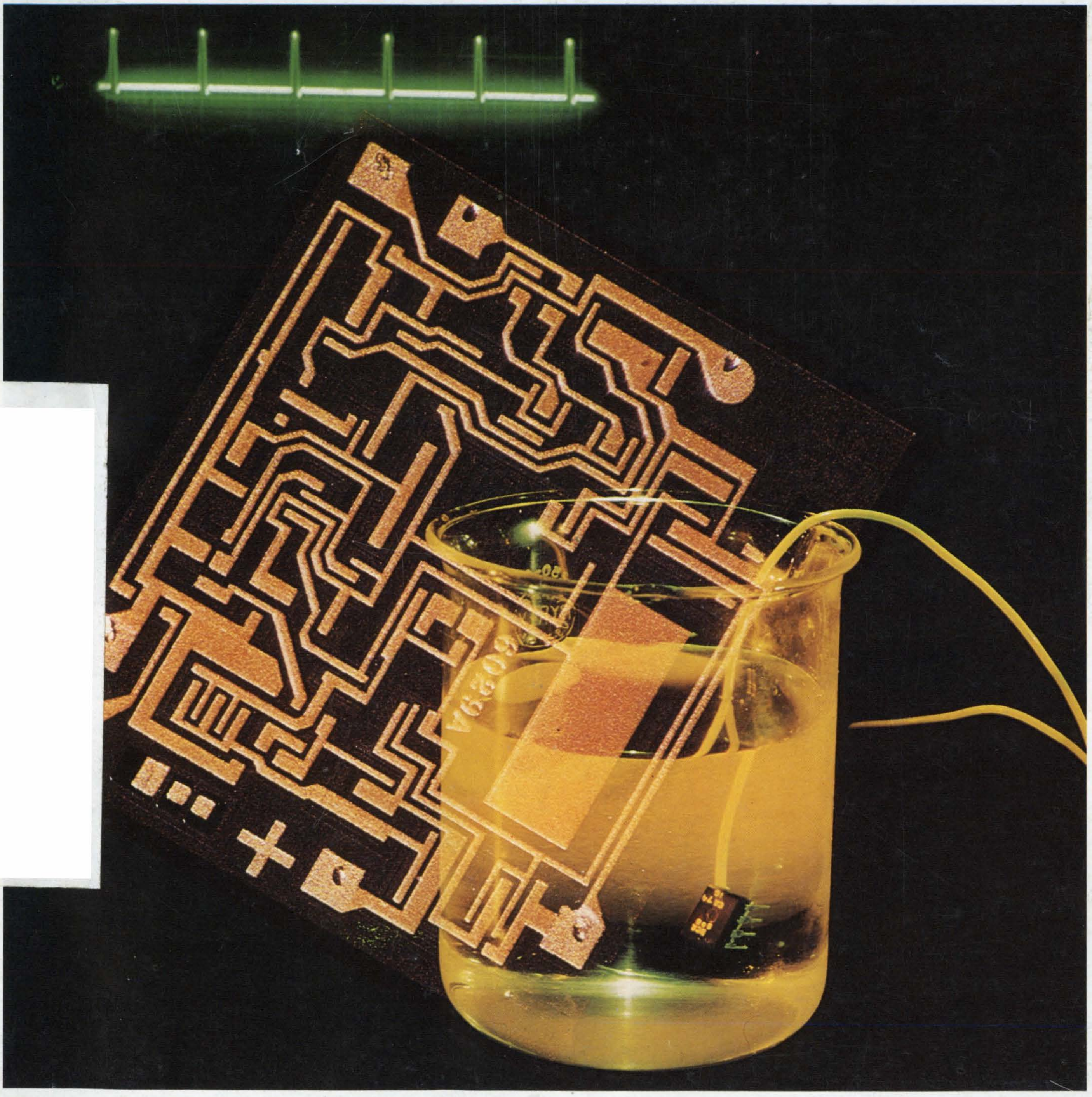
Electronic Design®

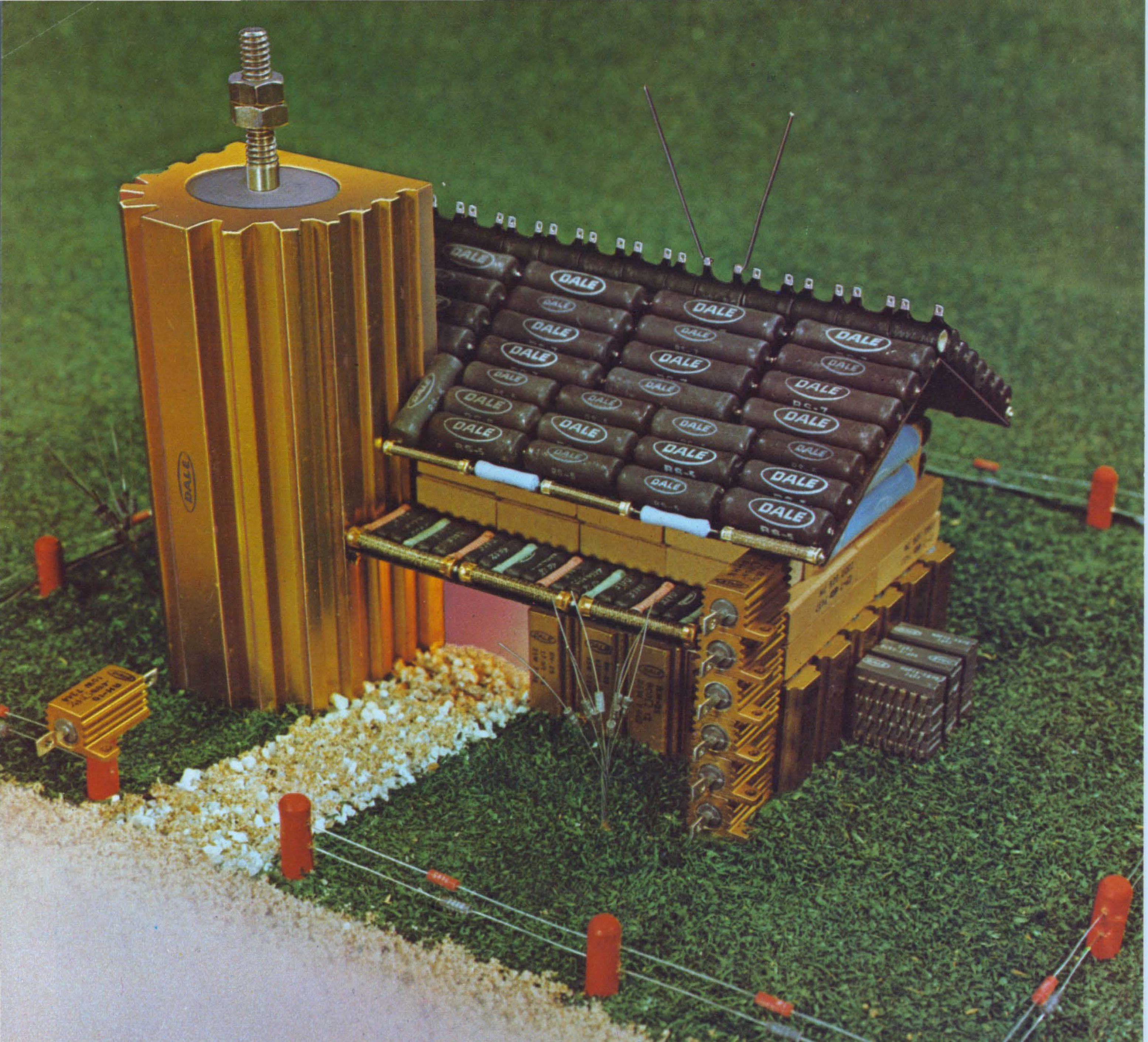
VOL. 23 NO. 9

FOR ENGINEERS AND ENGINEERING MANAGERS

APRIL 26, 1975

**Hermetic performance in plastic** DIPs is achieved by elimination of many IC-chip failure modes. While past approaches sought the elusive perfect seal, silicon-nitride passivation and corrosion-resistant metalization have raised reliability a hundredfold at no added cost to the user. Check these high-rel circuits on p. 97.





# Powerhouse.

Dale makes more power wirewounds...E-Rel, precision, industrial, commercial... has more QPL's...more ways to meet your special housing and performance requirements...and just plain works harder to make sure you're satisfied.

*Here are four ways to prove it:*

- For Complete Cross Reference Guide, Circle 251
- For Comprehensive Wirewound Resistor Wall Chart, Circle 252
- For Guide to Non-Standard Wirewound Resistors, Circle 253
- Call 402-564-3131 for immediate information.

DEPENDABLE DALE®

DALE ELECTRONICS, INC., 1300 28th Avenue, Columbus, Nebr. 68601
In Canada: Dale Electronics Canada Ltd.
In Europe: Dale Electronics GmbH, 8 Munchen 60, Falkweg 51, West Germany
*A subsidiary of The Lionel Corporation*

 *Our complete product line can be found in Electronic Design's GOLD BOOK.*

# More designers are choosing McMOS today

## Because today it's the CMOS that offers more

As business has become increasingly tighter, more design and purchasing people have turned to Motorola's McMOS* family of CMOS logic for new design requirements. Careful evaluation of relative merits convinced them that they would benefit more ways with McMOS.

*broadest*

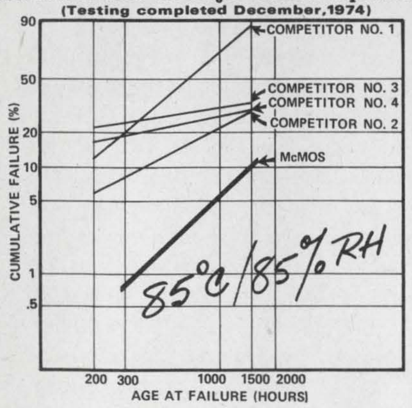
### FUNCTIONAL COVERAGE

More than 80 different MC14000/14500 devices form a balanced mixture of the industry's richest MSI line-up and the necessary simple gate and flip-flop types. This includes functions most TTL and CMOS suppliers haven't even attempted yet; and *25 new line additions* are scheduled in 1975.

