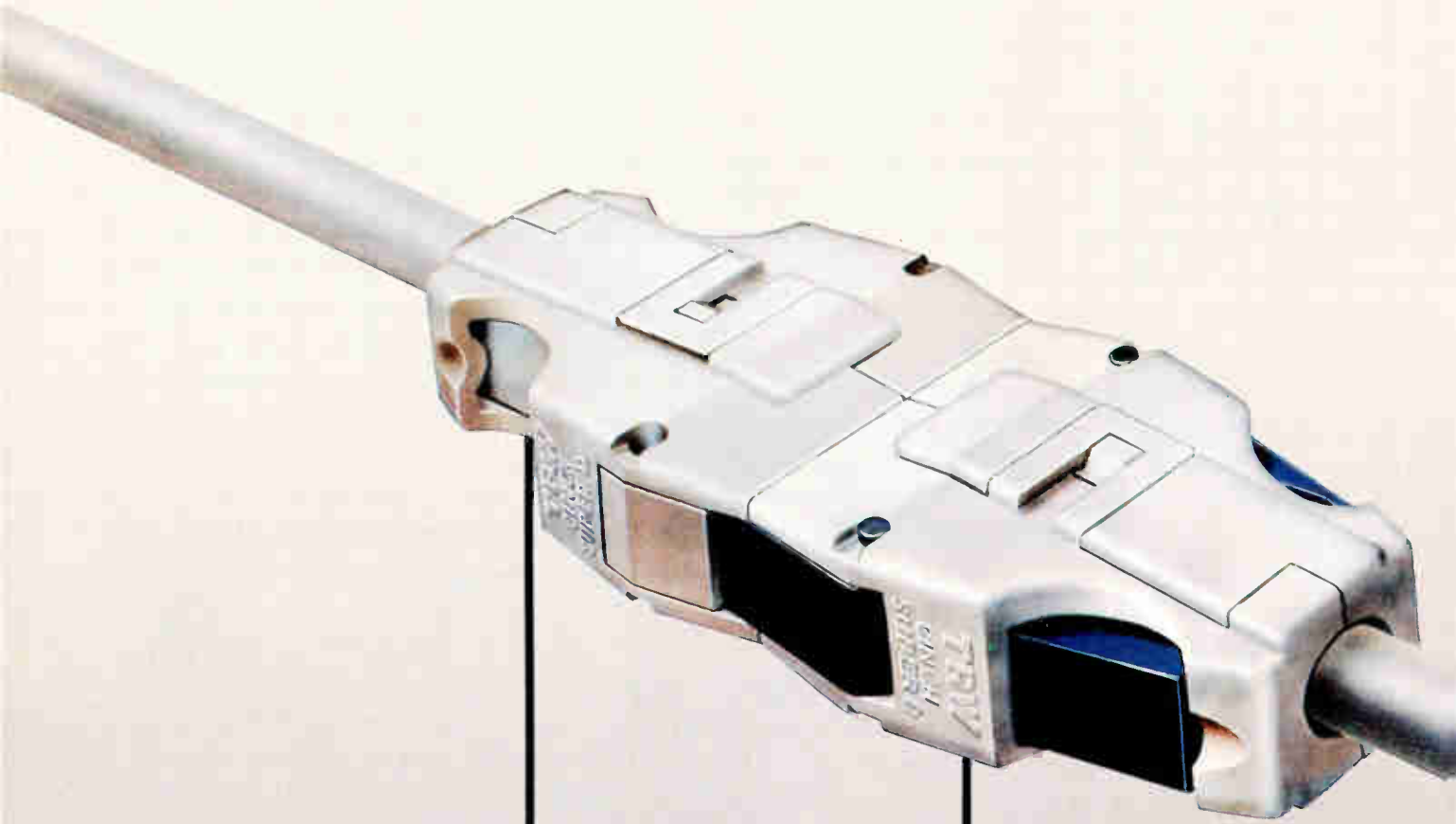
For price and availability outside the United States, please contact the nearest Tektronix Field Office, Distributor or Representative.



For immediate action, dial our toll free automatic answering service 1-800-547-1512

Tektronix
COMMITTED TO EXCELLENCE

Super D*



Rapid Solderless Termination 4-point Contact Eliminate Wire Stripping.

Super D Adaptor System For D-type Connectors

Choose From Four Standard Super D Connector Sizes... 9 (on left), 15, 25, and 37 (right) contacts.

*Trademark TRW Inc.

U.S. Patent Nos.
3,902,154 4,035,049 4,090,770
other Patents Pending

A unique all plastic snap-locking connector system that costs less and does more than standard D-Subs.

Here's Why Super D* is "The D With The Difference".

Different? You bet! TRW Cinch's all new Super D connector system has the exclusive design features and cost-saving benefits that move it to the top of any D-Sub line!

Let's begin with cost savings. Most D-subs require soldering or crimping. Not Super D connectors. Our new pre-loaded pin/socket contacts provide solderless insulation displacement 4-point termination.

This unique contact also gives you twice as many contact points at mating end as other D-sub designs. All without wire prepping or stripping. Result? Immediate assembly time reduction and a positive cost savings with increased reliability!

But that's not all! Besides fast, solderless termination, Super D connectors also have snap-on plastic hoods that feature an exclusive Latch-N-Lock design for positive, audible locking with no additional tools, parts or labor. Just push to connect, squeeze and pull to disconnect. It's that easy!

To convert standard TRW Cinch D-subs to the Super D system, ask us about our special adaptor system for D-type connectors.

Looking for style and design? Look no further! Super D's cost-effective all-plastic assembly is both smooth and functional to complement the styling of your computer, peripheral, data communication, instrumentation or video equipment.

This plastic design effectively insures against shock hazards.

Super D connectors employ *selective* gold plating only where it is needed. We've eliminated expensive gold from non-functioning surfaces. So you get performance without added cost.

The Super D connector is available in four sizes (9, 15, 25, and 37 contacts) for cable-to-cable and cable-to-panel modes. Each will intermate with existing D-type connectors. And, you'll be glad to know that the Super D system is designed to meet EIA Standard RS449 plus IS04902 and 4903 for your DTE and DCE equipment.

To further speed your termination time, TRW Cinch has designed three terminating tools specifically for the Super D connector system. Use Auto-Clinch D* for high volume; Certi-Clinch D* for moderate production and field installation; and Uni-Clinch D for field repair.

So take a long, hard look at the D-subs you're using now. Then, take a look at Super D connectors. There *is* a big difference! To get the Super D difference, write or call your TRW Electronic Component Sales Office . . . listed in EEM, or TRW Cinch Connectors, A Division of TRW Inc., 1501 Morse Avenue, Elk Grove Village, IL 60007. 312/981-6000

TRW CINCH CONNECTORS

Circle 165 on reader service card

New easy-to-use educational module. Your best ticket to the microprocessor world. Ideal for teaching. Yourself. Or others.

TI's new TM990/189 University Module is a stand-alone learning lab. Fully assembled and designed for maximum hands-on experience. To ease and simplify learning and teaching.

Outstanding features include powerful 16-bit microprocessor with easy-to-learn, easy-to-use minicomputer instruction set; 45-key alphanumeric keyboard and ten-digit seven-segment display for easy assembly-language programming; ROM-resident software including system monitor for program debug and symbolic assembler; audio cassette interface; easy-to-add EIA and TTY interface; 1K-byte RAM expandable to 2K; 4K-byte ROM and 2K-byte expansion EPROM socket; 16-bit programmable I/O controller; user addressable LEDs, and sound indicator.

A 570-page tutorial text accompanies the module. It is a detailed guide for self-paced learning. Or the basis for a three-hour university course. Chapters include an overview of microprocessors; programming exercises; assembly language; memory systems; I/O concepts and designs; software engineering; product development; a variety of lab experiments, and much more. Also with the module: a 300-page user's guide.

The University Module complete with tutorial text and user's guide is only $299.00.*

To order your University Module contact your nearest authorized TI distributor. For more information, write Texas Instruments Incorporated, P.O. Box 1443, M/S 6404, Houston, Texas 77001.

Fifty Years of Innovation

OPTIONAL ACCESSORIES

TM990/189 Kit K1 **$72.00***

An I/O expansion kit that provides the following options to TM990/189:

1. Asynchronous Communication port
2. On-board relay for audio cassette interface
3. Off-board CRU expansion

TM990/189 Kit K2 **$34.00***

A RAM expansion kit that will double on-board RAM from 1K bytes to 2K bytes.

*U.S. prices, subject to change without notice.

TEXAS INSTRUMENTS
INCORPORATED

85577A

Circle 166 on reader service card

Chip gives processors protocols

Two-channel communications controller presents 8080, 8085, and 8086 systems with bit- and byte-oriented protocols

by John G. Posa, Solid State Editor

The 8080, 8085, and 8086 microprocesors have, so far, been deprived of comprehensive, easily interfaced multiple-protocol serial communications. "There is basically a hole in these families of microprocessors for a high-performance multiprotocol chip," says Henryk Szejnwald, product marketing engineer at NEC Microcomputers.

The μPD7201, designed and manufactured by parent company Nippon Electric Co. of Tokyo, is a two-channel serial communications controller that supports asynchronous and synchronous byte-oriented data communications protocols like IBM's Bisync, as well as such synchronous bit-oriented protocols as HDLC and IBM's SDLC. Its data rate is software-programmable up to a 660-kb/s rate (with a 3-MHz clock) and, as expected, is intended to meet the needs of 8080-style and most other microprocessor systems.

Szejnwald is quick to admit that, with these qualifications, NEC's new 40-pin chip is not unlike Zilog Inc.'s SIO controller chip for the 8-bit Z80 microprocessor. But to use the Zilog part in an 8080, 8085, or 8086 system means an undesirable amount of superfluous hardware design and software programming. "Intel did a study and I think they concluded that it requires six extra ICs besides the large software overhead," says Szejnwald. He adds that the converse is a much different situation, however: "For somebody who has a driver written for the SIO, the switch [to the 7201] will be easy." This easy swap was taken into consideration when the 7201 was designed.

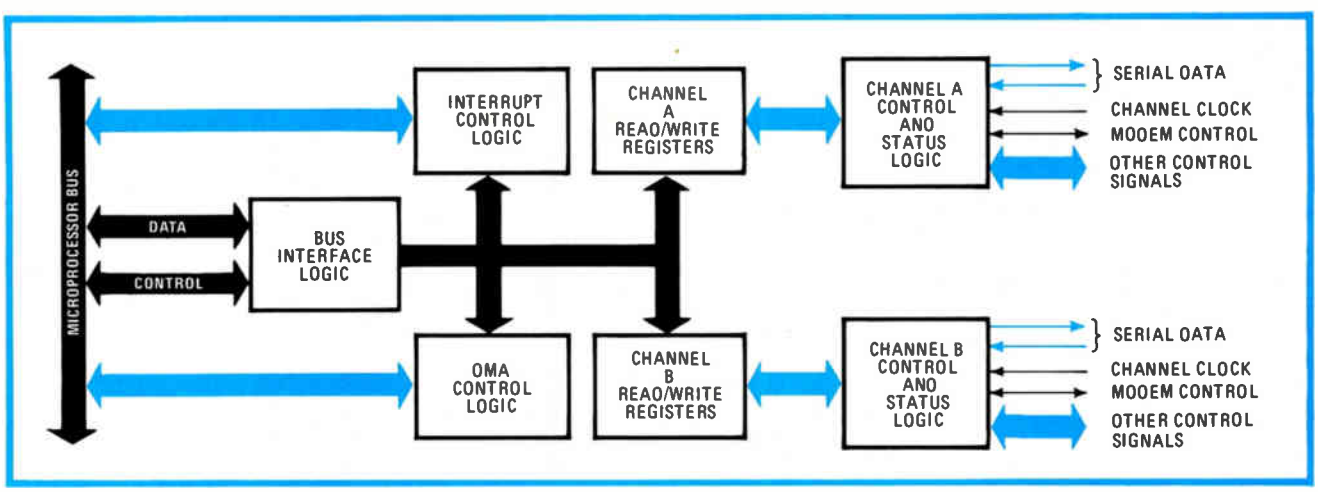
To achieve 8080 system compatibility, the new 5-V-only n-channel chip has different interrupt and direct-memory-access modes and read and write timing requirements than Zilog's SIO. Interrupt vector addresses and priorities are software-programmable, as is a flag that allows the device to meet the specifications of the 16-bit 8086 microprocessor. There are many other attributes under program control, too; indeed, NEC likes to say that the chip's "personality" can be optimized for the task at hand.

In fact, the chip can be used in applications beyond straight data communications. It can support virtually any serial protocol, according to NEC, and although both channels have built-in modem controls, these can be used for general-purpose input and output in applications without modems. For added faith in transmission, the 7201 can generate and test cyclic-redundancy-check codes in any synchronous mode and it can be directed to scrutinize data integrity in various modes.

Besides the two fully independent duplex serial channels the controller has four DMA channels. Transmitter data is double buffered and received data is quadruply buffered. The user may select between interrupt, DMA, or polling modes of operation.

The μPD7201, samples of which are now being offered, will be available in the fourth quarter for $40.00 each in quantities of 100.

NEC Microcomputers Inc. 173 Worcester St., Wellesley, Mass. 02181. Phone (617) 237-1910 [338]



How to avoid buying ATE hardware this year that you'll have to replace next year.

You can't afford to replace your test system every time there's a new advance in semiconductors. So before you invest in ATE equipment, look at the company's track record in keeping up with changing technology.

You'll find nobody has a better record than GenRad. That's because all our test systems are software-based.

And that's a crucial difference. It means you won't have to change your GenRad hardware to adjust to new technology. You simply install an updated version of our unique CAPS diagnostic software. In the last seven years alone, we've made nine major updates.

All GenRad functional board test systems are software-based. To adapt to a new technology, you simply install an updated software package.

Our continual software enhancement is the reason why the GenRad board test systems we introduced in 1972 are still testing state-of-the-art boards today.

As soon as a new IC is introduced, GenRad writes new software for it. So when you're ready to use it, your tester is ready to test it.

And since our system for field service testing runs the same test programs as our manufacturing systems, it stays up to date too.

We're also constantly updating our component test systems. The minute a company introduces a new component, we start to work on the software. So by the time you're ready to use the new component, your GenRad tester is ready to test it. And that's true for both linear and LSI digital IC's.

Doing developmental work? GenRad lets you choose the microprocessor that's best suited for the job without changing development systems. Our Futuredata development system supports virtually all the leading microprocessors. And as new chips become popular, we'll have the new software to handle them.

GenRad's Futuredata microprocessor development system is capable of programming and emulating—at full speed—all the popular microprocessors.

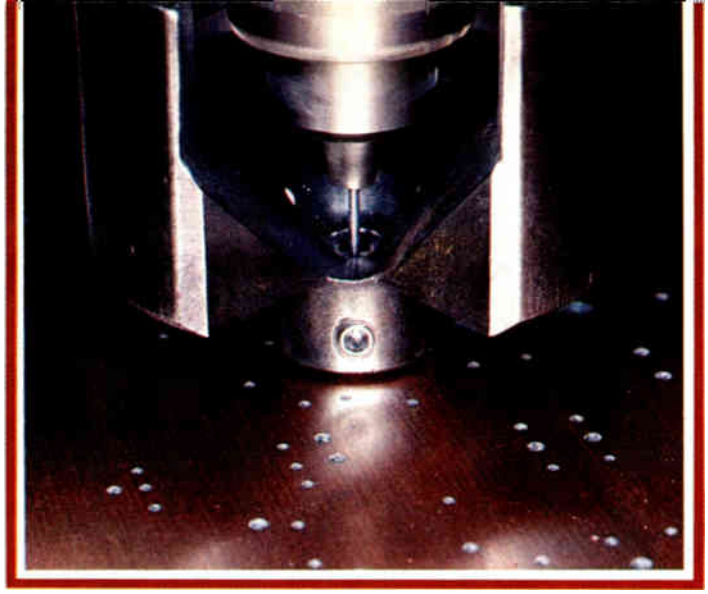
Software-based testing. It's one reason GenRad's ATE systems don't get older. They get better.

For details, write GenRad, Concord, MA 01742.

GenRad

Put our leadership to the test.

Circle 169 on reader service card



THE HOLE TRUTH

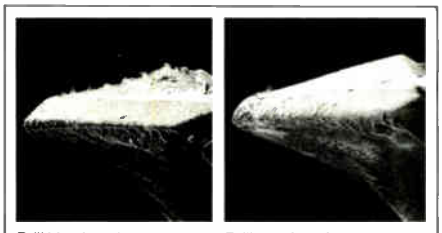
New GE Engineered FR-4. An advanced laminate designed to reduce drilling abrasion, improve thru-hole quality, and lower processing costs.

Now there's a PC board laminate with even better processing qualities than conventional FR-4. It's the new *Engineered* FR-4 epoxy-woven glass laminate from General Electric.

You can process Engineered FR-4 in exactly the same way as conventional FR-4, and tests by PC manufacturers have shown that you can enjoy improved yields and substantial productivity benefits.

The key to these benefits is a GE discovery: an exclusive epoxy adhesion promoter that greatly enhances the 3-D bonding of the epoxy resin to itself, and to the woven glass layers. The resulting uniform matrix gives the laminate much greater integrity than possible before.

As a result you can expect greater thermal shock resistance and reduced tendency toward delamination during processing. But the opportunity for cost reduction is greatest in the drilling and plating-thru operations. Less abrasion encountered during drilling means reduced heat generation and longer drill life. This is illustrated in the 260X photomicrographs below. Note differences in tip sharpness and wear.



Drill bit edge after 9300 holes in Engineered FR-4

Drill bit edge after 9300 holes in conventional FR-4

Because there is less drilling abrasion and less heat generated, the quality of thru-holes is greatly improved. With Engineered FR-4, there is less resin smear, rifling, void formation; and fewer torn glass bundles. This in turn provides a superior, more uniform surface for electroless copper plating.

New Engineered FR-4 is the first of a series of technology-oriented PC laminates designed to keep you ahead of today's application requirements. And it's now being produced at our high-capacity plant at Coshocton, Ohio. The unique GE Laminate Technical Center is located there, too, with sophisticated R&D instrumentation devoted to solving your PC processing problems.

See the hole truth for yourself. Contact us for a detailed brochure, and to arrange a trial run of new Engineered FR-4 at your facility. General Electric Company, Laminated and Insulating Materials Business Department, Box EL-5, Coshocton, Ohio 43812.

GE LAMINATES: THE DIFFERENCE IS TECHNOLOGY

GENERAL ELECTRIC

DEC introduces color terminals

Marking DEC's entry into color graphics, these display consoles cost under $15,000 and operate with the PDP-11 and LSI-11 computers

by James B. Brinton, Boston bureau manager

The recent burst of activity among manufacturers of color cathode-ray tube monitors [Electronics, *April 10, p. 153*] *was a warming-up exercise for the general movement toward color graphics among terminal and computer manufacturers. Current product introductions confirm a growing commitment to providing color for business and industrial uses at a reasonable price.*

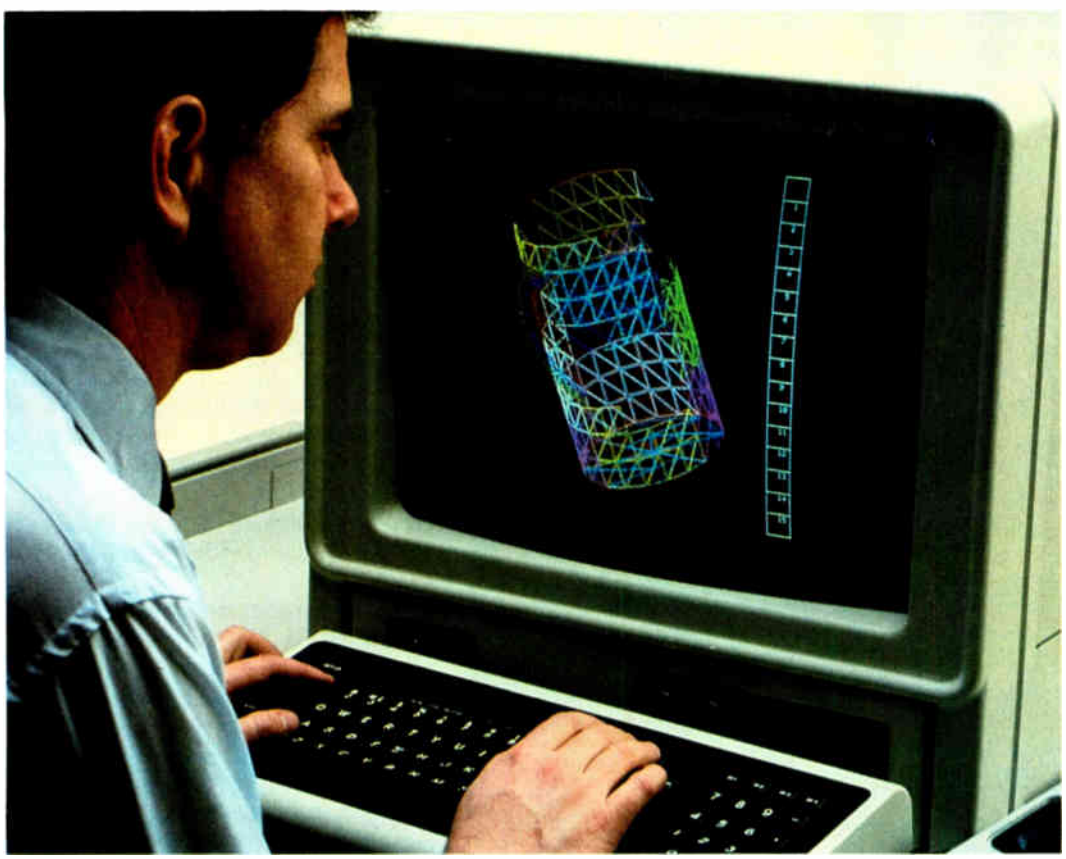
A family of display consoles from Digital Equipment Corp.'s Computer Special Systems group marks the firm's entry into color graphics. With its color displays priced under $15,000, DEC's market strategy is clear, says product manager James E. Carroll. "We are pricing ourselves aggressively relative to the Ramteks and others in the market, and we are trying to offer more."

"Some vendors' products really offer little for their base price," he continues. "Users must add interfacing and color—sometimes at twice the original investment. We want to offer units a buyer can go on line with now, without hidden charges."

The model VS11 is designed to operate with DEC's PDP-11 series and VAX-11/780 Unibus-oriented computers; the companion VSV11 works with the firm's LSI-11 computers. Both display types accept data from their host mainframes via direct memory access (the VS11 through a bus-converter subsystem), storing it in up to 1 megabit of image-buffer memory.

Software control. The monochrome versions of these displays yield 16 shades of gray on their 12-in. monitors; the color units offer 16 basic colors on 19-in. displays. Software control allows mixing the 16 colors to produce up to 256 tints.

To minimize host-processor over-



Graphics. Stress of complex cylindrical elements is displayed in full color on the DEC VS11 graphics subsystem using Patran-G software on the VAX-11/780.

head, DEC has made the units almost self-sufficient. Aside from DMA requests and the consequent flow of data to the terminals, the host has little to do with display operation. Its role is limited to control over graphics parameters, gray scale, and color—much of it through software.

Running the displays is a 2901-type bit-slice processor capable of executing 64-bit instructions in 160 ns. The display can thus be altered swiftly, a must for dynamic graphics applications. The display changes at about 640 ns per picture element. According to Carroll, this rate is "significantly faster than is possible with the serial-line graphics terminals on the market."

The speed comes partly from the units' DMA, bit-parallel input and partly from the fast processor control. At present, the limit is imposed by memory speed and the several modes that the memory must cycle through during operations, he says. The units use long-persistance phosphors, both in the color and the monochrome models, to eliminate fatigue-inducing flicker.

Resolution is good; the raster-scan systems generate more than 512 resolvable picture elements (pixels) per line across the face of the 19-in. color cathode-ray tube, and the CRT's spot size is about 0.7 mm. Resolution of the monochrome monitor also is 512 pixels per line. Convergence adjustments are unnecessary in the custom color unit, which has a three-gun, in-line design.

The VSV11 with a color-terminal option is base-priced at $13,600; its monochrome counterpart costs $7,900. The minimum-configuration price for the VS11 is $14,200 for color and $8,600 for monochrome. Deliveries begin in October.

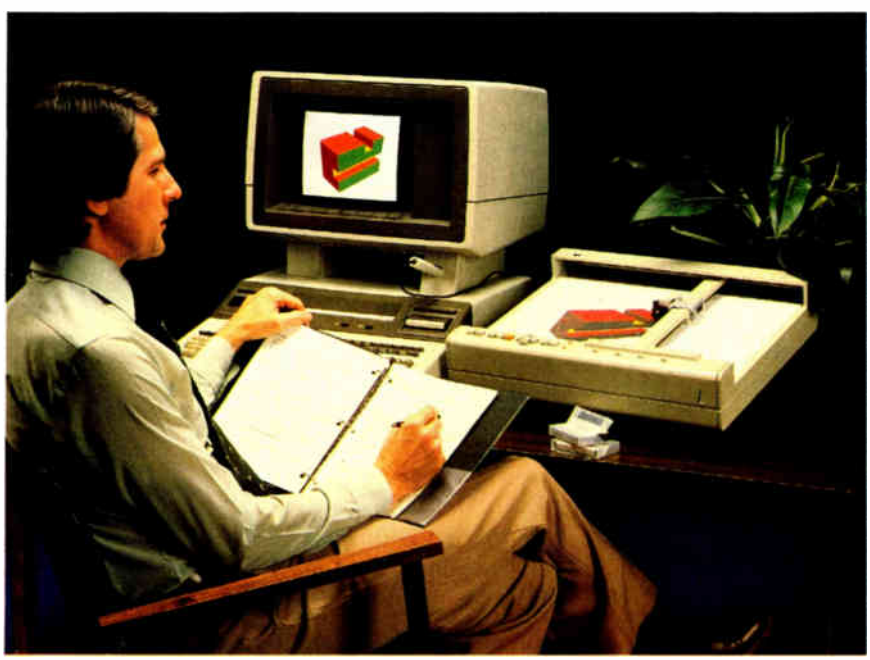
Digital Equipment Corp., 146 Main St., Maynard, Mass. 01754. Phone (617) 897-5111 [338]

Desktop computer has color display

HP's new computer system comes with a graphics monitor that offers 4,913 shades of color and a light pen that moves objects on the CRT display

by Bruce LeBoss, San Francisco regional bureau manager

Hewlett-Packard Co.'s system 45C is the latest and most powerful addition to the series 9800 family produced by HP's Fort Collins, Colo., Desktop Computer division. It constitutes a complete work station designed for engineers and scientists who must solve complex design and analytical problems. In addition to its operating system, read/write memory, Enhanced Basic language, keyboard, mass-storage system, and thermal line printer, the 45C integrates into a single desktop unit a sophisticated color graphics cathode-ray-tube display and a novel light pen that enables the user to pick, move, and draw objects on the cathode-ray tube interactively.



Work station. Hewlett-Packard's system 450 desktop computer includes a high-resolution color CRT display and a light pen and offers the 9872 plotter as an option.

The system 45C's display features a 13-in. high-resolution shadow-mask CRT (560 by 455 picture elements, or pixels) that uses three electron-beam guns to activate triads of phosphor dots with red, green, and blue emissions. This technique provides the system 45C's eight basic colors—white, red, yellow, green, cyan, blue, magenta, and black (the eighth "color").

To provide 4,913 shades of color on the System 45C, HP engineers use a technique called dithering, Hale notes. Here the raster-scanned CRT is divided into four-by-four arrays of pixels. In every array, each of the 16 pixels can be turned either on or off, and the combinations of pixels being turned on and off in three different memory planes yields the 4,913 shades.

HP engineers developed a software-assisted color-convergence system that allows a user—with key-

Facts from Fluke on low-cost DMM's

Conductance: What it is, and what it can do for you.

We've often referred to conductance as the "missing function" in DMM's – the capability so many of you have wanted in a DMM but couldn't find until we introduced the 8020A Analyst.

Since its introduction, the Fluke 8020A has become the world's best-selling DMM. And four more low-cost models with conductance ranges have been added to our line. But you'll still find this function only on Fluke DMM's.

Simply stated, conductance lets you make resistance measurements far beyond the capacity of ordinary multimeters. Until the 8020A, there was no way to make fast, accurate readings from 20 MΩ to 10,000 MΩ – ranges typically plagued by noise pickup. Yet, measurements at these levels are vital in verifying resistance values in high-voltage dividers, cables and insulators.

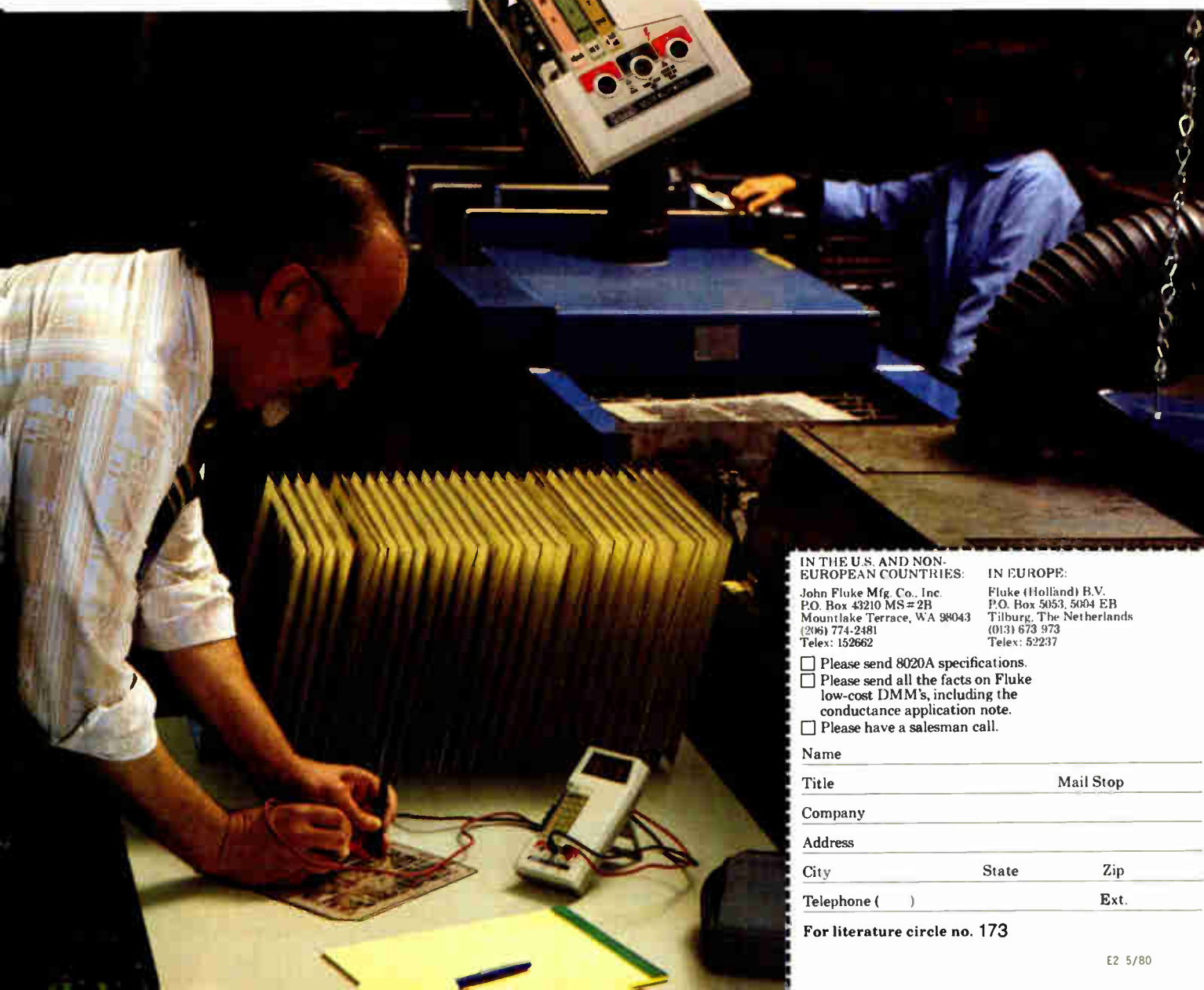
With conductance, the inverse of ohms, which is expressed in Siemens – Fluke DMM's can measure extreme resistances. Simple conversion of direct-reading conductance values, then, yields resistance measurements to 10,000 MΩ (and 100,000 MΩ with the 8050A), without special shielding and using standard test leads.

