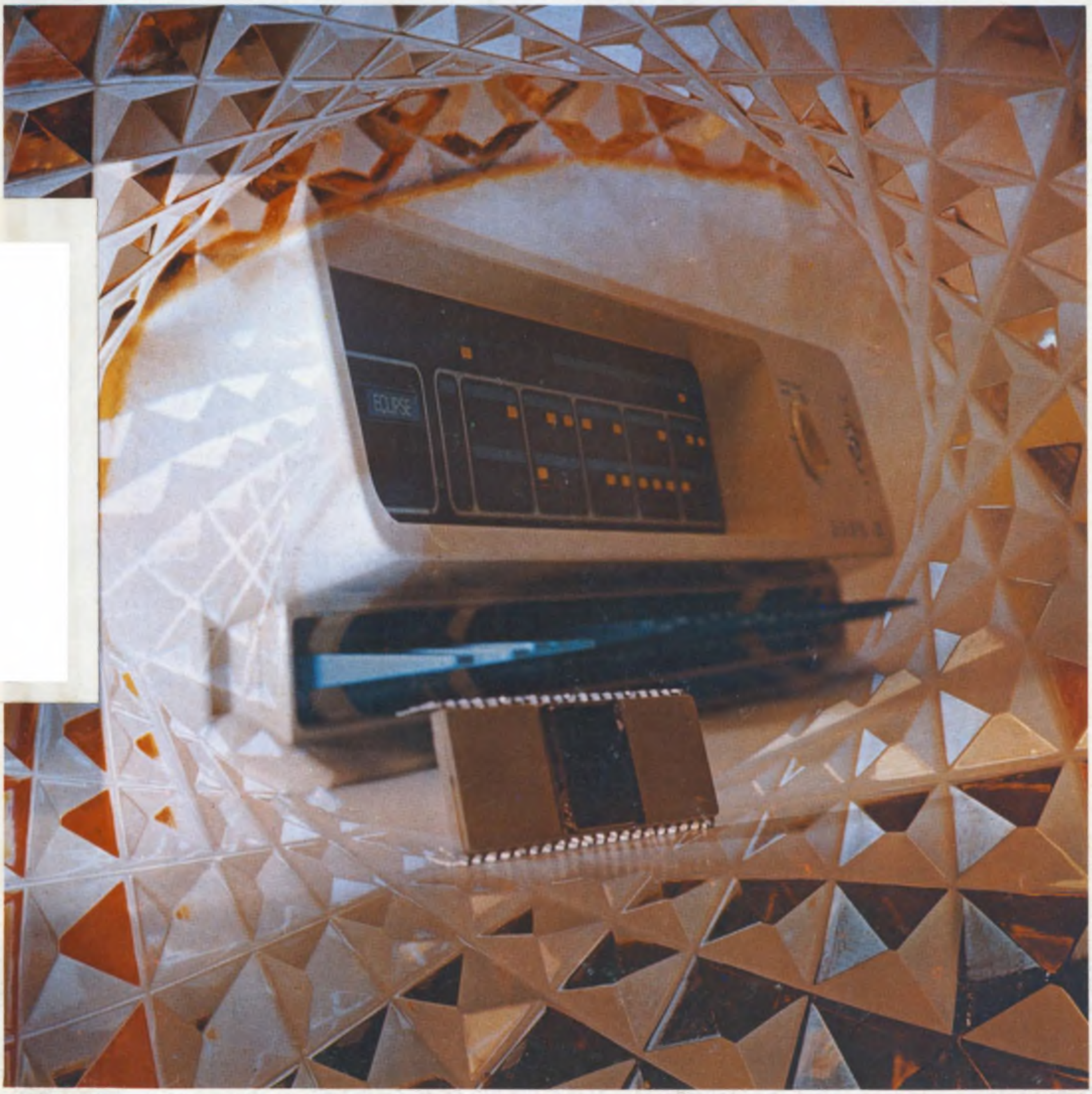
VOL. 23 NO. 10

Electronic Design

FOR ENGINEERS AND ENGINEERING MANAGERS

MAY 10, 1975

A multifaceted computer world confronts today's designer. He's got to keep up with progress in architecture made possible by improved chip technology. He has to consider the growing list of non-traditional peripherals. And he must recognize new computer uses such as in robotics and numerical control. Turn to P. 32.



Electronic Design 10

VOL. 23 NO. 10

FOR ENGINEERS AND ENGINEERING MANAGERS

MAY 10, 1975

NEWS

TECHNOLOGY

PRODUCTS

DEPARTMENTS

Cover: Photo by Jean-Pierre Ragot, Golddust Exchange, Boston, MA, courtesy of Data General Corp., Southboro, MA

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ces the first 8K
M.

EPROMs. They can be erased and reprogrammed again and again. To erase simply illuminate the die by shining a shortwave ultraviolet lamp through the transparent lid.

You can use Intel EPROMs for microprogram control, read-mostly memories, code conversions, lookup tables, random logic simulation, secure communications, etc. Their static operation, TTL compatibility, standard +5, −5, + 12V supplies, chip-select control, and three state outputs make system design easy and economical.

Intel's complete family of EPROMs and bipolar PROMs are available from distributor stock. Most Intel distributors also offer free programming for prototype quantities. Contact: Almac/Stroum, Component Specialties, Inc., Cramer, Hamilton/Avnet, Industrial Components, Inc., Sheridan and L.A. Varah Ltd. For more information call any Intel regional office: West, (714) 835-9642; Mid-America, (214) 661-8829; Great Lakes, (513) 890-5350; East, (617) 861-1136; Mid-Atlantic, (215) 542-9444. For your copy of the new application note AP-6 "Designing with Intel PROMs & ROMs" write Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051.

INTEL BIPOLAR PROMS

SIZE	PART NUMBER	ORGANIZATION	PINS	WORST-CASE ACCESS TIME (0° TO +75°C)	OUTPUT OPEN COLLECTOR OR THREE STATE	INTEL INTERCHANGEABLE ROM
1K	3601-1	256x4	16	50 ns	OC	3301A
	3601			70 ns	OC	3301A
	M3601			90 ns*	OC	M3301A
2K	3602	512x4	16	70 ns	OC	3302
	3602-4			90 ns	OC	3302-4
	3602L-6**			120 ns	OC	3302L-6
	3622			70 ns	TS	3322
	3622-4			90 ns	TS	3322-4
	3622L-6**			120 ns	TS	3322L-6
4K	3604	512x8	24	70 ns	OC	3304A
	3604-4			90 ns	OC	3304A-4
	3604L-6**			120 ns	OC	3304AL-6
	3624			70 ns	TS	3324A
	3624-4			90 ns	TS	3324A-4

*−55° to +125°C **Low Power

INTEL EPROMS

SIZE	PART NUMBER	ORGANIZATION	PINS	WORST-CASE ACCESS TIME (0° TO +70°C)	OUTPUT OPEN COLLECTOR OR THREE STATE	INTEL INTERCHANGEABLE ROM
2K	1702A	256x8	24	1.0 μs	TS	1302
	1702A-6			1.5 μs		1302
4K	2704	512x8	24	0.45 μs	TS	2308
8K	2708	1024x8	24	0.45 μs	TS	2308 or 2316A

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Across the Desk

More talk about torque

It is curious that some companies seem to take pride in a "me too" attitude. One letter to the editor recently bragged about the manufacture of a torque transducer like that of another manufacturer, but it omitted covering important differences in this field ("Acurex Corp. Sets the Record Straight," ED No. 26, Dec. 20, 1974, p. 7).

Apparently reference was made to a transducer type based on electromagnetic transmission of the torque signal from a rotating shaft. A good deal more was left to the imagination. Readers interested in torque-transducer application could be confused by the implication that a coupling is directly convertible to a torque transducer merely by addition of an electromagnetic signal path. A fundamental requirement is incorporation of a torque-detection element, which was prominent by its absence.

Conventionally torque transducer signals have been transmitted from rotating systems by means of slip rings (a feature incorporated in one torque-measuring system produced by West Coast Research). Contrary to the disclaimer of knowledge in the Dec. 20 letter, slip rings have proved reliable for signal transmission for many years. In fact, we have achieved speeds from 1 to 60,000 rpm with negligible noise, using the slip-ring technique. It is a surprise that others in the business do not know that this is a most reliable method, since it is the most widely accepted technique.

To join the "me too" ranks, let me state that West Coast Research can also employ other methods of signal transmission from rotating shafts—namely, FM wireless link or an electromagnetic (transformer) coupling and even an optical signal link.

Getting back to the torque detector: Probably still the most reliable and accurate, as well as straightforward, method of sensing torque is by means of a bonded strain-gauge bridge. Many torque-transducer manufacturers have not mastered this technique but employ other sensing methods, including variable-reluctance, differential-transformer and a variety of optical techniques.

Further, the measurement of power is not a direct measurement, as stated in the letter, but is derived from the torque signal and a rotational speed signal. It is necessary to combine angular rate measurement with torque to obtain a rate of energy input to the system.

H. M. Spivack

West Coast Research Corp.
P.O. Box 25061
Los Angeles, CA 90025

Parking-meter sensor makes him blow fuse

I note with alarm that a company is making a Hall-effect parking-meter sensor ("CMOS Parking Meter Eliminates Dead Time," ED No. 25, Dec. 6, 1974, p. 23). Aside from the fact that a less noble use

(continued on page 14)

Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Managing Editor, Electronic Design, 50 Essex St. Rochelle Park, N.J. 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld on request.

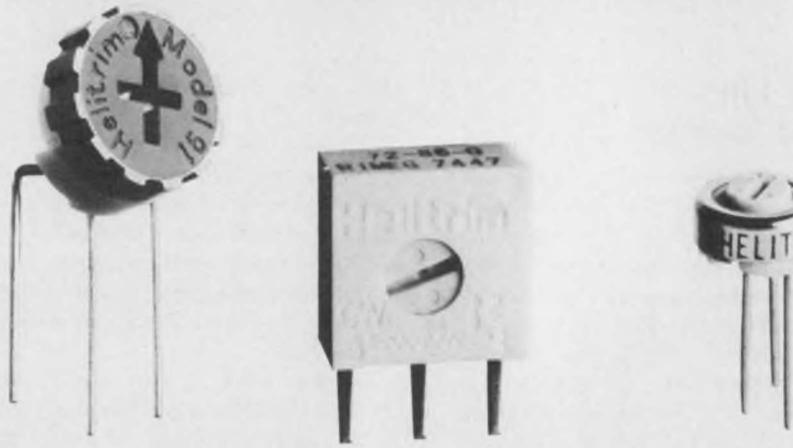
Industry standards...
Seven cermet trimmers that can

How?
- Through design versatility
- Fast delivery
- Excellent quality

Necessary Decisions:
1. Single vs. multiturn
2. Sealed vs. not sealed
3. Size
4. Resistance
5. Pin spacing
6. All-important, PRICE

Take a close look before you select your next trimmer. Call your local Beckman Helipot distributor for free evaluation samples, or immediate technical literature.

Beckman
HELIPOT DIVISION



Single-turn

Model 91
- High quality—low price
- Unique brush contact
- Excellent setability
- 100% inspected
- Protective dust cover
- Top or side adjust
- Screwdriver or hand adjust
- Standoffs prevent rotor binding and permit board washing
- Small 3/8″ dia. size
- 12 pin configurations
- Wide resistance range: 10Ω to 2 megΩ

Price: $0.42*

Model 72
- Sealed for board washing
- Available in VALOX 420-SEO housing
- Top or side adjust
- Brush contact
- Excellent setability
- Only 2 ohms of end resistance
- 3/8″ square
- 100% inspected
- 7 pin configurations
- 19 resistance values

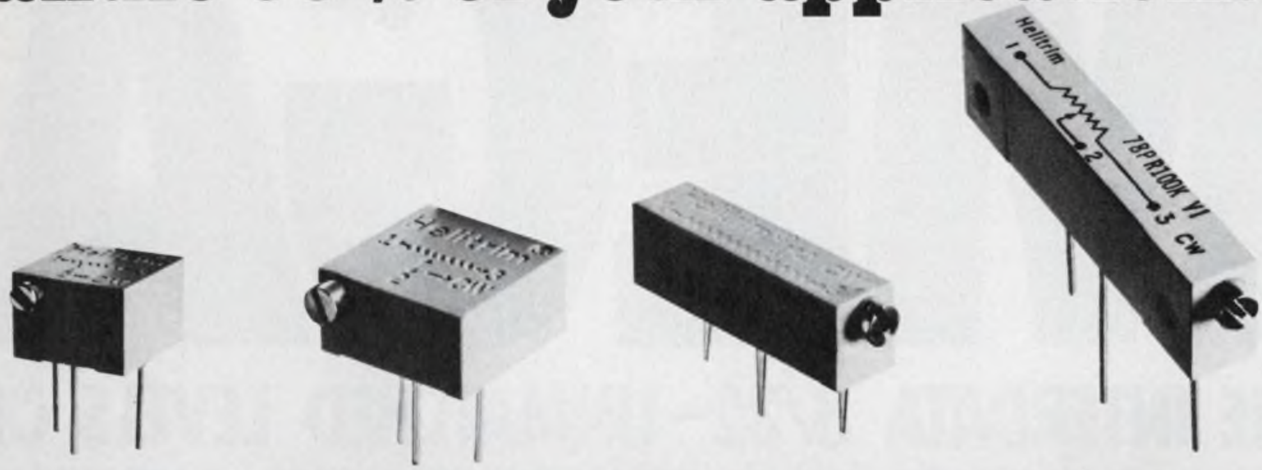
Price: $0.54*

Model 82
- Lowest profile trimmer in industry
- 1/4″ dia. by 0.150″ max. height
- Sealed for board washing
- Flame-retardant design
- 82P—top adjust
- 82PA—side adjust
- 100% inspected
- Brush contact provides excellent setability
- A cermet benefit that wirewound can't approach: resistance range 10Ω to 1 megΩ

Price: $1.12*

★ Still waiting for delivery on trimmers from another manufacturer?
Call your local Beckman Helipot distributor for a convenient cross reference from stock.

handle 95% of your applications.



Multiturn

Model 64
- Miniature, sealed trimmer
- 22 turns of adjustment
- Operates with 0.25 watt at 85°C derating to zero watts at 150°C
- 100% inspected
- 18 resistance values: 10Ω to 1 megΩ
- ¼″ square size is excellent for P.C. board packaging
- Uses Beckman's unique brush contact design
- Adjustability—voltage ratio within 0.01%

Price: $4.20*

Model 66
- Low-cost, multiturn with benefits of more costly trimmers
- Sealed for board washing
- 20 turns for adjustment accuracy
- Compact ⅜″ square housing
- Brush contact
- 3 pin styles for efficient space utilization
- Broad resistance range: 10Ω to 2 megΩ
- Operates with ½ watt at 25°C
- 100% inspected

Price: $2.70*

Model 89
- Our lowest cost multiturn
- Sealed for board washing
- ¾″ rectangular trimmer just 0.250″ high
- Needs no O-ring because of our unique ultrasonic sealing technique
- Only 2 ohms of end resistance
- 15 turns for accurate and quick adjustment
- 3 pin styles for mounting versatility
- Panel mount available
- 100 ppm/°C tempco
- 19 resistance values available
- 100% inspected

Price: $1.05*

Model 78
- Military performance at industrial prices
- 1¼″ rectangular only 0.195″ wide
- Sealed
- 3 terminal styles:
  - Flex leads
  - Printed circuit pins
  - Solder lugs
- Panel mount available
- Power rating 0.75 watt at 70°C
- 100% inspected
- 22 turns of adjustment
- Resistance range: 10Ω to 2 megΩ
- 100 ppm/°C tempco

Price: $2.28*

*1,000-piece price

INFORMATION RETRIEVAL NUMBER 8

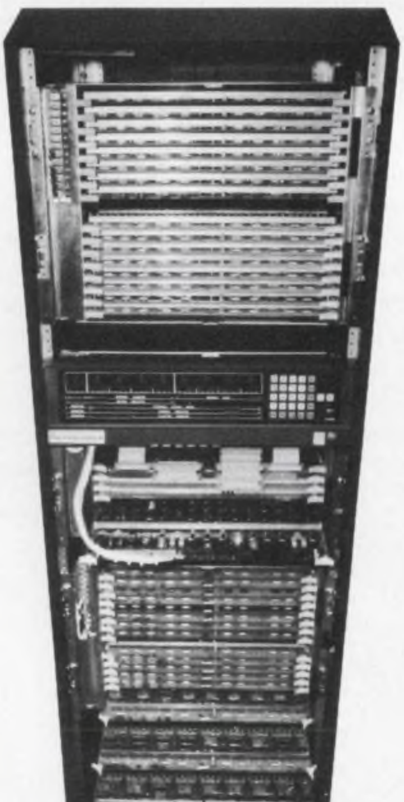
INTRODUCING THE WORLD'S FIRST

MEGA

THE INTERDATA 8/32–UNMATCHED LEVELS OF PERFORMANCE IN A MINICOMPUTER SYSTEM.

MEGAMINI ARCHITECTURE: AN ABUNDANCE OF SHEER POWER.

Interdata's new 8/32 Megamini has performance characteristics found only on large scale computers. Like direct addressing to one million bytes. Full 32-bit hardware with performance enhancers such as dual instruction look-ahead stacks, multiple register sets, interleaved 32-bit memory, and fast floating-point hardware. What our 8/32 Megamini means to you is an unequalled combination of power, flexibility, and reliability in a compact package. All at a price that's fully competitive.



The 8/32 MEGAMINI – with a full Megabyte.

MEGAMINI SOFTWARE: POWERFUL, FLEXIBLE, EASY-TO-USE.

Today's hardware must be designed to ease your software effort. You shouldn't have to spend a lot of expensive programming time trying to figure out how to get around minicomputer hardware limitations. With the 8/32 Megamini you don't – because there are none.

For example. The direct addressing capability of the 8/32 Megamini allows you to build programs and data arrays in any size up to the amount of memory you have – no more 64K limits.

It also means we can give you versatile and powerful software to help lower the cost of building your system. Software with a multi-tasking operating system, OS/32MT, with unique multi-user

Multi-Wire Technology – a key to MEGAMINI performance.

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MINI.™

COMPARE: THE INTERDATA 8/32 MEGAMINI VS. THE-LESS-THAN-MEGAMINI COMPETITION.

	INTERDATA 8/32	XEROX 550	IBM 370/158	DEC 11/70	DG Eclipse
WORD LENGTH	32 bits	32 bits	32 bits	16 bits	16 bits
INSTRUCTION TIMES (Register to Memory)					
Integer Add	1.25	1.8	.9	1.8	2.5
Multiply	3.54	6.2	2.0	3.9	8.8
Divide	5.8	14.4	9.9	8.3	11.2
Floating Point Add	2.3	6.1	2.4	8.25	5.5
Multiply	3.0	9.1	2.3	11.25	7.2
Divide	5.35	23.3	8.9	12.25	7.9
HARDWARE I/O	Yes	Yes	Yes	No	No
MAX. DMA RATE/SECOND	6MB	4MB	6.7MB	4MB	2MB
DIRECT ADDRESSING RANGE	1MB	1MB	16MB	64KB	64KB
GENERAL PURPOSE REGISTERS	2 stacks 16 each*	4 stacks 16 each	1 stack 16 each	2 stacks 8 each	1 stack 4 each
PRICING (Basic Configuration)					
CPU + 128KB Memory	$51,900	$128,700	N/A	$54,600	$32,500
CPU + 1048KB Memory	$179,400	$478,700	$1,905,700	$163,800	N/A

*(6 Additional Stacks Optional)

program development capabilities. Software that has an optimizing macro assembler, MACRO CAL. And software with a sophisticated telecommunications access package, ITAM, that allows you to treat remote communications terminals and computers as if they were simply local devices.

Now, with all of this available, you can concentrate your efforts on the real problem at hand – your application.

THE MEGAMINI: NOT JUST A COMPUTER – BUT A SYSTEM.

The Interdata 8/32 Megamini gives you a full range of peripherals, software and advanced features to choose from in tailoring your system: 166MB disc systems, fast line printers, 1600 BPI tapes and graphic CRT's. Plus software modules like FORTRAN, BASIC, EDIT, AIDS and many more.

FOR MORE MEGADATA, CLIP AND MAIL.

Interdata, Inc., Oceanport, N.J. 07757

☐ All that power sounds marvelous. Send me more information on the Interdata 8/32 Megamini.

☐ You may have hit on the solution to my megaproblem. Have a representative call me.

Name________________ Title________

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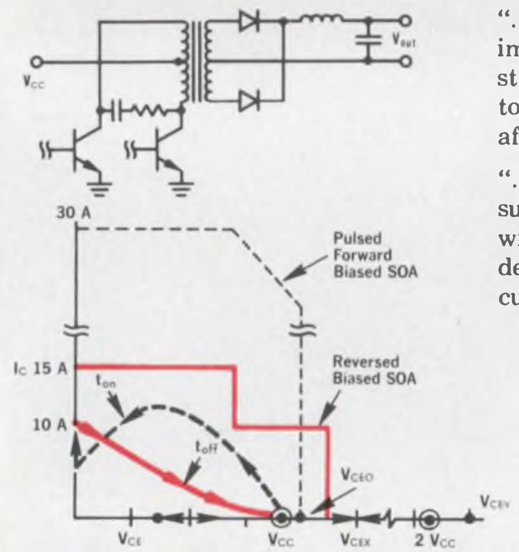
INFORMATION RETRIEVAL NUMBER 9

End switching puzzles

with Switchmode silicon power



". . . both blocking voltage and sustaining voltage are important in switch-mode applications. The circuit illustrated requires high blocking capability since the transistor is subjected to a substantially higher voltage than V_{CC} after turn-off . . ."

". . . for inductive loads, high voltage and current must be sustained simultaneously during turn-off, in most cases with E-B junction reverse biased. The safe level for these devices is specified as $V_{CEX(sus)}$ at given high collector currents as shown on the reverse biased SOA curve . . ."
(from Switchmode *Designers Data Sheet*)

The jigsaw's complete.

It's finally been done.

Motorola did it in '72 by introducing the now industry-standard 2N6306-6308 switches . . . we're doing it again in '75 with the 2N6542-6547 Switchmode family.

SWITCHMODE	V_{CEV} V	$V_{CEX(sus)}$† @ 100°C V	I_C Cont. A	$V_{CE(sat)}$ max @ I_C, 100°C	t_f† (max) @ I_C, 100°C	PRICE
2N6542/3	650/850	350/450	5	2/3	800ns	$2.25/ 2.85
2N6544/5	650/850	350/450	8	2.5/5	900ns	3.75/ 4.75
2N6546/7	650/850	350/450	15	2.5/10	1500ns	7.50/10.75

†Clamped inductive load

What you've had in specs up to now doesn't get you there. It might even lead you astray with incomplete info.

For example, when all you've got is forward bias SOA limits (and that's all you get from everyone else) and you need to know what happens in reverse or OFF-biased for clamped inductive loads, you've got a square peg for a round hole.

Same thing when you're trying to match a high-temperature inductive load to low-temperature resistive switching specs.

Apples and oranges.

That's when all your guesswork starts — cutting and fitting that finally leaves you at a workable, but fuzzy, point in the picture . . . a design without specs. An engineering never-never land.

Switchmode's* the name from now on.

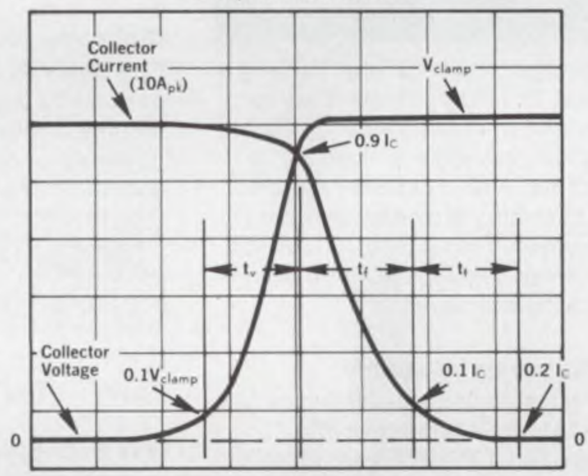
Switchmode silicon power is completely spec'd to tell you exactly how the device will operate under all operating conditions; forward, reverse, clamped inductive or resistive. Actual use conditions and real-world situations. You know how far your load lines can go and still be safe. You know what $V_{CEX(sus)}$, $V_{CE(sat)}$ and

"... in most applications, a large percentage of total device power dissipation occurs during turn-off time and t_f is normally used as a figure of merit. There are, however, two portions of the turn-off waveform that can add losses and in some cases can be significant. The interval t_v is part of total storage time t_s and is defined as voltage switching time. During t_v, the V_{CE} voltage changes from saturation to clamp voltage while collector current has only decreased by 10%. The time t_t occurs after fall time and appears as a "tail" on the collector current waveform. Significant dissipation occurs during the total period $t_v + t_f + t_t$ ..."

(from Switchmode *Designers Data Sheet*)

2N6546 TYPICAL TURN-OFF WAVEFORM

Clamped Inductive Load



t = 50ns/DIV

I_{CEV} are at 100° case. You know t_s and t_f performance as a function of collector current and temperature at high inductive energy. You know precisely where you stand with secondary breakdown . . . before it happens. The unknown is known.

No guess work. No empiricals. No unspec'd performance.

Just solid, practical data from a pragmatic, comprehensive Designers Data Sheet. A real "first".

These premier Switchmode units are nanosecond fall-time fast in clamped inductive loads. 450 V sustaining at 100°C case. Up to 15 amperes continuous. Triple-diffused rugged.

The world's moving faster to lighter, quicker, efficient switching power supplies. Find out how you can move with it — send for new Switchmode data sheets, Application Notes AN588, AN719 and AN737 and Engineering Bulletin EB-39 on new approaches to switching regulators. Box 20912, Phoenix, AZ 85036.

Switchmode

You'll never go back to linear or series-pass again.

from Motorola, the *Imaginative* power producer

INFORMATION RETRIEVAL NUMBER 11

ACROSS THE DESK
(continued from page 7)

of electronics is hardly imaginable, I object to the idea that a gizmo like that could be made sufficiently reliable so it could be used by untrained city employees.

If the device were sensitive enough to detect the presence of a motorcycle or a fiberglass car (Corvette, Avanti), it would also be decoyable. Taping a magnet onto the meter would be another effective countermove.

What knowledgeable individual would want to take the time to try to explain to a law officer that the parking meter had reset for unknown reasons, even though he did everything right? What officer would believe him?

Having been robbed over the years by vending machines that do things a human would never have the chutzpah to do, and having had my long-distance phone calls answered by machines that never reply, I believe there are areas where technology has no business. Adding machines and color TV, yes; parking meters, no.

James Rieger
Engineer
Naval Weapons Center
Code 3735
China Lake, CA 93555

Misplaced Caption Dept.

"Engineering said it wouldn't leak."

Sorry. That's Rembrandt's Woman Bathing in a Stream," which hangs at the National Gallery in London.

(continued on page 16E)

DEVICE TYPE	PACKAGING	ACCESS TIME (NS)	POWER SUPPLIES
TMS 4030	 22 PIN	300	−3V, +5V, +12V
TMS 4030-1		250	−3V, +5V, +12V
TMS 4030-2		200	−3V, +5V, +12V
TMS 4050	 18 PIN	300	−5V, +12V
TMS 4050-1		250	−5V, +12V
TMS 4050-2		200	−5V, +12V
TMS 4060	 22 PIN	300	±5V, +12V
TMS 4060-1		250	±5V, +12V
TMS 4060-2		200	±5V, +12V

MOS memories

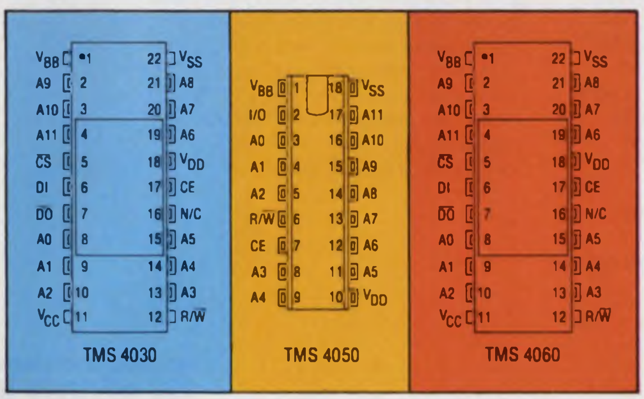
Design Flexibility.

Texas Instruments 4K RAM family. Helps you achieve optimum cost/performance designs.

When the design objective is to save space by increasing part density, the compact 18-pin TMS4050 may well be your best choice. You'll get 200ns performance and lower cost too—compared to 16-pin 4Ks, this is a 40% speed improvement and a 30% lower cost.

On the other hand, when separate data inputs and outputs are a design must, then the 22-pin TMS4030 or TMS4060 is the perfect choice.

Now with nine new 4K RAMs available, in plastic or ceramic, you can tailor the memory system performance to CPU needs. And you can design with confidence. Because TI has more experience in building 4K RAMs than any other manufacturer. In fact, TI can claim four big firsts in 4K technology:



- First to offer a 4K RAM.
- First to combine the single transistor cell with the reliable N-channel silicon gate process.
- First to have an 18-pin 4K.
- First to offer a 200ns 18-pin 4K.

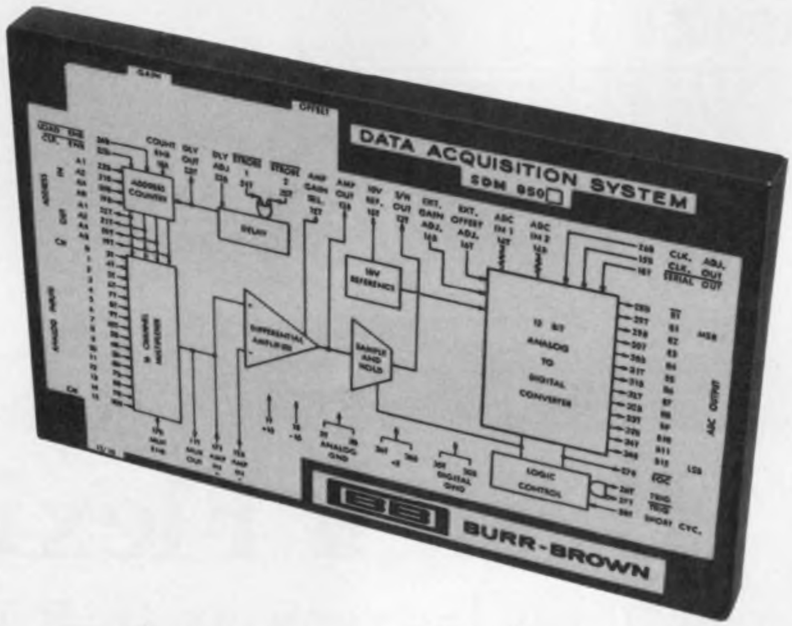
All TI 4K RAM types are in volume production. Availability is off-the-shelf through TI's authorized distributors in plastic (NL) or ceramic (JL).

For a Reliability Report or data sheets (indicate by type and number), write on your company letterhead to Texas Instruments Incorporated, P.O. Box 5012, M/S 308, Dallas, Texas 75222.

TEXAS INSTRUMENTS
INCORPORATED

83085

This Data Acquisition System is the Best Alternative to Building Your Own



Here's why. First, it's pre-engineered to save you design time and money. Then, we've put everything together for you, including a few very neat Burr-Brown microcircuits, to save your purchasing, production, and test time. All components are performance matched to offer low-cost, accurate, and reliable data acquisition. You eliminate a lot of hassle, and, in turn, you get a complete, high performance 12-bit, 8- or 16-channel modular analog data acquisition system that's ready to plug in. Your total cost is just our low price for the system plus the cost of your purchase order.

Designed to accept either 16 single ended (SDM850), or 8 differential (SDM851) analog data channels, each model contains its own Burr-Brown multiplexer, differential amplifier, sample/hold, 12-bit successive approximation A/D converter, and programming sequence logic. All working together to multiplex and convert up to ±10 volt analog data signals into 12-bit digital samples with guaranteed accuracies of ±0.025% at throughput sampling rates of up to 50kHz per second without the use of any external components. Throughput of up to 100kHz is possible in an "overlap" mode.

And, a complete set of compatible multiplexer expanders and a DC/DC converter are available to let you configure your system to accept up to 128 differential or 256 single-ended analog signals.

Each system module is 100% tested for every channel and burned in for 168 hours to assure that key system parameters are met and premature component failures are eliminated. Each is housed in a 0.375" H x 4.6" W x 3.0" L steel case designed to minimize space requirements while providing electromagnetic shielding.

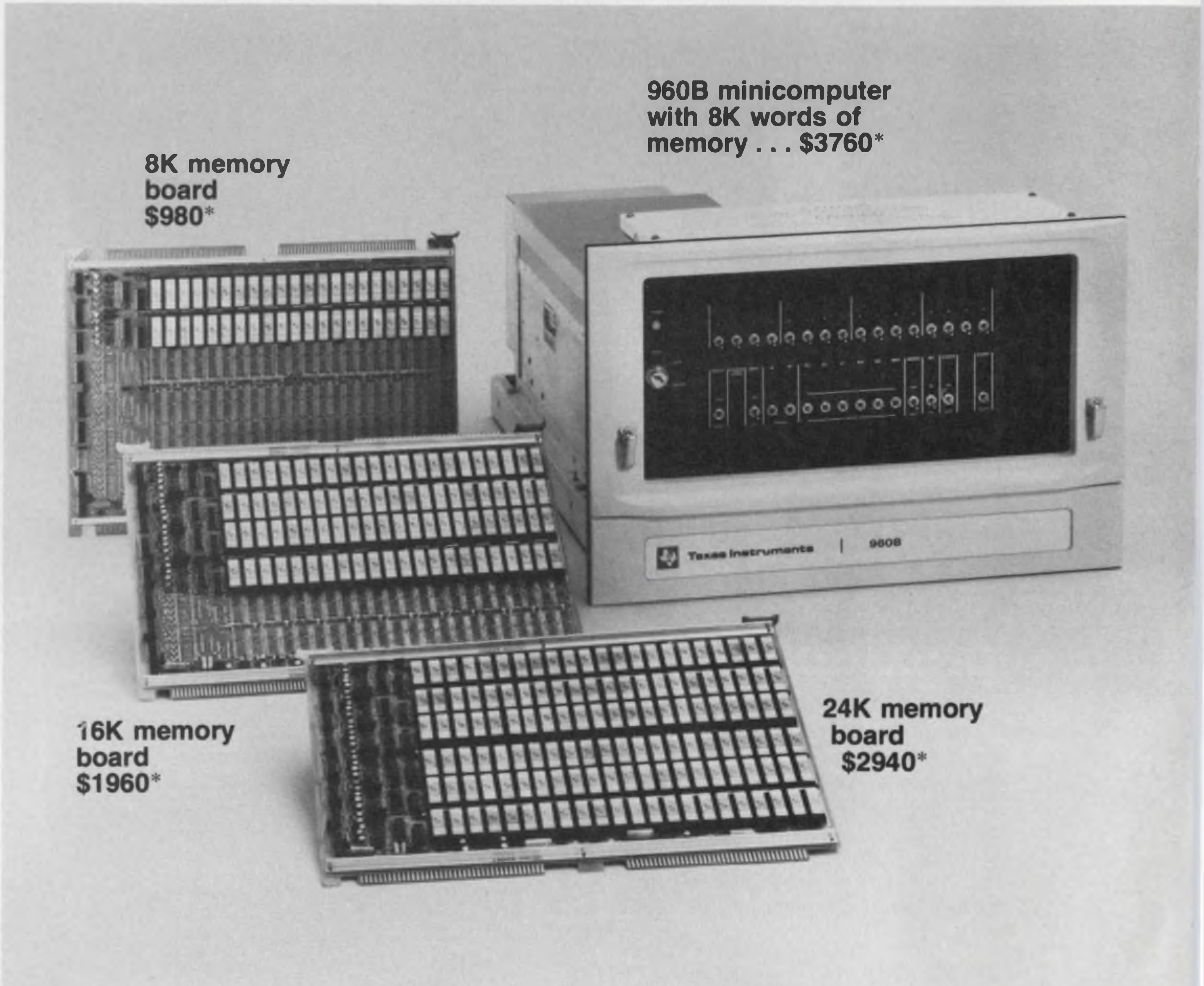
You could build one of these modules yourself, but your parts cost alone would probably equal or exceed our unit price for either model of just $595. When you add your costs for design, documentation, purchasing, production, and testing, we're convinced you'll think a "buy" decision is the best alternative... especially when you see our OEM pricing. Burr-Brown, International Airport Industrial Park, Tucson, Arizona 85734. Telephone (602) 294-1431.

BURR-BROWN

INFORMATION RETRIEVAL NUMBER 14


FEDERAL RESERVE NOTE
THE UNITED STATES OF AMERICA
10
WASHINGTON, D.C.
TEN

New low prices and Texas Instruments 900



*Prices quantity 100 OEM, USA only.

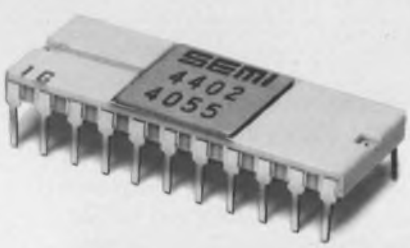
Improving man's effectiveness through electronics

SHIFT INTO HIGH PERFORMANCE WITH A 4K STATIC RAM

FULLY STATIC: The SEMI 4402 is a fully static 4K RAM. That's important. For one thing, it means you can now design a 250 nsec MOS memory system around a 4K device without worrying about refresh or charge pump circuitry. For another, static RAMS are inherently less susceptible to soft bit error problems than comparable dynamic devices.

350 NANOSECOND CYCLE: The SEMI 4402 4K static RAM has a *complete cycle time* of just 350 nsec and 200 nsec maximum access time. That makes it the fastest 4K static RAM in production. Now you can design a truly high performance MOS memory around a static 4K device.

AVAILABLE NOW: The SEMI 4402 4K static RAM is here now. We're already delivering it to customers at the memory system level. And it is second sourced by a major supplier of MOS devices.



LOW POWER: The SEMI 4402 4K static RAM has similar power levels to comparable dynamic devices. However, power conservation is achieved by the Chip Select Input, which causes the 4402 to enter a low power standby state whenever it is unselected. Normal V_{DD} is 12 Vdc, but V_{DD} can also be reduced to 5 volts without risking loss of stored data. And the 4402's differential output results in inherently high noise immunity memory systems.

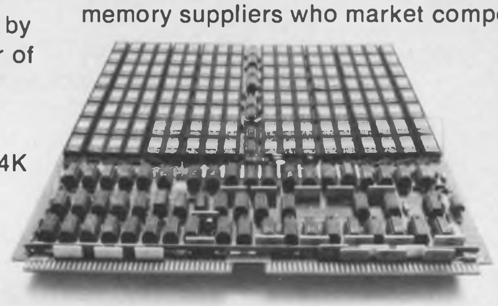
PERFORMANCE TESTED: Like all SEMI NMOS components, the 4402 4K static RAM must meet our own tough test standards, since we use it in our memory systems — for example the MICRORAM 3400N. With our reputation riding on its performance, you may be sure the acceptance standards are high indeed. In fact we 100% ac and dc test our components twice — at wafer and again in the package.

Part No.	Bit Org.	Access Time
RAMS		
SEMI-1801	1024 x 1	90 nsec.
SEMI-1802	1024 x 1	70 nsec.
SEMI RA-3-4256	256 x 4	1 usec.
SEMI RA-3-4256B	256 x 4	1 usec.
ROMS		
SEMI RO-3-4096	512 x 8	500 nsec.
SEMI RO-3-5120	512 x 10	500 nsec.
SEMI RO-3-16384	4096 x 4	1.0 usec.

More new products to come . . . additional 4K static RAMs, ROMs

MODEL SELECTION: In addition to the 4402, EMM SEMI offers you a complete line of static NMOS RAM and ROM components to meet your design needs. Make your selection from the adjacent chart.

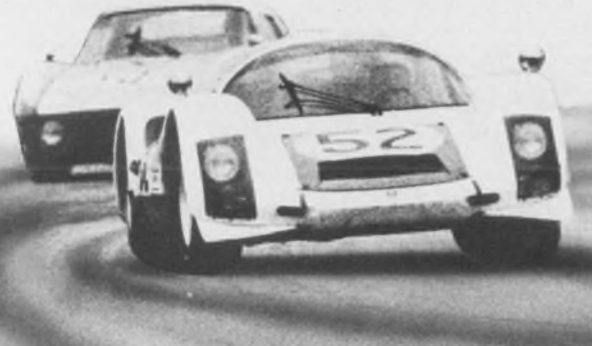
PROVEN TRACK RECORD: At EMM we've been making memory components and systems since 1961. Unlike memory suppliers who market components only, all EMM components are all performance proven in our own systems. When you buy from EMM, you get the benefit of the unusually high acceptance standards we impose on ourselves, as well as our years of experience in meeting the needs of the memory marketplace. If you'd like further information about any of the products featured here, or any other EMM components or systems, contact your local EMM office today.



EMM SEMI

A division of Electronic Memories & Magnetics Corporation
3883 North 28th Avenue, Phoenix, Arizona 85017
Telephone (602) 263-0202

INFORMATION RETRIEVAL NUMBER 153



See our full Product Line at THE NCC Show in Anaheim, May 19-22, Booth 2440

(continued from page 14)

Liquid-crystal supplier lets us in on 'secret'

We found "Focus on Displays" (ED No. 26, Dec. 20, 1974, pp. 52-62) to be very interesting, well-written and an accurate reflection of the current status of this industry. We were disappointed, however, in not finding Ashley-Butler listed among the companies at the end of the article.

Ashley-Butler is the world leader in the design, development and manufacture of large-area liquid-crystal displays. Most of our business has been in the area of custom displays, ranging from 3 × 5 to over 12 × 12 in. Unfortunately our name and capability seem to be a secret throughout much of the industry.

We hope that situation will change, as Ashley-Butler has recently designed, developed and delivered a liquid-crystal digital clock for the home and office market. This clock reached the market before Christmas and has sold extremely well. The clock's appeal rests in the unique appearance made possible by the dynamic-scattering liquid-crystal displays.

Richard Klein
Director of Engineering
Ashley-Butler, Inc.
208 U. S. Highway 206 S.
Somerville, NJ 08876

Right facts, wrong pic

In the new-product item "Microprogrammed Minis Are 32-bit Machines" (ED No. 4, Feb. 15, 1975, p. 112), the wrong picture accompanied the description of the SEL 32/50 and SEL 32/55 minicomputers from Systems Engineering Labs, Fort Lauderdale, FL. The photo was that of the Connectran data-set simulator from Computer Transmission Corp., El Segundo, CA. Here is the correct picture of the SEL 32/50 and 32/55 minis.

The Connectran incidentally is a dial-up data set simulator that eliminates two data sets and phone line. A single unit gives local data

service at distances up to 1200 feet via 11-pair twisted cable.

For Systems Engineering Labs

CIRCLE NO. 318

For Computer Transmission

CIRCLE NO. 319

Astrodata reports it's alive and well

I have read with interest your article on Disney World in the Feb. 15 edition ("That Dazzling Dizzy Disney World Is Run by Computer," ED No. 4, p. 24). I was shocked by the reference to Astrodata as a company that is "now defunct." I wish to advise that Astrodata is a viable company located in Anaheim, CA.

I am pleased to report that the formation of a single division for manufacturing and marketing telex switching systems under the sponsorship of the Plessey Co., Ltd., is proceeding as scheduled.

A retraction of the statement contained in your article would be in order.

Leo F. Imhoff
Vice President of Administration
Astrodata Inc.
270 E. Palais Rd.
Anaheim, CA 92803

Ed. Note: Astrodata reports that it filed for reorganization under Chapter 11 but was rescued from bankruptcy by a financial house in New York on Aug. 17, 1972. The company was forced to abandon the Disney computer project before its completion and no longer makes computers.

MEASURES REAL POWER

NEW

This unique new electric power sensor is finding success in an amazing number of worthwhile applications. And many more are yet to benefit! The reasons are clear.

The new real power sensors have qualities ideally suited to contribute to the solutions of today's energy and economic situations. The modules accurately measure real electric power (±0.25%). They are simple, reliable, and reasonably priced. F. W. Bell, Inc. real power sensors are versatile, rugged, and easily applied to single phase, three phase, 60 Hz to 10 kHz sinusoids and non-sinusoids, and any power factor operation.

Here are some application examples of PX series transducers which are now in use.

ACTUAL PERFORMANCE vs. REAL POWER:

Bell real power sensors provide the information necessary to rate electrical equipment performance versus real power consumption. An example would be gallons per kilowatt for a pump, or cubic feet capacity versus watts for refrigerators.

BENEFITS:

Accurate
Low loading, one watt
Simple, reliable
Inexpensive
Used to save energy and money

TORQUE MEASUREMENTS:

Bell real power sensors are in use measuring motor torque. Shaft torque is real power divided by shaft angular velocity. The real power sensor provides the accurate power signal for the torque computation.

VISCOSITY SENSOR:

Bell real power sensors are used on pump motors to sense and measure the viscosity of the pumped fluids.

POWER DRAW MEASUREMENTS:

Bell real power sensors are employed in portable and fixed energy management systems. The real power sensor can be used with recorders, PT's, CT's, and related equipment to measure the power consumed within a manufacturing or other facility. The results are used in energy management to reduce power bills and maintain operation with reduced energy consumption.

For complete application and technical details, use the inquiry card.

A Member Company of
Allegheny
Ludlum
Industries,
Incorporated

from Bell

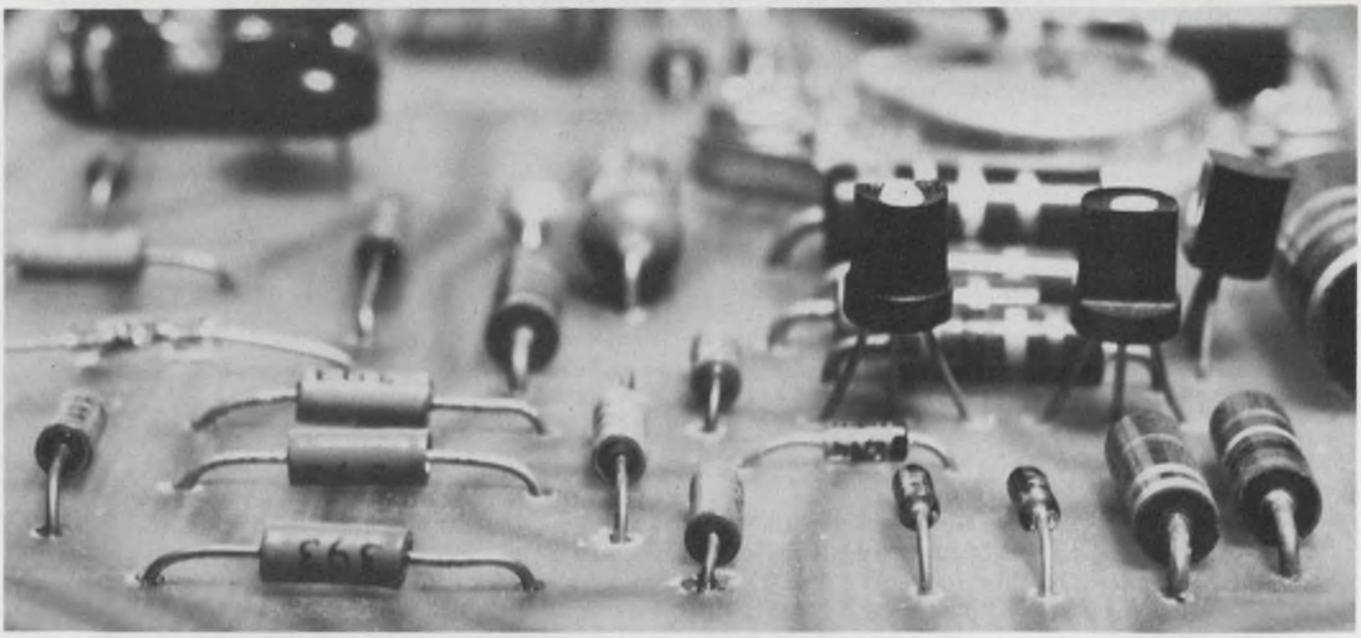
The Gaussmeter People

4949 Freeway Drive, East
Columbus, Ohio 43229

A Subsidiary of The Arnold Engineering Company

F. W. BELL INC.

INFORMATION RETRIEVAL NUMBER 155



Stripswitch.™ Not much to you. But big to us.

If we had to design a new switch for circuit board applications, we'd design Stripswitch again.

Not some other switch. Stripswitch.

The one with coded output—decimal, BCD, complimentary, special binary, and 1-, 2-, 3-, and 4-pole.

The one with 1 to 11 stations, each with 8, 10, 12, or 16 positions, actuated by thumb, finger, or screwdriver.

The one that mounts both horizontally and vertically, and reads out on the front or the side.

The one you wave-solder to your board, or plug into DIP sockets and strips.

Actual size.

The one made of durable Valox*, with lots of legends and markings, color codings, and rotation limit stops.

The one that costs less than $1.00 per station if you order enough stations.

That's little enough, whether you buy Stripswitch from us or our distributors—G. S. Marshall, Hall-Mark, or Schweber.

And *that* makes it big.

EECO
FOR SWITCHES

1441 East Chestnut Avenue, Santa Ana, California 92701
Phone 714/835-6000

*Registered General Electric trademark

INFORMATION RETRIEVAL NUMBER 15

MAY 10, 1975

Laser and radar systems speed pinpointing of targets

A hand-held laser system that can determine the range of a target in one second is being built for the Army by the RCA Government Communications and Automated Systems Div. in Burlington, MA.

Meanwhile in nearby Wayland, MA, Raytheon's Equipment Div. has developed a radar that pinpoints the site of a mortar or artillery emplacement after one shell has been fired.

The RCA laser system, being developed for the Army Electronics Command, Fort Monmouth, NJ, resembles field binoculars. The system measures the range and displays it in meters in the sighting eyepiece. The unit, designated the AN/GVS-5, weighs only 5 lb.

The user sights the target and activates the system by pushing a "fire" button. The laser emits a narrow beam at the target, and a receiver collects the reflection. The time delay is converted to distance in meters.

The laser transmitter incorporates a chemical Q switch wafer—a saturable absorbing dye in acrylic—that costs only pennies to produce. The Q switch is packaged in a compact, sealed resonator subassembly about the size of a cigarette. The subassembly consists of a rod coated at one end to provide a mirror that gives partial reflections, a cylindrical filter to keep ultraviolet light away from the Q switch and a mirror that gives total reflections.

The complete module mounts directly to the transmitter telescope. If a failure occurs, the entire assembly can be removed and replaced with a new one.

The unit's receiver elements consist of a detector/preamplifier module, video amplifier, range counter and display module.

The Raytheon radar system pinpoints mortar or artillery emplacements with a minicomputer and a digital Doppler signal processor. It is a completely redesigned, solid-state version of a mortar-and-artillery-locating radar that saw action in Vietnam, according to H. H. Thomas, program manager at Raytheon.

The detection range is 24 km, as opposed to 12 km in earlier systems. The advance has been achieved with all-solid-state design and an electrostatically focused klystron. Full coverage of 360 degrees is provided as opposed to earlier units that could monitor only one sector at a time.

Designated the AN/TPQ-31, the radar is reported to have achieved 98% average probability of detection on the first round fired during field tests of 1000 rounds.

During the first few weeks of the tests at a Marine Corps base in 29 Palms, CA, the firings were used to refine signal and target data-processing algorithms. Very high subclutter visibility—the ability to see through ground clutter caused by reflections from bulbs and other obstructions—is attained with a fast-Fourier-transform signal processor, Thomas points out. This is necessary, he says, because the artillery and mortar shells have such small cross-sections.

The detected targets are fed to a Univac 1616 minicomputer, which is to be placed by the UYK-20, a standard Univac military version. The computer takes the two-dimensional data of the target and infers the third dimension by adding the most probable parabolic trajectory.

From the velocity projected, the computer also predicts what type of projectile the incoming target is, as well as the launching and impact points.

Transducer simplifies image processing

The development of a unique optoelectronic image transducer has led to simple, image-processing devices.

The transducer consists of a thin cadmium-sulfide layer deposited on a substrate that is excited with hf or vhf surface acoustic waves. It was developed by Philip Kornreich and Stephen Kowel, associate professors in the Dept. of Electrical and Computer Engineering, Syracuse University, NY.

According to the inventors, conventional image processors are complex and require computer systems. In their device, image processing is done as an integral function of the device itself.

The following devices have been built:

- A focus detector for still and movie cameras.
- A simple motion detector for optical surveillance or motion compensation systems.
- Pattern recognition of simple forms.

The image transducer works, Kornreich explains, because the conductivity of the cadmium-sulfide layer is altered by two phenomena: light falling upon it and mechanical deformation of the film caused by the passage of surface acoustic waves through the layer.

The coupling of light and sound produces signals that represent the spatial Fourier transforms of an image on the surface. The opto-transducer output is taken from the cadmium-sulfide layer. The electrical output is the equivalent of the Fourier transform of the image.

The transform signal—unlike that of a TV camera—cannot be directly processed to give a recognizable image, Kornreich notes. However, he points out, the inherent characteristics of these transform signals make them useful where conventional image-device signals are not.

As an example, Kornreich points to the focus detector, recently patented, which could be used in home movie cameras to keep the scene in focus, despite camera or subject movement.

This is a simple form of the

device, Kornreich notes. The cadmium-sulfide layer is deposited on a lime-glass substrate and is excited by the sine-wave output of a single discrete surface-acoustic-wave transducer. The transducer is fed from a 20-to-30-MHz source.

When an image is focused onto the opto transducer, high-frequency components appear at the opto-transducer output, Kornreich explains. These sine-wave components are largest when the image contains the sharpest edges—at the point of sharpest focus.

The opto-transducer output is fed to a tuned network to improve the signal-to-noise ratio.

The latest device under development gives a two-dimensional scan of the image surface, Kornreich says, as contrasted with the in-focus device, which scans in only one direction. The new device, which has a 17-by-17-mm photosensitive surface deposited on a 20-mil-thick lithium-niobate crystal, has two interdigital transducers mounted on the niobate substrate, with one at right angles to the other.

These interdigital transducers are fed sine-wave signals at 140 MHz, Kornreich says, and when the signals are applied in the proper phase relationship, it is possible to scan the sensitive sulfide in any desired fashion, such as in rasters or circles.

Where the X and Y acoustic scans meet on the cadmium-sulfide surface, Kornreich says, inherent nonlinearities in the electrical characteristics produce a mixing effect and beat frequencies appear, which can be monitored.

The niobate device is suitable for detecting motion in a scene, Kornreich points out, because when the image moves, the phase of the Fourier transform signal shifts, while the magnitude remains constant.

Harris offers new line of 24-bit computers

Harris Corp. has developed a family of six packaged, virtual-memory, 24-bit computers ranging in size from 96,000 to 768,000 bytes. The machines are aimed at the growing big-mini market already supplied by such companies as Interdata, DEC, Data General, Systems Engineering Laboratories, Computer Automation and Hewlett-Packard.

Besides virtual memory, the new line's competitive features include bundled software, compatible across all six machines; remote job entry capability for use with large host processors and a scientific arithmetic unit that provides floating-point hardware for fast calculations. All systems are supported by the Vulcan operating system, which permits concurrent time-sharing, multibatch and real-time processing.

Other major software packages include Fortran IV, Cobol, RPG II and extended Basic.

Shipments of the computer system will begin in the fall.

CIRCLE NO. 315

Switch inside knob saves valuable space

As instruments shrink, space behind the front panel becomes more valuable. So much so that designers at Tektronix in Beaverton, OR, have designed a special knob that contains the electronics for a 32-position switch. It requires virtually no space behind the panel.

The first use of the new switch/knob is in the 7L5 spectrum analyzer module that Tektronix recently introduced. The device mounts on the panel with two screws and has seven wire leads coming out of it.

In describing it, Carlos Beeck, a senior engineer at the company, notes that 5 LEDs and five photosensors, along with a coded shutter, are mounted inside a 1-in.-diam-knob. Also included in the knob is an internal shaft, on which the knob can rotate, and a mechanical detent mechanism. By coding of the shutter and selection of the right detent mechanism, it is possible to produce a switch with as many as 32 positions, Beeck says.

The switch/knob is said to give higher reliability because it eliminates mechanical switching. The output from the device is either a ONE or a ZERO. Darlington drivers are used to provide higher current-handling capability.

Advanced sensing used to study causes of fog

Using three advanced remote-sensing techniques, researchers at the Naval Electronics Laboratory Center in San Diego are investigating how and why fog forms.

The approaches are these:

- A frequency-modulated, continuous-wave radar that senses moisture fluctuations in the atmosphere.
- A sound-detection and ranging system (Sodar) that gives a picture of the thermal structure of the atmosphere.
- A light-detection and ranging system (Lidar) that senses particulate matter in the air.

According to Ray Noonkester, a research physicist on the project these sensing systems, when used together, provide an accurate picture of the thickness and structure of the part of the atmosphere in which the fog forms.

The radar-sensing system, he notes, produces a swept S-band signal that ranges from 2.8 to 3 GHz. This system is capable of sensing air-turbulence structures as small as 5 cm. It can indicate small moisture fluctuation in the atmosphere and rainfall rates as low as 0.01 mm an hour. Drizzle or rain can be sensed aloft, even if it doesn't reach the ground. This is important, Noonkester says, because drizzle that does not reach the ground may be responsible for some types of fog.

The acoustic sensing system uses bursts of audible acoustic energy that are scattered by temperature fluctuations in the atmosphere.

The system consists of a 2-kHz source, audio power amplifiers and a 3-by-3 array of Altec Lansing speakers. The electrical input power to the system is 1350 W. However, since the transmitter and transducer are only 27% efficient, the radiated acoustic power is only 365 W.

To detect small particles in the air, such as those found in fog and clouds, the Navy researchers are using a light-detection and ranging system that contains a GaAs laser diode array. This system can determine the location of the lower boundary of clouds, while the other systems determine the upper boundary.

INFORMATION RETRIEVAL NUMBER 19

Washington Report

Solar energy program planned by U.S.

The Energy Research and Development Administration is planning an ambitious solar energy program, starting with a 10-MW solar power plant that it hopes to have in operation somewhere in the Southwest in four to five years. It is seeking proposals from industry for the design of a plant that would use the central-receiver concept with four basic subsystems: a field of solar-radiation collectors, a radiation absorber and boiler heat exchanger, a thermal storage unit and a heat-to-electricity conversion cycle. The collector field will consist of an array of controlled heliostats that will reflect radiation to an absorber boiler atop a tall tower.

In another move, the agency has awarded three contracts for nine-month studies of energy-storage concepts involving flywheels, compressed air and thermal. Rockwell International has the flywheel project and General Electric the two other studies.

Increase in defense R&D sought

The Defense Dept.'s Advanced Research Projects Agency will try to match Soviet defense-related R&D with a $226.6-million request for fiscal 1976, a boost of $24.3-million over last year's appropriation.

With this money, the agency will break new ground in work on "organic superconductivity and new semiconductor materials to perform new tasks at microwave, submillimeter and optical wavelengths," George H. Heilmeier, director of the agency, told a Senate Armed Services Committee's subcommittee on R&D.

Among the major thrusts will be the development of charge-coupled technology applications to satellites, advanced air defense radar and higher-powered chemical lasers. To solve the problem of locating hostile weapons, the agency envisions a small remotely piloted vehicle (RPV) equipped with a lightweight, low-cost, high-performance radar, or a laser line scanner.

New radio service for offshore drillers proposed

Because of growing offshore drilling activity, particularly in the Gulf Coast region, the Federal Communications Commission is proposing a new radio network—Offshore Radio Telecommunications Service. At present there are some 2200 platforms in the Gulf, and the number is expected to reach 5000 within two to three years. Businesses operating drilling and other operations maintain communications through the common-carrier Rural Radio Service and the private Petroleum Service.

The FCC considered a number of frequencies, from below 100 MHz to above 900 MHz, before finally deciding to allow shared use of the uhf-TV Channel 17 (488-494 MHz). Major factors in the decision were the off-the-shelf availability of a complete line of equipment for this frequency band and the fact that use of Channel 17 in the Gulf offshore area would have "only minimal impact on future television service." While awaiting public comment, the FCC has already frozen the TV assignment table for Channel 17 in the region.

The agency will likely have a similar problem to solve on the West and East Coasts in the future when more areas of the Continental Shelf are opened for petroleum exploration.

NASA and NSF expecting full budgets for 1976

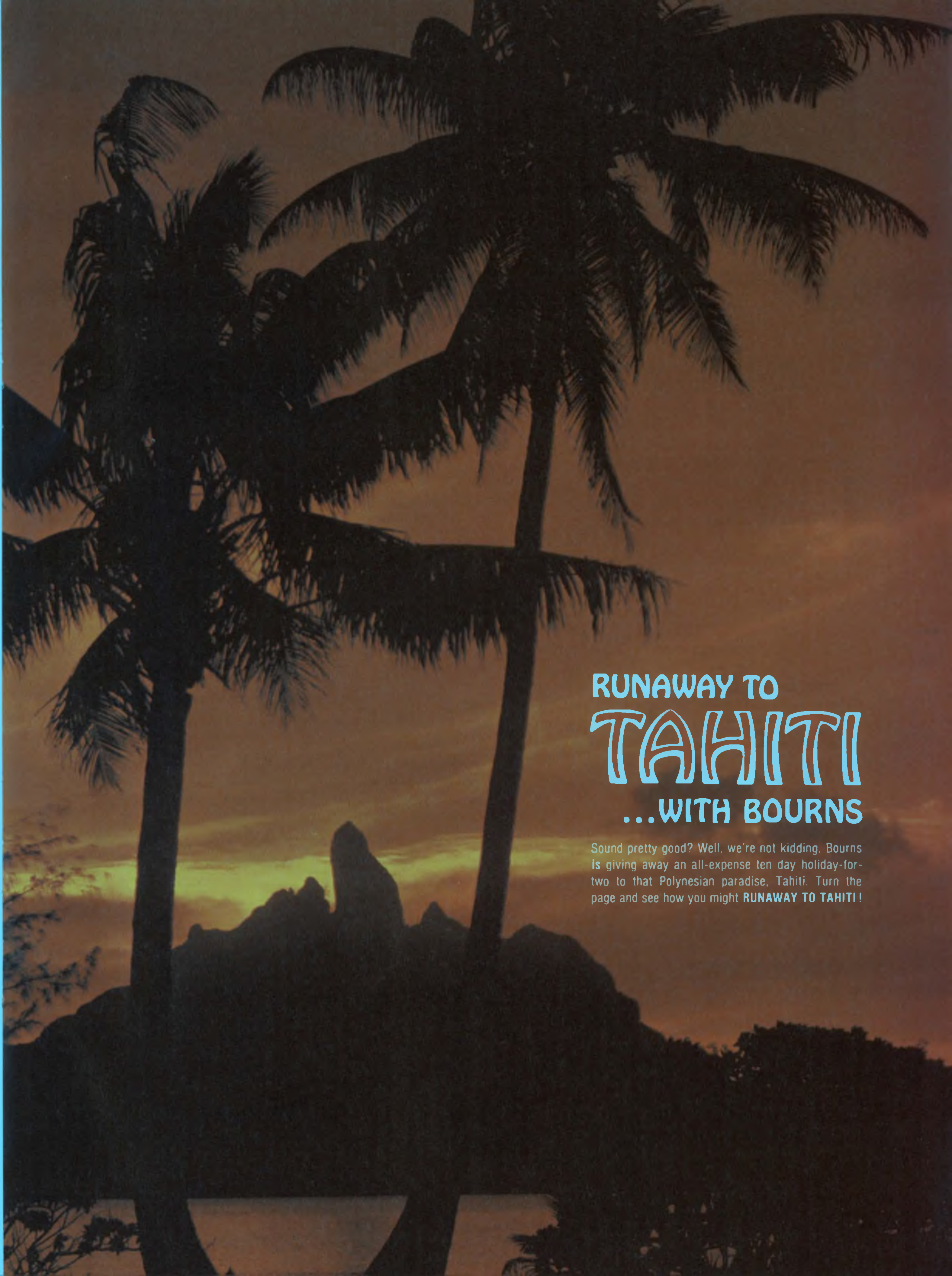
Although the Senate has yet to act, both the National Aeronautics and Space Administration and the National Science Foundation are likely to get the funding authorization they want, pretty much as requested by the President.

The House has authorized $3.59-billion for NASA fiscal 1976. The agency had asked for $3.54-billion. On the other hand, the House reduced the three-month transition budget (July 1 to Sept. 30, 1976) request of $959-million to $922-million. Some $30-million is to be deferred from research and development and used for construction of facilities.