### RELIABILITY

Word gets around when product is reliable; and, of course, when it isn't. The word's around that McMOS is reliable. That's based on users' experience . . . and on test documentation. If the latter is important to you, contact the nearest Motorola sales office for a copy of the latest on plastic McMOS documented reliability. Motorola's standard off-the-shelf CMOS will do the job without gimmicky, expensive special programs.

**Motorola McMOS vs. Major CMOS Competition**
(Testing completed December, 1974)




*easy*

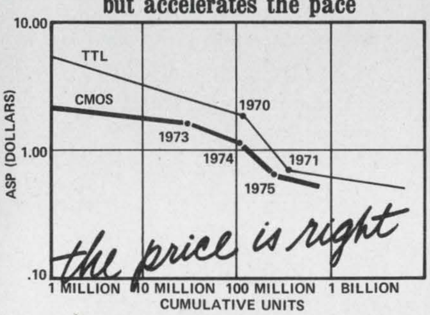
### TTL·CMOS CONVERSION

Now Motorola makes it easy to cross over to CMOS and get the low power, high noise immunity combination no other present logic form offers. There's an up-to-date TTL-CMOS Function Cross Reference you'll get if you circle the bingo number on this ad.

### TTL·LIKE PRICING

Production and technological breakthroughs like those achieved at Motorola's ultra-modern CMOS facility in

**CMOS follows the TTL pattern, but accelerates the pace**




Austin, Texas have created record breaking availability and pricing. We're able to price McMOS much lower now than was originally anticipated for this time. Now, for comparable functions, CMOS *is* selling competitively with TTL.

*most*

### MSI FUNCTIONS

That the McMOS family is heavy in MSI is no accident. It's been structured that way from the beginning because designers have indicated from the beginning that MSI had to be the cost-effective way to go in CMOS.

*new*

### SPECIALIZED FUNCTION SERIES

Now there's a whole new dimension to McMOS. The MC14400 Series is a growing set of specialized function MSI subsystems. It all started with the MC-14435 A/D logic subsystem, followed by the MC14490 Hex Contact Bounce Eliminator, MC14411 Bit-Rate Generator and the MC14415 Quad Hammer Driver. Others, for specialized application in telephony, data handling, and watch/clock circuitry, will be available during 1975. Several of these are just coming out now: the MC14410 Two-of-Eight Tone Encoder, MC14440/50/51 Timepiece units, and MC14419 Keyboard Encoder.