Here the 8020A is being used to check leakage in a teflon pcb. With a basic dc accuracy of 0.1% and an exclusive two-year warranty, this seven-function handheld DMM has made hundreds of new troubleshooting techniques such as this possible, and more are being discovered every day.

For more details, call toll free **800-426-0361**; use the coupon below; or contact your Fluke stocking distributor, sales office or representative.

FLUKE®

8020A Multimeter



IN THE U.S. AND NON-EUROPEAN COUNTRIES:

John Fluke Mfg. Co., Inc.
P.O. Box 43210 MS=2B
Mountlake Terrace, WA 98043
(206) 774-2481
Telex: 152662

IN EUROPE:

Fluke (Holland) B.V.
P.O. Box 5053, 5004 EB
Tilburg, The Netherlands
(013) 673 973
Telex: 52237

☐ Please send 8020A specifications.
☐ Please send all the facts on Fluke low-cost DMM's, including the conductance application note.
☐ Please have a salesman call.

Name

Title Mail Stop

Company

Address

City State Zip

Telephone ( ) Ext.

For literature circle no. 173

E2 5/80

board commands, indicators on the CRT display, and 39 independent controls—to align the three electron-beam guns sequentially in 13 different areas of the CRT display and thus provide sharp colors across the entire display. Once convergence is adjusted, Hale says, the display can remain untouched for weeks to even months, depending on the operating environment.

The system 45C has eight "soft" keys located along the bottom of the display-screen bezel, each of which can be user-defined to show printed messages on the CRT display or to specify a color. The color commands allow the user to display alphanumerics and geometric figures simultaneously.

The light pen supplied with the standard system 45C is a graphics tool that, using the system's tracking cursor, makes possible resolution down to the pixel level. The cursor can move at the same speed and direction as the pen.

Also, the system 45C's graphics statements—based on HP's Advanced Graphics Language—include, in addition to the 35 commands of prior system 45 machines, 35 new or enhanced commands to ease both the use of color and the light pen in graphics computation and interaction. With a single command, for example, the internal printer replicates the image in gray scale, or a color graphics package combined with HP's microprocessor-based 9872 plotter can provide the user with color hard copy.

The price for the standard system 45C configuration is $39,500 and includes the color CRT display and color graphics firmware, interactive light pen, 187 kilobytes expandable to 499 kilobytes of user-available read/write memory, and two 217-kilobyte cartridge-tape drives and the internal (80-column, 480-line-per-minute) thermal printer. The operating system, as well as the functions for display, graphics, and control, is contained in 152 kilobytes of read-only memory, to leave the read/write memory entirely available to the user. Other ROMs are available for I/O, mass-storage, advanced-programming, data-communications, and data-base management functions.

A streamlined entry-level configuration with only 56 kilobytes of read/write memory, one tape drive, and no light pen or internal printer is available for $31,500. Delivery of either configuration takes 8 to 10 weeks after receipt of the order.

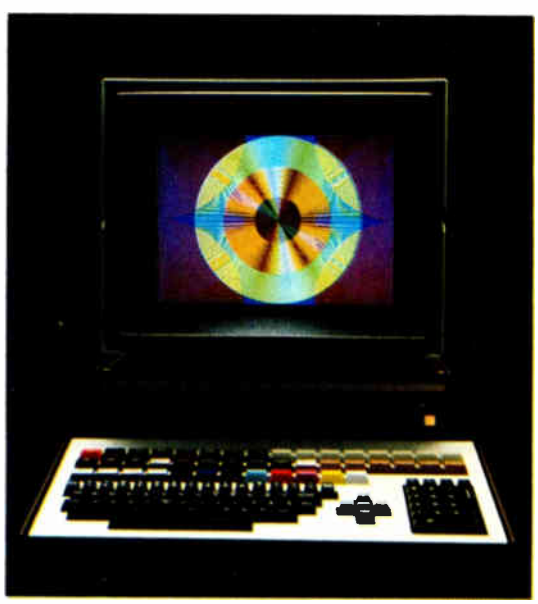
Hewlett-Packard Co., 1507 Page Mill Rd., Palo Alto, Calif., 94304. Phone (415) 857-1501 [339]

OEM color terminal costs under $6,000

Microprocessor-based graphics terminal offers noninterlaced operation, 512-by-512-dot resolution, and a 60-Hz refresh rate for eight colors

by Ana L. Bishop, Assistant New Products Editor

"We intend to make black-and-white terminals wholly obsolete in this decade," says Terence Hughey, president of Chromatics Inc. His statement accompanied the announcement by the Atlanta-based firm of a high-resolution color graphics terminal that will sell for under $6,000 to original-equipment manufacturers. It is on display this week at the National Computer Conference.



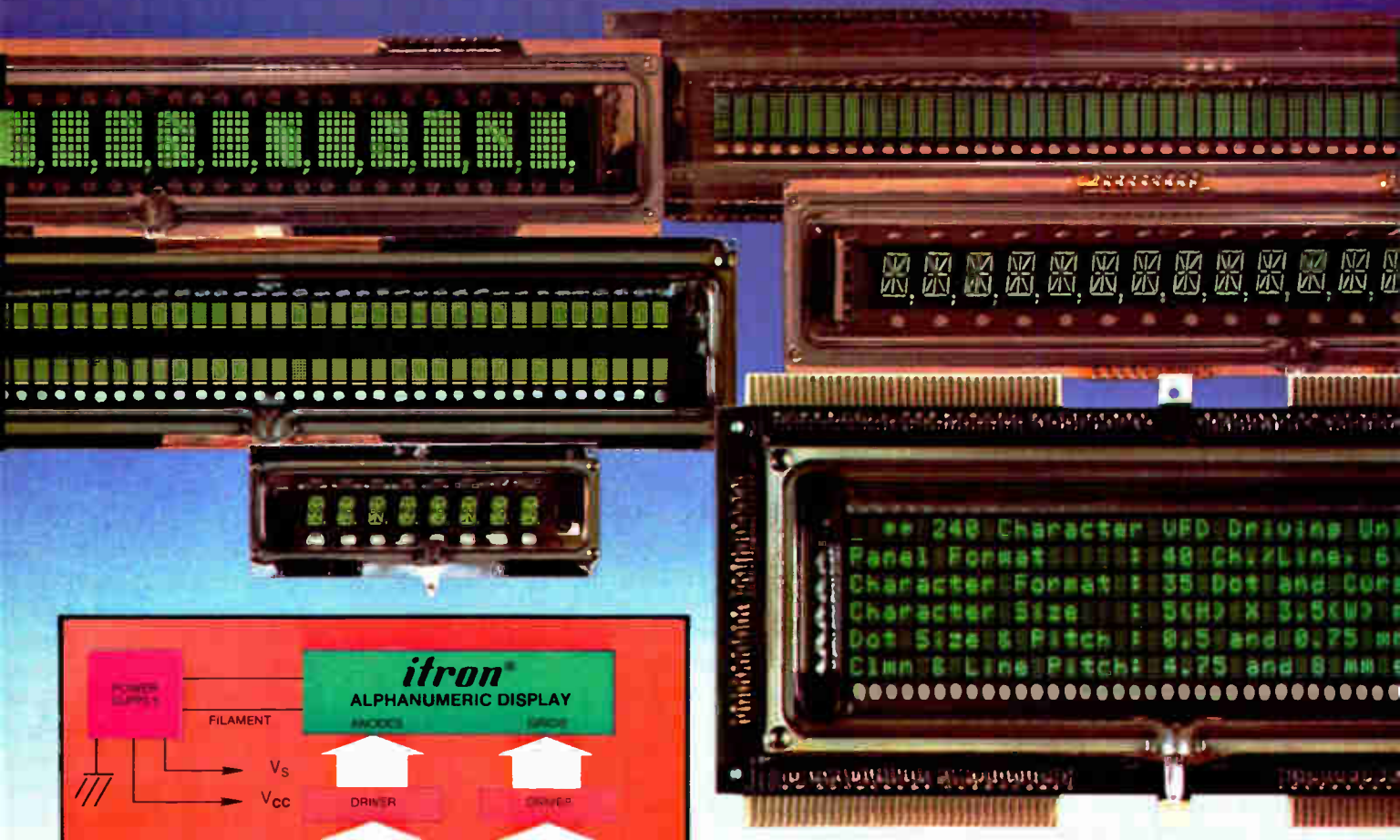
Noninterlaced. Chromatic's CG 3999 terminal uses a Z80 microprocessor to achieve a 60-Hz refresh rate and noninterlaced operation on its 19-in. cathode-ray tube.

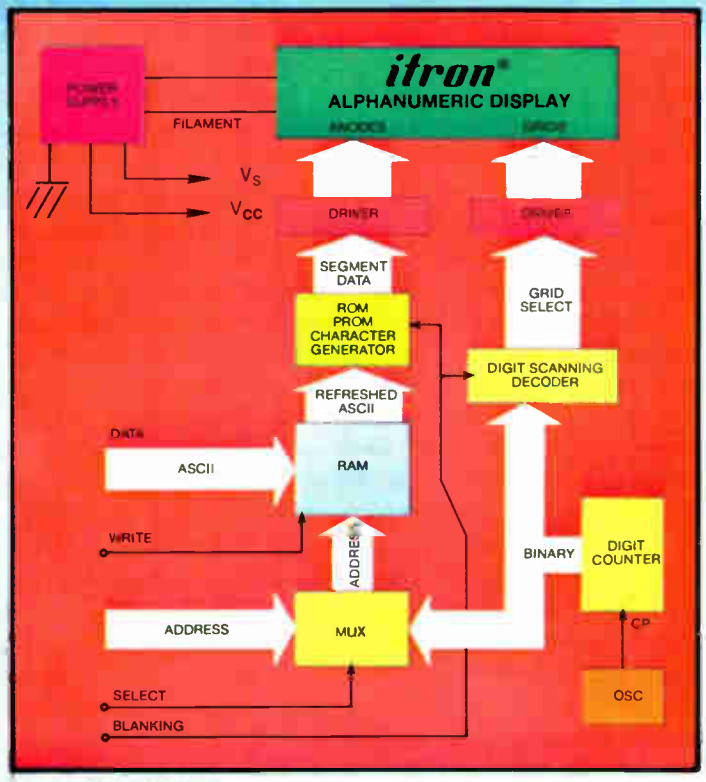
The terminal, model CG 3999, is a stand-alone computer "in its own right"—a basic machine also made to be integrated into a larger system by the system builder, says Don McKinney, director of marketing and sales. The unit contains a Z80 microprocessor with 128 kilobytes of random-access memory to refresh the colors on every dot on the screen at a 60-Hz rate.

"In this price range, no one else can offer noninterlaced operation," claims McKinney. Chromatics uses a standard 19-in. low-resolution television tube made by Panasonic but adds circuitry designed within the company to achieve a fairly high, 512-by-512-dot resolution.

"This is a significant price and quality breakthrough for process control applications in the OEM mar-

Itron Advanced Alphanumerics. They'll put your readouts upfront.





With itron's evolutionary 14-segment and dot matrix alphanumeric displays, your readout designs are sure to be frontrunners everytime. They're offered in a wide selection of character heights from 5 mm to 15 mm, and character counts that range from an 8-character 14-segment mini-package array, all the way up to the unique 240 character, 5 x 7 dot matrix (6 line x 40 characters/line) plug-in panel—and even 5 x 12 dot matrices for upper/lower case fonts.

Their long-term field-proven reliability, even under severe environments, further enhance their desirability for most every application where bright, easy-to-read legibility (even at a distance and under high ambient light), wide viewing angles and flat-glass simple-to-mount packages—plus low voltage and low current-drain are paramount. So, since brevity is called for, contact us to find out all the particulars on how to put your readout designs in the forefront with itron's Advanced Alphanumerics.

itron®
FLUORESCENT DISPLAYS
Patented and Manufactured by
ISE ELECTRONICS CORP.

INTERNATIONAL REPRESENTATIVES
WEST GERMANY: Neumuller GmbH, Eschonstr 2, 8021, Taufkirchen, Munich. Phone: 089/6118-245. Telex: 522106
FRANCE: Europavia France, 5 Avenue Leon Harmel 92167 Antony Cedex. Phone: 666-21-10. Telex: 42204381
UNITED KINGDOM: ITT Meridian, West Road, Harlow, Essex CM20 2BP. Phone: 0279-35351. Telex: 817202
SWEDEN: AB Nordqvist & Berg, Box 9145 S-10272, Stockholm Phone: 08-690400. Telex: 10407
DENMARK: E. V. Johanessen Elektronik A-S, Titagade 15-2200, Copenhagen. Phone: 01/839022. Telex: 16522
HONG KONG: Phone: 5-232420. TAIPEI: Phone: 351-0293

NORITAKE ELECTRONICS, INC.
EASTERN OFFICE: 41 Madison Avenue, New York, NY 10010 • (212) 481-3440 • Telex: 12-5469
CENTRAL OFFICE: 16250 Northland Drive, Southfield, MI 48075 (313) 569-0088
WESTERN OFFICE: 22410 Hawthorne Boulevard, Torrance, CA 90505 • (213) 373-6704 • Telex: 67-4910

NORITAKE COMPANY, LIMITED
JAPAN: 1 - 1, Noritake-Shinmachi, Nishiku, Nagoya-Shi • (052) 562-0336 • Telex: J59738
EUROPE: Burotel Belgium SA, Rue de la Presse 3-5, 1000 Bruxelles • (02) 217-83-60 • Telex: 4626962

Circle 174 for Sales Contact

Circle 175 for Literature Only

New products

ket," says Hughey. "Until now, comparable quality anywhere in the color field has cost at least $2,000 more." Hughey forecasts a marked trend over the next few years toward lower prices and greater sophistication in the color segment of the graphics terminal market. "My goal for Chromatics is that by the mid-1980s there will be no reason for a user not to choose color."

The 3999 offers eight colors, achieved by making the red, green, and blue beams of three in-line guns converge through the holes of the shadow-mask screen. "By ANDing and ORing the colors, we get magenta, cyan, yellow, and white," explains McKinney. Black is the eighth "color." Sector convergence is done manually and, as long as there is no electromagnetic interference, it lasts for months.

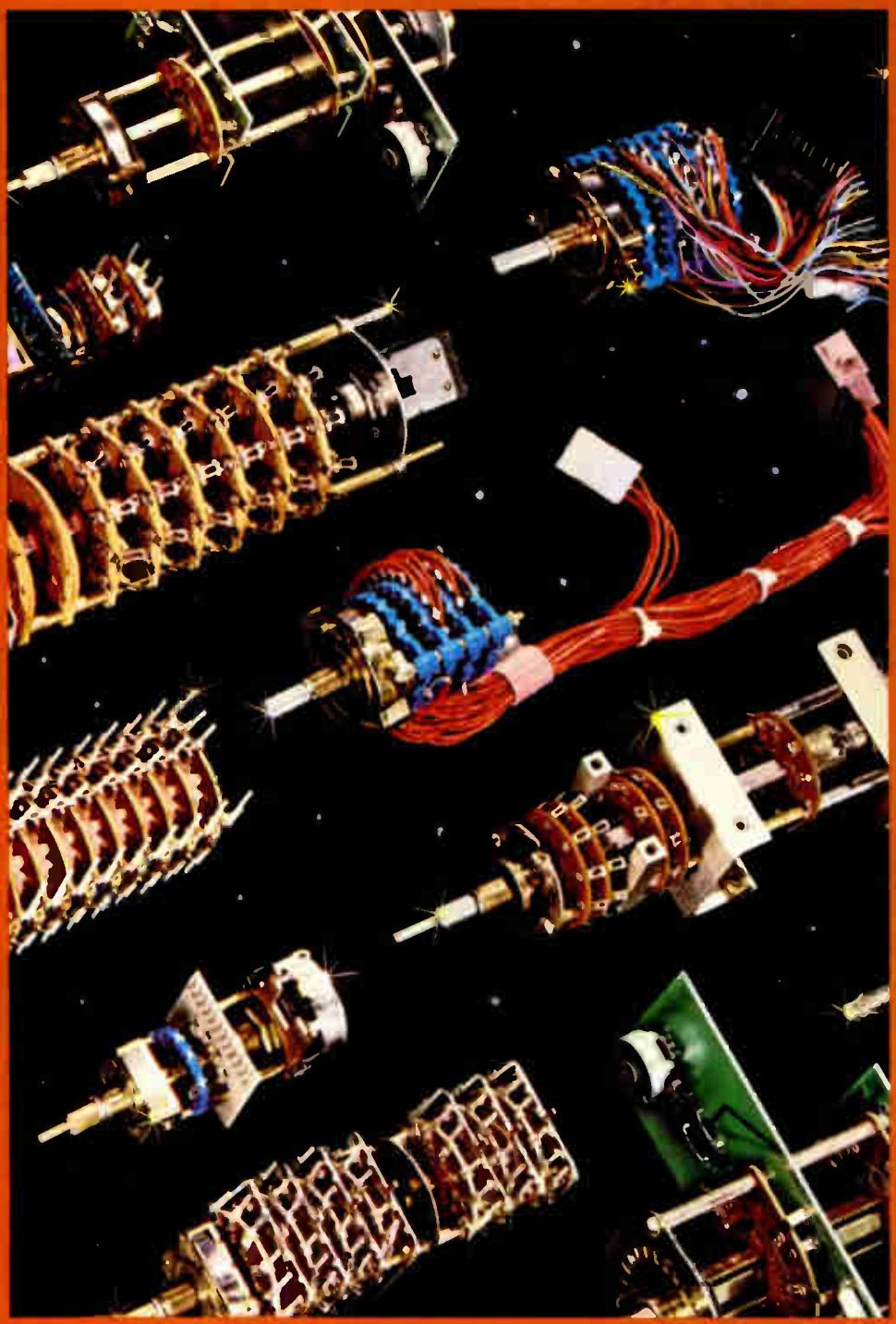
Memory. The 3999 uses the CP/M operating system. User memory is 128 kilobytes and can be upgraded in increments of 32 kilobytes by replacing a board and chip. In addition, it has 32 kilobytes of erasable-programmable read-only memory. The graphics capability is programmed in firmware. Errors can be diagnosed and corrected down to the chip level.

The terminal offers several digital and analog interfaces, including the RS-179 and RS-232-C, as well as a direct-memory-access interface. It has no interfaces for external buses. The stand-alone unit is not a large-scale computer, but it can store data on a disk, massage, and display it. It offers such general computer functions as input/output and storage.

The basic terminal with RS-232 port, Z80 microprocessor, random-access memory and graphics firmware measures 19.8 by 24.2 by 24 in. The base price for a single unit will be $7,995, but drops to $5,995 when ordered in lots of 100 units by the OEM. This summer Chromatics will double the size of its manufacturing facilities—built when the company was founded in 1976—in order to handle a six-month backlog.

Chromatics Inc., 3923 Oakcliff Industrial Court, Atlanta, Ga. 30340. Phone (404) 447-8797 [340]

The no-one-else-comes-close line —Oak Rotary Switches



No one else comes close
in broad selection
—from tap switches to 60 position binary, BCD or hexadecimal coded switches, from ½" to 2 5/16" diameter multiple section switches—and Oak will build them into almost any PC board or component assembly that you specify.

No one else comes close
in innovativeness
—with creative new concepts like CMS333 that replaces solid silver clips and blades to provide equivalent performance at lower costs—or the Unidex® and Monodex® indexing mechanisms—or the Moduline® assembly system.

No one else comes close
in availability
—you can get most popular types from stock through Oak distributors nationwide. . .who can also construct over 2 million other variations, with the unique Moduline system, or you can use the Oak "Minuteman" service for fast factory delivery on short runs.

Consult our EEM pages or contact any Oak sales office or distributor for product line information.

IN TOUCH WITH TOMORROW

OAK Technology Inc.
SWITCH DIVISION

Crystal Lake, Illinois 60014
Telephone: 815/459-5000
TWX: 910•634•3353•TELEX 72•2447

In Europe
OAK Holland BV
Sales Department P.O. Box 201
3640 AE Mijdrecht-Holland
TEL. 31 2979-2111 TELEX 18183

For technical data—circle the reader service number.

200—1/2", 8-12 pos.	205—2-5/16", 9-24 pos.
201—1", 2-10 pos.	206—2-1/2", 8-36 pos.
202—1-5/16", 2-12 pos.	207—Programmable types
203—1-7/8", 12-20 pos.	208—PCB types
204—1-11/32", 4-14 pos.	209—Distributor types

210—For a salesman's call

The NEW Electronics Buyers' Guide is now available!

The 1980 EBG is only a postage stamp away! Completely new listings of catalogs, new phone numbers, new addresses, new manufacturers, sales reps, and distributors! The total market in a book—four directories in one!

1.
Directory of products. Over 4,000 products, over 5,000 manufacturers.

2.
Directory of catalogs. Includes six post-paid catalog inquiry cards for 10-second ordering.

3.
Directory of manufacturers. Local sales offices, reps, and distributors, with phone numbers. Number of employees and engineers, dollar volume, name of company contact.

4.
Directory of trade names of products and their manufacturers. You can trace a product by its trade name only.

The only book of its kind in the field.

If you haven't got it, you're not in the market.

To insure prompt delivery enclose your check with the coupon now.

Yes, please send me _____ copies of 1980 EBG.

☐ I've enclosed $30 per copy delivered in USA or Canada. Address: EBG, 1221 Avenue of the Americas, New York, N.Y. 10020.

☐ I've enclosed $52 for air delivery elsewhere. Address: EBG, Shoppenhangers Road, Maidenhead, Berkshire S16, 2Q1 England.

Name _____

Company _____

Street _____

City _____

State _____ Zip _____ Country _____

Everything You'd Expect of a Data Acquisition and Control System.

Probably More.

Our System 620 handles all types of I/O signals—high and low level transducer signals, discrete signals, contact closures, frequency, analog output—and it has many other features that you may not expect. **Remote operation,** for example.

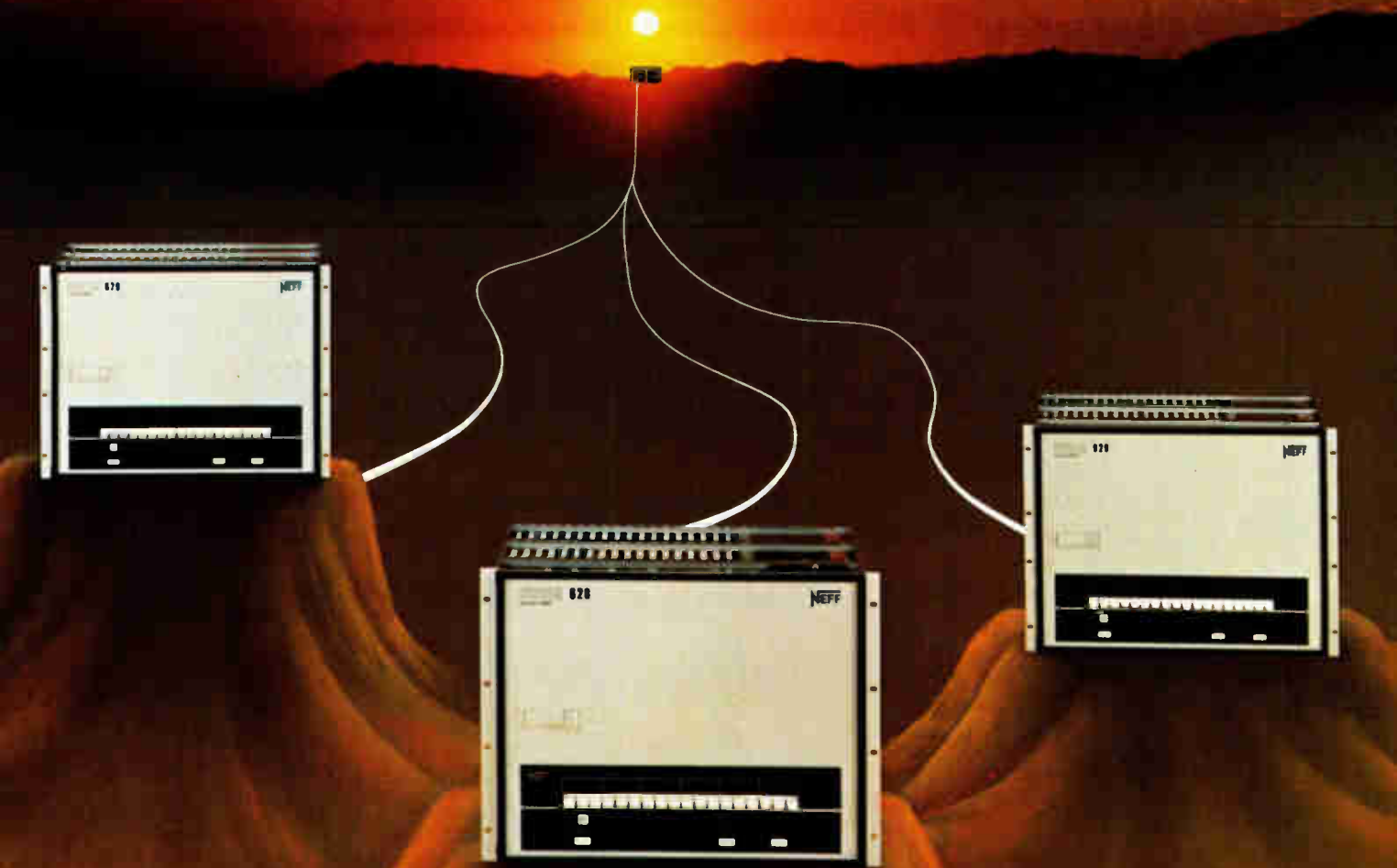
Data acquisition and control processes frequently require a centrally located computer. Installation expenses mount as shielded cables, routed through cable trays or conduit, are stretched between the computer and remote sites.

That's why we included a Serial Controller in our System 620/Series 500. It controls up to eight System 620s located up to 20,000 feet away and operating at full performance specifications. Two coax cables to each site provide the communication link that allows throughput rates to **50,000 data words per second** and analog input capacity **expandable to 2048 channels at each site**—not limited, as you might expect, to a few channels.

Remote operation is only one feature of the versatile System 620. There are more, including some you may not expect and possibly just the one to solve your measurement or control problem. They're described in our new brochure—yours for the asking—or, for immediate answers, call us today.

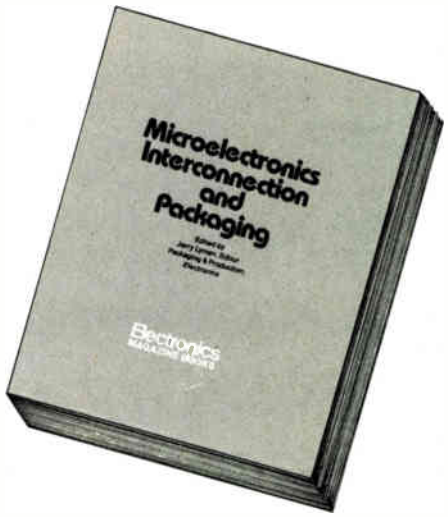
NEFF INSTRUMENT CORPORATION

700 South Myrtle Ave., Monrovia, CA 91016
(213) 357-2281 TWX 910-585-1833



Circle 179 on reader service card

Optimize microelectronic interconnections at all levels!



With this information-packed resource covering all the techniques, materials, and procedures you need most...

Microelectronics Interconnection and Packaging

edited by Jerry Lyman, Packaging and Production Editor of *Electronics* Magazine 318 pages, $12.95

Stop searching through dozens of resources for the answers to your most pressing microelectronic design questions. Start discovering the most efficient and effective methods—directly applicable to your own projects—when you turn to this authoritative reference. Articles drawn from recent issues of *Electronics* highlight everything you need to know about...

- all forms of IC lithography • plasma etching (dry processing) • breadboards • a new and potentially important substrate, porcelainized steel • polymer thick films • the cause and cure of "hook" in pc substrates • pc substrate types • effects of nuclear radiation on various IC logic families • chip and film carriers • in-circuit testing (digital and analog) • automatic testing of backplanes and pc boards • and more.

Take a look at just this sampling of on-the-job problems you'll solve quickly.

- You have to choose a low-cost, high-density assembly method for consumer circuits. Don't make a decision until you've checked the sections on the modified thick-film approach on porcelainized steel and polymer thick films on standard plastic pc substrates.
- Should you buy an e-beam lithography system for 2μm geometries on production IC chips? You won't when you've read about a system that works just as well at one-fourth the price!
- You need to wire electronic equipment for a long-life space mission. Read the section on stitch-wired nickel conductors before you act!

Contents

Order today, and don't forget the other valuable books listed in the coupon below.

Electronics Magazine Books
P.O. Box 669, Hightstown, NJ 08520
(609) 448-1700, ext. 5494

No. of Copies	Title	Price
_____	Microprocessors	$ 8.95
_____	Applying Microprocessors	$ 9.95
_____	Large Scale Integration	$ 9.95
_____	Basics of Data Communications	$12.95
_____	Circuits for Electronics Engineers	$15.95
_____	Design Techniques for Electronics Engineers	$15.95
_____	Memory Design: Microcomputers to Mainframes	$12.95
_____	Personal Computing: Hardware and Software Basics	$11.95
_____	Microelectronics Interconnection and Packaging	$12.95

Discounts of 40% on orders of 10 or more copies of each book.

If after my 10-day free-trial examination I am not fully satisfied I understand that my payment will be refunded.

☐ Payment enclosed ☐ Bill firm ☐ Bill me

Charge to my credit card:

☐ American Express ☐ Diners Club
☐ Visa ☐ Master Charge*

Acct. No. _____ Date Exp. _____

*On Master Charge only, first numbers above name _____

Name _____ Title _____

Company _____

Street _____

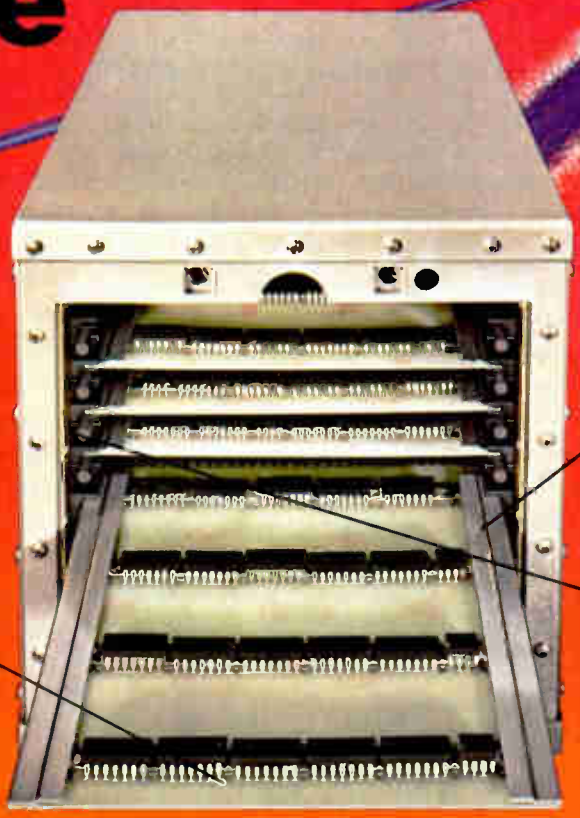
City _____ State _____ Zip _____

Signature _____

ANNOUNCING IERC'S SIMPLE NEW CONDUCTION HEAT DISSIPATION SYSTEM FOR DIPS

How to get the heat out without any fanfare

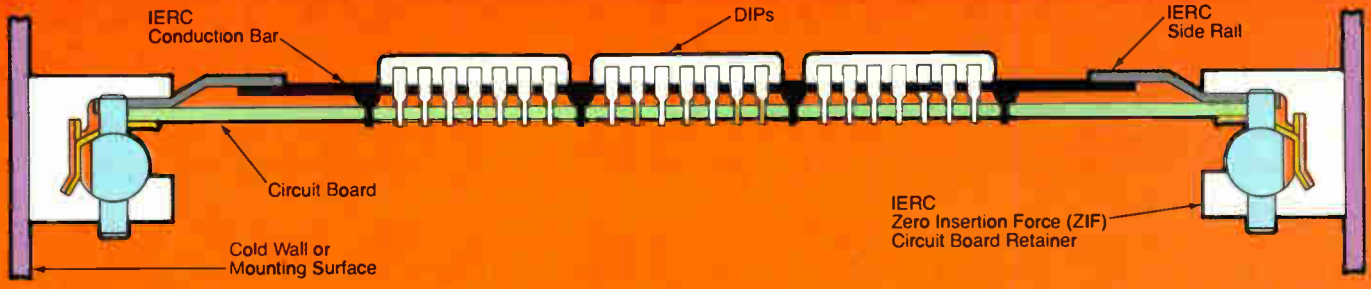
IERC's new 3-component conduction system matches—and in many cases exceeds—the cooling capabilities of forced-air systems, yet costs less and is easier to assemble.