The National Science Foundation's request for $755.4-million has been approved to the dollar by the House, but a number of Congressmen have been sharply critical of some social-research aspects, particularly a program called "Man: A Course of Study." That program, funded at $7-million, has been called objectionable because of sections dealing with sex and violence among Alaskan Netsilik Eskimos. The NSF has agreed to stop funding the program.

Capital Capsules:

In the interest of increasing competition, the Coast Guard has announced that it is **willing to test and evaluate 400-kW (minimum) solid-state Loran-C transmitters, although it has one in hand developed under contract by Megapulse, Inc.** The Coast Guard wants three transmitters now, with a total purchase in the future of up to 20 units. . . . Companies with research and development capabilities in modular infrared, IC video amplifier modules and visible light-emitting diode arrays are being invited by the Army Electronic Command to make their capabilities known. **The Army has a need for high-density infrared detector FLIR arrays and video-processing integrated circuits, to be used in thermal imaging systems.** . . . Westinghouse, in a project funded by the Air Force, **has built and tested a prototype rotor that will be the heart of a new kind of electrical generator that could supply an aircraft with 5 million kW of power.** Based on superconductivity, the generators are to weigh less than a third of what conventional generators now weigh. The needed low temperature is maintained by circulating liquid helium through the rotor, which is an electromagnet mounted in a thermally insulated vacuum vessel. . . . **A "wrist worn personal fitness monitor" is being sought** by the Law Enforcement Assistance Administration to be worn by law enforcement and other public service personnel whose work involves periods of stress. **The device would provide a readout of pulse rate, body temperature and blood pressure.** Currently available electronic components must be used.



RUNAWAY TO TAHITI ...WITH BOURNS

Sound pretty good? Well, we're not kidding. Bourns Is giving away an all-expense ten day holiday-for-two to that Polynesian paradise, Tahiti. Turn the page and see how you might **RUNAWAY TO TAHITI!**

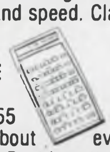
RUNAWAY TO TAHITI ...WITH BOURNS

THE PRIZE...

Runaway to the fabled Polynesian islands of Tahiti, Moorea and Bora Bora. **Ten** days of fun, adventure . . . and relaxation on the crown jewels of the Pacific. All expenses paid — deluxe hotels, air travel (from U.S.), inter-island travel, introductory island excursions, Tahitian feast, personal guide service . . . plus spending money. You can go marketing, paddle an outrigger canoe, do your own bicycle or motor scooter exploring, go sailing, take a glass bottom boat ride, water ski, snorkeling . . . or, go deep sea fishing, if you like. Above all, soak up the sun and relax.

OTHER PRIZES...

LASER . . . INTERNATIONAL CLASS SAILBOATS
The next best thing to sailing to Tahiti . . . is sailing in your home waters. So . . . Bourns is giving away **two** LASER sailboats to the next two winners (after 1st). The LASER — world's most successful new one-design — is 14-feet of cartoppable fun and speed. Class fleets everywhere.



NEW HP-55 PROGRAMMABLE CALCULATORS
HP's new Model 55 scientific calculator does about everything but whistle for a cab. Besides all the mathematical stuff . . . the HP-55 also has 20 addressable storage registers, built-in digital timer (stopwatch) . . . and it stores and runs up to 49-step programs. Bourns is awarding **two** of these beauties.

TEXAS INSTRUMENTS SR-50 ENGINEERING CALCULATORS
The ultimate engineering "slide rule" calculator . . . squares, roots and reciprocals, quadratic equations, n^{th} power and roots, sines, cosines, tangents, exponentials, logarithms. Ten-digit display, 2 digit exponent, plus 2 signs. We're giving away **TEN.**

NEW POTENTIOMETER HANDBOOK
McGraw-Hill and Bourns have collaborated to produce **THE** comprehensive handbook on variable resistive components. Over **320** pages, extensively illustrated, covers everything from design, applications, explanations of performance specifications and test methods . . . and much, much more. McGraw-Hill will sell them for **$13.50.** We're giving away **ONE-HUNDRED.**

NOTE: Delivery of above prizes free within continental U.S. **only.**

Photo by Irwin Christian

CONTEST RULES

All you have to do to enter . . . is complete the questionnaire below. To answer the questions **correctly,** you must read and comprehend the information contained in the eight mini-ads on the next two pages. This questionnaire is no gimmick . . . if you want a chance to RUNAWAY TO TAHITI, you will **have** to answer every question . . . and answer each correctly. This gives **serious** contestants improved odds over those who are only casually interested. However . . . everyone has an equal **opportunity** to win. You may enter as many times as you wish . . . **BUT ONLY ON QUESTIONNAIRES CLIPPED FROM ACTUAL TRADE MAGAZINE ADS.** Winners will be drawn from all **correctly** answered questionnaires. All prizes will be awarded. Only one prize per entrant (one per family). If you wish to have a list of the actual winners, simply send a self-addressed, postage paid envelope with your entry. Bourns employees, and employees of Bourns advertising agency, authorized reps, distributors, and trade magazines are ineligible for this contest.

READ THE MINI-ADS ON THE NEXT TWO PAGES, THEN COMPLETE THIS QUESTIONNAIRE AND MAIL TO: RUNAWAY TO TAHITI, C/O BOURNS, INC., 1200 COLUMBIA, RIVERSIDE, CALIFORNIA 92507.

1. Bourns gives you a choice in low-cost 3/4" rectangular trimmers. How many adjustment turns variations are offered?____________
2. What is the 1000-pc. price of the Model 3006 trimmer?____________
3. Did you know Bourns makes a 3/8" square multi-turn trimmer that sells for only $1.10 ea.? What is the Bourns Model No.?____________
4. Who offers the widest selection in square multi-turn trimmers?____________
5. The power rating of the 3352 single-turn trimmer is____________. The 1000 pc. price is____________.
6. What Bourns Division offers "Free Lunches For a Week . . . if"?____________
7. Did you know that Bourns can **now** deliver special thick-film networks (with chip capacitors, special circuits, etc.) in 5 to 8 Weeks?____________
8. Bourns Model 3540____________-turn, 3/4" x 7/8" Diam. Precision Potentiometer sells for____________ in 1000 piece quantities, ____________section configurations are offered as standard option.
9. Bourns Magnetics Division manufactures audio, power and pulse transformers in sizes up to____________pound(s).
10. How many **standard,** off-the-shelf resistor networks are available from Bourns? ____________
11. Does Bourns Model 3680 Pushbutton potentiometer need adjustment or phasing before installation?____________
12. Bourns 3/4" cermet panel controls have the most____________- for-size.
13. Do you have an application for Bourns 3680 Pushbutton Potentiometer?____________ If yes, what____________
14. Did you know Bourns new 3851 and 3858 conductive plastic panel controls are direct replacements for the Allen-Bradley Model J . . . but require only 1/2 as much behind-the-panel space?____________

Name____________

Address____________

City____________ State____________ Zip____________

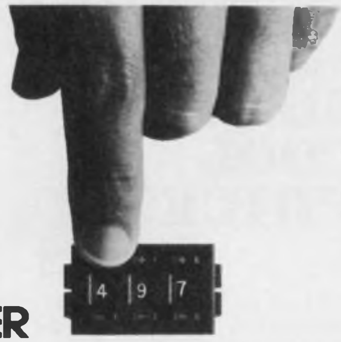
Company____________ Phone____________

BOURNS INC

TRIMPOT PRODUCTS DIVISION
1200 COLUMBIA AVENUE, RIVERSIDE, CALIFORNIA 92507
PHONE 714 684-1700, TWX 910 332-1252 CABLE: BOURNSINC

RUNAWAY TO TAHITI ...WITH BOURNS

Update Your PANEL with the NEW BOURNS® PUSHBUTTON POTENTIOMETER



The new Model 3680 Pushbutton Potentiometer integrates a precision incremental decade potentiometer with an easy-to-read digital display. AND a speedy pushbutton control action. It is handsome, accurate, and a "snap" to install. Everything is INSIDE the Model 3680 . . . no resistors or mini-PC boards are required . . . nothing clutters the back of the unit to steal precious space. No pot-to-dial phasing required . . . it's ready to install when you open the box.

FEATURES SUMMARY

- 0% to 100% capability by 0.1% steps
- In-Line Digital readout
- Accuracy (Dial Reading to Output Ratio) ±0.5%
- Convenient snap-in mounting with bezel
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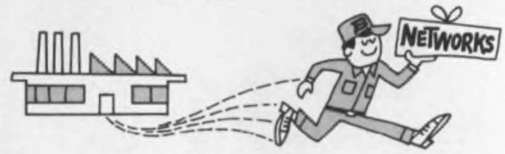

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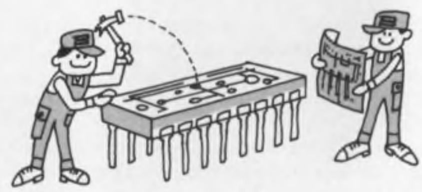

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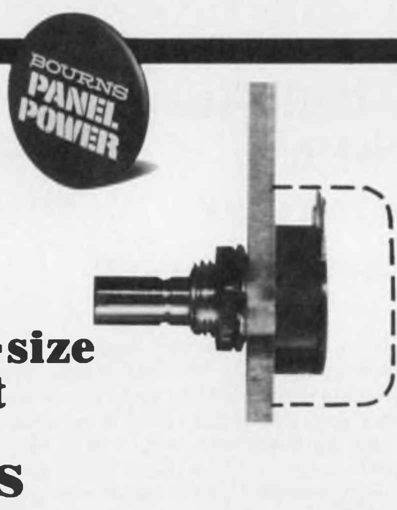

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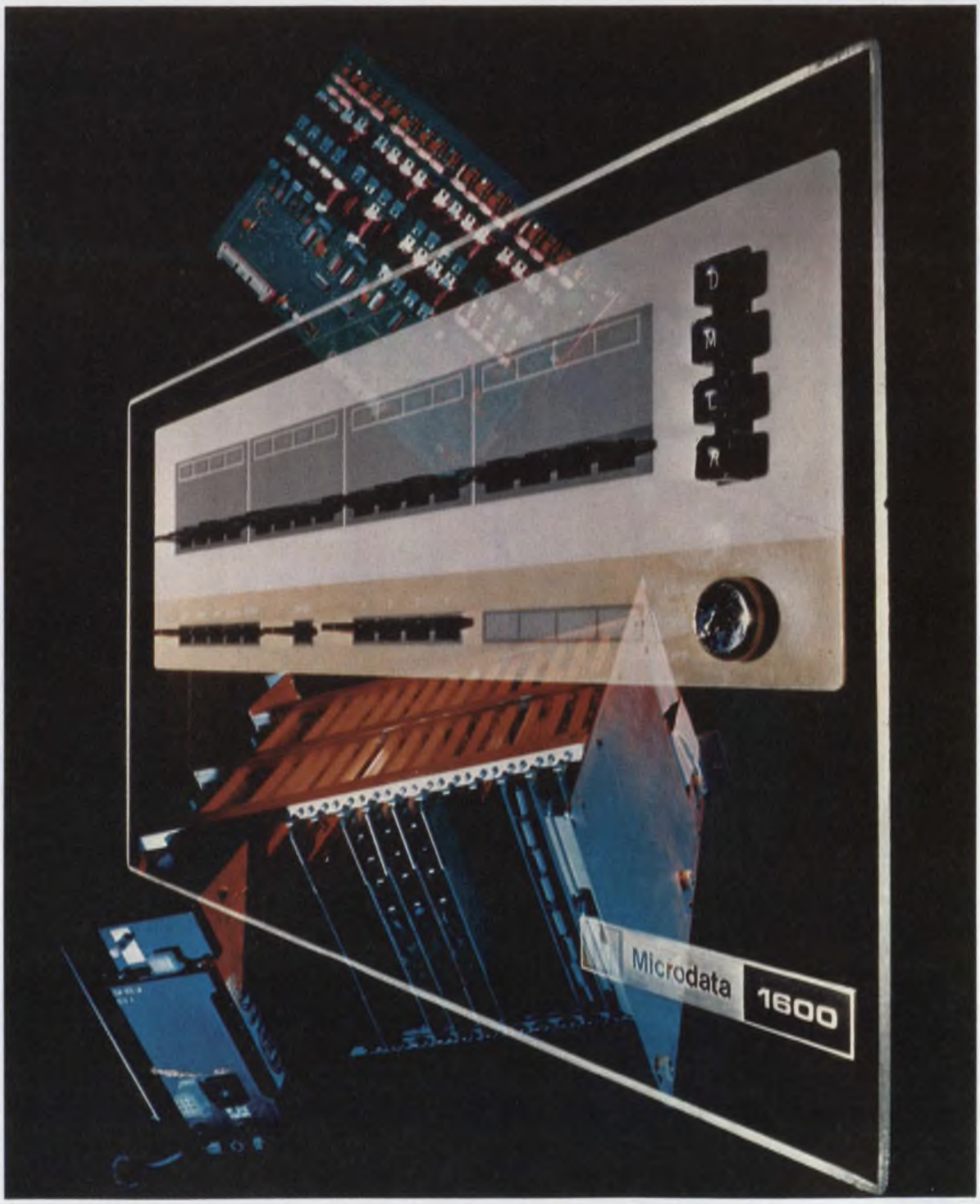
COMPUTER '75



From micro to maxi, it's the era of change

Progress in solid-state, as reflected in the latest LSI microprocessors and semi memories, is producing a new generation of computers, from micros to large mainframes.

Microcomputers have borrowed such features as microprogramming and pipelining from large systems, thereby speeding some operations and permitting faster entry of instructions.

Built-in MOS/LSI microprocessors are drastically reducing the size and cost of established minicomputer lines.

Finally, even the structure of large computer systems is changing. Solid-state RAMs—consisting of magnetic bubbles, MOS shift registers or CCDs—are expected to produce substantial architectural changes.

Solid-state progress is not only changing the shape of computer hardware but it is also altering the traditional roles of the computer in data processing and number crunching. The emergence of mini and microcomputers is sparking a growing army of what would have been considered "far out" applications only a few years ago.

Dedicated systems are turning up in sports-stadium scoreboards, electronic games, intelligent street and highway traffic controls, musical synthesizers and vending-machine coin changers.

Not only are computers being applied to nontraditional uses but peripheral equipment itself is also becoming nontraditional, spurred in large part by semiconductor progress. The Termiflex hand-held computer terminal, for example, looks like a calculator but it's a lot more complex. It's got a 20-switch keyboard that can generate and display all 128 ASCII characters. Then there's the new line of visual computer peripherals that enable computers to "see" as well as hear and speak. One example is a digital line-scan camera from Reticon that looks like a camera, except that the film plane is replaced by a linear array of photosensing diodes.

As LSI devices, computers and computer systems increase in complexity so do the requirements for test and measuring equipment. For troubleshooting a high-speed digital system, the oscilloscope just won't do the job. The growing family of logic analyzers can often do what the conventional scope can't. "Intelligent" machines to diagnose ailments or to self-program are another response to increasing circuit complexity.

Software, too, has kept up with the increasing complexity of computer hardware. Powerful programs now enable designers to "see" a system work before it's actually built. These programs need minimal computer background; the computer does most of the translation from engineering notation to computer-usable form. Analog design programs range from dc to microwaves, and digital design covers gates to microprocessors.

For a fast look at changes in computer technology, turn the pages of this special section.

Semiconductor ROMs form the control memory for Microdata's 1600, an 8-bit microprogrammable mini.

Contents

COMPUTER '75

Micros or large mainframes, advances in ICs are producing radically improved machines

Edward A. Torrero, Associate Editor

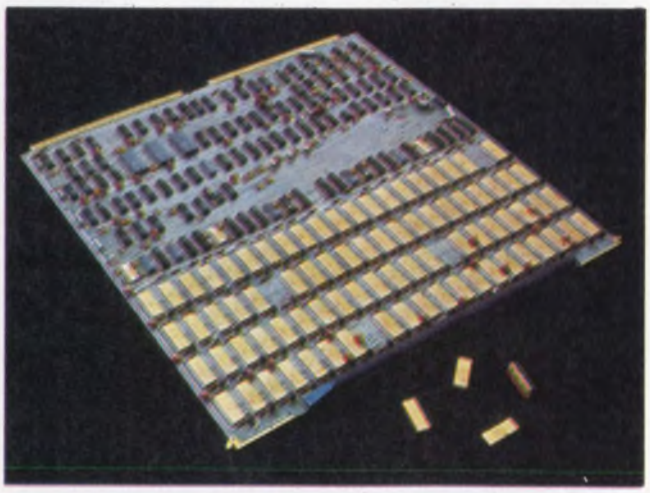
Many of the improved capabilities of today's computers can be traced directly to solid-state advances. Increased speeds, heightened component densities and lowered costs resulting from new monolithic circuits are helping computer architects build new and better machines.

Advanced integrated circuits in the form of LSI microprocessors and microcontrollers—and especially the latest memories—are turning up in virtually every kind of computer from micro to large mainframe. In the process, traditional distinctions are becoming blurred as computers take on features usually associated with their larger—or, in some cases, smaller—cousins.

A new generation of minicomputers provides a vivid example. Here are some of the major trends:

- Low-end minis that use MOS/LSI microprocessors are being offered as smaller and cheaper versions of established models. In addition bipolar/LSI microcontrollers and bit-slice processors are providing architects with the tools to maintain both the speed and structure of earlier models in newer low-cost versions.
- Steadily falling IC-memory costs have accelerated the use of high-density MOS dynamic RAMs for main memory and high-speed and bipolar RAMs for cache, or buffer, storage. Cache memories increase over-all system speed when the relatively slow MOS RAMs are used for main memory. At present MOS RAMs offer a top storage capacity of 4096 bits, and available 1024-bit bipolar RAMs have an access of about 50 ns.
- An increasing number of capabilities hitherto associated with large mainframes are being incorporated into high-end minis. Features like virtual memory and virtual machine, and stacks for instructions and data are being tailored for

A 32-bit minicomputer with 1 Mbyte of core cycles at 450 ns average, 300 ns minimum. Interdata's 8/32 Megamini uses high-speed Schottky-TTL circuits.



A semiconductor memory module from Data General has correction circuitry that can run without an error, even though four chips have been removed.

minis. And 32-bit architectures are supplanting the established 16-bit structures for newer models.

Micros on the move, too

Similarly microcomputers have borrowed from larger systems such features as microprogramming and pipelining, with the latter independently speeding some serial operations to allow faster entry of instructions. Moreover improved MOS techniques have led to 16-bit microprocessors on a single chip for a dramatic reduction in parts count.

With the Pace chip from National Semiconductor, Santa Clara, CA, for example, a single IC can replace the 15 to 20 packages used in the company's older, but faster and more flexible, 16-bit multichip processor. Also, Pace provides an improved interrupt structure consisting of six vectored levels. And it simplifies data processing involving 4-bit BCD and 8 and 16-bit binary operations.

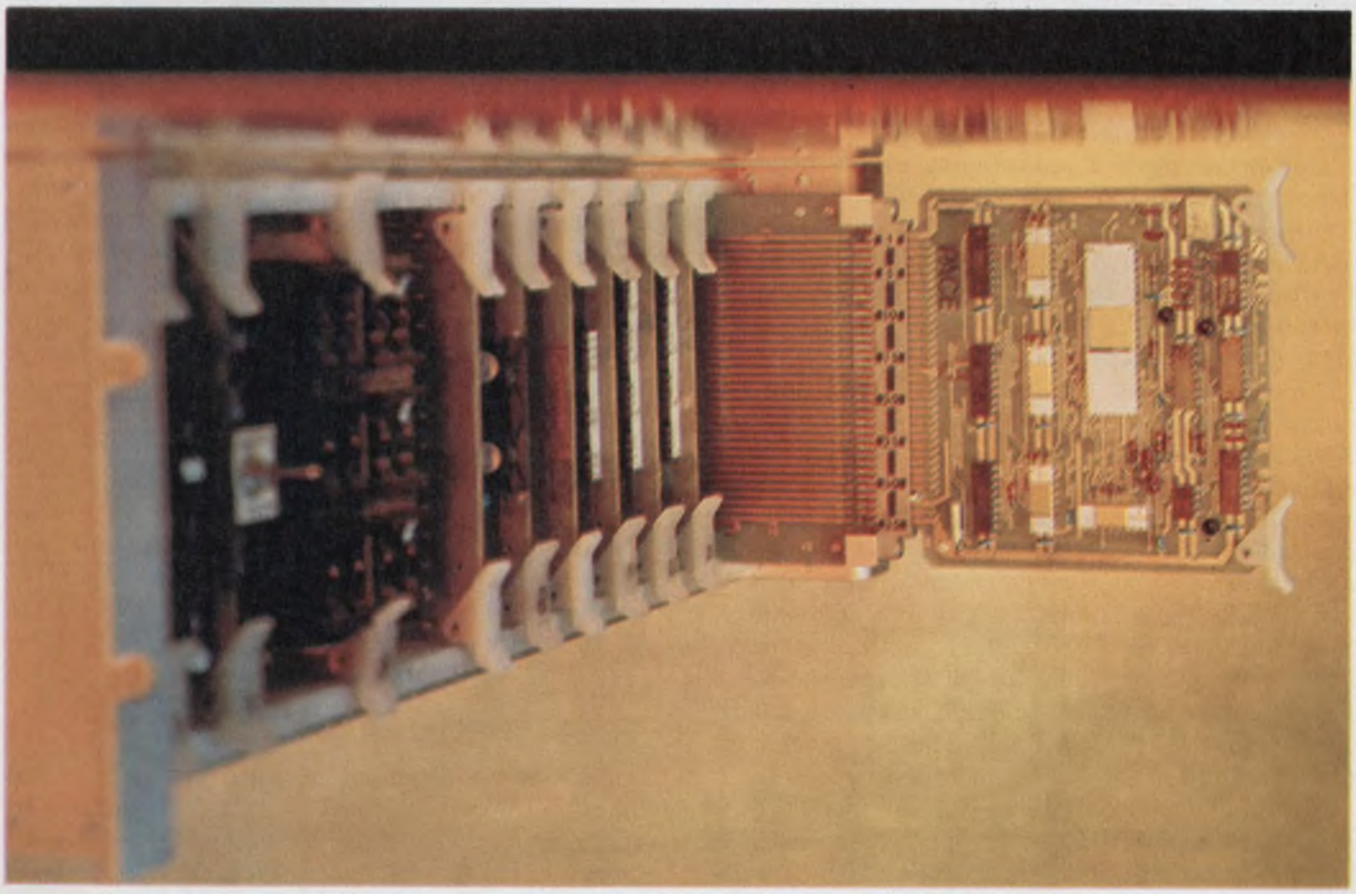
Like most other new LSI microprocessors, the Pace chip seeks to fill a host of applications. But even newer versions in development could mark a departure from the wide-ranging role that earlier "computers on a chip" had sought.

"We believe the market has matured so that we no longer have to make a processor all things to all people," says George Reyling, a project manager at National. The company is working on a dedicated microprocessor called the CMP-8, intended essentially for communications. "Specialized markets," Reyling observes, "may dictate specialized architectures."

The benefits of a dedicated approach would include specialized instructions and interface characteristics. The number of components would also be less. And memory costs would be down, since an application program could be shortened.

In a data-handling and routine application, for example, a dedicated approach would de-emphasize arithmetic capabilities, Reyling explains. "It would improve addressing modes and probably have memory-to-memory instructions rather than memory-to-accumulator." As a result, data could be moved from one memory directly to another, bypassing the microprocessor.

"But it's not clear one answer is the best," Reyling points out. A dedicated system could be



A 16-bit microprocessor on a single chip replaces the 15 to 20 ICs of older multichip versions. National Semiconductor's Pace microprocessor chip uses p-channel MOS/LSI techniques.

A single system processor controls input/output and arithmetic processors in the hierarchical architecture of the Xerox 560 computer, a 32-bit midi. Independent processors can simultaneously access memory. And input/output transfers can take place simultaneously with computing operations.

achieved with a specialized microprocessor architecture or specialized support chips that could be developed to have increased intelligence.

Minis use micros

One minicomputer manufacturer that has embraced custom LSI microprocessors is Digital Equipment Corp. The mini maker in Maynard, MA, uses custom chips manufactured by Western Digital, Newport Beach, CA, in DEC's recently introduced LSI-11. This is a smaller-sized version of the company's popular PDP-11.

"We have taken the original PDP-11 and reduced package size by a factor of 20 in five years," says Robert Van Naarden, DEC's product manager for the LSI-11. Other benefits of large-scale integration include reduced costs and increased capabilities, "but with no real change in architecture," Van Naarden points out.

The first PDP-11, with 4-k words of memory, sold for $10,000. An LSI-11 with the same amount of memory sells for $990. And the basic LSI-11 comes as a single module, in contrast with the original PDP-11 box that housed power supply, fans and a number of modules.

The single 8-1/2 × 10-in. LSI-11 module contains a 16-bit MOS/LSI microprocessor on three basic chips: a chip that emulates the larger mini's data path, another that provides instruction decoding, and two Microm chips that contain the machine's microcode. The entire chip set implements the instruction set of a PDP-11/35—a medium-range model in the PDP-11 series. The board also contains 4-k × 16 bits of memory and an I/O channel.

The microprocessor chip set provides DEC with a microprogramming capability. So the same processor hardware can be used to develop new models. A change in the mini's microcode—involving a simple change of Microms—would result in a machine with different capabilities.

In the LSI-11, DEC has used this flexibility to add features not found in the mini that it emulates. The new model, for example, has a microcoded ASCII-console routine that avoids the programmer's usual panel of lights and switches. Instead, a designer can employ the same terminal used for program development. Similarly a microcoded octal debugging technique—an aid in testing and troubleshooting—circumvents the usual practice of manually loading pape tape. One benefit of these two features is that the micro-based mini can be loaded from a remote location.

4-k MOS RAMs reduce costs

Another minicomputer with a 16-bit word length—Hewlett-Packard's 21MX—benefits directly from the increasing availability of 4-k-bit dynamic RAMs. "IC manufacturers have been able to increase production and decrease costs," says Bob Frankenberg, a section manager at HP's Data-Systems Div. in Cupertino, CA. "We have passed the savings on," he adds in reference to recent price cuts.

Besides decreasing over-all hardware costs, Frankenberg says, lower-priced RAMs are leading to increasing use of high-level languages, such as Fortran. "And they offer 50 to 60% greater reliability than core," he adds.

The use of low-cost 4-k RAMs made possible such architectural changes as a dynamic mapping system—a memory management scheme that expands address space from 32 k words to 1 million words. The expanded space is divided into four spaces: one is for the system, another for the user, and the rest are for direct-memory-access channels.

Available microprogrammed instructions allow access of one memory space to another. A "dirty-page" indicator tells which memory spaces have already been written into. And a parity-error indicator permits a page with "bad" bits to be eliminated.

System speed can be maintained at 650 ns—the memory-system cycle—through the use of 64-bit TTL RAMs in the mapping system. The high-speed memories have 35-ns access. "We couldn't have achieved the system speed with slower memories," Frankenberg reports.

In addition the HP mini employs the clock-off time of 4-k RAMs to perform address translation. During this period the bipolar memories are accessed. "It's a down time anyway, so we make use of it," Frankenberg says.

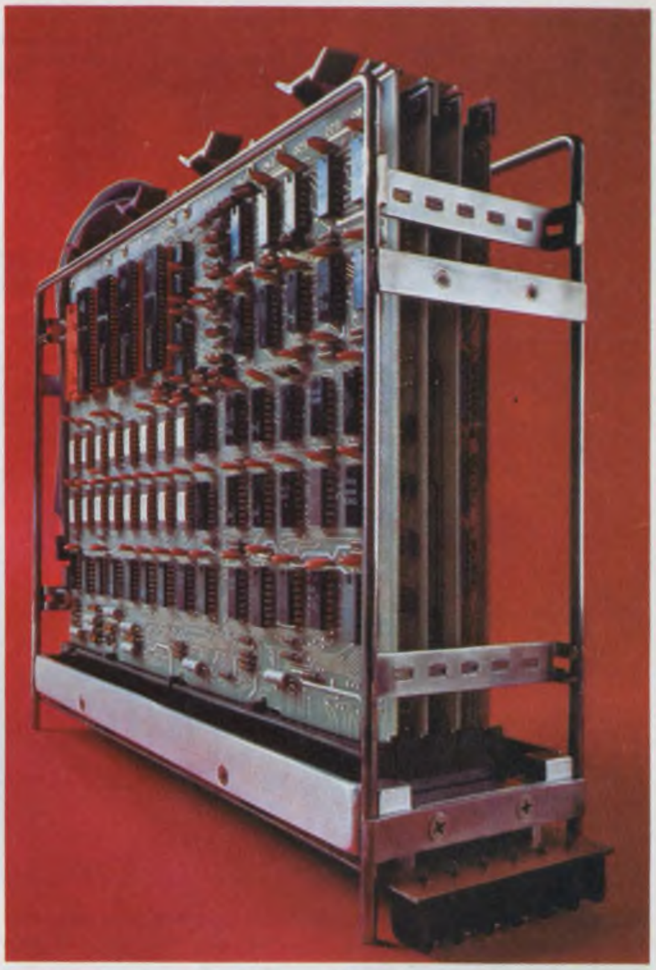
Refresh requirements for the dynamic RAMs can pose problems, especially in real-time processes. "A DMA transfer from a peripheral disc, for example, can't wait for the memory to do its thing," Frankenberg observes. The HP solution structures the system to ensure the transfer without recourse to a cost-increasing FIFO, or first-in, first-out stack. In essence, "we move refresh slightly out of the way, but never in a way that loses data."

High-speed memories also show up in the microprogrammable mini's control store. The HP 21MX uses 256-bit RAMs manufactured by Fairchild, Mountain View, CA. Once a microprogram has been developed in the volatile control store, 256 × 4-bit bipolar PROMs can be used to store the program permanently. The PROMs come from Harris Semiconductor (Melbourne, FL) and Monolithic Memories (Sunnyvale, CA).

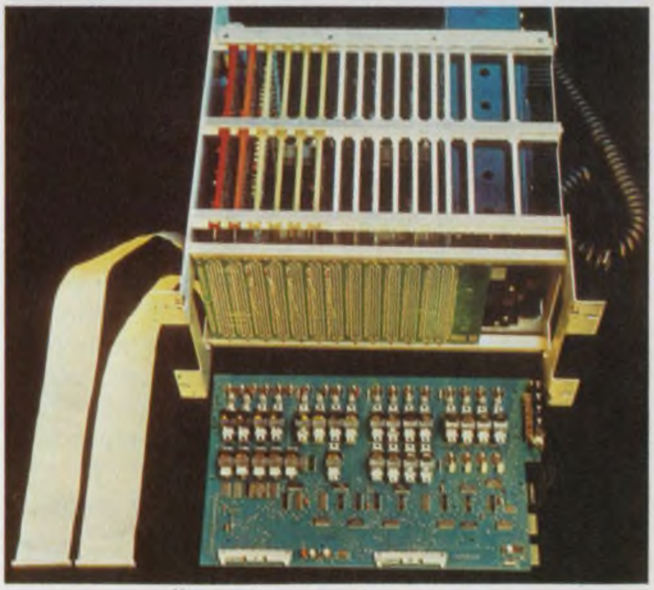
Minis move up to 32-bits

In an effort to cut software costs while taking advantage of low-cost ICs, Interdata offers minicomputers with a 32-bit architecture. The latest model from the Oceanport, NJ, manufacturer is the 8/32, which the company calls Megamini.

"Unlike competing units that claim a 32-bit



An 8-1/2 × 10-in. board contains the major elements of a mini. The Digital Equipment Corp. LSI-11 board uses a multichip, n-channel microprocessor.



A microprogrammable mini from Interdata employs a push-down—or last-in, first-out—stack architecture to simplify use of high-level language and its compiler.

Aiming for users who need special memory and security features, Honeywell offers the 68/80, the top of the Series 60 computer line. The latest advance in the Multics system, the 68/80, provides up to 6 billion bytes of addressable virtual memory. Multics can accommodate up to 10 processors on one system.

architecture," says William Sweet, Interdata's product line manager, "we have it."

To a programmer, each part of the Interdata machine—instructions, registers and data—looks 32-bits long. "When a programmer sees 16-bit registers," Sweet asserts, "he sees a 16-bit machine."

For Sweet, 16-bit machines imply limitations on software. "Programs can live with 16 bits," he says, "but programs have to live with other things too—like data, which can become larger than the program."

For example, an operating system—the control software that acts like a "traffic cop"—may require over 64-k words of space. And a large optimizing compiler allowing simultaneous, multiuser operation can require 100-k to 200-k bytes, Sweet points out. However, 16-bit machines tend to be limited to 64-k-word chunks.

Sweet attributes much of the speed improvement of the minicomputer's architecture to improved ICs.

High-speed, Schottky-TTL circuits are employed in the mini's processor for a cycle time of 240 ns. And while core is used for memory, interleaving techniques with 32-bit modules achieve an effective 32-bit cycle time of 450 ns. The speedy 8/32 executes a floating-point multiply in 3 μs, and it has a DMA burst transfer rate of 6 Mbytes/sec.

As impressive as the specs are, Sweet points to the machine's optimizing compiler for perhaps the single best example of the power of the 32-bit machine. Besides increasing the speed of a designer's Fortran program, the compiler automatically produces re-entrant code. As a result, many users can interact with the compiler at the same time. With a 16-bit machine, Sweet notes, the compiler must be segmented and users don't have the same simultaneous access.

Increasing word size further

For some proponents of increased word lengths, even 32 bits isn't long enough. "Some say you need 36 bits," says Bill Poduska, vice president of engineering at Prime Computer, Framingham, MA. Mainframe computers, which established the 32-bit word standard, also employ 36-bit—the IBM, Honeywell and Univac machines, for example. And 64 bits are offered by computers from Control Data Corp.

"It's not really a matter of precision any more," Poduska asserts, "because the 32 and 36-bit word lengths are so close." Instead the argument is either for four 8-bit characters (32 bits total) or four 9-bit characters (36 bits total).

"We originally got 8-bit characters basically because IBM said so in the 360," Poduska reflects. Display considerations led to 7-bit plus parity-bit character codes.

Meanwhile Prime Computer is taking advantage of lower-priced IC memories by incorporating error-correcting codes in such machines as its 300 series. "Adding, say, 5 bits for checking to 16 bits of information could make for a 33% cost penalty in memory," Poduska says. However, prices are low enough so manufacturers are willing to absorb the incremental costs.

In addition Poduska sees increasing use of virtual memory and virtual-machine techniques. Memory systems, already up to 1/2-million bytes, can go to 250 million words in a virtual memory, and it also has the advantage of simplified software and increased reliability. A virtual machine implies virtual memory and more. It maps memory plus instructions. So when a user executes, say, an I/O instruction, the machine traps and implements it directly.

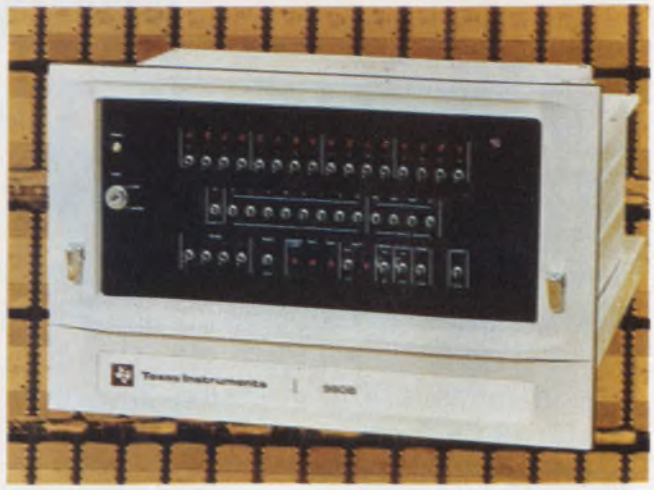
Cache, or buffer, memories and microprogrammable central processors—traditional mainframe features—are catching on fast with mini manufacturers. The Eclipse line from Data General, Southboro, MA, combines these features with 200-ns cycle times and single-bit error correction. And the machine can operate with 800-ns core or a 700-ns semiconductor memory without additional controllers or interfaces.

"Microprogrammable machines are sometimes thought of as slow machines," says Ron Grunner, Eclipse system manager. "They often need a large number of instructions." In the Eclipse, however, the architecture allows several operations to be performed in parallel. A writable control store gives users access to 256 instructions. And each instruction is 56 bits long.

The Eclipse cache memory consists of a cluster of 200-ns bipolar units arranged in four blocks of four words each. Each memory board contains one cache. When addressing memory, the CPU checks cache and main memory. If the work is in cache, the data are transferred in 200 ns.

An error check doesn't require extra CPU time; it takes just 300 ns. Error-detection/correction memories use 5 bits more than noncorrecting units. The extra bits are for a computation made by both memory and CPU when they exchange data.

Error-correcting circuitry is also used in the 980B mini from Texas Instruments. Aiming for control applications, this mini combines a bit-handling capability with a dual architecture that seeks to overcome so-called context switching.



Incorporating MOS memory elements with single-bit error correction and multibit error detection, TI's 980B minicomputer allows single-bit manipulation.

The most far-reaching changes, however, will probably appear in large computer systems. Already solid-state memories, like the charge-coupled-device, are expected to improve data-access times now limited by electromechanical storage units. Moreover block-oriented solid-state RAMs—consisting of magnetic bubbles, MOS shift registers or CCDs—will undoubtedly produce substantial architectural changes.

LSI processors are changing mainframes

But the greatest impact is expected from LSI microprocessors. Within a few years, computer architects believe they will be able to build new machines using standard, off-the-shelf micro chips and related ICs. Several little processors would be microprogrammed and put together in a configuration that is controlled by software. With these multiprocessing computers, large-system CPUs could be altered or upgraded without significant changes in hardware.

However, major system problems remain to be solved. "On one level, there's the problem of interference between several processors accessing a commonly shared memory," says Dr. Ugo O. Gagliardi, director of Honeywell Information Systems Technical Office in Waltham, MA. "And if you don't go with a common memory, you have the problem of proper utilization of each private memory."

But that's a simple matter compared with software control, the complex problem of controlling several processors that are fairly asynchronous and independent, Gagliardi explains. ■■

Fairchild introduces a universal standard 8-bit microprocessor that's simple to configure, easy to program, handles more than half of all small systems applications and costs less to use.

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Because basically, it's the most *simple* to use.

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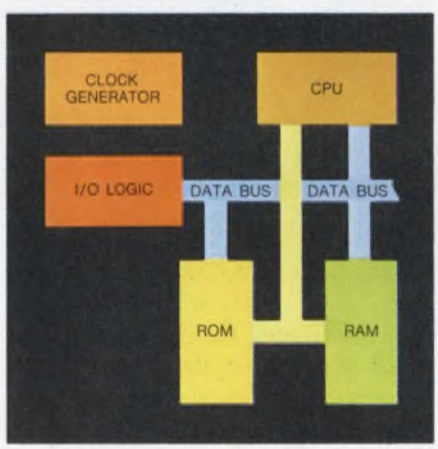
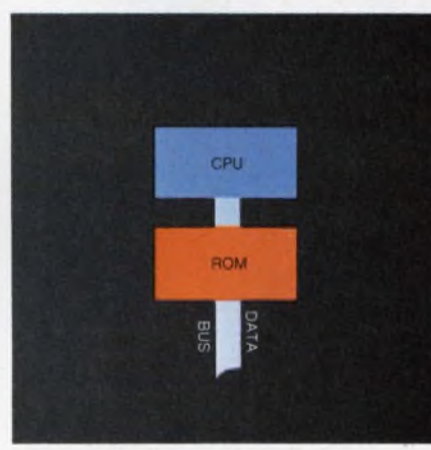


Minimal microprocessor system before the Fairchild F8.



Minimal microprocessor system after the Fairchild F8.

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The F8 supercontroller. How simplicity was achieved.

To reach the functional densities and speed of the F8, we turned to our proven Isoplanar, ion-implanted, N-channel technology, which allows up to 40% more function per unit area.

This permitted added functions to be included on both CPU and ROM chips. Yet, the F8's CPU remains the smallest 8-bit, N-channel chip in the business.

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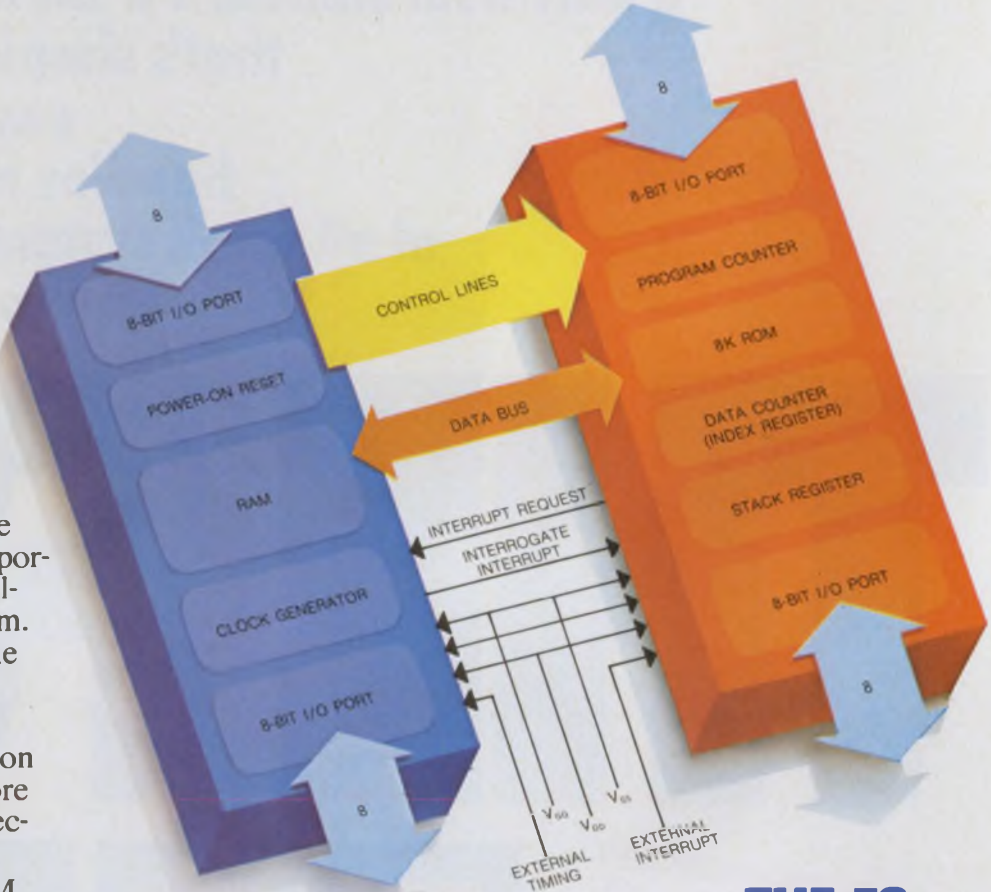


THE F8.
MICROPROCESSOR SYSTEM

Introducing the basic F8 system. And 5 key changes.

In developing the new F8, Fairchild designers have introduced a number of important hardware features available with no previous system.

Changes inspired by the hard-earned experience of users themselves:

1. Two 8-bit I/O ports on the CPU chip. And two more on the ROM chip. 32 bidirectional lines in all.

2. 64-bytes of fast RAM scratchpad *built into* the CPU chip.

3. A clock generator and power-on reset *built into* the CPU chip, too.

4. A programmable interval timer *built into* the ROM chip.

5. 60% of the 70 instructions are 1-byte.

Other F8 features and refinements include:

A speedy 2 μs minimum instruction execution time.

Direct TTL I/O compatibility.

A typical power dissipation of less than 300 MW per chip.

Local interrupt with automatic address vector.

And much more.

Result—a complete 2-chip microprocessor system that's really *just* 2 chips. Easier to handle, much more versatile, generally less expensive and just a pleasure to use.

3 additional devices for mid-size, memory-intensive or multiprocessing systems.

Along with the basic 2-chip configuration, Fairchild has designed three additional F8 devices for easy system expansion:

1. *The 3852 Dynamic Memory Interface Circuit* allows the user to expand his system using standard dynamic memory—such as the Fairchild 4096-bit RAM.

In addition, synchronous DMA channel control signals are generated by the 3852.

2. *The 3853 Static Memory Interface Circuit* permits the user to expand his system using standard static memories including Fairchild's 2102 and 3538 RAMs, and 3514 and 3515 ROMs.

The 3853 also features interrupt control circuits and a programmable timer.

3. *The 3854 DMA Direct Memory Access Circuit* provides a fast, direct data path between a high-speed peripheral device and F8 processor memory without tying up and slowing down the CPU.

The 3854 can also be used to provide a synchronous data path between multiple processors.

All three additional F8 chips are in final development or production now.

F8 applications. The first standard super-controller goes to work.

The advantages of the F8 design become still more evident when its range of applications is considered.

In fact, the new F8 covers a broader spectrum of applications than any other microprocessor. (See chart.)

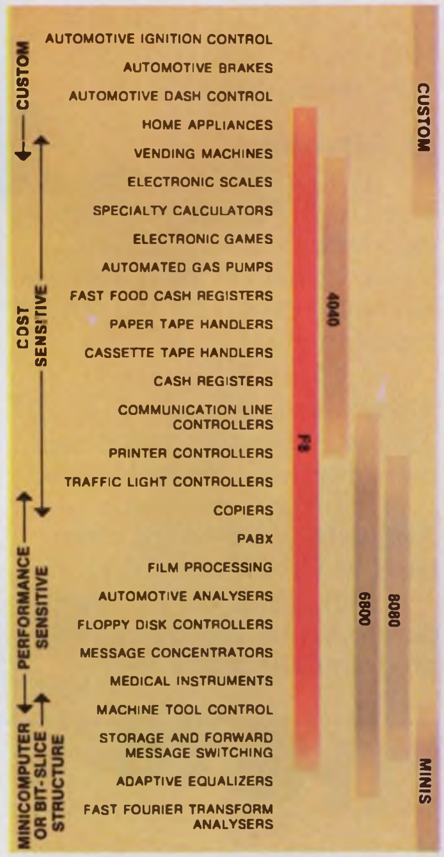
Applications which the chart indicates are cost-sensitive are ones in which total system performance is limited by the fact that data is entered manually (like cash registers and calculators).

In these applications, the reduced parts count of the 2-chip F8 system will usually be the lowest cost solution.

For applications requiring fast data processing or numerical analysis, benchmark performance of the economical F8 generally meets or exceeds that of other microprocessors.

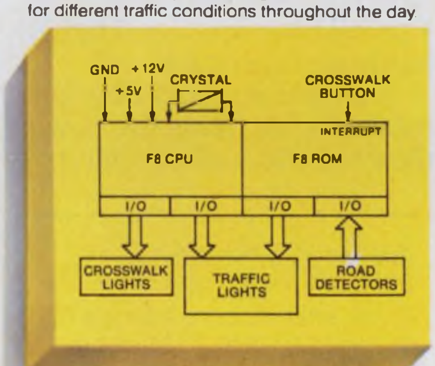
For the designer whose primary concern is economy in one application and performance the next, the F8 provides one system for virtually every need.

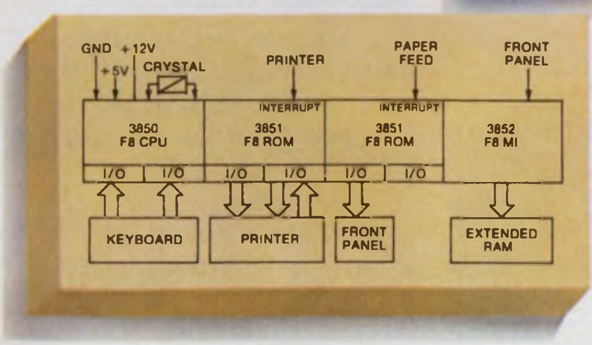
Because of the breadth of F8 applications, it is a logical candidate to become an industry standard.



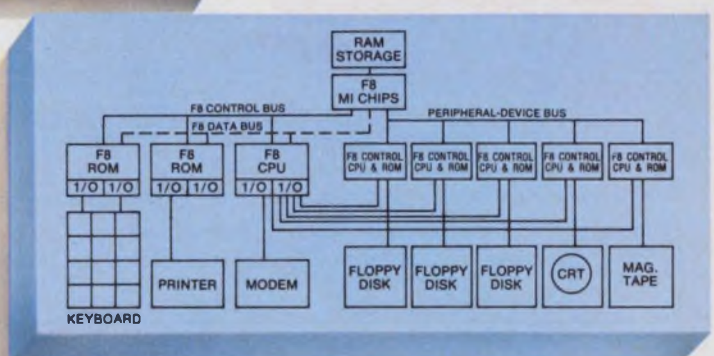
Microprocessor Application Spectrum

Traffic-light controller. Designed around a basic 2-chip system, the F8 traffic light controller handles crosswalk lights, crosswalk button interrupt, street signal lamps and road traffic detectors. The controller automatically adjusts signals for optimum flow for different traffic conditions throughout the day.





Intelligent terminal. Only four F8 chips are required to handle this smart terminal's keyboard input and printer, as well as provide memory interface for external RAM storage.



Key-to-floppy-disk. Multiple F8 processors are used in this key-to-floppy-disk system. Each controller consists of a CPU and a ROM. The processors are linked through a multiplexed memory channel provided by a DMA chip. This system illustrates the modular approach to expansion achievable with the F8. Because all controllers can operate simultaneously, total system throughput is increased.

Fairchild's F8 system is supported by extensive software and hardware aids.

F8 software.

1. *The F8 User's Manual.* The User's Manual provides chip specifications, defines Cross Assembler and Cross Simulator programs and covers the instruction set in detail.

2. *Cross Assembler.* Accessible now on the G.E. Timeshare Network. Additional networks available as required.

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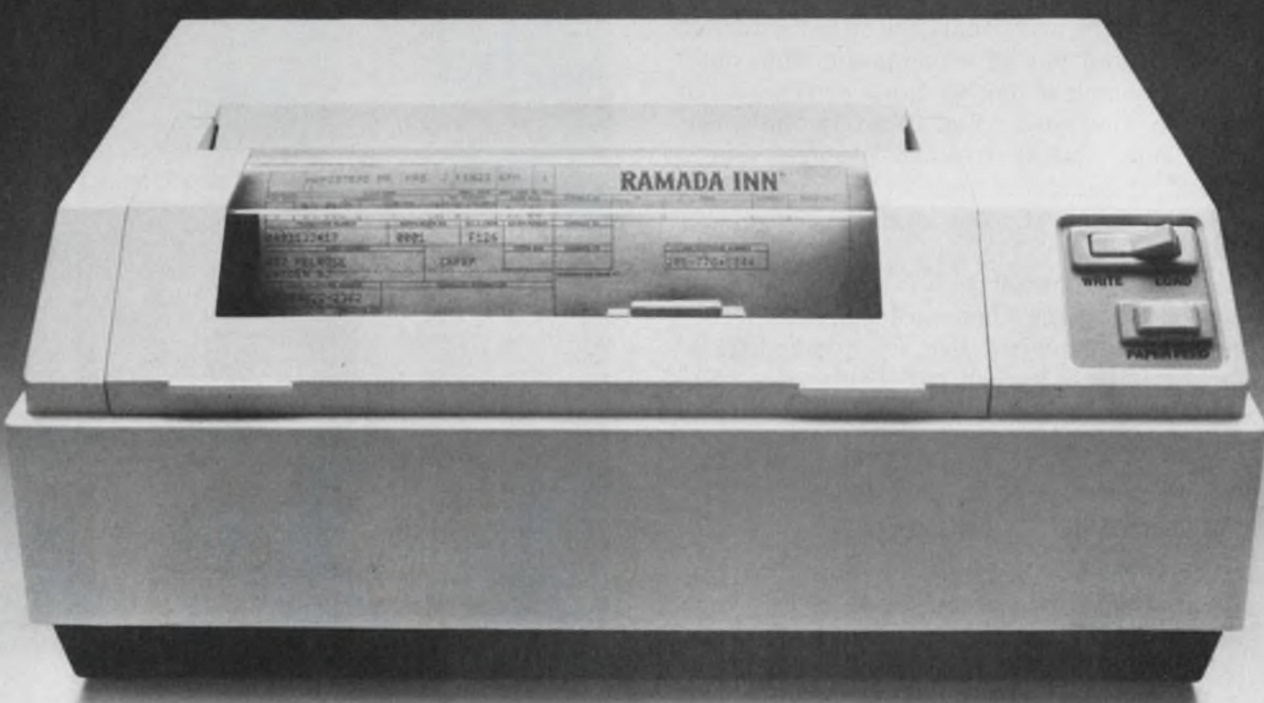

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INFORMATION RETRIEVAL NUMBER 27

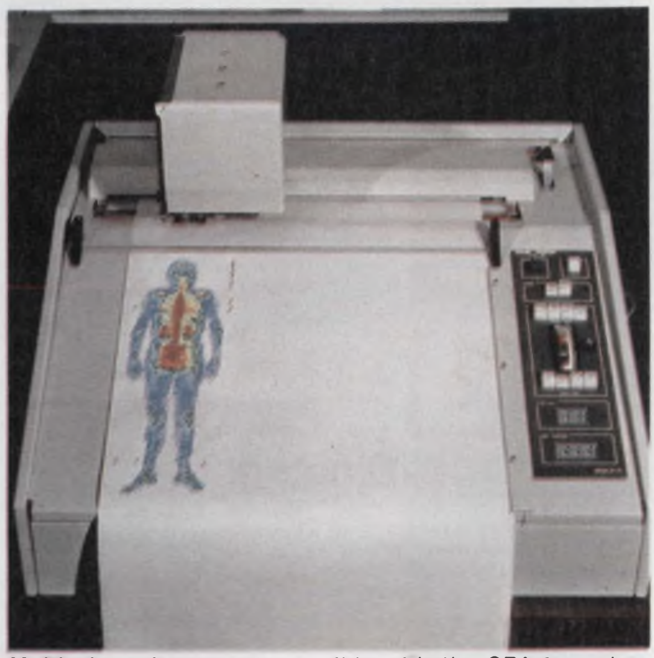
COMPUTER '75

Novel ways of entering data are under study, including the power of positive thinking

Jules H. Gilder, Associate Editor

There are more ways than one to get information into and out of a computer. You don't have to punch it out on cards or type it out on a printer, you know. You can talk the information in and listen to it when it comes out, if you're tired of humdrum approaches. Or you can even "think" it in, if your system is properly equipped.

These techniques exist today. And some commercial systems using them are available. They are part of a growing list of nontraditional peripherals. Besides speech and brainwave techniques, at least a half dozen other nontraditional peripherals are available.



Multicolor printouts are possible with the CPA-1, a nine-color image printer from Elscint

'Think' your data in

The "mind-reading" system for thinking data into a computer is being developed at the Stanford Research Institute, Menlo Park, CA. According to Dr. Lawrence Pinneo, head of the project, it is an automatic biologically controlled communications system.

Pinneo notes that there are certain patterns in human electroencephalographic and electromyographic signals that are associated with language. By using pattern-recognition techniques, these patterns can be identified and correlated with specific words.

So far Pinneo and his researchers have been working with a limited vocabulary of between seven and 15 words. In describing how the system works, Rebecca Mahoney, a member of the research team, notes that the EEG pattern associated with a specific word for a particular person is recorded and stored in the computer memory. This record is called a template, and each time a word is to be recognized, the EEG pattern associated with that word is compared with the different templates in the computer until a match is found. If a match is made, information in the EEG pattern in question is added to the old template and a new updated template is produced. Once a word is recognized, it can be read out or used by another part of the system.

Recent advances in the mind-reading interface have made it possible to reduce the memory required by the system. The latest version uses a LINC 8 computer with 8 k of memory to produce on-line recognition accuracy of 50 to 53%. While this is still not good enough for direct brain-to-computer communication, it's a big step in that direction. Accuracy can be increased if more than the present seven electrodes are used to pick up information or if the system is given more time to analyze the data.

The ultimate goal of this project is to minimize the need for slow, conventional input devices, such as punch cards and teletypewriters.

Voice systems are here

An equally interesting system that has already advanced to a state of practicality is the voice data-entry systems. Several organizations have developed these peripherals, and others are trying to advance the state of the art.

The two major developers of commercial voice-input devices are Threshold Technology Inc. of Cinnaminson, NJ, and Scope Electronics Inc. of Reston, VA.

Threshold offers the VIP 100, an isolated-word recognizer that responds to individual words or carefully articulated phrases. According to Marvin Herscher, vice president of Threshold, the VIP 100 is an adaptive system that recognizes spoken words from a wide variety of speakers, regardless of vocabulary, dialect or acoustic environment. The standard system comes with enough memory to store 32 words or phrases, but with optional equipment it can be expanded to 100 words.

The machine must first be trained to recognize the speaker's voice. This is done simply by having the user repeat to the machine several times the words to be recognized. The machine automatically analyzes the audio and stores a reference pattern.

Once the VIP 100 recognizes a spoken word or phrase, it generates a digital code that identifies the sound. This code can then be used to enter data into a computer, retrieve stored information or control machine operations.

Herscher points out that the use of voice input for computers eliminates a lot of potential sources for error and speeds up the over-all system. In fact, he notes, with voice input, it is possible to reduce systems that previously required the handling of data by three or four people to systems where data are entered by the originator.

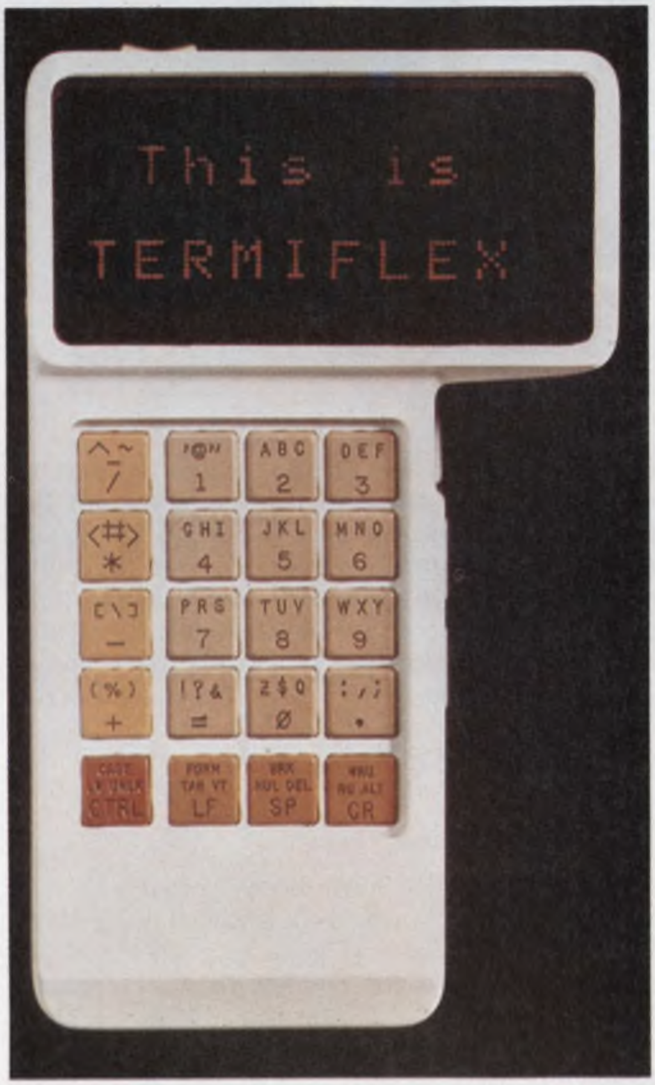
Citing an example of how the VIP 100 works, Herscher notes that Continental Can Co. uses it for quality control. An inspector measures certain critical dimensions on the lid of "pull tab" cans and simultaneously enters the information by voice into the VIP 100 system. The output from the VIP 100 is fed to a tape machine, where the data are collected. The tape is then taken to a computer for analysis.

In addition to speeding data entry, voice-input systems also make it possible for handicapped people to program computers. Work in this area is being done by Scope Electronics. According to Wally Birdseye, technology applications manager, a system has already been set up that permits a handicapped person to program a mini remotely by voice.

A more advanced system is being developed and should be ready for use by late fall. It would allow several quadraplegics to time-share a DEC-10 computer remotely over telephone lines.

Scope is also tackling the problem of recognizing continuous speech instead of just individual words or phrases, Birdseye says. This is more difficult to do, because some way of determining where one word ends and the next begins must be determined.

Another system developed by Scope not only lets the user talk to it, but answers him right



Termiflex hand-held computer terminal can generate all 128 ASCII characters and display them in two lines of 10 characters each. An internal 1000-character memory automatically stores incoming and outgoing data. The terminal weighs only 1.5 lb.

Voice-input systems are being used at Continental Can Co. to enter quality-control data into computers. An inspector makes several measurements on pull-top lids and enters the data by voice into Threshold's VIP 100 system, which prepares punched tapes. A computer then determines if quality control is satisfactory.

back. It's known as VRASS (voice-recognition and synthesis system), and it was developed for the Naval Air Development Center, Warminster, PA. VRASS, says Birdseye, can recognize and synthesize up to 150 individual words and phrases. In operation, spoken messages are entered into the system, and a complex message decoder, using up to 18 levels of syntax control, determines the message content. Information is outputted by a synthesized voice.

The talking computer

Talking systems have been available for a while. You may have been involved with them indirectly if you've ever gone to a bank and the teller has verified the balance in your account. Many banks have a system that simply requires the teller to punch in your account number. The balance in your account is then checked by computer and a voice synthesizer tells the cashier on the telephone how much money you have in your account.

Many of the voice synthesizers are nothing more than sophisticated tape or disc recorders, where basic sounds, words or even phrases are individually recorded and played back under computer control.

Some voice synthesizer manufacturers have taken advantage of semiconductor memory technology and produced all-solid-state synthesizers such as the Expandable Voice Annunciator from Master Specialties Co., Costa Mesa, CA.

According to Ken Renard, product manager for voice systems, words or phrases that take a maximum of 0.5 sec to pronounce are digitized by a four-bit analog-to-digital converter and stored in a read-only semiconductor memory that is between 2 k and 16 k in size. The larger the size of the memory, the higher the fidelity of the output.

To output a message, ROMs are addressed in the correct sequence, and the digital information is fed to a digital-to-analog converter to get back the analog audio signal. The signal then goes to an amplifier and speaker.

This approach to voice synthesis is limited, because it requires a memory chip for each word in vocabulary. A better approach, which is being investigated, is to store the basic speech sounds in ROMs. This would make it possible to contruct any word.

Cameras give a computer 'eyes'

Not only are computers capable of hearing and speaking, but with the availability of semiconductor image-sensing arrays, they are now capable of "seeing" as well. Digital cameras using photodiode arrays can feed data into computers so that noncontact inspection, process control and measurements can be made.

An example of this type of visual computer peripheral is the LC600 digital line scan camera from Reticon Corp., Mountain View, CA. The LC600 looks like an ordinary photographic camera, except that the film plane is replaced by a linear array of small photodiodes. Array lengths vary from 64 to 1024 diodes long, and center-to-center spacing as small as 1 mil is possible, notes Reticon's president, John Rado.

A lens images an object onto the array, which is electronically scanned to produce a train of analog electrical pulses having an amplitude proportional to the light intensity of the diodes. The analog pulses are then compared with preset back-and-white thresholds and are converted into digital pulses. The digital pulses can then be fed to a computer, where they can be counted to determine the position of an edge, or the pulses between two transitions can be counted to measure a diameter, Rado points out.

The video system is being used in several production systems for measuring and sorting objects. In the sorting operation, Rado explains, the image of the various objects are fed into a computer and form what is called a signature. As an image passes in front of the camera, its signature is compared with those in the computer memory. When a match is made, appropriate action is taken.

A more advanced computer video system is available from Dicomed Corp., Minneapolis. This system is capable of much higher resolution than the Reticon, and it can also be used for full color applications. A drawback, however, is that it is primarily designed to be used with a film input.

The input image is broken down to as many as 16 million array elements for the highest resolution version. Each element can have one of 256 intensity levels. An 8-bit code indicates what the intensity level for each element is.

The data are fed into a computer, where they are processed for either enhancement or recognition of a particular feature and then read out onto a color film recorder. The recorder consists of a CRT display with a moving spot whose intensity varies according to the 8-bit code and a special camera. To produce a color picture, sequential recording with red, green and blue filters is used. Three times more memory is required than for black and white pictures. A typical 2000-by-2000 full-color array takes about 5 min to record.

Brain-to-computer interface system being developed at Stanford Research Institute allows a person to enter data into a computer by "thinking" it in. Accuracy and system vocabulary have to be significantly increased to make thought input a viable method of entering data into a computer.

Printer gives nine colors

For lower-resolution output applications that require color capability, a nine-color printer from Elscint Inc., Palisades Park, NJ, can be used. Originally developed for nuclear medicine applications, the CPA-1 printer accepts BCD input signals to produce nine-color prints on ordinary printer paper.

Color is achieved in the CPA-1 through use of a nine-color ribbon, and a picture is composed of rectangular segments that measure 0.4 mm in width and from 1 to 6 mm in length. The rectangles are printed at a density of 3 per millimeter. This results in a continuous pattern that looks very much like a brush painting.