*more*

### INFORMATION AVAILABLE

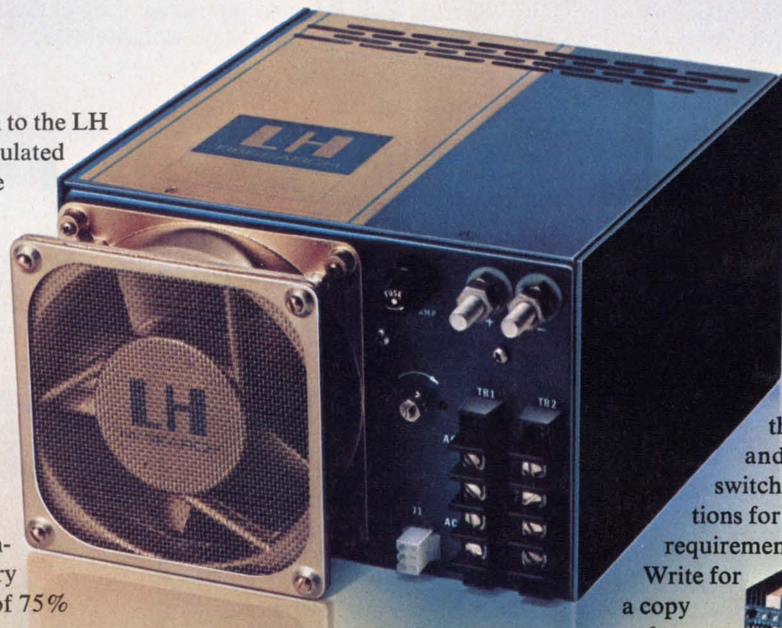
McMOS, the CMOS of today; offering more, doing more, for more people. For information that will inform you if you're curious, and help you if you're serious, write to Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036, or circle the reader service number.

**MOTOROLA McMOS**
*– complementary MOS for contemporary systems*

* TRADEMARK MOTOROLA INC.

INFORMATION RETRIEVAL NUMBER 2

# Now! A 5V, 120-amp switcher with forced-air cooling, up to 3 outputs, 75% efficiency, measures only 8"W x 10"L x 5"H, and weighs less than 12 lbs.



The newest addition to the LH line of switching regulated power supplies is the super-compact forced-air cooled 120-amp series. With dimensions ideal for computer memory system installations, these switchers are available in single or multiple output models with extremely high efficiencies: 80% on primary output, an average of 75% on all others.

**Up to three outputs**

Primary output is 5 VDC, 120 amps; second and third outputs are ±12, or ±15 at 8 amps. Combined load on all outputs is limited to 600 watts. All outputs are fully regulated as a standard feature, and all are adjustable from the front panel.

**Outstanding features**

Over-temperature protection and RFI line filtering are standard features; over-voltage protection is standard on primary output, optional on secondaries. Other options include remote on-off, master-slave paralleling, and paralleling of up to 10 units. Mounting is by side or bottom in any direction. They operate in ambient temperatures of up to 50°C without de-rating.

**Selectable AC inputs**

AC inputs can be externally selected 115/230V, 47 to 63 Hz, simply by changing a jumper on the front terminal strip.

**Easy maintenance, high reliability**

In single-output models all components are mounted on just two circuit boards, multiple-output models use three, so the entire switcher can be disassembled in less than five minutes. Through the use of ribbon cable, interconnections have been reduced 90%, greatly enhancing reliability.

**Ask for full-line folder**

Our new 6-page folder fully describes the new 120 amp units and other standard LH switchers, and discusses options for specific requirements. Write for a copy today.

**Most comprehensive switcher line made**

LH Research makes several hundred standard switchers, with single and multiple outputs from 250 to 600 watts, and AC or DC inputs. All are extremely compact and lightweight, with six package shapes to suit your assembly. Efficiencies are 75-80%, and costs are as low as 75 cents a watt. Among the newest is the double dual model, which has two isolated 250-watt outputs plus two low power outputs, and weighs only 16 pounds.

LH RESEARCH

LH RESEARCH, INC., 2052 South Grand Avenue, Santa Ana, CA 92705 • (714) 546-5279

INFORMATION RETRIEVAL NUMBER 3

# Electronic Design®

VOL. 23 NO. 9

FOR ENGINEERS AND ENGINEERING MANAGERS

APRIL 26, 1975


## NEWS



## TECHNOLOGY



## PRODUCTS



## DEPARTMENTS



**Cover:** Photo by Bruce Hull and John Semonish, courtesy of RCA Solid State Div., Somerville, NJ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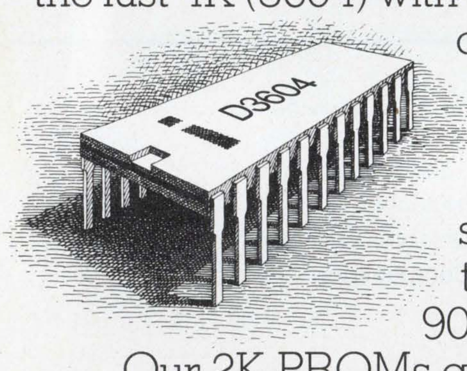
# If you need fast
# Intel has the competi

We've just added five new three state 2K and 4K PROMs to our Schottky bipolar PROM family. Intel is now the first supplier with a complete family of 1K, 2K, & 4K bipolar PROMs, and 1K, 2K, & 4K interchangeable metal mask programmable ROMs. Intel PROMs give you the competitive edge in speed, power, and reliability, at competitive prices.

When you're looking for 4K PROMs, Intel offers open collector or three state outputs, silicon fuse reliability, and immediate delivery from distributor stock. You can select the fast 4K (3604) with 70 ns guaranteed access time from 0° to +75°C or the low power 4K (3604L-6) that dissipates 60% less power when deselected and has 20% less operating power.




Intel's 16 pin, 1K PROMs have the edge in speed with 50 ns guaranteed access time from 0° to +75° C. For military applications you can get 90 ns access time from −55° to +125°C.

Our 2K PROMs give you twice the memory in a 16 pin package, 70 ns access time, and your choice of two low power parts with either open collector or three state outputs.

All Intel PROMs are easily programmed with high programming yields on any one of several commercially available programmers. With a programming time of 1 ms/bit any PROM can be programmed in a

# PROMs, you can bet
# tive edge.

few seconds. With an order of 10,000 or more Intel bipolar PROMs, we'll provide the programmer.