1 **Conduction Bars** absorb the heat generated by the DIPs and make up the first section of an efficient thermal path out to a cold wall.

2 **Side Rails** transfer the heat from the conduction bars to the circuit board retainers.

3 **New IERC ZIF (Zero Insertion Force) Circuit Board Retainers** provide a positive thermal interface between the side rails and the cold wall, completing the heat transfer path.



These three off-the-shelf components are easy to assemble, allowing quick fabrication of a custom heat dissipation system. Conduction bars can be flow-soldered into any configuration along with other board components and place no restriction on the number of DIPs, distance between DIPs, or even the number of rows of DIPs. Standoffs raise the conduction bars .020" above the board to accommodate circuit traces.

Both the conduction bars and side rails are made from high-thermal-conductivity copper while the exclusive new ZIF circuit board retainers feature a unique locking action that provides an excellent thermal interface. These revolutionary retainers are the key reasons IERC's conduction bar system is so superior. They allow true zero insertion force installation to protect expensive circuit boards, then lock with a simple 90° turn of a cam actuator to provide both positive mechanical integrity and a highly efficient thermal interface.

All components in the new IERC conduction heat dissipation system come in a variety of lengths so that the system can be adapted to virtually any circuit board design.

For more information, contact IERC or your nearest IERC Sales Representative.

IERC

International Electronic Research Corporation, a subsidiary of Dynamics Corporation of America, 135 West Magnolia Blvd., Burbank, California 91502, (213) 849-2481

Circle 181 on reader service card

Microcomputers & systems

Chip addresses 1 megabyte

Latest generation of microcomputer uses 8-in. Winchester disk for RAM

The jump from a Z80-based microcomputer system containing an 8-in. Winchester disk to a Z8000-based microcomputer system with an 8-in. Winchester disk may seem only evolutionary, but it reveals the great difference in power between the two generations of microprocessors. The first of these systems—the C8001 introduced at the National Computer Conference last year—addresses the 65 kilobytes of random-access memory allowed by its Z80A processor. The second, the C8002 computer system, which will be shown at this year's NCC, directly addresses up to 1 megabyte of RAM.

The C8002 is among the first microcomputer systems to be built around Zilog's 16-bit Z8000 processor. It addresses 128 kilobytes of parity-checked RAM in its basic configuration, but that configuration can be expanded to 256-, 512-, and 1,024-kilobyte configurations. The mainframe also includes a 10-megabyte 8-in. Winchester disk and a 12-megabyte cartridge tape drive for backup. The C8002 retains the C8000's Z80A processor but, instead of using it as the central processing unit, has it handle direct memory access to the disk and tape drives.

Software. With initial shipments scheduled for July, Onyx Systems will support the Unix version 7 software, as well as a C language compiler, with additions in August of Basic, Cobol, and an IBM 2780 emulator for its communications package. A provision for Fortran comes with the Unix operating system, and Onyx should have it retargeted for the Z8000 and available in the third quarter. A data-base management software package developed by Micro-Soft of Bellevue, Wash., will also become available at the same time as the Fortran introduction.

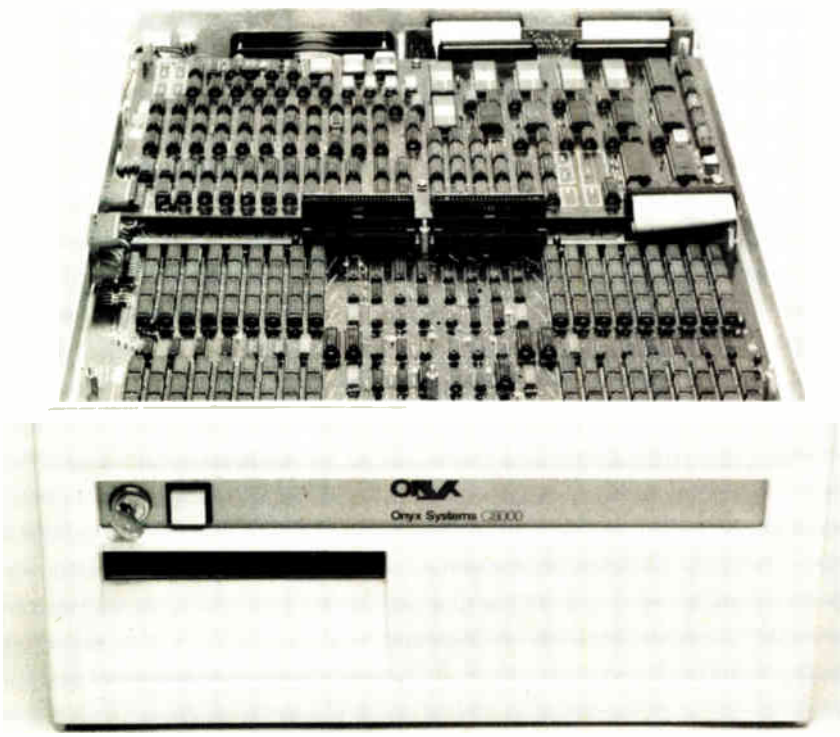
According to Onyx president, Robert Marsh, "The power of the C8002 lies between that of the DEC PDP-11/34 and the PDP-11/45." At a $16,000 base price for a unit with 128 kilobytes of RAM, that represents a significant price-performance improvement, he adds.

The C8002 can be accessed by 10 serial ports, including nine RS-232 ports and one RS-422 high-speed interface. The serial ports allow the unit to support up to eight terminals and a modem, plus a bidirectional parallel port for a Centronics-type printer. The RS-422 port will be used in a local networking option that Onyx plans to introduce in the middle of next year. The C8002 can also support up to 15 similar drives.

Rather than using the Zilog memory management unit, Onyx has designed its own, which Marsh describes as "a cross between that used for the DEC PDP-11/45 and that used for the IBM Series/1." It segments the memory into two areas of 64 kilobytes each for instructions and for data. Within those segments, the memory is allocated in 2-kilobyte pages. The memory management unit has 16 sets of maps to keep track of its memory allocations.

To handle the heavy number crunching, the C8002 also has a 64-bit arithmetic processing unit based on AMD 9512 floating-point processor chips.

Onyx Systems Inc., 73 E. Trimble Rd., San Jose, Calif. 95131. Phone (408) 946-6330. [391]



Z8-based microcomputer has Basic/Debug interpreter

The Z8-SBC single-board microcomputer features a Z8 Basic/Debug interpreter that is masked onto the 2-kilobyte internal read-only memory in the Z8 central processing unit. The microcomputer is designed for a variety of data-processing and data-acquisition applications. The language is a subset of the original Dartmouth Basic.

The 3.94-in.-by-6.3-in. board can accommodate up to 8 kilobytes of random-access memory, read-only

TM 500 lets you fill in the blank.

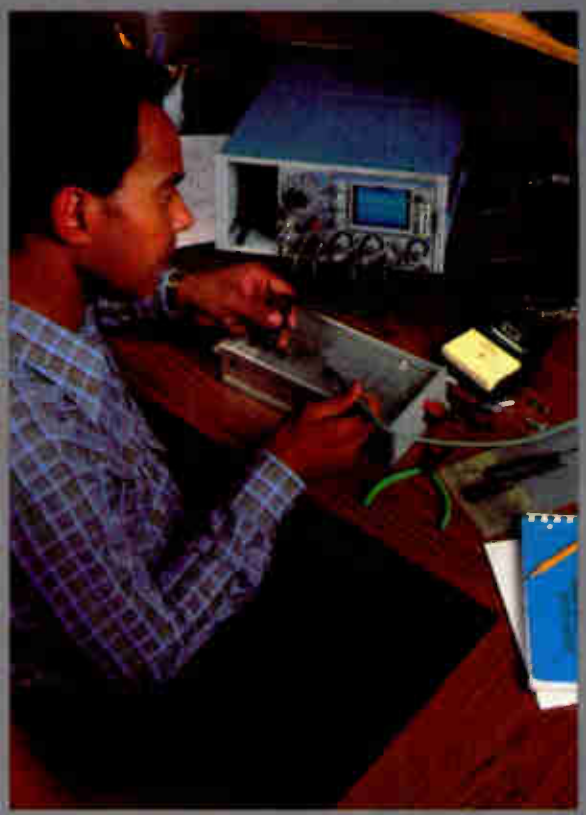
Our custom plug-in kit spans your measurement gap.

Sometimes test and measurement problems demand solutions standard instruments just can't provide. So instead of drawing a blank, TM 500 lets you fill one in. With the product of your own ingenuity.

It's done through our blank custom plug-in kits, either one or two compartments wide. You get a perforated main circuit board for easy assembly of both ICs and discrete components. And, the necessary mechanical parts. Plus complete information on use of the power supplies in the TM 500 mainframes.

There's even a one-compartment kit complete with power supply components to power your own creations.

Now you can have those specialized devices that make the difference. Like signal switching circuitry, preset oscillators, or a/d converters. And for new ideas, we can supply a series of Construction Notes with complete schematics and parts lists for building a number of custom plug-ins.



We also offer nearly 40 standard plug-in modules, covering everything from DMMs to oscilloscopes to generators.

To find out more about TM 500, contact your local Tektronix Field Office, or write Tektronix, Inc

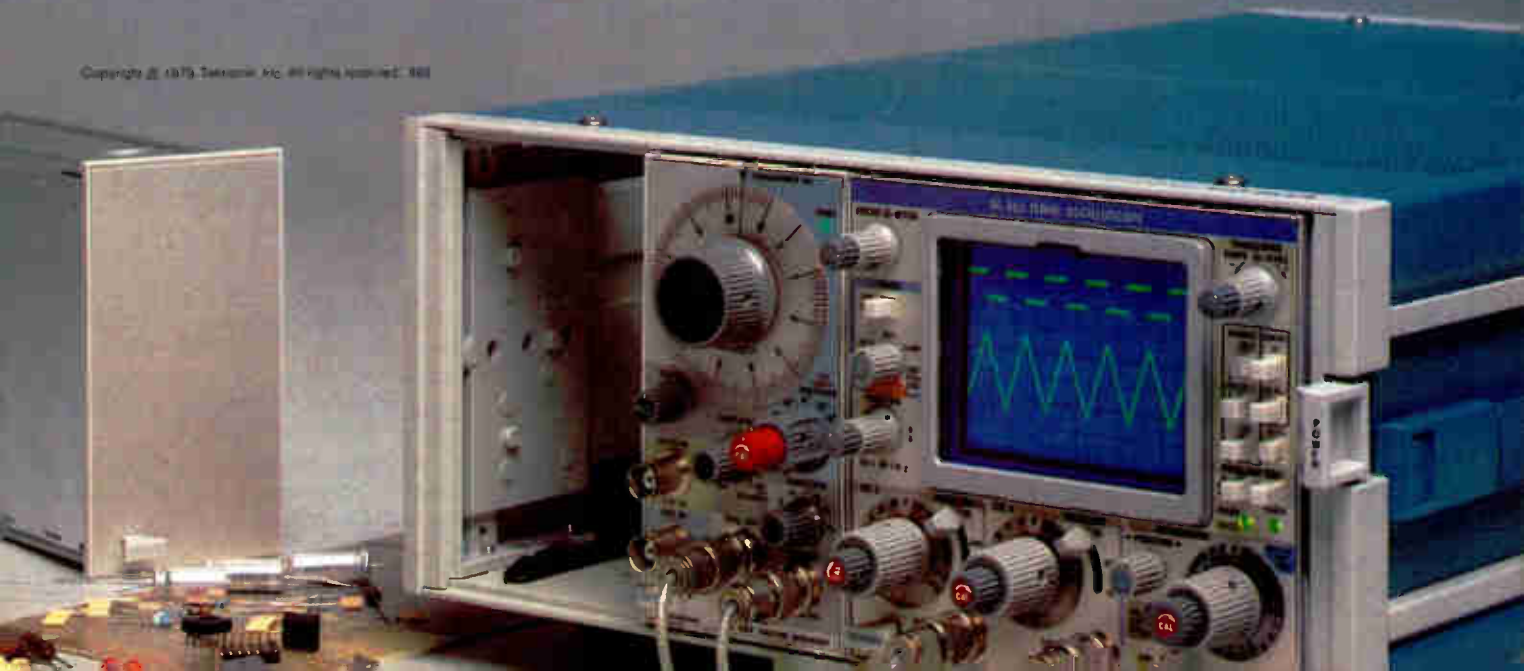
TM 500 Designed for Configurability

Tektronix
COMMITTED TO EXCELLENCE

Tektronix, Inc.
P.O. Box 1700
Beaverton, Oregon 97075
(503) 644-0161
Telex 910-467-8708
Cable TEKTRONIX

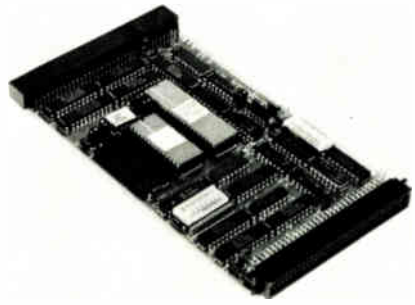
Europe, Africa, Middle East
Tektronix Int'l., Inc.
Postbox 827
1180 AV Amstelveen
The Netherlands

For immediate action, dial our toll free automatic answering service 1-800-547-1512



See page **205**

New products



memory, or erasable programmable ROM. It has two counter-timers, five 8-bit parallel input/output ports, a programmable asynchronous serial channel that supports RS-422 or RS-423 interfaces, 124 general-purpose registers, and three levels of interrupts. The board has an effective instruction speed of 3.72 MHz and operates from a single +5-v power supply. Priced at $695, or $795 with an additional 4 kilobytes of RAM memory, the Z8-SBC will be available in July of this year.

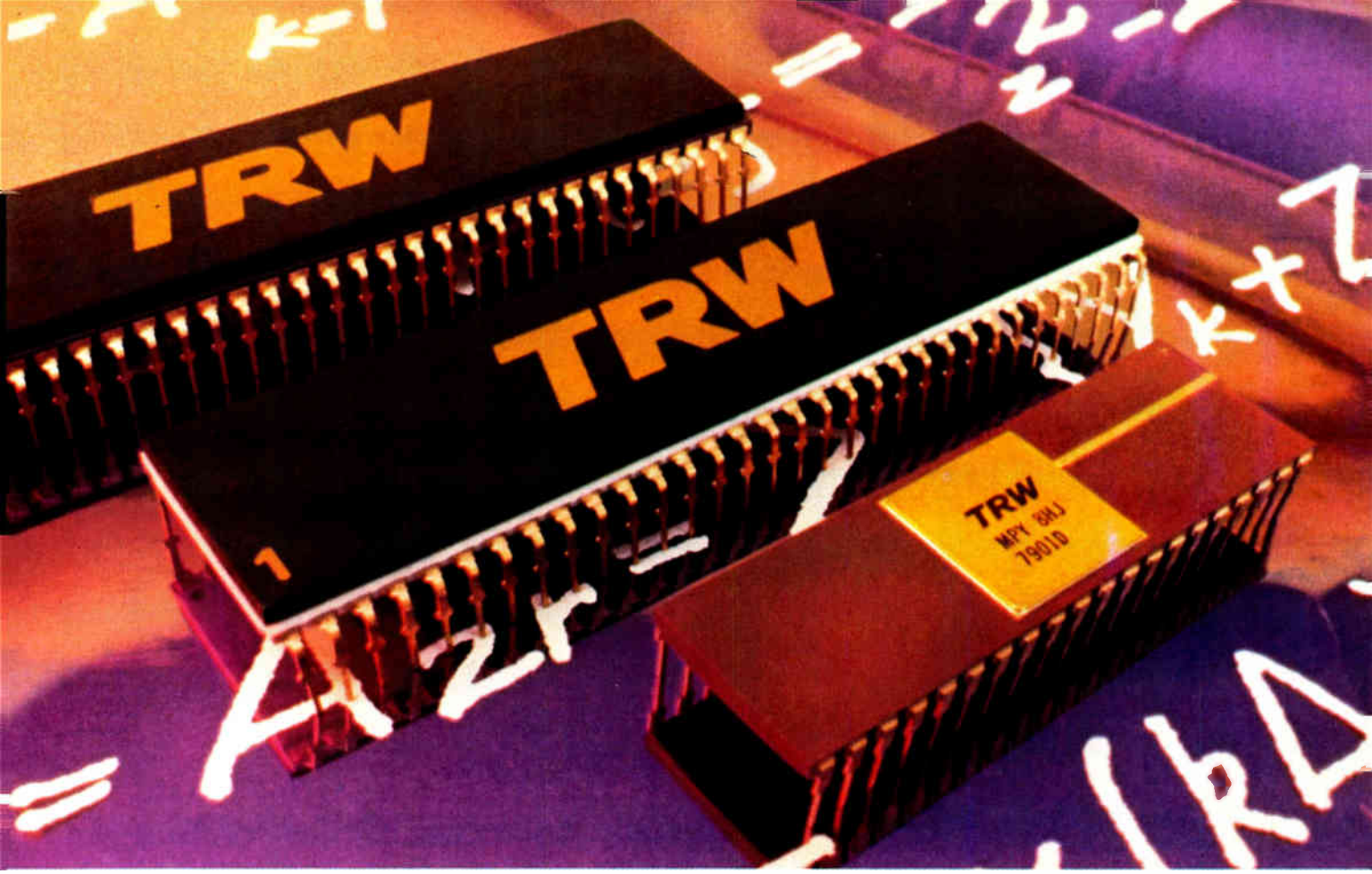
Zilog Inc., 10340 Bubb Rd., Cupertino, Calif. 95014. Phone Mel Thomsen at (408) 446-4666 [376]

1-megabit bubble memory operates to 70°C

The 7110-1 is the first commercial 1-megabit magnetic bubble memory specified for operation to 70°C. A design enhancement of the 7110, it permits the operation of microcomputer systems at temperatures above 50°C. Another advantage of the 7110-1, says the manufacturer, is that bubbles can be used at temperatures at which tape and disk memories cannot operate.

Rated for operation from 0° to 70°C ambient temperature, the 7110-1 differs from its predecessor, the 0°-to-50°C-range 7110, in that it extends the temperature range of the module's storage and bootstrap loops. Also, the 7110-1 has a lower-amplitude current-pulse requirement for writing. The one-piece, U.S. price of the 7110-1 is $1,985.

Intel Magnetics, 300 Oakmead Village Dr., Santa Clara, Calif. 95051. Phone Stew Sando at (408) 987-6046 [379]



16x16-bit multiplication in only 100 nsec

(From a single chip.)

If you design digital filters or FFT processors... or if you want to increase the computational speed of a microprocessor... take a look at our "HJ" line of bipolar, monolithic multipliers. These super-fast chips give you added performance at greater speed and save circuitry, power and money in the process. One of our customers used 4 of our MPY-16HJ's and tossed out 98 multipliers he'd previously needed for the same function. That's real savings! One of our "HJs" ought to give you real savings, too.

Plus such important features as...

- On-chip input and output registers with 3-state outputs.
- Two's complement or unsigned magnitude.
- Controllable transparent output registers (12x12 and 16x16 only).
- TTL compatible.
- Double precision product.
- Single power supply, + 5V.
- Pin-compatible with our "AJ" series multipliers.

Multiplier	Word Size (Bits)	Speed (nsec)	Power (Watts)	Unit Price (in 100s)**
MPY-16HJ*	16x16	100	3.0	$157
MPY-12HJ*	12x12	80	2.0	$103
MPY-8HJ*	8x8	65	1.0	$ 47
MPY-8HUJ	8x8	65	1.2	$ 47
MPY-8HJ-1*	8x8	45	1.0	$ 57
MPY-8HUJ-1	8x8	45	1.2	$ 57

*Guaranteed operation over T_C = −55°C to +125°C available for military applications.

**U.S. Prices

These super-multipliers are in stock at Hamilton/Avnet.

For immediate information, call us at (213) 535-1831 or send us the coupon or just attach your business card to this page and mail it back to us.

TRW LSI Products
P.O. Box 1125
Redondo Beach, CA 90278

Please send data sheets on the HJ family of multipliers.

Name

Company

Div/Dept Mail Code

Address

City

State Zip E-5

TRW keeps you ahead in digital signal processing

TRW LSI PRODUCTS
An Electronic Components Division of TRW Inc.

VAX Virtual Memory. Ask any user.

"We were looking for large program capacity. And VAX ran circles around the competition."

Skip Little,
Supervisor of Systems Analysis and Systems Programming,
VAX Computer Group,
Woods Hole Oceanographic Institution,
Woods Hole, Massachusetts

Scientists at the Woods Hole Oceanographic Institution gather massive amounts of data about the earth's oceans. But until recently the only way they could analyze much of that data was by sending magtapes to and from a giant Cray 1 computer located 1800 miles away.

So the Institution decided to buy its own VAX from Digital.

Here's what Skip Little, Supervisor of Woods Hole's VAX Computer Group, has to say about VAX program capacity: "Some of the smaller versions of Cray modelling programs can actually be run on VAX. That's remarkable because the Cray 1 computer is the world's most powerful commercially-available system."

Now the problems they had in doing large data analysis and timesharing simultaneously are a thing of the past. Says Little, "We're able to lock our biggest jobs—like synthetic seismogram generation and fluid dynamical modelling—into VAX's main memory, while other timesharing users can be handled by the virtual memory system."

And Little has found that program conversion is a breeze: "We've converted programs from practically every kind of computer you can imagine with great ease."

"With VAX's virtual memory, there isn't a PC board around that's too large for LASAR to handle."

Fred Grant,
LASAR Product Manager,
Teradyne, Inc.,
Boston, Massachusetts

Teradyne, Inc. makes a wide range of automatic test equipment including computer-based systems for testing printed circuit boards. To help their customers program the most complex of these PC board test systems, Teradyne developed a sophisticated software package called LASAR.™

But until Teradyne looked at Digital's VAX-11/780, LASAR was only available to customers through a timesharing service on a large batch-oriented mainframe. The software package was just too big for anything less.

Now with LASAR running on VAX, Teradyne will have the program capacity they need, in a system their customers can afford to purchase.

"When you reach the limit of main memory, VAX automatically puts the program into virtual memory," Grant says. "That's a key factor in our LASAR development work. Test programmers can develop more complete programs without being limited by memory size."

Has Teradyne sacrificed performance by switching from the mainframe?

"Definitely not," says Grant. "In our benchmarks, VAX matched up one-to-one with the mainframe. That really impressed us."

And VAX's interactive capability should be a big plus for Teradyne's customers: "Several people can program on VAX simultaneously, and they can monitor the progress of their programs as they work.

"There's more programmer involvement with VAX, and more efficiency too."

"Without Digital's VAX, our specialized design work just wouldn't be as cost effective."

Stephen Tritter, Senior Principal Engineer, Engineering Computer Facilities, E-Systems, Inc., ECI-Division St. Petersburg, Florida

The ECI Division of E-Systems, Inc., designs high-technology electronics and communications equipment for the U.S. Government. And that requires huge computer programming space.

So virtual memory capability was an important factor in the E-System decision to buy a VAX.

"We're doing a lot of work now that we couldn't have done without Digital's VAX," says Steve Tritter, Senior Principal Engineer.

"For example, we use the VAX to help us design our own LSI integrated circuit chips. That means keeping track of thousands of points, each with several different characteristics. It's a big job.

"And while that analysis is running, other people are performing high-frequency radio propagation studies using as many as 210,000 memory locations, or running Fast Fourier Transforms with up to 8,000 points."

Tritter says that ECI regularly has 10 to 12 engineers working interactively on VAX at a given time.

"We're very happy with VAX system performance," he adds. "We expect to add more memory, and eventually service 50 to 60 simultaneous users."

Digital's VAX-11/780, with its 4 billion bytes of virtual memory, has set a new standard for program capacity. This means you can run large programs easily on VAX, with a potential for growth that's unmatched in the industry.

But don't just listen to us. Send for our free brochure.

And listen to our customers.

☐ Please send me the new "VAX—Ask Any User" brochure and detailed Technical Summary.
☐ Please contact me.

Name _____ Title _____

Company _____

Address _____

City _____ State _____ Zip _____

Phone _____

My application is ☐ Education ☐ Medical ☐ Laboratory ☐ Engineering ☐ Government ☐ Resale ☐ Other

Send to: **Digital Equipment Corporation**, MR1-1/M55, 200 Forest St., Marlborough, MA 01752. Tel. 617-481-9511, Ext. 6885.

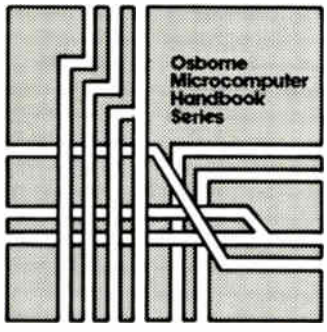
N-5-22-0

digital

Circle 187 on reader service card

A new way to keep up-to-date on microcomputer components

1980 Osborne Microcomputer Handbook Series



1980: the first is here

The 8089 I/O Processor Handbook, by Adam Osborne

Intel is developing the co-processor concept; the 8089 is the first of the Intel co-processors. The **8089 I/O Processor Handbook** provides a fully detailed description of this innovative device, its operation, and use in 8086 systems. This Osborne Handbook contains complete discussions of pins, signals, timing, the instruction set, and programming and configuration guidelines. The 8289 Bus Arbiter, which may be required in large system configurations, is also described.

#39-X $5.95

Also in 1980: **The CRT Controller Handbook**
The 68000 Microprocessor Handbook

Osborne Microcomputer Handbooks will continue to update the Introduction to Microcomputers, Volume 2 and 3 series.

Update the cumulative volumes: 1978-1979

An Introduction to Microcomputers
Volume 2 — Some Real Microprocessors

Every major 4-bit, 8-bit and 16-bit microprocessor through 1978 is described in this original 1400+ page volume. Architecture, timing, instruction set and usage are detailed for each of the 20 microprocessors, including the Intel 8086 and TMS9940.

1979 products are covered in the Volume 2 update package. Updates include Zilog Z8 & Z8000, MC6801 & 6809, and 2900 Series Chip Slice Devices.

Books and updates loose-leaf, unbound. Custom Volume 2 binders sold separately.

Volume 2 1978 ed.	#15-2	$25.00
Volume 2 1979 Updates	#97	$25.00
Volume 2 binder	#16-0	$5.00

An Introduction to Microcomputers:
Volume 3 — Some Real Support Devices

The first reference book to focus exclusively on microprocessor support devices, the 1978 edition offers 700 + pages of extensive coverage of Memory Devices, Parallel and Serial I/O Devices, CPU Single- and Multi-Function Support Devices, and System Busses.

1979 products are covered in the Volume 3 update package. Updates include Am9511 Arithmetic Processor, 8-, 10- and 12-bit A-to-D and D-to-A Converters, Floppy Disk Controller Devices, and Motorola EXORciser Bus.

Books and udpates sold loose-leaf, unbound. Custom Volume 3 binders sold separately.

Volume 3 1978 ed.	#18-7	$15.00
Volume 3 1979 updates	#98	$25.00
Volume 3 binder	#19-5	$5.00

To order, return coupon with check or money order. Include 75¢ per item for 4th class mail, $1.25 per book UPS, or $2.50 per book air mail in the U. S. California residents also include local sales tax. To place an order by phone call 415/548-2805.

Book	Price	Quantity	Amount

OSBORNE/McGraw-Hill
630 Bancroft Way, Dept. E19
Berkeley, CA 94710

Name _____
Address _____
City _____ State _____ ZIP _____
Phone _____ HOW TO SHIP _____

Tax
Shipping
TOTAL

Your low cost way out of the impedance jungle.

Before they get on board,
fend off wild RCL components for $795 (usa).

Those untamed components. They swarm over your circuit boards, eat into your resources, trap you in the impedance jungle.

But there is a low cost, reliable way out. Armed with the Model 252, you breeze through a wide range of values for resistance (R), capacitance (C), inductance (L) and conductance (G) at ±0.25% accuracy. The push of a button gives you dissipation factor (D).

At $795, the 252 rivals instruments costing twice as much.

- 0.25% basic accuracy
- Wide ranges (0.1 pF resolution to 200 µF)
- 3½-digit display (no manual balance)
- Dual analog outputs (C or L with D)
- External bias (to 50 VDC)
- Four measurements/second
- 4-terminal Kelvin Klips® (guarded)
- Input protection
- Easy calibration, servicing
- 1 kHz test frequency (120 Hz option)
- Low power design
- Lightweight, tiltstand handle

For systematic GO/NO-GO sorting, there's an optional limits comparator and sorting fixture.

Want autoranging? Gear up with the Model 253. And if you test at low frequency, check out the 120 Hz Model 254.

For over 25 years we've tamed the ways of the impedance jungle. A detailed 252 brochure shows you how.

The sure way to innovation.

esi ELECTRO SCIENTIFIC

Electro Scientific Industries, Inc., 13900 N.W. Science Park Drive, Portland, Oregon USA 97229, 503/641-4141; telex 15-1246

Circle 189 on reader service card

Semiconductors

Reference ICs gain in accuracy

Voltage accuracy attains ±0.2%, temperature stability quadruples

A series of precision hybrid voltage-reference integrated circuits developed by Motorola Semiconductor is said to improve output voltage accuracy by nearly an order of magnitude and temperature stability by a factor of four. Maximum initial tolerances are ±0.2% for the family, according to Roger Janikowski, product planner, linear ICs, at Motorola's IC division.

The devices come in standard (0° to 70°C) and military (−55° to +125°C) temperature ranges. The commercial MC1400 series and the military MC1500 units are both intended for applications in data acquisition and conversion and instrumentation.

Two production process improvements combine to permit the higher-performance references, Janikowski says. "A series of advances in thin-film resistive network deposition is the basic one, and that has been enhanced by active laser trimming of the resistor networks themselves." The deposition techniques, which place thin-film networks on the silicon substrate carrying the active devices, make possible volume production of monolithic thin-film devices. And laser trimming helps raise overall specifications, "while adding only a small premium to the price of the devices," says the Motorola engineer.

The Motorola devices are available in four output voltages: −2.5, 5, 6.25, and 10 V. The input range should be 1.0 to 40 V above the output voltage. The output voltage temperature coefficients are typically 2.5 ppm/° C, or a voltage change of 0.0175% over the commercial temperature range.

Moreover, the output reference is externally adjustable over a ±6% range using the output trim terminal. This allows, for example, the 10-V reference to be adjusted to 10.24 V for binary applications, such as digital-to-analog conversions. For data conversions, the initial ±0.2% accuracy opens use of these devices to most 8-bit applications, without external adjustment, and to up to 12-bit uses by employing the trimming feature.