The printed color is changed by the BCD input. The highest BCD number represents the highest intensity, which is red, and the lowest number indicates the lowest intensity, violet. The color brown is used to indicate an overrange condition.

The contrast range of colors is controlled by pushbuttons. For example, by selection of the proper button, it is possible to make yellow the highest intensity color and blue the lowest.

While the CPA-1 can be used with computers to clarify output data, the software to control it has to be in the computer. The reason for this is that the nuclear scanning system it was originally designed for has the control software built into the image processor.

Try a hand-held terminal

An unusual peripheral that seems to be an extension of the portable terminal and calculator technologies is the Termiflex hand-held computer terminal from Termiflex Corp., Nashua, NH.

Although it looks an awful lot like a calculator, the Termiflex is far from being a simple computing device. It features a 20-switch keyboard that, along with three shift keys, can generate and display all 128 ASCII characters.

The 1.5-lb terminal also has several selectable parameters. These include communication speed, which can be 10, 15, 30 or 120 characters per sec. Parity can be chosen as either odd, even, mark or space. And the transmission mode can be selected as either half or full duplex. Other programmable features include upper or lower-case characters and line justification.

William Turner, vice president of the company, notes that data are displayed on 10 5-by-7 LED dot matrices. There can be up to two of these 10-character lines in the terminal. When a line is filled, the Termiflex automatically transfers the data in the first line to the upper display line and continues writing data in the lower. As this, too, fills up, data in the upper display are placed into memory and the data from the lower display move up again. This is known as scrolling. The unit has a scrolling memory of 100 lines, for a total storage capacity of 1000 characters. Data can be recalled by operation of a single switch that causes the data in memory to move forward or backward.

Applications for the hand-held terminal are many, Turner notes. It can be used as a control device for automated equipment or as an auxiliary terminal for debugging computers. It is particularly suited for field-service use, because with its power supply and acoustic coupler, it takes up only half the space of a standard attache case.

Write the data into a computer

Instead of punching data into a computer via a keyboard, you can write the data in if you use the Alphabec-75 pen from Xebec Systems Inc., Sunnyvale, CA.

The Alphabec-75 is a computerized pen that converts handwritten copy directly into ASCII coded data. In addition the pen's ballpoint or fiber tip creates hard copy, so that no special forms or data tablets are needed.

Data entered via the pen are limited to 16 characters—10 digits and 6 control symbols. As data are entered, they are displayed on a readout unit; verification of the data is immediate. If an error occurs, you can erase it simply by drawing a line from right to left over the wrong character.

At the heart of the ASCII pen are small motion transducers that sense the direction of movement. This information is sent to a control module that contains pattern-recognition circuitry, which defines each character.

If desired, the ASCII-coded data generated by the pen can be stored on a cassette tape with a density of over 145,000 characters per cassette. Or it can be sent via a built-in RS-232-C interface to a computer. Asynchronous transmission can occur at rates between 110 and 2400 baud. Synchronous transmission can take place at between 1200 and 4800 baud.

Smart cable eases connection

The newest of the nontraditional peripherals is the intelligent cable from Computer Automation of Irvine, CA. The smart cable is part of a universal interfacing system that makes it possible to bring together processors with up to eight standard and custom input/output devices.

The brain of the intelligent cable is the PicoProcessor—a small microprogrammed processor optimized to control I/O devices. It is capable of transferring data, manipulating device control signals, monitoring status and generating and responding to computer interrupts.

In use, the PicoProcessor is placed near the peripheral of interest. This eliminates the problem of special cabling to different peripherals with different electrical characteristics. The intelligent cable provides fast and convenient data transfer without the high cost of many direct-memory-access controllers or selector channels, which can service only one or two devices at a time.

Input and output operations and word and byte transfers can take place concurrently in any mix on all channels. Once an I/O operation is begun by the outputting of a single control word to the desired channel, data transfers are completely automatic and require no program intervention until the required words are transferred

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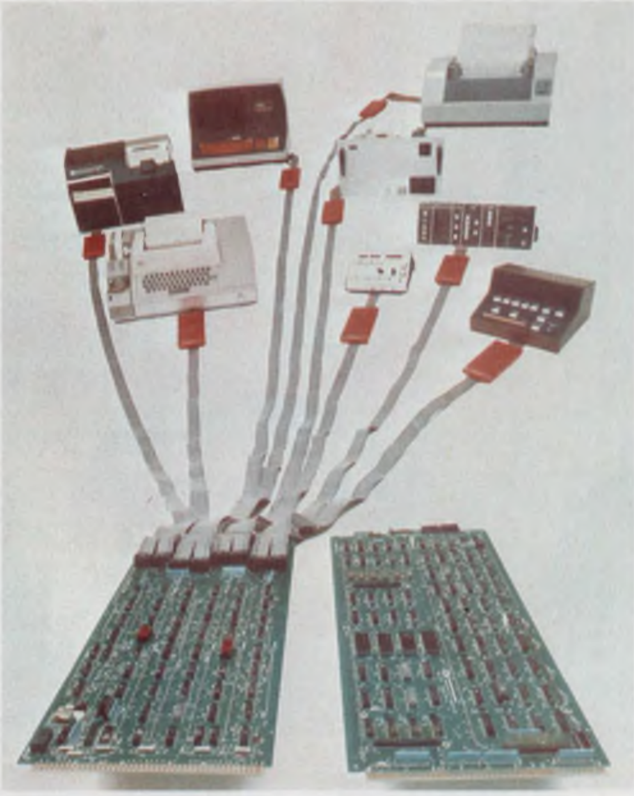


The intelligent cable, from Computer Automation, contains a PicoProcessor that makes it possible to bring together a processor with up to eight peripheral devices. It can manipulate data and respond to control signals.

Digital cameras can feed data to computers so that noncontact inspection, process-control and size and position measurements can be made. This system—the LC600—is from Reticon.

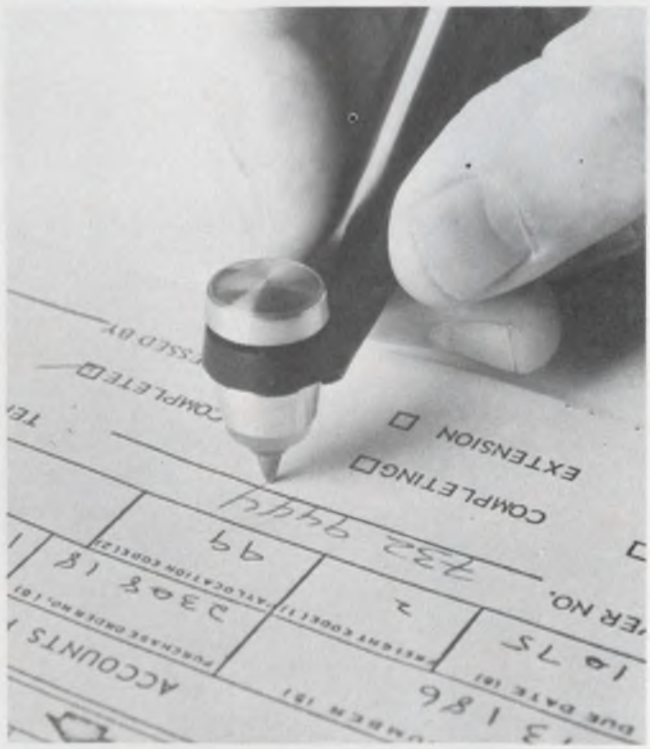
or an error condition is detected by the PicoProcessor.

Although most telephone data-entry techniques require the use of Touch Tone telephones, the latter are not absolutely necessary. A dial-pulse interpreter, developed by Goldmark Communications Corp., makes it possible to use an ordinary rotary dial telephone to enter data into a computer.

The advantage of having a rotary dial interface is that if you want to enter the data from a remote location, you don't have to hunt for a Touch Tone phone. In addition many telephone exchanges still do not have Touch Tone capability.

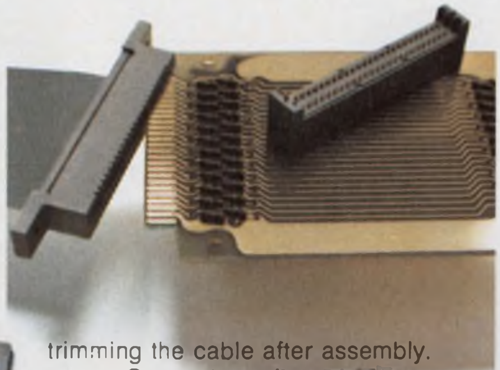
The dial-pulse interperter attaches to the telephone line and samples the dial-generated pulses that occur after completion of the telephone connection. Specially designed chirp detectors, storage registers and word comparators are used to allow accurate interpretation.

The output signals available include four lines of BCD TTL. optional single-relay contact closure and optional TTL one-of-10 output. In addition a LED display will show the dialed digits. ■■



Written data can be entered directly into a computer with the Alphabec 75 ASCII pen from Xebec Systems. Sensors in the head of the pen determine the direction of motion and produce signals that are used to identify the number being written.

Design with the complete flat cable/connector system.



Assembly-cost savings are built in when you design a package with "Scotchflex" flat cable and connectors. But more important, 3M Company offers you the full reliability of a one-source system: cable *plus* connectors *plus* the inexpensive assembly aids that crimp the connections quickly and securely (with no special operator training required).

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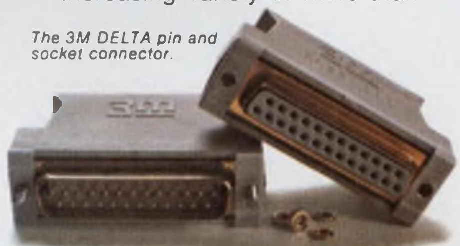
And "Scotchflex" now offers you more design freedom than ever. From stock you can choose shielded and non-shielded 24-30 AWG cable with 10 to 50 conductors, and an ever-increasing variety of more than 100 connectors to interface with standard DIP sockets, wrap posts on standard grid patterns, printed circuit boards, or headers for de-pluggable applications. 3M's DELTA "D" type pin and socket connectors are now also available. For full information, write Dept. EAH-1, 3M Center, St. Paul, MN 55101.



The 3M DELTA pin and socket connector.

3M COMPANY

3M's "Scotchflex" line.

"Scotchflex" is a registered trademark of 3M Co.

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Nobody has an easier to apply line of no-strip, no-solder, round-conductor flat-cable connectors than AMP.
Quick, easy terminating. The new AMP shuttle-tool is designed for reliable and repeatable production. Loading is easy. The operator simply pulls out the shuttle to load the cable and housing, and then pushes the shuttle in, to terminate. Alignment is automatic and positive. Pneumatic tooling is also available.
AMP

COMPUTER '75

Dedicated systems giving rise to once 'far out' applications from sports scoring to security

Jim McDermott, Eastern Editor

The traditional roles of computers in data processing and number crunching are being overshadowed by a growing army of dedicated systems for what a few years ago would have been considered "far out" applications. Sparked by the emergence of the minicomputer, and now the microcomputer, these dedicated systems are turning up in the following:

- Sports stadium scoreboards with TV.
- Error-free fire engine dispatching.
- Automatic point-of-sale transactions.
- Personnel identification by physical features and voice.
- Electronic games.
- Intelligent traffic controls.
- Automatic vending-machine coin changers.
- Talking computers.
- Musical synthesizers.
- Laboratory-animal motion analyzer.
- Computer-generated horoscopes.

The most advanced sports stadium scoreboard and its controlling system, built by Conrac for the Buffalo Bills football team at the Erie County Stadium near Buffalo, uses a computer to store or display messages on a matrix of 9600 (80 × 120) incandescent lamps. While this has been done before, the principal advance is in the fact that TV pictures can also be shown.

"We can take any video signal from a camera or tape recorder or TV network and convert this to digital information to control each of the matrix lamps," says Ken Epple, general manager of Conrac Media Corp., Duarte, CA.

The computer used is a Computer Automation Alpha 16 with a 24-k memory. The video image produced is 27 feet high and 47 wide, he notes, and the system works well for closeups.

Small, specialized computers have made their

Pictures from a local portable TV camera or from network stations are processed by computer and projected from a computerized football scoreboard by Conrac.

A dogfight flight training system for the Navy pits pilot against pilot in mock air-to-air combat. The computer-based system, by Cubic Corp., provides mission replay.

Community safety is improved by this computer-operated fire-engine dispatching center in Citrus Heights, CA. Mistakes formerly introduced by handwritten messages and look-up of fire locations in a hand-file are automatically sensed by the computer, a Xerox 530. The errors are instantly flagged on the CRT terminal readout.

Speedup of checkout at these supermarket lines is improved substantially by National's Datachecker electronic checkout system. The electronic cash-register terminals at each stand are linked to a backroom microcomputer consisting of an IMP-16 microprocessor and a disc file, where product data are stored.

way into the $3-billion amusement-game industry with the advent of a rash of electronic coin-operated games. Most use a TV screen as the display and playing field. Probably the most familiar is the electronic ping-pong game, in which the players bat a dot of light back and forth across a net on a TV tube.

Leading the field here is Pong, developed and produced by Atari Corp., which was founded by Nolan K. Busnell, a 31-year old engineer who worked his way through the University of Utah by managing games at a Salt Lake City amusement park. Some 65 ICs are used for the computer and sound effects in this game.

Dedicated computers are promoting public safety in such areas as law enforcement and fire fighting. A prime example of computer benefits is the Xerox Dispatch System for Fire Agencies, a computer-assisted approach to vehicle dispatching using the Xerox 530 computer.

Installed in Citrus Heights, a suburb of Sacramento, CA, the dispatch system provides

This security system uses the unique geometry of a human's hand to verify or deny entry to employees at My Toy Corp. The handprint is scanned by an Identimat machine and is compared with the digital description on a magnetically encoded card.

An instant check on baggage handled by the automated system at Eastern Airlines' Miami Terminal is made at the computer. The DEC computer, laser optical readers and conveyors are linked in this Bendix system. The optical baggage tag is a coded bullseye.

faster and more accurate information to fire stations. In its present configuration it has 32-k words of core memory and 24.5 million bytes of disc storage.

Before the computer was installed, a fire dispatcher would answer a phone call, write down the information, look up the street involved on a Roladex file card and finally write the dispatch information on an Electrowriter that transmitted the message to the fire stations.

"With the new system," says Donald Larson, assistant chief of communications, "the dispatcher types in the street address of the fire, and it appears on a CRT screen. The computer then supplies all the data for dispatching units to the blaze. This includes the nearest cross street, the availability of fire hydrants and items like who to contact for the key to a building."

A hard copy of the CRT screen data is rapidly sent to the fire stations via a Xerox Mobile Printer.

"This system eliminates error—mistakes in dispatching the wrong units or sending them to a wrong street or wrong address," says Larson.

The computer also serves as a double check in detecting and rejecting many errors that might be introduced by the dispatcher or by an excited caller. For example, if the dispatcher types in a nonexistent address, misspells the street name or inputs an address and telephone number that do not match, the computer prints out on the CRT: "Record not found."

Computers that can identify a person by his handprint or by his voice are being used to provide improved plant security as well as to eliminate time-card cheating in which one person checks in another's time card.

An automatic palm reader, produced by Identimation Corp. of Northvale, NJ, and controlled by a Nova 1200 minicomputer, is installed at each of seven employee entrances at My Toy Corp., a Brooklyn, NY, toy manufacturer. An employee who wants to enter the plant inserts an encoded plastic identification card into the identification unit and then lays his palm on top of the reader.

The unit scans the size and shape of the hand and obtains a digital readout that is compared with that in the plastic card. If the readings agree, the computer checks further to verify that the individual has access to the department. If the check is positive, the computer records the time of entry in a payroll file. If the check is negative, an alarm sounds.

Electronic checkout speeds marketing

A prime example of the use of microcomputers to speed personal marketing chores is National Semiconductor's supermarket electronic checkout system. The full 800 CS Datachecker system includes multiple checkout stands. Each stand has an electronic cash-register, an electronic scale, an electronic coin dispenser and an optical scanner. Checkout, says National, is speeded up to 45% when the optical reader is used. Without it an improvement of 25% is still obtained.

Data from the checkout stand are fed to a backroom system comprised of the IMP-16 microprocessor and a disc store. The IMP-16 provides full 16-bit parallel processing capability. The scanner reads the standard optically coded label and transmits the product description to the microprocessor. The processor matches the description to pricing information in the disc memory. The entry is recorded by the system, registered on the terminal display and printed on the customer tape.

The computer also monitors item movement and updates store inventory automatically. Also, totals are available by department, terminal, clerk or item to help in labor scheduling and sales evaluation.

A "way out" application of minicomputers is the calculations, for astrologers, of the orbital positions of the sun, moon and planets, along with other astrological data, such as nodes, planetary distances and daily motion.

The results of such calculations are presented in both graphic and printed-report form for interpretation by the astrologer, says Neil Michelsen, founder of Astro Computing Services, Pelham, NY.

The computer used is a 64,000-bit Interdata with a 10-megabyte disc, a 400-cpm card reader, a 33 ASR Teletype and a Versatec 1200A printer-plotter.

A computer-operated system that collects and interprets visual data about laboratory-animal behavior has been installed at the University of Kansas Medical Center, Kansas City. It recognizes acts the researchers want identified, including resting, rearing, sitting, grooming, walking, smelling or looking.

The system, produced by Kantronics, Lawrence, KS, uses a TV camera that looks at the lab animals and feeds the video output into a quantizer. This unit converts the analog information to binary data for computer use.

This traffic controller is a key element in a Connecticut system by Automatic Signal, Norwalk, that cut travel time by 45% through a high-traffic shopping district. Local intersection control is exercised by a CMOS microcomputer that talks to the system computer.

Microprocessors monitor marine-engine performance for maintenance and failure prevention. This diesel generator is watched by an Advanced Electronics Development Corp. system using gas, water and oil sensors.

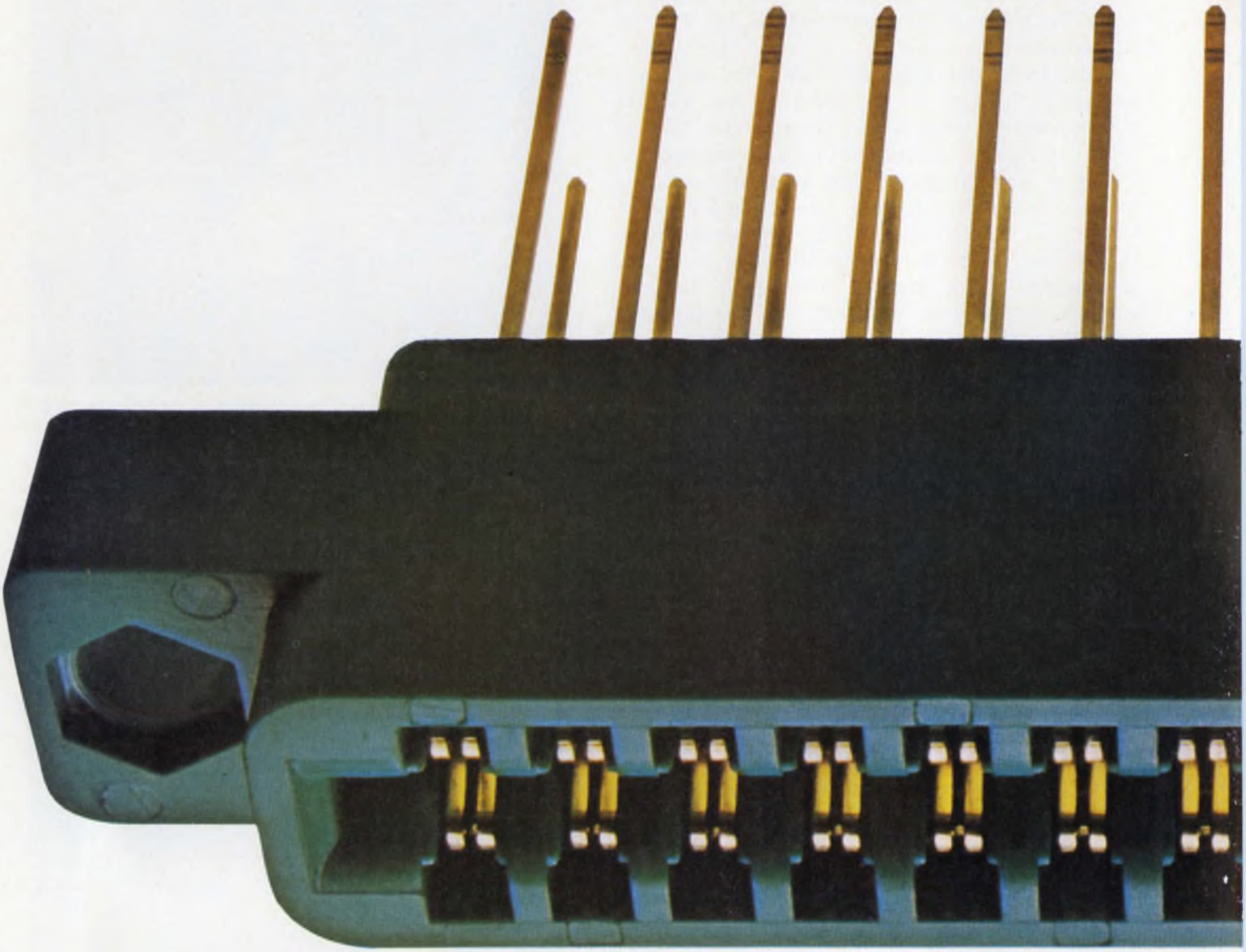
The talking computer

A computer that talks to its users eliminates the need for costly, space-consuming data terminals; it requires only a Touch-Tone telephone, for access to information. The audio response system, part of a Honeywell 3200 computer, is used by the EDP Corp., in Detroit to serve its largest customer, the Ferndale Cooperative Credit Union.

Tellers call the computer, identify the credit union, the transaction to be made and the customer by Touch-Tone button entry. The computer responds with a vocabulary designed to handle withdrawals, payoffs, account information, fast-cash credit and management reports.

For example, if a teller is processing a withdrawal, the computer tells him how much money is in the account. Since the Ferndale Co-op requires a minimum balance, the system also states the maximum a customer may take out.

The voice response is on a cylinder containing 63 sound tracks, like those on movie film. The computer program selects the words, recorded in a woman's voice, in the order that provides a sensible response to the query. ■■



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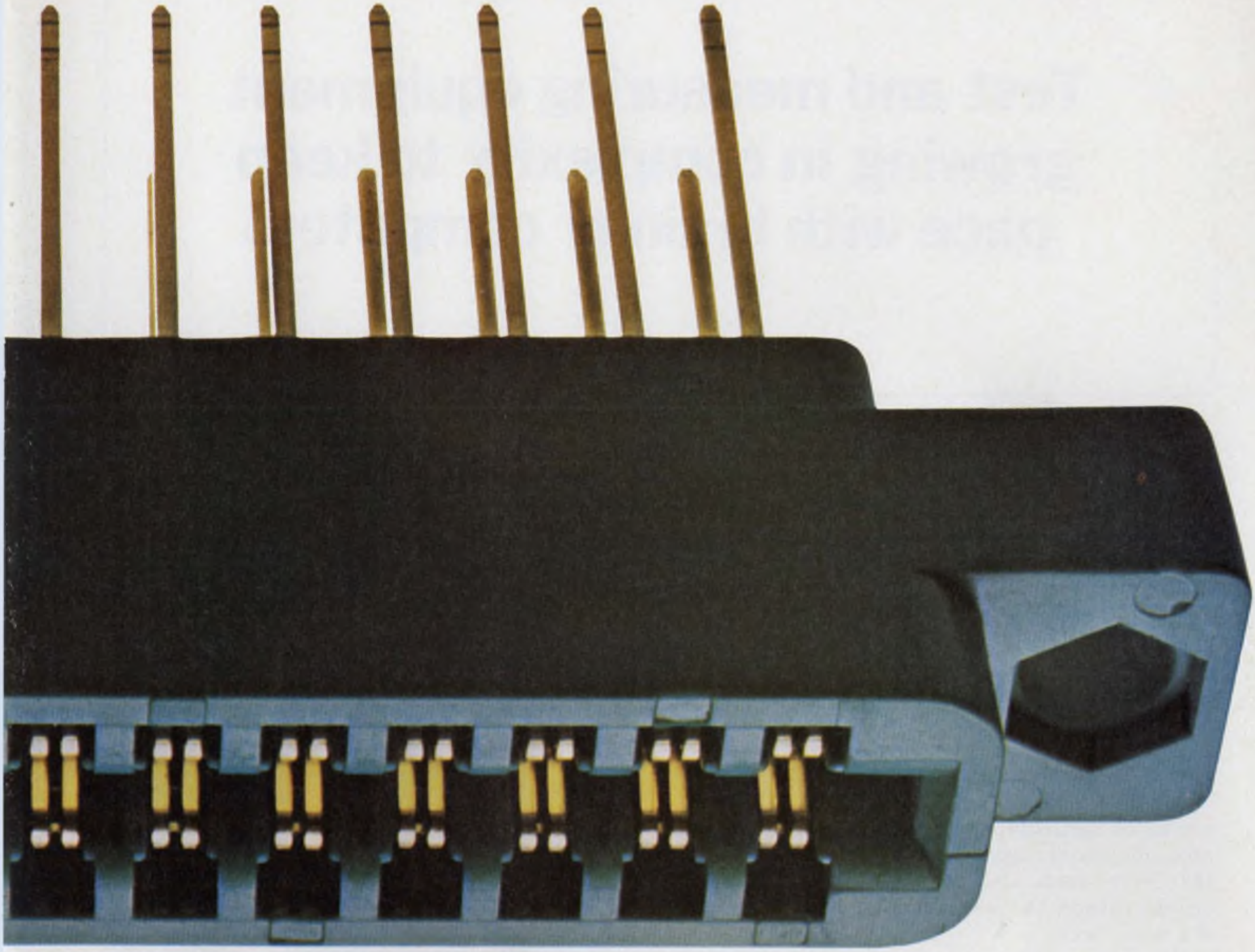


COMPUTER '75

Test and measuring equipment growing in complexity to keep pace with brainier computers

Stanley Runyon, Associate Editor

When it comes to test equipment, the oscilloscope remains king. But as LSI devices, computers and computer systems move up in complexity, so do the requirements for test and measuring equipment. New and different test gear is needed: equipment that can handle mixed analog and digital circuitry, instruments that can wade into long data streams and pick out a preselected pattern, and testers that can simulate logic, analyze faults and then guide test personnel right to the trouble spot.

All these capabilities, and more, are the hallmarks of test equipment today. And the venerable, 40-year-old scope—though faster and better than ever—must find other roles to play or must change to meet the new demands. As it turns out, it's doing both.

When you need to look at complex or superfast analog signals, practically nothing can beat the real-time scope. But when you troubleshoot a digital system that spews out a 50,000-word sequence, how do you zero in on a few needed words? Or suppose you must look at sixteen 12-bit words simultaneously. You've got a problem if you try to do it with a standard scope. With a new class of instrument—the logic analyzer—it's a snap.

Diagnosis by computer: Teradyne's L100 automatic test system checks arithmetic boards for the company's M365 computing controller, and it pinpoints any faults.

The new breed for the new need

Children of necessity, logic analyzers do what the conventional scope can't: They store and display simultaneously many data channels, let you look forward or backward in a bit stream with respect to a trigger, and recognize and trigger from a preset combination of bits.

While these are the attributes shared by the analyzers now available—from Biomation, E-H Research Laboratories and Hewlett-Packard—the resemblance doesn't go much further. Whereas the HP unit, the 1601L, accepts 12 parallel inputs and displays the bits as 16 consecutive words in numeral ONE and ZERO form, both the AMC 1320 from E-H and Biomation's 8200 display eight parallel signals in true time relationship—that is, they use pseudo-voltage levels

A computer-directed halo of light shines through a PC board and shows an assembler where to place the next wire. The computer then tests the connection (IBM).

Computerized checkout of an Interdata 7/32 minicomputer processor board. The terminal displays input data plus expected and actual output data.

to represent ONEs and ZEROs.

Thus the 1601L answers functional questions exclusively: Which loop is hung up? What RAM bit isn't right? Why does the counter skip? By contrast, the 1320 and 8200 perform timing and voltage measurement as well—but with nowhere near the resolution of a conventional scope.

Other differences exist between the three units. For example, Biomation's 8200 zips along at a hefty 200-MHz data rate, while the AMC 1320 places second at 50 MHz. Trailing, but still sucking in data at a brisk clip, is the 10-MHz 1601L. And while the 1601L needs an external clock and the 1320 works only from its own, the 8200 can use either.

Of all the attributes of this new line of test equipment, perhaps the most important is pattern recognition. With it, you can page through a long sequence, say 100,000 words, and pull out one slice of bits. So useful is this feature that it has formed the basis for an entirely new piece of test gear: the pattern analyzer.

Modeled after a widely used software debugging tool (stop on address n), the pattern analyzer—also called a word recognizer, event trigger or logic trigger—has opened new doors for conventional scopes. For instance, with the HP 1620A, you set 16 toggle switches to ONE, ZERO or a don't-care position. The unit then sits back to wait for the preselected word. When the word arrives, the 1620A delivers a fast pulse that can trigger a standard scope or other device.

Jitter-free scope triggering is made possible by another box—the Tektronix 821 word recognizer. Though the 821 handles just four bits, you can cascade units to build up a 16-bit capability. Tektronix also offers a digital-delay unit and a digitally delayed time base, plug-ins for the company's scope and TM500 modular instrument line. Both units are diagnostic tools for scope analysis of high-jitter data streams.

Stable scope triggering is also offered by Philips. A trigger-circuit modification of the company's PM3260 scope, plus a special probe, slashes loading down to a wee 1-pF. Both ECL and TTL options are available.

While the new crop of diagnostic hardware can make life a bit smoother in the lab or field, an entirely new class of testing tool takes over in production. In this area, automatic test equipment (ATE) reigns.

Put your tester to the test

To run sequences of tests on thousands of devices, logic PC cards or systems requires automation. On that, everyone agrees. But when it comes to where to test, what tests to run and how many of each kind, you'll get 30 different responses from as many ATE vendors. And users of ATE voice their opinions, too.

There's no doubt that the earlier you catch a bad device or manufacturing defect, the less you'll spend for test and repair. Incoming inspection therefore plays a key role in the test process, and practically all computer vendors and users of digital ICs run at least go/no-go checks on all devices at this stage. For this purpose, equipment traditionally ranges from small benchtop testers to large, computer-controlled machines. In between these extremes, you'll find a host of intermediate testers—dedicated units, fixed-pattern testers and other approaches.

Which tester to buy has always been a problem. And with the arrival of built-in microprogrammed processors in the newest small testers —such as those from Mirco Systems, Phoenix, AZ—the line between benchtop units and computer-based systems is becoming blurred.

One problem tackled by some of the newer testers is that of programming. Traditionally program entry is done by software, front-panel switches, pattern generators or with personality cards. But benchtop machines like Fairchild's Qualifier 901 attempt to cut through programming complexity and expense with new methods. With the Qualifier, the user inserts a plastic card, optically encoded for each device to be tested. The 901 then does the rest.

At the PC-card level—another crucial point in the test process—you'll also find numerous testers in fierce competition, with as many test approaches as there are machines. Which is best? As usual, it depends on your application.

Major areas to investigate include test speeds, accuracy, voltage and current range and resolution, software or other programming, patterns available, data collection and analysis, devices handled and timing capabilities. These are all traditional areas of ATE capability. But as the latest products in ATE reflect, there are new areas to investigate too.

As ICs grow more complex, as more and more devices are squeezed onto a single chip, and as newer and tougher-to-test memories—like the 4-k RAM—appear, testing headaches grow, and ATE must do more. How do you check quickly complex logic boards with thousands of devices per board? How do you rapidly pin down the trouble spot in, say, a 5000-device IC when only 18 pins are accessible? The answer is, you probably can't—unless your ATE can automatically detect, isolate or guide you to the fault.

Tracking down footprints

Practically every card tester introduced in recent years offers some form of guided-fault isolation. For instance, models in the just-unwrapped series of capable testers from Computer Automation, Irvine, CA, automatically direct the operator to the fault's origin. This fault diagnosis is similar to that in systems built by such tester outfits as Data Test, Faultfinders, Fluke/Trendar, General Radio—a pioneer in guided fault—Hughes Aircraft, Instrumentation Engineering, Macrodata, Siemens/Computest, Teradyne, and others.

In Data Test's 5700, a computer tells the operator to touch a probe to a given point and start a test sequence. The computer then digests the logic transitions at that point and diagnoses the problem, if any. When logic functions aren't accessible through input pins, the 5700 can direct the user to the right spot.

Still another board tester, the Shortfinder FF202 from Faultfinders Inc. of Latham, NY, programs itself, then uses a microprocessor to test between nodal points for shorts, opens, leakage and the like. The unit then automatically isolates circuit defects and prints data for repair. The 202 handles both bare and loaded PC boards, a unique feature says the company.

"Intelligent" machines, ones that diagnose ailments or that self-program, are one response to increasing circuit complexity. Yet another approach is to test while you design or while you build. That testing is becoming more intertwined with the actual development and production processes is revealed by two systems, one in use at IBM and the other commercially available from Computer Automation.

In the IBM system—called STEP (system for test and plug)—a computer directs light probes along three orthogonal axes to identify connecting pins on circuit boards for the company's 370 computers. A halo of light shows the operator exactly where a wire should be connected out of the thousands of possible connections.

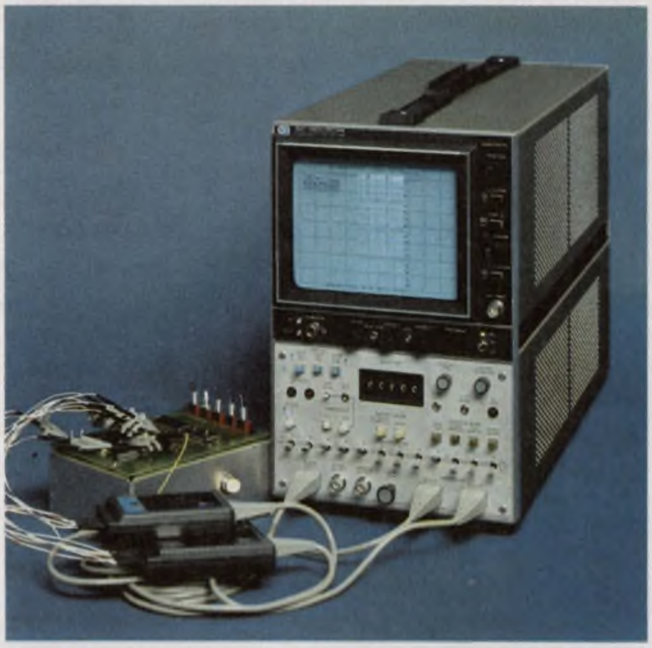
The STEP system then performs a 100% electrical test of the insertion. Only if the connection is correct will the light probe move on.

BigSim, a simulation software system for Computer Automation's 4900 tester, takes testing out of the production arena and moves it into the design lab. In fact, no hardware need be built at all. With simulation, it's all done on paper and in the machine: The ability to design, verify, locate test points, configure multiple cards, produce test programs—like those for go/no-go and automatic/guided-fault isolation—and then run all tests. Simulation can save many hours later on, when hardware is finally produced.

Software, of course, occupies a key spot in systems test, where the complete, functional computer is wrung out by diagnostic routines. And with the rise of mixed, or hybrid, analog and digital circuit boards, software and test hardware are working harder than ever.

One example of this is CAPS VII, a software package developed by General Radio, Concord, MA. With the package, GR's 1792D logic-board tester can measure such analog parameters as voltage, current, frequency and transition times. The program can then shift to the digital mode and run through all logic tests.

Diagnosis by software forms the core of inhouse testing of computer systems, especially peri-



Logic analyzers form a new class of test instrument to meet the needs of digital-logic troubleshooting. The main features of the class include the ability to display many signals simultaneously, to single out a grouping of bits and to look forward or backward along a bit data stream. Left: Biomation's 8200. Right: the HP 1601L.

pheral equipment. Computer systems, however, have a habit of failing in the field, no matter how thoroughly tested before shipment. How to service and maintain equipment in the field poses a problem that calls for new test methods—and new types of test instrumentation.

The demise of house calls?

To service equipment on site requires portable testers—lots of them. A data-communications center, for example, may include terminals, modems, interfaces, printers, tape and disc memories and other peripherals, all of which will need servicing at one time or another.

To fill the need, test gear is offered by such companies as Atlantic Research of Alexandria, VA, Nu Data, Little Silver, NJ, International Data Sciences, Providence, RI, Pulsecom in Falls Church, VA, and Tau-Tron of N. Billerica, MA.

Tau-Tron's line of equipment includes units for bit-error-rate testing that blaze along at up to 1 GHz—the fastest rate available today.

Atlantic Research markets Intershake, a portable instrument that can analyze, simulate and generate practically any signal condition needed to check all data-communication system components, including software. Intershake works online or off-line and stores tests internally or in spare pop-in PROMs.

Both International Data Science's Model 60 and Nu Data's 921-S interface test set can be shoved into a pocket, and both units test interconnections between a modem and terminal to ensure conformity to EIA 232, the Electronic Industries Association standard for data transmission. The Model 505-2 from Pulsecom performs similar troubleshooting.

Such "line snoops" and other portable test gear can literally fill a service van or station wagon. But add such extensive gear to the cost of house calls today, and field service becomes a very expensive proposition. So much so, in fact, that an increasing number of computer vendors are looking into remote call-up diagnostics to examine terminals or other devices.

Already in use at Datapoint, IBM, GTE Information Systems, Sycor and Western Union Data Services, remote call-up automatically dials a processor in the field and then transmits test routines when the processor answers the phone. Test results are analyzed and displayed either on site or at the remote test center. The idea, of course, is to avoid a service call, if possible.

Whether remote testing will eliminate such calls entirely remains to be seen. One thing that won't be eliminated by remote diagnostics, ATE or logic analyzers, however, is the oscilloscope.

As evidenced by such new performers as Hewlett-Packard's microprocessor-based scope, the Tektronix digital-processing unit and the Philips line of multiplying scopes, and also by the programmable, calculating oscilloscope from Norland Instruments of Fort Atkinson, WI, scopes are taking on a new look. And they are gaining a foothold in the world of digital measurements. ■■

Even after you buy it, HP's 182 Mainframe keeps on giving you a choice. A choice of other plug-ins as measurement needs change . . . a choice to update as new plug-ins are developed . . . a choice of three entirely separate modes of measurement.

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COMPUTER '75

One man's view

Will the micro KO the mini? Not if the mini manufacturers counterpunch, says Ely of HP

John Mason, Associate Editor

First there was the giant computer. The data processor to end all data processors. Centralization was the answer. One big machine would do the brain work for an entire facility.

Then came the smaller machines. Decentralization became an acceptable concept. But was it really the way to go?

Then the minicomputer arrived. This was real revolution! Decentralization was right, after all. And the mini was king!

And then—and who was ready for this?—the microprocessor appeared.

Will there be a battle? Is it curtains for the mini? For Digital Equipment Corp. For Data General? For Hewlett-Packard?

Hewlett-Packard's Paul C. Ely Jr. says there will be a battle but the mini will survive—if the manufacturer knows what he's doing. Ely is general manager for the company's Computer Systems Group in Cupertino, CA.

Changes are taking place in the computer industry all right, Ely agrees. The microprocessor is having an impact.

"But fortunately," Ely explains, "the minicomputer has always enjoyed the advantage of having a very broad base, as far as applicability is concerned. As industry grows and makes new demands, the minicomputer moves in to fill them.

"The microprocessor and the minicomputer aren't at war but the microprocessor has captured some territory and is forcing the mini to move. The mini has consistently come down in price and up in performance. So the microprocessor is simply taking over the smaller, cheaper jobs that the mini is now too big to handle. Together, the microprocessor and the mini have expanded the market."

Ely sees three important trends in the giant minicomputer companies:

1. Manufacturers rarely sell someone a bare CPU these days. They provide the mini in a complete system with integrated peripherals. "Even the OEMs want complete systems," he says. This trend, which actually started about three years ago—before microprocessors—is evident in many product lines: "DEC's PDP-11/70, Data General's Eclipse, and HP's 3000 CX," Ely notes.

2. A system's software is more powerful than it used to be. "You give them really comprehensive operating software that will solve their problems," Ely says. As a result, less money is spent for developing custom software and a better, more reliable software results.

3. Manufacturers have got to build their own peripherals. This gives the systems manufacturer a chance to make a unique performance contribution to his product at the systems level. It also gives him control of his reliability and costs.

How to stay alive

Some minicomputer houses will be around two years from now and some won't, Ely says, adding: "HP and apparently DEC are actually experiencing a period of growth during these generally bad economic times. To survive, you have to move forward into systems integration and peripherals. And you must also move backward into IC technology."

As an example, Ely notes: "In the past almost any group of engineers with a bright idea could buy logic from Fairchild or Texas Instruments or Motorola, build a CPU, put together a simple, though perhaps clever, software package to run it, and they were a 'mini supplier.'

"These are the people who may be replaced by the microprocessor companies," Ely predicts.

To survive in the long run, he says, manufac-

Paul C. Ely, Jr., general manager of Hewlett-Packard's Computer Systems Group, Cupertino, CA, is responsible for the company's newly consolidated computer and computer system's operations. Previously, he was general manager of the Data Systems Div.

turers must know how to build electromechanical devices and at least the main systems peripherals, such as discs and tapes, for mass storage and for line printers and terminals to interact with the system.

"This is where the money in a system is," Ely says, "not in the CPU.

"Apart from cost," he adds, "reputation is at stake. If you buy your discs, you won't be able to differentiate them from those of your competitors. And you can't claim that your discs are better unless, in fact, they are and unless you make them. As the industry matures, the ones who have developed their own capabilities in these key peripherals will be successful.

"This doesn't mean that we're going to stop buying all peripherals. But we do plan to build a large share of the ones that represent the essential performance limitations in our systems."

Expertise in LSI design is also required, Ely says. Minis of the future won't be built with standard circuits from a semiconductor house; they'll be custom-designed, he predicts.

"Some of the minicomputer companies are vertically integrating backwards into IC technology by working closely with a supplier," the HP manager points out. "That's what DEC has done with Western Digital to make their LSI-11. This is an LSI version of the DEC PDP-11. We in HP have invested in an in-house LSI capability and Data General has bought an LSI facility."

Ely feels strongly enough about the need for expertise in IC technology to predict: "The extent to which we are successful in this will determine our competitive success in the long run."

Will the IC houses become systems producers?

"Microprocessor companies don't at this point have the software capability to become a systems house," he says. "They can, however, acquire this by first recognizing the need for it, hiring a competent staff and gaining experience.

"Developing a peripheral capability, on the other hand, is more difficult. This requires both an engineering and a manufacturing capability —something that's very different from manufacturing ICs and that calls for a substantial investment. Making a good disc is a sophisticated electromechanical job which requires major machine-shop facilities."

More uses are being found for the minicomputer because new industrial areas are discovering its applicability, and also because it's now being offered as a more complete, practical system, Ely says.

"OEMs, who began buying relatively simple CPUs to use as controllers, now frequently put a whole computer system in their product. They build sophisticated computer-controlled systems into products that formerly would have received no more than a simple disc-based unit.

"We see a lot of new business in the energy-related industries. We are selling computers to OEMs who sell to exploration companies, service companies and manufacturers of drilling equipment. There are a large number of small technically based companies that serve the energy field that are in a rapid state of growth today.

"A great deal of training and patience are required by the user of today's minicomputers," Ely says. "I personally think that HP has done a good job in this area, but we're going to do even better." ■■

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2N6306	250	16	15/75	3.0	0.8	3.0	125	6/4
2N6307	300	16	15/75	3.0	1.0	3.0	125	6/4
2N6308	350	16	12/60	3.0	1.5	3.0	125	6/4
2N6542	300	10	7/35	3.0	1.0	3.0	100	7/8
2N6543	400	10	7/35	3.0	1.0	3.0	100	7/8
2N6544	300	16	7/35	5.0	1.5	5.0	125	1/1
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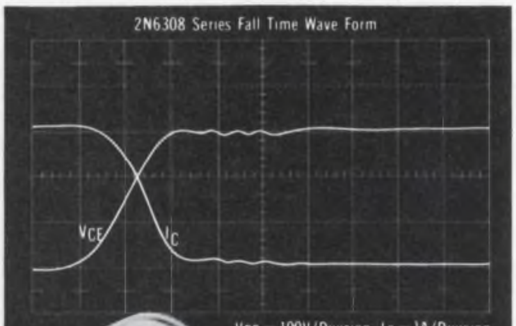

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COMPUTER '75

Automated industrial controls not yet ready to go it alone without guidance of humans

Morris Grossman, Associate Editor

Can man be designed completely out of automated industrial systems?

From the standpoint of hardware, there are no insurmountable obstacles. But from the standpoint of practicality, it does not appear feasible today.

As Ed Aldredge, manager of process computer systems of Union Carbide, South Charleston, WV, explains it: "An operator is usually required for start-up and shut-down procedures. Further, a human observer is better able to head off trouble by anticipating trends and interpreting relationships not defined in a computer's program. He is also concerned with adjustments for subtle changes in raw materials and unprogrammed deviations of operating conditions."

For example, a baking ingredient such as yeast may vary with season and the supply source. Sara Lee's engineering department head, B. L. Weller at Deerfield, IL, says that these variations can't be predicted by computer. Dough twisting continues to demand human control, though Sara Lee's baking facilities are otherwise highly automated with a Honeywell 610 computer control for batching and other baking processes.

Since humans are still essential, even with computer control, the man/machine interface must be designed to accommodate man's limitation and strengths. A display must show all critical variables, but at the same time it must avoid overloading the operator.

Alarm priorities must be clearly defined and corrective actions unambiguously indicated. A primary failure can cause many other variables to exceed their limits. But only the most critical should be displayed at first by a well-designed control panel. To show all could confuse the operator and lead to incorrect reactions.

As logs are measured in a sawmill, a PDP-8 tells an operator of a four-blade saw which sizes and lengths to select to get the maximum yield of usable lumber.

Similarly for trend evaluation. The challenge is to provide sufficient information, but not too much. Excessive signals can easily hide significant variations, because there is just too much to watch.

Help for the man/machine interface

For operations likely to occupy the eyes and hands of an operator fully, Threshold Technology

Inc., Cinnaminson, NJ, provides its VNC-100, a voice-input control system. The desk-top-sized VNC-100 can be "taught" to recognize and identify an assigned operator's voice. And this voice data can be stored in tape off-line. The voice converter is trained simply by repetition of each word in a vocabularly about five to 10 times.

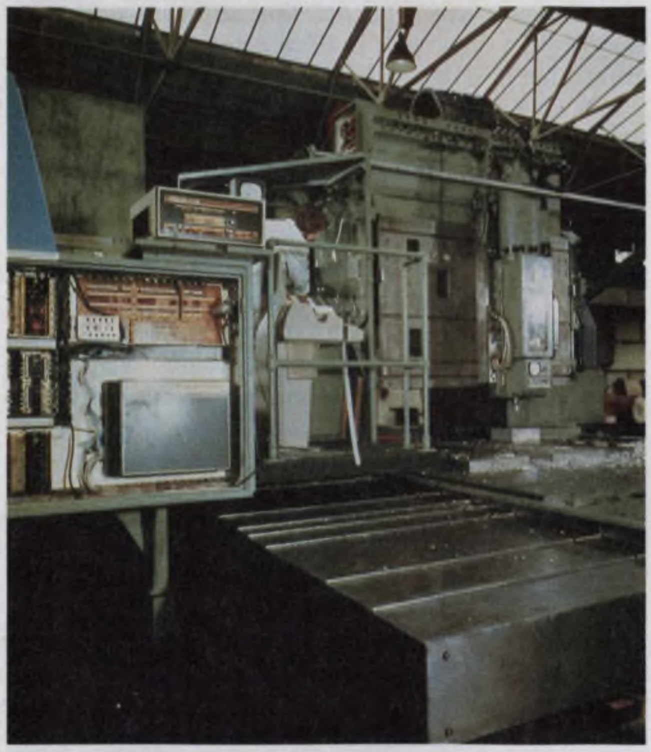
Unskilled factory personnel can read data into a computer, direct the operation of a computer-controlled manufacturing or testing process. And skilled machine programmers can prepare programs in ordinary English for, say, a numerically controlled (NC) machine tool. All this while the programmer is making observations, adjustments, calculations or handling prints, charts or tools.

"Future shock" is another serious man/machine problem to confront automation designers and vendors, especially in the conservative machine-tool industry. Paper-tape numerical control (NC), the newer computerized numerical control (CNC) and its hierarchical superior, direct numerical control (DNC), have induced "computerphobia" among machine operators, according to GE's, NC manager, James Conley. "GE's cure for these fears," says Conley, "is to make the control interface to at least look familiar as in its Mark Century 1050 Microprocessor CNC. Also the diagnosis software is in English; not in a computer code.

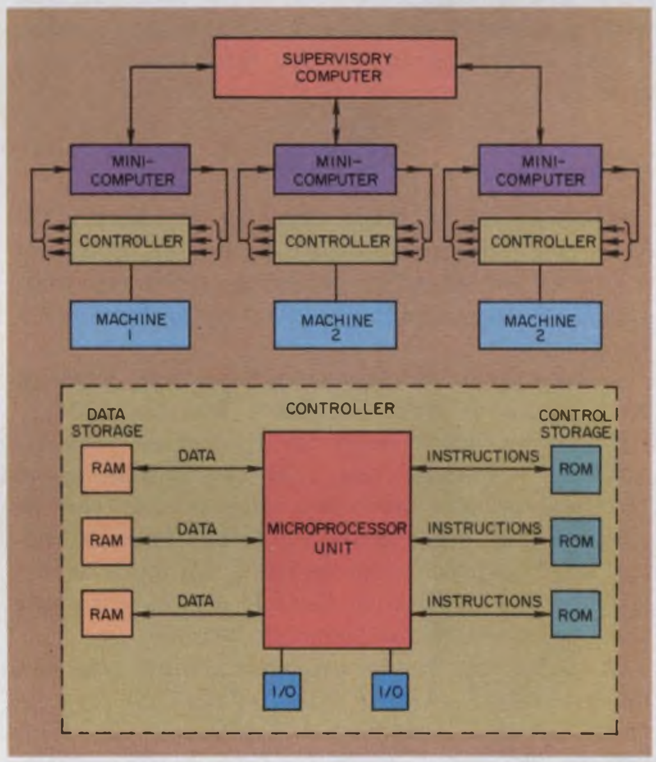
"The microprocessor is going to play an increasingly important role in the lower levels of hierarchical control systems," explained Conley. "The slow speed and limited memory in microprocessors are adequate for a small number of control loops. The 1050 is configured as a distributed processor, where several microprocessors work together, each on a specific task. However, all microprocessors share one data bus and main memory system. But in spite of advances in CNC equipment, the tape and hard-wired controller are going to be around for a long time," he predicted.

DNC, in its ultimate implementation, is a hierarchy of computers from large central general-purpose machines to individual NC, CNC or merely controller-equipped machines. Such a system is the control of a fully automated factory. A master library of parts-making programs, stored in a central memory bank, is distributed, when directed by the central computer, to individual machine controls. Even the conveyer system that moves the parts between machine stations is centrally controlled.

This ultimate implementation does not yet exist, but Ingersoll-Rand Co.'s heavy machining center in Roanoke, VA, comes close. Six NC



A large milling machine is controlled by a PDP-14 minicomputer at the Toulouse factory of Aerospatiale, France's largest aircraft maker.



The hierarchy of computers in a fully automated system ranges from a large central unit to local smaller units and microprocessors within controllers.

machine tools—multi-axis milling and drilling machines—arranged around a conveyer transfer system, under control of an IBM 360/30 computer, can make as many as 16 different kinds of metal parts. Just three operators and a supervisor run the entire complex. An equivalent conventional machine shop would need about 30 manual machines and 30 operators to do the same job.

However, there are few such installations. The main reason lies in the economics of parts manufacturing. Few companies are willing to risk the huge amount of money needed to find out if large DNC systems are reliable, economical and flexible enough to accommodate future changes.

In the meantime low cost systems, such as GE's Mark Century 550 Series, are the trend. The 550M, for instance, can be fitted to a three-axis tool like a Bridgeport milling machine. Most small machine shops have at least one Bridgeport. And this familiar mill, even when outfitted with the 550M's closed-loop NC and tape reader, is not likely to upset the most conservative operator.

Hierarchical steps up and down

Allen-Bradley's Mike Gregory, product manager for numerical-control equipment does not expect to see extensive growth in DNC this year, although Allen-Bradley continues to build such systems.

A step up in hierarchy from a single-machine NC system is Allen-Bradley's Bulletin 1795, a DNC supervisory computer. It comes with all essential software. The 1795 can handle up to 16 CNC or NC machines, and it also can be coupled into other manufacturing, process control or data-processing systems. Its modular design is said to make it flexible and to eliminate the need for custom-designed systems.

A step lower on the hierarchic totem pole is a machine such as the Adapt-A-Path CNC system from General Automation, Anaheim, CA. This system, too, comes complete with software. "The Adapt-A-Path, for continuous profile milling, is directed by an SPC-16 minicomputer. The software can perform all the mathematical computations needed to define even the most complex three-dimensional cam surface. The operator need only call it into use," according to Raymon J. Noorda, executive vice president of General Automation. "In addition, the system can match control signals to the characteristics of a retrofitted machine tool's drive system; it can sense tool errors and correct them smoothly; it can drive tools directly from its memory and eliminate paper-tape handling; it can match most program formats, and it allows on-site programming and editing."

But true adaptive control—much publicized at the last three Machine Tool Shows in Chicago—has a long way to go and is not yet off the ground, according to Charles F. Carter, director of product development of Cincinnati Milacron, Cincinnati, OH. However, he sees practical technical gains in all levels of numerical-control hierarchy in 1975, even in hardwired NC. "CNC still offers more than NC. But, meanwhile, many of the sophisticated features of CNC are filtering down to NC. Also programmable controllers are starting to be improved by the use of microprocessors."

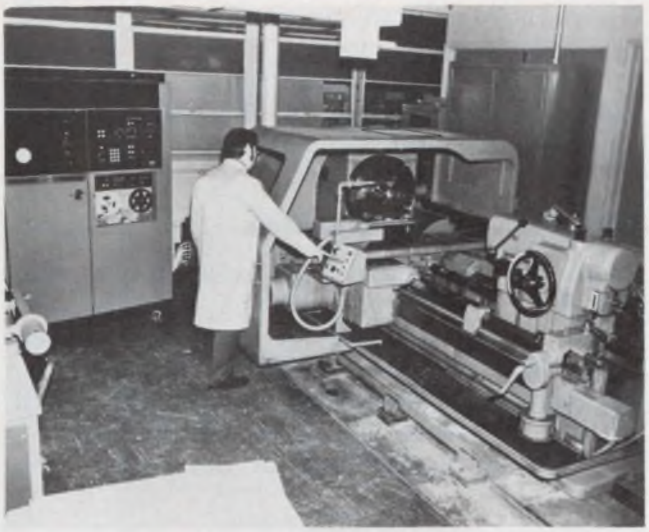
Minis in the hierarchy

The direct centralized control system can suffer from a host of problems. Some of these are:

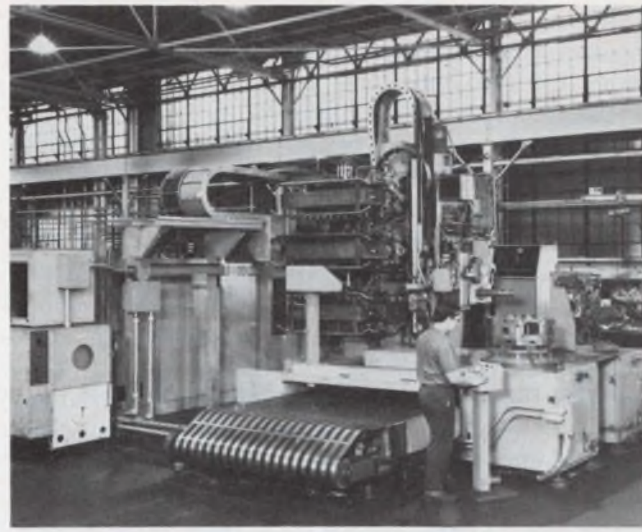
- Widely dispersed operations. The plant might be spread over a large area, and data communications equipment is expensive and error prone.
- Changes are difficult. The addition or modification of a process requires a lot of reprogramming and possible downtime.
- Vulnerability to catastrophe. A breakdown of the central computer can stop all operations, despite major efforts to prevent them.

By contrast, a system that is designed around independent minicomputer-controlled subsystems can carry on, even if a central control might be down. Also, in the initial design and build up of such a large system, the use of minicomputers makes it easier to concentrate on one section at a time. As each subunit is made to function properly, it can be tied to the central computer. Further, with a hierarchy using minicomputers, the software for the central-computer can be much simpler than with DNC. The minicomputers al-

Three-dimensional contour cutting with hyperbolic interpolation is directed by General Automation's Adapt-A-Path and its SPC-16 minicomputer.



Computerized numerical control, as represented by GE's 8500 Series, provides a programmable and solid-state output to previously relay-sequenced machines.



Computer numerical control directs Cincinnati Milacron's CIM-Xchanger Series 25HC machine, which carries 90 tools that can be randomly accessed by the program.

low distribution of a great amount of the control intelligence to the local level.

The Inland Steel Co. has taken this approach. It uses PDP-11/45s at local process-control levels. All software development is being done with the view of a future interface to an IM 370 central-control computer.

The computer system is designed to monitor the furnaces. Weighed raw materials, temperature, exhaust-gas composition, level of furnace charge and other parameters are monitored and controlled. Hot spots are detected and corrected, and the composition of the steel produced is predicted and controlled.

The Rock Island Refinery, Indianapolis, also has chosen PDP-11s. But its oil refinery operation, for the present, uses the minicomputers only as process monitors. Operator interaction is via several video and hard-copy terminals.

Again, system designers have taken the step-by-step approach to build the over-all system in small, manageable bits. Rock Island's future plans include an expansion to a hierarchical computer system eventually to perform over-all control over the oil refinery. Controls to be added include those for the tank farm, loading docks, a maintenance work-order system, warehouse inventory and lab instrumentation.

Low end of the totem pole

"The programmable controller, at the simplest end of the machine-control spectrum, is expected to outstrip its past growth in 1975," reports Allen-Bradley's Mike Gregory, product manager for NC equipment, Cleveland. And he foresees that "the programmable controller is a perfect application for the microprocessor. Their computing and sequencing capabilities will make them cheaper and more powerful in the 1975 to 1980 period."

But the microprocessor is not a minicomputer. It isn't a number cruncher. It has comparatively long instruction times (0.5 to 5 μs for minis vs 10 to 30 μs for micros) and short instruction sets (to 150 instructions for minis vs 50 for micros).

"Nevertheless they add a new dimension to the availability of 'intelligence' at the controller level of machines," explains John Underwood of Industrial Nucleonics, Columbus, OH. "We have taken advantage of microprocessors in our thickness controller, the AccuRay 510, a radioactive isotope based thickness gauge. It uses an Intel 8008 microprocessor in the initial field-test units, though future versions may use the 8080. Desired thickness is preset with dials, and the controller's output regulates the thickness of sheet metal during the rolling process."

Many more announcements of such microprocessor applications can be expected in 1975. In particular, solid-state controllers for NC machine tools are ripe for conversion to the use of microprocessors. However a very large population of machine tools have yet to be changed from electromechanical-relay to solid-state controllers.

Conversion to solid-state controllers

Computers can be made to interface with relay controllers. "But a controller made of the same components as computers—logic gates and solid-state or magnetic memories—can do a better job," according to Kenneth Jannotta, product administrator of the Eagle Signal Div. of Gulf & Western Industries, Inc., Davenport, IA. "And the same solid-state controller can be used on many different machines, or sequences can easily be changed merely by a change in program."

"Eagle Signal's Controlpac 600 can be thought of as a logic system with many solid-state logic gates, instead of relays, which can be arranged in almost any desired order," he says. "The size of its program memory and the number of required inputs and outputs are the only limiting factors. And the 600 can be expanded to meet almost any requirement."

Allen Bradley's Bulletin 1755 Mini-PMC controller is in many ways similar to the Eagle Signal unit. The 1755 provides a maximum capacity of 62 input/output functions and also features pushbutton programming that can edit, search and clear. An option is available to print or punch hard-copy outputs. The memory-loader unit displays system status, and it also serves to diagnose problems.

With controllers such as these, computers can now interface machine tools with mutually compatible circuits. And because of the controllers' programmable features, machine manufacturers no longer need specialized controllers for different machines, nor do they have to rewire a machine's controller when sequence, interlock or other changes must be made.

Computers control power networks

Power utilities use computers to help control their networks. Again, the system is usually not under direct computer control, except for special, well-defined routines. In a peak-load period, a dispatcher may be called upon to make as many as 20 decisions an hour. He may have to start or shut down a generator, redistribute the load among several generators, or be required to take a transformer out of service for inspection or repair. A computer can clearly help, but it also needs human guidance.

To take a transformer out of service with the help of a computer, the dispatcher calls up a diagram of the section of the network involved on a cathode-ray display. He checks the load flow and availability of reserve transformers or load paths. A light pen directed at the displayed equipment symbols can select the switches to be open or closed and the transformers to be used. The dispatcher uses an alphanumeric keyboard to direct specific actions.

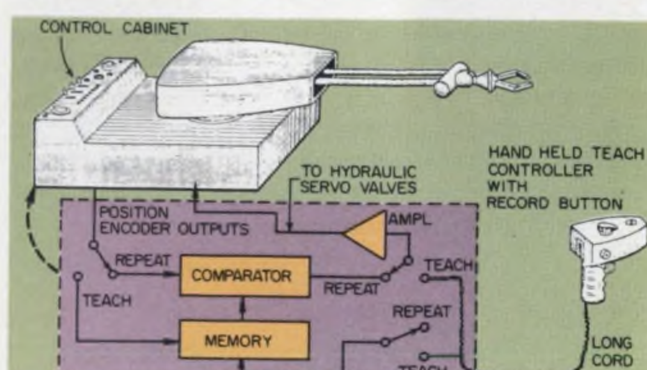
The operation is protected by the computer with security, logic and load-limit checks. The computer determines the consequences of all directed actions. If the computer approves, an appropriate display gives the go-ahead, and only then is an execute command effective.

The desired sequence—disconnect of a given transformer—is then automatically carried out in proper sequence by the computer program. The successful conclusion of the operation is logged on printed records, filed in the computer memory and indicated on a screen.

Electricity users need computers

Both users and producers of electricity can employ computers to optimize their systems. Nick Wells, product manager of Digital Equipment Corp., Maynard, MA, estimates that "you can cut your plant's electric bill by 10 to 20% without any effect on your manufacturing capacity or efficiency." In dollars, this can be very con-

Programmable controllers, such as this Eagle-Signal CP600 with solid-state circuitry, are replacing the conventional relay-sequencing controller.



Today's robots must be "taught." A skilled worker must take them through the paces. Future robots will be "choreographed" by software.

siderable, with today's high kilowatt-hour costs.

Power companies determine their customer rates both by power consumption and peak demand. High demand for only a half hour can raise the power charges for the whole month. And unusually high peak demand in one month may influence the charges for the next 11 months. The high-demand rate can cost as much as four times the rate for uniformly distributed power.

"A computer-directed power-demand control system that can cost between $20,000 to $60,000 can save its cost in six to eight months in a plant with about a $200,000 electric bill, especially if it is subject to highly fluctuating power demands," according to Wells.

Such a system can be programmed to shed and restore loads automatically. Certain heavy loads, such as those associated with air-conditioners, space heaters, some fans and lights, can be safely interrupted for 15-to-30-minute intervals on a priority basis. Of course, operator intervention can modify the program on-line to change shed/restore priorities and on/off time limits.

The robots are coming

While some system designers are deliberately designing man into their system, others are diligently trying to design him out.

A new bulletin of the National Bureau of Standards, *Dimensions*, says that the 1980s promise to be the decade of the robot. Today they can perform only very simple things.

"The industrial robots in use today are only pick-and-put devices," C. A. Rosen and D. Nitzan of Stanford Research Institute, Menlo Park, CA, note in a paper. "They are limited to simple activities, such as loading and unloading presses, stacking parts, spot-welding or paint-spraying. A major limitation of these robots is their lack of anything but the most primitive sensory feedback. No commercially available industrial robot has visual-ranging or tactile-force sensors."

Thus today's robots can't determine the position or orientation of parts for inspection or assembly tasks. Many laboratories in addition to SRI, such as the Charles Stark Draper Laboratory, Cambridge, MA, and IBM's Thomas J. Watson Research Center, Yorktown Heights, NY, are engaged in research and development work in this area. SRI is working to develop computer programs that can control manipulators with visual and tactile sensors to perform tasks of simple inspection and assembly.