Intel PROMs are the most reliable bipolar PROMs made. Our polysilicon fuses show no regrowth or opening—not even after billions of fuse hours of high temperature reverse bias at 125°C. We have not had a single failure in over 1.2 billion hours of operating system life tests at 85°C. Intel's complete family of bipolar PROMs and EPROMs 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<br>3601<br>M3601 | 256x4 | 16 | 50 ns<br>70 ns<br>90 ns* | OC<br>OC<br>OC | 3301A<br>3301A<br>M3301A |
| 2K | 3602<br>3602-4<br>3602L-6**<br>3622<br>3622-4<br>3622L-6** | 512x4 | 16 | 70 ns<br>90 ns<br>120 ns<br>70 ns<br>90 ns<br>120 ns | OC<br>OC<br>OC<br>TS<br>TS<br>TS | 3302<br>3302-4<br>3302L-6<br>3322<br>3322-4<br>3322L-6 |
| 4K | 3604<br>3604-4<br>3604L-6**<br>3624<br>3624-4 | 512x8 | 24 | 70 ns<br>90 ns<br>120 ns<br>70 ns<br>90 ns | OC<br>OC<br>OC<br>TS<br>TS | 3304A<br>3304A-4<br>3304AL-6<br>3324A<br>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<br>1702A-6 | 256x8 | 24 | 1.0 μs<br>1.5 μs | TS | 1302<br>1302 |
| 4K | 2704 | 512x8 | 24 | 0.45 μs | TS | 2308 |
| 8K | 2708 | 1024x8 | 24 | 0.45 μs | TS | 2308<br>or<br>2316A |

**intel® delivers.**

INFORMATION RETRIEVAL NUMBER 4

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Peter Coley

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# Across the Desk

## Calculator keyboards draw a 'boo and hiss'

In the rush to fill the swelling market for scientific and programmable calculators, the design of business calculators has taken an unfortunate turn. Adherents of the abacus will applaud the trend. However, adherents of the old adding machine with 10 digit keys and a few function keys—sized and located for low-error-rate, touch-typing input—will boo and hiss.

In the new pocket types and in some of the desk models, errors are encouraged by the built-in need to look away from the source document while entering. Proving a total and correcting errors are complicated by the absence of hard copy. When cost estimates are run through successive levels of management approvals, attached adding machine tapes are both a good discipline and useful for spot checks of cost entries, which contribute significantly to the totals.

Hard copy has been traded off against size and cost in the case of the pocket calculators, and that is a reasonable trade-off. However, there doesn't seem to be a good case for poor keyboard design. A better keyboard design would at least relieve the error problem and I hope that will be considered by manufacturers. At the very least, I look for a separated zero key that a large thumb can find.

*Tom Owens*
*Group Manager*
Zerox Corp.
1701 Research Blvd.
Rockville, MD 20850

## The ostrich approach to service problems

Reading George Rostky's editorial "Service With a Smile" (ED No. 2, Jan. 18, 1975, p. 47) reminded me of a story about one company's service department. A field salesman had been complaining for several months that a certain item hadn't been working on the last several units that had been delivered. The service engineer's response had been typical:

"Just give us a chance to correct the problem. We're working on it, and you'll be the first to know when it's fixed. Meanwhile stop bugging us. We can't get our work done if we're on the phone."

So that's what the salesman did—stopped bugging. Six months later he thought he would follow up on the progress toward the solution. When he called the service engineer, the response was:

"Oh, we stopped getting complaints about that six months ago and decided that the problem had gone away."

*Jerold W. Harrison*
*Chief Engineer*
Electro-Mechanical Systems Inc.
531 Marcilene
Wichita, KS 67218

## Woperson deplores 'masculine orientation'

The article "Job Ratings Hinge on Mutual Commitment" (ED No. 23, Jan. 18, 1975, pp. 68-70) has a masculine orientation that is unusual in today's egalitarian cli-

*(continued on page 16)*

**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.**

SOLID STATE LEADERSHIP

Amplifiers • Oscillators • Filters • Mixers

## Mixer/Amplifier Packages

We've engineered our WJ-C30 series of mixer/amplifier packages to be virtually off-the-shelf items, while still remaining flexible enough to meet your specific design needs.

All units consist of high quality W-J mixers and thin-film cascadable amplifiers. These components afford tremendous adaptability in responding to a wide range of RF and IF bandwidth, noise figure, conversion loss and power output requirements.

These packages have an RF coverage of 2.5 to 18.5 GHz, with each model offering options of eight different IF bandwidths ranging from 5 to 1500 MHz. Overall noise figures range from 7.5 to 12.0 dB (min.), depending on which IF option you select. Power output also varies.

One option delivers an IF bandwidth of 5 to 200 MHz, overall IF noise figure of 7.5 dB (min.) and power output of +12 dBm (max.), while a second option would give you an IF bandwidth of 10 to 1000 MHz, overall IF noise figure of 14.5 dB (min.) and power output of +23 dBm.

It's really very easy. You simply select the specifications and we'll deliver a high quality mixer/amplifier in a compact, economical package.

To find out more about these new mixer/amplifier packages, call your local W-J Field Sales Office or Watkins-Johnson Applications Engineering in Palo Alto, California at (415) 493-4141, ext. 637.

**THE WJ-C30 SERIES**

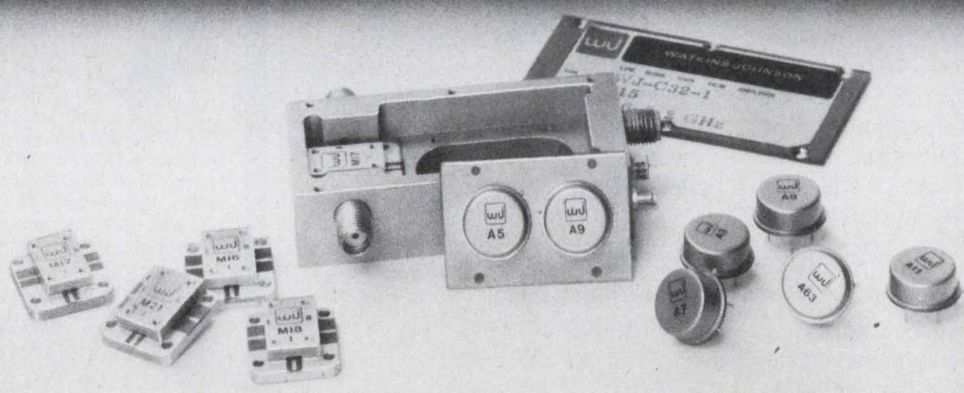
High Intercept Mixer/Amplifiers (+13 dBm L.O. Drive)

| Model | Frequency |
|---|---|
| WJ-C32 | 2.5 to 5.2 GHz |
| WJ-C33 | 4.0 to 9.0 GHz |