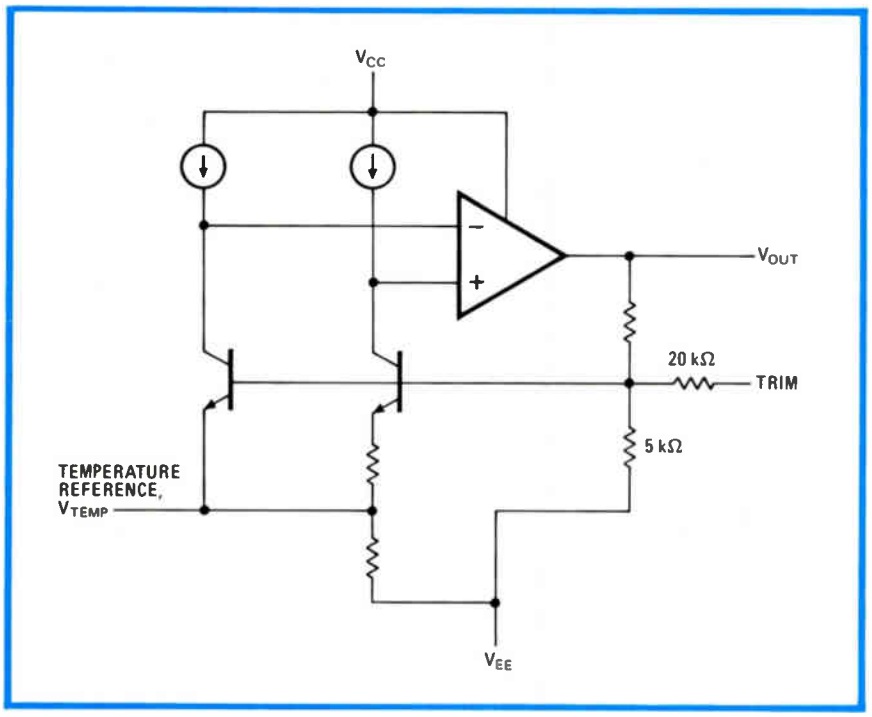
Another important feature is that "they can either source or sink greater than 10 mA of load current with excellent regulation," according to Janikowski. As a result, the devices have other advantages: they can be used as negative or positive voltage references; they can also act as a floating (ungrounded) reference when hooked up for two-terminal operation; and the buffer amplifiers and current sources normally needed for zener references can be eliminated.

Other specifications include:

- Low-current consumption, 1.0 mA typical.
- Ripple rejection of 87 dB typical at 120 Hz.
- Long-term stability of 25 ppm/1,000 hours typical.
- Line regulation of 0.5 mV typical and 3.0 mV maximum.

The MC1400 commercial series sells for $3.25 per unit for 100 or more, the MC1500 military unit (with a typical temperature coefficient of 4.0 ppm/°C) for $8.50. The units come in ceramic dual in-line packages, case model 693. All are available through Motorola original-equipment manufacturer sales or through distributors.

Motorola Semiconductor Products Inc., P. O. Box 20912, Phoenix, Ariz. 85202. Phone Roger Janikowski at (602) 962-2124 [411]



16-K C-MOS ROM draws only 7 mA of current

The SCM5316 is a complementary-MOS read-only memory intended as a low-power replacement for the industry-standard 2316 n-channel MOS ROMs and 2716 and 2516 electrically programmable ROMs. Drawing only 7 mA of current, the static device has a maximum access time of 55 ns. Organized as 2,048 8-bit words, it incorporates a storage cell with control circuitry that automatically reduces current drain to 0.1 mA upon chip deselection for a C-MOS

You can just about call the tune, whatever your requirements,with Kodak Precision Line products. They include quality films of excellent dimensional stability for masters, intermediates, copies and work masters for printed-circuit and other reprographic applications. In addition, there's a glass plate for making photomasks, as well as for those applications where exceptional dimensional stability is a necessity.

One of our most exciting numbers is Kodak Precision Line film LEN7. Its quality compares with the finest circuit negative films available at any cost. Yet LEN7 costs less. See it in action. You won't blame us for blowing our own horn.

For details on the whole repertoire of Kodak Precision Line products, write Eastman Kodak Company, Dept. GA029, Rochester, NY 14650.

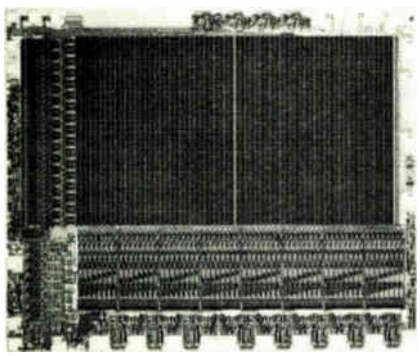
1880 Kodak *1980*

interface or to 1 mA for a TTL interface. The ROM needs only one 5-v ±10% supply and operates over −55° to +125°C.

Solid State Scientific Inc., Montgomeryville, Pa. 18936. Phone (215) 855-8400 [413]

8-K bipolar PROMs can be accessed in 60 ns maximum

The Am27S180 and Am27S181 high-speed electrically programmable read-only memories have a maximum access time of 60 ns over the commercial temperature range. The Schottky devices are organized as 1,024 by 8 bits and are available with open-collector (the 180) and three-state (the 181) outputs. Requiring only a single +5-v supply,



the units have a typical power dissipation of 600 mW.

The bipolar devices incorporate a platinum silicide fusible link at each memory location. An intact fuse represents a logic 0; 1s are selectively programmed to a logic high by applying appropriate voltages to the circuit.

Prices for the units start at $33.35 each in 100-unit lots.

Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, Calif. 94086. Phone (408) 732-2400 [414]

Dual 12-A Schottkys come in TO-220 plastic package

International Rectifier offers the first line of U.S.-made 12-A dual Schottky devices for power supplies in TO-220AB plastic packages. Designated the 12CTQ series, each of the devices has two 6-A diode chips connected by a common cathode but with electrically separate anodes.

Manufactured using the company's 830 process, the circuits have a reverse leakage that changes little with changes in junction temperature and does not degrade in terms of voltage with increased temperature. The reverse leakage is 6 mA at 125°C; the junction temperature rating is 175°C for nonrepetitive operation and 150°C for repetitive. There are four devices in the family, with working peak reverse voltage ratings of 30, 35, 40, and 45 v, respectively. The maximum 45-v rating is better than that of competitive units, the company says.

The price is $3.50 each for the 30-v unit in quantities of 1 to 49; for 100 to 999, the price is $2.62 each. The 45-v dual Schottky sells for $7.25 each in quantities of 1 to 49; for 100 to 999, the price is $4.90.

International Rectifier, Semiconductor Division, 233 Kansas St., El Segundo, Calif. 90245. Phone (213) 772-2000 [415]

Optoelectronic IC drives up to 8 TTL loads directly

The OPL 550 optoelectronic integrated circuit has a buffer with a totem-pole output that drives up to eight TTL loads directly without additional interface or signal processing circuitry. The discrete monolithic photosensor also includes a photodiode, a linear amplifier, and a Schmitt trigger. The device is encapsulated in a molded plastic package that has an integral lens for optical coupling to a compatible infrared-light–emitting diode. Typical propagation delay times are 2 μs and typical rise and fall times are 25 ns. The chip operates within the temperature range of −40° to +70°C. A buffer with open collector output, the OPL 550-OC, is also available. For 1,000 units, the price is $2.50 each. Delivery is from stock.

Optron Inc., 1201 Tappan Circle, Carrollton, Texas 75006. Phone (214) 242-6571 [416]

8-lane express for fiber optics.

Amphenol™ 801 Series connectors. 8 individual channels. Low insertion loss. Plus the assembly speed of Amphenol circular connectors.

Now there's a fast, precise reliable way to make up to eight separate fiber-optic connections at one time. And to replace any optical channel as required.

The insertion loss per channel is only 1.5 to 2.0 dB with most fibers. It's done with our spring retainer* that makes each channel independent of the tolerance build-up of any other.

The 801 Series looks familiar because it's an adaptation of our Mil-qualified circular connectors. So you get environmental sealing. And the speed of rear insertion/rear removal. And you can use M83723/31-12 insertion and removal tools.

801 Series connectors are available in 4-channel or 8-channel configurations (shown above). Both are designed for single fibers, but they can be adapted to multiple fiber bundles. When using multi-fiber bundles, you can mix electrical and optical contacts in any combination.

Optional strain relief mechanism protects the fiber bundle, maintains integrity of fiber optics interconnect and can be potted for environmental sealing.

Put the speed and performance of our 801 Series to work on your fiber-optic problem. For more information, call the sales office or distributor nearest you. Or contact our Danbury, Connecticut operations. (203) 743-9272.

4-channel

Shown 2/3 actual size

*Patent pending

BUNKER RAMO

AMPHENOL NORTH AMERICA

A Division of Bunker Ramo Corporation

Amphenol North America Division Headquarters: Oak Brook, Illinois 60521

Sales Offices: Atlanta (404) 394-6298 • Boston (617) 475-7055 • Chicago (312) 986-2330 • Dallas (214) 235-8318 • Dayton (513) 294-0461
Denver (303) 752-4114 • Greensboro (919) 292-9273 • Houston (713) 444-4096 • Indianapolis (317) 842-3245 • Kansas City (816) 737-3937
Knoxville (615) 690-6765 • Los Angeles (213) 649-5015 • Minneapolis (612) 835-4595 • New York (516) 364-2270 • Orlando (305) 647-5504
Philadelphia (215) 732-1427 • Phoenix (602) 265-3227 • St. Louis (314) 569-2277 • San Diego (714) 272-5451 • San Francisco (408) 732-8990
Seattle (206) 455-2525 • Syracuse (315) 455-5786 • Washington, DC (703) 524-8700
Canada: Montreal (514) 482-5520 • Toronto (416) 291-4401 • Vancouver (604) 278-7636 • **International:** Oak Brook, Illinois TELEX 206-054

Circle 193 on reader service card

Computers & peripherals

Printers sell for about $1,000

Two matrix printers print 80 and 250 characters/s and have standard interfaces

With two new matrix-type units being shown at the National Computer Conference, Pertec Computer Corp. is expanding its peripherals line into the lower end of the printer business. The new units are manufactured in West Germany by Triumphwerke, Nuremberg, AG, parent company of Triumph Adler Inc., a U. S. subsidiary that acquired Pertec in 1979. Los Angeles–based Pertec plans to sell the printers worldwide.

Of the two matrix units, model P250 is the faster performer, turning out 250 characters per second. Although it will be priced above $1,000, it is billed by the company as "a low-cost alternative to a line printer." Weighing about 55 lb, the printer is light enough to be portable and is designed for most distributed data-processing and multiterminal systems. With industry standard interfaces (serial RS-232 and teletypewriter), it transmits at 50 to 19,200 b/s. A 2-K character buffer (512 bits are included) and synchronous data transfer are optional.

The other printer, the P80, aims at low-speed data processing; it prints at 80 c/s. With simple construction intended to ease maintenance and add reliability, the P80 costs less than $1,000. It provides up to three copies, with underlining and true character descenders, according to the company.

Other P80 characteristics include bidirectional logic that provides the ability to change print direction at any position and to process continuous forms, single sheets, or roll paper. It has transmission speeds of 110 to 9,600 b/s and a 256-character buffer. Weight is approximately 16.5 lb.

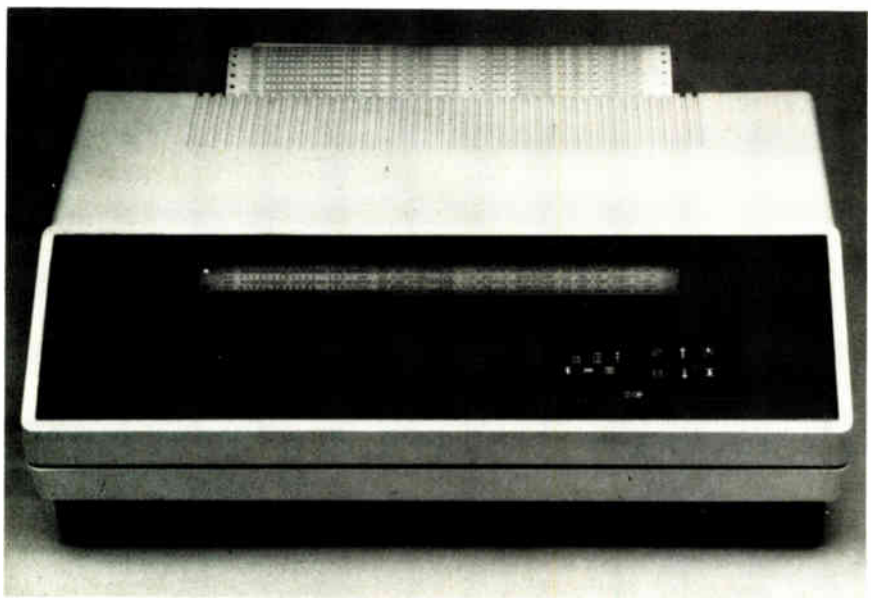
The P250 printer has a 7-by-9-dot matrix size, with a 9-by-9-dot size available as an option. It offers also a selection of character sets, numerous typefaces, and variable character spacing for up to 198 characters per line. For paper handling and fast ribbon replacement, the printer offers a bidirectional tractor-feed device, as well as self-test routines.

Voltages for the P250 are 100 to 240 V (±10%) at 47 to 63 Hz. Power rating is 50 W standby and 150 W in operation. Temperature is 10° to 35°C.

For the P80, which also incorporates industry-standard parallel and serial interfaces, self-diagnostic functions are provided, along with multiple character sets with either 80 or 120 characters per line. Voltage and power requirements are similar to the higher-priced model, except for ready state, which takes 15 W.

The printers will be available by late summer.

Pertec Computer Corp., Peripherals Division, 21111 Erwin St., Woodland Hills, Calif. 91367. Phone (213) 999-2020 [361]



Typewriter-sized printers use new head mechanism

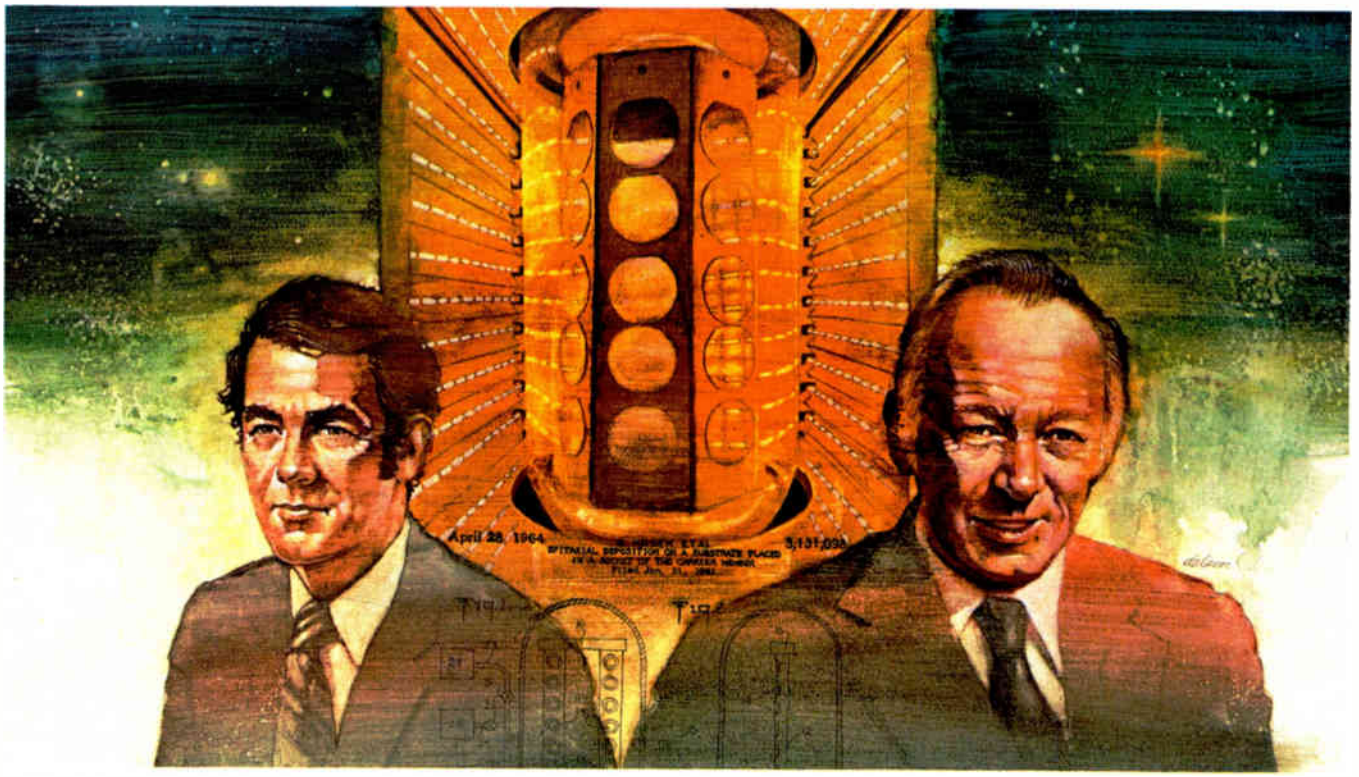
A pair of typewriter-sized impact matrix printers capable of "office-quiet" operation is being added by General Electric to its family of TermiNet printers. The printers, part of the new TermiNet 2000 multimicroprocessor-based product line, are the 2020, which prints 30 characters per second, and the 2120, with a print rate of 120 characters per second.

The units rely on a newly designed blade print head, whose print dots, or pins, are each attached to a metal arm emerging from the side of a flat wire coil. The print head, placed in the field of a samarium-cobalt magnet, is 9 pins high and 7 wide; conventional matrix printers employ 7-by-7-dot matrixes.

Quiet operation. An injection-molded enclosure 22 in. wide, 18.5 in. deep, and 5.5 in. high, along with the new print head design, contributes to the quiet operation. GE rates operation noise at about 58 dBa. Each printer weighs 22 pounds.

The TermiNet model 2030 prints bidirectionally at 60 characters/s and a 150-character/s rate is provided by the model 2120. Print density is selectable at 10, 13.2, and 16.5 characters per inch along a 13.2-in. print line.

The keyboard is microprocessor-scanned and employs capacitive key switches. For American models, an ANSI typewriter-paired arrangement is standard and an ANSI/APL layout is optional, as are layouts for inter-



Walter Benzing (right) pioneered work in epitaxial silicon deposition in the late '50s. In 1970, he and Michael McNeilly (left) coinvented the use of radiant heating in epitaxial reactors – the most widely used epitaxial technology in the semiconductor industry today.

No. 5 in a series

SEMI Presents... Great Moments in Semiconductor History

It was the work on bulk silicon growth done in the late '50s at the research labs of Merck and Company which led to the technology of growing epitaxial films on silicon single crystals. By vapor phase growing the film, and doping it as you go, Walter Benzing and his team discovered, one could achieve a plurality of layers having different conductivities. Direct preparation of P/N diodes and the more important n+/n structure from this method were usable in high frequency transistors.

Benzing, George Krsek and others received a patent for their method and a multiwafer reactor to achieve this breakthrough in the early '60s.

From the early Radio Frequency reactors, Benzing and Mike McNeilly (one of the founders of Applied Materials) worked on a radiant reactor which would ensure more wafer uniformity, handle larger wafers and more wafers per load. Their radiant heating reactor, most widely used today, yielded them a patent in the early '70s. Their greatest breakthrough was in being able to produce a wafer free of crystallographic slip. In more recent years, the same radiant heating has been applied in a reduced-pressure reactor which reduces autodoping.

SEMI is "breaking through" in 1980 too. This is the year of our Tenth Anniversary Celebration and the first year SEMICON will be managing the SEMICON/Southwest Trade Show at Market Hall in Dallas, October 8–9. Prior to that, we will gather for another "Great Moment" at SEMICON/East in Boston, September 23–25.
Hope to see you then . . .

SEMICON/East
September 23–25, Boston

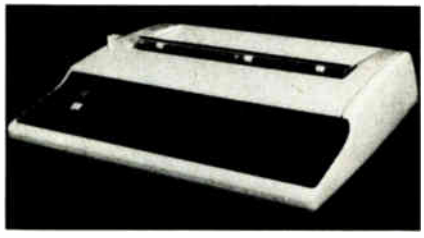
SEMICON/Southwest
October 8–9, Dallas

SEMICON/Japan
November 19–21, Tokyo

SEMI

Semiconductor Equipment and Materials Institute
625 Ellis Street, Suite 212, Mountain View, CA 94043
(415) 964-5111, Telex: 171-977 SEMI-MNTV

Circle 195 on reader service card 195



national use. A numeric cluster also is available as an option.

The new printers, employing switching-type regulators, require 30 W (the 2030) and 50 W (the 2120). The units use dual 8085 microprocessors, offer a received-data buffer, and feature nonvolatile configuration memory. In addition, the printers incorporate modular software and provide a full RS-232 data interface.

The new product line will be sold directly to original-equipment manufacturers and through a new network of distributors. Full-scale production will begin in September for the TermiNet 2030 and by the end of the year for the TermiNet 2120.

Price for a single 30-character/s model will range from $1,400 (receive-only) to $2,300 for a send/receive unit with a keyboard and all options. Price for a single 120-character/s unit will range from $2,100 (receive-only) to $3,000 for a unit with all available features. OEM-quantity discounts will be available.

Data Communication Products Business Dept., General Electric Co., Waynesboro, Va. 22980. Phone (703) 949-1000 [362]

High-resolution color terminal refreshes at 30 Hz

The Whizzard model 7250 parallel raster terminal, the first member of a 7200 family, offers an average pixel writing time of better than 160 nanoseconds. That allows updating of complex pictures at standard 30-Hz frame rates on a 512-by-512-pixel color or monochrome raster monitor.

The unit supports multiple monitor setups, with up to four 16-color monitors or up to 16 monochrome monitors. It is completely compatible with the firm's existing vector graphic refresh systems but differs from them in its use of a digital vector generator rather than an analog vector generator.

Explains Peter J. Shaw, vice president and director of marketing at Megatek Corp., "this gives OEMs the flexibility to address a much wider range of applications, while maintaining device independence of their software." The 7250 has a capacity of 196 kilobytes of memory, with each 32-bit word holding up to two vectors or four characters. Combined with the 4,076-by-4,096 virtual vector space, this provides detail in real-time steps from 512 by 512 to 4,096 by 4,096.

Prices for black-and-white monitor systems start at $20,000, and those for color systems start at less than $25,000. Deliveries are slated for late summer.

Megatek Corp., 3931 Sorrento Valley Rd., San Diego, Calif. 92121. Phone (714) 455-5590 [363]

Modular system includes up to 32 peripherals

A modular computer system from Infotecs—Control Center 2—consists of a terminal with a cathode-ray tube, a 150-character/s impact printer, and a control cabinet for a high-speed floppy-disk dual drive, two plug-in processor boards, and a power supply. The system can be expanded to include 32 peripheral devices. Software developed for earlier Infotecs systems can be run on the new system.

One unusual aspect of the system is the use of multiple dedicated processing units instead of the more conventional central processing units. This allows simultaneous multiprocessing. As devices—CRTs or printers, for example—are added to the system, additional DPUs are added also to eliminate the processing bottleneck. The basic hardware price is $11,500 and delivery time is quoted as 30 days.

Infotecs, One Perimeter Rd., Manchester, N. H. 03103. Phone (603)624-2700 [365]

Check Beckman's specs before you select your source for Converters.

Beckman's Series 7580 and 7541 12-bit D/A converters replace the popular DAC 80 and 7541 pin-for-pin. But they offer better performance, use less power and are priced competitively.

Now *you* can write in better specs because *our* specs are better over a wide range of temperature and power supply variations. And Beckman converters offer much tighter end-point linearity specs than other manufacturers, resulting in better full-scale accuracy. Calibration is simpler, too. You need only to set zero and full scale once to fully calibrate your system.

You can also expect greater design flexibility because Beckman's CMOS DACs consume less power and are TTL and CMOS compatible.

Just as important, the 7580 and 7541 are competitively priced in both military and commercial versions. And they're available now-from stock.

Better performance, lower power consumption, greater design flexibility and competitive prices right from stock. Maybe you should check Beckman's specs. You might just find us to be your prime source for converter products.

For more information, contact your local Beckman representative or write: Advanced Electro-Products Division, Beckman Instruments, Inc., 2500 N. Harbor Blvd., Fullerton, CA 92634. (714) 773-7935.

Design Beckman converters in. Design problems out.

BECKMAN

Circle 197 on reader service card

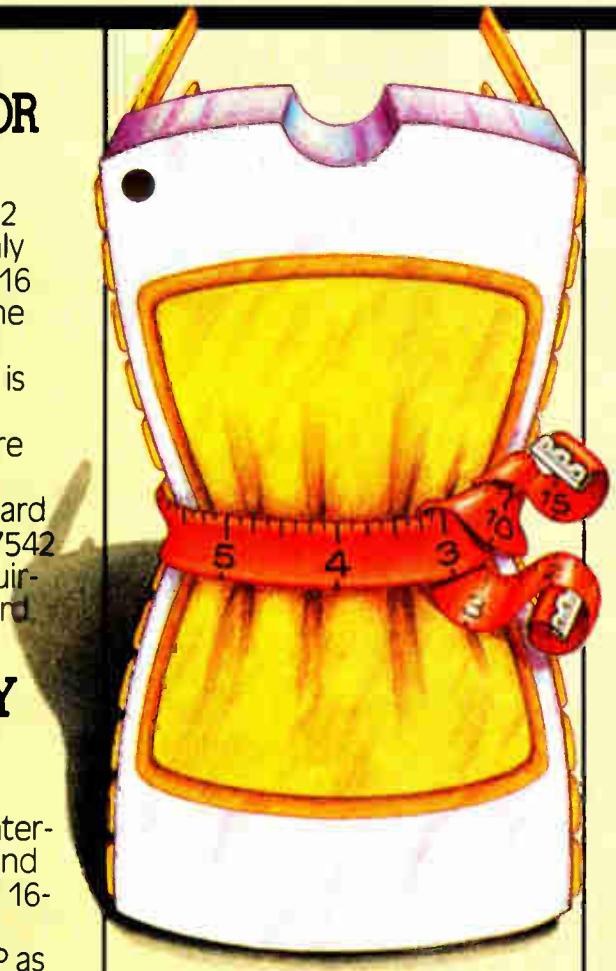
12-BITS, 16 PINS. THE END OF THE FAT DAC.

THE 12-BIT DAC FOR TIGHT LAYOUTS.

Our compact new AD7542 is the world's first and only 12-bit D/A converter in a 16 pin DIP. It needs only ⅓ the board space of the usual 24 pin DIP, and since data is brought in as three 4-bit words, only 4 data lines are required rather than 12, which saves lots of PC board track. This makes the AD7542 ideal for applications requiring several DAC's per board.

DIRECT AND EASY μP INTERFACE.

Our slim, new DAC is designed specifically to interface directly to the data and control buses of 4, 8, and 16-bit microprocessors. The AD7542 interfaces to a μP as static RAM, with data loaded into it in three 4-bit words, using simple memory WRITE instructions. It even has a separate asynchronous clear input to simplify initialization during power up.



AND IT'S AN HONEST 12-BITS.

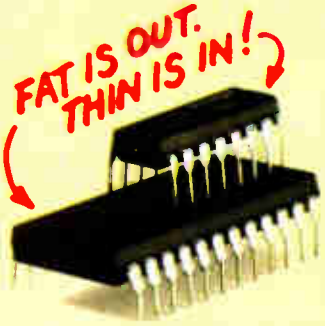
The AD7542 is a *real* 12 bit DAC, offering *true* 12 bit performance. Its monolithic CMOS construction gives you guaranteed 12 bit linearity over temperature (±½ LSB from T_{min} to T_{max}), and a low gain TC (typically ±2ppm/°C).

It operates on a +5V supply and features latch-up free operation. It also has all the analog versatility of CMOS DAC's, including 4-quadrant multiplication, and a low 40 mW power consumption.

ALL FOR AN UNBELIEVABLE $9.50.

You might think the world's smallest 12-bit DAC comes with a big price tag. It doesn't. You can get our AD7542JN (±1 LSB max linearity error) for only $9.50 in 1000's, or our AD7542KN (±½ LSB) for $10.50 in 1000's.

For the full story on this lean, new DAC, contact Doug Grant or Don Travers at (617) 935-5565, or write Analog Devices, Inc., P.O. Box 280, Norwood, MA 02062



ANALOG DEVICES

WAY OUT IN FRONT.

Analog Devices, Inc., Box 280, Norwood, MA 02062; East Coast: (617) 329-4700; Midwest: (312) 894-3300; West Coast: (714) 842-1717; Texas: (214) 231-5094; Belgium: 031/37 48 03; Denmark: (02) 84 58 00; England: 01/94 10 46 6; France: 687-3411; Germany: 089/53 03 19; Japan: 03/26 36 82 6; Netherlands: 076/879 251; Switzerland: 022/315760; and representatives around the world.

Circle 198 on reader service card

Instruments

Position indicator with LED display goes commercial

Size reduction has always been a way of life for those designing solid-state components. And where harsh service was demanded, few of the more advanced designs saw service beyond military applications such as ground-based radar antenna equipment. But all that may be changing, if a recent product introduction by Natel Engineering Co. is any indication.

The device—model SD4071 dual-angle two-speed position indicator—reads angular displacement in two axes and has several features that could be useful in such demanding applications as industrial robot production measurements, construction gear, oil drilling rigs, and vehicle testing.

As a two-speed device, it offers 0.01° resolution (for a five-digit version) or 0.001° resolution (for a six-digit version). Light-emitting diodes display angle measurement for each axis. Each axis has two synchros; one yields rapid coarse data, whereas the other produces fine data for high accuracy.

In operation, on-board processors convert the synchros' angular displacement into digital signals; plug-in modules adapt the converter electronics to the synchro gear ratios used (those ratios range typically from 1:16 to 1:72, with 1:36 being the most common). The choice of ratios is determined by the accuracy needed.

Moreover, replacement converter modules are precalibrated as a condition of purchase. Five-digit resolution is provided by a converter with 16-bit capacity and six-digit by one having 20-bit capacity. Most customers, says the company, like to have one or two on hand.

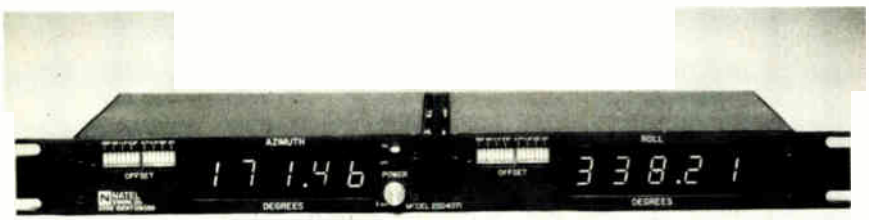
Besides the flexibility permitted by the replacement converter modules, Natel's angle indicator can also be set up to operate with a variety of synchro input and reference voltages by adjustment of internal switches. Also provided are switchable voltages that permit up to 360° angle offset.

In addition to displaying angle position in two axis, the device provides other outputs for data storage and other uses. For one, it converts synchro or resolver inputs into a linear dc output proportional to the angle input. The output may also be in the form of binary or angle logic, the company reports.

Other options include binary angle offset controls to provide both, a 0° to 360° offset between synchro input and output, and a linear dc output proportional to the angle input. A ±180° bipolar input is also available.

Prices start at $1,995 and delivery is from stock.

Natel Engineering Co., 8954 Mason Ave., Canoga Park, Calif., 91306. Phone (213) 882-9620 [352]



17-lb oscilloscope features 5-in. CRT

A small 17-lb, 25-MHz dual-trace oscilloscope has a large screen for its size. It measures 5.25 by 12 by 16.25 in., yet has a 5-in. rectangular cathode-ray tube with an internal graticule for optimum accuracy. The portable model OS1200 has been designed for analog and digital uses in laboratory and field service.

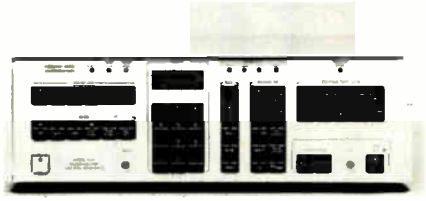
The unit's 14-ns rise time, 6-kv accelerating potential, and built-in signal delay make it a good choice for measuring narrow digital pulses with fast rise times and low repetition frequencies. A 1-v dc-coupled Z-modulation input eases its use with logic analyzer outputs. Timebase speeds range from 200 ns/cm to 1 s/cm with vernier control over a range of 2.5:1. The dual input channels have a maximum sensitivity of 2 mV/cm over the full 25-MHz bandwidth.

The oscilloscope with probes sells for $1,299. Delivery is 30 days after receipt of order.