Two IBM researchers, David D. Grossman and Peter M. Will, report that no language exists for describing the choreography of part motions or operations, especially to direct assembly tasks.

"We fail to realize the subtle complexity of moving," they say in a paper. "There is evidence that these difficulties may be fundamental, because motion is controlled by the right-hand functions of the human brain, and language and logic by the left-hand. Thus there is a schism between language and nonlinguistic motion—at least in human terms." Of course, some existing computer languages do control motion, but they are restricted to the limited motions of numerically controlled machine tools or handling equipment.

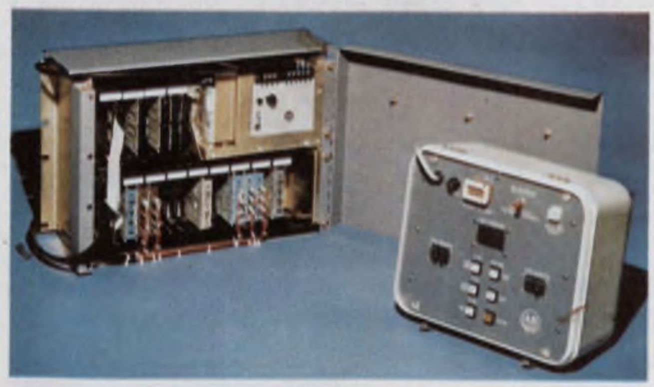
"At the present time, to get around this lack of language, a "robot" is "taught" a job, instead of being preprogrammed with a computer language," says J. Engelberger, president of Unimation, Inc., Danbury, CT. "The machine is led through the operation by skilled operators and the motions digitally recorded. Then the recorded behavior can be played back repeatedly."

Unimation produces such teachable programmable machines—loosely called robots. The wrench-articulated arm of a $20,000 to $50,000 Unimation robot can be taught to perform up to 1000 steps.

Unimation also is studying tactile sensors and the use of a TV camera or laser range-finder to tell the robot the shape, orientation and distance of objects.

No major technical barriers are apparent to building, in the near future, robot factories that can build robots.

"But the potential for major social disruption by such an advance could be far more profound than was the original Industrial Revolution," according to Engelberger. "Between now and 1984 a 50 to 80% reduction in the number of needed factory metal workers can be expected. However, industrial robots also will create new and better jobs. Workers' jobs will not be merely eliminated, but rather redesigned to be less routine, tedious and dangerous." ■■



Pushbutton programming on this programmable controller made by Allen-Bradley, the Bulletin 1755-Mini-PMC, can sequence 62 input/output functions.

COMPUTER '75

With new, powerful software, designers can 'see' a system work before it's actually built

Seymour T. Levine, Associate Editor

Today's computers allow designers to conceive, analyze, test, troubleshoot and even lay out an entire system without leaving their terminals.

Most of these computing systems include conversational programs—almost all of which discourse with the designer in his own terms: nodes, branches, gates, currents, semiconductors, even whole chips. This powerful software needs minimal computer background; the computer does most of the translation from engineering notation to computer-usable form. Analog design programs range from dc to microwaves, and digital design covers gates to microprocessors.

Admittedly the best available programs emphasize coverage of analog circuits more than digital. But a designer has many alternatives from there. For those with some computer-programming experience, the enhancements for the latest dialects of Fortran, Basic and APL make it easy to write your own analysis routines. A recent innovation of most of these languages is their ability to operate on input data that resembles English-like statements and turns them into mathematical variables needed for solutions.

Another useful tool, especially for the designer of digital systems, is simulation language, such as IBM's GPSS V (General Purpose Simulation System V) and Rand Corp.'s Simscript II. These languages are more abstract than circuit-design languages, but they can easily represent, trace and catalog sequences of events in a complex digital

Computer-aided designs often start with a spec and end with complete PC board layouts. RCA uses Applicon graphics terminals to master the layout problems associated with complex MSI and LSI components, after CAD programs verify the design.

Service centers with multiple computer systems form the backbone of Control Data's Cybernet. The computer network offers time-sharing access to design programs on user terminals, as well as allowing user computers to augment their processing power with the network.

Common terms

Assembly language—A machine-oriented language based primarily on a one-to-one relationship between machine instructions and user-supplied source code.

Batch Environment—A situation in which the computer receives instructions and program(s) from a terminal or other peripheral device, then executes the requested operations at its own convenience.

Breakpoint—A place in a computer program where the program can be stopped by external intervention during execution, such as from the operating system. The user can then examine registers and memory locations, alter data generated by the program and even request that execution resume from that point.

Compiler—A computer program that translates source program statements to executable machine code.

Delimiter—Any means used to separate data items at input. Most frequently used are spaces or commas. The delimiter for the two integers 123 678 is the space between them.

Interactive environment—A situation in which a computer continually responds to the user upon receipt of directives from his terminal.

Interpreter—A computer program that translates and executes each source instruction separately.

Microprogram—Stored routines in CPU control memory that define machine instructions as a series of elemental steps to be executed by the processor's control section.

Operating system—A collection of software that schedules jobs, assigns resources such as peripherals, manages all data transfers between computer and its peripherals, and then performs various housekeeping functions.

Source program—The statements written by the programmer, usually in a language convenient to the expression of the problem.

String—A contiguous set of memory addresses each of which contains a single alphanumeric character. The string "TODAY IS COLD" occupies 13 bytes in IBM equipment, which includes the two spaces between words. Strings are often enclosed in quotes when written in program statements.

controller or even a bipolar CPU module.

The wide availability of advanced microprocessors has created a need for software tools to accelerate their programming. Often referred to as assemulators or cross assemblers, these run on large computers and are neither logic design programs nor languages. And each assembler is tailored to a specific microprocessor. The assembly language text is inputted in the same form used by the microprocessor. The program then permits editing of the text and simulation of the action of the processor.

Gather your data together

Engineers may also benefit from software designed to help business cope with ever increasing amounts of data. This need has spurred the development of management systems for organization, maintenance and retrieval of data in large computer data bases. Data-base systems allow the designer to collect data from many simulations. The computer can then be directed to organize the data by specific characteristics or to report exceptions to expected results.

In choosing design programs, you will find that the most comprehensive packages work with the largest systems—either in-house or at service bureaus. But bigger is not always better. Large computers have complex operating systems. In the event of an error, the diagnostic messages require considerable software expertise to interpret, and the time spent in debugging can outweigh the time saved in problem preparation.

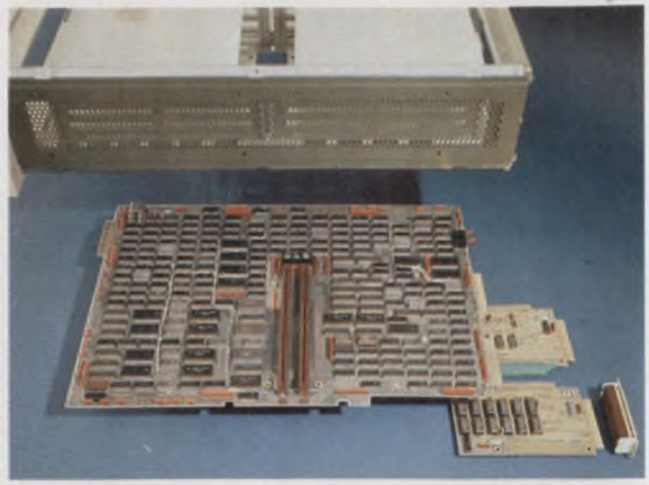
On the other hand, minis and calculators feature simple user commands and responses that sharply reduce debugging time. However, the problem must be inputted and solved in more piecemeal fashion than with the maxi. Many engineers find this a very cost-effective approach.

In a sense, time-sharing services offer the best of both worlds—simple conversational debugging combined with access to large computers that can handle the advanced packages. The penalty, of course, is price. This is not the cheapest way to do things; but it can serve as a good introduction to what's available. Convenience is another factor. Widely separated users of time-sharing can jointly participate in a problem's solution over the vendor's national or even international computer network.

Analog circuits are easiest to analyze

Applications software for the designer covers a broad spectrum. Continuous systems, as represented by analog circuits and microwave networks, present little difficulty. The algorithms are fast, thorough and highly developed.

Digital systems programs, while effective, usually work on a gate-by-gate level. And a large board of MSI can easily saturate the facilities provided. But work on discrete simulation is progressing. Some of the newer programs can deal



Flexible high-level languages can be used to design computers. Algol-based assemblers written on the HP 2100 were used to develop the microcode for the HP 21MX. String processing is an important feature.

The arithmetic prowess of programmable calculators makes them a natural for CAD. HP's 9830A (left) executes a comprehensive microwave design program called BAMP, and Tektronix offers microwave software on its Model 31 (right). The use of graphical peripherals plus programming ease help make calculator systems popular design tools. Graphics tablets can also be used with some of these units.

with these circuits on a higher level—namely on the basis of register-to-register data transfers. It is on this level that one usually designs controllers and CPUs.

Analog circuit analysis programs for large machines have a common input language and can perform dc, ac and transient analysis in a single program. Although all these capabilities existed even in 1969, the user had to provide separate descriptions to several programs to obtain the same results, and the number of elements seldom exceeded 200. Today's programs offer rapid execution of networks of up to several thousand elements. With IBM's ASTAP (Advanced Statistical Analysis Program), a 1041-element network executed on a System/360 Model 85 uses a total of 180 s, of which the setup accounts for 162 s.

Most circuit analysis programs perform time analysis through state-space techniques. To gain speed, the associated matrices are handled with sparse-matrix techniques—that is, the program skips over zero elements in the state matrix instead of computing with them.

Another technique—implicit integration—permits the use of large time steps, if the necessary integrations converge. Together these techniques often boost execution speed by a factor of 10, compared with the speeds attainable with ECAP and SCEPTRE, which, incidentally, still find wide use.

Circuit-analysis programs work well with nodes and branches—but what about servo mechanisms? IBM's CSMP III offers input descriptions in terms of integrators, summers and other analog-computer paraphernalia. Like ASTAP, the program performs time analysis with state-space methods; however, the sparse-matrix and implicit-integration techniques are not available.

Thanks to a head start on computer analysis plus ready availability of good algorithms, single analog circuit packages can perform a broad variety of analyses (see "Linear Systems Analysis Simplified," ED No. 11, May 24, 1974, pp. 70 to 78).

Commercial packages, especially on time-sharing services, go even further. Tymshare's version of SPICE adds dc analysis, white-noise generation, transient analysis, sensitivity and temperature variations. General Electric's version of ECAP includes ac, dc and transient analyses, as well as sensitivity. IBM's ASTAP includes most of these features and adds Monte Carlo statistical analysis. The analysis helps predict changes in network performance with variations in component values.

SPICE is a very unusual circuit design program offered by National CSS, Stamford, CT. The program features a miniature operating system that allocates and releases memory dynamically. Combined with virtual memory, the program allows the user to simulate circuits of staggering complexity. The largest to date had 2000 bipolar active elements. The original version of SPICE, written at the University of California at Berkeley, had a capacity of 400 nodes and 100 transistors.

Computer optimization of circuit parameters is another feature that helps smooth the design procedure or, at the very least, assists in choosing component values. As a rule, the optimization procedures prove most effective in the frequency domain. The mathematics is straightforward and the computer does not have to calculate an entire transient response for each iteration. Also, some of the algorithms used for linear programming carry over, since the entire system can be described in matrix form with constant coefficients.

Practically all programs for CAD offer built-in models for bipolar transistors, FETs diodes JFETs and MOSFETs. SPICE offers the user Ebers-Moll or Gummel-Poon for bipolars; Hodges and Schichtman for MOSFETs and junction diode or Schottky-barrier versions for diodes.

Know the circuit model used

For critical simulations, you will have to know which model best describes the device to be analyzed. Spec sheets for the various semiconductors do not provide numerical values for use with the models. If you can't get values for the 10 to 24 parameters involved, the vendor's software will insert default values. It's up to you to know if these serve your application.

As a rule, the algorithms used work very well with nonoscillatory circuits. However, bilevel circuits, such as Schmitt triggers, can cause the program to hang up. Dc analysis can be stymied by bilevel circuits as well. Ask the vendor what the program action is, in this event. In some cases you can intervene and adjust the time step or initialize the circuit to a stable state. In other cases the program stops execution, and the values obtained are not guaranteed as to accuracy.

As the chart shows, many CAD programs run on large mainframes, often in a batch mode. These require slightly greater programming skill on the part of the user than similar products on time-sharing services. For example, ASTAP provides for the insertion of user defined functions, to be written as Fortran function subprograms—thus implying some skill with that language. Tymshare lets you define models in component blocks. Another language, CSMP III, accepts modules in the form of Fortran subroutines when in a batch mode, but it has been adapted by Tymshare to accept input in the form of a connection list and description of blocks made up of CSMP elements.

Logic design programs are not quite as sophisticated. Despite wide use of MSI and LSI devices, most of the programs treat logic on a gate-by-gate basis when in fact a single MSI chip accounts for hundreds of gates. There are several reasons why. For one thing, time-sharing vendors say most programs offered to them are not debugged enough for general use. Some engineers feel they can visualize the operation of complex logic without a computer because only ONEs and ZEROs are involved. Finally, analog theory predates digital by 10 years and is well publicized.

The Logcap simulator is probably one of the most advanced. Instead of using collections of gates, it permits the insertion of transfer-function macros for shift registers. The program is available from National CSS in time-sharing and from RRC International in package form (see chart). As a rule, the logic simulators can produce timing diagrams, mimic propagation delay and detect spikes. University Computing Co., Dallas, TX, series of programs includes test-pattern generation and fault isolation.

Test programs such as CAFIG from Bendix Corp. make use of Eichelberger's theorems (see "Algebra Finds Logic Circuit Glitches," ED No. 4, Feb. 15, 1974, p. 90) to check for logic glitches. Three-valued representations of logic—ZERO, ONE and Indeterminate—figure prominently in many checkout algorithms. CAFIG which stands for Circuit Analyzer and Fault Isolation Generator, finds digital input patterns with which to test a given logic board. In addition, the program computes the output pattern for each input pattern and specifies a replacement fault output for a given simulated fault. The program handles 1000 gates on a 20-bit mini, the BDX

Sampling of commercially available design programs

Category	Program name	Type of analysis performed	Models used	Source	Language and Machine	Time-sharing vendor
Circuit modeling and analysis	OPTINET	Ac steady-state analysis; sensitivity analysis; circuit optimization	Network elements; cataloged circuits	RRC International, Troy, NY	Fortran IV; IBM 360/67	Request from originator
	UCCAP/ SCEPTRE II	Dc failure analysis; transient analysis; nuclear environment simulation; worst-case and others. Keeps up with Air Force Sceptre II releases	Ebers-Moll nonlinear semi model; passive circuit elements	University Computing Co., Dallas, TX		
	I/TRAC3	Transient, dc, radiation and ac analysis; optional worst-case and Monte-Carlo	Ebers-Moll semi models; passive circuit elements	Berne Electronics, White Plains, NY	Fortran IV IBM 360/67; DECsystem 10; CDC 6600 and others	—
	Digital Filter Design program (24 programs)	Determines coefficients for low-pass, bandpass, band-stop and high-pass digital filters. Produces closed loop designs from one of three Z transforms	Five prototypes: Butterworth Bessel Butterworth-Thompson Chebyshev Elliptic	Technology Service Corp., Santa Monica, CA	Fortran IV; CDC 6000 XDS Sigma 5/7 DECsystem 10	—
	ASTAP	See text	Network elements and stored models	IBM (contact local sales rep)	Fortran IV IBM/360 and 370 series	—
Logic	LOGCAP-2	Simulates logic networks with up to 30,000 nodes. Handles rise and fall delays. Has three-state simulation; generates test programs	Gates; one-shot high-level algorithmic models MSI/LSI library	RRC International, Los Altos, CA	Fortran IV IBM/360 and 370	National CSS, Norwalk, CT
	I/LOGIC	Simulates logic networks. Produces timing diagrams at point of charge or at equal intervals. Detects races and hazards	Blocks that include FF's one-shots and gates. Up to eight inputs per block	Berne Electronics, White Plains, NY	Fortran IV IBM 360/67 CDC 6000 DECsystem 10 and others	—
	LOGSIM III	Simulates logic networks; detects spikes; has on-off delay option; simulates stuck at ONE or ZERO	Gates, shift registers r/w memories, flip-flops, etc.	Software Products Co., Hope, MI	Fortran IV	LOGSIM II available from University Computing Co., Dallas, TX
	CAFIG®	See text	Logic diagram	Bendix, Teterboro, NJ	Assembly; BDX 6200 mini	—
	D-LASAR	Generates test patterns that detect 95% of failures	Input schematic internally exploded to NAND gates	University Computing Co.	Fortran and assembly	University Computing Co.
	DLG	Evaluates stimulus patterns to generate fault dictionary with resolution to 1.2 ICs	—		Univac 1108	University Computing Co.
Microwave	COMPACT	Optimizes microwave passive and active circuits; works in frequency domain; manipulates up to 15 parameters. Provides circuit analysis, stability analysis and sensitivity analysis	Two-port scattering or Y parameters	Compact, Los Altos, CA	Fortran IV; IBM 370/158 CDC 6600 DECsystem 10	United Computing Systems, National CSS, Tymshare
	MAGIC (useful from near dc to microwave)	Performs constrained optimization with element values adjusted between specified minimum and maximum size	Resistors, capacitors, inductors stubs and transmission lines. Present limits—100 branches, 50 variable elements, 100 constraints, 40 frequencies	—	Univac 1108 Fortran and assembly	University Computing Co., Dallas, TX
	BAMP	See text	Two-port scattering matrices	Hewlett-Packard	HP-2100 (mini) HP-9830A (calculator)	General Electric Mark II
	TWA-3	Traveling-wave multi-signal operation in two dimensions. Includes multisignal effects and harmonics	—	Shared Applications, Ann Arbor, MI	Fortran IV DECsystem 10, IBM 360/67 CDC 6600	—

Note: Abbreviated descriptions of many of the programs in this table were abstracted with permission from the ICP Software Directory, Vol. 2, Jan., 75, publ. by International Computer Programs, Carmel, IN

6200, and uses 16-k of core.

BigSim, a program used with Computer Automation's Capable 4900 tester (which uses a 64k Alpha LSI-2 mini), similarly takes a description of the circuit in terms of logic elements and gates, then generates random input patterns to be used for acceptance testing and fault isolation. The system will accept algorithms for registers.

Specific programs for large machines that perform these and similar feats include Logcap-2 from RRC International and D-Lasar from University Computing Co. (see table).

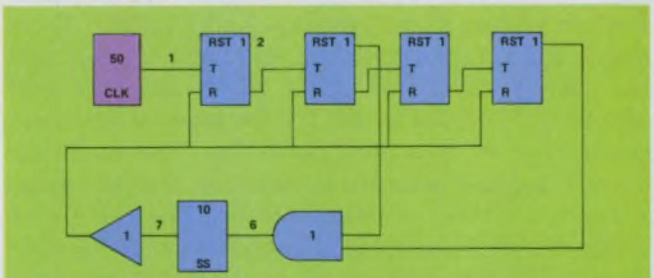
Microprocessor design thrives interactively

The newer class of logic programs and languages don't deal with logic at all. And they work almost exclusively in a time-sharing environment. They mimic microprocessors and permit the user to view the effects of his programs in advance. These vendor-supplied programs consist of two major subdivisions: assembler and simulator. Initial input consists of assembly-language statements for the target microprocessor inputted from a user terminal. Mainframe programs allow editing of the source text and then pass the code to a simulated assembler, where the user receives useful error messages. Once the errors are corrected, the user can have his code executed by a simulated microprocessor. The simulator permits examination of the simulated processor registers and selected memory locations. And the simulator usually offers instruction traces, while the simulated processor executes and permits the user to have the simulation stop at prearranged breakpoints. Peripheral-device simulation is limited.

Once the designer is satisfied that his program performs its intended tasks, he can request a binary tape for transfer to the microprocessor chip programmer.

One thing to remember is that the time-sharing vendor did not write the program the microprocessor vendor supplied; hence there is a surcharge for use of the packages. At present such packages are available for a number of chips, including the Intel line (4000 and 8000 Series), National Semiconductor (IMP 8, 16), Rockwell International (PPS Series) and RCA (Cosmac). Time-sharing vendors that offer this service include Tymshare, General Electric and National CSS. Zeno Systems of Santa Monica, CA, offers the assembler portion for the Intel chips to use on the DECsystem 10. An assembler from Innovonics of Silver Spring, MD, handles the Intel 8008, 8080 and DEC's MPS series with a PDP-11 mini. Both the Innovonics and Zeno programs are interactive.

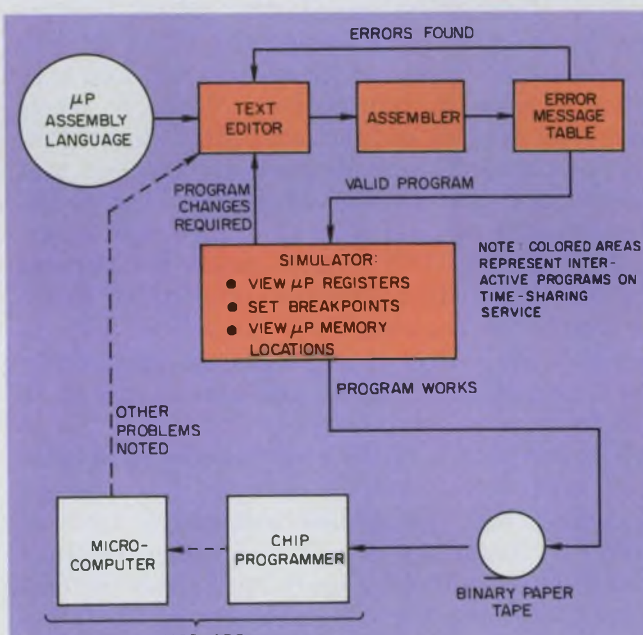
The trend to minicomputer and even calculator-based design algorithms is particularly notice-




```
-TYPE RST

1,CLK,50,T
2,RST,1,1,F,-8
3,RST,1,-2,F,-8
4,RST,1,-3,F,-8
5,RST,1,-4,F,-8
6,AND,1,3,6
7,SS,1,10,6
8,INV,1,7
9,OUT,20,1,1,2,3,4,5

- LOGSIM

: INPUT

INPUT FROM: RST

: RUN
START TIME = 0
FINISH TIME = 900
```

```
          BLOCK NUMBER
 TIME  1   2   3   4   5
      01  01  01  01  01
   OS 1   1   1   1   1
   70  1   1  1   1   1
  120 1    1  1   1   1
  170  1  1    1  1   1
  220 1   1    1  1   1
  270  1   1   1  1   1
  320 1    1   1  1   1
  370  1  1   1    1  1
  420 1   1   1    1  1
  470  1   1  1    1  1
  520 1    1  1    1  1
  570  1  1    1   1  1
  620 1   1    1   1  1
  670  1   1   1   1  1
  720 1    1   1   1  1
  770  1  1   1   1    1
  820 1   1   1   1    1
  870  1   1  1   1    1
  920 1    1  1   1    1
 950F  1   1  1   1    1
  900  STOP AT TIME LIMIT

QUIT
```

A conversational environment geared to the needs of the engineer helps make CAD cost-effective. An almost 1:1 translation of circuit to computer input takes place with the LOGSIM program, shown executed on the Tymshare network.



Microprocessor assembler simulators offer 60 to 80% assurance that the final product will work. These interactive programs accept microprocessor assembly language, permit editing of the text and then let you debug the software on a simulation of the microprocessor. A binary tape of a successful program is burned into PROM or ROM.

able in microwave design. BAMP, a Hewlett-Packard algorithm executes on General Electric's Mark II service, the HP 2000/S mini and the 9830A calculator. This Basic Analysis and Mapping Program treats the problem as an interconnection of two port networks. The resulting output includes scattering matrices, S-Plane mapping, and circuit stability factor. The calculator easily matches mainframe accuracy with its nine digits. But the speed ratio is about 5:1 in favor of the mini. When the mini is servicing 10 users, the speed advantage drops to 2 or 3:1. The number of two-ports allowed is almost unlimited on the mainframe or mini, but it drops to 60 two-ports for the calculator because of its memory size.

A glance at the chart will show that a number of programs also perform optimization of microwave networks. The reasons are the same as for linear lumped parameter systems. Of the optimizing types, Compact is available on several time-sharing services as well as directly from the vendor. Magic goes slightly beyond conventional optimization, since its parameter selection can be constrained to specific limits.

Once the designer leaves the relatively cozy world of electronics-oriented languages, he can still select from the major high-level languages or from a class of specialized languages designed for multi-discipline use.

Simulation languages, such as Simscript II or GPSS, tend to come with much more comprehensive diagnostics than do the general-purpose languages, such as Fortran and PL/I. If you have the facility to run these, you will find both quite suitable in representing logic or whole computer systems in functional form. Both GPSS and Simscript II provide an event monitor that keeps track of events and advances a clock to the next instant of time when a change may occur.

With IBM's GPSS, which stands for General Purpose Simulation System, transactions (such as data through a computer) move from point to point in the system mode, make use of facilities such as arithmetic units, and can be stored in queues such as cache buffers.

Persons with a fairly good knowledge of Fortran will find Simscript akin to the Fortran language, with augmented statements such as PERFORM (transfers control to a named routine) and IF THEN ELSE (if a condition is true perform some operation otherwise do something else). The remaining features include statements for time advance, event-processing and accumulation of analysis of statistical data. Incidentally, GPSS also provides for similar analysis.

The latest release of Simscript comes from Rand Corp. as Simscript II (1968). GPSS V, the latest IBM version, uses disc-based swapping to ease memory requirements and can interface with PL/I.

Computer buffs continually predict the demise of Fortran and cite its machine dependence, lack of powerful string manipulation statements and awkward use of subroutine statements. But the language is improving. Recent enhancements include the ability to accept strings of characters and to form them into numerical variables and vice versa. For file handling, the user can have the program terminate when it runs out of data cards or when erroneous data are supplied. To further simplify card-data entry unformatted read statements allow integers and alphanumerics to be entered in free style with spaces or commas between each. IBM refers to this as list-directed input; the list is the set of variables named at the READ or WRITE statement.

ANSI keeps languages stable

In addition to periodic enhancements, the Fortran language is one of three supported by the American National Standards Institute; the others are PL/I and Cobol. BASIC is now under consideration. Support by the institute, headquartered in New York, NY, ensures coordination of language changes with continuing review of updates. In some measure this minimizes the effects of moving programs between various machines or the need to rewrite them frequently.

The ability to express strategy with the IF THEN ELSE statement together with string-handling capability and in-house availability made ALGOL the language used to develop microcode for Hewlett-Packard's 21MX minis. A microcode assembler spends much of its time manipulating symbols and specifying the actions to take. The 2100 mini was used as the tool in developing the Writable Control Store Routines for the 21MX. Note that Fortran is only recently acquiring some of this capability, and even now cannot perform comparisons on character strings.

APL deserves much wider use in the engineering community. This gut feeling of APL users stems from the language's origins. Kenneth Iverson originally developed the language, not for computers, but as a means to convey mathematical algorithms more efficiently than is possible in algebraic notation. What Iverson wrote in 1969 was based on elementary matrix multiplication—namely, the product of sums.

Matrix operations make extensive use of two operands—addition (+) and multiplication (×). A typical matrix operation resembles $a \times b + c \times d + e \times f \ldots$

But you can substitute max and min for + and ×, and the procedure results in the shortest path through a set of nodes. Look a little closer, suggests Alan Rosen, vice president and technical adviser of Scientific Timesharing, and you can see row or column vectors that represent processor registers, and then you can define operations that represent functional data transfers.

As to its logic power, Iverson did a complete description of the System/360 computer in 1964, published under the title "A Formal Description of System 360" in the IBM Systems Journal, Vol. 3, No. 3. Also, since the language is matrix-oriented, it's small wonder that MARTHA, a linear frequency-analysis program was written in APL. The program handles microwave circuits and is available in Scientific Timesharing's system.

The type of computer support available can often prove decisive when you're choosing a language or design technique.

With larger time-sharing vendors, such as General Electric, National CSS, Tymshare and Rapidata, the machines form a shared network in which several users in different areas can work on the same problem or segments of it. There is one precaution: FCC regulations prohibit the use of these facilities purely for message transfer.

If you give your imagination free rein, you can easily simulate a network of CPUs. The idea, says Alan Rosen, is to have several people each simulate one CPU at their terminals in APL language. But Scientific Timesharing Co. also allows several users to share a common file simultaneously. Thus, in effect, these people simulate CPUs and the intercommunication between them.

Present Fortran programs tend to be very fast, thanks to optimizing compilers such as IBM's Fortran IV (H Extended) compiler or those available from mini houses like Data General, Computer Automation, and Varian. The IBM diagnostics, however, are best suited for an experienced programmer. Universities use friendlier compilers designed to get students on and off line rapidly. Waterloo University in Waterloo, Canada, offers WATFIV, which returns very descriptive diagnostics that really boost debugging speed. However, these compilers cost about $5000 a year for private use, but are available at a nominal charge to universities.

Microprogramming can influence run times

The advent of microprogrammed computers can play hob with a common argument against interpretive languages like Basic and APL. The argument states that interpreters run slowly because they execute in piecemeal fashion, statement-by-statement. Compiler-based languages such as Fortran run fast because the source statements are converted to machine instructions before execution.

But with microcode, the machine instructions are themselves interpreted through microprograms—so why use compilers?

On current IBM equipment, which is microcoded, APL tends to run three to five times slower than Fortran. However, on the IBM 370/145 users can obtain an APL Microcode Assist. The execution speeds of the APL and Fortran are often equal; sometimes APL outspeeds Fortran by 2:1. But even so, Fortran still affords greater input-output efficiency on mass-storage devices like tape and disc.

If you happen to use Control Data's CYBER 70 or CYBER 170 computers, you can gain expanded processing capability by hooking into the company's CYBERNET services, which offers a very wide variety of circuit-analysis programs. For example, TESS handles up to 601 nodes and 600 elements and performs worst-case, as well as nonlinear transient, analyses. CC-TEGAS3, developed by comprehensive Computer Systems and Simulation of Austin, TX, offers test-generation for digital systems, fault-tolerance analysis and detection of races, hazards and spikes.

The ever increasing processing power of the newest minis has not been overlooked by the software vendors. Interdata's new 8/32, with its megabyte of memory, will shortly house the program called CYCARDS. This is available on Control Data, GTE-Sylvania and National CSS time-sharing services, and it does single or multilayer PC board routings. The program, written by Scientific Calculations, Rochester, NY, handles some 400 components and 3000 pins. Subroutines at widely spaced core addresses communicate easily, thanks to the mini's 32-bit memory-address range.

Calculators are also beginning to get their share of some of number-crunching design algorithms. Like the minis, they present the user with a very friendly environment in which to develop programs. In fact, their low cost, ease of use and excellent numerical prowess often overshadow the simple language offered, such as BASIC or algebraic notation. In addition the calculators readily interface with graphics plotters. The plotting speed often exceeds that of a time-sharing service that is sending at the customary 300-baud rate. ■■

Need more inputs?

For more information on software or time-sharing vendors, the following organizations offer publications and directories:

Auerbach Publisher's Inc., 121 N. Broad St., Philadelphia, PA 19107. (215) 491-8200.

Datapro Research Corp., 1805 Underwood Blvd., Delran, NJ 08075. (609) 764-0100.

International Computer Programs, 1119 Keystone Way, Carmel IN 46032. (317) 844-7461.

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Decimal degrees – deg-min-sec	yes	yes
Polar-rectangular conversion	yes	yes
y^x	yes	yes
e^x	yes	yes
10^x	yes	yes
x^2	yes	yes
$\sqrt{x}$	yes	yes
$\sqrt[x]{y}$	yes	no
$1/x$	yes	yes
$x!$	yes	yes
Exchange x with y	yes	yes
Metric conversion constants	13	3
% and Δ%	yes	yes
Mean and standard deviation	yes	yes
Linear regression	yes	no
Trend line analysis	yes	no
Slope and intercept	yes	no
Store and recall	yes	yes
Σ to memory	yes	yes
Product to memory	yes	yes
Random number generator	yes	no
Automatic permutation	yes	no
Preprogrammed conversions	20	7
Digits accuracy	13	10
Algebraic notation (sum of products)	yes	no
Memory (other than stack)	3	9
Fixed decimal option	yes	yes
Keys	40	35
Second function key	yes	yes
Constant mode operation	yes	no

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COMPUTER '75

Top computer show unfolds in Anaheim with spotlight on new directions in design

It's called the world's largest show for the computer industry—the annual National Computer Conference—and it's rallying May 19-23 in the Anaheim Convention Center around the theme "Challenges in a New Era": the era of the microprocessor, with its impact on computer architecture . . . of new mass-memory systems offering low-cost, on-line storage of a trillion bytes of data . . . of simplified programming that even a non-Ph.D. can understand.

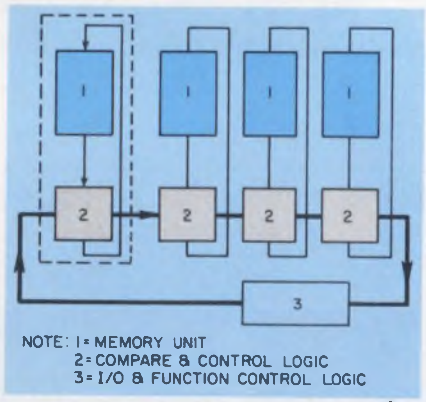
More computer organizations will be represented in the California city this year than were on hand for last year's show in Chicago. The sponsor, the American Federation of Information Processing Societies, says that 269 organizations will occupy 796 booths, against 246 in 812 booths in 1974. Thirty-thousand visitors are expected to attend, compared with 25,909 last year.

Of the 89 technical sessions, about two-thirds are applications-oriented to the end user. The rest are for computer designers.

Topics of particular interest at this year's show include architecture, storage and microprocessors.

Computer architectures that once would have been economically impossible to develop are becoming feasible with emerging microprocessors, the rising level of integration of memories and the rapidly falling cost of memory devices, according to Dr. Ugo Gagliardi, director of Honeywell Information Systems Technical Office, Waltham, MA.

Jules H. Gilder, Jim McDermott and **David N. Kaye,** Associate Editors



A simple arrangement for a sorting memory is shown above. A segment of the bus is extended to become a memory segment. This consists of a memory unit and the compare and control logic. An additional segment is used as the input-output unit.

Gagliardi, chairman of Session 70, "Impact of New Technologies on Computer Systems Architecture," points out that one of the newer architectures that has become practical is the multiple processor structure.

An excellent example of this architecture is given in a Session 76 paper by researchers from Bolt Beranek & Newman, Inc., Cambridge, MA. A paper, "Pluribus—a Reliable Multiprocessor," is co-authored by S. M. Orenstein, W. R. Crowther, M. F. Kraley, R. D. Bressler, A. Michel and F. E. Heart.

Bressler, a senior computer scientist, points out that to exploit the decreasing cost of system components, researchers have assembled collections of units into multiprocessor systems. The Pluribus line of machines, developed as a switching node in the ARPA network, uses 13 Lockheed minicomputers in the largest configuration assembled to date, he reports.

"In this architecture, multiprocessors are used in a network where all the processors are equal with each other. And each can service any job," Bressler says.

He points out that the processors are treated as equal, both in hardware and in software. Consequently there is no assignment of priority among the processors.

The identity of the processor performing a particular task is of no importance, Bressler notes.

The machine software consists of a single conventional program run by all processors. About one-quarter of the program is stored in each processor, with the remaining three quarters in a common memory.

Bressler sees the system, which has a bandwidth of 7.5 Mbits, as suitable for communication schemes, where the computer power is not directed towards extended computations but where modularity and reliability are important. In this system, he points out, no one piece is vital to any given task. If one piece breaks, another takes over.

With this architecture, Bressler comments, the machine can be built in a small configuration to handle small bandwidths, or in a very large configuration for large bandwidths, without any significant change in the program.

A somewhat different architecture is discussed in a Session 76 paper, "Microprocessor-Based Multiprocessor Ring-Structured Network," by Hoo-min D. Toong, assistant professor of electrical engineering and computer sciences at the Massachusetts Institute of Technology.

"The microprocessor has really opened up the area of intelligent networks with data base and resources that are truly shared," Toong says.

"The ring structure is a totally different architecture. In contrast to structures like trees and graphs, it provides for communications applications, reliability, simplicity of design and relatively low cost.

"We're implementing a ring network now in which, in this case, Intel 8080 microprocessors are used as intelligent nodes on a ring structure. But the scheme is independent of the type of microprocessor used."

The microprocessors give a great deal of flexibility in the type of resources that can be interfaced into such a network, Toong says. One resource category is peripherals. Other computers can even be connected into the ring. The "resource" doesn't necessarily have to be a hardware device.

But some of the problems of the ring structure under study are programming language and the operating system in such structures, Toong reports.

At present, he notes, software is a bottleneck. This was true with minicomputers, he observes, and it's now true of microprocessors.

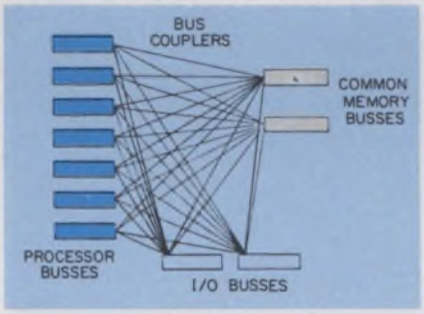
In another paper, Prof. P. M. Thompson of the University of Ottawa, Canada, points out that in a system organized to sort data according to any set of descriptors, the main limitation to speed lies in communication between the parts of the store.

A solution to the communication problem is provided by the segmented bus, Thompson points out in the Session 82 paper, "A Data-Sorting System Using a High-Speed Bus." The segmented bus is used in its simplest form for the sorting array, he notes.

Words are transmitted by being clocked from segment to segment in "carriers" along the bus. If there is an empty carrier, Thompson says, words can be entered at the input-output segments.

If empty carriers are present at appropriate ports, it is possible to enter several words at the same time, Thompson says. And in like fashion, several words can be put out at the same time.

However, Thompson points out, as a word is sent out, its place can be taken by a new input word.



In the Pluribus multiprocessor architecture a novel feature is treatment of all processors as equal units. The hardware is joined together by special bus couplers that permit units on one bus to access those in another.

The advantage of this operating structure, Thompson says, is that the segmented bus permits communication between one pair of ports without preventing it between another pair. Or it can provide communication between several pairs at the same time.

Thompson notes that the whole system, including bus and input/output units are clocked at the same speed. ■■

There long has been a need for a peripheral system with low-cost, on-line storage of a trillion bytes of data, with no manual intervention. With the recent announcement of IBM's 3850 mass-storage system and a new mass-memory about to be unveiled by Control Data Corp., the impact of such huge storage systems is about to be felt throughout the computer industry.

Control Data's hopes for success of the new memory system are based not on parity, but on tangible advantages over the 3850. These include:

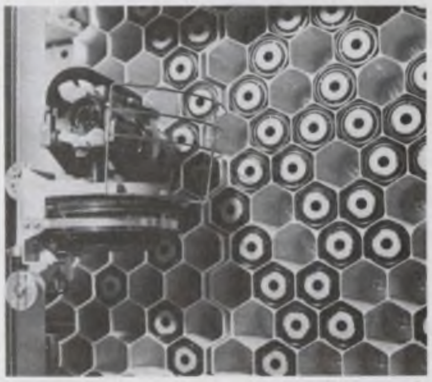
- Faster average access to any byte of information.
- Faster transfer rate of data.
- Plug compatibility with existing IBM hardware.

Information on the new memory system will be spelled out in presentations in Session 48. William F. Morgan, Control Data's executive consultant for peripheral products, points out why a mass-memory system is desirable and what characteristics it should have. A key point he brings out is that it is not at all uncommon for a system to require 2000 magnetic-tape reel mounts a day. This is very costly and time-consuming, he points out, and makes attractive the use of some mass-memory systems that make data automatically available.

Details of the new memory are given by Gary E. Puffett, manager of mass-storage systems at Control Data, in his paper, "A Mass-Storage Facility."

The new system has total capacity of about 21 trillion bytes and average access time of only 7 sec to any byte of information, compared with the 10 sec needed by the 3850.

C. T. Johnson of IBM in Boulder, CO, counters the Control Data assault on IBM's three-month reign by presenting the good points



Vast amounts of data can be stored on data cartridges housed in the honeycomb storage compartments of the IBM 3850 mass storage system. Two cartridges can store the same amount of data as one disc pack.

of its 3850 mass-storage system.

Among the things Johnson notes is that the 3850 has total storage capacity of 35 trillion bytes—14 trillion more than the capacity of the Control Data memory.

And the IBM data-transfer rate is 874 kilobytes/sec, Johnson says. At first glance, this rate looks like an advantage over the Control Data unit. But becasue of lower reliability of the helical-scanning technique used to read out data, the IBM system needs a lot of error correction. This slows the system to an actual transfer rate of about 200 kilobytes/sec.

The Control Data system doesn't have this problem, and its 806-kilobyte transfer rate is the actual transfer speed.

Another interesting feature of the Control Data unit relates to the interfacing of the memory. IBM's 3850 requires a new controller—the 3803. The Control Data memory doesn't. It can plug right into the 3832 controller, which is existing IBM hardware.

The race between IBM and Control Data is only the beginning. Other companies are working to develop mass-memory systems that will eliminate the need for people to handle memory media. Both the IBM and Control Data systems make possible on-line storage at off-line cost.

Enter electron-beam memories

Another mass-memory discussed at Session 48 is an electron-beam memory from Micro Bit Corp., Lexington, MA. In a paper on "Bridging the Memory Access Gap," Dennis Speliotis, manager of advanced systems, describes a prototype system that was delivered for evaluation to Control Data three months ago and a product line that will be introduced by the end of the year.

According to Speliotis, an electron beam is used to read and write data into a specially designed storage tube. The prototype system consists of nine tubes, each with a capacity of 128 kilobits, for total storage of 1.2 megabits. It is being used with a Star 1B computer, a scaled-down version of the Control Data Star computer.

The product to be introduced by the end of the year is known as the System 7000, Speliotis notes. It will consist of 18 parallel storage tubes, each with a capacity of 4 million bits, for total system storage of 75 megabits.

Speliotis points out that the electron-beam memory has six extra tubes, used to accommodate a 6-bit Hamming code that can correct a single error and detect double errors.

The access time of the electron-beam memory is 5 μs to a block of data. Once at the correct block, the system requires only 0.5 μs/bit to read out data. Thus, for the 18-tube system, data can be read out at 36 megabits/sec. Writing, Speliotis says, is four times slower than reading.

Discussing costs, Speliotis points out that the OEM price for a plug-compatible system is only 0.04 cent/bit.

Applications for electron-beam memories, he says, include replacement of head-per-track discs and main-memory add-on, if a cache memory is used with them.

The head-per-track disc replacement looks particularly attractive, Speliotis notes. Current discs, such as the IBM 2305, have an average access time of 2.5 ms and an OEM cost of between 0.12 and 0.2 cent/bit. This doesn't compare very well with the 5 μs and 0.04 cent/bit of the electron-beam memory.

In the main-memory add-on application, Speliotis notes that by use of a cache memory, the electron-beam can match the performance of the IBM 370/158 memory.

Novel memories described

At Session 55, electron-beam memories are also being discussed, along with other "novel memories," such as holographic and Josephson.

In a paper on "BEAMOS—A New Electronic Digital Memory," William C. Hughes, a program manager at General Electric's R&D facility in Schenectady, NY, discusses an electron-beam memory that uses a target constructed from four pieces of silicon. Unlike the two memories described by Micro Bit's Speliotis, the GE system is capable of storing 32 million bits per tube. The access time is 30 μs, and the cost for storage on a systems level is only 0.02 cent/bit.

According to Hughes, the basic storage principles are the same for both systems, but GE uses a different technique for reading out data. This accounts for the higher storage capability.

The large quantity of data, he notes, is accessed by a matrix lens. This consists of an 18-by-18 array of electronic lens-deflection systems that divide the 32 megabit array into that many parts. Each lens thus has access to a smaller area of the total storage plane.

Hughes indicates that the 32-megabit module has been successfully constructed and tested and that commercial development is close at hand. Hughes indicates that it will take at least another year until a final memory system will be commercially available.

Film is better than tape

Some companies looking at the mass-memory market believe that film is a better storage medium than tape.

One of these is Harris' Electro-Optics Operation in Melbourne, FL. In a paper on "Holographic Memories: Fantasy or Reality?"

Holographic techniques can be used to permit 4-by-6-inch microfiche cards to replace 2400 ft reels of tape. A prototype of the system has been delivered to the Air Force's Rome Air Development Center.

A. Knox Gillis points out that magnetic-tape memories have a tendency to degrade with time. To make sure that the stored data remains retrievable, it is necessary to re-record it every few years.

In contrast with this, Gillis notes, data recorded on film are permanent and need not be refreshed.

But the availability of holographic memories to the computer industry will be limited during the next 10 years to archival read-only types, Gillis says. The reason, he adds, is that there are still many problems to the production of read/write holographic memories, including the perfection of light valves and page composers to organize the data.

In the meantime, read-only holographic memories are close to commercial application, Gillis reports, with Harris already having delivered a working memory to the Air Force. It uses a synthetically fabricated hologram (see "Optical Data Systems Find a Niche in the World of Fast, Fast Computing," ED No. 9, April 26, 1974, p. 126).

With this approach, it is possible to store all the data normally held on a 2400-ft magnetic tape on a single microfiche card. If improved interferometric recording techniques are used, that same amount of data can be stored on a square centimeter of film, Gillis says. ■■

How do you use microprocessors efficiently? Four sessions at the conference —11, 17, 23 and 29—are devoted to this topic, with heavy emphasis on improved software.

A Session 11 paper describes how the use of 16-bit instructions and address-word lengths, plus multiple accumulator architecture, can make programming easier and more efficient. In this presentation, Alan Weissberger of National Semiconductor, Santa Clara, CA, uses the company's Pace—the industry's first 16-bit microprocessor—as an example.

With the Pace, Weissberger notes, the instructions and operands are fetched in single memory cycles rather than the multiple memory references required for byte-oriented data or instructions.

"This enhances system throughput and improves program execution time," he says.

The need to develop more and better software for microprocessors is also emphasized in two Session 29 papers. Louise H. Jones of the University of Delaware, looks at instruction sequencing in a variety of microprogrammed computers. She considers both microprocessors and minicomputers and concludes that most current microprogrammed computers use inefficient instruction sequencing routines. She calls for a more structured technique of microprogramming to allow easier implementation of control logic.

In another Session 29 paper, Gary A. Kildall of the Naval Postgraduate School in Monterey, CA, reviews microcomputer software design. He notes a trend toward higher-level languages, such as

PL/M from Intel and PL/M+ from National Semiconductor, to make the programming of microcomputers easier. He also sees a trend away from external cross-assemblers and toward inexpensive internal assemblers.

The fastest and most efficient method of transferring data between a microprocessor and external systems is analyzed in a Session 11 paper by Gary Sawyer, an applications engineer with Motorola Semiconductor, Phoenix, AZ.

For the transfer of data within microprocessors, Sawyer points out, the most commonly used technique is to send the data from the memory through the processor and then to the outside.

A second technique, direct-memory address, transfers data directly between memory and external systems, Sawyer explains, thereby bypassing the processor. This method is always faster, but it requires more hardware.

Bipolar slices for speed

When speed is of primary importance, bipolar microprocessors are the choice of many designers over the MOS variety.

In a paper in Session 23, Marcian E. Hoff Jr. from Intel Corp., Santa Clara, CA, tells how to make a central processor from bipolar microprocessor components.

The company uses two-bit slice processors. Each slice contains arithmetic, logic, register and data-bus portions of a computer central-processing unit. These slices can be used together to form a computer of a desired word length.

David C. Wyland of Monolithic Memories, Sunnyvale, CA, describes a 4-bit slice bipolar processor made by his company. He also compares alternatives to choose microprocessors.

"The single-chip microprocessor has the lowest system cost, along with moderate performance," he says. "The multiple-chip design, with a dedicated instruction set and dedicated control chip design, results in high performance at moderate chip count and price. The multiple-chip design, using general-purpose control and data-flow chips, results in high performance and a flexible design with somewhat higher chip count than the custom multichip approach. However, it has similar system costs, due to the use of high-volume chips."

Putting them to work

The first microprocessor-based oscilloscope was the 1722A from Hewlett-Packard, Colorado Springs, CO. Walter A. Fischer, in a Session 17 paper, "The Synergistic Combination of an Oscilloscope and a Microprocessor," describes the 1722A.

"The microprocessor adds an order of magnitude more accuracy to the standard oscilloscope, by providing greater resolution and readability than had previously been possible," Fischer notes. "Specifically, better than 1% measurements can be made on time intervals as small as 30 ns or 4% of full scale." ■■

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Editorial

Stepping outside

When visitors would arrive a few minutes late for an appointment with Joe Fleet, he would refuse to see them—regardless of how much they could help him or his company. In Joe's mind this taught them a lesson—just as one teaches a lesson to naughty schoolchildren. In the process, and Joe probably wasn't aware of this, it established his authority and made him feel important. The psychology books I used to read would probably suggest that Joe was misdirecting hostility and compensating for deep-seated inferiority feelings.

Joe works hard for his company. Building it is one of his passions. Yet he has hurt his company on many occasions because engineers who can get other jobs prefer not to work with him; customers who can find alternate suppliers prefer to avoid him (though he's nicer to customers than to vendors and co-workers); and suppliers (whom he tries to eat for breakfast) turn him off at the first sign of a seller's market.

Joe is by no means stupid. So he senses a lot of the hostility and sees it as further proof that "people are no damn good." Most people who know him feel it's a pity Joe has that hang-up—that need to put other people down all the time. Wouldn't it be great, they say, if Joe could step outside himself for a while and see himself as others do. It probably would be.

But very few of his observers suspect that their vision of themselves might be imperfect. Possibly because nature tries to protect us from unpleasantness, most of us can't see our own hang-ups. It's easy for us to see how Joe's behavior hurts Joe and his company. Joe can't see it. But Joe can see us. He may wonder sometimes if it wouldn't be wonderful if we could step outside ourselves and see ourselves as others do. Would it?

George Rostky

GEORGE ROSTKY
Editor-in-Chief

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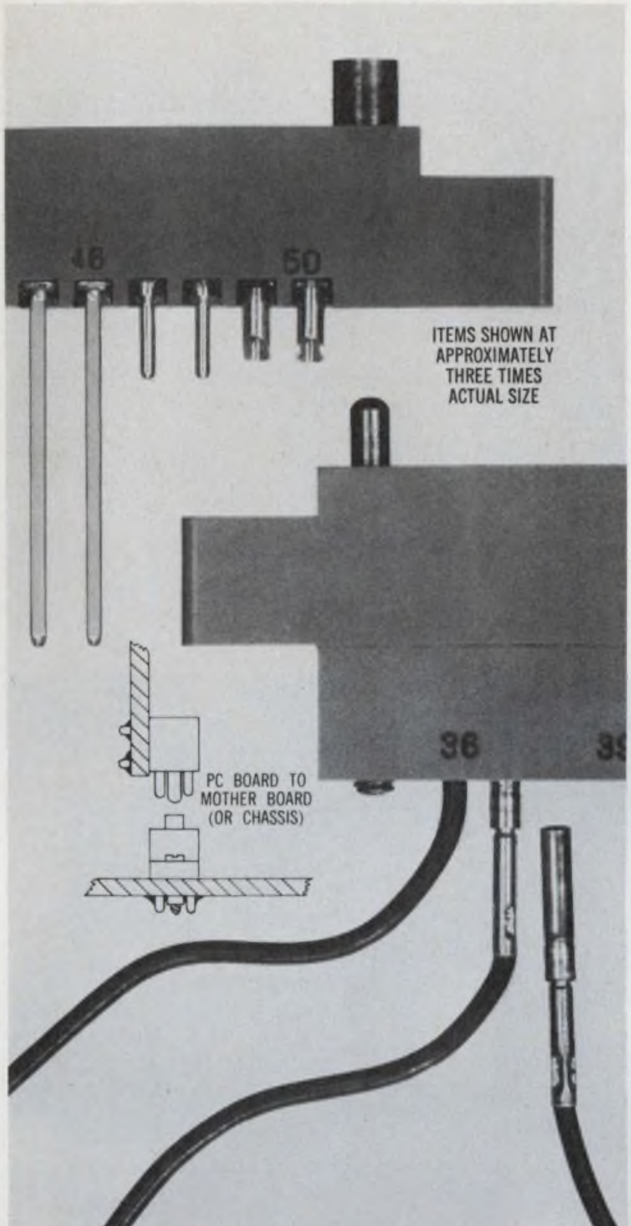

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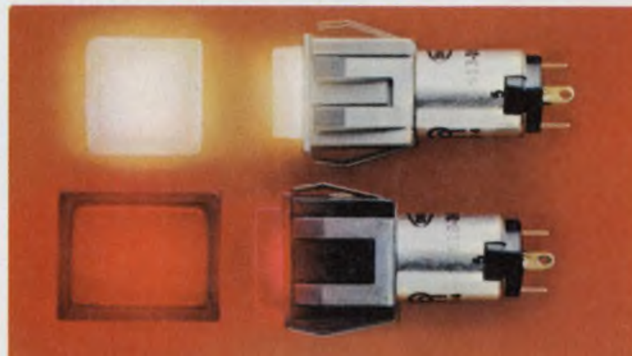

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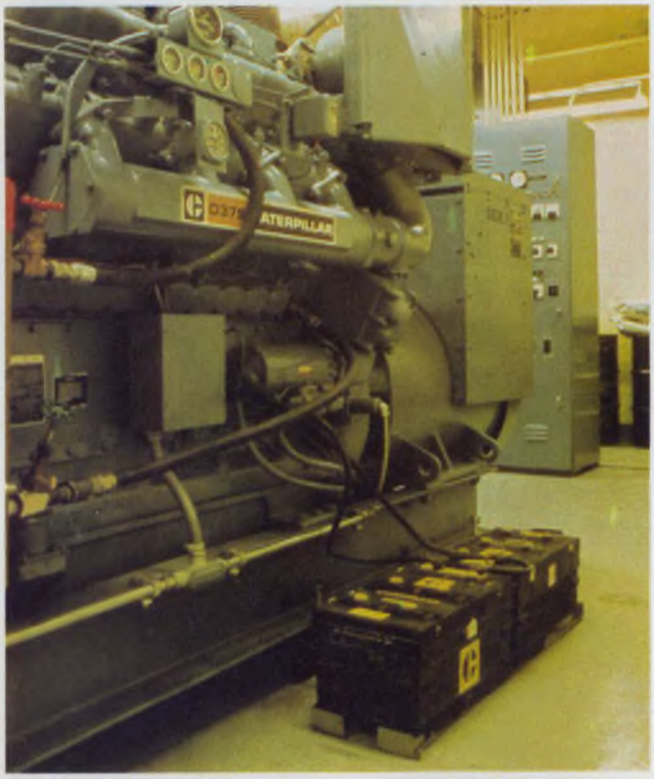
INFORMATION RETRIEVAL NUMBER 48

FOCUS on Uninterruptible power supplies and inverters

Few spec sheets contain all the information you'll need to specify the right inverter or to put together a trouble-free UPS (uninterruptible power supply) system. The problem exists not just because of the pressures of competitive spec writing—of which there are plenty—but because vendors can't characterize a UPS or inverter completely without knowledge of the application. And, of course, the applications are limitless.

Like a piece in a jigsaw puzzle, an inverter/UPS must be a perfect fit with its adjoining sections—the prime power source and load. If it doesn't fit, you've got trouble. To avoid a migraine, take this advice: Don't start selecting a unit until you've investigated both your source and load and know both intimately. What you'll uncover may surprise you.



After providing 15 minutes of protection, the battery bank for a 360-kVA UPS from Cyberex Inc. has done its job, and a back-up engine generator takes over.

A source of trouble

Brownouts . . . blackouts . . . dips . . . surges . . . EMI . . . spikes . . . fast transients. More and more, these are some of the unwanted extras that come with power, be it utility, battery, system source or whatever.

Indeed it's because of the increasingly poor quality of the ac power mains that the UPS has become essential for computers and other critical loads. And even battery sources—which power inverters in portable and other equipment—are subject to voltage dips, noise and spikes fed back from other loads hooked to the common system line.

Surprisingly, many users of ac line power don't realize how unconstant the line actually is or what undervoltage, overvoltage or transient conditions can do to equipment.

Because of drops in the distribution system from the source to the point of use, the steady-state voltage can be cut by up to 12% under normal conditions. Add to this the dynamic loading effects caused by start-ups, shutdowns, load switching, lightning and other problems, and you get this typical picture:

In a metropolitan area, expect major faults

Stanley Runyon
Associate Editor

To ensure no power failures at an electric utility's control center, an Exide Superguardian UPS powers the crucial computer. A remote-control console displays the UPS system status (top), while three rectifier/chargers form the heart of the supply, backed up by two 192-cell lead-acid batteries (left).

with a 75% voltage drop—or more—about 10 times a year. Minor faults, with drops to 25%, will occur 500 to 1000 times a year. And transients and spikes will occur more than 10,000 times yearly, with surges zooming to 2000% and lasting up to 10 ms.

To top it off, countless smaller fluctuations can also be expected, and like the other dynamic faults, they are unpredictable and difficult to measure. These are the "normal" line conditions—excluding brownouts, which can snip up to 8% more from the normal level.

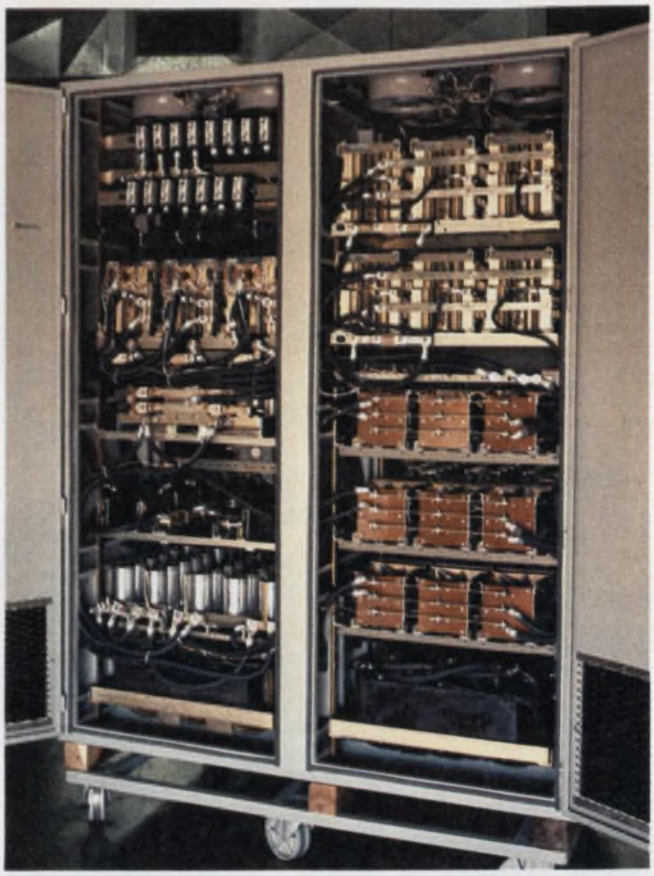
What are the effects of momentary dropouts or voltage deviations? In computers, look for malfunctions, processing errors and loss of valuable memory if the failure lasts for more than a few cycles. A slight overvoltage will cause some computers to malfunction, while others will do so on undervoltage. Still other machines are sensitive to transients.

Generally computers can stand ±8 to ±10% variation in line voltage and ±0.5 to ±3% in frequency, but this depends on the computer. Based on the experience of IBM, you can expect from 25 to several hundred processing errors yearly from power-line disturbances in some installations.

Low line can flatten the load

In other types of equipment, let the line drop just 10% below the 120-V nominal and these things can happen: Motors give 19% less torque, run almost 10 degrees hotter and burn out faster. Solenoids take 20% more time to actuate and give 20% less holding power. A battery's charging rate drops 20%—as does the output of electrical heaters. Grinders remove 25% less metal, and fluorescents put out 15% less light—and can be damaged. The list goes on and on.

The moral is this: Know your source. You can't specify a UPS adequately until you've pinned down all the line conditions that the UPS will see at its input end. To do this, you'll have to chart a history of disturbances at your equipment's power input over a fairly long period of



Meters keep track of voltages, currents, frequency and other parameters in International Power Machine's 125-kVA UPS (left). The system includes a rectifier/charger, inverter and static and manual switches (right).

time—say, at least a year.

This requires monitoring equipment—not just chart recorders or voltmeters, but high-speed recording voltmeters or transient recorders—instruments that can grab and hold split-second fluctuations. When you're through, you should have numbers for nominal line voltage and frequency, a history of dropouts and variations, including amplitudes and durations, and a description of noise or distortion on the line.

Other information may be needed, especially in large-scale installations. Included here is the current capacity of the prime power source, the maximum available short-circuit current at the UPS input terminals, the impedance of the source (to determine input harmonics) and other factors—in short, a complete power profile.

No less important to a UPS (or inverter) is what it sees at its delivery end—at the load. You can't rate a UPS or define its operating characteristics until the load is completely defined. This means going beyond a simple match of the load's kVA rating to that of the UPS. It means that you've got to know the load's power factor and magnitude, as well as what the load can tolerate in voltage and frequency variations, harmonic distortion, noise, transients and the like.

The "load," of course, means all equipment that will be tied to the UPS or inverter. Computers, peripherals, cooling systems, relays, motors—all should be included. Remember that the power factor of a typical equivalent load is usually around 0.8 lagging—not 1.0 as is commonly supposed. If the figure drops below 0.8, you'll probably need some correction for power factor.

Curiosity doesn't kill

To define the load fully, ask some additional questions: Is my load nonlinear? Is it fixed or does it vary? What about current in three-phase loads—is it unbalanced? What is the maximum down time my load can stand? Does the load pull a high in-rush current at start-up? If it does, for how long?

In-rush current can pose a particularly sticky problem to a UPS or inverter. If in-rush is forgotten—as it often is—you'll end up with a supply that can't handle the load. When you turn on the power, the supply will probably go into a current-limiting mode and drop the output voltage.

You can get around the in-rush problem in a number of ways. You can spend a lot more and get an oversized system that can handle the peak currents. Or you can use a switching scheme in which the load starts from a higher current source—like the utility line—and then transfers automatically to the UPS/inverter when the current falls to its nominal operating level.

Such transfer is usually accomplished by what UPS vendors term a static transfer, or bypass, switch. The switch, which can do the job in 4 ms or less, can have other duties as well.

When you consider in-rush, don't forget that of the UPS itself. When ac power returns after an outage, current can zoom to full value in a short time. If the surge is too fast or severe, it can disturb other equipment on the utility line. If you're really unlucky, the surge will trip a circuit breaker or knock out a standby generator—and there goes your critical load. The solution here is a power "walk-in" or current-limiting circuit.

After you've learned both your source and load—especially what the former can do and what the latter can take—check into the UPS/inverter itself. When you do, be prepared for an uphill specifying job.

Spec it, don't design it

You may think that a product that can cost as much as $250,000 or even more is bound to be fully and accurately specified. Don't count on it. In specs like efficiency, transient response, regulation and even power rating, there are traps for the uninitiated. Other specs hurt in another way: by their omission.

If manufacturers "inadvertently" underspec, engineers tend to do the opposite—perhaps because they've been burned before. Be cautious. But don't try to design the UPS. It'll be hard enough to determine performance, much less tell a vendor how many SCRs to use or what battery bus voltage.

The heart of any UPS is its inverter. Consequently most important UPS specs center on the inverter. In general, most inverters fall into three major categories, depending on the end use: (1) The OEM, limited-power (< 200 W) inverter; (2) The high-power inverter built specifically for a UPS system, and (3) The static inverter aimed primarily at airborne, mobile and military markets.

All inverter types change dc to ac. Of the three types, the OEM often delivers square waves, while the high-power and static, by and large, provide 60 or 400-Hz sinusoidal power. But regardless of type, all inverters are power supplies and must be specified as such.

As in any supply, regulation is a key spec. It can be defined as in PY1-1972, the NEMA standard for dc power supplies. But many vendors have their own approaches. Regulation is often given for variations other than full to no load, or regulation is listed without stating other necessary conditions.

Interest in UPS protection is growing, not just for high-power uses but for smaller loads, too. Fulfilling that need are such units as Wilmore's 1202 (bottom)—at 250 VA one of the smallest UPS units around—the Topaz 3-kVA unit (center) and Elgar's UPS-252-1 (top), a 2.5-kVA supply.