Low Level Mixer/Amplifiers (+7 dBm L.O. Drive)

| Model | Frequency |
|---|---|
| WJ-C35 | 2.5 to 5.2 GHz |
| WJ-C36 | 4.0 to 9.0 GHz |
| WJ-C37 | 6.0 to 16.0 GHz |
| WJ-C38 | 8.0 to 18.5 GHz |

# You select the specs




# ...all components are off-the-shelf.

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INFORMATION RETRIEVAL NUMBER 7

# Why you can afford the very finest in function generators.

**B**ecause Interstate's new F77 truly is a universal signal source. With F77's 0.00002 Hz to 20 MHz range, you can test with frequencies from infrasonics through video, and beyond. There are 6 output waveforms, 7 operating modes, and precision interface controls (waveform inversion and a 5/95% waveform variable symmetry vernier, for example) that can be actuated with remarkable variations. And output amplitude is specified at 15 volts p-p into 50 ohms — that's 50% more voltage swing than most 20 MHz function generators provide.

**B**ecause the F77 also incorporates a very capable, independent sweep generator offering linear and logarithmic performance, with a selection of auxiliary outputs. Sweep up or down, sweep reset control, and continuous, triggered, burst, sweep-and-hold modes, too. Interstate's special frequency dial has a direct-reading sweep limit cursor, plus two calibration scales (X1 and X2) to improve resolution and permit continuous tuning across the 20 Hz-to-20 KHz audio band.

**B**ecause this function generator is the first of its kind to deliver real pulse generator capability. The F77 produces a 15 ns rise time pulse to 20 MHz with constant width setability from 30 ns to 10 milliseconds, and full offset and mode flexibility. The generator's fully-calibrated attenuator gives you 15-volt unipolar pulses into high impedance loads, particularly useful for testing MOS, or millivolt pulses down to 1.5 mv.

**B**ecause there's also a constant duty cycle pulse (in addition to F77's standard pulse) for a variety of digital signal response applications. Circuit sensitivity to duty cycle on/off times can be tested using varying pulse rates without adjusting the width control.

**B**ecause the F77 can be used as an analog power amplifier to amplify externally applied signals as much as 600%. Even TTL pulses can be amplified to drive 50-ohm loads, and the resulting output has controlled dc offset and attenuation.

**B**ecause the F77 gives you many other high performance and human engineering features, like VCF capability for sweeping frequency-sensitive devices, and "oscilloscope-style" triggering with a variable start-stop phase control to generate haversines and havertriangles. There's even a "brown-out" switch to allow the instrument to operate at low line voltages.

**B**ecause the F77 only costs $1,095.*

*U.S. price; other 20 MHz Series 70 models available from $695.

IEC

Subsidiary of A-T-O Inc.

**INTERSTATE ELECTRONICS CORPORATION**

707 E. Vermont Ave., P.O. Box 3117, Anaheim, California 92803 (714) 772-2811

INFORMATION RETRIEVAL NUMBER 8

Knotty problems in wire, cable, and cords can pop up at any stage of a project. Hopefully, they arise early in design. Oftentimes, they surface later. This can put an unexpected crimp in your product's profit or performance.

We're ready to offer backup help in performance, design, processing, assembly, installations, and ordering. Whatever wire and cable application idea you put on paper, Belden can help put life into it! Our total engineering approach to your problems can identify and analyze the "knots" before they tie up a major project.

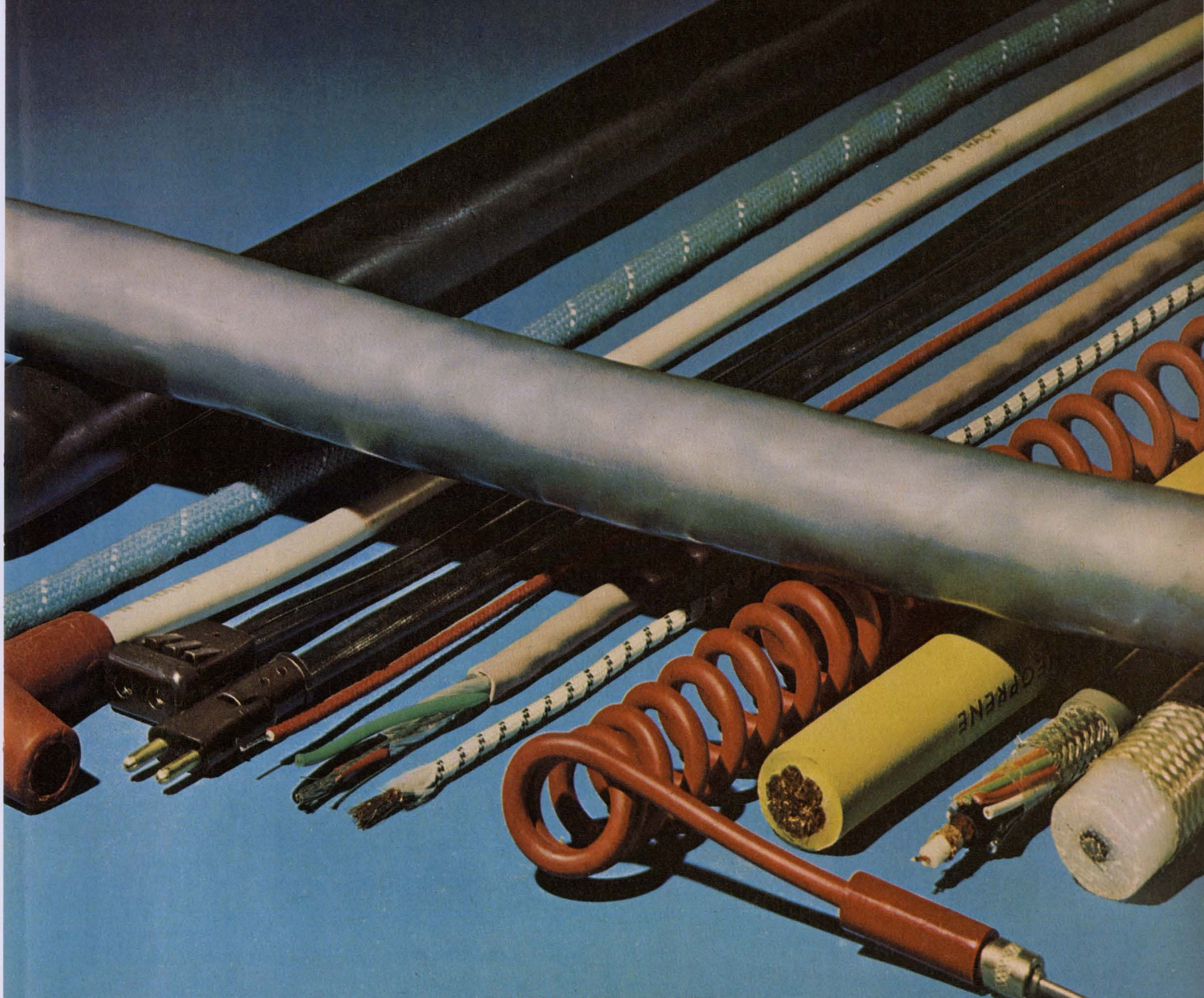
If you have problems involving electrical parameters, space, compatibility, human engineering, color coordination, precision, materials, fabrication, processing, put-ups, installation, Belden has the ability to engineer reliability and ease of assembly into wire, cable, and cords without letting costs run wild due to over-engineering.