Gould Inc., Instruments Division, Marketing Services, 3631 Perkins Ave., Cleveland, Ohio 44114. Phone (216) 361-3315 [353]

GPIB function generator has intelligence

The model 5900 may be the first intelligent programmable-function generator intended for use with the



general-purpose interface bus (GPIB). The microprocessor-based unit has a built-in automatic programmer that can learn a procedure and repeat up to 200 of the steps at any given rate. This capacity eliminates the need for a controller in low-level systems and reduces the demands on a central processor's time in larger systems. The feature, combined with the unit's arithmetic and automatic-incrementing and decrementing, makes possible precise linear sweeps over a 10,000:1 range, log sweeps over the unit's entire 100-μHz-to-5-MHz range, and nested

loops that can intermix log and linear sweeps as well as operate on frequency, period, pulse width, duty cycle, amplitude, dc offset, or burst cycle. Nine storage registers are available.

The 5900 produces sine, square, triangle, pulse, and sawtooth waveforms in continuous, gated, triggered, digital sin/log sweep, and triggered-burst modes. Its 30-v peak-to-peak output has a 10-mv resolution. The unit has a front-panel attenuator that will provide attenuation ratios of 20, 40 or 60 dB. The price is $3,000 and delivery is in 90 days.

Krohn-Hite Corp., Avon Industrial Park, 255 Bodwell St., Avon, Mass. 02322. Phone (617) 580-1660 [354]

Multichannel FFT analyzer links to computer terminals

The model 6080 multichannel fast-Fourier-transform analyzer can be used as such or combined with peripherals and computers to operate as a 128-channel real-time analyzer, high-speed data-acquisition system, or modal analysis system. A proprietary bus concept allows a large number of data-acquisition cards, each with its own auto gain stage, a 12-bit analog-to-digital converter, and anti-aliasing filters to be connected to common signal-processing and central-processing-unit buses.

The instrument can be used with a Zonic 6081 or Tektronix terminal to perform a variety of functions, including 30-ms, 400-line FFT, and with a DEC minicomputer to perform advanced modal analysis. Twenty-two sample rates, from 20 Hz to 102.4 kHz, can be selected internally, and frequencies to 40 kHz can be analyzed. Two optional modules are available; one provides band-selectable frequency analysis, and the other provides transfer functions from swept sine excitation and order analysis of rotating machinery. The instrument sells for $19,950.

Zonic Technical Laboratories Inc., 2000 Ford Circle, Milford, Ohio 45150 [356]

Active Filters

Frequency Selection Where You Need It

Frequency Devices offers expanding families of over 100,000 unique active filters. These filters are designed to meet the broadest possible range of application requirements.

- Fixed, tuneable and programmable frequencies
- Lowpass, Highpass, Bandpass and Band Reject transfer functions
- 2, 4, 6, 8, and 10-Pole designs
- Tchebyscheff, Elliptic, Butterworth and Bessel characteristics
- Passbands from DC to 1 MHz
- Corner frequencies from 0.001 Hz to 50 KHz

For special needs Frequency Devices manufactures a host of application-specific active filters.

- EEG, EKG and EMG for biomedical work
- C-Message, Phosphometric, FSK, CCITT and PCM for tele- and data communications applications
- Anti-Aliasing for A/D conversion
- ANSI 1/Nth Octave for broadcasting, aircraft vibration and OSHA noise standards
- Filters for elimination of powerline interference and harmonics
- Filters for tone control, demodulation, comb filtering, phase lock control and many more.

Frequency Devices designs, manufactures, and delivers active filters to industrial, federal or military specification.

Frequency Devices INC.

25 Locust Street, Haverhill, MA 01830
Tel: 617-374-0761 TWX: 710-347-0314

Communications

Codec partitioned into encoder and decoder chips

A two-chip complementary-MOS codec set has been partitioned into an encoder with filters on one chip and a decoder with filters on the other. The model S3501 encoder and model S3502 decoder have been designed to handle voice frequencies in each channel of pulse-code-modulation channel banks.

The separate chips are said to eliminate any possibility of crosstalk between transmit and receive channels. Also, they enable users of only transmit or receive devices to buy chips highly suited to their specific purposes.

Each chip contains a bank-limiting filter and an analog-to-digital or digital-to-analog converter that conforms to the transfer characteristics specified in the μ-255 law. The filter consists of a sixth-order low-pass elliptical filter followed by a third-order Chebyshev high-pass filter. Rejection below 65 Hz is at least 25 dB, which minimizes noise induced by power frequencies. The analog-to-digital converter uses charge redistribution techniques to perform the conversion.

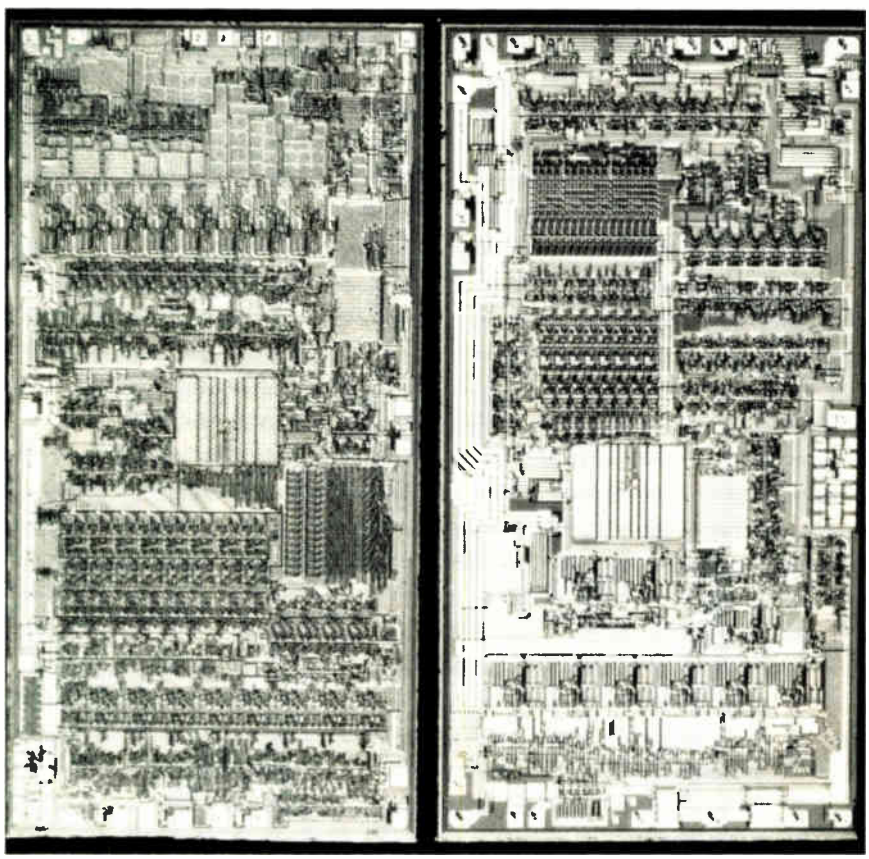
The units receive and transmit 8 bit data words containing analog information and do so at up to 3.2 Mb/s, with analog sampling at a nominal 8-kHz rate. The 8-kHz strobe signal also generates all internal timing signals in a phase-locked loop so the device's pin count can be reduced.

The 18-pin encoder has control logic for common-channel interoffice systems and D3 signaling, a loop that nulls long-term offsets, and an uncommitted operational amplifier for gain trimming and anti-aliasing. The filter on the 16-pin decoder has sin X/X correction, and the op amp is for directly driving a 600-Ω load. In addition, it has optional TTL or relay drive from the A or B signaling output.

Each chip needs one reference voltage and two noncritical power supplies (typically ±5 V dc). In the absence of the 8-kHz strobe, the units power down. They also do this when the phase-locked loops sense unlocking. Standby power dissipation is 15 mW per chip; the typical operating power dissipation is specified at 70 mW for the S3501 and 55 mW for the S3502.

The chips come in ceramic dual in-line packages. Each set sells for $37.50 when ordered in quantities of 100 sets.

American Microsystems Inc., 3800 Homestead Rd., Santa Clara, Calif. 95051. Phone (408) 246-0330 [401]



Processor transmits speech and 1,200-b/s data together

Until recently, simultaneous transmission of speech and full-duplex data over a single, four-wire voice circuit was limited to 600 b/s, and even then the quality of the voice, with its 1,800-Hz bandwidth, was marginal. Now a speech and data processor, the model 6860, allows transmission of high-quality speech simultaneously with a 1,200-b/s data rate.

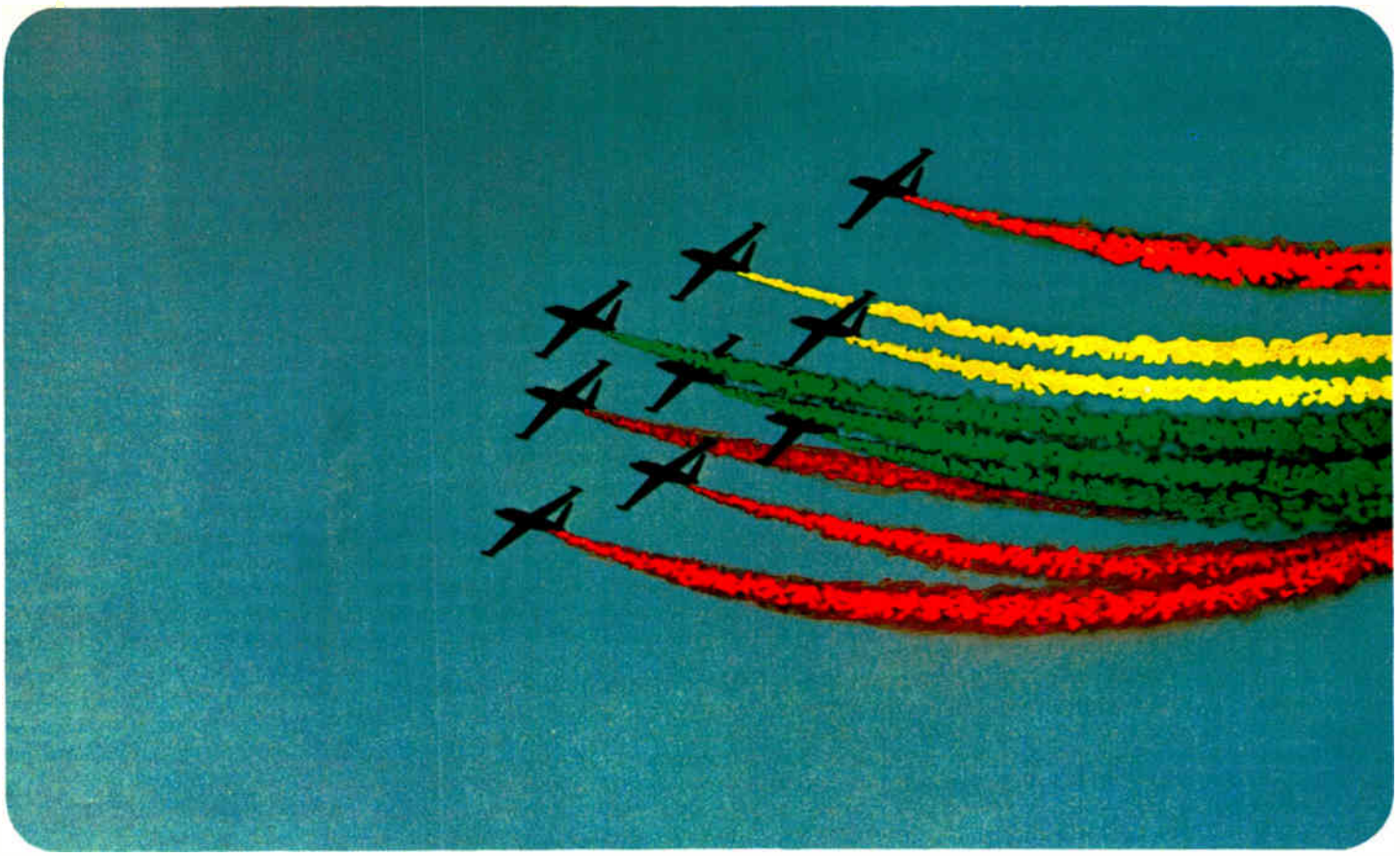
The speech-processor portion of the system uses a voice compandor to provide a low-noise circuit and includes ear and mouth (E&M) signaling to interface PBX and PABX terminals. The modem portion features data distortion of less than 1%, a modem-loopback switch, and light-emitting-diode displays that aid in the supervision of digital functions. Digital interfaces include an RS-232 connection or one that meets the Consultative Committee of International Telephony and Telegraphy standard V.24.

The communications processor sells for $3,264 per terminal end and can be delivered in 60 days.

RFL Industries Inc., Boonton, N. J. 07005. Phone Al Jordon at (201) 334-3100 [403]

Optical transmittive coupler has insertion loss of 0.6 dB

A two-port-by-two-port optical transmittive coupler has an insertion loss of 0.6 dB and directivity of −30



Fly by color!

The Electron Tube Division is now readying a range of specially ruggedized, extremely high brightness, high-resolution, multicolor CRT's, destined for the head-down display (HDD) systems of the new generations of civilian and military aircraft that are being developed for the 1980's. The use of these tubes in HDD's permits displaying several different parameters simultaneously on a single screen, by using different combinations of scanning standard (TV or stroke-writing) and color. This reduces total display area, simplifies data assimilation, and reduces recognition errors. All of these new tubes will use the penetration screen principle, pioneered by THOMSON-CSF. Typical of these new tubes is a 5" x 5", 3-color, high-resolution tube with a contrast-enhancing directional filter. Primarily destined for the MIRAGE 2000, the new French combat aircraft, this tube, or a derivative thereof, is suitable for any military aircraft in which high readability is required under the intense lighting commonly found in cockpits. Similar tubes have been developed for civilian aircraft where environmental conditions are slightly less severe. In addition, because the copilot must have access to the same information as the pilot, these tubes use wide-viewing-angle, neutral-density filters for contrast enhancement, instead of directional filters.

THOMSON-CSF

DUMONT ELECTRON TUBES

750 BLOOMFIELD AVENUE / CLIFTON NJ 07015 / TEL. : (1.201) 773 20 00 / TWX : 710 989.7149

BRAZIL – THOMSON-CSF COMPONENTES DO BRASIL LTDA.
C.P. : 4854 / BROOKLIN / SAO-PAULO / TEL. : (55.11) 61 64 83
FRANCE – THOMSON-CSF DIVISION TUBES ELECTRONIQUES
38, RUE VAUTHIER / 92100 BOULOGNE-BILLANCOURT / FRANCE
TEL. : (33.1) 604 81 75
GERMANY – THOMSON-CSF GmbH BEREICH ELEKTRONENRÖHREN
FALLSTRASSE 42 / 8000 MÜNCHEN 70 / TEL. : (89) 76 75 1
ITALY – THOMSON-CSF TUBI ELETTRONICI SRL
VIALE DEGLI AMMIRAGLI 71 / I - 00136 ROMA
TEL. : (39.6) 638 14 58

JAPAN – THOMSON-CSF JAPAN K.K. / TBR BUILDING
KOJIMACHI 5-7 / CHIYODA-KU / TOKYO / 〒102
TEL. : (81.3) 264 63 41
SPAIN – THOMSON-CSF COMPONENTES Y TUBOS S.A.
CALLE ALMAGRO 3 / MADRID 4 / TEL. : (34.1) 419 88 42
SWEDEN – THOMSON-CSF KOMPONENTER & ELECTRONRÖR AB
BOX 27080 / S 10251 STOCKHOLM 27 / TEL. : (46.8) 225815
UNITED KINGDOM – THOMSON-CSF COMPONENTS AND MATERIALS LTD
RINGWAY HOUSE / BELL ROAD / BASINGSTOKE RG24 OQG
TEL. : (44.256) 29155

3879

Circle 217 on reader service card

New products

dB. The Maxlight model C2X2-200 has an 0.38 numerical aperture and works well with plastic-clad silica optical waveguides with a 200-μm core. It allows the user to design a wide variety of single-fiber configurations that he could not design in the past. For example, duplexing, branching, monitoring, and mixing are now feasible applications.

The coupler operates passively and requires no external connections other than to the waveguides. The core diameter is 208 μm. The units operate from −30° to 80° C. Four cabled fiber leads may be varied in length by the user. Each lead is terminated using a semirigid connector adapter sleeve whose inner surface provides an optical cladding with a high-strength molecular bond to the silica core.

The coupler may be ordered with the adapter sleeve only or with optional AMP or Amphenol 905-series connectors installed. Single-unit prices start at $198 with delivery from stock to four weeks.

Maxlight Optical Waveguides Inc., 3035 N. 33rd Dr., Phoenix, Ariz. 85017. Phone Gary Nelson at (602) 269-8387 [405]

Selective call receiver is field-programmable

The model 7924 is a programmable call receiver designed for use in all types of secure combinatorial switch selectors, which include mobile radios and remote telephone answering systems. Contained in a multiple dual in-line package, this dual-tone multifrequency (DTMF) device can correlate a sequential code of digits in a preselected time interval. When it is used with the TC-100 DTMF encoded keyswitch, one or more 7924 receivers may be placed at various locations along a two-wire system up to several kilometers long.

In quantities of 1 to 49, the 7924 sells for $150 apiece; 50 to 99 units sell for $125 each; and 100 to 499 units sell for $100 apiece. Delivery is from stock to four weeks.

Telaris Telecommunications Inc., 2772 Main St., Irvine, Calif. 92714 [406]

"Finally, a flat cable as tough as me."

"One visit from my Spectra-Strip rep convinced me that their Spectra-Guard™ extruded jacketed cable is my kind of flat cable.

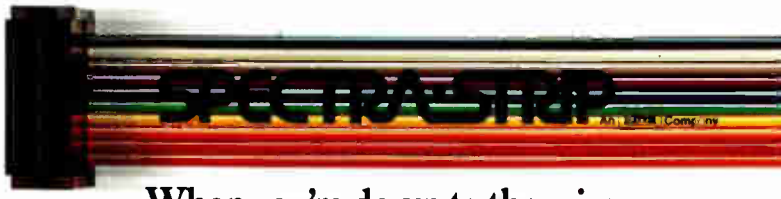
All the benefits of planar. Plus the toughness of an extremely flexible extruded hide—er, jacket—that's perfect for all my cabinet-to-cabinet wiring.

Both the cable and jacket are flame-retardant and UL-listed to 105°C and 150V. The cable—flat, twisted pair or Twist 'N' Flat®—is available gray or color coded, with or without EMI/RFI shielding. And the outer jacket is easily removed for mass termination using any of the Spectra-Strip IDC connectors.

When things get hot around here, I even have Spectra-Strip or one of their value-added distributors provide terminated and tested jumpers and custom assemblies, and does that ever save time and money!

So if you've been trying to dig up a reliable source for your planar cable, IDC connectors and assemblies, I strongly recommend that you write Spectra-Strip, 7100 Lampson Avenue, Garden Grove, CA 92642, telephone (714) 892-3361. In the East, call (203) 281-3200.

Tell them you want to see how tough they are."



When you're down to the wire

Data acquisition

D-a converters aid raster-scan CRTs

Fast-settling d-a converters offer small size and low-glitch performance

Fast-settling, low-glitch digital-to-analog converters have been a boost to raster-scanning cathode-ray-tube display terminals. Though such displays may have lower resolution than vector-scanning systems, they usually are brighter, offer a wide range of colors, and cost less.

Until now, d-a converters for raster-scanning applications have fallen into two categories: they have been either relatively large, power-hungry modules or monolithic devices prone to random output spikes, or glitches. The typical monolithic unit also needs a number of outboard passive components.

The HDD d-a devices from Analog Devices Inc.'s Computer Labs division, Greensboro, N. C., are not only fast, but also small—they come in dual-width, dual in-line packages. They require no outboard parts and need relatively little power.

The 8-bit HDD0810C and 10-bit HDD1015C are emitter-coupled-logic–compatible for speed and use 125-MHz input registers to store display data. The C suffix indicates that the units offer digital control of the composite signal, sync, and blanking at packaging pins. The composite blanking output is 1 V with the units terminated in a 75-Ω load. Companion units without digital composite control, that is, without the C suffix, are available at lower cost.

All four units settle in 10 to 15 ns to within 0.2% and 0.1% of full scale for the 8- and 10-bit versions respectively. The slew rate is 200 V/μs; the rise time is 4 ns. The update rates are 100 MHz for the 8-bit converter and 67 MHz for the 10-bit.

The units offer low-glitch output as well: 200 pV-s, maximum. With so-called deskewing capacitors added between the input registers and the initial converter stage, glitch output then reaches a maximum level of only 100 pV-s.

These are current-output devices and their output format meets EIA performance standards RS-170 and RS-373 for video even though television applications are expected to account for only 5% to 30% of sales.

The units come complete with internal voltage reference, and both the 8- and 10-bit versions are guaranteed to be monotonic and are accurate to within ±0.1% and ±0.5% of full scale, respectively.

Linearity and the zero-offset temperature coefficient are 5 and 1 ppm/°C, respectively. The gain temperature coefficient is 80 ppm/°C for both converters.

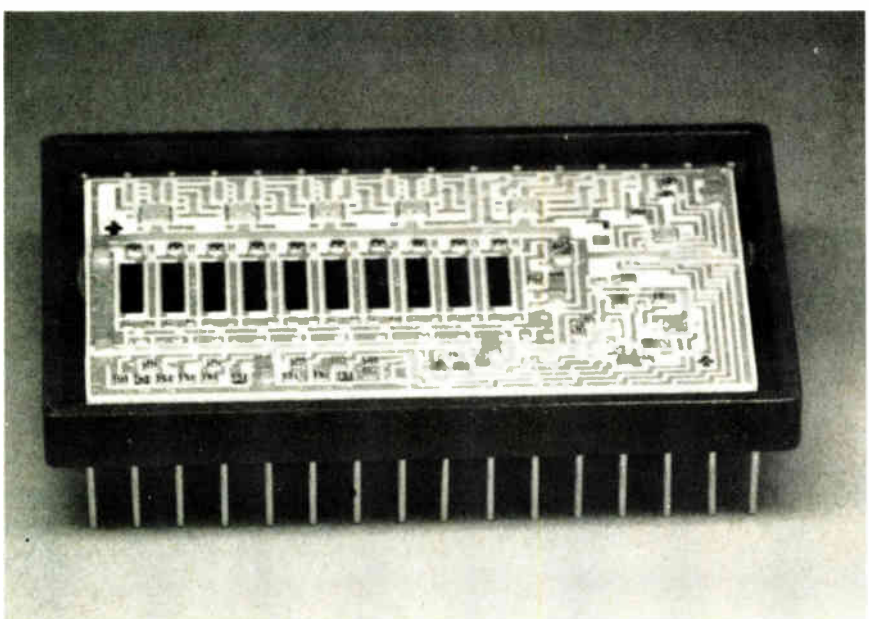
The converters have a unipolar output-current range, or gray scale, of 0 to −17 mA and ±1.1 V output-voltage compliance. For applications requiring a wider output-current range, the two units that come without a video composite output—the HDD0810 and HDD1015—offer a range of from 0 to more than 27 mA.

The HDDs require only a single −5.2-V supply, with the 8-bit model drawing only about 380 mA and its 10-bit companion drawing only about 450 mA.

The devices are designed for a zero to ±70°C commercial temperature range and are packaged in a ceramic dual in-line package; for industrial applications, hermetically packaged versions operate over a −30° to +85°C range.

In 100-unit lots, prices are $135 for the HDD0810C and $151 for the HDD1015C. For the units without composite video output, prices fall to $129 and $143, respectively. The HDD d-a converters are available from stock.

Analog Devices Inc., Computer Labs Division, 505 Edwardia Dr., Greensboro, N. C. 27409. Phone Arnold Williams at (919) 292-6427 [381]



12-bit data-acquisition system sells for $165

This 16-channel, 12-bit data-acquisition system accepts analog inputs over a ±10-V range. The SDM854 operates from −25° to +85°C, has 12-bit, ±0.01% or ±0.025% linearity, throughput sampling rates of up to 27 kHz, and high input impedance of 5×10^9 Ω. Its internal circuitry is protected when input signals range up to 20 V higher than the unit's positive or negative supply. This protection is a special advantage when the system is used in electrically

Plessey Miproc 16 bit super power suits your needs!

Miproc-16 is the fastest 16-bit microcomputer card family available and has a compute-rate of 4 million instructions per second.

INSTRUCTION POWER Up to 170 instructions including multiply/divide and bit manipulation give Miproc-16 formidable processing capability.

16-BIT POWER 16-bit program words make programming easy. 16-bit data words maintain high precision in arithmetic operations.

ADDRESSING POWER 16-bit dual memory architecture gives 65k words of directly addressable program memory *and* 65k words of data memory with 8 powerful address modes.

INTERRUPT POWER Multilevel, priority vectored interrupt system handles context changes in less than 2 microseconds.

I/O POWER 256 directly addressable I/O channels with data I/O rates of up to 1.7 megabyte/s under program control, and up to 20 megabyte/s for DMA.

HIGH SPEED PROCESSING POWER The unique dual memory architecture combines with high-speed Schottky TTL technology to execute most instructions in a single 250 nanosecond machine cycle.

SOFTWARE POWER Comprehensive package available which utilises the powerful facilities of the DEC PDP11 including cross-assembler, PL Miproc high level assembly language and a full Coral package. And soon a disk-operating system with PASCAL.

HARDWARE POWER Comprehensive range of processor, memory and interface cards backed up by sophisticated hardware development aids.

RUGGEDIZED POWER Miproc can be configured to meet any known military specification.

FLOATING POINT POWER Ultrafast hardware, floating point add-on.

Available as standard commercial or full military systems.

Commercial Miproc is adaptable for various configurations and caters for up to three Miproc CPUs.

Military Miproc in a 1-ATR conduction-cooled chassis to MIL-E spec gives up to 3.3 million instructions a second, and unrivalled cost/performance.

PLESSEY
MICROSYSTEMS

Plessey Microsystems Inc, 19546 Clubhouse Road, Gaithersburg, Maryland 20760 Telephone: (301) 948 2791 TWX: 710 828 9708
1641 Kaiser Avenue, Irvine, California 92714 Telephone: (714) 540 9931 TWX: 910 595 1930
France: Paris (01) 776 43 34 Holland: Noordwijk 01719 19207 Germany: Munich (089) 23 62 270
Japan: Eiji Kitahara, Tokyo 244 3782 UK: Towcester (0327) 50312.

0654 20122

New products

noisy industrial environments.

Included in the SDM854's 54.6-by-43.3-by-5.6-mm package are an analog multiplexer, address register, sample-and-hold circuit, 12-bit analog-to-digital converter, delay timer, clock, voltage reference, and three-state output buffers that simplify 4-, 8-, and 16-bit data-bus interfacing. Chips are mounted on an 80-pin quad in-line ceramic substrate that offers total isolation and an effective heat sink, says the company.

Prices are $165 for the SDM854AG (0.025% linearity), $185 for the SDM854BG (0.01% linearity). Delivery is from stock.

Burr-Brown, P. O. Box 11400, Tucson, Ariz. 85734. Phone (602) 756-1111 [383]

10-bit a-d converter samples at 20-MHz rate

Perhaps the first 10-bit, 20-MHz analog-to-digital converter, the model MOD-1020 allows the user to double sampling rates for radar digitizers, digitize baseband signals in communications applications, and extend spectrum analysis bandwidths, says the manufacturer. Its root-mean-square signal-to-noise ratio is 56 dB, minimum; and the peak signal-to-rms noise ratio is 65 dB, minimum.

On a printed-circuit board, the MOD-1020 includes all the circuitry necessary for a complete 10-bit accurate conversion, such as track-and-hold, encoder, timing logic, references, and output latches. It also features pin-selectable analog inputs of 1 V peak to peak or 2 V p-p at 500 Ω or 1 kΩ; a noise-power ratio of 45 dB, minimum; a 15-MHz large-signal input bandwidth; a 30-MHz small-signal input bandwidth; and transient response and overvoltage recovery times of 50 ns.

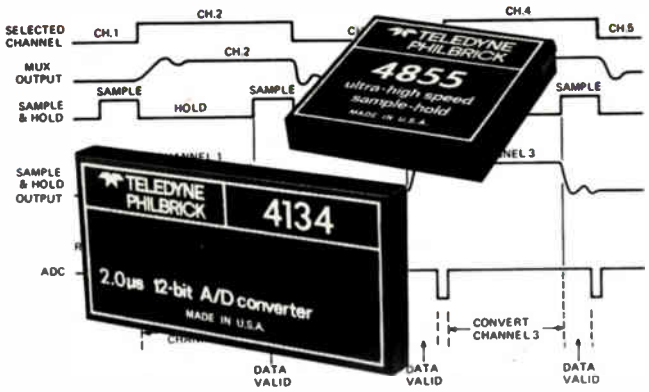
Packaged on a printed-circuit card, the MOD-1020 a-d converter sells for $1,795 when ordered in quantities of 100. Delivery is from stock.

Analog Devices, Computer Labs Division, 505 Edwardia Dr., Greensboro, N. C. 27409. Phone Ed Graves at (919) 292-6427 [384]

DATA ACQUISITION: THRU-PUT AT 488 kHz

You can obtain true 12-bit performance . . . by combining Teledyne Philbrick's 4855 high-speed sample-hold with our new 4134 12-bit, progressive approximation A-to-D converter. Data acquisition thru-put rates of 488 kHz are achieved without the sacrifice of accuracy. With these and our other data conversion products, combinations of thru-put/resolution trade offs can be attained to solve your design problems.

For additional information and special OEM pricing, contact Ted Serafin, Product Marketing Manager at (617) 329-1600, ext. 354.



TELEDYNE PHILBRICK Data Converters, V/F/V Converters, Linears, Nonlinears, Power Supplies
Allied Drive at Route 128, Dedham, MA 02026
Tel: (617) 329-1600 TWX: (710) 348-6726 Telex: 92-4439

Circle 225 on reader service card

GEE WHIZ!! OSCILLOSCOPES!

● 2.9" H x 6.4" W x 8.0" D. ● Low, low prices. ● 15- & 30-MHz bandwidth. ● Weight: 3 lbs. ● Battery or line operated. ● Single- or dual-trace models.

MS-15 $349.80
15 MHz — Single-Trace
- External & internal trigger.
- Line synchronization mode.
- Power usage—<15 W.
- Battery or line operation.
- 2.9" H x 6.4" W x 8.0" D.

MS-215 $465.45
15 MHz — Dual-Trace
- External & internal trigger.
- Line synchronization mode.
- Power usage—<15 W.
- Battery or line operation.
- 2.9" H x 6.4" W x 8.0" D.

MS-230 $598.15
30 MHz — Dual-Trace
- External & internal trigger.
- Line synchronization mode.
- Power usage—<40 W.
- Battery or line operation.
- 2.9" H x 6.4" W x 8.6" D.

NLS products are available from Nationwide Electronic Distributors.
Send for our brochure today!

Circle 226 on reader service card
Circle 248 on reader service card
Circle 249 on reader service card

Non-Linear Systems, Inc.
Originator of the digital voltmeter.
Box N, Del Mar, California 92014 Telephone (714) 755-1134

There's no body like our new

ZOOM BODY

The new AO STEREOSTAR¾ Zoom "T" microscope features the "T" zoom body with coaxial illumination and photo capabilities. It may be just what you need to boost output in your production, assembly or inspection department.

The Zoom "T" gives you a constant 4" of working room. It has a 1x - 6x magnification range, and with auxiliary lenses and eyepieces it offers a total range of 5x - 300x. Magnification can be conveniently changed with controls on both sides of the body. No matter what magnification you're working with, you get crisp, sharp image definition.

Modular in construction, the Zoom "T" can be ordered with or without the coaxial illuminator. In fact, any accessory can be simply added at any time. However, if you're working with highly reflective opaque surfaces, coaxial illumination is invaluable because it gives contrast without hot spots, glare, reflections or shadows.

We invite you to compare the new AO STEREOSTAR Zoom "T" microscope, feature by feature, with any other competitive microscope.

We're confident you'll immediately see that it offers the outstanding value in its field. See your AO dealer or representative for a demonstration. Or write for a detailed brochure. American Optical, Scientific Instrument Division, Buffalo, NY 14215.

AO American Optical

Products newsletter

Minicomputers drive Protos development system

The National Computer Conference this week will see the 4/95 and 4/97 minicomputers from Computer Automation Inc. that form the basis for the Irvine, Calif., company's new Protos software development system. Key to the new design is **a memory management unit that makes it possible to convert 16-bit logical addressing into a 22-bit physical address format**, allowing 8-megabyte capacity. Access time has been cut to about 125 ns. The price of the 4/95, which is offered with central processing unit, memory management, and cache (with up to 128 kilobytes of random-access memory), starts at $8,500 and goes up to $30,000 for a full megabyte of capacity. The 4/97 Protos, built around the 4/95, is scheduled for delivery in October and will be priced between $80,000 and $120,000.