As a result, you can't compare competitive products safely for regulation. To do so, you must know this: What is the regulation for full load and line variations? Does frequency alter regulation? How is regulation affected by temperature? What load power factor was used to measure regulation? (Some units don't regulate well at < 0.8 factors.) Exactly what is the worst-case regulation?

On the other hand, bear in mind the common tendency to buy more regulation than your load actually needs, just to be "safe." This can turn out to be costly in terms of money, equipment size and cooling requirements. So avoid extra tight regulation.

One spec you shouldn't avoid, even if the vendor does, is efficiency. Though the definition of efficiency is simple (power out over power in), it's tough to find out how efficient a supply is.

Keep cool with high efficiency

Obviously the higher the efficiency (η), the less the drain on the battery for the inverter or UPS. Conversely, the higher the η, the smaller the battery needed for a back-up period. Perhaps most important, a highly efficient supply needs less cooling or heat sinking, lasts longer and is generally more reliable.

So vendors like to boost efficiency as much as possible. But watch out. If they can't do it technically, they may try to jack it up with a pencil. Some deceptions are obvious; others aren't.

First, efficiency should be calculated by division of output watts by input watts—not volt-amps. Second, a lone figure for η, without qualifications, can mislead. The listed value may be that of the inverter alone. But what about the rest of the system? Static switches, rectifier banks, charging circuits—all of these dissipate power and cut into the η. Are they included in the figure?

Ask another question: How does efficiency vary with line and load changes? An η of 85% sounds great. But unless stated otherwise, the number usually holds only at full load and nominal line voltage. At lighter loads or higher input levels, η is sure to drop appreciably. Just how much? Ask.

Because efficiency does vary with the operating point, and because it's easier to define than measure, be careful in making competitive comparisons. Measurements of η can be way off because current waveforms aren't necessarily sinusoidal. This leads to large errors in average-responding instruments that are calibrated in rms value. In fact, one inverter vendor claims that when source impedance is considered along with complex current, only a thermodynamic (calorimetric) measurement of power loss can give a true picture.

If you buy a unit that has more capacity than you now need—in anticipation of future load growth—remember this: Since the system won't be working at capacity, it probably won't be as efficient. This leads to more source drain than you expected and increased heat—which must be removed.

Some inverter vendors don't spec efficiency at all. With the η missing, a potential user may think he can bury the inverter in a dead airspace with little or no heat sink. But η isn't 100%, and you've got to remove the heat or risk a frizzled inverter. Other vendors are more generous: A fine-print spec in the footnote tells you to stay below a base-plate-mounting temperature. How do you do it? That's left to your imagination.

Massive power source on wheels: one of three Teledyne Inet inverter switching sections, mounted on rollers for maintenance convenience.

Heat removal in any supply is not easy. But keep in mind that a 10-C increase in temperature can double the failure rate of SCRs or other semiconductors. Batteries also wince at temperatures other than 25 C. Lower temperatures cut into capacity, while elevated ambients (> 30 C) slash battery life expectancy. Besides temperature, look into altitude, humidity, vibration, shock and potentially corrosive atmospheres. All can affect performance.

Batteries can cause their share of problems in other ways, especially in large UPS systems that literally need a room full of them. The first problem with batteries is how to specify one.

Powering a flashlight is one thing . . .

Sizing battery systems can become so complex, in fact, that at least one vendor uses a computer to do the job. Besides battery type (the most commonly used are lead-calcium, lead antimony and nickel cadmium), you've got to establish ratings for such parameters as ampere-hours, end, float and equalization voltages, full-rated and short-circuit (overload) currents, projected life, charging times and other factors. No less important are the requirements for battery connections, protective circuits and personnel safety.

Perhaps the best approach is to ignore the details. Tell the vendor how long the battery must support the load—the full load—and let him do the rest. Then hold him to the contract.

Remember that as the back-up time goes up, so does the battery and charger size, cost and the electric bill. Large battery systems are also potentially dangerous and require preventive maintenance.

So keep back-up to a minimum. For a computer, the usual battery capability runs between five minutes and one hour—enough time to sew up the computer, ride through the outage, or connect to standby motor-generator power if a sustained loss is expected. For other applications, like phone exchanges, batteries can work for up to eight hours. (Battery chargers are usually sized for 8, 12 or 24-h recharge.)

Be aware that if the vendor can't maintain the battery float voltage for any reason—like scrimping on charger design so that at low-line voltages the battery isn't kept fully charged—you probably won't get the specified back-up time. Take a good look at the charger's capabilities.

Remember, too, that UPS or inverter specs can change as the battery runs down. Overload rating, for instance, may be given at full output voltage, with no mention of dc input voltage. But overload rating can plunge significantly as the battery discharges—and in some designs can disappear completely. Where is this stated on the data sheet? In many cases, it isn't.

Overload, current-limiting, fault-clearing protection and start-up in-rush are all related, of course. Check them all out together.

Overload is one area to be watched, for other reasons. Many inverters are touted to be current-limiting at some overload point—say, 125 or 150%. What you aren't told, though, is that the inverter can't deliver the overload current long enough to clear the fault—that is, to trip or blow the protective device. Watch for this.

With some equipment, not only may specs be missing but hardware, too. To get the rated performance, you have to add external components —such as filters, transformers, fans and other goodies. Even when you seem to be getting something, you may not be. One inverter vendor has generously provided extra windings on his output transformer in case the input drops to 20 V or less. But in his eagerness to give more, not less, this vendor forgot to mention that the user must add switching circuits to ensure continued operation at low input voltage.

Another unfulfilled promise: static switches that aren't. A true static switch should be solid-state. But some manufacturers use semiconductor switch sections on the ac-line side and substitute electromechanical contacts on the inverter side. Consequently you can't switch fast to clear a fault or if the inverter fails. Check for this. While you're at it, check into another area often ignored by inverter suppliers: transient performance.

It's a dynamic world

Though you may find it tough to determine an inverter's dynamic characteristics, don't give up. One vendor candidly admits that transient or dynamic behavior can make or break system performance.

What you have to pin down are such specs as dynamic impedance and regulation, damping, recovery characteristics, duration and amplitude of voltage excursions (max and min), and other factors. When you do, watch for deceptions. For instance, transient response, or regulation, during a load change can be made to look good simply by limits on the specified change. Thus while some vendors list a 100% step load variation, others use 50% or even 20%.

Games are played with recovery time, too. A unit that settles within a few microseconds or recovers to 0.1% in 5 μs sounds pretty good. But ask: To 0.1% of what, for what load change and exactly what happens to the output during that "few" microseconds?

Protection from transients can be important. Line-generated impulses can zap a sensitive input circuit. And don't forget that switching spikes or noise can be generated internally and radiate or feed back to the power source and its other loads. To avoid interference troubles later, look into the inverter (or UPS) EMI specs and protective filtering, if any. Look also for transients that occur during a transfer mode.

Spikes and noise (and EMR, too) don't play favorites, of course. These unwanted signals would like nothing better than to get into your load and change a few ONEs to ZEROs. And all too often they do. The reason is simple: You weren't told that the spikes existed—at least not outright.

Ripple and noise may have been specified, all right. But the vendor lumped the hash together with distortion and listed it all as an rms figure. Since spikes contribute little to an rms value, the vendor has succeeded in hiding their existence. One thing he probably won't hide, though, is his equipment's output distortion.

A sinsusoid with high purity—one low in harmonics—would seem to be desirable. So engineers tend to look for it. But what does total harmonic distortion (THD) of 1% really buy?

Remember that the utility line's THD probably runs around 2 to 3% anyway and that most loads don't complain at the figure. Some loads don't wince at a THD of 10% or even higher (many inverters offer square-wave outputs). So see what your load can tolerate and avoid overspecifying distortion.

You should also realize that a source's output harmonics are related to its output impedance and that the harmonics depend greatly on the load—and also the input voltage, in some cases. Thus you may get an excellent sinusoid at nominal line. But when the inverter's input drops, say hello to your new square wave.

The load can drastically distort a sine wave. Inverter manufacturers usually measure distortion into a linear load. However, in most cases the UPS or inverter sees a transformer and choke or a capacitor-input rectifier circuit—a highly nonlinear load. Though you started with 5% distortion (the linear-load spec), you can easily end up with 15% with the filter-rectifier load.

To minimize the problem, look for units with low output impedance. This will also help improve regulation and transient performance. Another point: While distortion is measured in rms, the load may care more about peak or average values (power-supply inputs, for instance). So don't ask just for THD but for form and crest factors, too.

How much harmonic distortion a given unit produces depends also on the basic inversion technique. Some methods yield little or no harmonics. Others need heavy filtering or shaping to arrive at the final sinusoidal shape. And herein lies the basis for a controversy—the "my-way-is-best" syndrome.

While it's true that inverter design has progressed significantly since the 1960s, no single existing method has the edge over any other in all areas. Each has advantages, each limitations. In the end it's performance that counts, not internal design or the fact that a unit is a "third or fourth-generation" design. So don't get sucked in by these arguments.

Other areas of controversy are sure to pop up in the search for the right unit—power transistors vs SCRs, for instance, or single-phase UPS systems vs three-phase. Again, there are relative virtues and weaknesses to be considered —not just labels. Consider this, too: Is that UPS system really uninterruptible?

Even a UPS has its downs

A UPS is more than a product. It's an insurance policy. And like most policies, the system will pay off—but only to the extent you don't forget or violate the fine-print limitations. Since no UPS is failure-proof, any system is bound to develop a problem sooner or later. Obviously you'd like this to be later.

Vendors also want to offer reliable products—to stay in business, if nothing else—so most will promote reliability. To do this, they point to MTBFs, understressed components, conservative design, satisfied customers, reputation, financial stability, longevity of the company and other criteria. Our advice: Take MTBFs with a grain of salt, listen politely to the design talk, then go out and check the rest.

If an inverter does fail, most systems will automatically transfer the load to the ac line (called a reverse-transfer system). If an electromechanical relay does this, you can expect a dropout of about 50 to 150 ms. If your load can't be out that long, remember, a static switch can do the job in less than 4 ms.

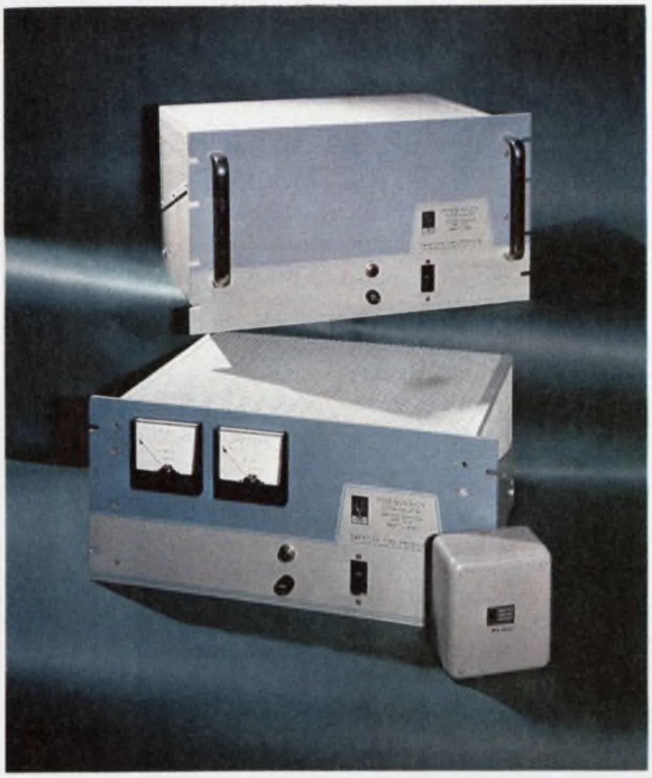
For the ultimate in reliability, partial or total redundancy is necessary. But watch out. Paralleled inverters don't ensure failure-proof operation. One inverter can fail and take the others down, unless a switching arrangement is used to isolate the defective unit. Since redundant operation costs a lot more; you'll have to make sure you really need it. As you mull it over, think about this: Do you really need a UPS at all?

If the problem is just noise on the ac line, a UPS is an expensive way to isolate the load. Instead, check into isolation transformers specifically made to attenuate common-mode and other noise. If brownouts or wide line fluctuations are the culprit, investigate ac line regulators or preregulators, which can cut variations by a factor of 5 or more. Preregulators bring another benefit: You can relax the power-supply specs on your own equipment.

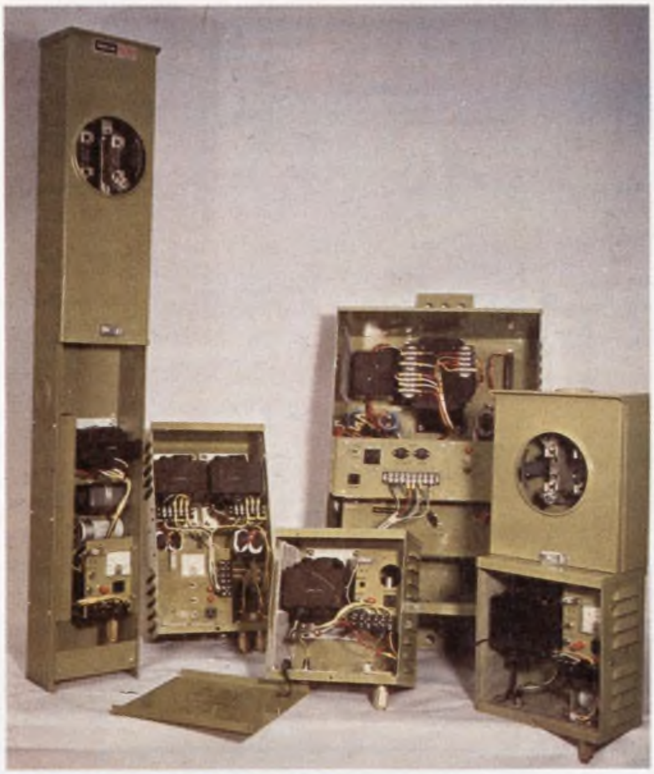
Still another option is to not use an inverter at all but a dc/dc converter. After all, if you're going to drive a dc power supply anyway, why not skip the extra step of inversion—with its extra energy loss—and go right to a converter and battery charger? This makes sense to some extent. But don't forget that all dc/dc converters must first invert to ac, then proceed to transform, rectify and filter to get the final dc levels.

Who's who in UPS/inverters

Many other tradeoffs must be made with inverters and UPS systems, some of which you may not think of—and which the vendor may strangely forget to mention. Keep in mind the following: acoustical noise and possible structural loading problems; stability of the output frequency; grounding, maintenance, safety and engineering support; potential inverter start-up problems. And don't forget to find out how the



Frequency changers and inverters from Bulova are intended for synchronous motor drives, chronographs, timers and other precision applications.



Various standby systems and ac power supplies marketed by Sola Electric show the great variety in packaging of such units. Sola also makes line regulators.

vendor tested his system.

But once you're clear on your needs and what to expect when you enter the marketplace, the next step is to ask: What's new and who's who in inverters and UPS systems?

Probably the most significant movement over the years in such power sources has been toward all-solid-state designs. Faster and higher-power transistors and other semiconductors have teamed up with ICs to give more power in smaller and lighter packages. And with PROMs, LSI and other digital logic, vendors like Abacus Controls and others have come up with digitally synthesized waveforms, to cut weight even more.

Other trends include crystal control of output frequency, fault protection with automatic reset and, at last, a movement toward standardization of specs (ISA, NEMA). Today vendors put systems together for you so that you don't have to select individual batteries, inverters, control circuits and the other necessary units that make up a UPS.

Generally suppliers can be grouped according to output power, application or expertise in a specialized area. For example, if you need an inverter to power fractional-horsepower motors—say, for fans or blowers—check into the Power Conversion Operation of Rotron, Inc. Since Rotron also markets the motor, the company will match exactly the motor load to the inverter (to 1000 W).

For high-voltage inverters to drive rectifiers or voltage multipliers, Advanced High Voltage Corp. offers units that change 28 V dc to 7.5 or 15 kHz at up to several thousand volts and 45 W. Inverters for rugged mobile and marine environments are the specialty of Advance Conversion Devices, while Bulova's Electronic Div. concentrates on stable frequency sources rather than power.

To survey your input line properly, you'll need special equipment, such as the Model 3401 power-line disturbance monitor from Programmed Power Inc. The unit keeps track of and measures such things as frequency error, under and overvoltages and transient magnitudes.

Inverters for military, airborne and aerospace applications demand stringent specifications. Such units are the forte of Aerospace Avionics, Avionic Instruments Inc. (AI^2) and Unitron Inc. Each offers a fairly wide line with a broad range of individual features.

Need a small dc-to-ac power source for laboratory or field use? Companies such as Terado, Topaz, Tripp Lite and Wilmore offer them up to about 1500 W. Terado and Topaz also sell UPS systems, the former to 1500 W and the latter to 10 kVA. Intended for emergency lighting and alarm systems are UPS systems made by Exide Lightguard Div. Various models deliver up to 1350 W for a minimum of 90 minutes.

Manufacturers offering complete UPS systems are numerous indeed. In power ranges up to about 50 kVA, you'll run into outfits like Deltec, which offers single and multiphase systems, static transfer and partial or total redundancy; and Elgar, a company that builds to its own industry forecasts, not to order, so you can get fast delivery.

When you get up into the really large-scale systems—50 to 2000 kVA—other names pop up. Atlantic Research's modular concept allows the company to deliver up to 75 kVA in 25-kVA steps, or to provide up to 450 kVA in 75-kVA steps. Cyberex Inc. will parallel modules to get you up to the higher powers. The Exide Power Systems Div. of ESB Inc. guarantees an over-all system efficiency of 86% (it says it will sign a penalty clause). And International Power Machines, formerly Static Products, markets 3-ϕ units that deliver to 250 kVA. Need 415-Hz power for your computer? International can supply it.

Well known in the large-scale UPS/inverter field are Solidstate Controls, Teledyne Inet, and Westinghouse. Each has the resources and experience to deliver uninterruptible power to practically any load, and to provide just about anything in the way of protection, redundancy, controls, maintenance—you name it.

Finally, if you decide that line regulators are all you need, check into those made by Sola Electric, Tele-Dynamics, TDC Div. of Frequency Technology, Topaz and others. MCG Electronics specializes in ac transient suppressors. And if you go the dc/dc converter route, instead of dc/ac, vendors abound. Check out RO Associates' line, for one. Sorensen's STM series works from ac or dc, and automatically switches to the dc source if the ac fails.

Another option: Acopian Corp. supplies ac-to-dc systems with built-in, redundant power modules. Hook one to your battery operated inverter and you've got reliable power. ■■

Need more information?

The products cited in this report don't represent the manufacturers' full lines. For additional details, circle the appropriate information retrieval numbers. For data sheets and more vendors, consult ELECTRONIC DESIGN's GOLD BOOK.

Abacus Controls Inc., 65 Fourth St., Somerville, NJ 08876. (201) 526-6010. (George A. O'Sullivan). **Circle No. 401**

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TDC Div. of Frequency Technology, Inc., Box 365, Whitcomb Ave., Littleton, MA 01460. (617) 456-3374. (Emil B. Rechsteiner). **Circle No. 439**

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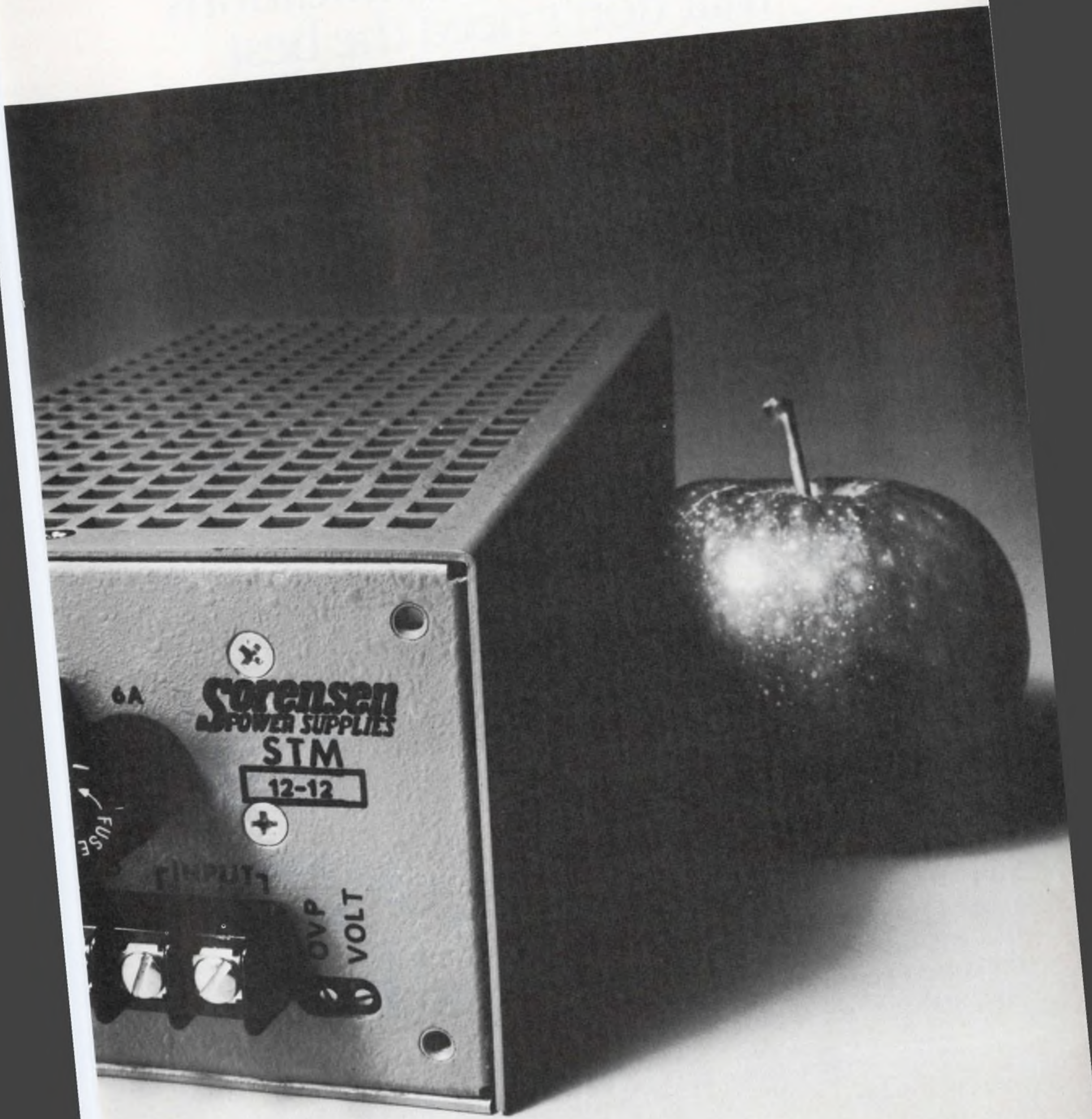
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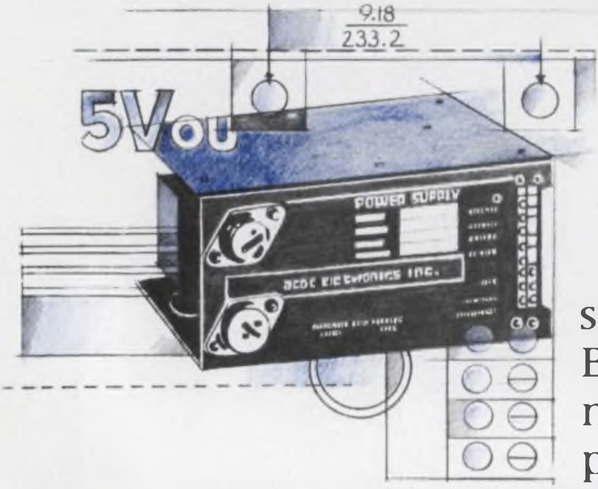

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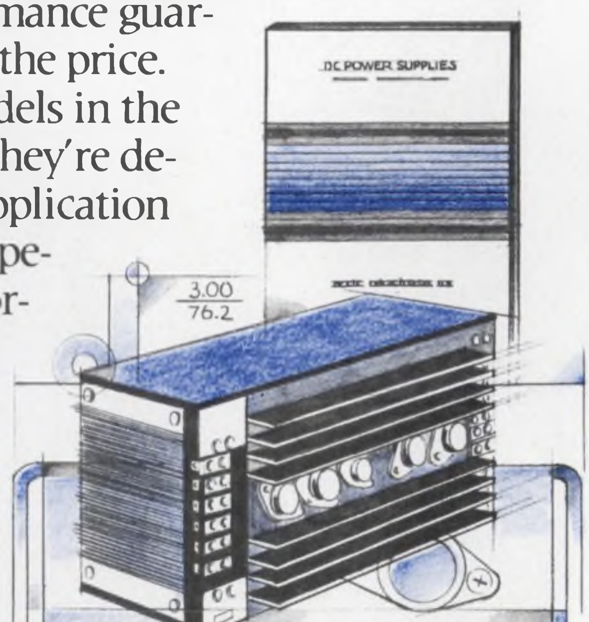

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INFORMATION RETRIEVAL NUMBER 53

Technology

Explore microcomputer I/O capabilities

and then select the chips. Here are pointers on what to expect from different input/output architectures.

Most buyers of microcomputers are dazzled by the intricacies of CPU-chip design, but the usefulness of a microcomputer depends closely on its ability to exchange data with peripheral devices. A word to the wise: Explore the I/O architecture before you buy.

A microcomputer's I/O architecture breaks down into these areas:

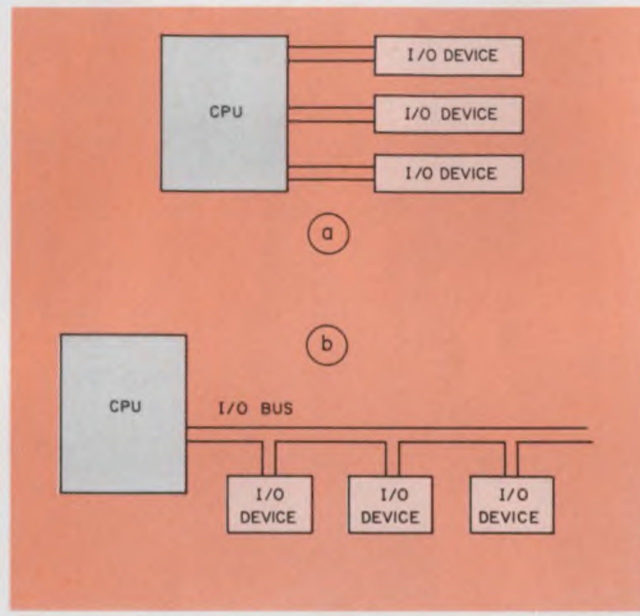
- Transfer techniques.
- Instruction formats.
- Busses.
- Bus structures.
- Interrupt schemes.
- Memory-access techniques.

Three kinds of I/O transfer techniques

Most microprocessors allow for three types of I/O transfer techniques—programmed transfer, interrupt-program control and hardware control. In the first two cases, found in most simple applications, the microprocessor controls the transfer. In the third case, system hardware controls transfer.

When all I/O operations are under program control—with all instructions to receive or transmit information included in the program—data are transferred whenever the corresponding instruction is executed.

To transfer data, the program addresses a peripheral device with an input or output command. In some cases the program must first check the availability of the peripheral by checking its status and waiting until it is ready. Typical of this approach are applications where information is entered one character at a time—as from a keyboard. In such cases the microprocessor must spend significant "overhead time" waiting for the data to be entered. This isn't a disadvantage in desk-calculator applications, in which the CPU does not have other functions to perform. But it might not be acceptable in a real-time monitoring system.



1. **I/O bus structures employ several schemes.** A radial system is the simplest, but it limits the number of I/O units (a). A party-line system reduces the number of lines needed for a distributed system (b). The latter system also comes in a daisy-chain version, which connects devices serially.

The interrupt-program approach requires a smaller I/O overhead than that of programmed transfer. I/O devices can signal the microprocessor by an Interrupt whenever they are ready to transmit or receive information. When information is received and identified, the microprocessor interrupts its normal program, stores its state and jumps to a subroutine that allows it to perform the transfer operation. Once the interrupt has been serviced, the microprocessor returns to the state at which it was interrupted or some other predetermined state, and it resumes its normal operation.

This approach allows the microprocessor to spend a minimum of time servicing an I/O device. Hence it can perform more operations or handle more peripherals.

Hardware control of information transfer was not used much in early microprocessor applications, but most newer CPUs can accommodate it.

André G. Vacroux, Member of Technical Staff, Bell Telephone Laboratories, Holmdel, NJ 07733.

The method requires a significant amount of additional hardware, since the I/O device must initiate and control the data transfer directly into or from microcomputer memory.

But the software support is minimal. It is limited to the initiation, termination and recovery aspects of the transfer. These aspects are performed automatically without microprocessor intervention.

The hardware-control approach, also known as direct-memory access or data break, can be used to transfer blocks of characters directly between a peripheral device—such as tape, cassette or floppy disc—and the main microprocessor memory.

I/O instruction formats differ

The handling of programmed I/O operations varies significantly from one microprocessor to another. Most microprocessors have special I/O instructions of varying length. But some don't have any; the I/O ports are treated as if they were RAM locations.

One of the simplest examples of a special I/O instruction is that of the single-byte instruction, with a different word for each I/O port. Typical is the I/O instruction format of the Intel 8008:

01 RRM MM1.

The five RRMMM bits define 1 of 32 (2^5) possible I/O operations, where RR = 00 implies one of eight input operations and RR $\neq$ 00 one of 24 output operations.

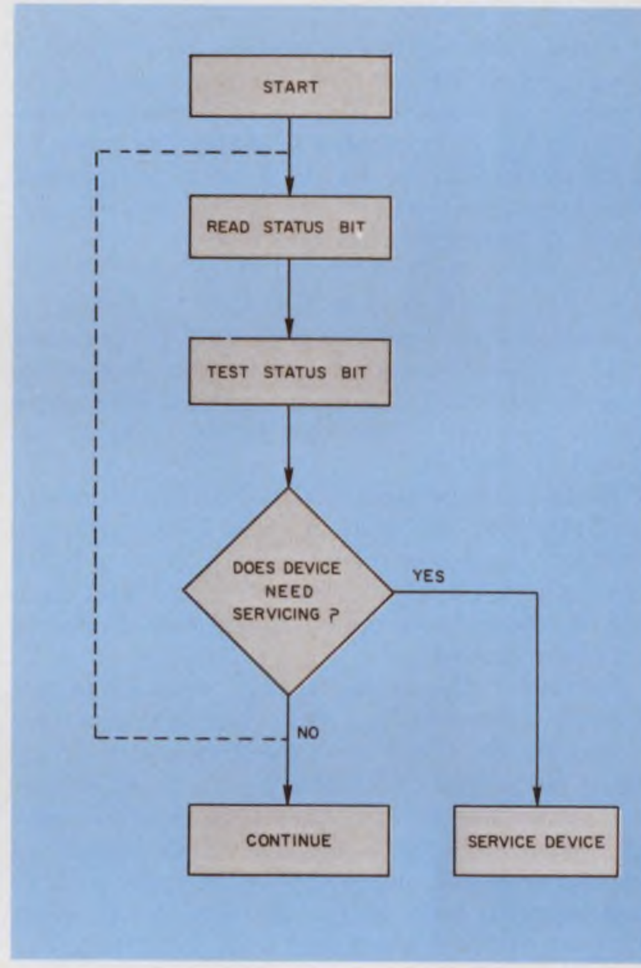
The Mostek 5065 has two types of single-byte instructions. One provides the usual I/O operations for 16 input and 16 output ports:

Input accumulator command 01 10 XXXX
Output accumulator command 01 00 XXXX

The second type has this form:

Input accumulator skip 01 11 XXXX
Output accumulator skip 01 01 XXXX

During the execution of these I/O instructions (which can be used to access either the same or different I/O ports, depending on system configuration), the CPU tests a flag bit, which may be controlled by the addressed peripheral. Whenever the flag bit is a ONE, the next two bytes of instruction are skipped. This option simplifies the dialogue between CPU and peripheral. Depending on a peripheral's state of readiness, the program can perform an immediate branch.



2. **Peripheral devices can be polled periodically** to find if any need service. However, this simple technique can be time-consuming.

Despite the extreme simplicity of the I/O instructions for the Intel 8008 and Mostek 5065, this approach limits the number of I/O ports that can be addressed. With the 8008, the number is 32; with the 5065, it's 64. In addition, 1/8 (32/256) or 1/4 (64/256) of the possible instruction words are used for I/O alone. Hence few combinations are left for other purposes.

Some microprocessors use a multibyte I/O instruction, although here, again, there are significant variations. Intel's 8080, for example, employs a 2-byte I/O intruction with the following form:

1 1 0 1 X 0 1 1
A A A A A A A A

The first byte specifies an input or output instruction (depending on the value of X). The second byte distinguishes between as many as 256 input or output devices. Hence a few combinations of instructions allow the use of many I/O ports. However, twice as many bytes of control memory are needed.

A different 2-byte I/O instruction is found in the Rockwell PPS-8. The microprocessor is designed to operate with up to 16 performance-enhancing I/O devices, each of which has two 8-bit ports. Software controls the devices, and internal registers store control and status information. The I/O instruction has this form.

0 1 0 0 1 1 1 0
A A A A X C C C

where the first word indicates an I/O operation, AAAA defines one of 16 I/O devices, X specifies an input or output operation and CCC determines which register within the device is being accessed by the CPU.

From a comparison of the I/O instructions of the Intel 8080 and the Rockwell PPS-8, you can see that there is a tradeoff for a given number of instruction bits. The tradeoff is the total number of I/O ports vs the intelligence built into the interface devices.

However, it's almost always possible to use memory addresses for I/O devices. I/O ports are considered as if they were RAM locations; an input is performed by reading memory and an output by writing into it. Though a program may look somewhat more obscure (I/O operations become more difficult to spot if the program isn't documented), operations performed on input data can be those associated with RAM data. For example, add, compare and test bits. This technique also allows for a number of I/O devices, limited only by the size of the memory that can be addressed by the microprocessor.

This approach has been chosen by Motorola for its M6800 microprocessor, which doesn't have any instructions reserved for I/O. The number of bytes for I/O operations—typically one to three—depends on the type of operation and on the addressing mode. Special peripheral circuits in the M6800 family—such as the Peripheral Interface Adapter or the Asynchronous Communications Interface Adapter—are designed to be compatible with this approach.

The new National PACE processor doesn't have any special I/O instructions either. Like the Motorola M6800, it relies entirely on the addressing of I/O ports as if they were memory locations. Hence all memory-reference instructions can be used to perform I/O operations.

Information travels on busses

Parallel lines and control logic, referred to collectively as the I/O bus, transfer information between microprocessor and I/O devices. The bus contains three types of lines: data, device address and command.

Data lines consist either of one bidirectional set or two unidirectional sets. In the latter case, one set is used exclusively for inputting of data to the CPU and the other for outputting of data. In most cases the width of the bus—number of lines—equals the word length of the microprocessor.

Device-address lines are used to identify I/O devices. The theoretical maximum number of available address lines changes significantly from one microprocessor to another. It depends on the way I/O operations are handled. The number of I/O ports can vary from 32 (or 2^5, as in the Rockwell PPS-8 or Intel MCS-8) to 65 k (or 2^{16} as in the Motorola M6800 or National IMP-16).

Command lines allow a peripheral to indicate to the CPU that it has finished its previous operation and is ready for another transfer.

Other lines are also present. You can find interrupt lines on which devices request service, enable or disable lines that can be used to control the interrupt, as well as lines that provide timing whenever required.

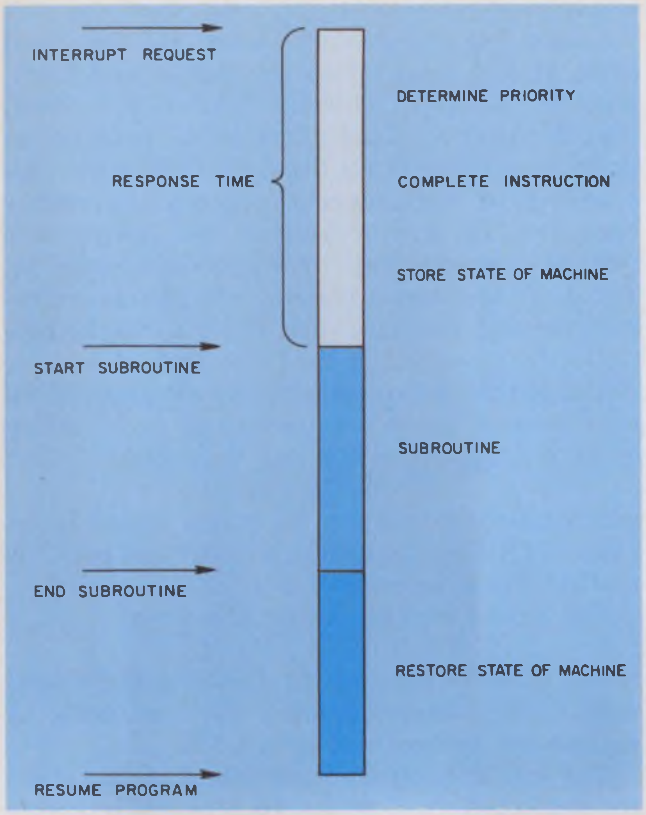
The different busses are frequently combined on the same lines to simplify construction and, in some cases, to reduce costs. However, this may increase the number of control lines. The extra lines are needed to extract the necessary information from the common bus.

Three ways to structure the I/O bus

I/O bus structures can take three different forms: radial, party-line or daisy chain (Fig. 1).

A radial-bus system connects each I/O device to the microprocessor through a dedicated set of lines. It does not allow the connection of more than one I/O unit. Because of its simplicity, a radial bus provides a convenient solution, although it isn't usually compatible with the limited number of CPU pins. However, it is a possibility with the Rockwell PPS-4 system.

A party-line bus is time-shared for data transfers between the CPU and many I/O devices. It must provide means of identifying which device is being called on at a given instant. It does not allow the simultaneous use of more than one I/O unit. All devices are accessed in parallel, and the choice of one or another is controlled entirely by



3. **An ideal interrupt-service routine** automatically saves the state of the microcomputer and then restores it after the interrupt has been handled.

the microprocessor. This bus structure would be justified mainly in the case of a distributed system, since it would significantly cut the number of required lines.

A daisy-chain bus is very similar to the party-line, except that the connections are made in serial fashion. Each unit can modify the signal before passing it on to the next device. This approach is used mainly for signals related to interrupts or polling circuits. Whenever a device requires service, it blocks the signal. A priority is thus established, since the devices that are closest to the microprocessor have the first chance to request service.

The Fairchild F-8, for example, uses the daisy-chain concept to organize its interrupt priorities. Each RAM or ROM chip—which also provides I/O ports—can accept one interrupt input. And each chip can connect to its neighbors to establish priorities. The daisy-chain technique is also used in the Rockwell PPS-8.

Generally a system's bus structure depends on the CPU used. Pin-limited, first-generation CPUs have a single bus that must be time-shared between memory addresses, instructions, input and output data, device addresses and control signals. This time-sharing requires involved peripheral circuitry, consisting of numerous latches, multiplexers and timing circuits. Also, output information has to be latched before it can be directed toward the appropriate output device—usually another latch. Hence output bus structures usually have to be of the party-line type.

In second-generation microprocessors more than twice as many pins are available. Typically there is a bus for addresses and another for instructions and data, and most control signals are directly accessible. Although some time-sharing still is needed, there's no need for two-stage buffering between the CPU and output device. Nevertheless I/O busses employ a party-line configuration.

Moreover more microprocessors are allocating one or more pins for external flags. For example, the National IMP-16 has two flag bits, while the newer PACE chip offers four external flags. The Mostek 5065 has one external flag. All of these flags simplify programming when a single bit of information has to be exchanged.

Interrupts need servicing

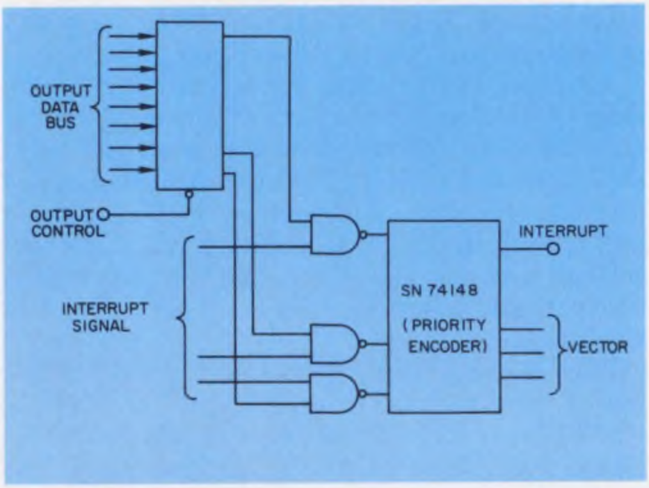
Some applications require that a peripheral device be serviced as soon as possible after some external condition has occurred. In some cases, especially when the microcomputer is not very busy, this can be done by program control. But most frequently it's necessary to establish some sort of interrupt structure that allows asynchronous external events to change the processing sequence.

When interrupt facilities are not available, the only way to find out whether a device requires servicing is to interrogate it periodically by inputting a status bit and testing it. When the need for service is identified, the program branches to a special subroutine, at the end of which the program returns to its regular operation.

This technique is quite easy to implement (Fig. 2). But significant time could elapse between the moment service is requested and the moment the processor recognizes it. The time can be lessened if the program sits on a small interrogating loop (dashed line in Fig. 2) or, if the microcomputer is programmed to interrogate the inputs frequently. Neither case, however, represents efficient use of a microcomputer.

To eliminate wasteful loops without sacrifice in speed, most microprocessors have at least one interrupt input. Whenever an interrupt occurs, the microprocessor terminates the instruction it is executing and branches immediately to a service subroutine (Fig. 3). Ideally the subroutine should do the following:

- Save the microprocessor "state"—all the information contained in the accumulator, the registers and the internal flag flip-flops. (This operation isn't always simple.)
- Acknowledge the interrupt signal on a special line, when it is available.



4. **Either an enable/disable function or a priority structure** can be obtained readily for a microprocessor that has neither. A conventional input port can be used to control the interrupt input.

- Perform the operation called for by the interrupt.
- Restore the state of the machine.
- Resume execution of the program.

The elapsed time between interrupt and the start of the interrupt-handling subroutine is called the "response time." The difference between the total time elapsed and the actual execution time is referred to as the "overhead." Both times should be kept as low as possible.

Interrupt capabilities vary

The capabilities of microprocessors can vary considerably in the way they save the state upon receipt of an interrupt request and restore this state upon completion of servicing. For the Intel 8008, for instance, an extensive amount of software is required. And additional hardware is necessary for saving, at least temporarily, the accumulator and one of the registers. You could avoid the external circuitry by reserving two of the seven internal registers exclusively for status saves. But speed and program efficiency probably would be impaired.

Newer microprocessors, such as the Intel 8080, Motorola M6800 and National PACE, have special instructions that save the state of the microcomputer by pushing status information into a push-down, or last-in first-out, stack.

For those applications that have few interrupt sources, the Mostek 5065 offers a unique solution: It incorporates three independent sets of accumulators, program pointers and link flip-flops. Whenever an interrupt occurs, the processor can simply shift from one level of operation to the next, thus making status saves and restorations unnecessary.

Recent microprocessors—such as the Intel 8080, Mostek 5065, Motorola M6800 and Rockwell PPS-8—have Interrupt Enable and Interrupt Disable instructions that set or reset an internal interrupt-control flip-flop. These allow the disabling of the interrupt request, whenever necessary. In microprocessors not having this feature, the only way to achieve the same result is to use external hardware to gate the interrupt signals. The hardware, in turn, can be controlled by a conventional output (Fig. 4).

The Mostek processor employs two special instructions to control the enabling or disabling of its interrupt. The first has the form

$$0\ 0\ 0\ 0\ 1\ 0\ \ M_1\ M_0,$$

which allows a designer to enable either Interrupt 1 (M_0) or Interrupt 2 (M_1) or both, by making the appropriate bit a ONE.

The second instruction has the form

$$0\ 0\ 0\ 0\ 1\ 1\ \ M_1\ M_0,$$

which allows a designer to disable either Interrupt 1 (M_0) or Interrupt 2 (M_1) or both, by making the appropriate bit a ONE.

The PACE microprocessor has a status register that reserves 6 of its 16 bits for interrupt control. One of these bits can disable all of the interrupts. It is automatically set to a ZERO by the interrupt service routine, but it can be reset by software. The five other interrupt-control bits each enable or disable one of the four interrupt inputs or a built-in interrupt that is generated when the stack is full or empty.

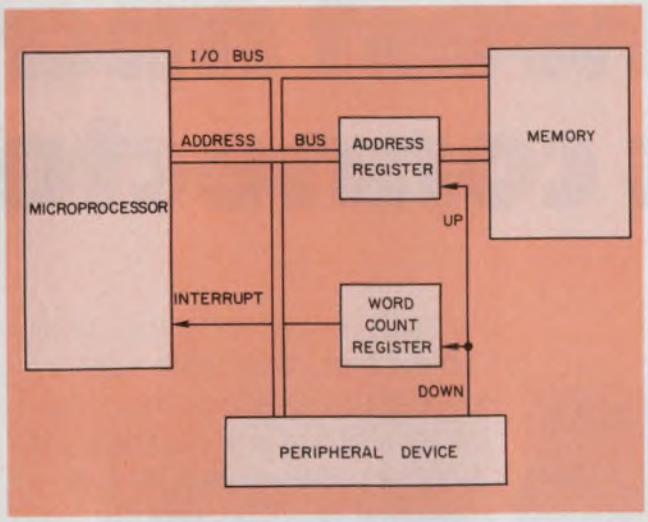
To control the status bits, however, you must use a few instructions. These load one of the accumulators or registers with the information and then duplicate it in the flag registers.

Each source of an interrupt signal is usually associated with a program-controlled Arm flip-flop. A programmer can enable (Arm) or disable (Disarm) one interrupt source without affecting the others. Until the recent introduction of improved support circuitry, this feature could be implemented only with external hardware under output control.

Assigning priorities to interrupts

Interrupt requests are frequently assigned priorities. Whenever two interrupts occur simultaneously, the one with the higher priority is considered first. Furthermore a higher-priority interrupt can interrupt the service routine of a lower-priority interrupt. Most microprocessors don't have built-in priorities, and these must be handled either with software, external hardware, or both.

Among the exceptions are the Mostek 5065, which obtains two levels of interrupts through two pins. Also, National's PACE assigns priori-



5. **A direct-memory access facility** permits efficient transfer of large blocks of data between memory and peripheral device.

ties to its four interrupt inputs, and so does the Toshiba TLCS-12 to its eight interrupt inputs. Of course, the daisy-chain structure in Fairchild's F8 or Rockwell's PPS-8 automatically provides priorities.

Most microcomputers have a single-level interrupt: The interrupt causes a transfer of control to a preassigned memory location that contains the beginning of the programmer's interrupt-processing routine. When more than one device may cause the interrupt, the program must poll all possible sources to determine which requires servicing.

For some microprocessors—for example, Intel's 8008 and 8080—the interrupt is "vectored." Whenever these units receive an interrupt request, the microprocessor immediately interrogates a few input bits (the vector). These bits specify one of several addresses—typically eight —and the program jumps to these to find the appropriate service subroutine. Vector interrupt makes polling unnecessary whenever the number of interrupt sources is smaller than the number defined by the vector.

In some cases—the Intel 8008 and 8080—the vector must be constructed with external hardware that encodes the eight interrupt conditions. This can be achieved easily with priority encoders like the SN74148. In other cases—such as the National PACE—the vector is automatically constructed within the CPU.

Multiple-level interrupts are not found very frequently in presently available microprocessors. The exceptions include the Rockwell PPS-8, with three levels (one of which is dedicated); the Toshiba TLCS-12, with eight levels; the Mostek 5065, with two levels, and the National PACE, with four levels. Multiple-level interrupts allow the microprocessor to determine immediately which device is requesting an interrupt. At the same time multiple levels simplify assignment of interrupt priorities by eliminating the need for special hardware or software.

Many applications require the fastest possible transfer of large amounts of data between the microcomputer memory and peripheral devices. System efficiency can be increased by avoidance of time-consuming programmed word transfers in which the microprocessor supervises each operation.

Increased efficiency can be achieved by addition of a direct-memory access (DMA) facility. It allows an I/O device interface to "steal" a memory cycle from the program and transfer a word of data directly from or to a memory address specified in a special address register. With an automatic increment of the address register after each word transfer, successive words of data can be transferred into successive memory locations.

A separate, word-count register keeps track of the progress of the transfer. Typically the register is loaded at the beginning of the operation with the number of data words to be transferred and decremented after each transfer. On reaching zero, the word-count register signals the completion of the transfer operation by generating an interrupt signal.

Circuitry initiates memory cycle

Additional control circuitry is also required to initiate the memory cycle, once the data are ready to be transferred (Fig. 5). This circuitry depends on the CPU used. Although most 8-bit CPUs have DMA capabilities, the problems of implementation can vary significantly from one unit to another.

Direct-memory address can be initiated either by a peripheral device or by the microprocessor. In either case programmed control loads the address register with the address of the first memory location, and the word count register with the total number of words to be transferred.

With the Intel 8080, a Hold input can be used to request the CPU to enter a state in which the following occurs: The data bus and the address bus go to their high impedance state, thus allowing an external device to gain control of that bus. The CPU acknowledges the Hold input with an acknowledge signal on its HLDA pin.

In the Mostek 5065, the same result is obtained, respectively, with WAIT (input) and DMA (output).

The most efficient way to implement DMA is given by the Rockwell PPS-8. A special, additional chip can be used to control up to seven independent DMA operations. ■■

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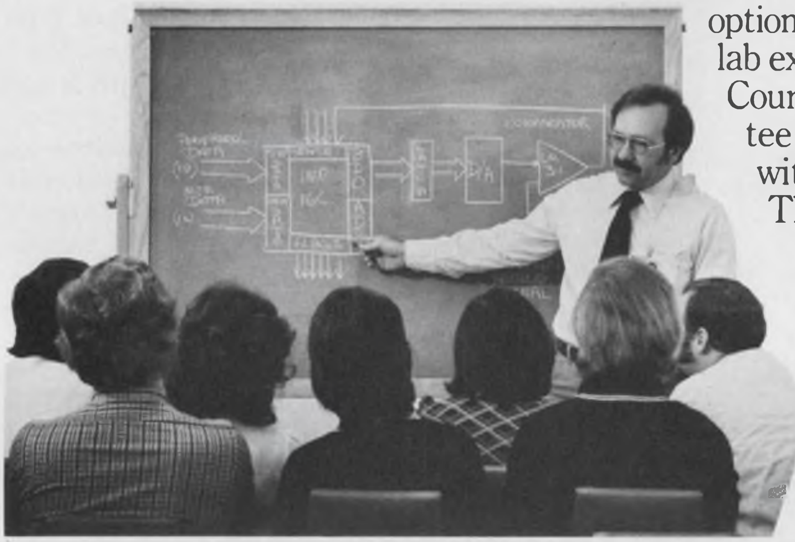

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Simplify add-on peripheral controllers

with LSI data-communications circuits. A mini-to-terminal interface provides one practical example.

With available LSI data-communication circuits, it's possible to cut costs and simplify the design of peripheral controllers for minicomputers. And the same design techniques can be extended to microprocessors.

Peripheral controllers interface minis or microprocessors (which use a parallel-data format) and peripheral equipment (which employs a serial format). Hence controllers perform serial/parallel data conversions, and they contain interface, timing and synchronizing circuitry. Many of these features have been incorporated into two LSI data-communication circuits: the UART (Universal Asynchronous Receiver/Transmitter) and ACIA (Asynchronous Communications Adapter).

Either LSI circuit can be used in applications involving such peripheral equipment as teletypewriters and terminals. Typically such applications call for low transmission rates—below 1200 bps or 120 char/sec—and operation in an asynchronous mode. A teletypewriter, for instance, operates asynchronously at 10 char/sec maximum rate.

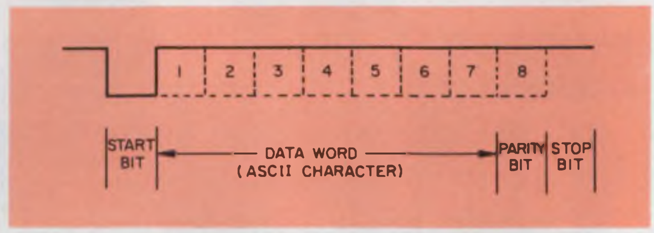
The design of a peripheral controller conveniently breaks down into these three phases:

- Interface and control logic.
- Data conversion.
- Software.

Let's see how a design proceeds with the following example: a controller for a popular minicomputer must transmit and receive data from a TI ASR 700 tape-cassette terminal.

Consider the system basics

The terminal uses an asynchronous serial bit stream consisting of data bits that are preceded by a Start bit and followed by one or more Stop bits (Fig. 1). The Start and Stop elements don't contain information, but they do establish bit and character synchronization at the receiving device. Also some mechanical teletypewriters—and some recent integrated terminals—require more than one Stop bit, due to the mechanical response time of the unit.



1. **Peripheral devices use asynchronous** formats.

The TI terminal also uses the ASCII (American Standard Code for Information Interchange) code for representation of alphanumeric information. In the transmission of data, a clock signal is not transmitted along with the data, and gaps (idling) between the characters may result. Therefore the receiving device must generate a clock that is synchronized to the data for purposes of data sampling.

In the mini, data are handled in a 16-bit parallel form without Start and Stop elements. The mini uses 16 address lines to select the peripheral device for data transmission. Under program control, the mini asserts a peripheral address, and parallel data either transfer to or from the peripheral controller—a "write" or "read" operation, respectively. Then the controller converts the parallel data to serial form for use by the terminal, or vice versa.

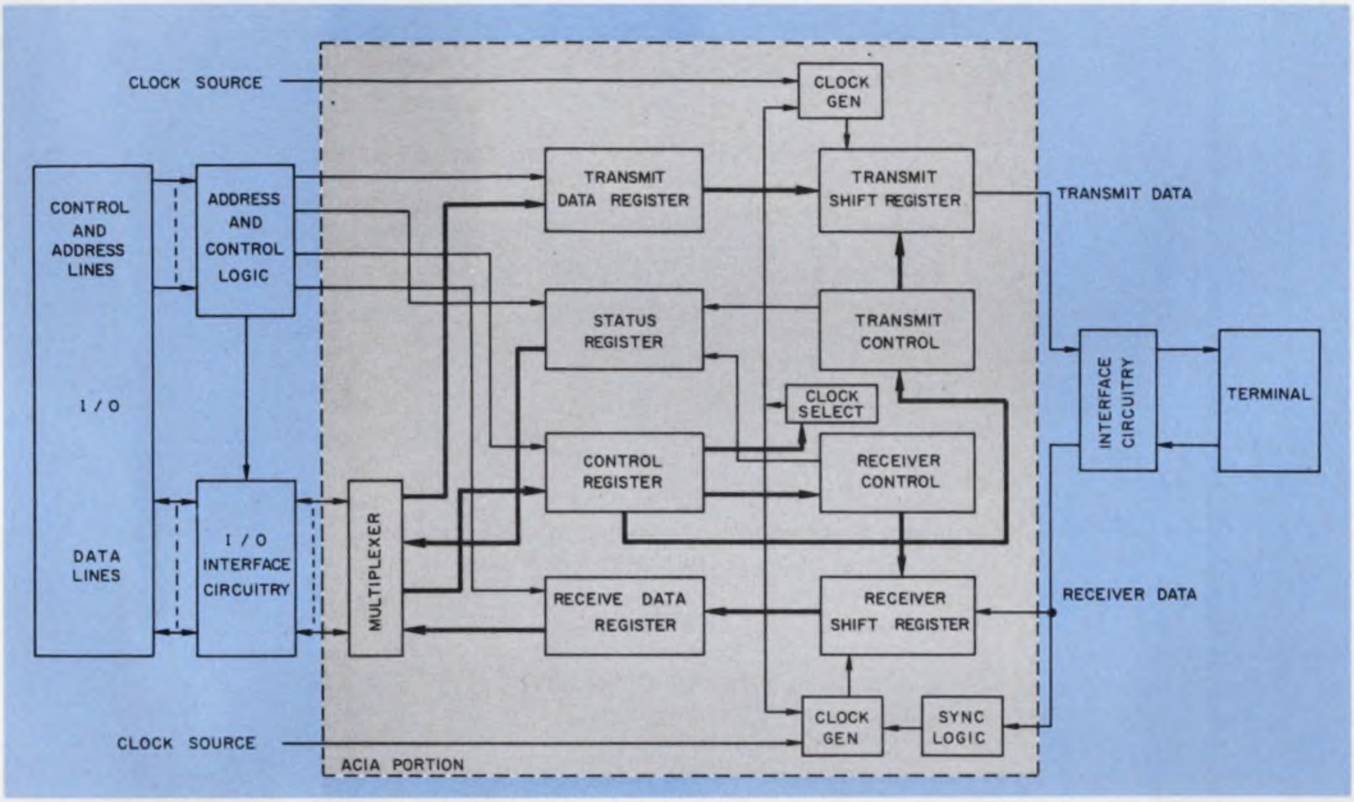
The peripheral controller consists of six sections (Fig. 2): Address and Control Logic, I/O Interface Circuitry, Multiplexer, Transmitter, Receiver and Status-and-Control Storage.

Again under program control, an 8-bit character (in ASCII code) is loaded into the transmitter portion; Start and Stop bits are added to the character and it is transmitted in serial form to the terminal. Likewise in the receiver section, the incoming serial character has its Start and Stop bits stripped, and the character becomes available to the mini in parallel form.

Either the UART or ACIA can be used to perform the serial/parallel conversions.

The transmitter portion of the UART adds a Start and one or two Stop bits to the character

Karl Fronheiser, Computer Applications Engineer, Motorola, Inc., Semiconductor Products Div., Phoenix, AZ 85008.



2. **A peripheral controller** consists of the blocks shown. An ACIA incorporates much of the circuitry needed.

as it shifts out serially. If internal parity generation has been selected, a parity bit also is inserted in the last data-bit position (the 8th bit in ASCII). The transmitter's input data storage has double buffering, so that one character can be loaded into a buffer as another character transmits out of a shift register.

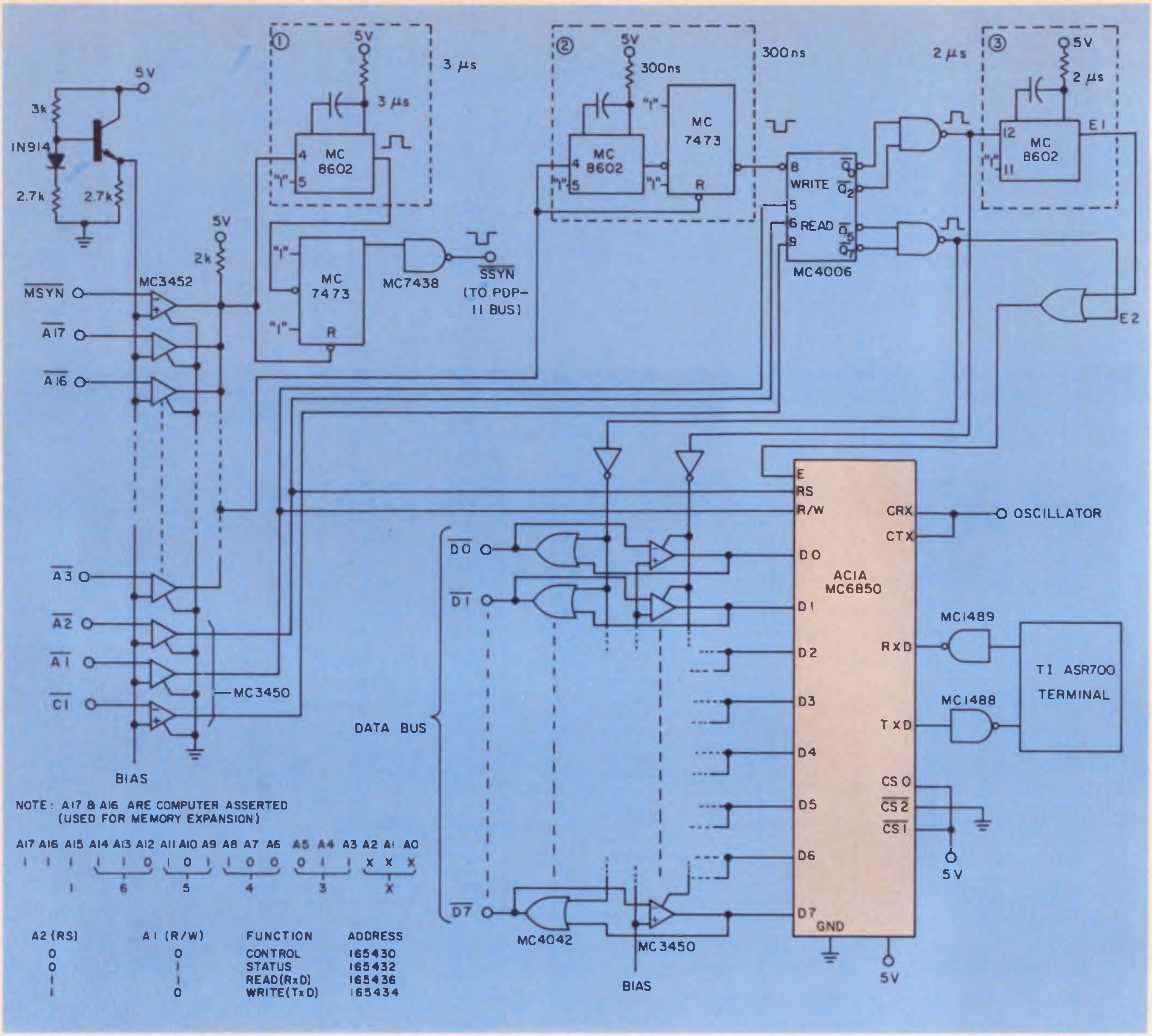
Detection of the Start bit—logic ZERO—initiates the UART's receiver cycle. The Start bit's leading transition synchronizes an internally generated clock to the data. Sampling is enabled at the approximate midpoint of the bit times. The Start-bit detection circuitry latches when the Start bit remains low for half a bit time. Then remaining data bits can be sampled at their approximate midpoints.

The UART's receiver also has double buffering, so that one character can be read from a buffer as a shift register receives another. The status of each incoming character is checked for parity and framing and overrun errors. A framing error indicates the absence of a Stop bit, and an overrun indicates that a character previously received has not been read by the mini.

UART and ACIA differences

Thus far, the characteristics of a UART are identical to that of an ACIA. With a UART, however, control inputs, status outputs and data buffers are accessible through unidirectional lines. Thus the I/O bus of the mini requires additional multiplexing for read or write operations. The ACIA incorporates the multiplexing circuitry, so that status, control and data registers are accessible through a single bidirectional bus.

A schematic of the peripheral controller appears in Fig. 3. Bus drivers and receivers must



3. **The hardware requirements** for the controller are indicated in this schematic.

meet the mini's I/O interface specifications, shown in the table.

From Fig. 3, an open-collector quad line receiver (MC3452) decodes the mini's address bus. The address and data bus of the mini are in complemented form. A biasing network connected to appropriate address-receiver inputs simplifies the address decoding. Also, the biasing network sets the threshold level of the receiver.

Address lines $\overline{A_{02}}$, $\overline{A_{01}}$ and control line $\overline{C_1}$ use an active pull-up, TTL-compatible receiver (MC3450) to drive other TTL-compatible logic in the controller. And the bidirectional data bus employs both a driver (MC4042) and receiver (MC3450).

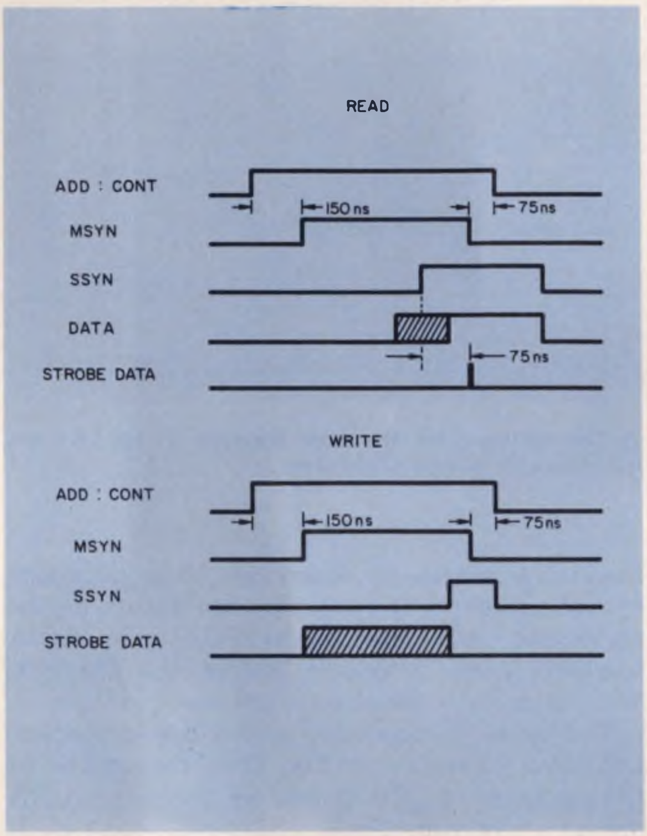
During the read and write operations, the PDP-11 places the controller address on the address bus, along with control bits and a Master Sync (MSYN) command (Fig. 4). The MSYN signal allows for the skew between the address and control bits; it indicates to the peripheral that the address and control bits are present.