When we can't get out the "kinks" using standards, we'll innovate a solution for your problem. We're here with service and multi-plant facilities that can meet your demands. Need answers? Phone:

(312) 681-8920, Electrical Division
(317) 966-6681, Electronic Division
(312) 887-1800, Transportation Division

Or, write Belden Corporation, 2000 South Batavia Ave., Geneva, Illinois 60134.

H-4-4



INFORMATION RETRIEVAL NUMBER 9

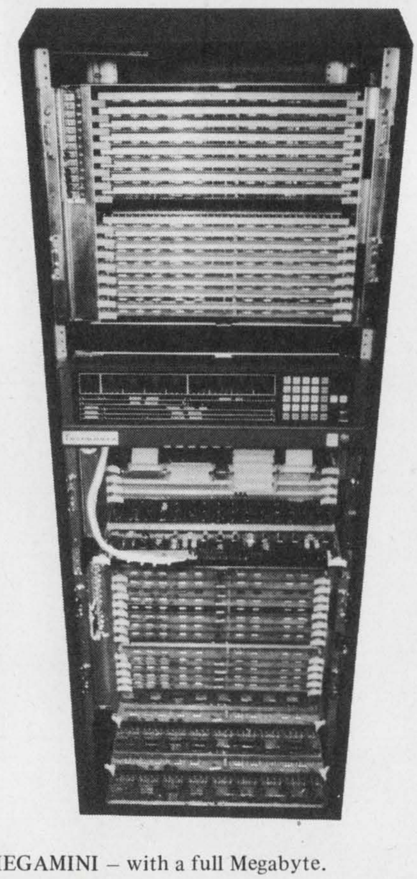
# INTRODUCING THE WORLD'S FIRST

# 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.



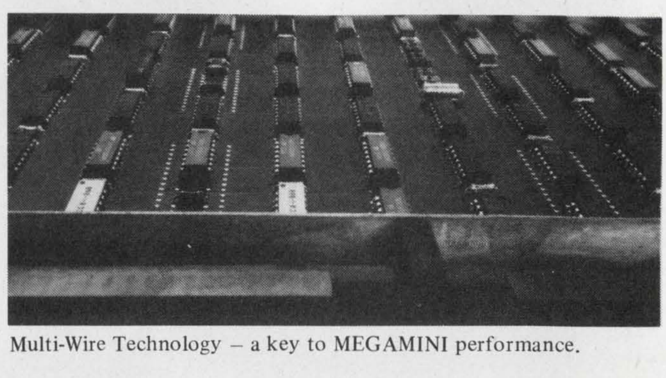
The 8/32 MEGAMINI – with a full Megabyte.

### 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.

Interdata and Megamini are trademarks of Interdata, Inc.

# 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 | $44,500 |
| 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.

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INFORMATION RETRIEVAL NUMBER 11