HP adds IEEE-488 interface to HP 85 . . .

This week at the National Computer Conference, Hewlett-Packard Co. is introducing the first enhancements to its HP 85 personal computer. The HP 85, which was itself introduced earlier this year, has a built-in 40-character-wide thermal printer. However, **with a new IEEE-488 interface,** it will be able to feed printers with 80- and 130-character widths, as well as handle forms. The model 82937A interface fits into one of the four rear slots in the HP 85 and costs $385.

The Palo Alto, Calif., company is also showing a **read-only memory that performs the necessary input/output functions to make the computer into an instrumentation controller.** The $295 ROM gives the HP 85 I/O statements similar to those used on the HP 9835A desktop computer.

. . . and 12.1-megabyte Winchester disk to HP 250 computers

Hewlett-Packard has put a standard 12.1-megabyte Winchester disk in its HP 250 computer, replacing the options for dual and triple flexible disks. The new disk system has four times the capacity but the same $23,000 price tag as the discontinued triple-floppy system. Its **average seek time is 70 ms, with a maximum transfer rate of 526.7 kilobytes/s.** A single 1.2-megabyte flexible disk is included for backup and data loading. Three additional capabilities offered by the Palo Alto manufacturer are a larger add-on memory priced at under $20,000/megabyte; an intelligent network processor and remote-job-entry software for data communication to HP, IBM, and other computer systems; and a facility to read and write IBM 3741–formatted flexible disks.

Scope calibrator module for TM500 is programmable

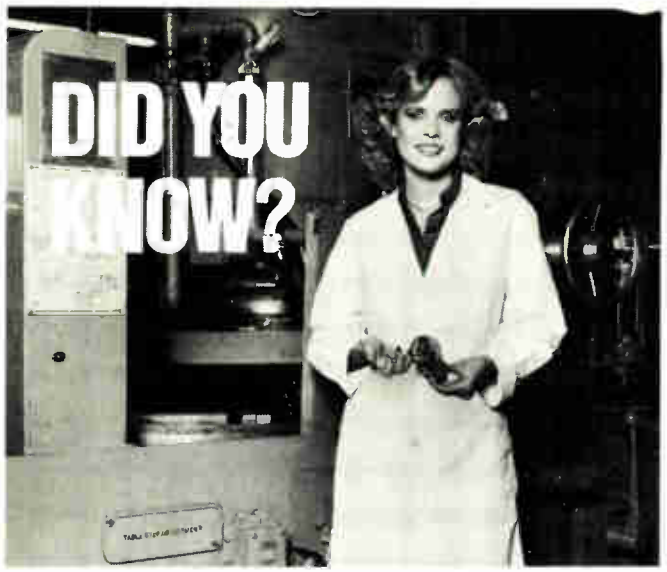
Tektronix Inc. is offering an oscilloscope calibration generator that plugs into the TM500 series of instruments. But that's not all: the model CG-551AP module is programmable. The microprocessor-based scope calibrator can be used to verify vertical gain, horizontal timing and gain, vertical bandwidth and pulse characteristics, probe accuracy and compensation, and current probe as well as calibrator output accuracy. The Beaverton, Ore., firm expects the IEEE-488 programmable unit to be used as part of an automated system that would include a controller and a printer. Besides governing operator actions and calibration signals, **software for the system also compares test results from the CG-551AP with the user's permissible standards** and is included in the $12,000 price.

New literature

Computer software and related reports. The "1980 Directory of Computer Software and Related Technical Reports" contains a listing of machine-readable software used by the Federal government, along with technical reports about the software. More than 350 programs are divided into 27 subjects on social sciences, economics, science, and technology. Report topics include modeling and simulation, statistical analyses and evaluation, data base management systems, and search and retrieval systems. Software programs include the Cobol Compiler Validation System, Version 3; Fortran Compiler Validation System, Version 1; and Table Producing Language (TPL), Version 3. Ask for order number PB80-110232. The publication sells for $40. U. S. Department of Commerce, National Technical Information Service, 5285 Port Royal Rd., Springfield, Va. 22161.

Relays. A 60-page catalog presents detailed information on various lines of relays, including the line of QPL relays for high-reliability applications, a wide variety of industrial, commercial, and computer-grade relays, and a number of radio-frequency relays. The catalog also has a cross reference chart listing the Hi-G devices and their equivalent military parts. Engineering data on performance, electrical parameters, and mechanical and mounting specifications is presented for each relay series. Hi-G Inc., 580 Spring St., Windsor Locks, Conn. 06096. Circle reader service number 422.

Knobs. Machined aluminum and molded plastic knobs for electronic, medical, and audio equipment and instrumentation are illustrated in a 16-page catalog. Fourteen series of machined aluminium knobs are shown in 58 sizes; another 14 series of plastic knobs are shown in 59 sizes. The knobs come in regular, bar-pointer, double-bar-pointer, two-tone, and concentric configurations. Prices and complete ordering information are given. Front Panel Devices Inc., 530 Burnside Ave., Inwood, N. Y. 11696 [423]



When you need more than off-the-shelf magnets,

PERMAG HAS THE ANSWER!

...PERMAG has computer controlled machines for honing, slicing and dicing magnets to extremely close tolerances. And PERMAG has specially designed EDM machines that can put precision holes in magnets. Combined with our cutting, grinding and fabricating facilities, we can produce any magnetic assembly to your design. Each of our 9 modern plants is stocked, staffed and equipped to meet your every requirement.

ALL ACROSS THE COUNTRY — *"In the magnetic field, PERMAG is No. 1"*

NEW YORK • BOSTON • ATLANTA • TOLEDO
CHICAGO • DALLAS • LOS ANGELES • SAN FRANCISCO
MINNEAPOLIS/ST. PAUL

Consult Yellow Pages for address & phone number of PERMAG near you.

Circle 213 on reader service card

New NO CREEP PQ Heat Sink Compound

with

HIGH THERMAL CONDUCTIVITY

16.7 x 10^{-4} cal/sec cm°C, min.)

NEW SILICONE FREE PQ Heat Sink Compound is ideal for electronic assemblies & circuit applications where excessive heat can reduce service life.

- **NON-SILICONE** base fluids PREVENT CREEPING
- **HIGH THERMAL CONDUCTIVITY** (16.7 x 10^{-4} cal/sec cm°C, min.)
- **EXCEPTIONALLY LOW BLEED** AND EVAPORATION characteristics
- **EXCELLENT LUBRICITY** means easier, more efficient applications

Meets Western Electric Spec KS-21343. Available in 4 oz applicator tip tubes, 1 lb cans, 40 lb pails, 250 lb drum

AOS
Newark • Buffalo

238B Wilson Avenue
Newark, New Jersey 07105
201/589-0250

Circle 228 on reader service card

4 times larger than life

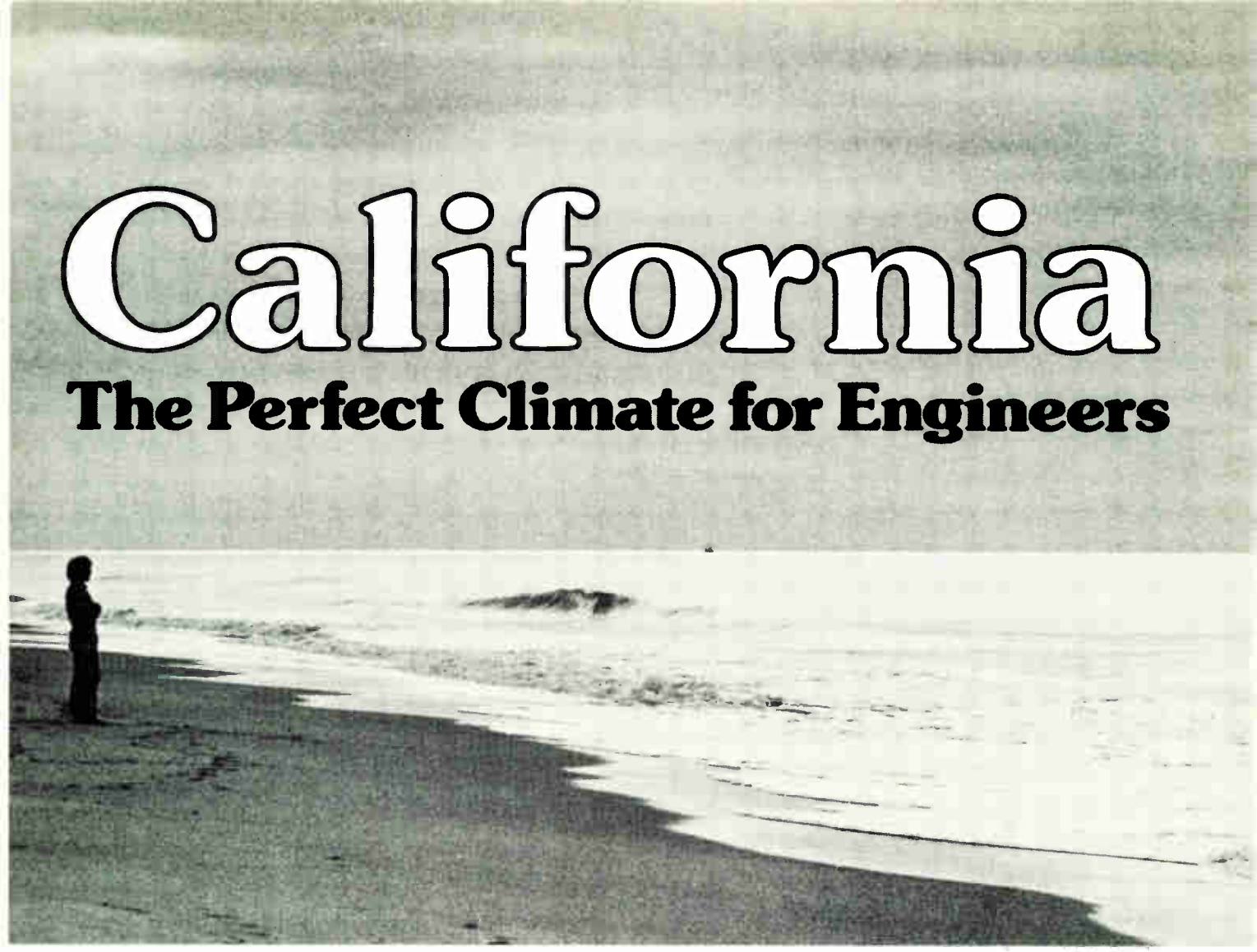
A breakthrough in wet tantalum capacitor capability

This unique product eliminates the primary problem inherent in silver cased wet tantalum capacitors namely, the interaction between the silver case and the electrolyte. The Puritan Type AT all tantalum capacitor offers a far better capacitance stability and lower E.S.R., and a higher ripple current handling capability than its silver cased counterpart. Moreover, Puritan has a reverse voltage capability of 3 V. d.c. at 85°C. Capacitance range 2·5 to 1200 mfd ; 6 to 100 Volt. Write or 'phone for further data.

Tansitor PuriTan™ capacitors

Tansitor Electronics, Inc.
West Road, P.O. Box 230, Bennington, Vermont 05201 Phone : (802) 442-5473
TWX : (710) 360-1782
Tansitor – reliable in so many ways

Circle 229 on reader service card



California

The Perfect Climate for Engineers

Engineers seeking a career with a future, above-average working conditions, high starting salaries, some of the best technical schools in the country for career advancement, plus a pleasant climate and lifestyle should seriously consider California.

The Golden Gate State offers great employment opportunities for engineers, especially those with EE and aerospace/aeronautical disciplines. To give you an idea of the state's tremendous demand for engineers, in 1978 schools in the United States graduated 54,740 engineers. At that time, companies in Southern California were seeking 30,000 engineers to fill their various and vital job requirements. The growth of this sector of the California economy has been phenomenal. The demand for engineering talent in the 1980s and beyond is essential for the state, for industry and for government needs.

Electronics represents a significant portion of California's manufacturing activity. This high-technology area employs over 400,000 residents who receive some $6 billion in wages on an annual basis.

According to Census estimates, California has:

- Over 200 computer-production parents or subsidiaries—30% of the nation's total.
- Over 400 producers of electronic equipment and systems—about 22% of the U.S. total.
- About 750 electronic component production operations—30% of the U.S. total.

There are more than 3,700 separate business locations in California that are classified as part of the electronic/electric equipment market.

The significance of California's rapidly-growing electronics industry is particularly evident in certain geographical areas of the state, mainly the metropolitan areas of Anaheim-Santa Ana; Los Angeles, Long Beach; San Jose; and San Diego. These four areas account for more than 89% of the industry's employment and 82% of the number of electronic/electric products firms.

A close look at employment trends in these metropolitan areas reveals that the electronics industry has been a dominant factor in each area's economic growth. In San Jose's famed Silicon Valley, for example, total manufacturing activity increased by 25,200 workers during the 1973-1977 period, with the electronics industry contributing 14,800 workers, or 59% of the growth.

Though Silicon Valley is now overcrowded, *Electronics* magazine (Feb. 20, 1980) reports ". . . even the established companies expect that this area will continue to be the jumping-off point for new companies excited about taking electronic technology to new applications.

"That is the key. To a large extent the new companies in the VLSI area will be those that apply microcomputers in new ways and develop new markets. Examples of this trend are already around us. Look at the toy and game industry,

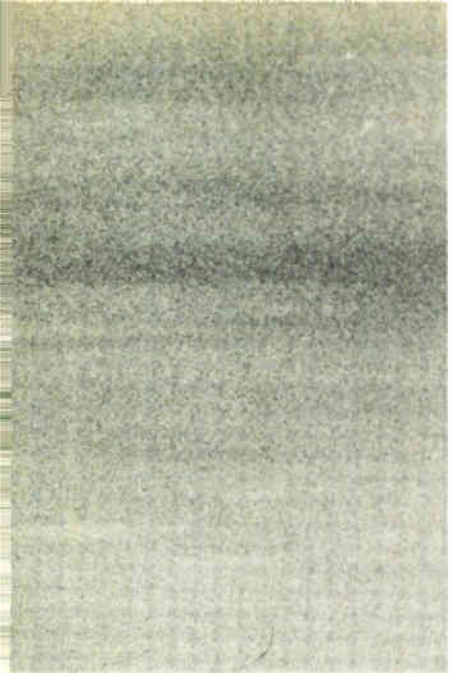


Photo by Joel Gordon, DPI

which until a few years ago was basically a cardboard and plastics business. Today all the major concerns are up to their elbows in electronics.

"Yes, the stakes are high in VLSI. But the outlook is for a decade of expansion. The migration of engineers to new industries will continue."

The result is a growing number of jobs for engineers in California.

The aerospace/aeronautical and the electrical/electronic industries are intricately related. Enrollment for aerospace/aeronautical engineers is about 50% below that of 10 years ago as a result of the cutback in the space program. This is one of the reasons for the great demand for engineers now and in the future.

In an effort to encourage engineers to work in California, many companies are offering incentives. Housing, for example, is a problem in California. To ease this problem, some companies are helping engineers and their families find suitable housing. This includes paying lodging costs until a house is found and also the closing costs on the house in some instances. In other cases, engineers recruited to work in California are offered company-owned condominiums at reasonable rents.

In addition, some companies are offering engineers who want to pursue their careers in California sign-up bonuses that can amount to several thousand dollars. They may also provide experts to solve tax problems at no extra cost.

Once on the job, the engineer is encouraged to upgrade his or her skills. Many companies pay full tuition costs for engineers who want to obtain a master's or PhD degree. In-house training to update one's skills or to learn new skills is provided by cassette on the company premises. Another method used for engineers' on-the-job education consists of closed-circuit television, with programs beamed from colleges and universities to the company classroom. This is an excellent way to upgrade skills at no cost or inconvenience to the engineer.

California's lifestyle is famous. The engineer who chooses to live and work in this beautiful 1,000-mile-long state bordering the Pacific Ocean can enjoy every type of cultural and recreational activity available any place in the world. The ocean, lakes, desert and mountains—California has them all.

California's Lt. Governor, Mike Curb. Engineers are in great demand in the 1980s.

Let's look at the state on an area-by-area basis where both EEs and aerospace/aeronautical engineers are in demand. In Los Angeles County's Los Angeles-Long Beach Metropolitan Area, according to a recent forecast by the United California Bank, "Aerospace will again be a key sector generating new job opportunities, with demand for workers strong in aircraft manufacturing and electrical machinery."

In Orange County's Anaheim-Santa Ana-Garden Grove Metropolitan Area, the forecast says, "Aerospace should continue to be responsible for a large share of job gains, including substantial increases among various electronic firms."

And in The San Diego Metropolitan Area the forecast is that ". . . aerospace will provide a major thrust to economic activity in 1980. Employment gains will thus be sizable among firms involved in aircraft, missiles, instruments and electronics."

The outlook for Santa Clara County's San Jose Metropolitan Area is: "Employment gains will be bolstered by the dominance of high-technology industries, including electronics and instruments. The slower growth in capital spending expected nationally is likely to have some moderating impact, but the strong momentum of the aerospace industry, together with sizable export demand, should lead to substantial gains."

That's the optimistic outlook for engineers seeking employment in EE and aerospace/aeronautical. California is the uncontested leader when it comes to hiring engineering talent. It hires more engineering graduates, more engineers with master's degrees and more engineers with PhDs than any other state. And the trend will continue.

In short, California is the perfect climate for engineers. If you are graduating from engineering school this year, are a recent graduate or a veteran engineer looking for a virtually guaranteed career with a future, don't miss the following California Career Opportunities Section that features specific companies seeking EE and aerospace/aeronautical engineers with your talents.

—John Brand.

Our most important resource is OUR PEOPLE

Founded in 1888 on the invention of the first adding machine, Burroughs has grown to become a major corporation serving all the aspects of the recording, computation, editing, processing and communication areas.

Our philosophy is to encourage and maintain strong resources for continued product invention, development, manufacturing and marketing.

Right now, we have leadership positions open involving the development of a state-of-the-art optical computer memory.

LEAD CIRCUIT DESIGN ENGINEER
Optical Computer Memories

Your job responsibilities include the design of analog and digital signal processing circuits for control systems and data storage. These functions will be implemented with monolithic integrated circuits as well as thick and thin film hybrid circuits. It is required that you have a strong background in worst case circuit design theory, transistors and OP amp design. Experience with wide bandwidth (20mhz) low noise analog circuits is desirable.

You will be working with several engineers on this project. A minimum of five to seven years applicable experience and a B.S.E.E. are required.

Burroughs Westlake is located away from traffic and noise in a beautiful country setting, yet just a short drive to downtown Los Angeles and our beaches.

We offer an excellent compensation and benefits package as well as company paid holidays, sick leave, life and family health insurance plus a stock plan.

Please send your resume or call collect:

Burroughs Corporation
Optical Engineering Dept. E
5411 N. Lindero Canyon Road
Westlake Village, CA 91361
(213) 889-1010

Affirmative Action/Equal Opportunity Employer

Burroughs

Circle A on the Resume Forwarding Page

Field Sales Engineers
Field Applications Engineers

"Intel's success affords our people many opportunities for rapid growth and advancement."
--Bill O'Brien, Western Regional Sales Manager

"There are 8086 reasons why you should call us today to pursue a sales career at Intel."
--Gerry Lawrence, Northwest Regional Sales Manager

Is profitability important? You bet it is -- because our success is based on reinvesting these earnings in continued research and development -- all in leading edge technology. This concentration on proprietary products lets us command and develop key market segments to minimize our vulnerability to economic cycles.

As you can see, we take success seriously. So if you are an aggressive, innovative individual with a BSEE or equivalent and at least 3 years' microcomputer design experience, please call Bill O'Brien at (714) 835-9642, or Gerry Lawrence (408) 987-8086 collect for further information.

Join Us At NCC. Stop by our booth and speak with Bill O'Brien and others about how Intel delivers career solutions by offering new and complex challenges.

If you are unable to call or see us at NCC, please send your resume or call Joyce Cordi at Intel Corporation, Dept. 19BD, P.O. Box 3078, Santa Clara, CA 95051; (408) 987-6298. An equal opportunity employer m/f/h.

intel

Circle B on the Resume Forwarding Page

Telecommunications
15 Years Profitability And Technological Innovation... A Winning Combination

Siliconix is the world's leading manufacturer of FET's and analog switch IC's. Our innovative technology has generated a variety of new products, including IC's for telecommunications and analog-to-digital conversion.

Share this winning combination with us. Our salaries are competitive, and our outstanding employee benefits include profit sharing, stock purchase plan, and our own discount gas station!

Telecommunications Applications Engineer

You will define and specify new telecommunications IC's, creating new designs and generating applications literature. This position entails heavy customer interface, requiring some travel. You should have a minimum of a BSEE plus 3 or more years in telecommunications hardware development (digital PCM switches, PCM line circuits, channel banks, or telephone sets). Other requirements include familiarity with design techniques and terminology, and writing ability. Experience with microprocessor hardware/firmware would be a plus.

Please send your resume in confidence to **Jean Sullivan, M/S 55-105, 2201 Laurelwood Road, Santa Clara, California 95054. Or call (408) 988-8000, extension 215.**

Siliconix incorporated

An Equal Opportunity, People-Oriented Employer

Circle C on the Resume Forwarding Page

Bridge your career

Engineering Development And Applied Energy Research

Technically Challenging Work in Multi-Disciplinary Teams

JOIN US AT
LAWRENCE LIVERMORE LABORATORY

Operated by the University of California
For the U.S. Department of Energy

- Engineering Development in Fusion Energy
- Power Conditioning and Pulse Power Systems Development
- Computer Control and Data Acquisition Development
- Instrumentation for Energy R&D
- Quality Assurance and Components Engineering

WITH

... Extensive equipment, technical personnel and facilities support
... On-site advanced degree and non-degree programs
... Three weeks' vacation
... Quick access to San Francisco Bay Area, ocean, mountains

DISCUSS YOUR INTERESTS WITH AN ENGINEERING MANAGER

Resumes may be sent in strict confidence to George Kumparak, Professional Employment Division, LAWRENCE LIVERMORE LABORATORY, P.O. Box 808, Dept. KET-050, Livermore, CA 94550. Or call Ed Lafranchi, Department Head, collect at (415) 422-8373, for more information. U.S. Citizenship is required. We are an equal opportunity employer M/F.

LAWRENCE LIVERMORE LABORATORY

An Equal Opportunity Employer M F

Circle E on the Resume Forwarding Page

Software Engineering Professionals

A New Era...

...has begun at Advanced Micro Computers. Our engineers and programmers are involved in projects that will make an impact on the future of the entire industry.

Our atmosphere, our energy, our outlook reflect our youth. Our stability, our maturity, and our resourcefulness reflect the support of Advanced Micro Devices.

Join us at the onset of a new age in microcomputer design and development. We have the following opportunities for software engineers:

Operating Systems

Sr. Software Engineer
Software Engineer

These positions include responsibility for the design and implementation of operating systems components. Both require a BSCS or BSEE along with appropriate program design and development experience in operating systems. Your background must include multi-user/multi-tasking systems, related peripheral equipment handling, file management and task scheduling, preferably in a mini computer environment. Exposure to systems implementation language would be beneficial.

Language Development

Sr. Software Engineer
Software Engineer

As members of the implementation team, your responsibilities will entail implementation of systems program languages. A BSCS or BSEE is required (MS preferred), along with at least 3 years' experience in compiler design (particularly code generation) for block structured languages such as Pascal or C.

Quality Assurance/Reliability

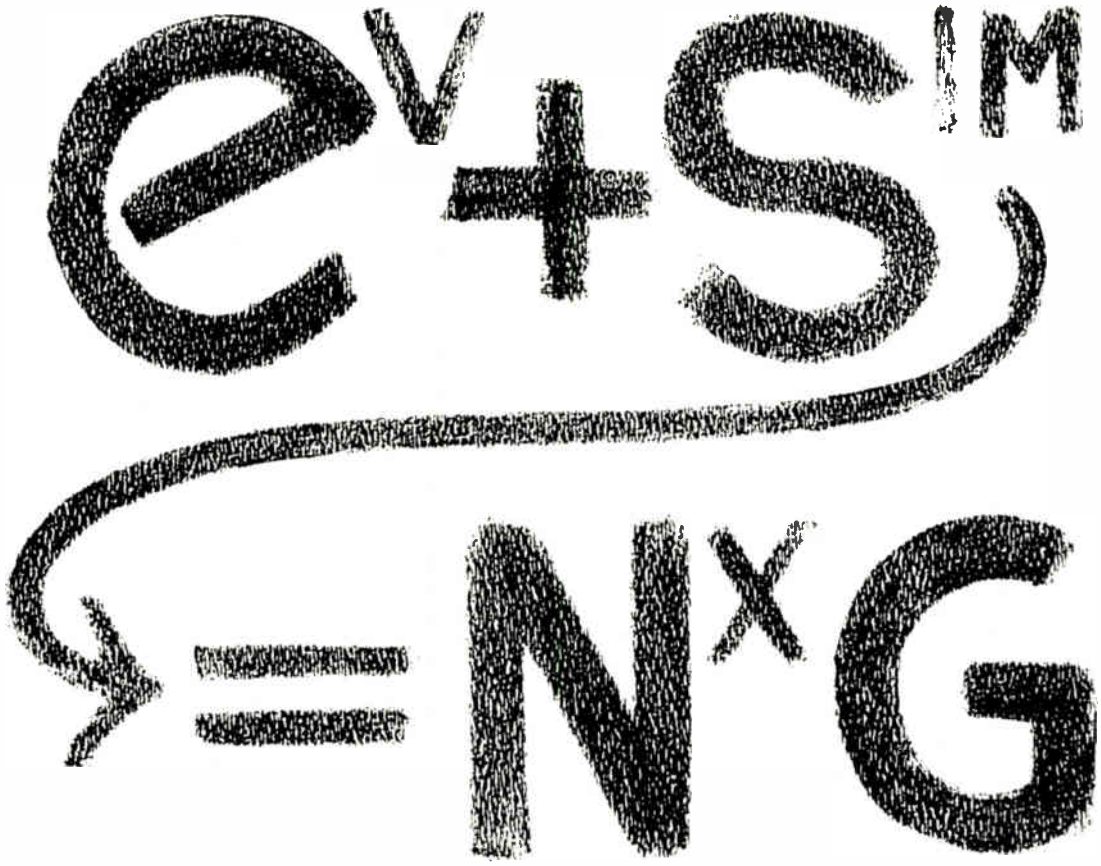
Software QA Engineers
All Levels

Positions exist at various levels for individuals to assist in developing QA methods and test procedures for our existing software projects. In addition, you will be involved with the development team for future software products. Requires a BSCS, BSEE or equivalent. Programming experience with mini or micro computers, 8080, Z8000, CP/M, Pascal or C is desired.

To learn more about how you can become a part of the new stage of development at Advanced Micro Computers, call **Shirley Boyer COLLECT** at **(408) 988-7777**, or send your resume to her at **3340 Scott Blvd., Santa Clara, California 95051.** An equal opportunity employer m/f/h.

ADVANCED MICRO COMPUTERS

Circle F on the Resume Forwarding Page



Evolution + Simulation = The Next Generation

At Link's Advanced Products Operation in Sunnyvale, CA, on the scenic San Francisco Peninsula, we're involved with developing the next generation of real-time computer graphics for ever-expanding applications of out-the-window scene and radar simulation technology utilized primarily for, but not limited to, total flight crew training for commercial, military and space end users.

Recent developments in the high technology field of simulation have virtually tripled our personnel needs for high-caliber, creative individuals with degrees or equivalent training, and background in the following areas:

- Hardware System Design
- Hardware Logic Design
- Software System Design
- Software Detail Design
- Scientific Data Base Development

At Link you will enjoy continued opportunity for career enhancement, a competitive salary that includes a professional overtime payment plan, and a comprehensive benefits plan including 100 percent advance tuition payment ... plus much more! Interested? We hope so and we invite you to respond with letter or resume, or for immediate consideration call us toll free or fill in and mail the coupon below to: **Personnel Office, LINK, 1077 E. Arques Avenue, Sunnyvale, CA 94086. At Link, we're proud to be an equal opportunity employer M/F/V/H.**

Link

A DIVISION OF THE **SINGER** COMPANY

Call us Toll Free, 24 hours a day at:
1-800-821-7700, Ext. 624
Missouri Residents Call
1-800-892-7655, Ext. 624

Name_____

Address _____

Phone (Home)_____ (Work)_____

Position Applying For:_____

Education & Experience:_____

_____

Present Salary:_____

U.S. Citizen or Permanent Resident?_____

Circle G on the Resume Forwarding Page

Looking for a place of your own, on the leading edge of technology?

Join us at Hughes.

Come join our engineers working on advanced test systems for airborne and spaceborne radar avionics; tactical systems guided by lasers, TV, and infrared control; and computer-controlled trainers and simulators.

At Hughes Support Systems, our role is the design and development of these systems, as well as training of customer personnel, maintenance and operation worldwide. We need your know-how, and we'll reward you well if you can handle one of these responsible jobs:

● Design of automatic test systems ● Digital hardware development ● Electro-optical equipment design ● Field system engineering ● Maintainability analysis ● Product support engineering ● Real-time software ● RF circuit design

Hughes offers you a home base in the easy-living climate of southern California, near LA International Airport and beach communities; excellent salary and benefits; and this unique brand of stability:

Our company has a backlog of over $4½ billion in contracts comprising 1,500 different projects. When we complete one, there are a lot more challenges waiting, at Hughes.

Let's talk about what you and Hughes can do for each other. Call collect to (213) 641-6691, or send your resume to:

Hughes Aircraft Company Support Systems Department 046, Professional Employment, P.O. Box 90515, Los Angeles, CA 90009.

HUGHES

Creating a new world with electronics

An equal opportunity employer, M/F/HC
U.S. Citizenship required

Circle H on the Resume Forwarding Page

Looking for a go-ahead career? Start where GROWTH OFFERS OPPORTUNITY.

General Dynamics is the nation's largest defense contractor. The Pomona Division is the Free World's leading producer and developer of tactical missiles and advanced weapons systems including Standard Missile-1, Standard Missile-2, Stinger, DIVAD, RAM, Viper, Sparrow AIM 7-F, Phalanx, Assault Breaker and more. These programs provide a continuing challenge for creative engineers in a growing company that is meeting America's defense needs for tactical systems.

At Pomona, advancing and applying state-of-the-art in engineering is a way of life.

The Pomona location offers a wide variety of lifestyles where every conceivable form of recreation is readily available year-round, with major entertainment offerings in nearby Los Angeles. General Dynamics offers you a chance to move to a company where growth does indeed mean career opportunities.

Professional openings range from entry level for recent college graduates to highly experienced employees in a wide spectrum of engineering disciplines:

Digital & Analog
Circuit Design
Guidance & Control
Systems Engineering
EMI/EMC
Test Equipment Design
Electro-Optical
Telemetry Systems
Microwave/Antenna
Fire Control Design
Microelectronics
Microprocessor Design
Engineering Writers
Hydraulic Design
Reliability
Power Supply
Electronic Packaging
Test Systems
Radar Systems
Signal Processing
Components
Stress Analysis
Electro-Mechanical Design
Auto Pilot Design
Servo Design
Logistics
ATE Design
Propulsion
Manufacturing Engineering
Industrial Engineering

Send your letter or resume for prompt technical review. You'll hear from us soon.

R.M. Kemp
Vice President,
Research & Engineering
GENERAL DYNAMICS
Pomona Division, Dept. 426
P.O. Box 3011, Pomona, CA 91766

An Equal Opportunity Employer M/F/H
U.S. Citizenship Required

GENERAL DYNAMICS
Pomona Division
Circle I on the Resume Forwarding Page

ENGINEERS AND ELECTRONIC TECHNICIANS

Today **Magnavox Advanced Products and Systems Company** is playing a key role in the most revolutionary advance in the history of navigation and position determination — the Navstar Global Positioning System. Navstar is an anti-jam, real-time determination of position, time and velocity, even under severe dynamic conditions.