Once an MSYN signal is asserted, the peripheral controller has a maximum time—up to 20 µs, depending on the mini model—to respond with a Slave-Sync (SSYN) signal. This signal can be delayed by the one-shot (1) in Fig. 3 to allow for data processing within the controller. The response of an SSYN signal indicates to the mini that the address has been recognized by the controller and performance of the request has taken place. After MSYN is cleared, the controller clears SSYN to free the bus for other purposes. One MSYN is generated for a read operation and two for a write operation.

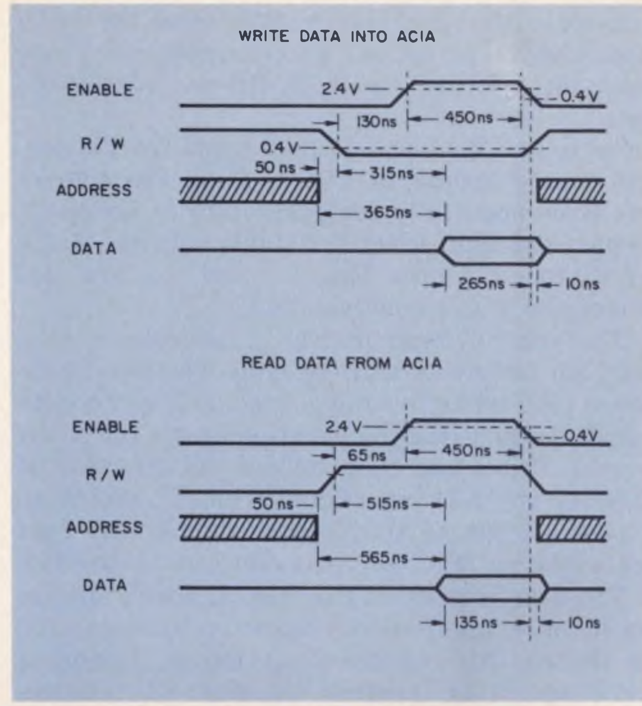
The mini treats a peripheral address the same as it does a core-memory address. This address requires a clear (destructive read) com-

Table. Mini interface requirements

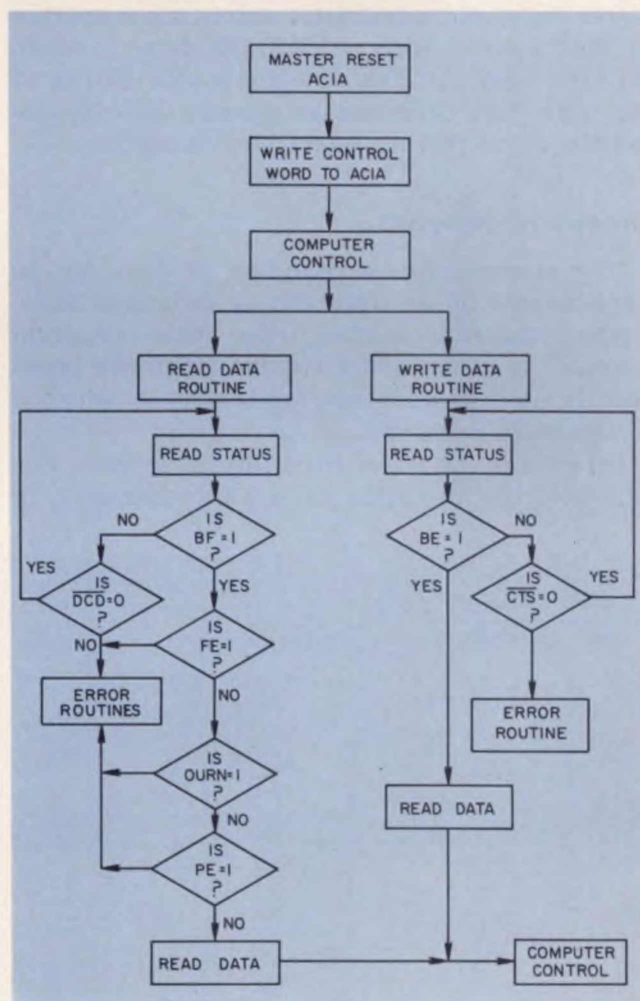
DRIVER (OPEN-COLLECTOR OUTPUT)	50 mA AT 0.8V	LOGIC "0"
RECEIVER	2.5V AT 160 μA	LOGIC "1"
	1.4V AT 0.0 μA	LOGIC "0"



4. **The mini establishes** these timing requirements for read and write operations.



5. **The ACIA has setup and hold** timing relationships that must be observed in the controller design.



6. **Read and write operations for the minicomputer** are outlined with the flow diagram.

mand before data can be written into core. But unlike core memory, data can be written into the peripheral controller without the need for a clear operation. Therefore the read command must be ignored by use of the $\overline{C_1}$ control bit, which indicates either a read or write operation.

The ACIA's four registers—control, status, receive data and transmit data—require four separate addresses that must be in even numbers, since the mini's A_{00} bit is used to indicate a byte operation. And for simplified decoding logic, address bits A_{01} and A_{02} select one of four registers. For example, address 165430 (octal notation) can access the control register while addresses 165432, 165434 and 165436 can access the status, transmit-data and receive-data registers, respectively.

To prevent "glitches" during register access, the Read/Write (R/W), Register Select (RS) and address inputs must be stable when the ACIA enable input is active. This requirement stems from the fact that the R/W, RS and address inputs are level-sensitive.

Setup and hold-time requirements for the control inputs appear in Fig. 5. Since the address bus is decoded fully for generation of an SSYN signal, the chip-select capability of the ACIA isn't needed. Hence C_{S0}, C_{S1} and $\overline{C_{S2}}$ are tied permanently to an active state.

The control logic in Fig. 3 provides timing for both the ACIA and the mini. The 4-to-10 decoder (MC4006) generates read and write commands. In turn, the commands generate the ACIA enable strobe, and they control the direction of data on the I/O bus. Control bit $\overline{C_1}$ selects an unused output of the decoder during the read command, so that the command can be ignored.

The delay circuit (2) in Fig. 3, which enables the decoder, also provides the setup time required by the ACIA's register-select inputs. During a write operation, another one-shot (3) ensures that enable setup and hold-time requirements are met.

Finally the controller-to-terminal interface employs standard RS232 devices. The ACIA receiver input and transmitter output are converted to RS232 levels with an MC1488 driver and an MC1489 receiver. The data input and output of the ASR 700 terminal is already RS232-compatible, so no further interfacing is needed.

Software requirements

The minicomputer's reception of data can be implemented on an interrupt or dedicated basis. Under interrupt control, the main program "jumps" to an interrupt routine. Then the interrupt is serviced and program control is returned to the main program.

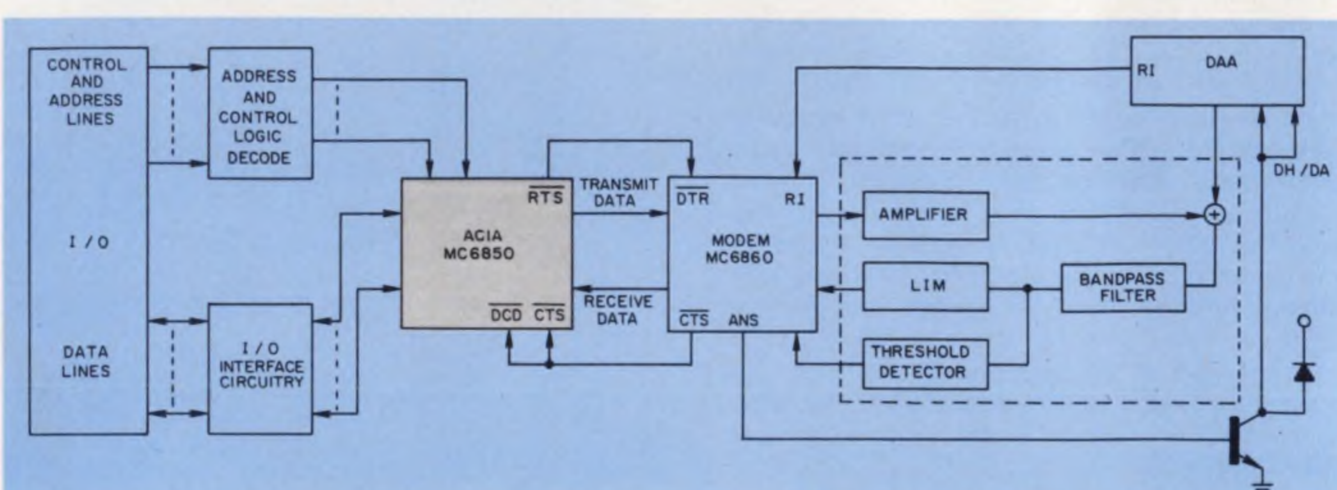
Interrupts can occur from several sources. For example, the reception of a data character in

```
ACIAC  =  165430   CONTROL REGISTER
ACIAS  =  165432   STATUS REGISTER
ACIADT =  165434   TRANSMITTER REGISTER
ACIADR =  165436   RECEIVER REGISTER

•  INITIALIZATION
            MOVB #263, ACIAC          ;MASTER RESETS ACIA
            MOVB #261, ACIAC          ;Control Word - Selects word length,
                                       etc.

•  READ ROUTINE
   READ1  : MOVB ACIAS, R1            ;GET STATUS OF ACIA
            COMB R1                   ;TRUE FORM
            BITB #001, R1             ;CHECK BUFFER FULL
            BNE 2 FRAM                ;BRANCH IF BUFFER IS FULL
            BITB #010, R1             ;CHECK DCD
            BEQ READ1                 ;READ STATUS AGAIN


            BR ERROR                  ;BRANCH IF CARRIER IS LOSS
   FRAM   : BITB #020, R1             ;CHECK FOR FRAMING ERROR
            BEQ OVRN                  ;BRANCH IF NO FRAMING ERROR
            BR ERROR                  ;BRANCH FOR FRAMING ERROR
   OVRN   : BITB #040, R1             ;CHECK OVERRUN ERROR
            BEQ PAR                   ;BRANCH IF NO OVERRUN
            BR ERROR                  ;BRANCH IF OVERRUN
   PAR    : BITB #100, R1             ;CHECK PARITY ERROR
            BEQ DATA                  ;BRANCH IF NO ERROR
   ERROR  : (ERROR ROUTINE)           ;ERROR ROUTINE
   DATA   : MOVB ACIADR, R1           ;GET DATA
            COMB R1                   ;TRUE FORM (NON COMPLEMENTED)
            RTS                       ;RETURN FROM SUBROUTINE

•  WRITE ROUTINE
   READ2  : MOVB ACIAS, R1            ;GET STATUS OF ACIA
            COMB R1                   ;TRUE FORM
            BITB #002, R1             ;CHECK BUFFER EMPTY BIT
            BNE DATA2                 ;BRANCH IF BUFFER IS EMPTY
            BITB #010, R1             ;CHECK CTS BIT
            BEQ READ 2                ;BRANCH IF CTS IS ACTIVE
            (ERROR ROUTINE)           ;ERROR ROUTINE
   DATA2  : MOVB R2, ACIADT           ;LOAD DATA IN TRANSMITTER
            RTS                       ;RETURN FROM SUBROUTINE
```

7. **The software for the flow diagram** in Fig. 6 uses minicomputer source statements.

the ACIA causes an interrupt. In a dedicated system, a subroutine samples the status of the peripheral until data are available. The ACIA works in either interrupt system, but the software example is based on a dedicated system.

The ACIA incorporates power-fail protection and power-on reset circuitry. These features avoid the reception of false indicators from the ACIA during a power-on sequence. But they don't eliminate the need for initialization after power-on. Initialization begins with a master reset of the ACIA. Then the control registers are used to program such parameters as word length and



8. **With a modem interface,** remote data entries can be achieved.

counter-divider ratios. The flow diagram of the read and write routines appears in Fig. 6.

In a read operation, the ACIA's buffer-full status bit is checked continually until data have been received. Then remaining status bits are checked for data errors due to parity, framing or overrun. A data error causes a jump to an error routine (not shown), which can cause retransmission of the previous character or can cancel the erroneous data. If no errors occur, the controller reads the data and program control returns to the main program.

In a write operation, the buffer-empty status bit is checked to see if data may be loaded into the buffer. After a character is loaded into the controller, the program control returns to the main program. An example of source statements—in the mini's language—for the read and write routines appears in Fig. 7.

Modem extends controller range

With the addition of a modem, the controller can transmit or receive data from remote locations over telephone lines. The ACIA can initiate the handshaking requirements between the local and remote locations through the chip's internal control functions. Fig. 8 shows a typical example that uses a low-speed modem (MC6860).

The modem converts the digital transmitted data from the ACIA into an analog form for transmission. Likewise, analog data received by the modem are converted to digital form for use by the mini. Telephone companies require the Data Access Arrangement (DAA) for protection of their equipment. The remote site also requires a modem to convert the data from analog form to digital form and vice versa.

The following procedure achieves "handshaking" between the ACIA and modem after the telephone channel has been established: The local modem (in Originate mode) is enabled via the Request to Send (RTS) output of the ACIA. The remote modem, upon answering the phone, transmits back its carrier frequency. Upon detection of this carrier, the local modem enables its Clear-to-Send (CTS) output, which is detected by the ACIA. Then data can be transmitted and received under computer control.

The CTS input of the ACIA is available as a status bit in the status register, and it also disables the transmitter portion when inactive. The Data Carrier Detect (DCD) input of the ACIA is available as a status bit and it also disables the receiver portion when inactive. In this example, the low-speed modem has only a CTS output. Therefore the CTS output of the modem is tied to both the CTS and DCD inputs of the ACIA to disable the transmitter and receiver simultaneously. ■■

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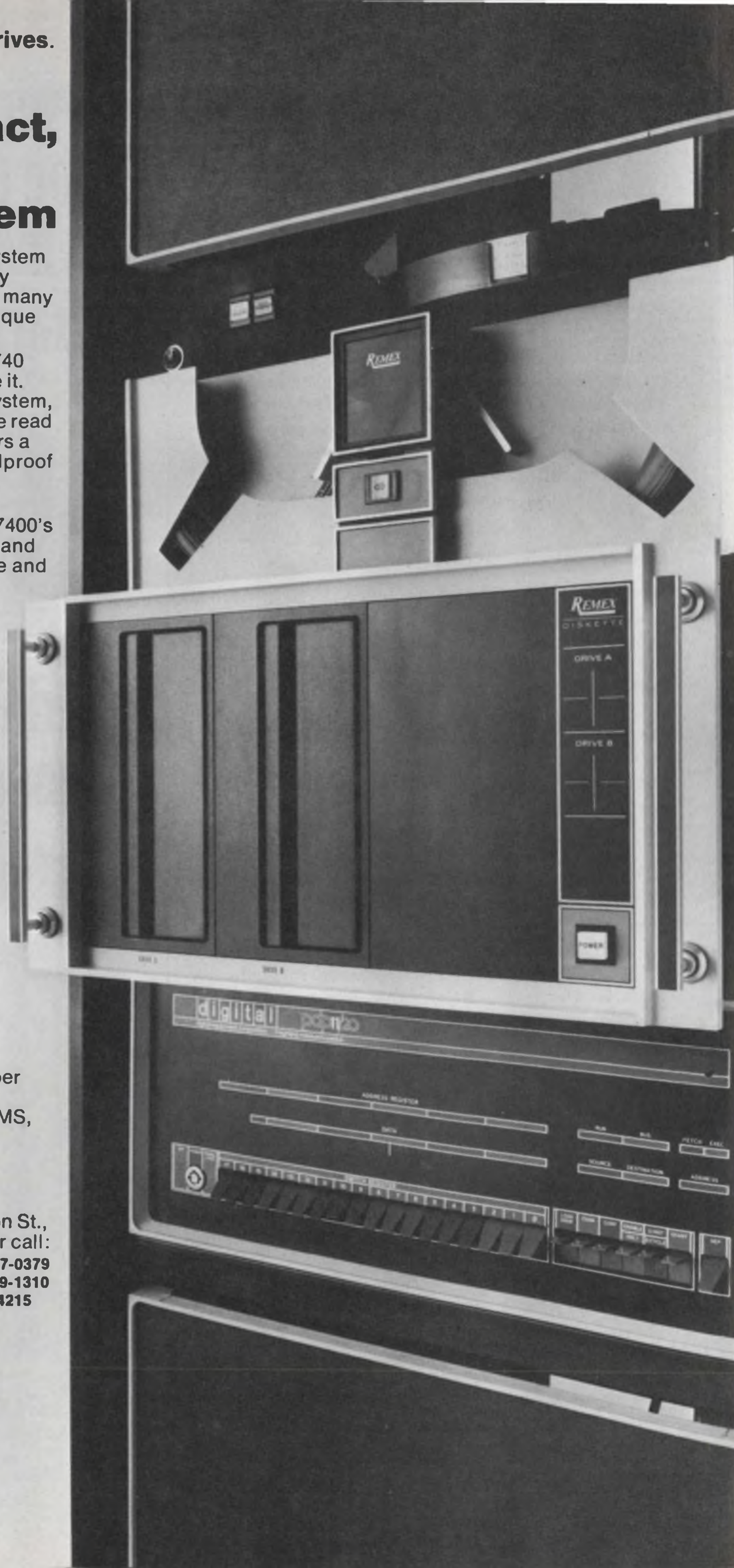


Keeping fast minis busy is a job for stack architecture. One computer can serve several users and make efficient use of virtual memory.

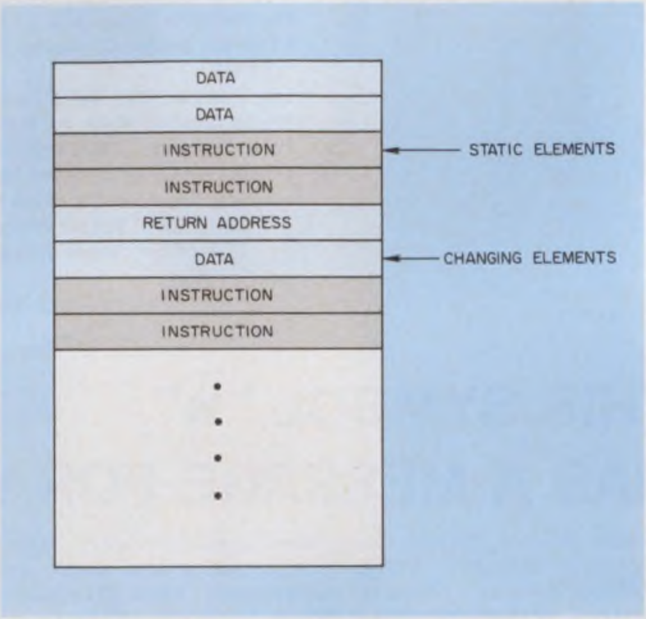
Fast minis are becoming a way of life, but keeping them busy is something else. It's not uncommon to find a CPU that is idle 80% of the time but spends the other 20% compiling a developmental Fortran problem. Multiprogrammed operation, in which one machine serves several users simultaneously, is a good solution. And stack architecture can create a suitable machine environment.

Important capabilities supported include: re-entrant coding, time-sharing, dynamic storage allocation and efficient use of virtual memory. As a side benefit, the architecture also enhances compiler performance.

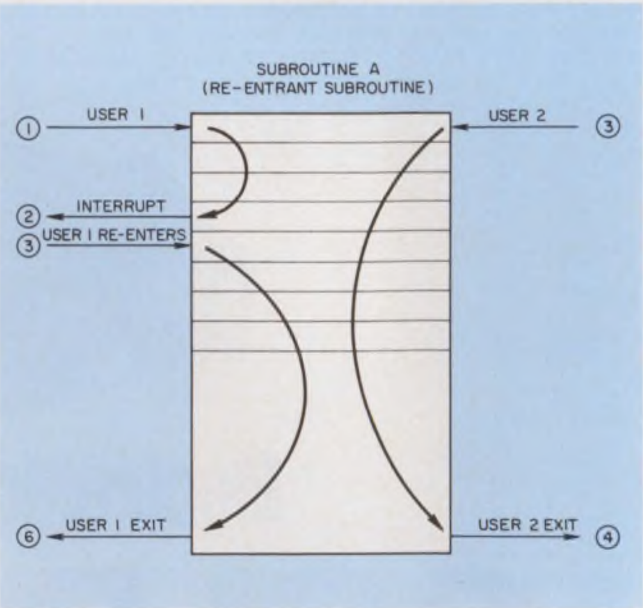
Stack systems separate data from code

Stack architecture differs from the traditional register-oriented design. A program in the main memory of a register-oriented minicomputer consists of a mixture of two elements: machine instructions and program data (Fig. 1). The machine instructions are usually *static*, while the data and return addresses *change* during the life of the program. And herein lies the problem: A program in a register-oriented computer consists of elements that change as well as elements that remain fixed. Therefore it is difficult to implement multiprogramming on traditional systems, because the programs cannot efficiently be made re-entrant.

Consider the case of two users, one with an active program, the other waiting (Fig. 2). The active program calls a commonly used routine, say Subroutine A. But in the middle of execution, the operating system interrupts the program of User 1 for a higher priority job from User 2. Assume that User 2's program also calls Subroutine A and completes execution. When User 1's program resumes at the point of interruption, all variable elements, such as data and return addresses, will have been destroyed.



1. **Data and instructions** for a given program are usually combined in a multiprogrammed computer.



2. **When several persons must use** the same program, the mixture of instructions with calculated results makes for difficult bookkeeping, especially if the routine can be interrupted then re-entered.

William E. Foster, Computer Systems R&D Manager, Hewlett-Packard Data Systems, 11000 Wolfe Rd., Cupertino, CA 95014.

There are four possible solutions to this problem:

1. Restart User 1 at the beginning of the subroutine. This has the obvious disadvantage of poor performance, along with the possibility that User 1 will never finish because of frequent higher-priority interrupts.

2. Provide multiple copies of the common subroutines, one for each user. This solves the re-entrance problem but is inefficient use of memory, because of duplication of programs (in our example, Subroutine A could have been a 30,000-word Fortran compiler).

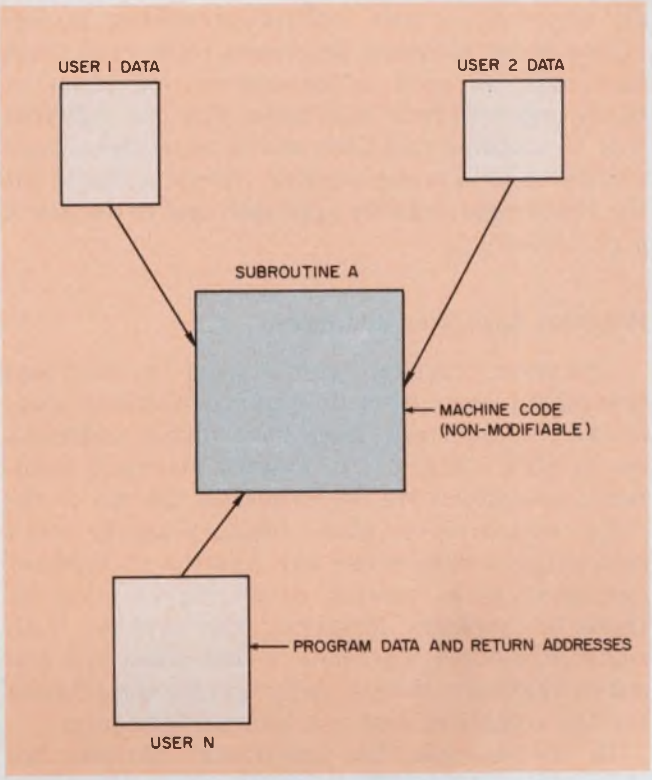
3. Provide a software solution, where all variable data are moved to a protected area of memory at the beginning of the subroutine and restored at the end. This is the approach that some real-time operating systems use, but, again, it has the disadvantage of poor performance, due to the overhead of moving data to and from the subroutine each time it is called. For commonly used functions, such as sine and square root, this could easily double their execution time.

4. Provide a design where programs are divided into two classes of elements: machine code that never changes, and variable elements, such as data arrays, temporary storage locations and return addresses. This is precisely the principle of stack architecture.

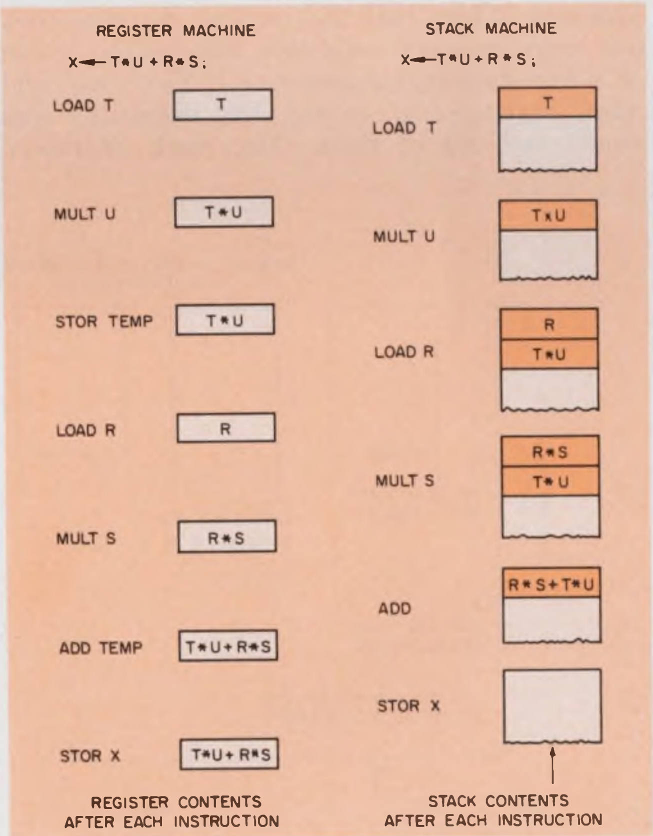
Stack architecture provides an efficient implementation of re-entrant programming (Fig. 3). In a stack machine, programs consist of *separate* code and data segments. It is not possible for a user to modify a code segment; therefore all programs are automatically re-entrant. It is never necessary to have more than one copy of any program or subroutine, even if many simultaneous users are accessing it. However, each user has his own unique data area. Data segments contain all information that changes as the program executes—such as variables, arrays and return addresses. Code segments contain all of the information that remains fixed—machine instructions and program constants.

In a multiprogrammed minicomputer system, programs should be shared among all active users; unnecessary duplication of code severely restricts the number of users that can execute concurrently. The example shows just one subroutine being shared, but in reality the system could be sharing compilers, libraries, application programs and even parts of the operating system itself, such as the file system.

Time-sharing is a subset of multiprogramming (the term, when applied to minicomputers, usually means a multiterminal system with just a single language available, such as BASIC). Shared code isn't necessary because just one program runs on the system—the BASIC interpret-



3. **Separation of code and data,** as with a stack machine, allows each user to work with any portion of the same re-entrant routine. There is need to save only the data calculated by the program and return addresses.



4. **A stack machine has virtually an unlimited** number of addresses, but a register machine must store to temporary locations.

er. However, a true multiprogramming system allows many different languages to be used from terminals, as well as concurrent execution of batch and real-time programs. The only efficient way to combine real-time multilingual time-share and batch on a minicomputer system is throw out the traditional register approach and to use stack architecture.

Registers have fixed addresses

The term "register" comes from the fact that traditional computers do their arithmetic operations in registers that have fixed addresses in the CPU (Fig. 4). In a stack machine, arithmetic operations are performed on the top of the stack, which moves about memory as the stack size changes. Therefore any location in memory can serve as a register, producing as many as there are memory locations. The problem with register-oriented machines is that when you run out of registers, things really become complicated for the compilers and you lose performance.

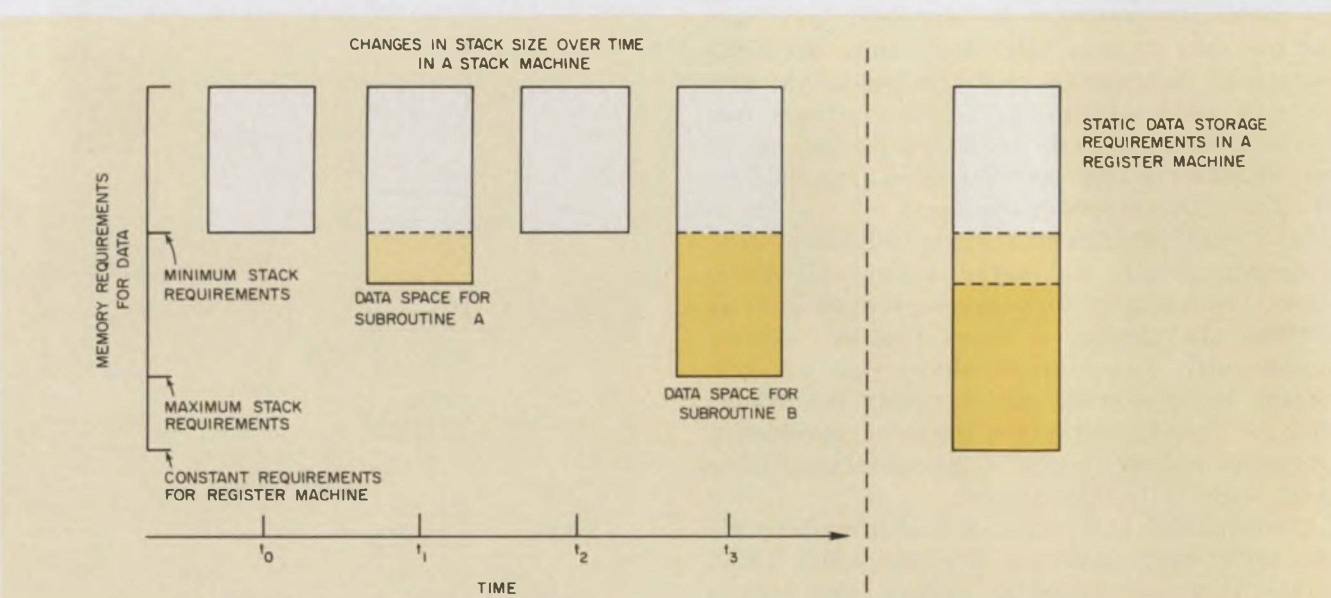
In the example, the traditional machine has only one register. The compiler must allocate a temporary location in the program and store the intermediate result (A*B) into it to evaluate the expression. This complicates the design of the compiler, wastes memory (for both the temporary cell and the program steps necessary to access it), and degrades the performance of the program. (Note that the register machine took one more memory reference instruction, which is a time-consuming operation.) You could add more registers, of course, but eventually you would run out of them. Also, each additional register slows the "context switching" time—the time when the system switches from one user to the next—because each register must be saved in memory and later restored if it is going to be used by the next user.

In the stack machine there is no need for temporary storage of intermediate results; arithmetic operations use the top-most elements in the stack. LOAD instructions "push" data onto the top of the stack, and STORE instructions "pop" data from the top of the stack. Intermediate results are automatically pushed deeper into the stack as new data are loaded, and the results are in place. ready for operation, without additional memory fetches.

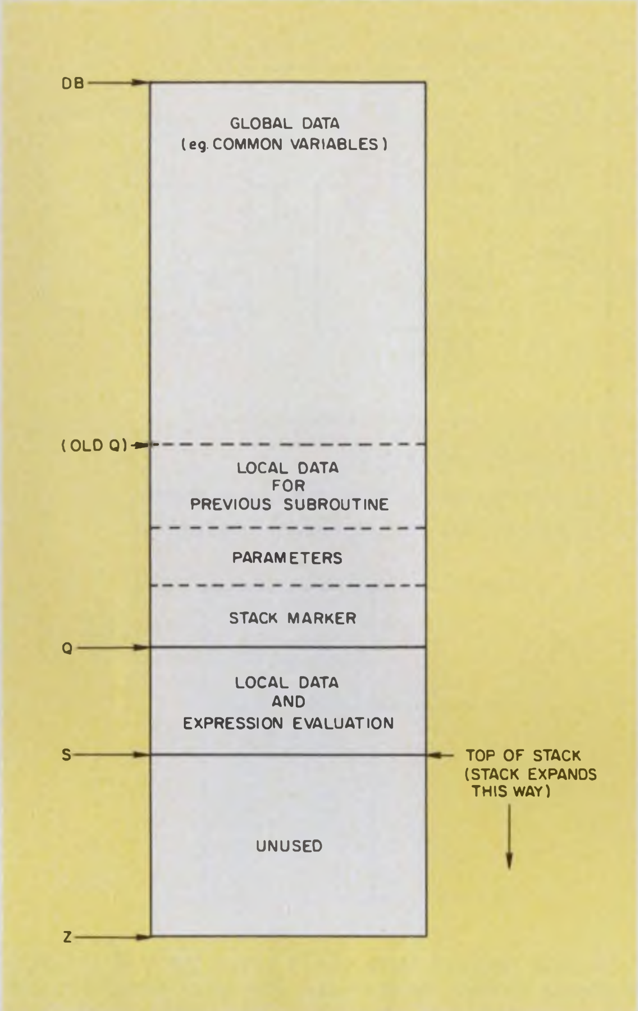
Storage can be allocated as needed

Stack instructions can be added to traditional, register-oriented minicomputers. And these instructions help in expression evaluation. However, a true stack machine—one designed with the stack in mind—uses the stack in many other ways. One is through dynamic storage allocation. which greatly reduces the total memory required to execute a program. In a traditional computer, storage for all the data requirements of a program is allocated when the program is loaded, because the data are embedded in the program itself. More efficient use of memory results if the storage is allocated on an as-needed basis, and pooled when no longer required (Fig. 5).

With stack architecture, when the program is first loaded, memory is allocated for the minimum requirements of the program, such as COMMON blocks in a FORTRAN program.



5. **Dynamic memory allocation becomes automatic** with a stack, since each subroutine uses only the amount of data space needed to perform calculations. In a register machine the maximum space is allocated at execution time, and it remains fixed. Hence a stack machine makes efficient use of memory.



6. **Four registers control stack boundaries.** DB and Z limit the stack to prevent interference between users. Q indicates the data base for a currently executing routine, and S follows the changing stack size.

Then, as subroutines are called, the stack is expanded to meet their requirements. When a subroutine terminates, the stack is cut back to its original size so the memory can be used by the next subroutine. Generally the maximum amount of storage required at a single time is less than the amount required for the entire life of the same program on a register machine.

Four registers control the stack boundaries in the CPU (Fig. 6). DB points to the beginning of the stack, and Z to the limit of the stack. These registers provide the protection required in a multiprogrammed system so that a user cannot get outside of his assigned boundaries. S points to the current top of stack, and it continually changes as expressions are evaluated and storage is allocated. Q points to the base of data for the currently executing subroutine. Just below Q there is a stack marker that contains return addresses and information on how far to cut back the stack when the current subroutine is finished. Below this are the parameters that have been passed to the subroutine by the calling program. A by-product of the stack that is very useful to systems programmers is that it permits all subroutines in any language to be recursive. When a subroutine contains a call to itself, the parameters are loaded on the top of the stack, Q is reset, and the process repeats.

The area between Q and S is for local storage of the currently executing subroutine and for storage of expression evaluation. The space above DB is used by global data, such as COMMON blocks. If S tries to expand beyond Z, the CPU interrupts the operating system and lets it make the decision whether or not to expand the stack beyond its current limit.

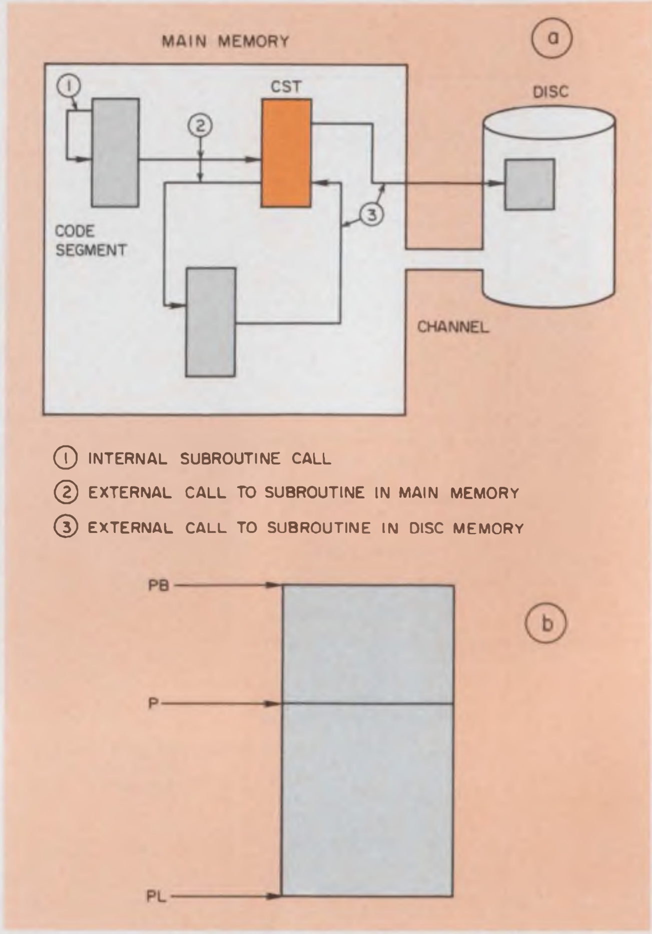
Because code and data are separated in a stack machine, it is relatively easy to implement an efficient virtual memory scheme. The machine code can be divided into variable length segments, so only that part of the program currently executing needs to be in main memory (Fig. 7a). The location of each code segment (either memory location or disc address) is kept in a resident table called the Code Segment Table (CST). The process of linking a segmented program together during execution is as follows:

1. Whenever a subroutine call statement is encountered in a program, the compiler emits a PCAL (procedure call) machine instruction. If the call is to be a subroutine within the currently executing code segment, the CPU merely branches to the beginning of the subroutine, with the return address left on the top of the stack (in the "stack marker" described previously).

2. If the call is to a subroutine that is external to the code segment, PCAL examines the CST to determine the location of the code segment. If the code segment is in main memory, the CPU branches to the appropriate location within that code segment.

3. If the CST indicates that the called code segment is not in main memory, the CPU performs an internal interrupt, branches to the operating system, and provides the disc address and length of the required code segment. It is now up to the operating system, through decisions made by the memory manager and the scheduler, to decide when to bring in the code segment.

This process makes it extremely easy to develop programs that are much larger than available memory. At any point in time it is only necessary for one code segment and the stack of the currently executing program to be in main memory. This makes more memory available to other users so that fast context switching between users can take place. Each time a PCAL is executed, the instruction sets a bit in the appropriate CST entry. These bits in the CST are periodically scanned by the operating system to determine which are the most frequently used



7. **A code segment table (CST)** keeps track of program segments in main memory (a). The stack simplifies this virtual memory operation, because program and data are separate. Three registers, PB, P and PL, protect and manage the code being executed (b).

code segments. The least used are swapped out to make room for the most-used segments.

Three registers are used to point to the currently active code segment: PB, P, and PL (Fig. 7b). PB points to the base of the code segment, while PL points to the end of it. P points to the currently executing instruction. PB and PL provide protection in code segments in the same way that DB and Z provide protection in data segments. This protection is critical for multiprogrammed environments. Another requirement for a system where use of main memory is very dynamic is ease of relocation of code and data. All instructions are PB or P-relative, and all data are relative to the stack registers (DB, Q, and S).

Q and S are relative to DB, and P is relative to PB. Therefore only one register has to be set when code or data are loaded into memory: PB for code and DB for data. It is not necessary for the operating system to patch the address portions of memory reference instructions or to change indirect pointers in the data segments. The relocation of code and data is very fast and efficient in a stack machine. ■■

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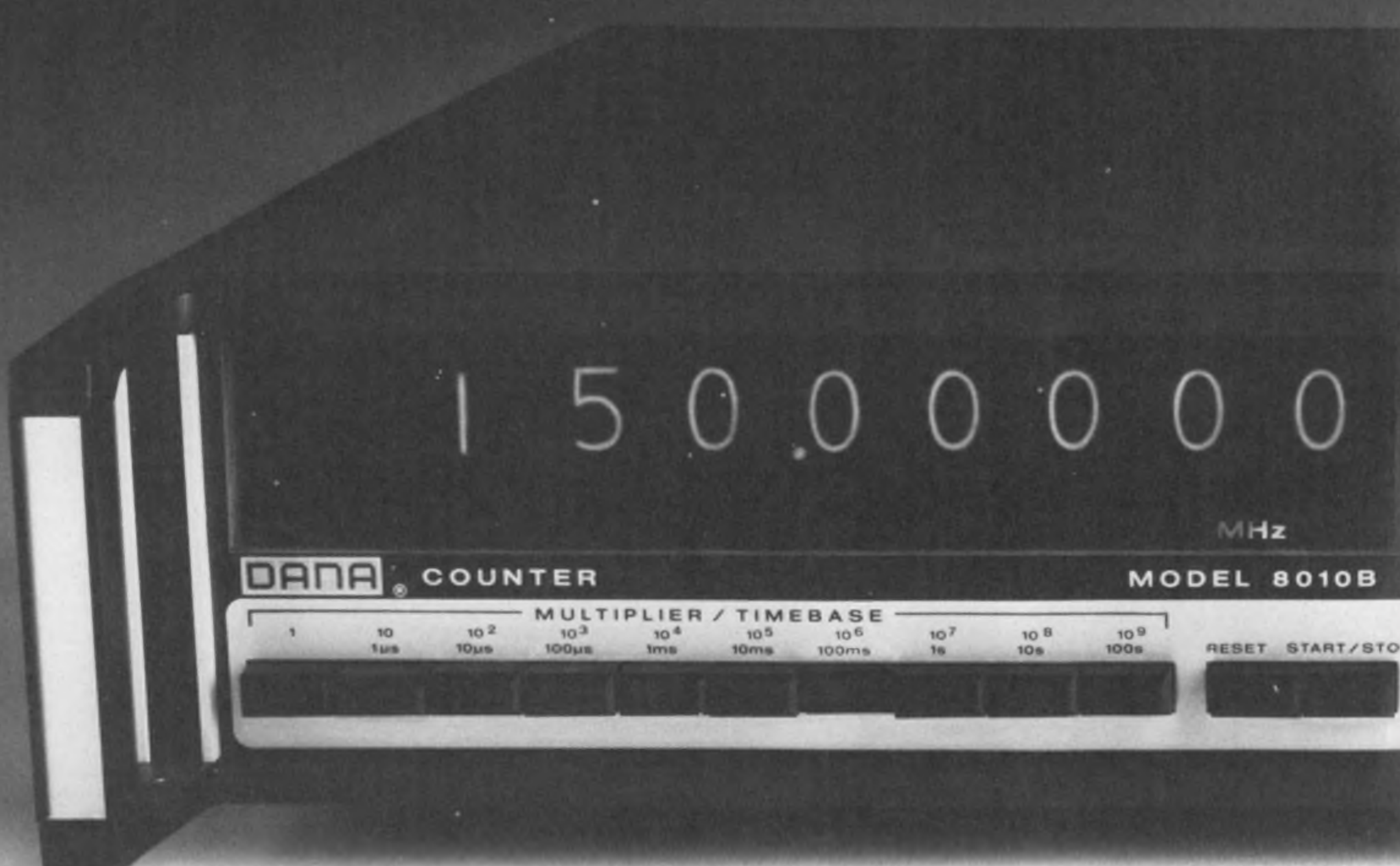

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INFORMATION RETRIEVAL NUMBER 59

Uncover data-acquisition errors despite complex specs. An error budget prepared from the data sheet verifies the performance directly from system printouts.

A precalculated error budget, plus an assist from the systems computer, provides fast checkout of a computer-based data-acquisition system design. The resulting test is easy to apply, yet it takes full account of the complex specifications for individual analog-input devices, such as multiplexers and digitizers.

With the error budget, you predict the allowable mean and rms errors of the entire system. The computer calculates mean and rms values from data samples collected while operating with a calibrated input source. Comparison of computed values with calculated maximum sample means and standard deviations tells the tale. In a few minutes, thousands of samples on many channels can be taken, digitized and printed out.

Plan the test approach

The errors may be divided into two types: systematic and random. The systematic are identifiable quantities, such as the settling error of a zeroing potentiometer.

Ware Myers, Senior Engineer, Xerox Corp., 9920 La Cienega Blvd., Inglewood, CA 90301.

Random errors occur because of electrical noise. Typically the probability density of this random noise has the customary gaussian or bell-shaped curve centered on the systematic error mean. In some instances less random forms of electrical noise, such as power-supply ripple, may cause systematic errors. In the present analysis this effect is ignored.

The computer calculation consists simply of the sample mean and standard deviation for N measurements. Along with the sample of N measurements, you also program channel gain, sample rate and other system variables. The equations to use with the acquired data are straightforward:

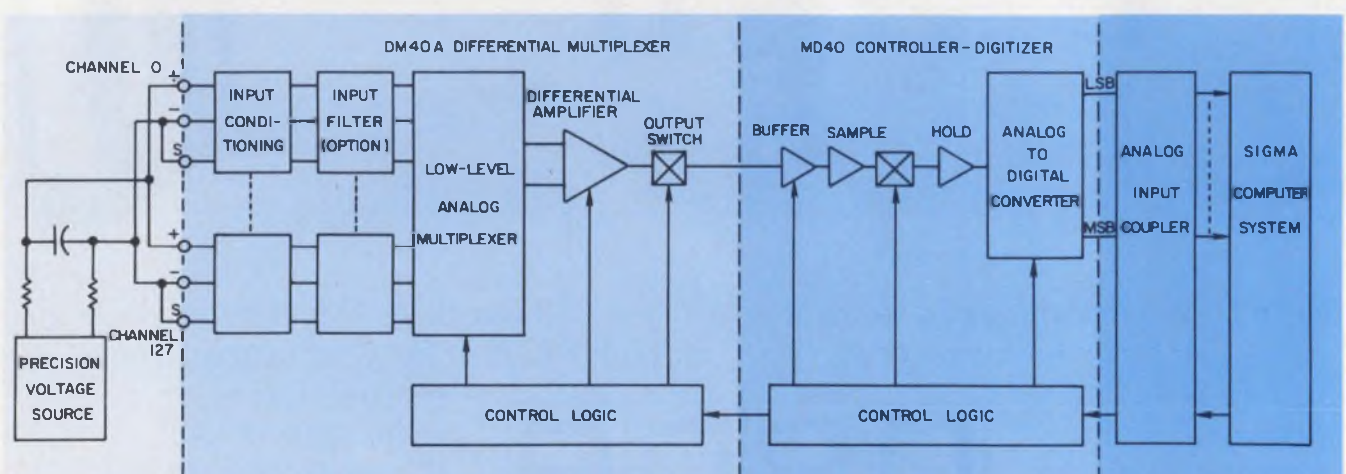
$$\text{Sample mean} = \frac{1}{N}\sum x_i = \overline{X}$$

and

$$\text{Sigma} = \left(\frac{1}{N}\sum_{i=1}^{N}(x_i - \overline{X})^2\right)^{1/2},$$

in which x_i is a single sample. The unit for x_i is the digital count as presented to the computer from the a/d converter.

Systematic errors fall into two classes: zero and reading errors. Zero errors represent inaccu-

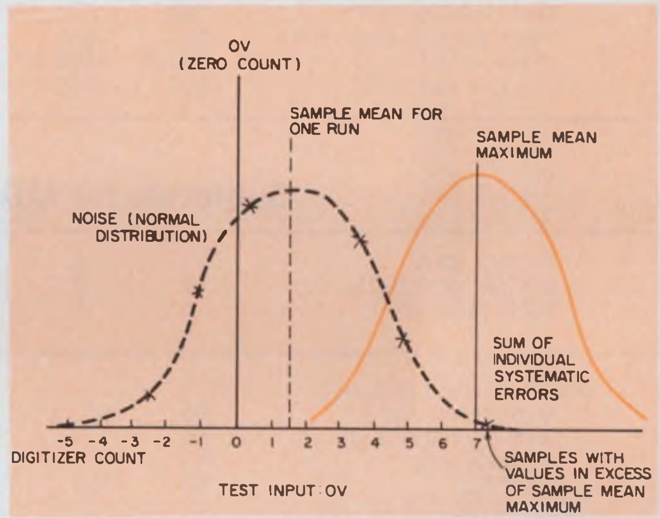


1. **To check out a data-acquisition unit,** set up a simulated system configuration and apply a precision voltage source. The computer can provide outputs to verify over-all performance as calculated from subsystem specs.

racies present during the processing of a zero input signal. Reading errors are additional inaccuracies present in the processing of a nonzero signal. Reading errors are directly proportional to the signal and usually are listed on spec sheets as a percentage of full scale.

Zero errors fall into two further spec categories: referred-to-input (rti) and referred-to-output (rto). For unity channel gain, simply add values. For higher gains, multiply rti by gain and add to rto value.

Specs for temperature-related errors, which are sometimes zero errors, are given as a value per degree C. Include these for a range of ±3 C within the assumed temperature range of the test itself. As used in this report, the temperature error is zero if the test is conducted at the vendor's calibration temperature. But even in a controlled environment, an allowance of 3 C (more in an uncontrolled environment) is advised.



2. **Performance capability is bounded** by two main factors: cumulative systematic errors and random electrical noise. The computer calculates the mean and standard deviation to compare with calculated values.

Table 1. Analog subsystem—zero error specs

DM40A Differential Multiplexer	
Zero trim resolution:	0.5 μV rti + 70 μV rto
Dynamic offset:	0.65 μV rti at 10 sample /s (filtered channels only)
*Zero stability tempco:	1 μV rti + 20 μV rto per °C (3 μV rti + 60 μV rto for 3 C range)
Input current On:	0.1 μV rti based on 0.1 nanoamp per leg input current multiplied by R_{s1} + R_{s2} or (100 + 0).
Input current Off:	3 μV rti (filtered only); computed as 0.1 nA × (R_{s1} + R_{s2}) plus 0.5 nA × (1020 + 1020) plus 2 μV
Input Settling Time: 1000 or 10,000 sample/s	±.01% FS or 5 μV rti, whichever is greater
15,000 sample/s	±.01% FS or 15 μV rti, whichever is greater

MD40 Controller-Digitizer (with buffer input)	
Zero resolution:	60 μV rti ± 100 μV rto
*Zero stability tempco:	
Single-ended input;	20 μV rti + 50 μV rto /°C, or 60 μV rti + 150 μV rto/3 C
Differential input.	30 μV rti + 50 μV rto per °C, or 90 μV rti + 150 μV rto/3 C
MD40 digitizer: Zero setting resolution;	±0.002% FS (10V) maximum, or 200 μV
Zero stability, tempco;	±0.001% FS per °C, or 100 μV per °C or 300 μV for 3 C
†Dynamic error at 13 bits.	±0.01% FS, maximum, or 100 μV

* Based on a calibration temperature of 25 C
† Full scale is 10 V

Subtotals for DM40A

System gain	1	8	64	512	1024	2048	4096	
DM40A gain (G1)	1	8	64	512	512	512	512	Units
MD40 gain (G2)	1	1	1	1	2	4	8	
DM40A (rti)								
Zero Trim Resolution	0.5						0.5	μV
Zero Stability (3 C)	3.0						3.0	
Input current ON	0.1						0.1	
Subtotal (rti)	3.6						3.6	
rti × G1	3.6	28.8	230.4	1843	1843	1843	1843	
Input settling error (rti)	—	—	—	5			5	
Input settling error × G1				2560	2560	2560	2560	
DM40A (rto)								
Zero trim resolution	70						70	
Zero Stability (3 C)	60						60	
Input settling error (rto)	500	500	500	—	—	—	—	
Σ (rti + rto)	633.6	658.8	860.4	4533	4533	4533	4533	
Σ (rti + rto) × G2	634	659	860	4533	9066	18,132	36,264	μV

Subtotals for MD40 and system total

System gain	1	8	64	512	1024	2048	4096	
DM40A gain (G1)	1	8	64	512	512	512	512	Units
MD40 gain (G2)	1	1	1	1	2	4	8	
MD40 Buffer Input (rti)								
Zero Resolution	60						60	μV
Zero Stability (3 C)	90						90	
Subtotal (rti)	150						150	
rti × G2	150	150	150	150	300	600	1200	
MD40 Buffer Input (rto)								
Zero resolution	100						100	
Zero Stability (3 C)	150						150	
Subtotal (rto)	250						250	
Σ (rti × G2 + rto)	400	400	400	400	550	850	1450	
MD40 Digitizer								
Zero setting resolution	200						200	
Zero Stability (3 C)	300						300	
Dynamic error—13 bits	1000						1000	
Subtotal	1500						1500	
MD40 zero error	1900	1900	1900	1900	2050	2350	2950	
DM40 error	634	659	860	4533	9066	18,132	36,264	
Total system	2534	2559	2760	6433	11,116	20,482	39,214	μV
÷ 2441 μV	1.04	1.05	1.13	2.64	4.55	8.39	16.06	Counts

3. **Specs that define system errors are complex,** and an error budget helps translate them to allowable measurement limits. Values referred to device inputs are multiplied by the gain and summed. The spec shown governs zero error—the case when the input signal is zero.

To perform the test, we calculate the allowable ranges for three quantities:

- Zero error.
- Zero error plus reading error (±80% FS).
- Noise with zero input.

The computed means taken with zero input and at 80% FS are compared with the allowable values. Finally the computer-calculated value of sigma is checked against the allowable range.

Consider the following configuration: a precision voltage source, differential multiplexer, controller-digitizer, analog input coupler and computer (Fig. 1). The differential multiplexer, Xerox Model DM40A, acquires up to 128 differential low-level signals. It conditions and optionally filters each channel, then multiplexes them into a single programmable-gain differential amplifier. The output switch can time-division multiplex up to eight DM40As to a common analog output bus. A programmable-gain buffer amplifier (part of the MD40 controller-digitizer) accepts the multiplexed analog signal and applies it to a sample-and-hold circuit. The a/d circuit provides sign plus 12 bits, which the analog input coupler applies to a Sigma-Series computer.

The computer controls the operation of the

Table 2. Reading errors with ±80% FS input

Subsystem	Error Source	Specification	μV at ±80%FS
DM40A	Gain trim resolution (all gains)	±.01%FS, max	±800
	Gain accuracy between any two steps†	±.02%FS, max	±1600
	Linearity, referred to straight line thru zero and FS	±.005%FS, max	±500
	Extra Linearity (filtered channels)*	±.01% Reading	±800
	Gain Stability all gains	±.002%/°C	±480 (3 C)
MD40	Buffer Input		
	Gain Accuracy (X1)	±.01%FS max	±800
	Gain Accuracy (X2, X4 X8)	±.02%FS max	±1600
	Gain Stability	±.0005%/°C max	±120 (3 C)
	Linearity (at X1)	±.003% FS max	±300
	Digitizer		
	FS setting resolution	±.01% max	±800
	FS stability	±.001%/°C max	±240 (3 C)
	Static linearity	±.01%FS max	±1000

* Not used for calculations without filters
† Omit for unity gain

System gain	1	8	64	512	1024	2048	4096	
DM40A gain (G1)	1	8	64	512	512	512	512	Units
MD40 gain (G2)	1	1	1	1	2	4	8	
±8V input error (unfiltered)	5040	6640	6640	6640	11620	18380	31900	μV
Zero Error 1000 or 10,000 Samples/s	2534	2559	2760	6433	11116	20482	39214	μV
Total	7574	9199	9400	13073	22736	38862	71114	μV
÷ 2441 μV	3.10	3.77	3.85	5.36	9.31	15.92	29.13	Count

4. **Add the allowance for reading error in Table 2** to the zero error to get the total systematic error.

test through the analog input coupler. Controlled items include buffer and differential amplifier gain and selection of the analog channel. With four gain settings for the buffer amplifier and differential amplifier, 16 gain settings are possible. Eight combinations suffice to test each gain value. Input filters to the differential mux are optional, as is digitizer resolution of 8 to 13 bits; use 13 bits for best results.

Without systematic errors, the probability distribution of the system outputs resembles a gaussian curve centered at zero counts on the digitizer. A given sample mean can lie anywhere between the limits set by the sum of the individual systematic errors (Fig. 2), yet it will have a variance equal to that calculated for the noise components. The limits used equal the expected mean plus or minus the sum of the systematic errors. If the computer-calculated sample mean lies in this range, the result is acceptable for systematic or calibration error.

The DM40A's contribution to zero errors is calculated as follows:

- List referred-to-input (rti) error specifications in microvolts separately.
- Sum all rti errors.
- Multiply the rti error sum by the DM40A gains.
- List and sum referred-to-output error specifications.
- Sum rti errors times gain and rto errors.
- Multiply this final sum by the MD40's gain.

The MD40 calculations for zero error follow a similar pattern.

Transferring detailed specs (Table 1) to the actual worksheets (Fig. 3) is a straightforward chore if you use the aforesaid steps. Calculations are performed separately for each unit then added together to provide the over-all system error.

After summation, the errors for the DM40A and MD40 are converted to digitizer counts through division by 2441 μV. Each count has the value given by

$$\frac{\text{Volts FS}}{\text{Counts FS}} = \frac{10\ \text{V}}{2^{12}} = 2441\ \mu\text{V}.$$

Reading error plus zero error equals the systematic error near full scale—or, as used here 80% of full scale. Reading errors for each unit are listed and summed in essentially the same way as for zero errors. Gain-related errors must be selected for the system gain used in each set of test samples. The subtotal of DM40A reading errors (Table 2) is multiplied by the MD40 gain and added to the total MD40 errors. These results plus zero errors from the worksheet (Fig. 3) give the total systematic error (Fig. 4).

Use rms addition for noise

Noise contributions add in an rms rather than algebraic sense, as shown in the worksheet for the calculation of rms noise (Fig. 5). The voltage standard introduces 50 μV at 80% of full scale and 1 μV at zero output. Additional calculations are supplied for grounded input,in which case the source does not contribute noise error.

Account must also be taken of the discrete nature of the data supplied to the computer. The computer cannot resolve 1-σ noise values of less than one or two counts. If the mean signal value happens to equal 0.5 count, even the slightest noise will produce a sigma of 0.5. Why? Out of 1000 values, 500 give a count of −1 and 500 a count of +1; none falls on the boundary.

The corrections in Table 3 account for a/d resolution and apply to converters with any number of bits. For sigmas of greater than two counts, the corrections needed are negligible.

For quickest results, program the computer for short-form output (Fig. 6a). Include program control of the number of samples digitized for each channel, the channel gain and sample rates. Then compare computer-calculated sample means and sigma with the chart values for volts and counts. Values for 0 V, 8 V (80% FS) and standard deviation should fall within the calculated limits (Figs 6b and 6c).

For further information, program a bar-chart histogram. Make the height proportional to the number of times a given count occurs. If more than three out of 1000 samples fall outside the 3-σ limits, the noise probably contains systematic error components. ■■

Table 3. Correction factor for digitizer count

Calculated mean square count	Corrected count
under 0.20	0.5
0.23	0.52
0.40	0.68
0.60	0.80
1.00	1.10
1.20	1.37
1.33	1.45
1.50	1.61
2.00	2.08
Above 2.00	Use calculated value

Worksheet for rms noise at 1000 sample/s

System gain	1	8	64	512	1024	2048	4096	
DM40A gain (G1)	1	8	64	512	512	512	512	Units
MD40 gain (G2)	1	1	1	1	2	4	8	
Voltage standard rms, (max rms)	50	50	50	1	1	1	1	μV
DM40A at sample/s (max rms)	3.2						3.2	μV
Σ (VS^2 + DM40A^2)$^{1/2}$ = rti	51	51	51	3.36	3.36	3.36	3.36	μV
rti × G1	51	408	3264	1720	1720	1720	1720	μV
rto, rms, max	100						100	μV
Σ (rti^2 × G1^2 + rto^2)$^{1/2}$	112	420	3265	1723	1723	1723	1723	μV
Σ (rti^2 × G1^2 + rto^2)$^{1/2}$ × G2	112	420	3265	1723	3446	6892	13784	μV
MD40 buffer input								
rti (max rms)	60						60	μV
rti × G2	60	60	60	60	120	240	480	μV
rto (max rms)	260						260	μV
Digitizer (max rms)	167						167	μV
Σ (rti^2 × G2^2 + rto^2 + Dig.^{2})$^{1/2}$	315	315	315	315	332	392	571	μV
Σ (DM40A^2 + MD40^2)$^{1/2}$	334	525	3280	1751	3462	6903	13796	μV
÷ 2441 μV	.14	.22	1.35	.72	1.42	2.83	5.65	Count
With grounded input	.14	.14	.16	.72	1.42	2.83	5.65	Count

5. **Random-noise specs cumulate in rms fashion** and include the effects of channel gain.