# Now! A better answer of connecting PCB's

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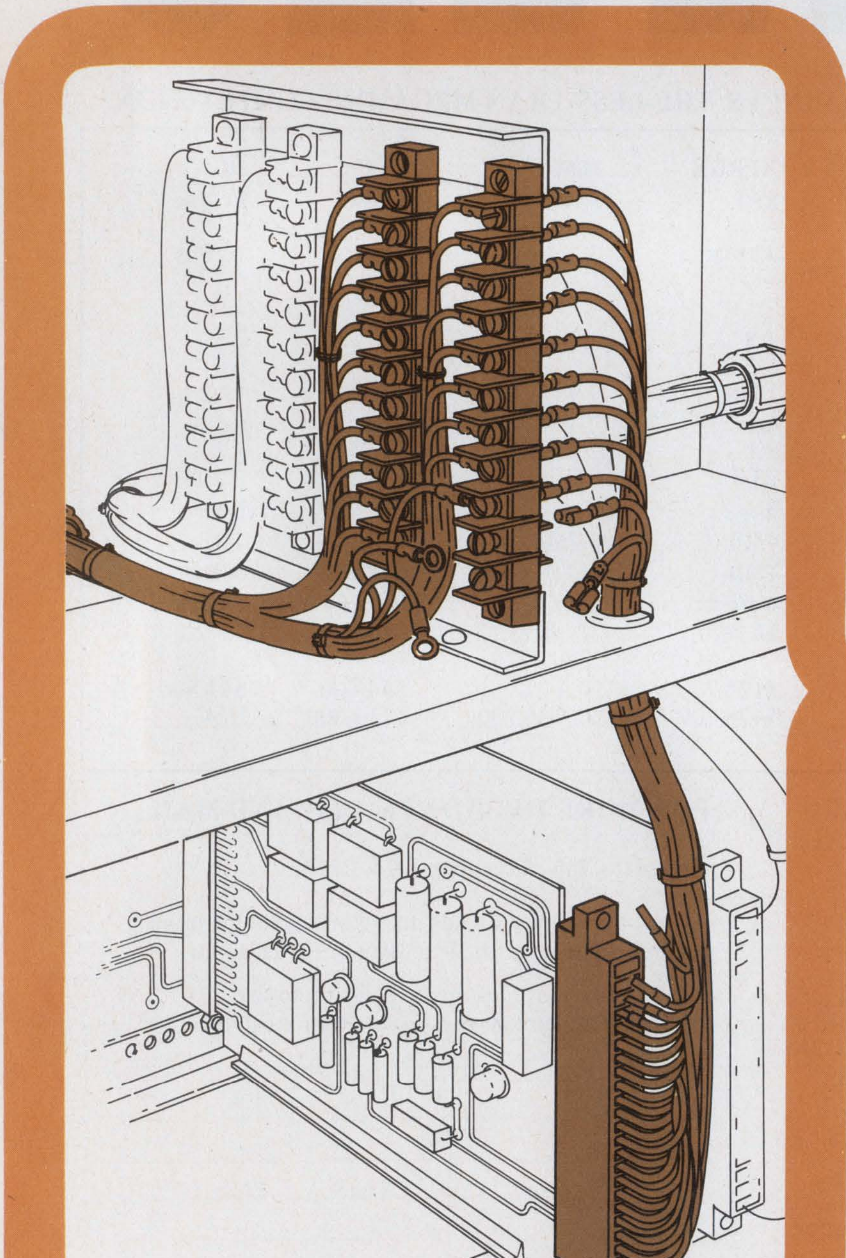
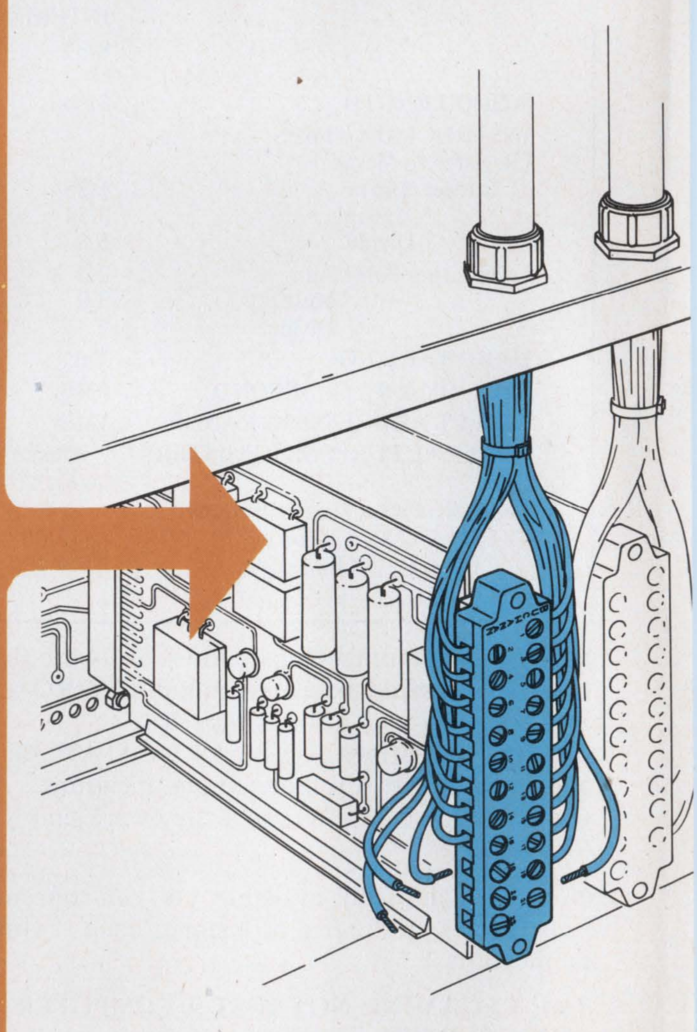


## to this...with



Just one Buchanan Printed Circuit Board Connector replaces the two barrier strips, the edge card connector, the double wiring, and the 110 costly terminations shown at left. Result: LTIC (Lower Total Installed Cost)!

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# system wiring

# Buchanan® PC Board Connectors

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- **Saves up to 5 connection points per circuit**
- **Eliminates barrier strips & terminal blocks**
- **Available for inside or through-the-panel wiring**
- **Saves time, money and cabinet space**

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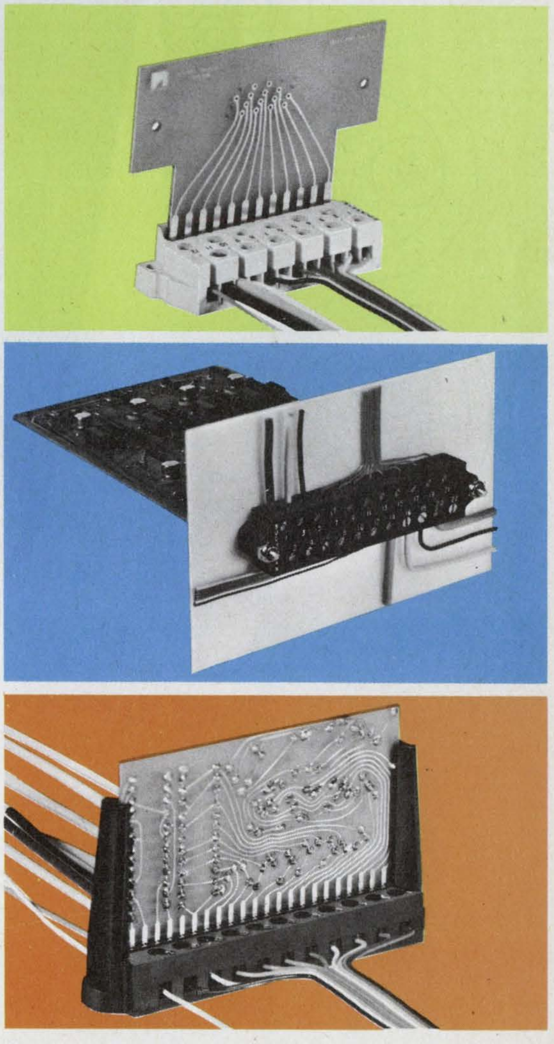