Meeting the great challenges of the future depends entirely on the people employed at **Magnavox** . . . people like you — who are provided the opportunity to grow with **Magnavox** and pursue areas of technology among the most advanced in the electronics field.

"NO OTHER COMPANY IN THE WORLD COMES CLOSE TO MAGNAVOX EXPERIENCE IN THE TECHNOLOGIES THAT ARE MERGED IN NAVSTAR."

This represents an enormous advance for both military and commercial positioning. It is made possible by Navstar's successful marriage of satellite navigation and spread-spectrum technologies: fields in which **Magnavox** exercises undisputed leadership.

Magnavox has outstanding resources for engineering, research, design, and manufacturing and we pride ourselves on having the people who can create and develop these resources into superior products.

If you are seeking a future where there is a diversity of technological challenges, complete involvement with projects, a strong management team and a stimulating work environment conducive to your professional growth, this is your opportunity to join a very successful electronics team . . . **MAGNAVOX!**

Current Career Opportunities:

ENGINEERS

- Analog Engineers
- LSI Engineers
- Power Supply Engineers
- Systems Mechanical Engineers
- Components Engineers
- Digital Design Engineers
- Systems Test Engineers
- Hybrid Engineers
- RF Design Engineers
- Sr. Communication System Analysts

ELECTRONIC TECHNICIANS

- System Test Technicians
- Power Supply Technicians
- RF/IF/L Band Technicians
- Components Technicians
- Calibration Technicians
- Analog Technicians
- Digital Technicians
- Electronics - Failure Analysis

Join the Leader . . .

Challenging Careers Now and for the Future!

We are an equal opportunity employer. Women, minorities and handicapped individuals are encouraged to apply.

Professional Placement, Dept. ELEC-522
2829 Maricopa Street
Torrance, CA 90503

Magnavox
Advanced Products and Systems Company

Circle J on the Resume Forwarding Page

ELECTRONICS' FREE RESUME FORWARDING SERVICE

for California employment advertisements only

If you're interested in any of the companies advertising in the preceding California Career Opportunities Section, but you don't have your resume ready and/or up-to-date, why not fill out and return the handy form below?

Then, as a free service, ELECTRONICS will xerox and send copies of same to as many companies as you indicate interest in by circling in the box at right.

After that, it's up to you and them —and good luck!

RESUME FORWARDING SERVICE BOX

To have ELECTRONICS xerox and forward a copy of your completed and returned resume form to any of the companies advertising in the preceding California Career Opportunities Section, just circle the letter below that corresponds to the letter listed under their ad.

A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z

Also, if you're actively job-seeking and willing to work anywhere in this wide world, why not consider placing this same resume in the Electronics Manpower Register, a computerized system which matches your qualifications to the requirements of industry employers.

To do so, just check off the box at the top of the form below. Remember, it's completely confidential, you'll be called before your name is placed on computer, and there's no charge to you.

☐ Check this box if you want this resume to be included in the Electronics Manpower Register

FREE RESUME FORWARDING SERVICE FORM TO CALIFORNIA EMPLOYMENT ADVERTISERS ONLY

It is important that your information be complete and that you type or print legibly in dark ink

☐ Check this box if you want this resume to be included in the Electronics Manpower Register

IDENTITY

Name | Date

Home address

City | State | Zip

Home phone (Include Area Code)

PRESENT OR MOST RECENT EMPLOYER

Parent company

Your division or subsidiary

Location (City/State)

Business Phone (If OK to use)

Education: List Degrees

Major Field	Year Degree Earned	College or University

Employment Information:

Position Desired

Industry of Current Employer

Present or Most Recent Position | From | To | Title

Duties & Accomplishments

Reason for Change

Previous Position | Employer | City/State | From | To

Division | Type Industry | Salary

Duties & Accomplishments

General Information: Summarize your overall qualifications and experience in your field.

Salary Desired

Min Salary

Current Annual Base Salary

Bonus | Total Years Experience | Date Available | Employed ☐ | Unemployed ☐ | Self Employed ☐ | Married ☐ Single ☐

Level of Security Clearance | US Citizen ☐ | Non US Citizen ☐ | I will travel: ☐ | light ☐ moderate ☐ heavy ☐

MAIL TO: ELECTRONICS, P.O. BOX 900, NEW YORK 10020

Manufacturing Test Development Manager

Take the lead in a key function in telecommunications technology

With an international reputation in telecommunications, this well established research center in Shelton, Connecticut is pushing the state-of-the art in telephone technology for new generations of service worldwide. Work now underway in advance systems and equipment provides new opportunity for a technical leader with pronounced talents in manufacturing test development.

You'll be heading a group responsible for product testability and for developing new test techniques for these new systems including new versions of ITT's highly innovative System 12 digital switching facility, and for liaison functions with U.S. and overseas manufacturing plants. To qualify, you should have good working knowledge in the following areas:

- **Digital LSI Board testing, ATE and Programming**
- **Line and trunk circuit testing**
- **Microprocessor and memory testing**
- **Functional unit testing of digital switching equipment**
- **Systems testing of digital switches**

Our Shelton location in famed Fairfield County, Connecticut offers bountiful opportunities for the good life. Flexible housing to suit all tastes in areas free from urban pressures and pollution. Water sports on Long Island Sound. Facilities for year-round recreation. The cultural attractions of readily accessible metropolitan cities. No State tax on earned income. And to put it all within your reach, full ranging ITT benefits include a home purchasing program and mortgage assistance.

For further details, send resume with salary requirements to **Mr. Eugene Edwards, ITT Telecommunications Technology Center, One Research Drive, Shelton, Conn. 06484.**

ITT Telecommunications Technology Center

An Equal Opportunity Employer, M/F

Systems Engineers

THE CHOICE

There will never be another opportunity like this... an opportunity to choose from such a broad range of disciplines and responsibilities.

Be a part of the largest systems program ever undertaken. The Strategic Systems Division of GTE's Sylvania Systems Group has embarked on the largest and most complex C³ system ever conceived. The challenges and opportunities presented by this long-term program are mind-boggling.

The MX C³ program will involve the world's largest fiber optic cable network, over 15,000 Kilometers; a radio communications systems incorporating over 600 VLF, MF, HF, VHF, UHF, and SHF radios; a hierarchy of over 5000 computers; and one of the largest software communications networks ever developed.

Although the design, development and implementation of this system will extend far into this decade, the real challenges and opportunities exist now, at the beginning. The capability demonstrated by Strategic Systems Division in winning this program will be applied to future major programs. We are committed to being the major strategic systems organization of the future.

Opportunities for Systems Engineers exist at every level of experience up to managerial in the broadest range of disciplines available anywhere. There will never be another opportunity like this...an opportunity to choose from such a broad range of disciplines and responsibilities.

You Have Everything To Gain and Nothing To Lose.

For immediate information, please phone Kevin J. Cronin at (617)449-2000, Ext. 3275, or just check off the level of responsibility and technical areas of interest to you. Give us a brief summary of your background. Mail this ad back to us. And we'll do the rest.

Name _____

Address _____

City _____ State _____ Zip _____

Phone _____

Degree _____

Experience _____

Or, if you prefer, forward your resume indicating position(s) of interest to Kevin J. Cronin, Sylvania Systems Group, Strategic Systems Division, 189 "B" Street, Needham, MA 02194.

Desired Level of Responsibility

- ☐ Engineer
- ☐ Sr. Engineer
- ☐ Principal Engineer
- ☐ Project Engineer
- ☐ Engineering Supervisor
- ☐ Engineering Manager

SYSTEMS ENGINEERING

Systems Analysis

Concept Development

- ☐ C³ Operational Concept Development
- ☐ Command and Control Analyses
- ☐ Trade Studies and Analyses
- ☐ Definition of Communication Interfaces

Simulation and Modeling

- ☐ Network Traffic Modeling
- ☐ Math Modeling and Simulation to Validate Systems Performance
- ☐ Trade Studies and Analyses
- ☐ C³ Simulation Requirements

Systems Architecture

- ☐ Nodal Integration
- ☐ Multi-Subsystems Activities and Trade Studies Coordination
- ☐ Development of Nodal Equipment Block Diagrams
- ☐ Trade Studies and Analyses
- ☐ Interface Design

SRA and Integration

Operational Analysis—Cable Systems

- ☐ Cable Architecture Requirements
- ☐ Cable System Requirements
- ☐ Data and Voice Terminal Requirements
- ☐ Timing and Synchronization
- ☐ HW/SW Partitioning
- ☐ Secure Interfaces
- ☐ BIT/BITE Requirements

Operational Analysis—Radio Systems

- ☐ Radio Architecture Requirements
- ☐ Radio Systems Requirements
- ☐ Radio Terminal Requirements
- ☐ Antenna Requirements
- ☐ Timing and Synchronization
- ☐ HW/SW Partitioning
- ☐ BIT/BITE Requirements
- ☐ Secure Interfaces
- ☐ Airborne Radio Requirements

Operational Analysis—Command & Control Systems

- ☐ Nodal Considerations/Integration
- ☐ Commands
- ☐ Status/Maintenance Requirements
- ☐ Processors/Memory
- ☐ Displays
- ☐ Security
- ☐ Secure Equipment and Interfaces
- ☐ Sub-system Interface Definition
- ☐ Communication Integration/Interface and Controls
- ☐ System Simulation Requirements

Operational Software

- ☐ Higher Order Language
- ☐ PDP 11 Architecture
- ☐ Computer Security
- ☐ Remote Software Change
- ☐ Communication Processing
- ☐ Real Time Command/Control Processing
- ☐ Compiler Development Support
- ☐ Bench Marking
- ☐ Performance Trade Offs
- ☐ Airborne Unique Software Requirements

Systems Integration

- ☐ Test Planning Analyses
- ☐ Logistic Support Analyses
- ☐ A & CO Technical Analyses
- ☐ Operational Analyses
- ☐ Maintenance Analyses

System Requirements Development

- ☐ Functional Flow Diagrams
- ☐ Forms B—Functional Requirements
- ☐ B-1 Prime Item Development Specifications
- ☐ B-5 Computer Program Development Specifications
- ☐ Operational/Maintenance Time Lines

Command and Control

Communication and Control Software

- ☐ Operating Systems Including Secure Operating System
- ☐ Communications Software
- ☐ Command Generation and Operational Status Monitoring Software
- ☐ CAMMS Software
- ☐ Code Processing Software
- ☐ Personnel Authentication Software
- ☐ Auxiliary Software
- ☐ Diagnostic Software

IS YOURS.

Systems Operability

- ☐ Systems Operability Concept
- ☐ Man-Machine Interface
- ☐ Displays and Controls

Processors and Interfaces

- ☐ Processors
- ☐ Bulk Store Technology
- ☐ Processor Interfaces
- ☐ Performance Trade Offs

C^2 Subsystem

- ☐ Data Network Architecture Requirements
- ☐ MF Radio Protocols
- ☐ Fiber Optic Cable Protocols
- ☐ Communications Protocols
- ☐ Message Formats
- ☐ Message Responses

Radio Systems

Communications Measurements and Analysis

- ☐ Wideband Atmospheric Noise Measurements
- ☐ Rough Terrain Surface Wave Propagation Measurements
- ☐ Propagation Analysis
- ☐ Mobile VHF System Analysis/Design
- ☐ Communications System Testing Concepts/Analysis

Radio System Design

- ☐ Higher Order Modulating Technology
- ☐ Error Detection and Correction
- ☐ Spread Spectrum Communications
- ☐ Modeling and Performance Estimation
- ☐ Implementation Feasibility Considerations
- ☐ MF Radio Conceptual Design

Radio Network Design

- ☐ Radio Network Layout
- ☐ Protocols, Routing Algorithms, Multiple Access
- ☐ Simulcast Operation/Disciplines
- ☐ Performance Estimation, Reaction Times, Survivability
- ☐ Airborne Entry/Control

Antenna Systems

Hardened Antenna Development

- ☐ VLF/MF/HF Buried Antennas
- ☐ Triplexer Development
- ☐ Erectable HF Antennas
- ☐ UHF/SHF Satellite Terminal Antennas
- ☐ EMP Mitigation Techniques and ESA Requirements Definition

Ground-Based Antenna Systems

- ☐ Wideband MF Broadcast Antennas
- ☐ UHF/SHF Satellite Terminal Antennas
- ☐ VLE HE VHF and UHF Antennas
- ☐ VHF Mobile Radio Antennas

Airborne Antennas

- ☐ MF Trailing Wire Antennas
- ☐ MF Ferrite Loop Antennas
- ☐ UHF/SHF Satellite Antennas
- ☐ VLE HE VHE UHE and SHF Antennas

Cable Systems

Voice Communication

- ☐ Secure Voice Order Wire Communication
- ☐ Secure Voice Switched Network
- ☐ VHF Mobile Radio Communication

Data Communication Section

- ☐ Cable Data Network Architecture
- ☐ Cable Network Routing Protocol
- ☐ Network Traffic Modeling
- ☐ Survivable Cable Communication Network

Fiber Optic Communication System

- ☐ Fiber Optic Cable Connectivity
- ☐ Fiber Optic Modem Design
- ☐ Fiber Optic Cable Plant Design
- ☐ Fiber Optic Component Evaluation

Mechanical Systems and Interfaces

- ☐ Environmental Constraints Analysis
- ☐ NH & S (Mechanical)
- ☐ Packaging Concepts
- ☐ Components/Equipment
- ☐ Test and Analysis
- ☐ Requirements Specification
- ☐ Cable System Requirements
- ☐ Site and Facility Interface Requirements
- ☐ ICD Requirements
- ☐ A & CO Requirements

Security Systems

- ☐ Secure Communications Equipment Integration
- ☐ Computer Security
- ☐ Code Processing
- ☐ Security Studies

Hardness and Survivability

EMP Analysis and Test

- ☐ EMP Analysis
- ☐ SGEMP Analysis
- ☐ EMP Test
- ☐ Requirements Analysis
- ☐ Allocations Analysis
- ☐ EMI/TEMPEST

Radiation Analysis and Test

- ☐ Analysis
- ☐ Requirements Analysis
- ☐ Test

Special Studies

- ☐ Hardness Assurance/Maintenance
- ☐ Subcontractor Support
- ☐ Thermal/Mechanical
- ☐ Fiber Optics

Maintenance Systems

On-Line Maintenance Subsystem

- ☐ Subsystem Design
- ☐ Nodal Requirements Allocation
- ☐ Maintenance Management (CAMMS)
- ☐ Maintenance Monitoring and Control
- ☐ BITE, BIT, SELF TEST Requirements
- ☐ Fault Error Requirements
- ☐ Man-Machine Interface Functions
- ☐ HW/SW Allocations
- ☐ SW Architecture

Off-Line Maintenance Subsystem

- ☐ Intermediate Level/Depot Level MSE
- ☐ ATE Subsystem Design
- ☐ Integration of IL/DL Functions
- ☐ IL/DL Repairable Items
- ☐ IL/DL Test Requirements
- ☐ Test Station Requirements
- ☐ Operating and Diagnostic SW Requirements
- ☐ Test Applications SW Requirements

Organizational MSE

- ☐ Requirements
- ☐ Test Equipment — Fiber Optic, Antenna, ESA
- ☐ B-3 Portable Tester Specs

An Equal Opportunity Employer M/F

The Choice is Yours. Make it Now!
Join the MX Team.

GTE

Systems

ENGINEERS

Conrac is "Flying"—Give Your Career Progress New Wings

We "get it all together" for you—extremely vigorous growth, new projects, newly expanded facilities, an exciting spirit of achievement. Plus the visibility, informality, and sense of participation you like. Current openings include:

SENIOR DESIGN

Computer based. Computer Interfacing Equipment. BSEE or equivalent with at least 5 years of visual design experience heavily in computer based or Interfacing systems or equipment. Ability is essential to work smoothly and effectively with the customer, Software Engineering and service groups. Familiarity with INTEL 8080 and PDP11 will be a plus.

PRODUCTION SUPPORT

Dynamic self-starter sought with BSEE/BSME or equivalent in production support or design, in a sophisticated digital/analog products environment (emphasis on digital). Requires excellent communication skills and ability to interface well internally with Purchasing, Manufacturing, QC, etc., in solving engineering problems.

PROJECT

Knowing how to get the job done will be your main asset in this opening, which requires at least 3-5 years' experience in digital and analog design/breadboarding and circuitry testing. Interface with draftspeople and technicians.

We pay highly competitive salaries for your expertise, and provide excellent benefits. Working conditions in a suburban industrial park are pleasant. We're small enough for first names yet big enough to support our technical people with what they need.

For immediate consideration, please send resume indicating earnings history, to:

ROY JOHNSTON
Conrac Corporation
Systems-East Division
43 Fairfield Place
West Caldwell, New Jersey 07006
An Equal Opportunity Employer M/F

CONRAC

DESIGN ENGINEERS

YOU'VE EARNED THE RIGHT TO HAVE A CHOICE!

AND THE RIGHT CHOICE IS FLORIDA!

Our prestigious client companies have several outstanding positions immediately available. These are career positions within professional working environment and offer dynamic personal and professional growth. Your experience should be in the following:

- BS/MSEE with 2+ years experience in logic (TTL, MOS) design using microprocessors for Data Communications/Telecommunications. $25K
- BS/MSEE, with successful experience in hardware/software design and test for microwave/radar systems, signal processing avionics or related. $28K
- BSCS/BSEE, with 3+ years realtime, software development, on various minis & micros. PDP-11, VAX, DG-NOVA, UNIVAC, 8080, 6800, Assembliers and FORTRAN! $30K
- BS/MSEE, 2+ years experience required in ATE design, Digital/Analog and software programming for sophisticated test equipment. $24K

Additional opportunities involving a broad scope of Engineering disciplines are also available. Compensation is excellent with relocation assistance included.

For immediate and confidential consideration, please forward your resume, or call:

(813) 872-1853

frank leonard personnel

1211 N. Westshore Blvd. Suite 100-E, Tampa, Florida 33607
Our Client is an Affirmative Action/Equal Opportunity Employer M/F. Client Company Pays All Fees.

TECHNICALLY ORIENTED...

Sales/Marketing Professionals...
$20,000-$60,000

If you have a science or engineering degree... we invite you to discuss your careers... ...with placement consultants who understand your particular qualifications & goals.

R.S.V.P. by calling or by sending your resume, in confidence, to:

r. m. ferren associates, inc.
(212) 986-5510
505 Fifth Ave., NYC 10017
CORPORATE INQUIRIES WELCOMED
FEE PAID Agency

Engineers

- Design
- Development
- Project
- Software

$20,000-$50,000

Riddick Associates' Engineering Division specializes in placement of electrical and electronics engineers with top companies in the Southeast and throughout the U.S. We provide advice on careers, resumes and interviews for a position tailored to your skills. Client companies pay all fees. For details call or send resume in strict confidence to Phil Riddick, President.

Riddick Associates, Ltd.
9 Koger Executive Center
Norfolk, VA 23502
Area 804-461-3994

COMMUNICATIONS TECHNICIANS

Aramco seeks seasoned communications specialists who have the kind of experience that comes with hard work, not titles or degrees.

We are the largest oil-producing company in the world, and the firm most responsible for developing Saudi Arabia's energy resources. Aramco's projects are among the largest and most complex *anywhere.*

An enormous communications system interlinks our vast network of operations. You are needed now to support this growing activity. So think about expanding your communications career with Aramco in Saudi Arabia. And also think about the security of a job in the energy industry.

We have immediate openings in the following areas:

Specialist Telephone Equipment Technicians

We seek experienced people with versatile skills. We'll expect you to perform in these areas: installation, modification, testing, maintenance and repair; and you must be skilled on all types of electronic and electromechanical automatic telephone exchanges, plus all related equipment and circuitry.

You should be a good record keeper, and you should have a high school diploma, or equivalent training that includes electronic and electrical theory. We also seek 8 years' or more experience in maintenance and repair of all types of telephone and teletype exchanges. Valid driver's license is required.

Electronics Technicians MW/MUX, VHF/UHF, HF-SSB

There are immediate openings in several major areas of Aramco's communications operations. We expect you to have at least 2 years' formal electronics training, plus 5 years' related work experience. Valid driver's license needed.

Senior Specialist Electronic Technicians

You should have a solid background in data circuitry and transmission via telecommunications facilities. You'll be involved in installation, maintenance, testing and repair of data services carried on microwave, multiplex and common switched facilities.

The vast Aramco communications network includes VHF/UHF, radio telephone and radio alarm/control links, music/TV broadcasting, and electronic maintenance shops.

We'll expect you to make recommendations on operations improvements, testing techniques, test equipment, administrative control and training. Providing work direction will also be an important part of your job.

You should have a high school diploma—plus 3 years' electronics tech school training and at least 10 years' related experience.

Senior Trouble Dispatchers

You'll be a troubleshooter, yourself. You'll be providing work direction to technicians in the areas of telephone trouble reporting, dispatching, test desk and frame operations.

You should have a high school diploma or equivalent—plus 2 years' tech training in testboard operations, including electrical and electronic theory courses. We also seek 8 or more years' experience in a commercial telephone system.

Unsurpassed compensation and benefits

The Aramco salary is competitive and a cost-of-living differential increases it even further. In addition, Aramco people in Saudi Arabia receive a tax-protected premium for overseas employment which can amount to as much as 40 percent of the base salary.

Money aside, Aramco offers an outstanding combination of benefits including comfortable housing, abundant recreation, an excellent American school system for the children, and 40 days' paid vacation every 12½ months, time enough to travel in Europe, Africa and Asia.

Interested? Send your résume in confidence to: Aramco Services Company, Department ELT-041080NNBA, 1100 Milam Building, Houston, Texas 77002.

CHALLENGE BY CHOICE

ARAMCO

SERVICES COMPANY

Manager, Hardware Engineering

Some of the most exciting work going on at NCR, is being done in NCR/WICHITA . . . including VLSI circuit design

There are excellent reasons for this. Wichita is a major NCR Engineering and Manufacturing Center for interactive mini and micro computers and peripherals, all of which have contributed greatly to the advanced technologies and products that have made NCR one of the largest and most respected computer companies in the world.

As Manager of Hardware Engineering Services, you will direct a highly skilled staff in VLSI circuit design, mask design/layout, and printed wire board design/layout services. You will also manage the use of interactive graphics systems in support of these functions. Your background should include a BSEE or related degree, and several years of relevant technical and managerial experience.

Equal to the advantages of joining NCR, are the advantages of living in Wichita: a clean, low-key, moderate-sized city where good neighborliness is a way of life.

For prompt consideration, send your resume and salary history to: Don Quakenbush, Professional Placement, Personnel Resources, Dept. F 78, NCR Corporation, 3718 N. Rock Road, Wichita, Kansas 67226.

NCR
Complete Computer Systems

An equal opportunity employer

digital design engineers

Frank Leonard Personnel, a highly respected force in the Professional recruiting industry, has been retained by members of its exclusive client/family to seek out the best Engineering talent available to fill several key positions.

Applicants will possess Bachelors and/or Masters Degrees in Electrical Engineering with 2-10 years experience in TTL, MOS, Logic Design. A working knowledge of Microprocessors including software required. Specific areas of concentration include the Data Communications, Medical Electronics and Digital Signal Processing fields.

These are career positions with major companies enjoying dynamic growth patterns. The environments are professional with advancement opportunity, competitive salaries and comprehensive benefits. Please submit your resume, including salary, in confidence or call:

(813) 872-1853

1211 N. Westshore Blvd. Suite 100-E
Tampa, Florida 33607

Our Client is an Affirmative Action/Equal Opportunity Employer M/F. Client Company Pays All Fees.

frank leonard personnel

ENGINEERS

- Design
- Avionics
- Systems
- Test
- Communication
- Digital
- Analog
- Micro Processing

Our specialty is placing engineers with electronic and agricultural machinery companies. Engineering positions available anywhere in the United States. Companies pay for interview, relocation and fees.

Send resume to either

ALPS PERSONNEL INC.
505 1st Natl. Bank Bldg.
Peoria, Ill. 61602 Ph. (309) 676-4042
or
ALPS PERSONNEL INC.
235 S. Maitland Ave., Suite 113
Maitland, Fla. 32751 Ph. (305) 628-2577

ANALYTICAL INSTRUMENT SPECIALIST, CHEMISTRY:

Professional position for a well trained and experienced technician-specialist who can maintain, repair, and operate NMR and MASS SPECTROMETERS, and who is capable in low level digital electronics. A career opportunity with a first-rate private university located in upstate New York. Send resumé in confidence to Virginia E. Leport, Personnel Dept., **University of Rochester,** 260 Crittenden Blvd., Rochester, N.Y. 14624. An equal opportunity employer (M/F)

SOUTH & SOUTHWEST POSITIONS
Engineering and Management positions throughout the South, Southwest and U.S. Employers pay all fees. Send resume in confidence to: Bob Hogue. *personnel consultants*
SouthWest Technical
P.O. Box 33070,
San Antonio, Texas 78233

GREATER TEXAS POSITIONS
Engineering and related management openings throughout the Southwest. Top clients paying all fees and relocation expenses. Send resume in confidence to: Alan Myler.

KEY SEARCH
P.O. Box 38271
Dallas, TX 75238

SOUTHWEST & SUNBELT
• Digital • Hardware • R&D
• Analog • Software • Design
$20,000 to $50,000
J. Robert Thompson Co., Inc.
2200 W. Loop South, S800, Houston, TX 77027 (713) 627-1940
Specialist for EE's - Co. Pays Fee
Since 1967 - will provide resume service - or send resume, salary history, geographic preference.

EMPLOYMENT SERVICES

Electronic engineering growth positions with clients located nationally. Our service is enhanced by the fact that I am an EE with 20 years in industry and over 10 years in placing professionals on an employer fee paid basis. Send your resume to Joe Torcassi, Director, J. Anthony & Associates, PO Drawer AD, Lynchburg, OH 45142. 513/364-2305.

POSITIONS VACANT

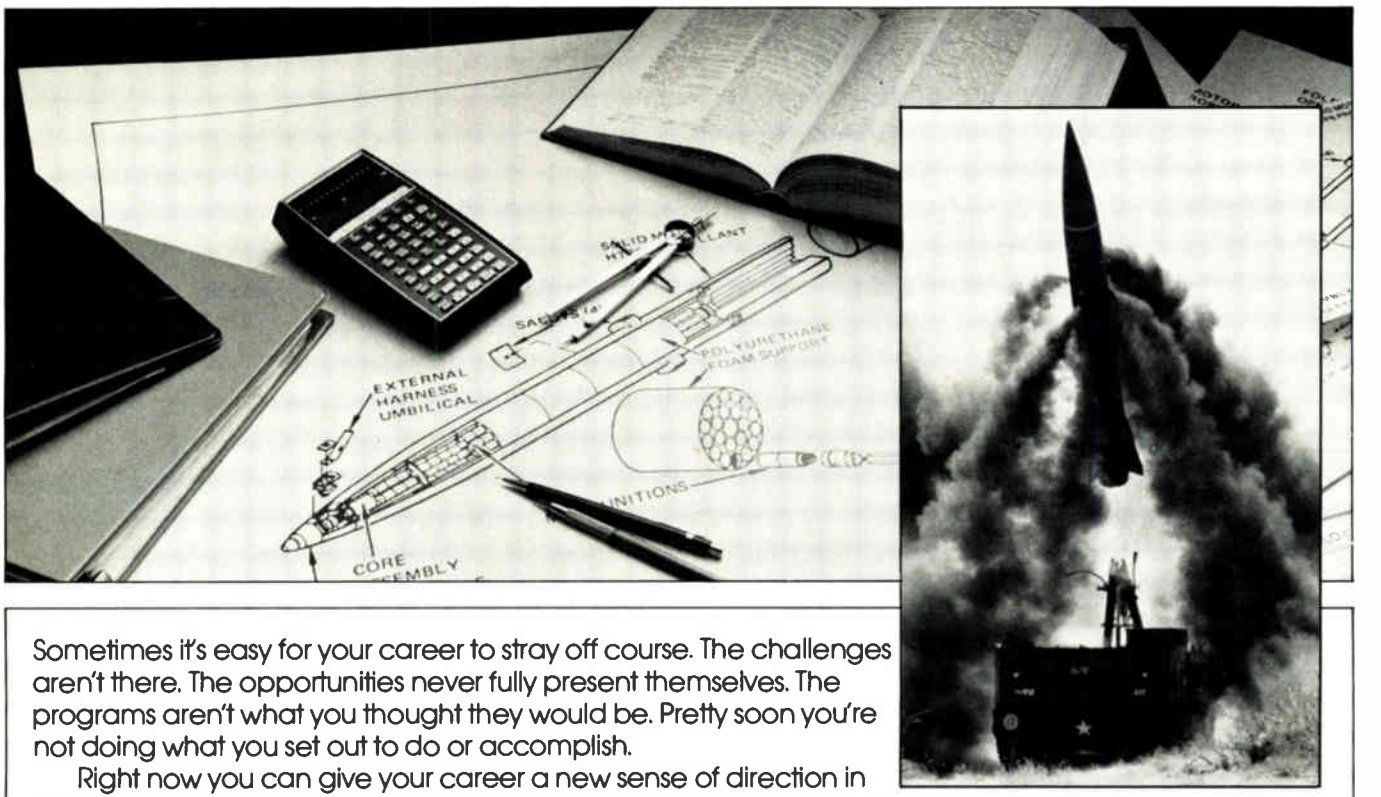
Electronics Instructor Black Hawk College has an opening for a Technology Instructor in a 2-year Associate Degree Program in Electronics/Instrumentation & Process Control. BS or equivalent experience in EE or EET preferred. Minimum of two years industrial work experience is required. Some teaching experience is desirable. Basic electronics plus digital, microprocessors and instrumentation. Tenure teaching position begins August 15, 1980. Send letters of application to Mr. Erwin Johnson, Engineering Related Technology Department, Black Hawk College, 6600-34th Avenue, Moline, IL 61265.

Electrical Engineer/Instructor. Qualifications: Electrical Engineer, Bachelor's Degree, Master's Degree preferred. Three years of applied experience in the design or application of engineering principles on electronic equipment or equal. Solid state and computer background as they relate to the communications field is desirable. Salary Range: depending upon training and experience. To apply send resume, transcripts and salary requirements in confidence to: Edward R. Maclosky, Director of Personnel, Springfield Technical Community College, One Armory Square, Springfield, MA 01105. An Equal Opportunity Employer.

South? Technical/Professional Placement Network—fee paid. Murkett Associates, Box 527, Montgomery, AL 36101.

Computer Software Designers needed immediately. Salaries to $40,000. Computers and microprocessors. Fee paid. CAPA, 808 Downtowner Blvd., Suite G, Mobile, AL 33609.

GIVE YOUR CAREER A NEW SENSE OF DIRECTION AT VOUGHT.



Sometimes it's easy for your career to stray off course. The challenges aren't there. The opportunities never fully present themselves. The programs aren't what you thought they would be. Pretty soon you're not doing what you set out to do or accomplish.

Right now you can give your career a new sense of direction in missile and missile system engineering at Vought. Currently we see an emerging need for new, more sophisticated missiles and missile systems, and we are working ahead in the advanced technologies that will make them possible. We're deep into Thermochromic Electro-Optic processing. Laser Gyro Missile Guidance Integration. Hypervelocity Kinetic Energy Kill Mechanisms. And Simulation, to name a few.

For you, this spells outstanding career opportunities now — and for the years ahead. We're offering you a chance to grow, to contribute, to make your mark in the exciting world of rocket and missile system engineering. We're offering you the possibility of doing what's never been done in these fields before. That, perhaps is the biggest challenge of all. And when you succeed, the most satisfying.

Vought is located in Dallas, Texas, at the very hub of the thriving Sunbelt. It's a great place to live, work and raise your family.

If your career is losing its sense of direction, get it back on course at Vought.

We have immediate openings in the following technical areas:

Guidance and Control Systems Engineering
Digital Hardware Packaging
Digital Systems Analysis
Fracture Mechanics
Video Electronic Design
High Speed Logic Design
Flying Spot Scanner Design
Visual Systems Design
N/C Programming
Propulsion Engineering
Computer/Software Engineering
Value Engineering
Pyrotechnic/Warhead Design
Tool Design
Technical Writing

Send your resume to:

VOUGHT an LTV company

Dept. CC-0515
P.O. Box 225907 • Dallas, Texas 75265
We Practice E.O.E. We Believe in E.O.E.