Short-form printout

CHAN	EXPECTED VOLTS	GAINS MUX	GAINS ADC	N	SAMPLE MEAN VOLTS	SAMPLE MEAN COUNTS	STD DEVIATION VOLTS	STD DEVIATION COUNTS
0128	000.0000V	0064	0001	01000	000.0000V	00000.0	0.0002V	000.1
0129	000.0000V	0064	0001	01000	000.0000V	00000.0	0.0004V	000.2
0130	000.0000V	0064	0001	01000	000.0000V	00000.0	0.0004V	000.2
0131	000.0000V	0064	0001	01000	000.0000V	00000.0	0.0002V	000.1
0132	000.0000V	0064	0001	01000	000.0000V	00000.0	0.0002V	000.1
0133	000.0000V	0064	0001	01000	000.0000V	00000.0	0.0002V	000.1
0134	000.0000V	0064	0001	01000	000.0002V	00000.1	0.0007V	000.3
0135	000.0000V	0064	0001	01000	000.0004V	00000.2	0.0009V	000.4

CHAN	EXPECTED VOLTS	GAINS MUX	GAINS ADC	N	SAMPLE MEAN VOLTS	SAMPLE MEAN COUNTS	STD DEVIATION VOLTS	STD DEVIATION COUNTS
0128	008.0000V	0064	0001	01000	007.9995V	03276.6	0.0024V	001.1
0129	008.0000V	0064	0001	01000	007.9995V	03276.6	0.0026V	001.1
0130	008.0000V	0064	0001	01000	007.9995V	03276.6	0.0024V	001.0
0131	008.0000V	0064	0001	01000	007.9995V	03276.6	0.0024V	001.0
0132	008.0000V	0064	0001	01000	007.9995V	03276.6	0.0024V	001.0
0133	008.0000V	0064	0001	01000	007.9995V	03276.6	0.0024V	001.0
0134	008.0000V	0064	0001	01000	007.9997V	03276.7	0.0002V	000.1
0135	008.0000V	0064	0001	01000	008.0002V	03276.9	0.0026V	001.1

(a)

Summary noise specification compared with test results

System gain	1	8	64	512	1024	2048	4096	Units
DM40A gain (G1)	1	8	64	512	512	512	512	
MD40 gain (G2)	1	1	1	1	2	4	8	
Grounded Input								
Calculated (one sigma)	.14	.14	.16	.72	1.42	2.83	5.65	Count
Corrected (one sigma)	.50	.50	.50	.78	1.45	2.83	5.65	
Test Run, Range	.0-.1	.1-.1	.1-.4	.4-.6	1.0-1.2	2.0-2.4	3.8-5.2	
±8V Input								
Calculated (one sigma)	.14	.22	1.35	.72	1.42	2.83	5.65	Count
Corrected (one sigma)	.50	.50	1.38	.78	1.45	2.83	5.65	
Test Run: Range +8V	.2-.3	.3-.4	1.0-1.1	.6-.8	1.1-1.3	2.0-2.5	4.1-4.6	
−8V	.1-.1	.1-.1	1.1-1.2	.6-.8	1.1-1.3	2.1-2.4	4.1-5.2	

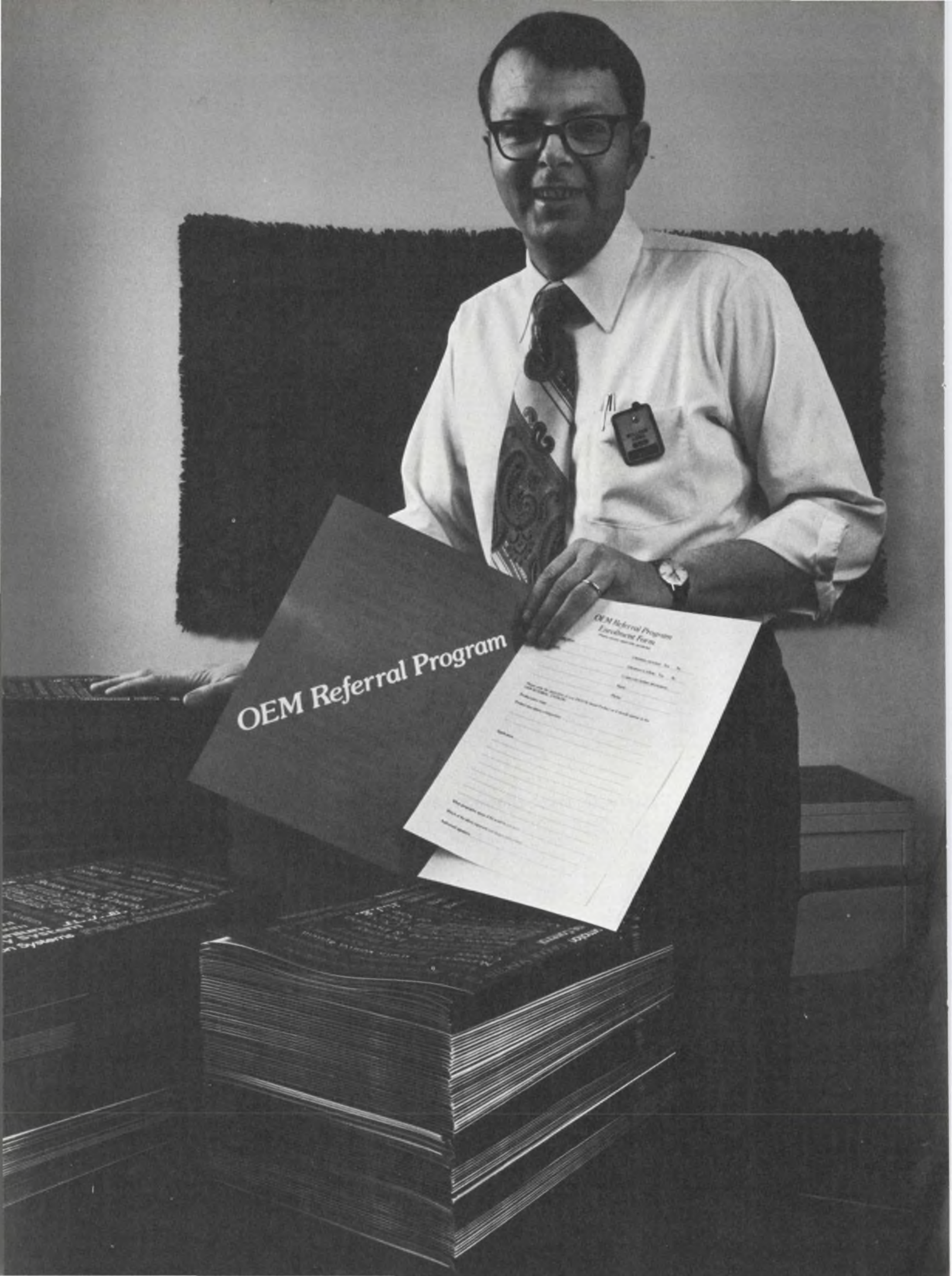
(b)

Systematic error allowance at 1000 samples/s

Input	Volts ($R_s < 100\Omega$)	Gain setting	Sample Means (Limits) Volts		Counts		Std. Dev. (Limits) Volts	Counts
zero		x1	0.0000	±.0026		±1.1	.0012	.5
		x8		±.0026		±1.1	.0012	.5
		x64		±.0028		±1.2	.0012	.5
		x512		±.0064		±2.7	.0019	.8
		x1024		±.0111		±4.6	.0036	1.5
		x2048		±.0205		±8.4	.0069	2.9
zero		x4096	0.0000	±.0392		±16.1	.0138	5.7
±8.0000	±.0005	x1	8.0000	±.0076	3277	±3.1	.0012	.5
±1.0000	±.0001	x8		±.0092		±3.8	.0012	.5
± .1250	±.00006	x64		±.0094		±3.9	.0034	1.4
± .015625	±.000002	x512		±.0131		±5.4	.0019	.8
± .007813	±.000002	x1024		±.0228		±9.3	.0036	1.5
± .003906	±.000002	x2048		±.0389		±16.0	.0069	2.9
± .001953	±.000002	x4096	8.0000	±.0712	3277	±29.2	.0138	5.7

(c)

6. **The computer provides values** for sample mean and standard deviation (a). Values for the standard deviation fall within corrected calculated values (b). Sample means easily meet the limits shown for mean values (c).


OEM Referral Program

Power op amp provides ± 100-mA output and up to 100-V/μs slew rate

A power driver for complementary output transistors can be used as a power op amp, if proper compensation techniques are used. Slew rates to 100 V/μs and output currents of ±100 mA are also easily obtained.

Two methods of compensation are used. For gains of five and higher, a single capacitor from the output to ground can stabilize the amplifier (Fig. 1). The table in the figure relates gain to power bandwidth, slew rate and the required capacitor size. Note that a closed-loop gain of five yields characteristics similar to the 741, but with the important advantages of ±100-mA output and little parametric change with capacitive loads up to 50,000 pF.

Because only small input-signal levels are normally present with input compensation, high slew rates and wide bandwidths can be obtained even at unity gain (Fig. 2). The slew rate at unity gain is 50 V/μs, and the 3-dB power bandwidth is 600 kHz. Slew rates and bandwidths are higher for higher gains. Although 47 Ω for R_c is adequate at unity gain, higher gains need slightly larger resistor values. Capacitor C_c increases for lower gains.

Jim Wyland, Signetics Corp., 811 E. Arques Ave., Sunnyvale, CA 94086.

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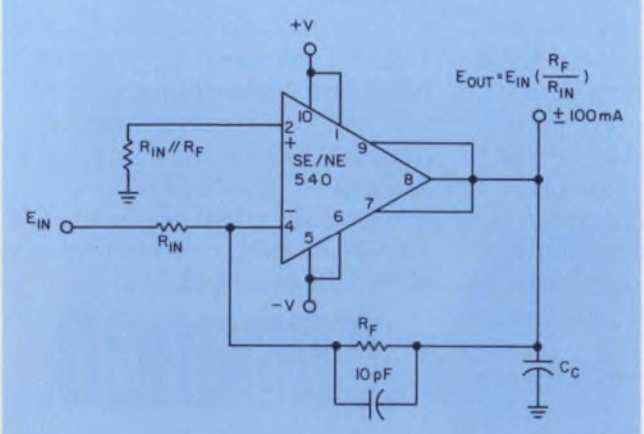
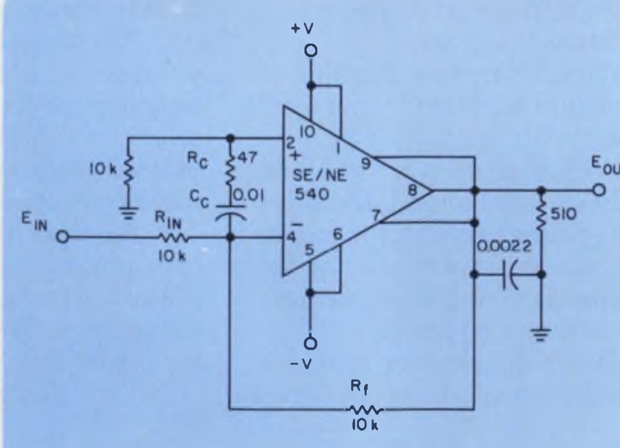


GAIN	C_C	SLEW RATE V/μs	POWER BANDWIDTH
100 UP	0.01	15	240 kHz
50	0.02	7.5	120 kHz
10	0.1	1.5	24 kHz
5	0.2	0.75	12 kHz

1. **Output compensation** of a power driver provides high-current output.



GAIN	C_C	R_C	SLEW RATE V/μs	POWER BANDWIDTH
1	0.01	47	50	600 kHz
10	0.0047	100	80	600 kHz
100	0	∞	100	800 kHz

2. **Input compensation** allows a high slew rate and wide power bandwidth.

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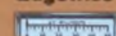
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INFORMATION RETRIEVAL NUMBER 61

Voltage comparator circuit gives audio alarm when tripped

Voltage comparators usually provide only an on/off output when a monitored voltage exceeds a reference level. But the circuit in the figure generates an audio output with little extra circuitry.

This comparator becomes an audio oscillator when the input signal exceeds a level established by zener diodes CR_2 and CR_3. Hysteresis of the trip point is obtained from positive feedback via R_1 and R_4, and free-running oscillation is prevented by CR_1.

When input signal e_i is low, the op-amp output voltage reverse-biases CR_1. This blocks current to R_3 and FET Q_1 has a zero gate-source bias. Thus Q_1 is on, and it holds the noninverting amplifier input at ground. Comparator switching occurs when e_i is large enough to raise the noninverting input above zero voltage.

The first comparator trip point is at

$$V_1 = n(V_Z + V_f).$$

Note that $n = R_4/R_1$. In the circuit shown, $n = 1$. Voltage V_Z is the zener voltage of CR_3, and V_f is the forward diode voltage of CR_2.

When e_i reaches the first trip point, the circuit switches to an oscillator mode. Positive-output swings of the oscillations forward-bias D_1 and supply current to R_3, which turns off Q_1 and charges capacitor C. A second trip point is reached when the capacitor voltage is

$$V_c = \frac{n(V_Z + V_f) + e_i}{n + 1}.$$

At this point, the amplifier output goes negative to again reverse-bias D_1 and turn on Q_1. This discharges C to a voltage equal to that at the noninverting amplifier input. The circuit then switches back to the charging mode.

Oscillations continue as long as e_i remains above the first trip point. If R_3 and Q_1 draw roughly equal currents, a triangular audio waveform, e_{01}, is produced across C.

The key to good circuit performance is the first trip point, since it determines oscillator turn-on. Errors that affect this trip point primarily result from component tolerances and thermal variations of the zener diode voltages. Tolerance errors can be compensated by adjustment of the R_1 and R_4 resistors. Thermal variations in the zener voltage, V_Z of CR_3, are largely compensated by the drift of forward diode voltage, V_f, of CR_2, and vice versa. The first trip point is thus controlled to better than 0.1% accuracy.

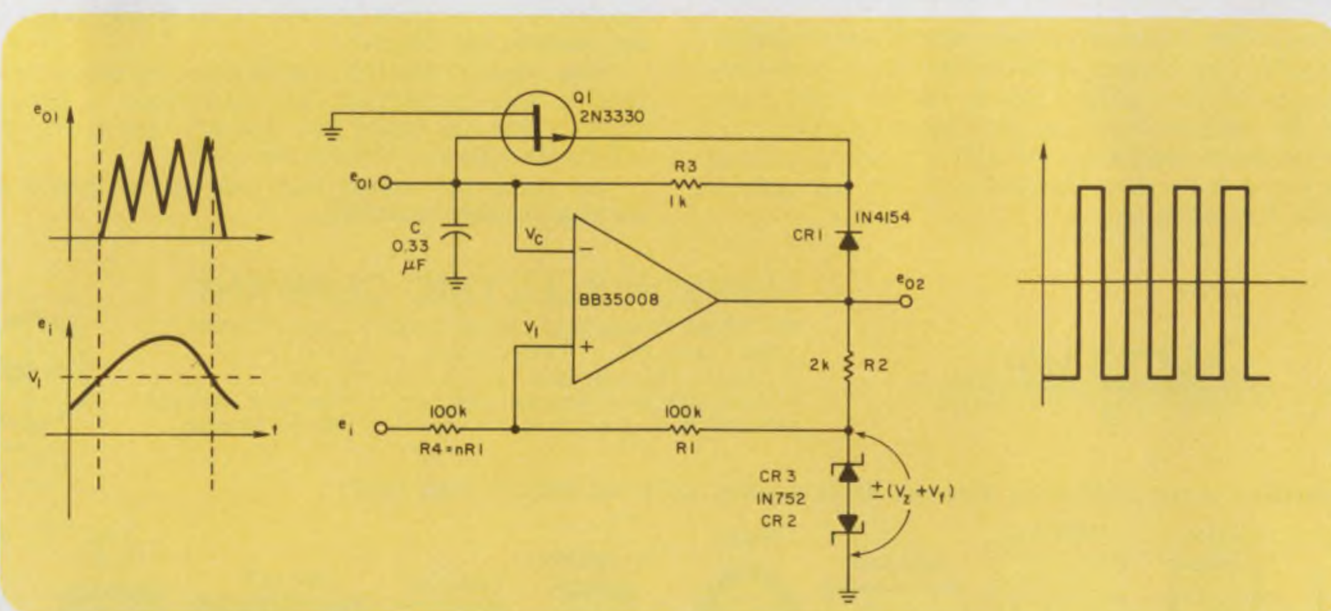
Precise control of the oscillator waveform or frequency is not required for an audio alarm. Frequency can be determined within an acceptable 30% range by

$$\omega \cong \frac{1}{R_3 C \ln\left(\frac{E_o}{E_o - V_Z}\right) + \left(\frac{CV_Z}{I_d}\right)},$$

where E_o is the positive saturation voltage of the amplifier and I_d is the discharge current drawn by Q_1.

Jerald Graeme, Manager, Monolithic Engineering, Burr-Brown Research Corp., International Airport Industrial Park, Tucson, AZ 85706.

CIRCLE NO. 312



Voltage **comparator generates an audio-alarm** output when an input signal exceeds the CR_2 and CR_3 voltage.

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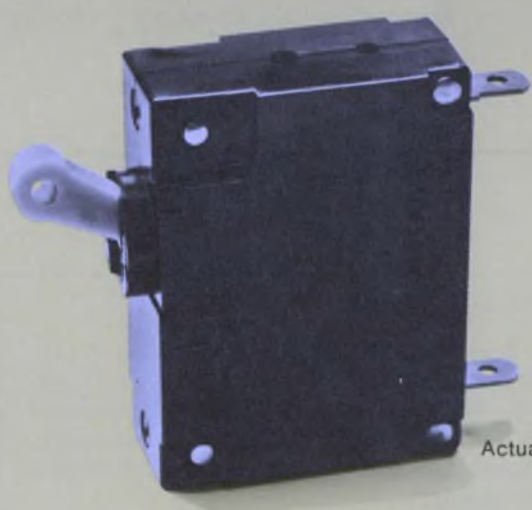


Actual Size

Monitor circuit detects and shows voltage excursions outside set limits

Expensive, bulky strip recorders are usually used to monitor dc levels for changes in amplitude from some nominal value and to record the event. Here is a simple circuit that can detect a change in voltage outside of a set range and provide a permanent indication of the event, as long as the monitored level does not drop to zero. The circuit is powered from the monitored source.

Zener diodes D_1 and D_2 are selected to provide the desired window above and below the nominal value of the monitored voltage, V_{in}. The H15A1 is an optical coupler with very low ON resistance, and Q_1 and Q_2 are inexpensive general-purpose transistors, such as 2N3393.

If V_{in} is within the window, Q_2 conducts and the SCR does not fire. If V_{in} increases above V_{z1}, Q_1 will also conduct, the optical coupler turns OFF, and the SCR fires to latch the LED and thus record the event. If V_{in} decreases below V_{z2}, both Q_1 and Q_2 are cut off and, again, the optical coupler is off and the SCR fires to record the event.

The values and component types have been chosen to monitor a nominal 12-V level with upper and lower set points of 14 and 10 V. Other set points can be determined as follows:

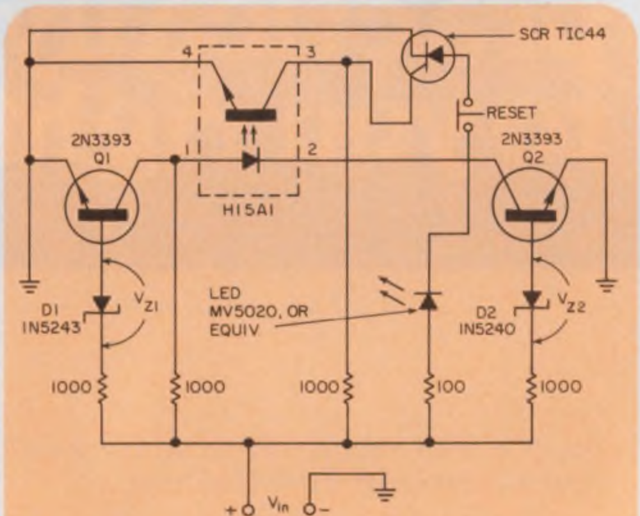
$$\text{upper set point} = V_{z1} + 2e_{bc},$$
$$\text{lower set-point} = V_{z2} + e_{bc},$$

where e_{bc} = transistor base-to-collector voltage drop. For the components shown:

$$e_{bc} = 0.4 \text{ V},$$
$$V_{z1} = 14 - 0.8 = 13.2 \text{ V},$$
$$V_{z2} = 10 - 0.4 = 9.6 \text{ V}.$$

The zeners in the figure meet these values within normal zener tolerances.

Robert A. Sullivan, President, Engineering Services, P.O. Box 6216, Shirlington Station, Arlington, VA 22206. CIRCLE NO. 313



No separate power supply is needed for this voltage-monitor circuit, which has a LED indicator. The monitored voltage must not drop to zero or the event indication will be lost.

IFD Winner of January 4, 1975

James deHaan, Design Engineer, Barber Colman Co., Park Plant, 1354 Clifford Ave., Rockford, IL 61111. His idea "Circuit Eliminates Switch Bounce in Keyboards and Gives Latched Output" has been voted the Most Valuable of Issue Award.

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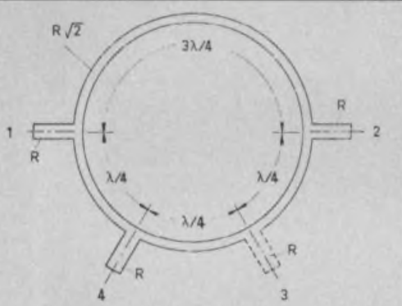
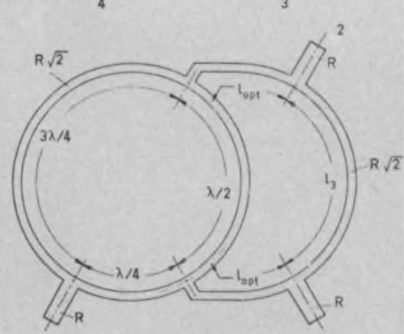
INFORMATION RETRIEVAL NUMBER 62

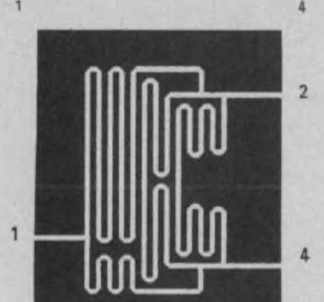
Ring hybrid junction operates at broadband

The ring stripline hybrid junction, a narrow-band device, has been redesigned at the Philips Research Laboratories, Aachen, West Germany, to form a broadband microwave balun.

The conventional ring hybrid junction gives balun action by coupling a single input to port 1 (Fig. 1). A split output is obtained at ports 2 and 4 with components of equal magnitude but 180° out of phase. This configuration has a disadvantage: It can be used only at or very near its design frequency. (Note that the dimensions of R are governed by the frequency and desired output impedance.)







The experimenters found that the addition of an extra loop (Fig. 2) gives the ring a broadband characteristic. However, the added loop must have an optimized length. A computer program modeling the stripline as a two-port network, described by the equations of a lossless line, gave the researchers the modified ring in Fig. 2.

A practical stripline balun for a midband frequency of 2 GHz was formed on an alumina substrate less than 1 cm^2 (Fig. 3). For the configuration shown, a bandwidth ratio of 0.5 was obtained (Δf divided by the midband frequency).

GaAs Impatt diodes use ferrite bias lines

Undesired high-frequency bias oscillations and other noise components, produced by high-efficiency gallium-arsenide Impatt diodes when they are operated as free-running oscillators or saturated amplifiers, have been suppressed by special filters designed at the Royal Radar Establishment in Worcestershire, England.

Gallium-arsenide Impatt oscillators and amplifiers used by the experimenters were uniformly doped n-type and read-type diodes, with broadband rf coaxial circuits having distributed-line bias arms. The difficulty encountered in bias-line design, the researchers report, is to keep shunt capacitance to a minimum and thus ensure that any series resonance across the line is well above the cutoff frequency of the diode's induced negative resistance. The resonances can be damped by the inclusion of a high-inductance element—namely, ferrite beads, which were used in a prototype four-stage bias filter.

The filter elements tried for the first stage were a helical stripline spiral and a winding of fine copper wire on a 1-mm-diam plastic rod. This first stage is a choke for the signal frequency. The researchers then suppressed intermediate components in two stages, using ferrite beads threaded over the rod and also over the fine wire. The high impedance of the ferrite beads makes them suitable for use in bias-line filters at frequencies up to at least 2 GHz.

Low frequencies were filtered with a conventional low-frequency filter.

Low VSWR achieved in X-band amplifier

A two-stage GaAs FET amplifier has been designed to give 9.5-dB gain over the 6.5-to-12-GHz frequency band. The amplifier, developed at the Plessey Co. in England, has a VSWR of less than 2.5:1 at the input and output.

The GAT3 Schottky-barrier FET used as the active device in this amplifier has a gate that is 120-μm wide and 1-μm long. There is a buffer layer between the epilayer and the gallium arsenide.

The first amplifier stage was biased for minimum noise, and the second stage for maximum gain. Careful attention was given to the input matching network design. For example, the wire bonds from the transistor chip to the microstrip circuit were included in the network, since such bonds can behave as 200-Ω transmission lines at X band.

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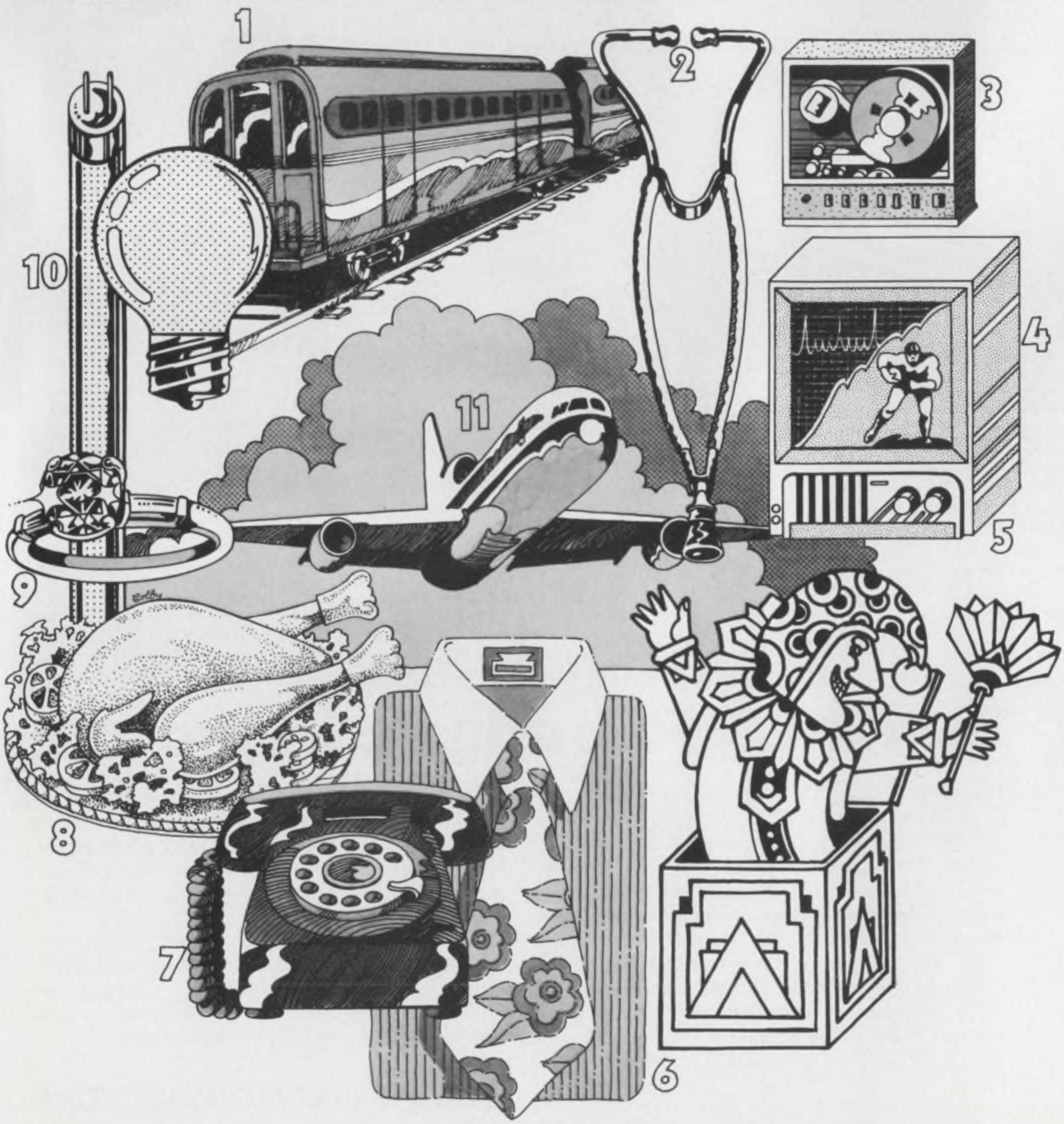

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You'd be surprised to know in how many industries Delco Electronics has firsthand power semiconductor application experience. They include, among others, transportation and medical, computers and communication, with products that range from motor speed controls to ultrasonic equipment. And the list goes on.

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INFORMATION RETRIEVAL NUMBER 65

New Products

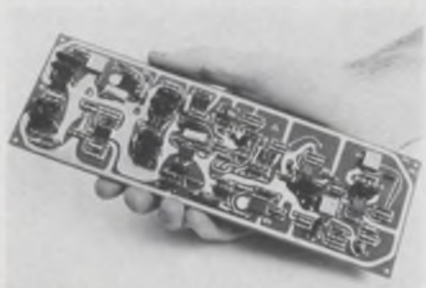
Monitor captures data at trigger midpoint

Universal Data Systems, 2611 Leeman Ferry Rd., Huntsville, AL 35805. (205) 533-4500. See text; 45 days.

Data Trap is the name of a monitoring device designed to trigger on a given character or series of characters and trap up to 256 characters on either side of the pattern. With an optional RS-232 interface the user can operate with rates up to 9600 baud. Trigger sequences up to 70 hex (4-bit) characters in length can be used. The price without CRT is $4000; an optional CRT adds $1500 to the price or the user can use an existing one.

Booth No. 2267 Circle No. 305

Cost plummets with 1200-baud PC modem



Vadic Corp., 505 E. Middlefield Rd., Mountain View, CA 94043. (415) 965-1620. See text.

A 1200-baud modem in module form performs the functions of a Bell 202D for $120. In quantities of 100 or more the price of the Model 81094 drops to $95. Operation at 1200 baud is half duplex over a two-wire leased line, or full duplex over a four-wire leased line for multipoint polled data communication networks.

CIRCLE NO. 306

Interfaces between mini and IBM/370 offered

Interdata, Inc., 2 Crescent Place, Oceanport, NJ 07757. (201) 229-4040. $3500 or $5000; stock.

Two programmable interfaces link the manufacturers minicomputers to IBM System/360 and 370 mainframe processors. The units transmit data at rates up to 500 kbyte/s and operate on the IBM multiplexer, block multiplexer or selector channel in single or multi-address configurations. One unit priced at $3500, recognizes a single IBM device address. The other interface, priced at $5000, recognizes up to 256 IBM device addresses.

CIRCLE NO. 307

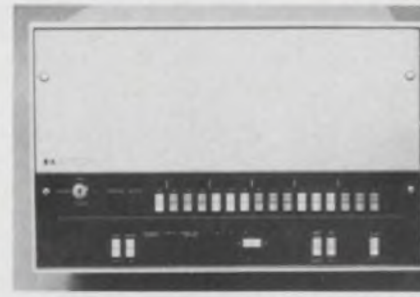
Automated drafting done by computer

Dimensional Systems, 31 Hartwell Ave., Lexington, MA 02173. (617) 852-2700. $125,000.

Datadraft, a computerized drafting system, produces finished, detailed drawings from engineering sketches in one-fith the time required for manual drafting. A typical "E" size drawing can be generated in about six hours. The operator enters the drawing information by placing a stylus on the various symbols and lines on the sketch. For each location a symbol or line type is designed by pointing the stylus to one of a variety of types on a user specified symbol "menu." Words and numbers are entered on an integral alphanumeric keyboard and are automatically positioned on the drawing. The information provided by the operator is processed and stored as a final drawing on removable or disc packs (100 to a pack) or magnetic tape. Drawings can be provided by the system plotter in any desired size. In addition, the processing system performs routine drafting tasks such as: straightening and orthogonalizing lines; text justification and insertion; and alignment of symbols horizontally and vertically.

CIRCLE NO. 308

Top-of-line mini added to 21MX series



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. From $8382 (32 k words); August.

The M/30 leads the 21MX computer series in memory size and powered I/O accommodations. With twice the memory capacity and 50% more I/O space, it is priced only 17% higher than the next smaller model in the line. A processor package can contain up to 128-k words (256 k bytes) of semiconductor memory, and 14 powered I/O channels. Like all 21MX minis, the M/30 has 128 instructions that include floating point firmware, memory parity, extended arithmetic unit (EAU), a bootstrap loader and operator panel. The CPU is fully user-microprogrammable. A new real-time executive, HP RTE-III, can manage 250 k (512 k bytes) of memory. RTE-III allows HP 21MX minis to operate as multiprogramming, multilingual machines with input-output spooling and multiterminal monitoring capabilities.

Booth No. 1437 Circle No. 309

Low-cost printer/plotter offers 100 point/in.

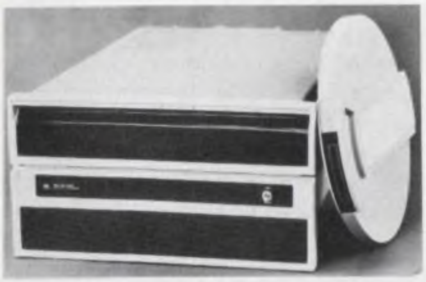
Gould Inc., Instrument Systems Div., 20 Ossipee Rd., Newton, MA 02164. (617) 969-6510. See text; 45 days.

The 5010 printer/plotter operates with a resolution of 100 dot/in. vertically and horizontally. It is designed for slower speed use at reduced cost than other members of the Gould family. The unit prints 132 char/line at a speed of 600 line/min and plots at 1.2 in/s. The unit is said to be 200 times faster than drum and pen plotters. The 5010 is available in three versions: plotter only for $6000; as a printer for $5000, or both at $6500.

CIRCLE NO. 310

DATA PROCESSING

Formatter makes disc easy to interface



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. See text.

A 15-Mbyte moving-head disc drive that uses cartridges, the Model 7905A with associated formatter, easily interfaces to any processor. The formatter also allows for error correction, multiprocessor access and automatic macro I/O operations. The disc is rack-mountable and measures 10.5-in. (26.7-cm) high, including power supply. Usable data capacity is 10 Mbytes on the front-loading cartridge and 5 Mbytes on the resident disc. Seek time for the 7905A is 5 ms track-to-track, 25 ms average. Average latency is 8-1/3 ms. Data transfer rate is 7.5 megabits per second. The disc drive and 13097 controller sell as a unit, disco/15 for under $8400; additional drives are priced under $5900.

Booth No. 1437 Circle No. 320

Semi-memory boards replace 16-k core units

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 732-5000. 1¢/bit; stock to 3 days.

The MOSRAM 104 is a complete memory with 16,384 words of 8 bits on a single 8.3 × 13.5-in. board. Access time is 500 ns; cycle time 750 ns and faster versions are available. The "104" directly replaces Dataram Model DR-104 core memory; a depopulated version 8192 × 8-bits replaces 8-k × 8 core memories. These are general-purpose boards suitable for use in mini mainframes and intelligent terminals. The units also offer low power drain, 6 W.

CIRCLE NO. 321

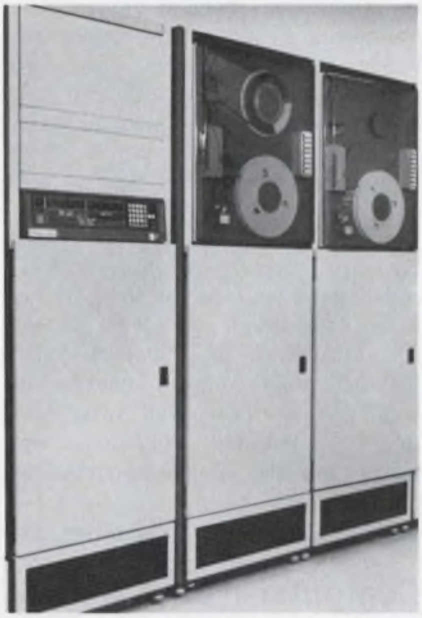
Core memory comes in compact 16-k modules

Control Data Corp., 3857 Louisiana Ave., St. Louis Park, MN 55435. (612) 830-6135. See text; 60 days.

The Model 94200 core memory module with a density of 2215 bit/in^3 offers expandable memory design in 64-k byte increments on a single card. A single card decodes up to 512-k bytes. The basic 16 k × 36-bit module has an access time of 350 ns. Options include 32-k × 18 and 16-k × 18 organizations. Quantity prices of 16-k × 36-bit units range from $1975 each to $2175 each.

CIRCLE NO. 322

Speedy 32-bit mini keeps pace with maxis



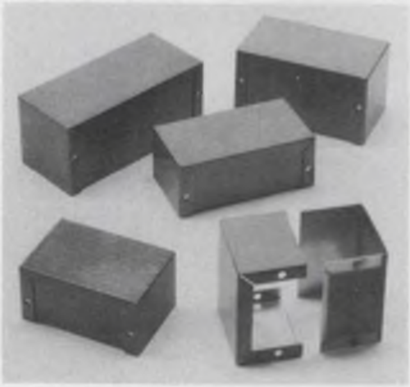
Interdata, 2 Crescent Pl., Oceanport, NJ 07757. (201) 229-4040. $179,400 (1 Mbyte memory).

The Model 8/32 Megamini, which highlights this exhibit, offers instruction execution times comparable to those of an IBM 370/158. Salient features include 32-bit architecture with up to one million bytes of directly addressable memory, supported by a multitasking operating system, OS-32/MT. Interleaved core modules offer a cycle time of 450 ns; Schottky logic gives a 240-ns processor time. Floating point hardware is available. Other products include a 30 char/s serial impact printer, dubbed the Carousel, and the Model 7/16 mini.

Booth No. 2337 Circle No. 323

ELECTRONIC PACKAGING

Compact enclosures, versatile, economical



Bud Radio, Inc., 4605 E. 355 St., Willoughby, O. 44094, (216) 946-3200. Available in 18 sizes.

Miniboxes from Bud. Use as separate housings or as part of a larger assembly. Flanges give assured shielding. Projecting covers on cowl-type units minimize glare, protect controls, dials. .040 and .050 aluminum alloy. Immediately available. Shipping economies. One of nearly 3000 products from Bud Radio. For further information phone —

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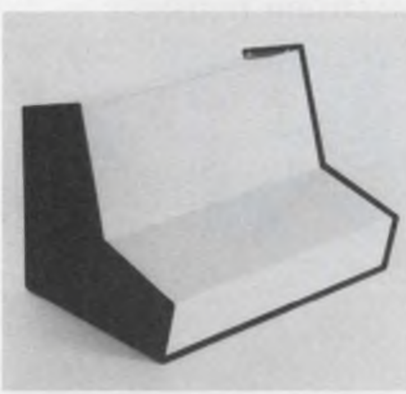

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IN OHIO, 1-800-362-2265, TOLL FREE

DATA PROCESSING

Quiet thermal printer has control capability

Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. $800; 30 days.

A quiet thermal printer, Model 5150A, accepts data from BCD (binary coded decimal) or ASCII sources and prints up to 20 columns of alphanumeric information. Of modular construction, it is available in various configurations including some as a system controller. The unit prints 5 × 7 dot-matrix characters at faster than three lines per second on heat-sensitive paper (available in rolls or fan-folds). Reliability and light weight result from design simplicity—thick-film thermal print head; no inking systems. The paper advance mechanism has only two moving parts. The mainframe contains a power supply, control logic, and print mechanism. Input interfaces are provided by plug-in circuit boards. Option 001 interfaces the printer to the HP Interface Bus (or directly to most ASCII-coded data sources) with a 20-column, 64-character readout. Option 002 interfaces BCD ±8421 coded instruments through 10-column inputs; up to two such interfaces may be installed. Additional options include a data-acquisition package.

CIRCLE NO. 324

Computer-type terminal performs control tasks

Electronic Associates, West Long Branch, NJ 07764. (201) 229-1100. Under $13,900.

Uses for the Spacer-75 terminal include data communication, data acquisition, computer-aided instruction and word processing. The MOS/LSI system is in an integrated package, containing alphanumeric and graphic CRT, ASCII or customized keyboard, an 8k to 32k word 16-bit minicomputer, and a floppy disc bulk storage unit. Options include 64 a/d channels, data acquisition modules and a full line of standard peripherals. Software support includes a Fortran IV compiler, Real Time Basic, text editor and debug routines.

CIRCLE NO. 325

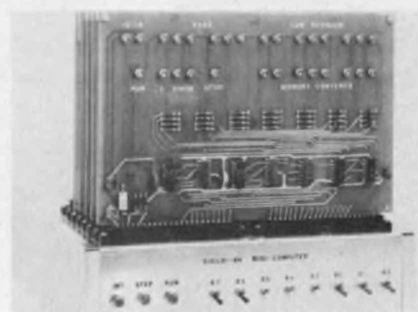
Fast printers controlled by μP

Applied Computing Technology, 17961 Sky Park Circle, Irvine, CA 92707. (714) 557-9972. $1945 (25 qty).

A microprocessor controlled printer is capable of printing 120 char/s bidirectionally. The series 900 achieves an effective speed of over 160 char/s. Standard features include 132 columns, multiple copies, horizontal tab, vertical formatting and forward-reverse line feed. The model printer forms characters in a 7 × 9 dot matrix. The unit can print 96 different characters. With keyboard input you can send or receive at speeds of 10, 30 or 120 char/s. Other features included are a 320-character buffer and a character view.

CIRCLE NO. 326

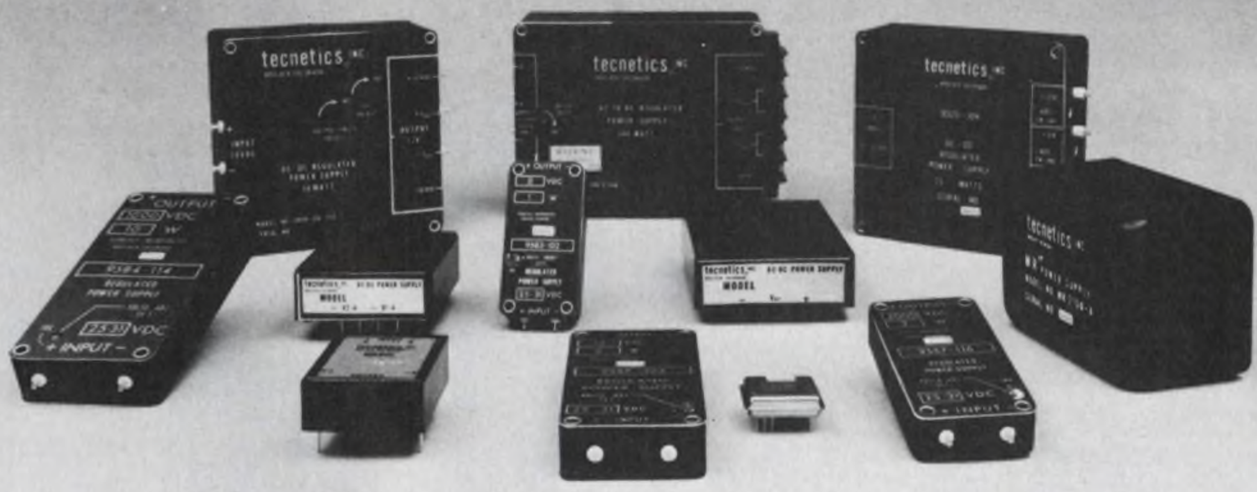
Kit-style microcomputer supports peripherals



Scelbi Computer Consulting, 1322 Rear, Boston Post Rd., Milford, CT 06460. (203) 874-1573. See text; third quarter '75.

The Selbi-8H is a modular computer based on the Intel 8008 microprocessor. It is constructed from a basic set of PC cards and can operate in conjunction with a wide variety of peripheral interfaces and devices. Among these are an oscilloscope display driver, ASCII keyboard interface and an interface for use with audio-type recorders. Instruction times vary from 11 to 44 μs. Chassis kits start at $440 which includes five boards: CPU, data buffer, input card front panel controller, and a 256-word memory card. The unit allows up to 4 k of memory or 16 k with an expander box. Available programs include peripheral support, calculator packages, assemblers and editors.

CIRCLE NO. 327



Your house or ours.

Why it is better to buy DC-to-DC power supplies.

Sure, you can probably build that power supply yourself. First you get out the old breadboard and start designing. When you think you have it, you start testing and compiling reliability data. Then you assemble a load of components. Maybe you have some, maybe you wait for purchasing to buy them. Finally, you set up inventory, inspection, quality control and manufacturing procedures.

All time consuming, and surprisingly expensive. Probably more expensive than you anticipated. Especially when you consider valuable engineering time which could have been put to more creative use.

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P.O. Box 910, 1625 Range Street, Boulder, Colorado 80302
(303) 442-3837 TWX 910-940-3246

INFORMATION RETRIEVAL NUMBER 72

Field tool kit contains 120 tools and parts

Jensen Tools and Alloys, 4117 North St., Phoenix, AZ 85018. (602) 959-2210. $245 (unit qty).

A new field-engineer tool kit, the JTK-77, contains virtually everything needed to service complex electronic and data-processing equipment and office machines. The JTK-77 contains more than 120 tools and work accessories plus an optional test meter. Three pallets hold most of the tools securely and conveniently, and present the tools in an orderly fashion to the user. The attache case is of hardwood construction with brass fittings and a walnut-brown scuff-proof Marvelon covering. It measures 17-1/4 × 12 × 6 in. with room to accommodate test equipment and extra parts.

CIRCLE NO. 328

Card extenders fit five-layer boards

Mupac Corp., 646 Summer St., Brockton, MA 02402. (617) 588-6110. $70 (10 up); stock.

A family of multilayer card extenders for five layer boards contains two ground planes to prevent adjacent high-frequency signals from coupling to each other. Quality pin and socket connectors on opposite ends of the extender ensure a long life of many insertions with high reliability, according to Mupac. As many as 216 signal lines are available on the large extenders of the family. Panels come 1/16 or 1/8-in.-thick, G-10, epoxy-glass material.

CIRCLE NO. 329

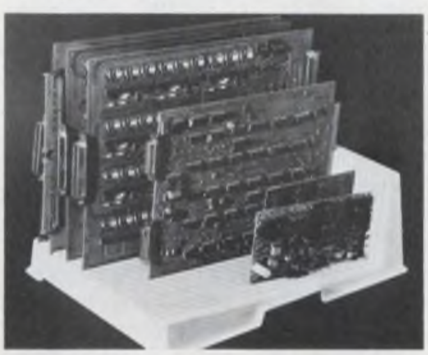
Conductive adhesive holds rf gaskets

Emerson & Cuming, Inc., Canton, MA 02021. (617) 828-3300.

When gaskets must provide electrical contact between mating surfaces, it is very important that adhesives used to bond the mating surfaces also be a good electrical conductor. Eccoshield VCA is first applied to all mating surfaces—both the gasket and the waveguide flange. The adhesive is pressure sensitive. Thus the flange connection may be taken apart repeatedly without need to change the gasket or adhesive. And the rf seal is not impaired. The volume resistivity of this adhesive is less than 0.001 Ω-cm, equivalent to the gasket material.

CIRCLE NO. 330

PC-board holder stacks assorted board sizes



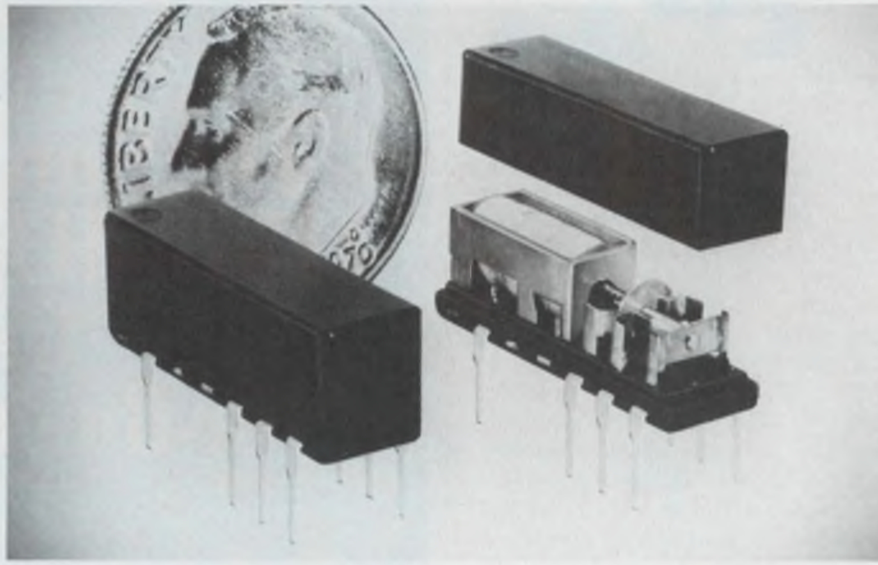
Manix Manufacturing, Box 496, Mann Rd., Huntingdon Valley, PA 19006. (215) 355-7200. OP251: $4.50; OP261: $6.

PC boards of different sizes can be simultaneously stored and stacked on the new E-Z-Stack holder. The product is molded of lightweight polypropylene. Its L-shape design permits boards either larger or smaller than the holder itself to be stored efficiently. Each holder is grooved to accommodate up to 25 boards with a maximum of 3/32-in. thickness. The space between grooves is 3/8 in. Two models are available—OP251 for boards to 6 × 9 in. and OP261 for large boards to 12 × 15 in.

CIRCLE NO. 331

COMPONENT

DIP relay is small in size and price



Babcock, Div. of Esterline Corp., 3501 Harbor Blvd., Costa Mesa, CA 92625. (714) 540-1234. P&A: See text.

The smaller the relay, the more expensive it is, right? Wrong, says Babcock. Its series BC74 electromechanical relays are housed in dual-in-line packages and cost \$1.65 when purchased in 1000 unit lots.

Not only are the relays small, but you have a wide choice of contact styles. You can choose from a one-form A, B, C (single or double break), U, V, W, X, Y and Z or a two-form C (common movable blade). Any of these styles is available in an 8-pin DIP that measures $0.78 \times 0.27 \times 0.3$ in.

All contact forms except X, Y and Z have a maximum dielectric strength of 500 V rms at 60 Hz; for the X, Y and Z at 60 Hz, the dielectric strength is 1000 V rms.

Similarly all but the X, Y, Z forms have contact ratings of 0.5 A for 100,000 operations or 0.25 A for 500,000 operations. The X, Y, Z ratings are 2 A for 100,000 operations and 1 A for 500,000. All units are specified for operation from 0 to 70 C.

The relay operate time of 3 ms for all forms includes any contact bounce. Release time is 4 ms, including any bounce. You can get the relay with nominal coil voltages of 5, 6, 12 and 24 V. Drop-out voltages for the BC74 relays are 10% of the nominal coil voltages.

Coils can be ordered with resistance values of 306, 441 and 1806 Ω for a 40-mW coil power requirement, or you can get coil resistances of 122, 176, 722 and 2890 Ω for 100-mW operation. All resistances are $\pm 10\%$.

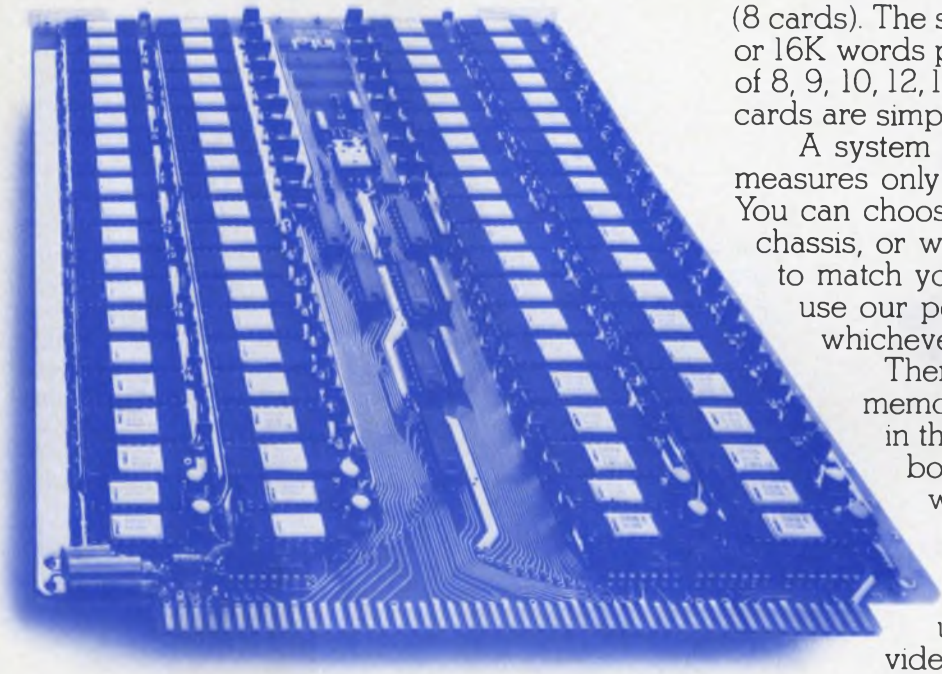
The closest competition to the Babcock BC74 is the Model 53451 dual electromechanical relay manufactured by AMP (Harrisburg, PA). The 53451 relays are housed in 16-pin DIPs that measure $0.9 \times 0.36 \times 0.5$ in., not including pin height. The package, though, contains two independent relays, each with two-form C contacts.

The AMP units have only one coil voltage, nominally 4.5 V, and require more power—about 135 mW per coil, as opposed to 40 or 100 mW for the Babcock relays. They also have a lower dielectric strength—only 300 V rms at 60 Hz.

Both the Babcock and the AMP relays have similar switching times and operating temperature ranges. However, the AMP unit costs about four times more than the Babcock relay.

For Babcock CIRCLE NO. 302
For AMP CIRCLE NO. 393

Now, 4 times the memory on the same size card.



The most compact and most expandable low-cost memory system you'll probably see for years to come is Intel's in-40 dynamic RAM system. It's a true new generation design, available right now in standard models from 16K words to 256 kilobytes or in custom configurations with quick delivery.

Besides highest density, the in-40 assures you higher performance than previous low-cost systems, whether solid-state or core. Built with Intel's newest 4K n-channel MOS RAMs, the in-40 provides an access time of 350 ns, cycle time of 550 ns, low power dissipation and TTL compatibility with very solid margins. **One single in-40 memory board stores 16,384 18-bit words or 32,768 9-bit words.** One single control unit board runs any system up to 128 kilowords or 256 kilobytes (8 cards). The standard options are 4K, 8K or 16K words per board and word lengths of 8, 9, 10, 12, 16 or 18 bits. For longer words, cards are simply combined.

A system expanded to 256 kilobytes measures only 8.175 x 10.5 x 5.0 inches. You can choose one of our standard card chassis, or we can make a custom chassis to match your requirements. You can use our power supplies or yours, whichever you prefer.

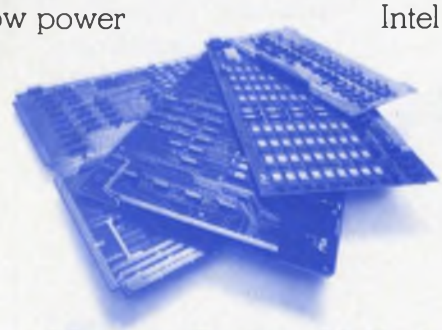
There probably never was a memory system as easy to expand in the field or in your factory. The boards are also interchangeable with our in-10 1103 systems—10,000 of which have already been shipped. Just allow 0.5 inch for each board. The universal control unit provides byte control, module select, address register, optional data register and control and data I/O and automatic refresh capabilities.

But your options on the in-40 and all other important semiconductor memory technologies are really unlimited. Intel also has the customizing expertise that comes from doing work for most of the industry's leading OEM's. And our billion-bit production plant gives quick delivery on standard or custom designs.

Call us if you want to store more words on fewer cards at lower cost.

Intel Memory Systems, 1302 North Mathilda, Sunnyvale, California 94086 (408) 734-8102

Regional offices:
Boston (617) 861-1136;
Philadelphia (215) 542-9444;
Dayton (513) 836-2808;
Dallas (214) 661-8829;
Los Angeles (714) 835-9642.



Memory Options Unlimited

intel memory systems

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INFORMATION RETRIEVAL NUMBER 77

COMPONENTS

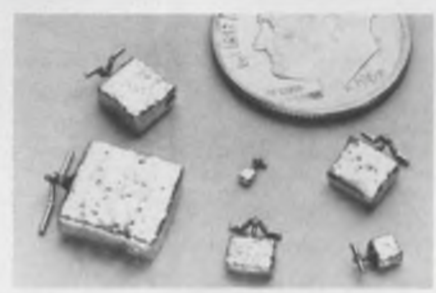
Kit contains $69 worth of switches for only $17

Cherry Electrical Products Corp., P.O. Box 718, Waukegan, IL 60085. (312) 689-7702. See text.

Cherry offers a switch prototype kit that contains 32 switches for only $17. This is a substantial reduction from the $69 the switches would cost if purchased individually. The kit provides a handy supply of basic switches for prototype work. It contains two thumbwheel switch assemblies, three keyboard switches and 27 snap-action switches. The snap-action units include five subminiatures, five miniatures, two low torque, four for panel mounting, nine assorted types and two units for low-energy applications. They are mounted in neat recesses of a 16 × 24 plastic board that can stand on a desk or hang on the wall. A special $50-off coupon gives complete details and contains a handy postage-free order card.

CIRCLE NO. 332

Small chips provide high capacitance



Corning Glass Works, Corning, NY 14830. (607) 962-4444.

High capacitance-to-volume ratios in forms specially designed for hybrid, thick-film and microcircuit use are the features of Corning's new MC, microminiature, chip, tantalum capacitors. The capacitor bodies are the negative terminals. And the positive terminals are solder-coated nickel wires. The six sizes offered range from 0.060 × 0.056 × 0.155 in. to 0.170 × 0.355 × 0.460 in. and provide capacitances from 0.1 to 100 μF. The smallest size has a +40%, −20% standard tolerance. All others have standard tolerance of ±20%. Tolerances of ±10% are available in all sizes.

CIRCLE NO. 333

You can measure the quality of Hoffman Enclosures

Being close isn't good enough in lots of electrical enclosure applications. It either fits or it doesn't. Hoffman quality assures a proper fit. One of our customers put it this way: "What Hoffman says in its catalog is true. Hoffman Electrical Enclosures are consistently well built, and tolerances are what Hoffman says they'll be."

Hoffman is proud of its reputation. We guard it by making numerous checks for dimensional accuracy during our quality control inspections. As one of the country's major manufacturers of electrical enclosures we have a reputation to protect.

We can help you protect your reputation too, with over 1,700 high quality electrical enclosure products. For a copy of our free, problem-solving catalog, call or write:

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HOFFMAN ENGINEERING COMPANY
Division of Federal Cartridge Corporation
ANOKA, MN 55303 DEPT. ED541

INFORMATION RETRIEVAL NUMBER 79

What's Practical Automation Doing With Digital Printers?

Everything New!

When we designed our new miniature Matri-Dot Series of alphanumeric digital printers, we dedicated them to you and your customers. Matri-Dot printers represent a significant breakthrough in design, performance, and price.

Built like a Practical Automation Printer means . . .

1. **Smallest Size . . .** only 3½"W x 3"H x 9"D
2. **Lowest Price . . .** $140 in 100 unit quantity
3. **Full Alphanumerics . . .** a complete 63 character set
4. **Ribbonless Printing . . .** unique inked platen lasts for 75,000 lines
5. **Standard Interfaces . . .** RS232C and others
6. **18 Columns . . .** 110 character per second print rate

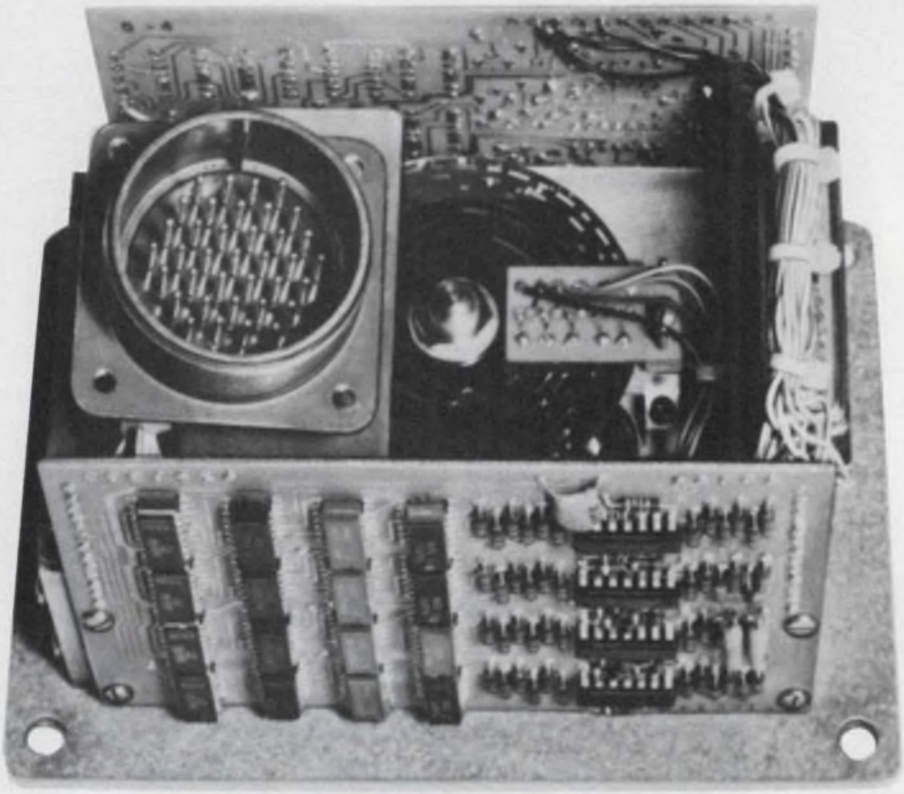
Six sound reasons to take the next important step . . . ask for a demonstration and become convinced!

PA PRACTICAL AUTOMATION, INC.

Trap Falls Road ■ Shelton, Connecticut 06484
Tel: (203) 929-5381

INFORMATION RETRIEVAL NUMBER 80

Programmable shaft-angle encoder works with any rotating shaft



Theta Instrument Corp., Fairfield, NJ 07006. (201) 227-1700. P &A: See text.

In the past, optical encoders had to be specially coded for each category of machine application. Now Theta Instrument Corp., with its Decitrak POE series of programmable optical encoders, has eliminated the need for custom encoder discs. Thus if your application changes, you can just reprogram the internal circuitry rather than replace the expensive encoder disc.

Theta's POE absolute encoders provide a parallel BCD TTL output that can be electronically modified to suit almost any shaft application. The output code can be multiplied by any three-decade programming that has a value between 0.001 and 0.999. The constant can be set by external thumbwheel switches or hand-wired as a permanent setting.

Encoders in the POE series are available with ranges from 999 to 999999, full scale. Maximum output error for any of the encoders is ±1 count over the entire operating range. The encoders operate at a max speed of 3000 rpm.

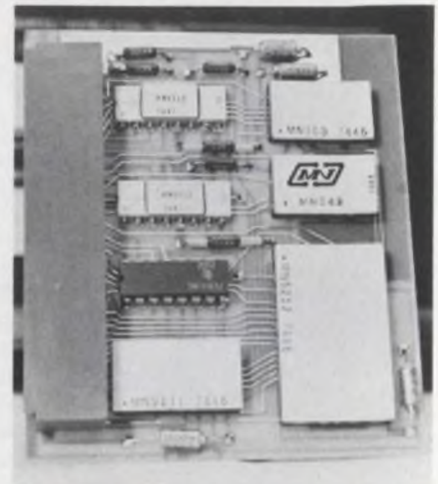
Only 0.2 oz-in. of breakaway torque is needed to start the encoder disc rotating from a dead stop. This force is less than a tenth that required by most contacting encoder types.

The encoder power requirement is only 5 V dc at 1 A. The operating temperature range spans 0 to 50 C. To connect the encoder to external equipment, an MS-3102A multi-pin connector is required. The POE encoders are housed in heavy gauge, 5.5 × 6.5 × 4.6-in. metal cases, which can protect the devices from severe industrial environments.

Prices for the POE series start at $995 for single quantities of the three-decade version. Delivery is from 60 to 90 days.

CIRCLE NO. 304

Data acquisition card handles 16 channels



Micro Networks Corp., 324 Clark St., Worcester, MA 01601. (617) 852-5400. For 1 to 9 units: MNA-7000, $595; MNA7000H, $1195; 2 to 4 wk.

The MNA7000 and MNA7000H are adjustment-free 16 channel data acquisition systems. Both units resolve input data to 12-bit words and measure only 3.15 × 2.75 × 0.45 in.

The MNA7000 is rated for 0 to 70 C operation, while the 7000H is rated for the full −55 to +125 C MIL temp range—an industry first. Both units, though, have a guaranteed linearity to ±1 LSB over their full operating temperature ranges, as well as ±1/2 LSB linearity at 25 C.

A fully differential instrumentation amplifier is provided in both units to buffer the selected signal. The amplifier's input impedance is 100 MΩ min., and its common-mode rejection is 72 dB min. from dc to 1 kHz.

In the single-ended mode, and the "pseudo" differential mode, 16 data input channels are available and, in the differential mode, you have eight channels with a common-mode range of ±10 V.

Several input range options are available: 0 to ±10, −10 to +10, and −5 to +5 V. Coding is straight binary (for 0 to +10 V) and offset binary (for bipolar ranges). Conversion time is 25 μs per channel (overlap mode) including the sample-hold delay. Power requirements are ±15 and +5 V.

CIRCLE NO. 301

It also comes assembled.

If you need dials, we have dials. If you need handsets, we have handsets. If you need Touch Calling keysets, we've got 'em by the thousands. Ringers and hookswitches, too. Or, if you need complete telephones, we have them for you in all the latest styles and colors.

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GTE AUTOMATIC ELECTRIC

INFORMATION RETRIEVAL NUMBER 88

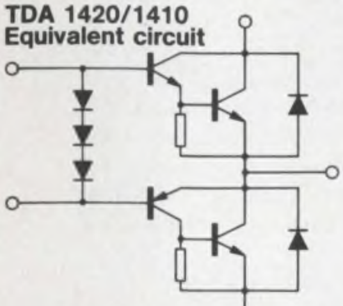
RIGHT ON TARGET AGAIN

SGS ATES

A perfect match when things get hot

1 st monolithic complementary darlington pair

TDA 1420/1410
Equivalent circuit



The TDA 1420 integrates a quasi-complementary (NPN/PNP) darlington pair and biasing diodes for perfect electrothermal matching. Applications for this versatile power IC include DC or stepping motor drivers, op amp power boosters, audio output stages, etc.

All this in Pentawatt®, the rugged 5-pin plastic pack.

For lower voltages try the TDA 1410.

Key parameters	TDA 1420	TDA 1410
V_{CEO}	44 V	36 V
V_{CES}	60 V	50 V
I_c	3 A	3 A
P_{tot} @ $T_c \leqq 60°C$	30 W	30 W

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INFORMATION RETRIEVAL NUMBER 89

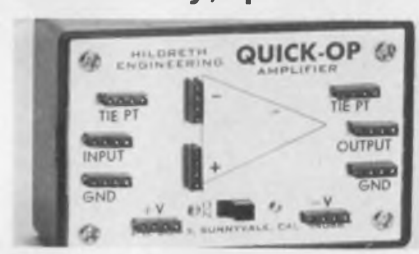
Presettable timer has 2, 3 or 4-digit accuracy

Kessler-Ellis Products, Atlantic Highlands, NJ 07716. (201) 291-0500. From $210; stock.

A solid state, electronic presettable timer is available with 2, 3 or 4-digit setting accuracy. The user can simply dial in a desired number of milliseconds, activate the start circuit and after the given pre-set time has expired, a normally open 9-A triac will fire, passing 110 V ac to a load. Timed increments from 1 ms to 1 min. are available either by use of an RC time constant circuit or a CMOS digital divider.