THE INTERNATIONAL CIVIL AVIATION ORGANIZATION,

an agency of the United Nations, needs competent and professional

ELECTRONICS ENGINEERS/TECHNICIANS

for short and medium term assignments in Africa, Latin America, Far East/Asia and the Middle East.

THE ASSIGNMENTS

involve one or a combination of responsibilities including systems planning, design, installation and commissioning, maintenance, formal classroom or on-the-job training duties on any or a combination of the following:

- —Aeronautical Telecommunications
- —Air Navigational Aids Systems
- —Ground and Air Radars
- —Flight and Air Traffic Control Radar Simulators
- —Computer Technology related to Air Traffic Control and Switching Equipment
- —Flight Calibration of Air Navigational Aids Systems
- —Avionics

THE TERMS

Excellent Remunerativn and Compensation package
(Basic salary ranging from US $29,940 to 40,460)

- —Tax free allocation allowance, cost of living allowance, dependency allowances
- —Education grant for recognized dependents
- —Six weeks annual leave and paid sick leave

LANGUAGE

Applicants need to be fluent in English, French or Spanish, depending on countries of assignment

Written application with detailed resume should be mailed in confidence to:

Project No: TAB - C1
Technical Assistance Recruitment
International Civil Aviation Organization
P.O. Box 400
Place de l'Aviation Internationale
1000 Sherbrooke Street West
Montreal, Quebec, Canada H3A 2R2

ICAO • OACI • ИКАО

VLSI DESIGN SPECIALIST

Researchers recognize Sperry Univac, a division of Sperry Corporation as a pioneer and leader in the computer field, whose innovative approaches have kept it on the forefront of computer development. Currently, exciting new developments are taking shape in our laboratories using state-of-the-art techniques. Join an experienced team developing VLSI digital integrated circuits using sub-nanosecond technology of GaAs FET's.

You should possess an advanced degree, MS or PhD in a related field with a minimum of 2 years MOS circuit design experience. Experience with device physics, device modeling and computer aided laboratory measurements is a plus.

If you feel you would like to work in an interdisciplinary environment that gives you exposure to advance technologies, send a detailed resume to:

Mr. R.A. Pagano
Research Staffing-Dept. 0522

SPERRY UNIVAC

P.O. Box 500
Blue Bell, PA 19424

Equal Opportunity Employer, M/F/H/V

FEDERAL COMMUNICATIONS COMMISSION

($47,889—$50,112)

The FCC is seeking an experienced executive to serve as Deputy Chief Scientist (technology), one of two principal assistants to the chief scientist responsible for directing the full range of programs, activities, and policies of the office. The accepted applicant will manage the development and completion of projects and programs involving research and analysis activities of a scientific, technical and related nature in the fields of engineering, mathematics and physical science covering the broad area of telecommunications.

Candidates must demonstrate managerial ability or potential to perform at a major management level, and have experience in telecommunications in broad areas of frequency spectrum usage, radio propagation, radio electronic equipment techniques and systems engineering.

This is a career position in the Federal Senior Executive Service with incentive and bonus opportunities and is located in Washington, D.C. If you meet the requirements, submit your resume or an SF-171 (Personal Qualification Statement) by June 11, 1980 to:

Chief, Executive Personnel and Development Staff

FEDERAL COMMUNICATIONS COMMISSION
1919 M Street, NW, Room 208
Washington, D.C. 20554 (202) 632-7120
Kenneth A. Gordon
Contracting Officer

VLSI Research
At General Electric Research and Development Center

As part of a major Company thrust in electronics, General Electric's Research and Development Center is mounting a new program in advanced VLSI R&D. This program will establish a leadership position in VLSI device research and support the explosive growth of IC applications in the General Electric Company.

We are looking for both junior and senior level scientists and engineers to perform research in the following areas:

- **Device Physics**
- **Silicon Process Development**
- **n Channel**
- **Bulk CMOS**
- **CMOS/SOS**
- **VLSI Design**
- **VLSI Architecture**
- **Analog Design**
- **CCD Design**

The R&D Center is one of the largest and most diversified industrial laboratories in the world. It is located in scenic upstate New York, approximately 150 miles from both New York City and Boston.

Investigate excellent salaries, benefits, and growth prospects by sending your confidential resume to: Mr. Neff T. Dietrich, University Relations and Recruiting, General Electric Research and Development Center, Ref. 78D, P.O. Box 8, Schenectady, NY 12301. Or call COLLECT (518) 385-8322.

GENERAL ELECTRIC

An equal opportunity employer, m/f/h

Engineers...

Grow With Us in Phoenix

Sperry Flight Systems is a recognized industry leader in the design and development of advanced flight control systems and high technology electronic systems for aircraft and space flight applications. Sperry has always been a pioneer — we're constantly advancing the state-of-the-art in aviation. As a result, we have experienced substantial growth in our share of the general aviation market. There are more jet airliners flying with Sperry automatic flight controls than with those developed by any other manufacturer. We're the largest supplier in the world of digital air data computers for fighter/attack aircraft. We developed the flight management computer system for Boeing's 757/767 Series. And that's only the beginning!

We're expanding . . . this consistent and substantial growth means opportunity for you! Here in Phoenix, you'll work in one of the nation's fastest growing high-technology centers. You'll live in a climate which allows year-round outdoor recreation. You'll enjoy all that Phoenix has to offer — the benefits of living near a cosmopolitan city plus a relaxed Southwestern lifestyle.

Control Systems Engineers

Help us design and develop advanced digital and analog flight control systems for aircraft or space vehicles. Responsibilities commence with the systems design, system definition, control systems analysis and simulation phases, progress through testing, and move into the system integration phase.

Software Development Engineers

You'll be heavily involved with system design, development and testing. You'll develop real-time flight software for aircraft or space vehicles, using a higher order language.

Electronic Design Engineers

Become part of our professional team involved with digital and/or analog circuit design, microprocessor applications and interface, state-of-the-art power supply design, and advanced electronic technologies.

For all of the above assignments, a BS or MS degree in Engineering is required, with several years of experience in related areas.

Sperry offers excellent salary and a complete benefits program. Talk to us about our high-technology projects and professional atmosphere. Send your resume and salary history, in confidence, to Charles Melker.

SPERRY
FLIGHT SYSTEMS

P. O. Box 21111
Phoenix, Arizona 85036

We're an Equal Opportunity Employer.

Meet the challenge medical electronics presents!

Let your expertise save lives . . .

At E for M/Honeywell the creation of new products to meet the ever-evolving needs of the medical profession is a challenge we meet everyday.

For more than 30 years we have lead the way in the health care field, our comprehensive product line and commitment to R&D assures our leadership position in the medical electronics field. If devoting your technical know-how to helping people appeals to you, consider these opportunities that are now available at our facility located in Pleasantville, New York.

SENIOR ANALOG CIRCUIT DESIGN ENGINEER
Design of low level, low frequency analog circuits and signal processing for physiological transducer interface.

HIGH SPEED ANALOG CIRCUIT DESIGN ENGINEER
Design of high speed circuits for CRT displays including deflection and video amplifiers and switching power supplies.

APPLICATION SOFTWARE PROGRAMMER
Realtime data acquisition and digital signal processing to be used with microprocessor based systems.

SYSTEMS SOFTWARE ENGINEERS
To develop software for multi-microcomputer based data acquisition systems.

While enjoying our pleasant campus-like setting at our headquarters in Westchester county, you'll also have available to you a wide range of educational, cultural and recreational facilities in this suburban community just north of New York City.

We offer excellent salary and benefits program. For consideration, please send your resume with full particulars to Mr. Cary Baskin, ELECTRONICS FOR MEDICINE, HONEYWELL, INC., One Campus Drive, Pleasantville, New York 10570. We are an equal opportunity employer m/f.

E FOR M / Honeywell

ATTENTION ELECTRONIC ENGINEERS!!!

Electronic Design Engineers	**24-36K**
Design Engineers (Digital)	**25-35K**
Analog Design Engineers	**-25-35K**
Systems Design Engineers	**-28-35K**
Electrical Design Engineers	**-24-40K**
Instrumentation Design Engineers	**-25-40K**
Test/Design Engineers	**-24-35K**

Our clients are aerospace and electronic firms who pay our fees for locating engineers. For more information, send note or resume to Al Madsen, C.E.C.

CORPORATE PERSONNEL CONSULTANTS, INC.
5950 Fairview Road
Two Fairview Plaza, Suite 608
Charlotte, North Carolina 28210
(704) 554-1800

MANAGER, DISTRIBUTED MICROPROCESSING

Client requires an Engineering Manager with software application abilities and managerial experience. Primary responsibilities include protocols to network software, and the development and maintenance of software for distributed systems

PROJECT ENGINEER DATABASE SYSTEMS

Project responsibilities in applied research and development are in the following areas: high level data sublanguages, query optimization, distributed database systems, and database design. Will consult with product development group.

Contact In Confidence

(212) 557-1000
FORTUNE
Personnel Agency, Inc
A NATIONWIDE SERVICE
505 Fifth Avenue
New York, NY 10017
FEE PAID Agency

ELECTRONICS ENGINEERS

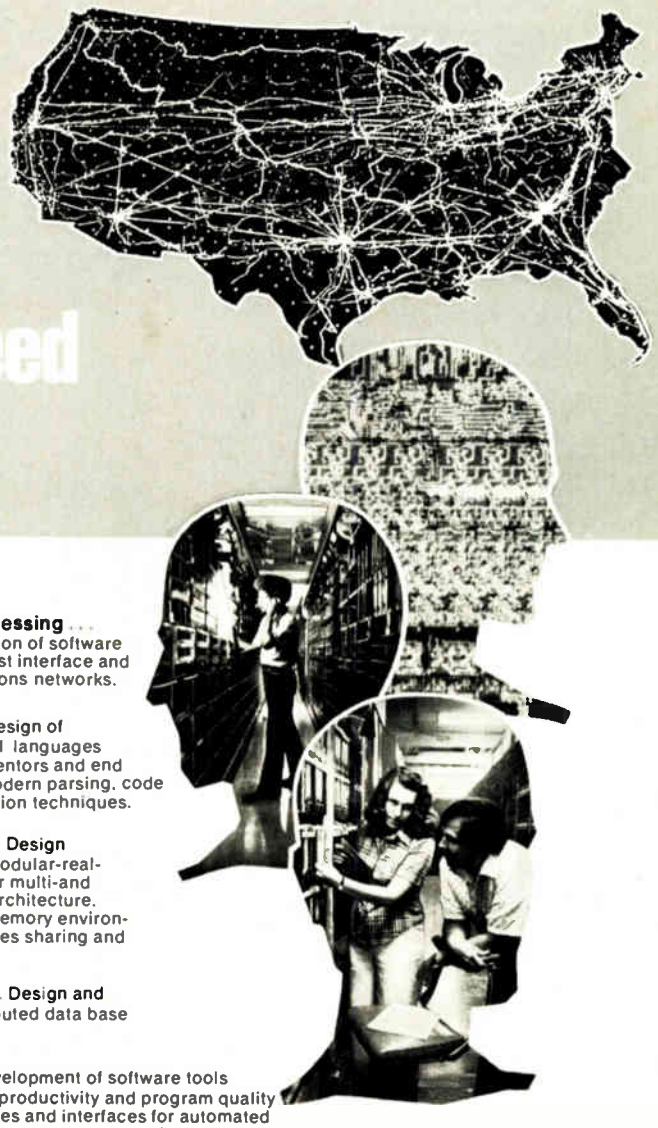
If you are an engineer looking for upward career mobility, call us. We specialize in electronics/aerospace nationwide. All fees assumed by our clients. Submit resume in professional confidence to: Jim Crumpley/Gayle Smart

Dorsey Love & Associates, Inc.
P.O. Box 4387 G.S.
Springfield, Mo. 65804

ENGINEERS
SEND YOUR CREDENTIALS TODAY! TRANSITION to your new CAREER OBJECTIVES using TSC's nationwide employment search resources.
TRANSITION SEARCH CONSULTANTS
2697 International Parkway, Suite 203, Virginia Beach, Virginia 23452
804-427-3700

ENGINEERS & SCIENTISTS

Innovative minds find the resources and intellectual stimulation they need ...at Bell Labs



The record speaks for itself. Bell Labs engineers and scientists have pioneered many of the major technical breakthroughs that have reshaped the modern world. We continue to advance the state-of-the-art on many fronts: LSI technology, innovative microprocessor applications, new approaches to computer hardware, software and systems architecture, to name a few. In part this is due to the environment we provide professionals. The engineer is not isolated here, and has freedom to pursue intellectual interests.

We offer career-oriented engineers and scientists the opportunity to take on responsibility for developing new products, new services, new tools and techniques for operating and maintaining the Bell System and its national network efficiently and economically.

You'll find the latest in computer equipment here, excellent libraries, strong technical support, and highly developed educational programs. Most important, your work will stimulate your professional creativity, productivity and personal growth.

If you hold an advanced degree in Computer Science, Electrical Engineering or other discipline relevant to the exciting field of telecommunications, or strong experience in any of the areas of work described, we want to hear from you. We offer salaries and benefits that rank among the best in the industry. These opportunities are available at our facilities in **Colorado, Georgia, Illinois, Indiana, Massachusetts, New Jersey, Ohio and Pennsylvania.**

Communications Processing . . . Design and implementation of software for terminal handling, host interface and distributed communications networks.

Compiler Design . . . Design of compilers for high level languages used by system implementors and end users. Background in modern parsing, code generation and optimization techniques.

Operating Systems . . . Design and implementation of modular-real-time control programs for multi-and distributed-processing architecture. Development of virtual memory environments for secure resources sharing and multi-user applications.

Data Base Systems . . . Design and implementation of distributed data base management systems.

Software Tools . . . Development of software tools to enhance programmer productivity and program quality Special purpose languages and interfaces for automated product testing, data management systems for control of source and object modules, documentation aids and specifications languages.

System Architecture . . . Applied research on multi-processor and multi-computer architecture. Assess cost/performance of distributed microprocessor arrangements.

Integrated Circuit Design . . . Design of LSI digital and linear circuits, static and dynamic memories and microprocessors.

Systems Engineering . . . Overall planning for network growth, introduction of new technologies and improvement of network operations and maintenance procedures.

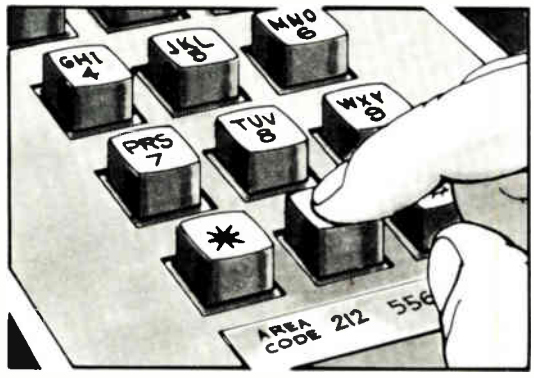
To initiate your prospective employment, please indicate your interest in investigating a future with Bell Labs. Write to us stating your area of preferred specialization and geographic location. Include a resume and transcript. Direct it to: Director of Technical Employment, Bell Laboratories, Center 831-78, 600 Mountain Avenue, Murray Hill, N.J. 07974

An Equal Opportunity Employer

Bell Laboratories

ENGINEERS

Expanded career opportunities are at your fingertips



call 800-321-6980

(In Ohio 800-362-6120)

Talk to Tom O'Brien or Dave Peterson about your skills and background for, positions such as...

Software Engineers Capitalize on your Comp. Sci. or related degree and apply your software experience – assembly languages, PASCAL, FORTRAN. Utilize our VAX 11/780 DEC 11/34 or TEKTRONIX Development Systems to support your designs.

Hardware/Firmware Design Engineers Design NC and PC systems employing advanced digital techniques. Degree and 2+ years experience desired. Your involvement would include design verification using VAX 11/780, DEC 11/34 or TEKTRONIX Development Systems.

Application Engineers Define customer control system requirements, prepare proposals and assist new product planning.

Product/Marketing Engineers Research and identify product opportunities based on industry requirements utilizing your degree and 2+ years of electronics or industrial experience.

These are opportunities with a future.

We are a dynamic part of an international corporation employing over 17,000 people. Our products apply "leading edge" computer and microprocessor technology that increases productivity for all types of industry.

Our careers are challenging and rewarding...

Let's Talk About It – Call Today: or if you prefer, send your resume to:

A-B QUALITY

ALLEN-BRADLEY
747 Alpha Drive
Highland Heights, Ohio 44143

An Equal Opportunity Employer M/F

SIGNALS AND COMMUNICATIONS ELECTRONIC ENGINEER

Engineering Department of major rail transportation firm has an opening for an Engineer with BSEE degree and at least 2 years experience in computer programming. Applicant shall be familiar with both hardware and software, with particular emphasis on computer graphics system, utilizing Fortran language.

Responsibilities will include supervising, technical assistance and preparation of all engineering documents utilizing a computer graphics system in connection with the development, construction, installation and modifications of railway signals and communications systems.

We offer salary commensurate with experience plus many liberal company benefits. Position located in Huntington, West Virginia. Please send resume to:

Mr. G.W. Kearney
Director
Signal and Communication

Chessie System Railroads
801 Madison Avenue
Huntington, West Virginia 25718

An Equal Opportunity Employer.

all positions fee-paid

ENGINEERS

ELECTRONICS ENGINEERS, $18,000-$50,000. Choice entry level to management positions immediately available in Pennsylvania & national locations. Reply in strict confidence to J. G. Weir, President, WEIR PERSONNEL SERVICES, 535 Court St., Reading, PA 19603 (215/376-8486).

ELECTRONICS ENGINEERS, $18,000-$40,000. Suburban New Jersey & nationwide. Numerous choice positions in co's utilizing the latest State-of-Art methods & equipment. Reply in confidence to James E. Mann, VP/Eng., ARTHUR PERSONNEL, SUITE M6, 8 Forest Avenue, Caldwell NJ 07006 (201/226-4555).

ELECTRONICS ENGINEERS, $18,000-$40,000. Nationwide positions in digital, analog, microprocessor, microwave & instrumentation technology. For immediate confidential response, send resume w/ salary history to Glenn English, President, GLENN ENGLISH AGENCY, 7840 Mission Center Ct., San Diego, CA 92108 (714/291-9220).

DESIGN ENGINEERS to $38K. Central Penna & nationwide. Design connectors/terminals, microprocessors, controls. Reply in confidence to Z. A. Gonglewski, MECK ASSOC. PERSONNEL, 1517 Cedar Cliff, Camp Hill, PA 17011 (717/761-4777).

npc NATIONAL PERSONNEL CONSULTANTS

Electronics advertisers

Classified and employment advertising

F. J. Eberle, Manager 212-997-2557

■ For more information of complete product line see advertisement in the latest Electronics Buyers Guide
• Advertisers in Electronics international
‡ Advertisers in Electronics domestic edition

Advertising Sales Staff

Advertising sales manager: Norman Rosen
3200 Wilshire Blvd., South Tower
Los Angeles Calif. 90010 [213] 487-1160

Product market managers:
Components: William Boyle, Rochester, N.Y.
Computers & Peripherals: Frank Mitchell, Boston
Test & Measurements: Don Farris, San Francisco
Semiconductors: Norman Rosen, Los Angeles

Atlanta, Ga. 30309: Peter Stien
100 Colony Square, 1175 Peachtree St., N.E.
[404] 892-2868
Boston, Mass. 02118: Frank Mitchell
607 Boylston St., [617] 262-1160
Cleveland, Ohio 44113: William J. Boyle
[716] 248-5620
Fort Lauderdale, Fla. 33308: Peter Stien
3000 N.E. 30th Place, Suite #400
[305] 563-9111
New York, N.Y. 10020
1221 Avenue of the Americas
John Gallie [212] 997-3616
Matthew T. Reseska [212] 997-3617
Philadelphia, Pa. 19102: Matthew T. Reseska
Three Parkway, [212] 997-3617
Pittsburgh, Pa. 15222: Matthew T. Reseska
4 Gateway Center, [212] 997-3617
Rochester, N.Y. 14534: William J. Boyle
Powder Mill Office Park, 1163 Pittsford-Victor Rd.,
Pittsford, N.Y. 14534 [716] 248-5620
Chicago, Ill. 60611
645 North Michigan Avenue
Jack Anderson [312] 751-3739
Robert M. Denmead [312] 751-3738
Detroit, Michigan 48202: Jack Anderson
1400 Fisher Bldg., [313] 873-7410
Costa Mesa, Calif. 92626: Edward E. Callahan
3001 Red Hill Ave. Bldg. #1 Suite 222
[714] 557-6292
Dallas, Texas 75201: John J. Uphues
2001 Bryan Tower, Suite 1070
[214] 742-1747
Denver, Colo. 80203: Harry B. Doyle, Jr.
855 Broadway, Suite 325
[303] 825-6731
Houston, Texas 77002: John J. Uphues
601 Jefferson Street, Dresser Tower
[713] 859-8381
Los Angeles, Calif. 90010: Chuck Crowe
3200 Wilshire Blvd., South Tower
[213] 487-1160
San Francisco, Calif. 94111: Don Farris,
Larry Goldstein, 425 Battery Street,
[415] 362-4600

Paris: Michael Sales
17 Rue-Georges Bizet, 75118 Paris, France
Tel: 720-16-80
United Kingdom: Simon Smith
34 Dover Street, London W1
Tel: 01-493-1451
Scandinavia: Andrew Karnig and Assoc.
and Simon Smith
Kungsholmsgatan 10
112 27 Stockholm, Sweden
Tel: 08 51 68 70 Telex: 179 51
Milan: Ferruccio Silvera
1 via Baracchini, Italy
Phone 86-90-656
Brussels:
23 Chaussee de Wavre
Brussels 1040, Belgium
Tel: 513-73-95
Frankfurt/Main: Fritz Krusebecker
Liebigstrasse 27c, Germany
Phone 72 01 81
Tokyo: Akio Saijo, McGraw-Hill
Publications Overseas Corporation,
Kasumigaseki Building 2-5, 3-chome,
Kasumigaseki, Chiyoda-Ku, Tokyo, Japan
[581] 9811

Business Department

Thomas M. Egan
Production Director
[212] 997-3140
Carol Gallagher
Production Manager
[212] 997-2045
Betty Preis
Production Manager Domestic
[212] 997-2908
Thomas Kazich
Production Manager Related Products
[212] 997-2044
Karen Walpole
Production Assistant
[212] 997-2843
Frances Vallone
Reader Service Manager
[212] 997-6057

Electronics Buyers' Guide

H.T. Howland, General Manager
[212] 997-6642
Regina Hera, Directory Manager
[212] 997-2544

Classified and Employment Advertising

Frank Eberle, Manager
[212] 997-2557

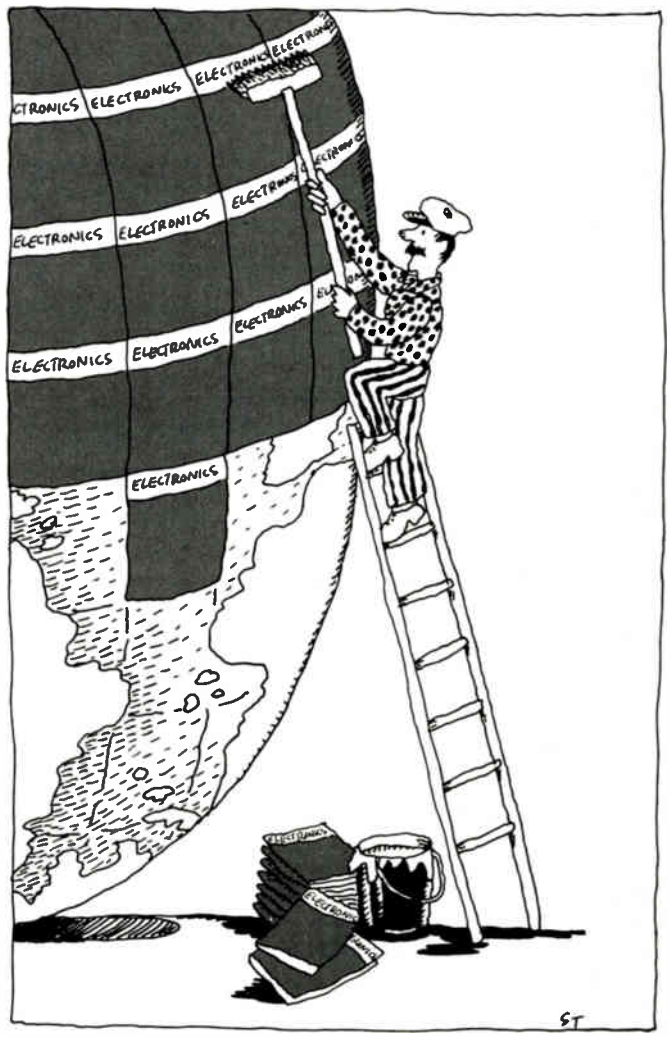
We cover the world of electronics technology with the only international edition in the field

You are reading the international edition of Electronics. The worldwide news and information is gathered for you by thirty-one editors stationed around the globe.

Every other week, the magazine is sent to subscribers in 123 countries outside of North America. Each issue is packed with important current information on industrial, scientific and military applications, electronics manufacturing, new products, new research, new designs.

Marketing information and statistics keep subscribers up to date with latest economic intelligence and new market developments, with interpretation of their meanings to the electronics industries.

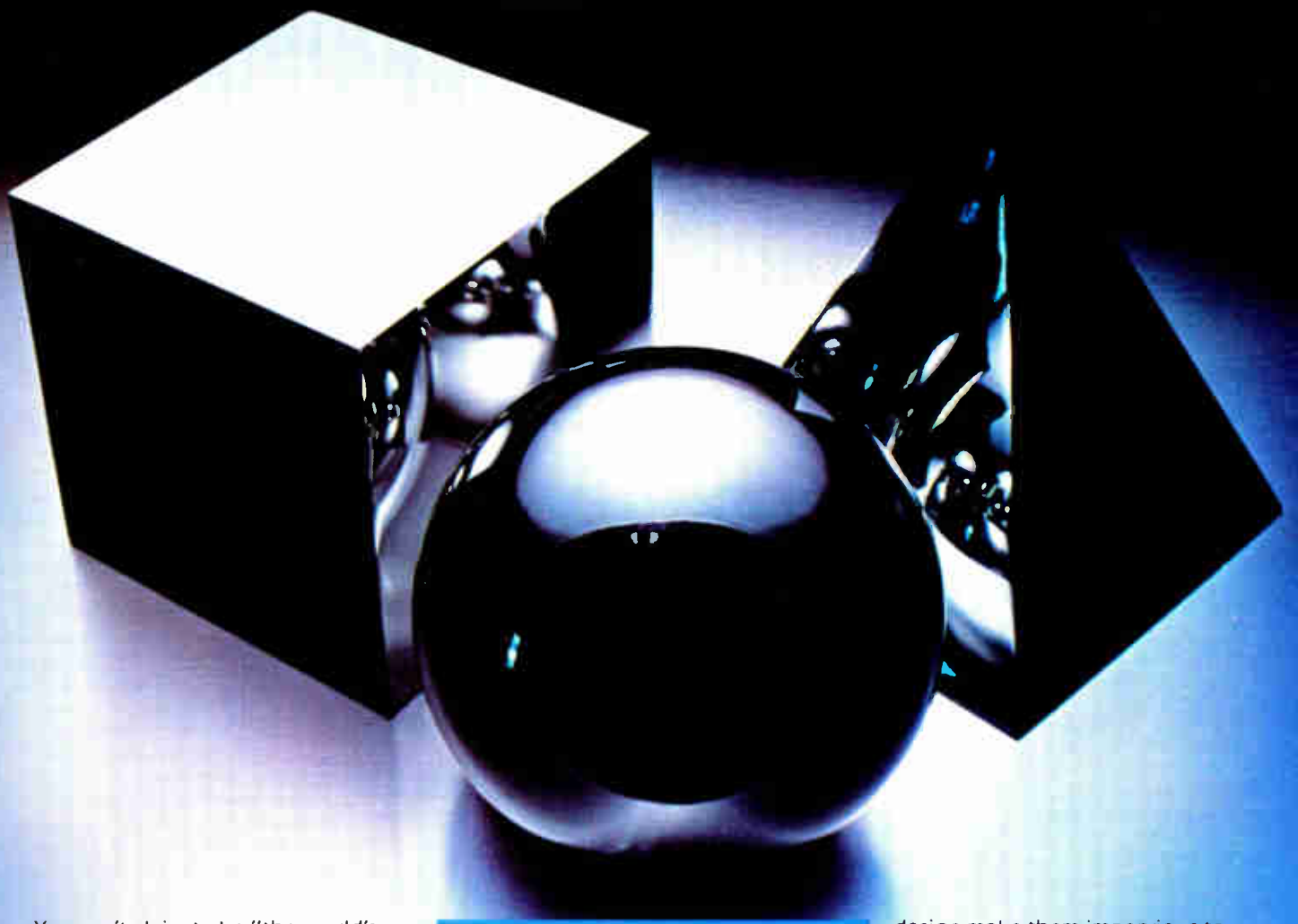
Electronics magazine's international edition is the only way electronics engineers can keep up with worldwide developments in the field wherever they occur. If you are not now a subscriber, you are invited to become one. Simply mail in the subscription card which is bound into this magazine.



Electronics Magazine
The one worth paying for.

The advanced design line of RF power amplifiers...

ENI.



You can't claim to be "the world's leader in power amplifiers" unless you are. And being the world's leader means giving customers the ultimate in RF power flexibility with a clearly advanced design. That's the reputation we've earned with our product line because there's simply nothing finer in all the world.

And our instrumentation can meet all of your applications, for RF signal generator amplification, RFI/EMI testing, signal distribution, RF or data transmission, NMR/ENDOR ultrasonics and more.

ENI's selection of solid state Class A power amplifiers is unsurpassed, combining a frequency spectrum of

10 kHz to 1 GHz with power outputs that range from 300 milliwatts to over 4,000 watts. Rugged, compact, and versatile, these units can be driven by virtually any signal source. They're completely broadband and untuned, amplifying inputs of AM, FM, TV, SSB, and pulse modulations with minimum distortion. Their unconditional stability and failsafe design make them impervious to severe mismatch conditions, and capable of delivering rated power to any load impedance from an open to a short circuit.

Clearly, when it comes to meeting your power amplification needs, you'll get the utmost in flexibility from the advanced design of RF power amplifiers... ENI.

For our latest full-line catalog, please contact us at ENI, 3000 Winton Road South, Rochester, NY 14623. Call 716/473-6900 or telex 97-8283 ENI ROC.

ENI

Circle 901 on reader service card

Pièce de Résistance...

The trimmer gourmet's choice.

Feast your eyes on Bourns Trimpot® trimmers – the choicest and broadest trimmer line anywhere. A banquet of trimmers with outstanding quality and performance at cost-effective prices to please the most discriminating design connoisseur.

Le Plus Grand Menu

Rectangular, square or round
Sealed or open-frame
Wirewound or cermet
Single or multi-tum

Select the size, shape, type of element and method of adjustment to suit your taste. They're served in an assortment of resistance values and pin styles to satisfy all of your design needs.

Bourns is dedicated to serving all of your trimmer requirements . . . both now and in the future. Look for future innovations in down-sizing, increased performance and cost-effective improvements. We're working on design solutions today for your application needs tomorrow.

Introducing the Trim Bin™ Trimmer Kit. Here are some appetizers to tantalize your trimmer palate: A complete assortment of the most popular Trimpot trimmers and MFT™ trimmers/resistors in a convenient package for just $99.95*. A value of over $200, the kit contains 127 parts representing 50 varieties of resistances and pin styles, plus adjustment tools and design aids. It's available from your local Bourns distributor.

Vive la Résistance! Call your Bourns representative or distributor for more information and for your new 94-page TR-1 trimmer catalog.

TRIMPOT DIVISION, BOURNS, INC., 1200 Columbia Avenue, Riverside, CA 92507. Ph: 714 781-5320. TWX: 910 332-1252.

European Headquarters: Bourns AG, Zugerstrasse 74 6340 Baar, Switzerland. Ph: 042 33 33 33. Telex: 78722.

*Domestic U.S.A. price only.

The last word in resistive components

BOURNS®

For Immediate Application—Circle 120 For Future Application—Circle 220