CIRCLE NO. 334

Breadboard amplifier allows easy, quick test



Hildreth Engineering, P.O. Box 3, Sunnyvale, CA 94088. (408) 245-3279. $11.95 (unit qty); stock to 2 wk.

The Quick-Op Amplifier lets you develop, test or experiment with a wide range of op-amp circuits. Forty solderless connectors are located on a function identified panel —just plug in resistors, capacitors, diodes, etc. A 741C op-amp is internally wired, offset nulled and tested, and two 9-V batteries mount inside the case to make a self-contained unit. Quick-Op can also be powered from external supplies through solderless tie points. The unit measures only 3.25 × 2.125 × 1.375 in. and weighs 4.5 oz.

CIRCLE NO. 335

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INELCO

INFORMATION RETRIEVAL NUMBER 92

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dB Multimeter...

The only low cost full function digital multimeter with 120 dB range. Operates on battery or line.

Model 2180 (shown)
Six functions, 31 ranges, AC-DC Volts, AC-DC Current, Ohms plus dB, integral battery charger standard. Basic DC accuracy 0.1%, 100µV resolution, dB accuracy, 0.5dB, 600 & 900 ohm termination standard, 3½ digit LED display. Compact and rugged enough to stand on! Only . . . **$395.**

Don't need dB? Compare the Model 2120; identical to the 2180 less dB with five functions, 26 ranges. **$295.**

Don't need dB or current? The Model 2110 offers three functions, 15 ranges. Delivery is from stock. **$245.**

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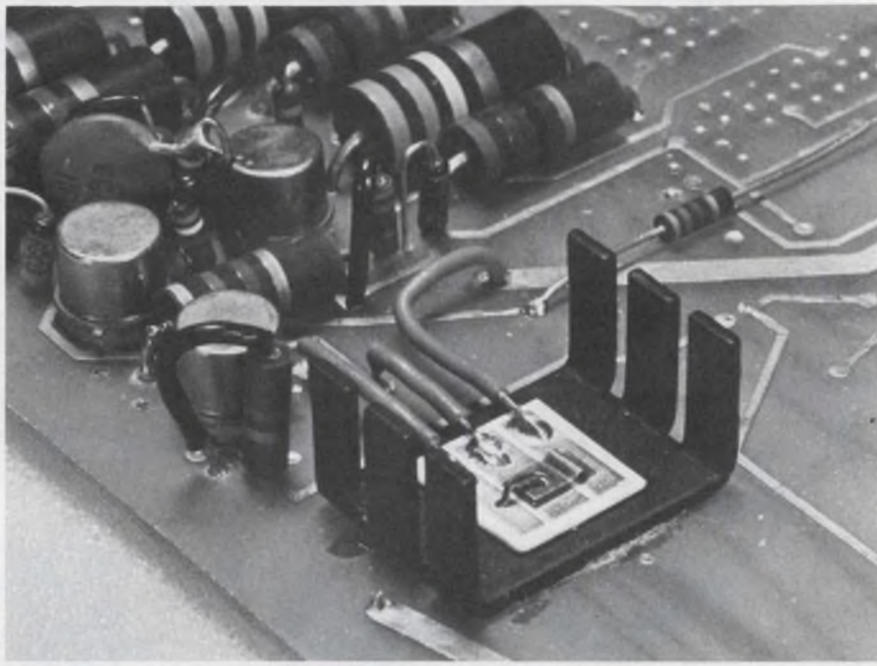
INFORMATION ONLY 280 DEMONSTRATION ONLY 281

Caseless thyristors reduce cost and ease assembly



Unitrode, 580 Pleasant St., Watertown, MA 02172. (617) 926-0404. P&A: See text.

Chip thyristors mounted on ceramic substrates can save you money while still retaining the benefits of conventional packages. So says Unitrode in offering its Chipstrate caseless thyristors.

Basically a Chipstrate consists of a glass-passivated, solderable power thyristor chip mounted on a thin square piece of alumina ceramic. Conductive paths are provided from the cathode, gate and anode of the chip to contact pads on the ceramic.

Since there are no cases, the devices cost, typically, 20 to 40% less than equivalent packaged units.

Chipstrates are available in SCR and triac versions that can handle from 10 to 55 A at voltages from 200 to 600 V. For elements with ratings of less than 30 A, the ceramic base is 0.5 in. on a side and 0.025 in. thick. Units rated for currents above 30 A measure 0.65 in. on a side and are also 0.025 in. thick.

All metallization is kept at least 0.05 in. from any edge of the ceramic base material. This simplifies compliance with the over-the-surface spacing requirements of Underwriters' Laboratories for certain applications.

Chips and contacts are mounted onto the substrate at 325 C, typically. A coating of silicone compound protects the mounted chip from physical damage. This permits subsequent circuit connection using 60/40 solder.

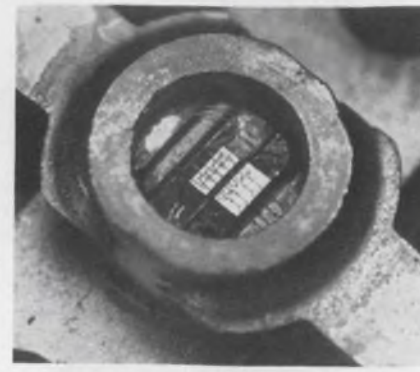
The alumina Chipstrate has a thermal resistance of about 0.7 C/W when used with the recommended mounting method. You can, though, optionally get the Chipstrate with a beryllia substrate. The beryllia has a lower thermal resistance of 0.14 C/W.

Also, you can get the Chipstrate with metallization on the bottom of the ceramic as well as on top—a possible simplification for some interconnect problems. You can get the Chipstrate with 95% of the commercial thyristor types available.

Prices in 5000-piece lots, with an alumina substrate, range from \$0.60 to \$4, depending upon voltage and current ratings. The beryllia substrates add about 10% to the cost. Delivery is from 2 to 3 weeks for small quantities and 8 to 10 weeks for big orders.

CIRCLE NO. 303

Rf transistor delivers 5 W at 2 GHz



Amperex Electronic Corp., Hicksville Div., Hicksville, NY 11802. (516) 931-6200. From $75; stock.

An rf power transistor, the 2005BLY, can deliver 5 W at frequencies up to 2 GHz with a 9-dB gain when operated from a supply voltage of 28 V. This transistor, designed for operation at 1636.5 and 1645 MHz, is a common base device with internal input matching networks and operates in a class "C" mode. The 2005BLY is an epitaxial npn planar transistor packaged in an hermetically sealed HLP-8 package. The transistor has gold metalization and diffused ballast resistors to increase transistor life over devices using the older aluminum metalization systems.

CIRCLE NO. 336

Quad-FET demodulator designed for vhf use

Siliconix, 2201 Laurelwood Rd., Santa Clara, CA 95054. (408) 246-8000. $12.40 (100-up); stock.

A quad-ring-demodulator, the U350, is designed for vhf balanced mixer and analog multiplier applications. The device has four matched U310 junction FET chips in a single TO-99 package. In active mixer applications, the demodulator has a two-tone intermodulation product—as high as +34 dBm—and a conversion gain of +4 dB. Transconductance of the U350 is 15 mmho typical and capacitance is as low as 10 pF with drain current of 10 mA. Noise figure is 8 dB at a frequency of 100 MHz. In multiplier applications, the device has only a 90 Ω maximum turn-on resistance.

CIRCLE NO. 337

DIGITAL SENSOR improves resolution

Electro Corporation, 1845 57th St. Sarasota, Fla. 33580. (813) 355-8411 $49 list: Stock to 4 weeks.

Model 58413 Di-Mag® Digital Magnetic Sensor is designed for applications requiring very high resolution. Geometrically matched sensing tip (pole-piece) allows maximum resolution when used with fine toothed gears. Unit has self-contained signal conditioning circuitry and produces outputs compatible with TTL, DTL or HTL logic.

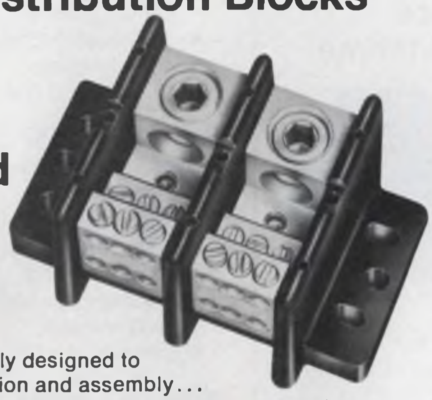
Send for complete catalog

ELECTRO

YES . . . WE'VE BEEN BUSY!
This honey of a new product is but one of many — look for more in the New Product Sections of your favorite publications.

INFORMATION RETRIEVAL NUMBER 104

Power Distribution Blocks With Built-In Time and Cost Savings



They're especially designed to simplify installation and assembly . . . speed up wiring . . . and provide a secure connection to prevent possible slip-out.

You don't have to wait, either. You get quick delivery on a wide range of sizes and types—at nominal piece prices.

Most blocks are UL recognized and certified by CSA.

Request Bulletin PT-300. If you have a special requirement, give us the specs. We'll design a block to your need.

Underwriters Safety Device Company

7300 W. Wilson Ave., Chicago, Ill. 60656 • 312-867-4600

INFORMATION RETRIEVAL NUMBER 105

THIS MAKES 40,000 CASSETTE RECORDERS. WHEW!

When it comes to cassette recorders, who you buy them from is as important as what you buy.

And when you buy the Sycor Model 135, you're dealing with a company that already has 40,000 recorders in service worldwide.

The popularity of our cassette recorder isn't really surprising.

The Sycor 135 is the ANSI compatible cassette drive with record overwrite capacity that lets you edit a whole data block without disturbing so much as a character on adjacent records.

The recorder that reads/writes at a fast 12.5 ips with quick starts and stops for high throughput. With a dual-gap head for Read-After-Write verification.

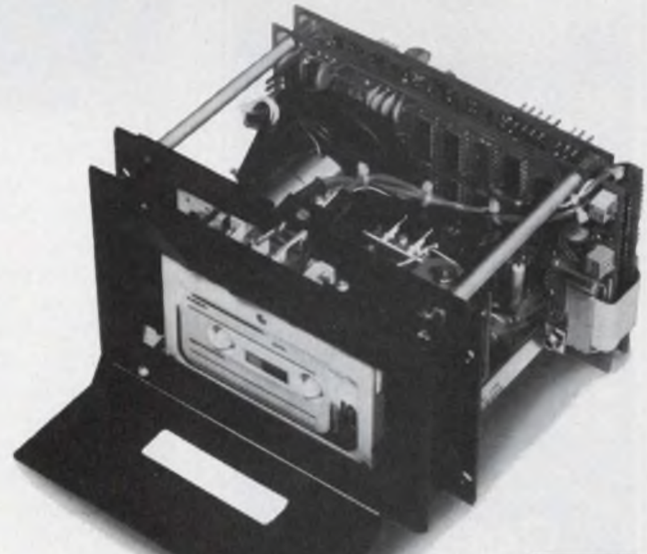
The recorder that accesses data at a clip of 60 ips.

For more information on our Model 135, or for help on any design or application problem, give us a call.

A company that's made 40,000 cassette recorders ought to be pretty good at finding solutions.

SYCOR

Contact OEM Department, Sycor, Inc., Ann Arbor, Michigan 48104. Telephone (313) 971-0900.



SYCOR INC

Internationally represented by Munzig International in London, Paris, Munich, Tokyo, and Geneva; and by STG International in Tel Aviv.

INFORMATION RETRIEVAL NUMBER 106

3-digit DPM comes in 3 models at $62 (100 up)

Analogic, Audubon Rd., Wakefield, MA 01880. (617) 246-0300. $62 (100).

A new series of 3-digit, universal DPMs, the AN2530, features true floating, high-Z input (1000-MΩ nominal, 100 dB CMR, 300 V peak CMV) and resistor programmed gain to 50 μV per count. The series comes in three versions: The AN2530-L (LED display), the AN2530-S (gas plasma) with accessory programmable connector AN86 and the AN2330-L (PC-card unit), a pin-compatible model. All three models use 5-V power, display three decimal digits and consume 3 W.

CIRCLE NO. 338

DMM guarantees accuracy over lifetime

Philips Test & Measuring Instruments, 400 Crossways Park Dr., Woodbury, NY 11797. (516) 921-8880. $335.

MOS circuitry is used throughout in the PM2522 multimeter. During the lifetime of the instrument, the specified accuracies (0.2% on dc) are guaranteed, and there is no need to recalibrate. CMR is 100 dB and input impedance is 10 MΩ. The 3-1/2-digit LED display has an automatic decimal point as well as polarity and overrange indication. All functions and controls are pushbutton selected and there is no need to change leads from voltage to resistance measurements.

CIRCLE NO. 339

Compact counter/timer is just 2 × 3 × 3 in.

Kessler-Ellis Products, Atlantic Highlands, NJ 07716. (201) 291-0500. Approx. $200; stock.

This solid-state counter/timer combination has the following standard features: compact size of 2 × 3 × 3 in.; built-in 110-V-ac power supply; unique "touch to reset" circuit eliminates all moving parts; display hold circuit for reading the display while it continues to count or time; optional BCD output; and a built-in crystal time base or 60-Hz divider for timing in seconds or hundreds, minutes and seconds or other combinations.

CIRCLE NO. 340

Analyzer diagnoses microprocessors

Motorola Inc., 455 E. North Ave., Carol Stream, IL 60187. (312) 690-1400.

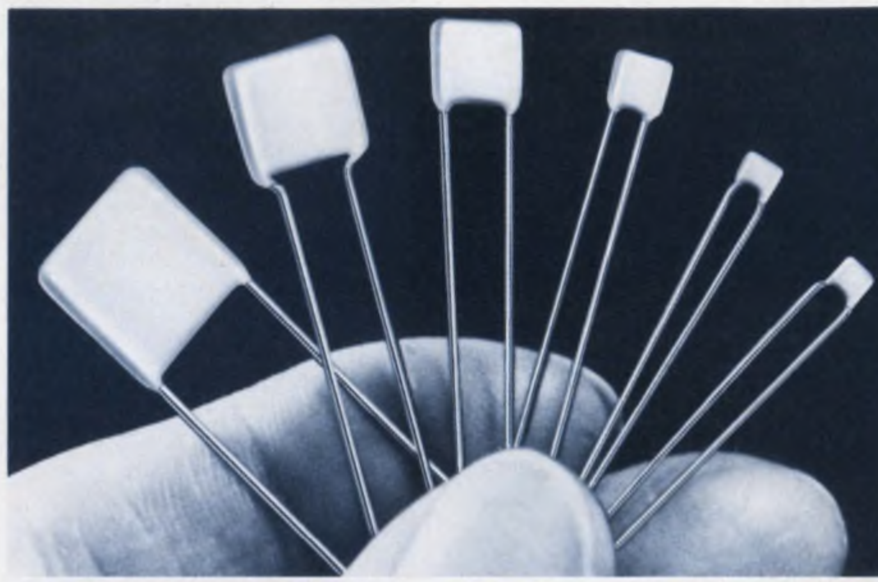
MPA-1 logic analyzer is a completely new diagnostic tool specifically designed to analyze both hardware and software operations of microprocessors. The unit displays 32 words of 24 bits each in hexadecimal characters on a 9-in. CRT screen. The characters are arranged in groups of four and two, representing a 16-bit address and 8 data bits. Any location within 65 k addresses may be selected as the trigger address with preset hex switches. The MPA-1 will display 32 consecutive addresses and the associated data. The display can be set to start or end with the trigger address; the starting or ending address can also be delayed from the selected address. Price and delivery are not yet available says Motorola at press time.

Booth No. 1222-1224

Circle No. 341

QUALITY IN VOLUME

When you achieve it, you can offer true competitive value. That's just what we're doing at USCC/Centralab for 1975. MONO-KAP™ radial, and MONO-GLASS axial monolithic ceramic capacitors are now available to volume users *from stock* to eight weeks. Our investment and "learning curves" last year guarantee competitive responsiveness — USCC will welcome your specials and non-stock orders. Here's an offer you haven't heard lately — your money is going to buy more at USCC. Cash in on the best values in monolithic ceramic capacitors.

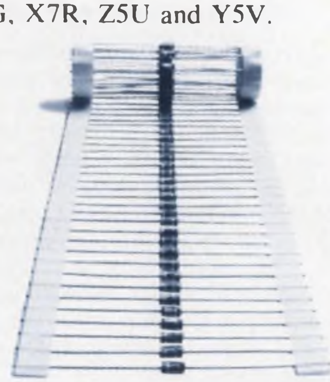


DISCRETE ASSEMBLY

MONO-KAP™ radial-leaded epoxy coated capacitors are reliable performers; they're rugged enough to work in MIL environments. 4.7 pF to 10 Mfd., 50 to 200 WVDC in 4 dielectrics, including Z5U, in a variety of case sizes featuring meniscus control to 0.032 inches. Large quantity orders from stock.

AUTOMATIC INSERTION

MONO-GLASS axials are glass encapsulated, designed for automatic PCB insertion; furnished reel-packed for high volume applications. They're available in 50 and 100 WVDC from 1 pF to 1.0 Mfd.; four dielectrics: COG, X7R, Z5U and Y5V.



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INFORMATION RETRIEVAL NUMBER 110

Miniature DPMs give big 0.3-in. display

Velonex Div. of Varian, 560 Robert Ave., Santa Clara, CA 95050. (408) 244-7370. $132 (3-1/2 digits); 8 wks.

Impac B Series of miniature DPMs features a 0.3-in. LED display. The meters are available in models with 3, 3-1/2, 4 or 4-1/2 digits. Dimensions of all units in the series are identical: Front panel area is less than 4.4 in.^{2} and behind-panel volume is less than 5.3 cubic in. Power consumption is less than 1 W.

CIRCLE NO. 342

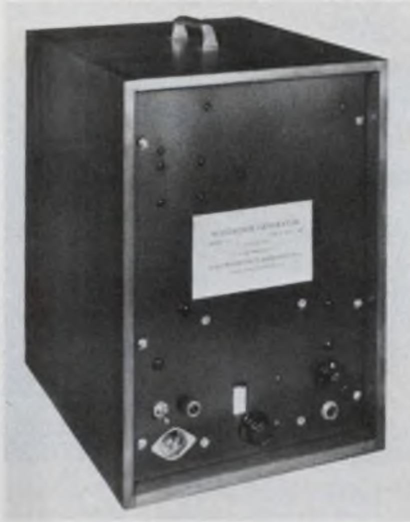
Six-hole mainframe added to modular line

Tektronix, Inc., P. O. Box 500, Beaverton, OR 97005. (503) 644-0161. $395.

Those who have discovered the company's TM 500 system of instrumentation, including DMMs, counters, signal sources, power supplies, and breadboard modules, can now put six plug-in modular instruments in a single, portable power module/mainframe. The TM 506 occupies only 17-1/2 in. of bench space. The unit is 20-in. deep and, like all TM 500 mainframes, only 6-in. high, including feet. The unit is also available in a rack-mounted version, which includes mounting ears and slide-out tracks. It is designed for installation and operation in standard 19-in.-wide racks.

CIRCLE NO. 343

Waveform generator imitates drawn patterns



Electro-Physical Research, Inc., P.O. Box 817, Sandy Hook, CT 06482. (203) 426-0148. $1725.

Waveform generator, Model CS-1, produces an electrical signal that is a faithful reproduction of the waveform drawn or photographed on a small glass slide. The pattern on the slide is electronically scanned, amplified and made available at the output terminals. The unit will produce the sound of any musical instrument or human voice, including short words; any combination of fundamental and harmonics in any phase and/or amplitude relationship; tone bursts and other transients; sine, square, and triangular waveforms; neural pulses and other waveforms. Normal frequency range is from 40 to 250,000 Hz; however, pulse times may be made as short as desired.

CIRCLE NO. 344

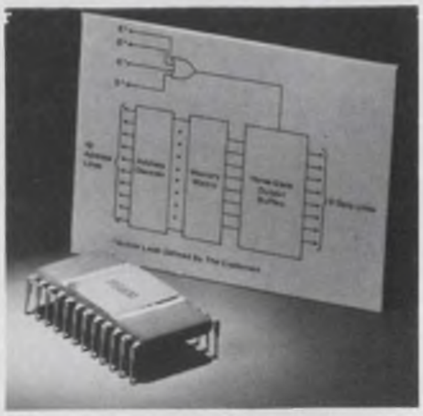
PROM duplicator handles 256-bit memories

Curtis Electro Devices, Box 4090, Mountain View, CA 94040. (415) 964-3136. $499.50; stock to 2 wks.

PR-2300S is a production programmer for the new 256-bit (32 × 8) 82S23 and 82S123 Schottky PROMs. The compact, table-top instrument will duplicate from a pin-compatible ROM, ROM simulator or computer with an average programming time of 1 s. Just insert the blank PROMs, press the START button and watch for a PASS or FAIL indication.

CIRCLE NO. 345

8-k ROM holds control programs



Motorola Semiconductor Products, Inc., P.O. Box 20294. (602) 244-3466. P&A: See text.

A 1024 × 8-bit ROM, the MCM-6830L, constitutes one of the memory components in Motorola's microcomputer chip set. The NMOS silicon-gate circuit stores the microprocessor's control programs, and it can be used in other bus-organized applications. The MCM-6830L is fully TTL compatible, and it operates from a single 5-V supply. Maximum read-access time is 575 ns. Housed in a 24-pin, ceramic DIP, the price of the ROM is $35.00, in 1-24 quantities, with a design-aid program stored in the memory.

CIRCLE NO. 346

Bucket brigade IC has dual 512-bit stages

Panasonic, Div. of Matsushita Electric, Pan Am Bldg., 200 Park Ave., New York, NY 10017. (212) 973-4980. Under $10 (1000-up).

A bucket brigade IC, the MN-3001, delays analog signals in the audio frequency range. The dual 512-stage BBD uses silicon-gate technology and has applications such as in playing a record where a time delay of tens of milliseconds is required for reverberation.

CIRCLE NO. 347

Amplifier simplifies microphones

N.V. Philips Gloeilampenfabrieken, Elcoma Div., P.O. Box 523, Eindhoven, the Netherlands.

The TCA980 monolithic amplifier is intended primarily for telephones and intercom systems. In a telephone handset, a capsule assembly containing the TCA980, a low-impedance dynamic microphone and a 0.22-μF capacitor can directly replace the carbon microphone. When used with a microphone having an impedance of 200 Ω and a sensitivity of 100 μV/μbar, the output of the amplifier is 22 mV/μbar. The output impedance of the TCA980 is typically 150 Ω. The new IC requires a supply current of 10 to 100 mA, and it comes in a TO-12 package.

CIRCLE NO. 348

256-bit CMOS RAM has 150-ns access

Solid State Scientific Inc., Montgomeryville, PA 18936. (215) 855-8400. $12.00 (1000).

An improved version of the company's 256-bit CMOS RAM is being offered. Organized 64 words by 4 bits, the new version has a typical access of 150 ns. Standby power is typically less than 0.2 μW/bit. The new memory comes in either epoxy or ceramic 24-pin DIP or flat pack.

CIRCLE NO. 349

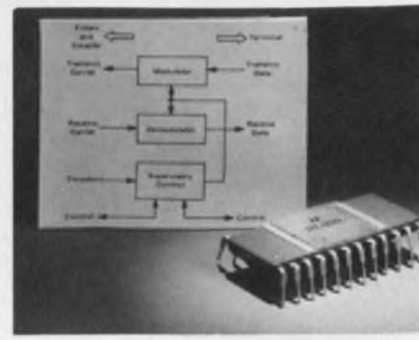
1-k MOS RAM has 145-ns max access

Synertek, 3050 Coronado Dr., Santa Clara, CA 95051. (408) 241-4300. $10.80 (100-999).

A fully decoded 1024-bit dynamic, silicon-gate MOS RAM—the SY1103A-1—uses ion-implantation techniques to achieve worst-case access times of 145 ns. By using ion implanted load devices, the SY1103A-1's chip-enable capacitance has been reduced to 18 pF. This reduces clock power dissipation by 35% and cuts the number of clock drivers required at the system level. Also, the precharge clock required with standard 1103-type RAMs is not needed with the new RAM. The memory has a 1024 × 1-bit organization and it comes in an 18-pin ceramic DIP.

CIRCLE NO. 350

Single chip holds modem



Motorola Semiconductor Products, Inc., P.O. Box 20924, Phoenix, AZ 85036. (602) 244-3466. $75 (1-24).

A 0-to-600-bps digital modem, the MC6860L, provides modulation, demodulation and supervisory control functions necessary to implement a serial data-communications link. The NMOS circuit employs frequency shift keying (FSK) modulation, and it permits data transfer via standard, voice-grade telephone channels. The MC6860L is compatible with the company's M6800 microcomputer family and interfaces directly with the MC6850 asynchronous adapter. Modes of operation for the MC6860L include full duplex, half duplex, simplex, automatic answering, automatic disconnect, originate only, answer only and answer/originate.

CIRCLE NO. 351

Calculator performs 360 conversions

MOS Technology, Inc., Valley Forge Corporate Center, 950 Rittenhouse Rd., Norristown, PA 19401. (215) 666-7950. Under $20 in high volume.

The MPS 2529-104 single-chip calculator array can perform 360 different pre-programmed unit conversions or up to three user-programmable conversions. The array also includes such basic features as algebraic entry, two parentheses levels, scientific notation and natural logarithms. Three full-feature accumulating memories are accessible to a user. Each is separately addressable from a keyboard with Store, Recall and M+ keys. The calculator array operates with a 40-key board and a 12-digit display.

CIRCLE NO. 352

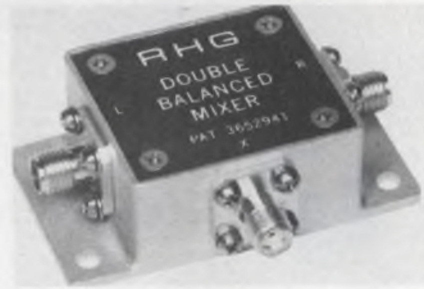
180° hybrid covers 2 to 12.4 GHz

Norsal Industries, Inc., 34 Grand Blvd., Brentwood, NY 11717. (516) 231-4040. $450.

The Model 4834, a 180-degree hybrid, spans the frequency range of 2 to 12.4 GHz. The unit offers an isolation of 17 dB, a VSWR of 1.4 and insertion loss of 1.7 dB. Amplitude and phase unbalance are ±0.5 dB and ±7 degrees, respectively. The 4834 comes in a 3-1/2 × 1-1/2 × 1/2-in. package, and it has an input power rating of 20 W average and 2 kW peak.

CIRCLE NO. 353

2-to-18-GHz mixer uses −10 dBm LO



RHG Electronics Laboratory Inc., 161 E. Industry Ct., Deer Park, NY 11729. (516) 242-1100. $625; 30 days.

Only −10 dBm of LO power is needed for the Model DMB2-18 multioctave double-balanced mixer. The new mixer has an rf range of 2 to 18 GHz and its i-f range of 1 to 350 MHz can be extended to 18 GHz with an external diplexer. Isolation from the rf to LO is typically 25 dB over the 12-to-18-GHz range. And conversion loss is typically 13 dB at −10 dBm LO.

CIRCLE NO. 354

Doppler module increases sensitivity

Plessey Semiconductor, 1674 McGaw Ave., Santa Ana, CA 92705. (714) 540-9979. $85 (100); stock.

A doppler module for intruder alarms achieves increased sensitivity by using separate transmitter and receiver cavities. The transmitter cavity is a Gunn-diode oscillator, and the receiver cavity is a mixer/receiver. A return signal that is 100 dB less than the transmitted signal produces an output of at least 40 μV. This is equivalent to the typical signal produced by a moving person 50 meters distant, assuming an antenna gain of 15 dB. Modules are available for frequency ranges of 8.8 to 9.9 GHz and 10.2 to 11.0 GHz, and units supplied can be pretuned to any frequency within their range. Minimum transmitter power output is 10 mW.

CIRCLE NO. 355

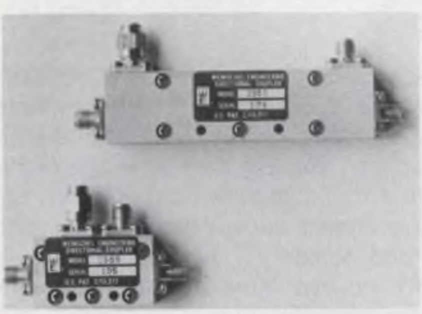
He-Ne laser costs $10 in volume

Hughes Aircraft Co., P.O. Box 9515, Los Angeles, CA 90009. (213) 670-1515. P&A: See text.

A new type of helium-neon laser, designed for emerging high-volume applications such as the video disc player market, will eventually cost about $10 in quantities of 100,000. The company expects to have the laser available as a standard product by mid-1975. The new He-Ne laser has internal mirrors and features Hughes' patented cold-cathode coaxial construction. It will be available either polarized, or randomly polarized, with power outputs up to 2-1/2 mW. Beam diameter is about 0.7 mm. Input power requirement to the laser is less than 6 W, which reportedly represents a 35% reduction from current models. Length of the unit is less than 10-1/2 in. It will be available either as a laser tube alone with a diameter of approximately 1 in. or in a pre-aligned package with a diameter of 1-3/8 in.

CIRCLE NO. 356

1-18 GHz couplers offer ±0.2-dB sensitivities



Weinschel Engineering, P.O. Box 577, Gaithersburg, MD 20760. (301) 948-3434. $125 to $150; stock to 30 days.

The Models 1551 through 1557 directional couplers cover the 1-to-18-GHz frequency range with frequency sensitivities of ±0.2 dB (Models 1551 through 54) and ±0.3 dB (Models 1555 through 57). Directivity is 20 dB minimum, 24 dB typical for Models 1551 through 54; 19 dB minimum, 23 dB typical for Models 1555 through 57. Insertion loss (excluding coupled power) is 0.3 dB maximum to 4 GHz, 0.4 dB maximum to 12.4 GHz, and 0.7 dB maximum to 18 GHz.

CIRCLE NO. 357

Downconverter yields 10-2000-MHz output

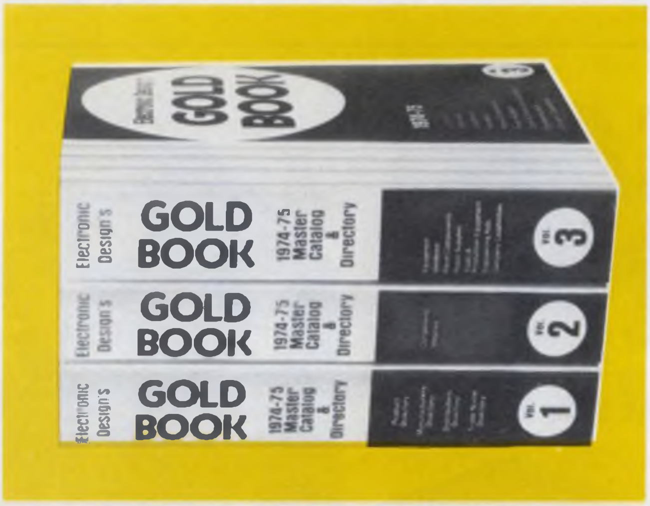
Miteq Inc., 100 Ricefield Lane, Hauppauge, NY 11787. (516) 543-8873. $1875; stock to 60 days.

The DN8006A downconverter can be used with either a 2100-to-4090-MHz or 4100-to-6100-MHz swept signal input to produce a 10-to-2000 MHz output. A power input of −10 dBm typically gives +10 dBm minimum output. In-band spurious rejection is typically 40 dB, with a harmonic rejection of 30 dB typical. An internal sampler when used with an external sweeper provides ±0.2-dB power flatness.

CIRCLE NO. 358

Electronic Design's

YOUR OWN INSTANT



SIMPLIFIES AND SPEEDS PRODUCT SEARCH

Want to know who makes what? Just turn to the GOLD BOOK's *Product Directory*. Each manufacturer's *complete* street address, State, zip, and phone is given every time it's listed. Contact is simplified . . . you (or your secretary) don't have to go to any other directory to get missing address information — a big help if you're contacting many suppliers at the same time.

Boldface type and page references steer you toward catalog pages on the products you're seeking that are bound in Volumes 2 or 3. And there are symbols to verify that the company really makes the product — not merely says it does.

WANT TO KNOW MORE ABOUT A COMPANY?

You'll find 7,528 manufacturers listed in *Electronic Design's* GOLD BOOK — more than twice the number contained in EEM. But there's more, too. In addition to complete address and phone number, whenever provided by the company you'll find:

TWX
TELEX
CABLE ADDRESS
FACSIMILE EQUIPMENT (make and call number)
QPL DESIGNATION
FEDERAL STOCK CODE NUMBER
NUMBER OF ENGINEERS
NUMBER OF EMPLOYEES
DOLLAR VOLUME
KEY OFFICIALS
SALES OFFICES
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Check the Geographical Section of the GOLD BOOK's *Distributors Directories.* You enter the section by state, then find your city — or one nearby — and the distributors located in that city. You can then go to the Alphabetic Section to find the complete address, zip, and phone. In most cases annual sales volume or net worth, year established, and names of key officials are included. (Distributors are also listed after the companies they represent in the *Manufacturers Directory.*)

LOOKING FOR A FOREIGN REPRESENTATIVE?

A good rep nowadays is hard to find. It's even hard to know where to start, especially if your company is looking for a rep overseas. Do your sales manager a favor and tell him that foreign reps are listed after each company in the *Manufacturers Directory.* (If you are an overseas subscriber, chances are you've already found this section very useful.)

Evaluation Samples

Cable pack

A sample pack features selected ribbon cable products including standard configuration, laminated, bonded flat and twisted cable. Spectra-Strip.

CIRCLE NO. 359

Electrical tubing

Dielectric plastic tubing rated for 600 V at 105 C comes in A.W.G. sizes from 24 up to 2-1/2 in. and in standard wall thicknesses from 0.03125 to 0.01 in. It meets ASTM and MIL specs, has CSA approval and meets the FR-1 flame test, U.L. Subject 224. Dielectric Materials.

CIRCLE NO. 360

Nylon spacers

Molded nylon spacers come in lengths of 1/16-in. increments from 1/8 to 1 in. and outside diameters of 3/16, 1/4, 5/16, 3/8 and 1/2 in.

CIRCLE NO. 361

Interconnection material

A sample kit contains three 1-1/2 in. × 3 in. metal-filled elastomeric sheets, one each in thicknesses of 5, 10 and 20 mils, and complete instructions on the use of the material. The kit is priced at $10. Chomerics, 77 Dragon Ct., Woburn, MA 01801

INQUIRE DIRECT

PC board switches

Series RK8000 subminiature PCB rocker-actuated switches are intended for solder pin insertion into 1/16, 1/32 and 1/8 in. PC boards. Request sample on company letterhead, indicating the expected end use. Control Switch, 1420 Delmar Dr., Folcroft, PA 19032

INQUIRE DIRECT

Application Notes

CAD of microwave circuits

How microwave circuit designers can simplify their calculations using a desktop calculator is the subject of an application note. A new software package, Microwave Pac Volume 1, is described. Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 362

FFT processing

"Theory and Application of Fast Fourier Transform Processing" discusses the system parameters involved in defining a Fast Fourier Transform requirement, as well as Fourier methods: the Fourier Transform, the Discrete Fourier Transform (DFT) and the Fast Fourier Transform (FFT). Spectra Data, Northridge, CA

CIRCLE NO. 363

Semiconductor fuses

Factors which should be considered in selecting semiconductor fuses are explained in a reprinted article. International Rectifier, Semiconductor Div., El Segundo, CA

CIRCLE NO. 364

Interfacing CMOS

Examples of practical circuits for a wide variety of interfacing situations between CMOS and other technologies and design constraints for each circuit are given in an eight-page catalog. Logic diagrams and tables of characteristics supplement the text. RCA Solid State, Somerville, NJ

CIRCLE NO. 365

Gear train system

"Gear Train System Studies for Use with Synchronous Timing Motors" covers tooth form proportions, wear and materials, surface endurance data, safe cyclic bending stress data and miscellaneous tabulated data. The book has a marked price of $2.50. General Time, Industrial Controls Div., Thomaston, CT 06787

INQUIRE DIRECT

New Literature

Readouts

A 60-page "Readout Product Selector Guide" details readouts made to accommodate incandescent, neon, gas discharge and light-emitting diode light sources. Dialight, Brooklyn, NY

CIRCLE NO. 366

Data systems

A 16-page brochure on the company's chromatography data system, PEP-2, includes descriptions of both the hardware and software for accomplishing a wide variety of laboratory chromatographic tasks. Perkin-Elmer, Norwalk, CT

CIRCLE NO. 367

Thick-film materials

Characteristics and typical applications of thick-film materials are presented in an eight-page brochure. Methode Development, Chicago, IL

CIRCLE NO. 368

Printer/plotters

High-speed electrostatic printer/plotters for graphic and alphanumeric presentations are described in a 12-page brochure. Gould, Instrument Systems Div., Cleveland, OH

CIRCLE NO. 369

Electronic project kits

Solid-state Modukit electronic project kits are featured in a four-page catalog. The catalog includes power supplies (factory assembled) and environmental lighting, which includes strobes, color organs, etc. Bowman Electronics, Garwood, NJ

CIRCLE NO. 370

D/a and a/d converters

Over 100 data conversion products are described in a 12-page catalog. Micro Networks, Worcester, MA

CIRCLE NO. 371

Linear ICs

A Linear IC Product Guide covers communications, controls, instrumentation, information systems, federal applications and consumer applications. The guide provides fingertip accessibility and selection of bipolar, MOS and CMOS ICs characterized for linear operation. RCA Solid State Div., Somerville, NJ

CIRCLE NO. 372

Relays and accessories

Over 1100 stock relays and accessories are shown in a 32-page catalog. Potter & Brumfield, Princeton, IN

CIRCLE NO. 373

Transistors chips

Silicon transistor chips, available in over 2000 2N types, are featured in a catalog. The catalog illustrates basic sizes and configurations, and presents specifications in tabular form. Semicoa, Costa Mesa, CA

CIRCLE NO. 374

Instrumentation

Descriptions and selection criteria for DPMs, linear ICs, thin-film resistor networks and substrates, function modules, a/d and d/a converters, power supplies, amplifiers, dual monolithic transistors, s/d converters and monolithic analog CMOS multiplexers, switches and converters are given in a 272-page guide. Analog Devices, Norwood, MA

CIRCLE NO. 375

Tantalum capacitors

A set of specifications and application notes for solid tantalum capacitors includes information on standard MIL metal case, nonpolar, subminiature and extended range hermetically sealed axial lead capacitors. Union Carbide, Components Div., Greenville, SC

CIRCLE NO. 376

Ferrite materials & cores

Catalog sheets on molded ferrite parts cover coil forms, sleeves, toroids and beads. The data sheets contain magnetic and physical specifications. Krystinel Corp., Port Chester, NY

CIRCLE NO. 377

Communications processor

An eight-page brochure presents an overview of the COPE 1600 remote communications processor's design features, performance capabilities, operating characteristics and general specifications. Harris Data Communications Div., Dallas, TX

CIRCLE NO. 378

Solid-State Databooks

The SSD-200C seven-volume, 4482-page set of 1975 Databooks covers RCA's standard line of ICs, discrete MOS devices, CMOS digital integrated circuits, power transistors, thyristors, rectifiers, diacs, rf and microwave devices and high-reliability ICs and discrete devices. Databooks may be ordered by individual volume at $3 each or the seven-volume set is available for $19. RCA Solid State Div., Box 3200, Somerville, NJ 08876

INQUIRE DIRECT

Motor relay

The PMS solid-state motor protection relay for large/critical ac motors is described in a six-page foldout. Weston Instruments, Sarasota, FL

CIRCLE NO. 379

Deviation controllers

Analog-digital indicating deviation controllers for process control systems are described in an eight-page booklet. Included are dimensional drawings, specifications, available options and ordering information. Beckman Instruments, Process Instruments Div., Fullerton, CA

CIRCLE NO. 380

Dielectric capacitors

A 116-page catalog on wound film dielectric capacitors includes capacitor basics and even points out some real pitfalls that some of the experts are reluctant to discuss. And for anyone with questions, they are readily answered by information on an application chart. Elpac Components, Santa Ana, CA

CIRCLE NO. 381

Integrated circuit modules

Abacus 1-100 series circuit modules are highlighted in an 18-page catalog. Specifications, characteristics, parameters and application information are included. Information Control Corp., El Segundo, CA

CIRCLE NO. 382

PC terminal switches

An illustrated 20-page catalog describes miniature toggle, pushbutton, slide, keyboard and rotary PC terminal switches and accessories. Engineering diagrams are tabulated for easy reference and identification of critical dimensions. Alco Electronic Products, North Andover, MA

CIRCLE NO. 383

Dc micromotors

Diagrams, photos and tables supplement an 8-page text describing dc micromotors. Portescap, U.S., New York, NY

CIRCLE NO. 384

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Vendors Report

Annual and interim reports can provide much more than financial-position information. They often include the first public disclosure of new products, new techniques and new directions of our vendors and customers. Further, they often contain superb analyses of segments of industry that a company serves.

Selected companies with recent reports are listed here with their main electronic products or services. For a copy, circle the indicated number.

Thomas & Betts. Connectors and terminations, fittings and accessories, wire harnessing devices and accessories, flat cable and connectors, telecommunication test equipment and cable-tie installation tools.

CIRCLE NO. 385

Union Carbide. Batteries and related products, polyethylene and chemicals.

CIRCLE NO. 386

Honeywell. Control systems and information systems.

CIRCLE NO. 387

Bausch & Lomb. Electro-optics, scientific instruments and consumer products.

CIRCLE NO. 388

Conrac. Communications, controls, information displays and automated assemblies.

CIRCLE NO. 389

Comsat. Communications satellites.

CIRCLE NO. 390

RCA. Electronic commercial products and services, consumer products and services, broadcasting, communications, government systems.

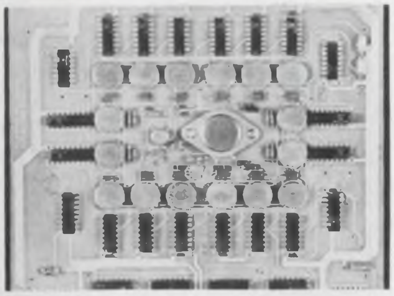
CIRCLE NO. 391

Raytheon. Government systems, consumer electronics, semiconductors, MSI/LSI ICs, medical electronics, microwave products, wire and cable, radar and minicomputers.

CIRCLE NO. 392

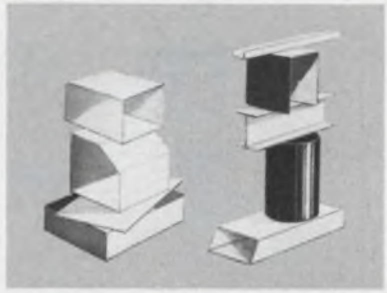
quick ads

New and current products for the electronic designer presented by their manufacturers.



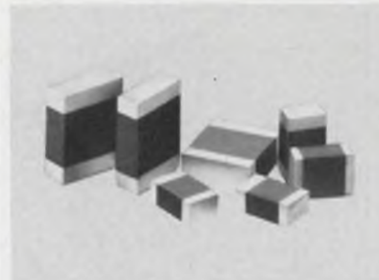
The 5 bit converter constructed on single printed circuit card. Total thruput time 50 n sec, with 20 MHz update rate. Temperature stability over full mil range, −55°C to +125°C with drift less than ±1 bit over entire range. M.S. Kennedy Corp; Pickard Dr, Syracuse, NY 13211 (315) 455-7077.

INFORMATION RETRIEVAL NUMBER 601



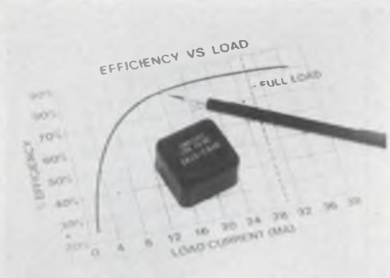
Glass laminated epoxy 155°C cases for component and circuit packaging are available in thousands of sizes. Thin wall tubes and headers offer optimum protection in all applications. Literature and samples available. Stevens Tubing Corp., 128 North Park Street, East Orange, New Jersey 07019. Telephone 201-672-2140.

INFORMATION RETRIEVAL NUMBER 604



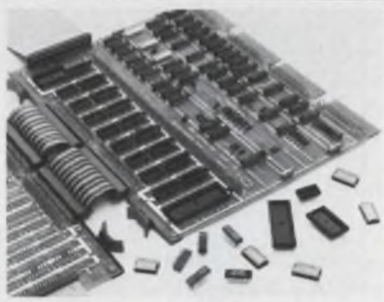
HIGH Q MULTILAYER CAPACITORS feature very high quality factors at microwave frequencies. Offered in three standard sizes: .050 x .040, .080 x .050, .125 x .095. Capacitance values from 0.1 pf to 1000 pf with close tolerance and voltages to 1000 VDCW. Johanson/Monolithic Dielectrics Div., Box 6456, Burbank, Ca. 91510, (213) 848-4465.

INFORMATION RETRIEVAL NUMBER 607



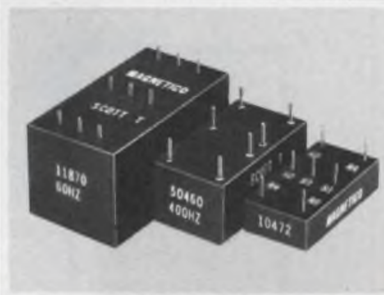
Activate gas discharge readouts! DC-to-DC power supplies convert low DC line voltages of 5, 9, 12 or 15 volts to nominal 200 and 250 volt DC levels required to run gas discharge information displays. Ideal for battery powered applications! Free literature. Endicott Coil Co., Inc., 31 Charlotte Street, Binghamton, N.Y. 13905

INFORMATION RETRIEVAL NUMBER 602



PDP-11 General Purpose Interface. The MDB-11C provides all features of a DEC DR11C plus additional 16 bit register, 4 selectable interrupt control levels, 16 decoded device addresses, takes only one quad slot, has maximum Unibus load of 1. Also, 20 wirewrap positions are provided. $390. MDB Systems, Inc., 981 N. Main Street, Orange, CA 92667.

INFORMATION RETRIEVAL NUMBER 605



Scott T Transformer. 11870: 60HZ, 90v, L-L in. 1.1x2.1x1.1. 50460: 400HZ, 90v, L-L in. 7/8x1-5/8 x11/16. 50642: 400HZ, 11.8v, L-L in. 7/8x1-5/8-11/16. 10472: 400-HZ, 11.8v, L-L in. 3/4x1-1/2x3/8. All with 6v RMS sine & cosine output. MAGNETICO, INC., 182 Morris Ave, Holtsville, N.Y. 11742 516-654-1166.

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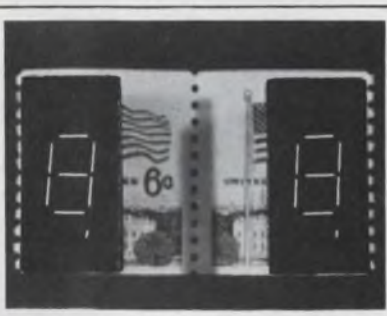

The Proven Incandescent Readout Standard 16 Pin DIP Flat Pack. All units 5 Volt 100,000 hrs. plus
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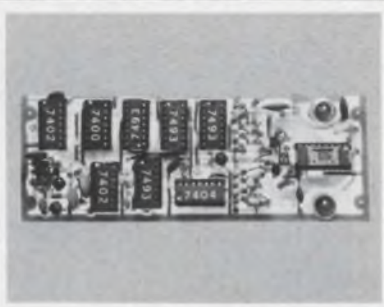
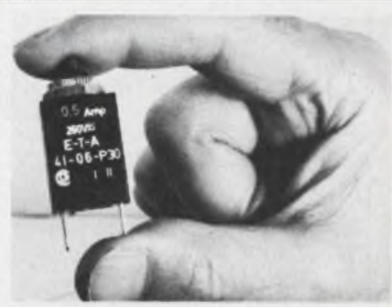
3015F-BM15 15ma/seg 4500 ft/lam
Field tested over 4 years in many applications. READOUTS, INC. P.O. Box 149, Del Mar, Ca. 92014 Tel. 714-755-2641 Telex 69-7992.

INFORMATION RETRIEVAL NUMBER 603



Low Cost Image Sensing Module contains a 1024 element (32-by-32) image sensor and all support circuitry on a single pc board. Digital video output may be displayed directly on an oscilloscope. Complete module (SE1024W) is $150. Kit (SE1024K) is $90. Cromemco, 26655 Laurel, Los Altos, CA 94022.

INFORMATION RETRIEVAL NUMBER 606

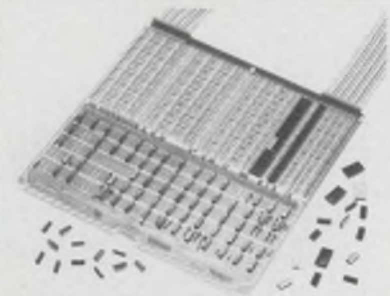


Overcurrent Protector, manual reset eliminates fuse replacement. Convenient panel mounting. 15 fractional ratings from 0.1 to 3 amp. Other models up to 400 amp. Trip-free and fool-proof, UL and CSA approved. High quality, low cost $1.29 ea. in 1000 lots. E-T-A Products Co. of America, 7400 N. Croname Rd., Chicago, Ill. 60648. Tel: (312) 647-8303. Telex: 253780.

INFORMATION RETRIEVAL NUMBER 609

quick ads

New and current products
for the electronic designer
presented by their manufacturers.



NOVA/DCC-116 general purpose interface board provides: multiple device selection, 4 I/O registers, DMA zero word count detect, 105 socket positions for 14, 16, 24 & 40 PIN IC's. Basic board (all features of data general 4040 plus multiple device select) $350. MDB Systems, Inc., 981 N. Main St., Orange, CA. (714) 639-7238.

INFORMATION RETRIEVAL NUMBER 610

Free catalog of 34,500 power supplies from the worlds largest manufacturer of quality Power Supplies. New '74 catalog covers over 34,500 D.C. Power Supplies for every application. All units are UL approved, and meet most military and commercial specs for industrial and computer uses. Power Mate Corp. (201) 343-6294.

INFORMATION RETRIEVAL NUMBER 613

Series "E" Electro-Pac Inverters, designed for heavy duty operation, provide a source of highly-reliable well-regulated (±2%) pure sinewave power from inputs of 48, 120, or 240 volts DC. ICS offers inverters from 0.5 kVA to 25 kVA, with 120, 240, 60 Hz or 50 Hz outputs. ELECTRO-PAC Div., ICS Inc. 129 Laura Dr., Addison, Ill. 60101

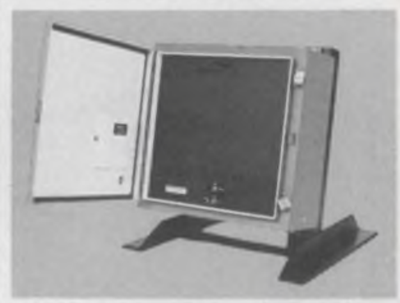
INFORMATION RETRIEVAL NUMBER 616

Synchro to Linear DC Converter: Infinite Resolution. Full (±180°) or Limited Angle DC Output (±90°), ±6 or ±15 minute accuracy at input rates up to 1440°/sec., 60 or 400 Hz input. Custom Output scaling available, Module 2.6" x 3.1" x .82" H. Price from $350 in quantity. Computer Conversions Corp., East Northport, N.Y. 11731—(516) 261-3300.

INFORMATION RETRIEVAL NUMBER 611

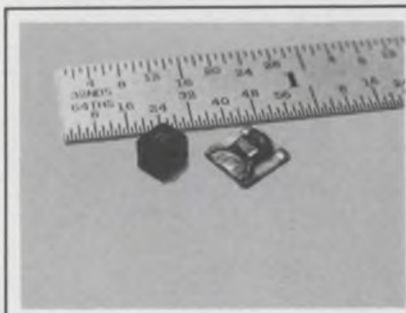
Introduction To Defense Radar Systems Engineering. Excellent introduction and practical reference to radar systems design and applications. #9194, 260 pp., $22.95. Circle the Info Retrieval No. to order 15-day exam copy. When billed, remit or return book with no obligation. Hayden Book Co. 50 Essex St. Rochelle Park, N.J. 07662

INFORMATION RETRIEVAL NUMBER 614



SCADA 80 - reliable, low cost, compact (20" x 20" x 8") remote control and data acquisition terminal with many computer interfaces; data speeds of 300/600/1200/9600 Baud; power consumption of 0.5 watt; analog, status, accumulator I/O options; OEM discounts. F & M Systems Co., 2525 Walnut Hill Lane, Dallas, TX 75229—(214) 241-4242.

INFORMATION RETRIEVAL NUMBER 617



High-Q Microminiature Chip Inductors, LC Tuned Circuits have wide inductance range, good stability. MIL-C-15305/commercial version, magnetically shielded/unshielded. Inductance .01 uH to 10,000 uH. LC factory-tuned circuit .25" square by .125". Vanguard Electronics Co., Inc., 930 W. Hyde Park Blvd., Inglewood, CA 90302/(213) 678-7161

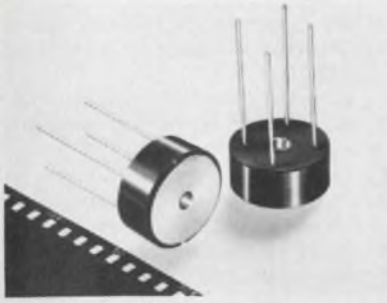
INFORMATION RETRIEVAL NUMBER 612

LABTRONICS' Multiple Restrike (M-R) Ignition produces high energy repetitive spark on each power stroke for effective ignition of air/fuel mix. Increase mileage up to 40%, longer points/plug life. Model VI $79.95, VI-B $59.95 1 yr warranty, 30 day guaranteed refund. Check, M.O. (postpd US) Labtronics, Inc. 3835 Hillside, Ypsilanti MI 48197

INFORMATION RETRIEVAL NUMBER 615

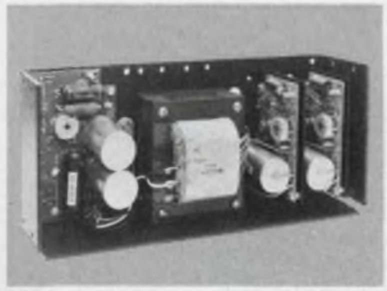
Straight & Right-Angle Headers provide an economical method of attaching complete matrices of .025" square posts to PC boards to serve as male contacts for interconnection systems. Available with up to 36 pins per row in several popular pin lengths, A P Products Inc., Box 110, Painesville, Ohio 44077.

INFORMATION RETRIEVAL NUMBER 618



3/4" Diam 10 amp Bridge Rectifiers from Tarzian with heat dissipating aluminum base. 240 amp surge rating. Heat dissipation is 25W@10A. Max case temp is 150° C. H-FB Series supplied as standard avalanche, fast recovery or with special terminals. Sarkes Tarzian, Inc., Semiconductor Div., 415 College Ave., Bloomington, Ind. 47401, 812-332-1435.

INFORMATION RETRIEVAL NUMBER 619



OPEN FRAME POWER SUPPLIES If you are using micro processors, you'll need special voltages for the chips and for rams and other companion devices. We'll supply the special voltage combinations in single, dual, or triple output units. Dynage, Inc. 1331 Blue Hills Avenue, Bloomfield, Conn. 06002 203-243-0315

INFORMATION RETRIEVAL NUMBER 622

Static Power Conversion & Line Isolation. Unitron offers precision static power equipment for military and industrial applicatons. 50/60 Hz to 50 Hz, 60 Hz or 400 Hz; 400 Hz to 50 Hz, 60 Hz, or 400 Hz; 28 VDC to 50 Hz, 60 Hz, or 400 Hz. Available in ratings from 250 VA to 25 KVA. Unitron Inc., 1624 N. First St., Garland, TX 75040. (214) 276-8591

INFORMATION RETRIEVAL NUMBER 620

MP12 Small Computer System. Configure your own application system with 4k MP12 CPU with programmed I/O, interrupts, DMA. Interface cards for teletype, modems, floppy disk, paper tape, A/D, printer, card reader, mag. tape. Real-time operating system, full supporting software. Fabri-Tek, Inc. 5901 S. Cnty. Rd. 18, Mpls, MN 55436 (612) 935-8811

INFORMATION RETRIEVAL NUMBER 623

Programmable Audio Switching System features up to 400 Two Wire Switchpoints. It may be interconnected in nearly any configuration ie, Multipole, Multithrow, Matrix or Scanner. System may be controlled by 16 bits TTL compatible I/O Buss or 28 VDC. MATRIX SYSTEMS CORPORATION (213) 882-2008.

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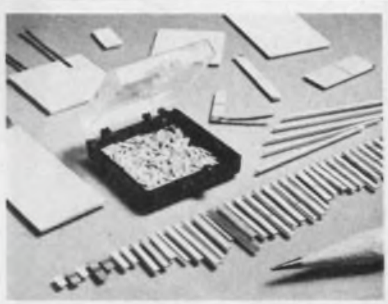

Low Power Electromechanical And Acoustic Transducers convert mechanical or acoustic to or from electrical energy. Applications include phono cartridges; microphones; head phones; delay lines; micropositioning and relays. E. Hanson, Gulton Industries Inc., Electronic Components Div., 212 Durham Ave., Metuchen, NJ 08804 (201) 548-2800

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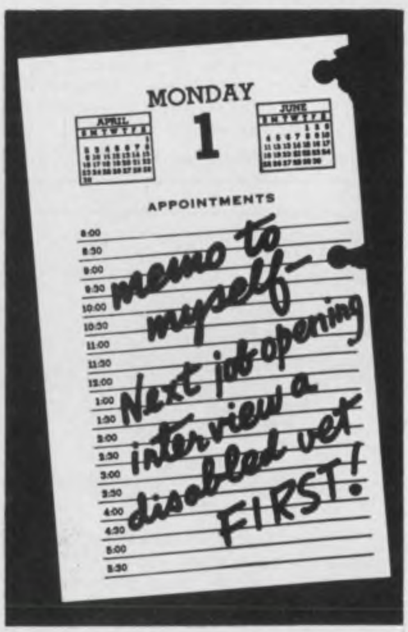

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Want to contact us? If you have any comments or wish to submit a manuscript or article outline, address your correspondence to:

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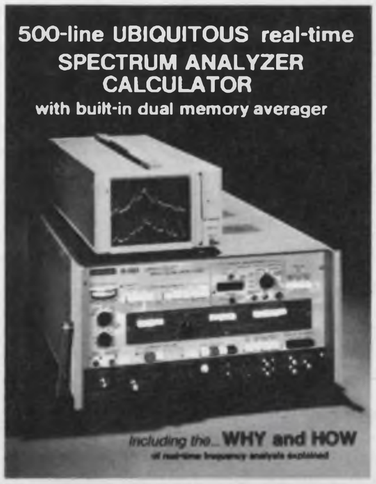

New 16-page brochure on latest Ubiquitous® 500-line Real-Time Spectrum Analyzer/Calculator UA-500A-1 contains complete application data & a "how to" section. The "why" explains the need for resolution, real time, & averaging. The "how to" section solves typical analysis problems: "how to be sure correct data is being analyzed," "how to analyze transients," "how to interface to a computer," "how to cancel background noise," "how to analyze rotating machinery."

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Lit., circle 172

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CIRCLE NO. 173

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Product Index

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new literature

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Model FS-100
Fiberscope

AO
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MINI-THUMBWHEEL SWITCH

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RETROFITS MOST MINIATURE THUMBWHEEL SWITCH PANEL OPENINGS.

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Before you buy, check out the remarkable Brush 110. Contact your nearest Gould sales engineer for a demonstration. Or write Gould Inc., Instrument Systems Division, 3631 Perkins Avenue, Cleveland, Ohio 44114.

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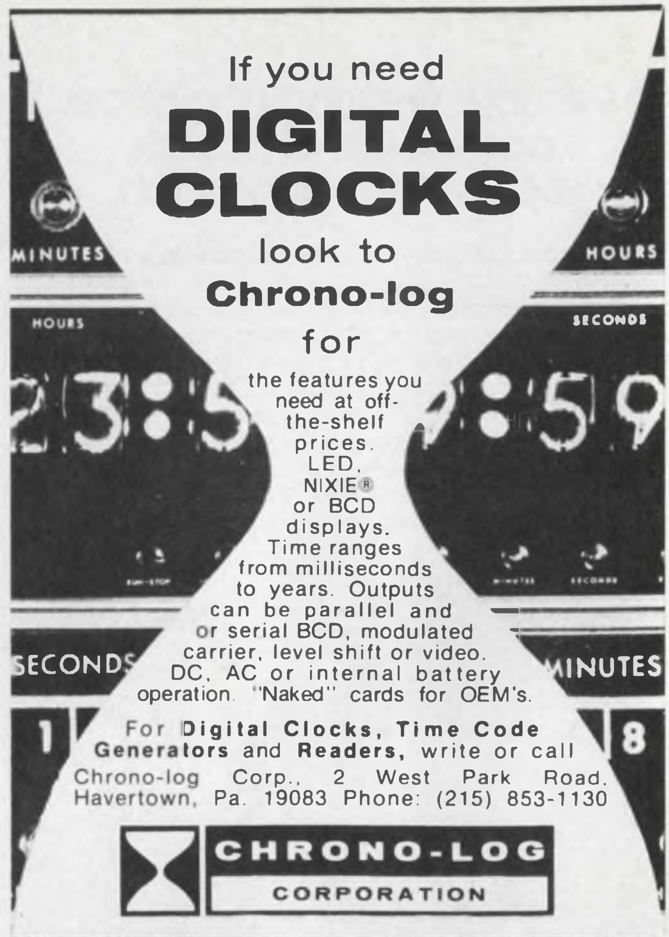

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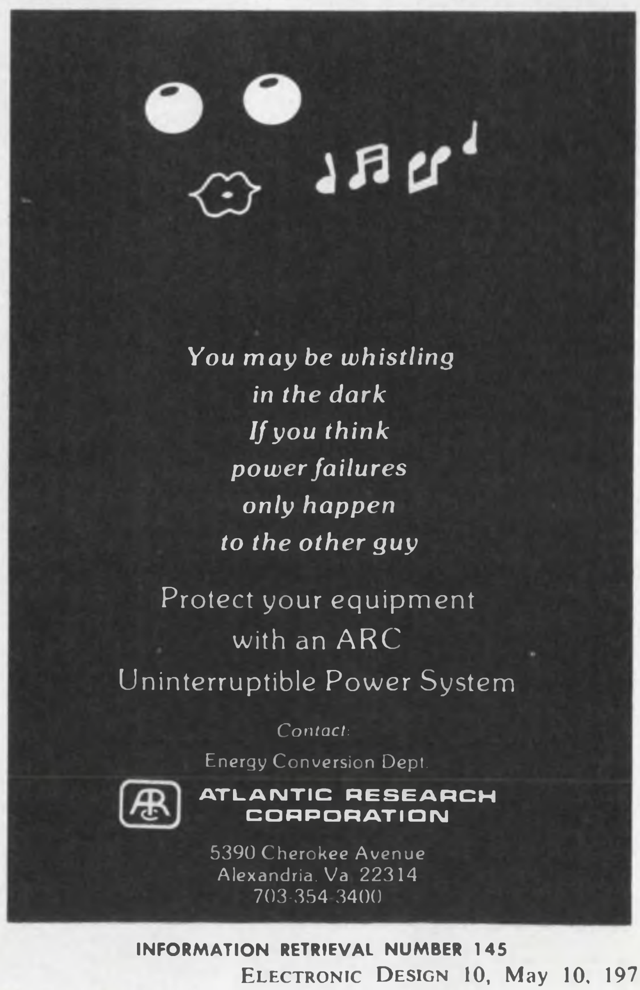

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Introducing, a New Design Spectrum* of Low Profile Relays.

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These compact relays are particularly suited for communication systems, data processing equipment, automatic control systems, process control, automotive and consumer electronics.

*Family of Relays

Free!

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RELAY BROCHURE

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Strobing terminals.

If you are interested in one or all of these op amps, contact your local RCA Solid State distributor. Or RCA.

Write: RCA Solid State. Box 3200, Somerville, New Jersey 08876; Ste. Anne de Bellevue 810, Canada; Sunbury-on-Thames, U.K.; Fuji Bldg., Tokyo, Japan.

RCA

	CA3080E	CA3100T	CA3094E	CA3078T	CA3130
Gateable plus programmable gain control	> 60 dB				Gateable
Unity gain crossover frequency, MHz		40			15
Slew Rate, V/μsec		25			10
Output, mA (peak)			300		22
Power consumption, mW				.0015	2.5
Single supply voltage required, V				1.5	5.0
Price (1K), $	0.55	1.50	0.90	1.25	0.75

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