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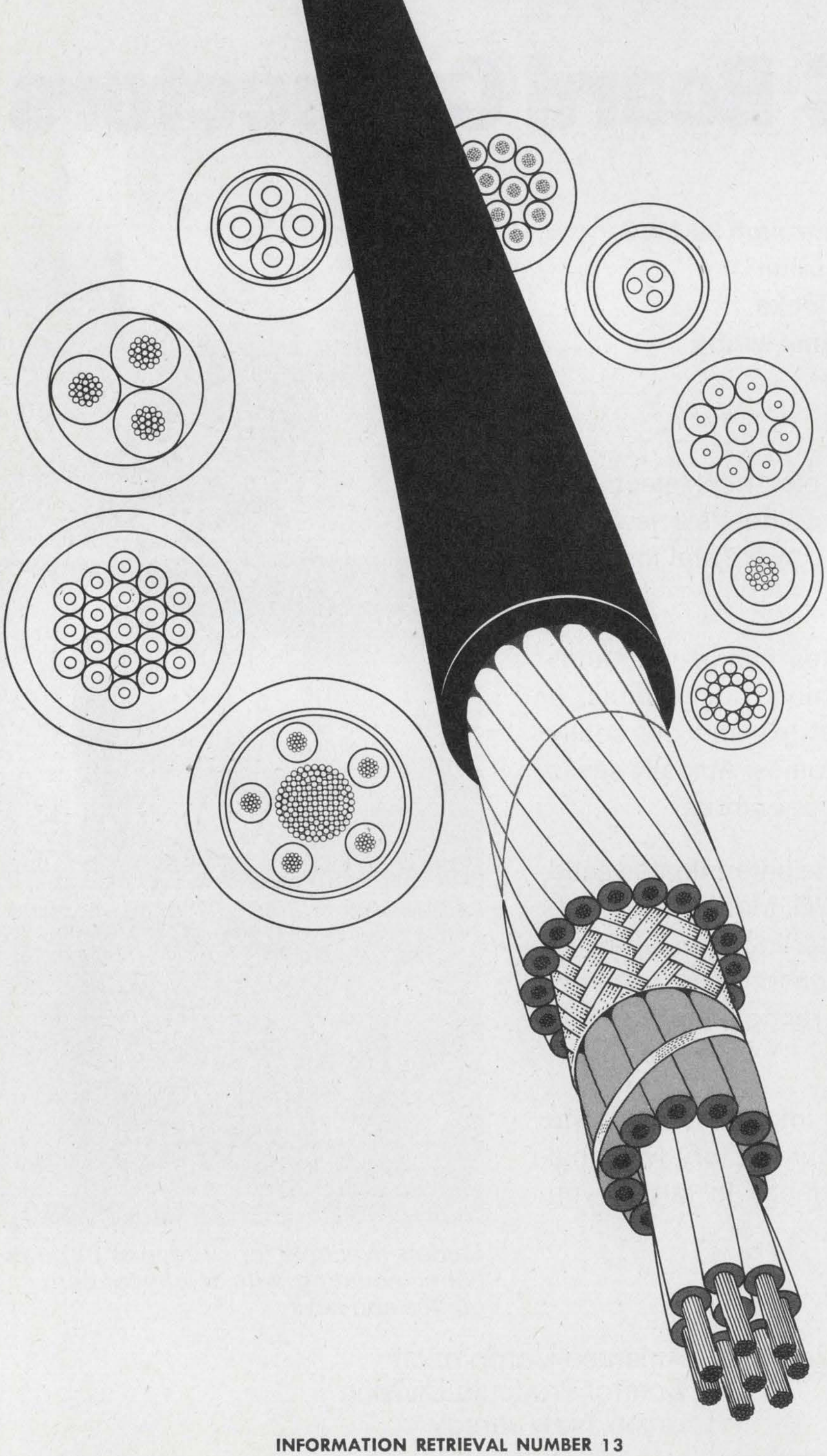




ACROSS THE DESK
*(continued from page 7)*

mate. "Man" and "engineer" are used almost interchangeably. More than 12% of the words in some paragraphs are masculine nouns or pronouns.

The pronoun usage is part of our language, although an occasional "he or she" would give the article a modern flavor. The use of masculine nouns is unnecessary and distorts the article. Why not use "engineer," "person," "worker," "employee," etc. instead of "man"?

Changes such as the following could be made:

"Forces the engineer and his manager to plan his work at least a year ahead."

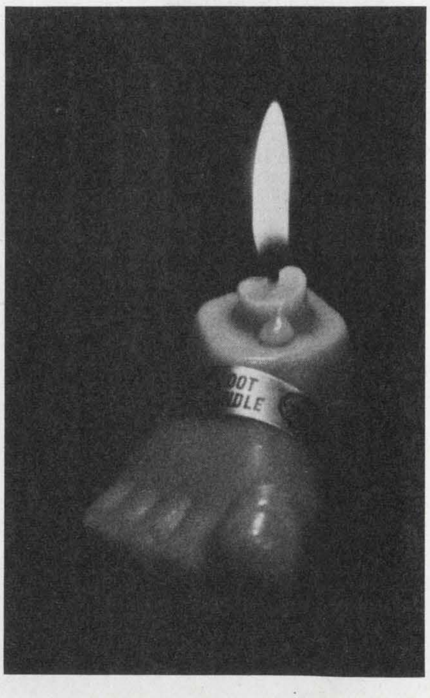
Could become: "Forces engineers and managers to plan work at least a year ahead."

"When the engineer writes his own appraisal, he knows if he did a good job or a bad one."

Could become: "Engineers who write their own appraisals know if they did pretty well or poorly."

*Martha Sloan*
*Assistant Professor*
Michigan Technological University
College of Engineering
Dept. of Electrical Engineering
Houghton, MI 49931

## Standards Dept.



# digital or analog


# Heath's new laboratory power supplies set new performance standards

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- Complete output protection
- Remote sensing automatically compensates for lead voltage drops
- Available factory assembled or in easy-to-build kit form

Heath's versatile new 2700-Series DC power supplies do much more than just provide the right voltage and current — they set new standards for precision and ease of operation.

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All 2700-Series power supplies are available in easy-to-build kit form or completely factory assembled and calibrated. Either way you get a power supply with the precision and performance that your application demands. Send the reply card or coupon for our latest catalogs and get complete details.

| Model | Readout | Maximum Rated Output Volts | Maximum Rated Output Cur. | Price* |
|---|---|---|---|---|
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| IP/SP-2701 | Digital | 60 V | 1.5 A | **$219.95 kit<br>$340.00 assem.** |
| IP/SP-2710 | Analog | 30 V | 3.0 A | **$169.95 kit<br>$255.00 assem.** |
| IP/SP-2711 | Digital | 30 V | 3.0 A | **$219.95 kit<br>$340.00 assem.** |
| IP/SP-2720 | Analog | 15 V | 5.0 A | **$169.95 kit<br>$255.00 assem.** |
| IP/SP-2721 | Digital | 15 V | 5.0 A | **$219.95 kit<br>$340.00 assem.** |
| IP/SP-2730 | Analog | 7.5 V | 10.0 A | **$169.95 kit<br>$255.00 assem.** |
| IP/SP-2731 | Digital | 7.5 V | 10.0 A | **$219.95 kit<br>$340.00 assem.** |

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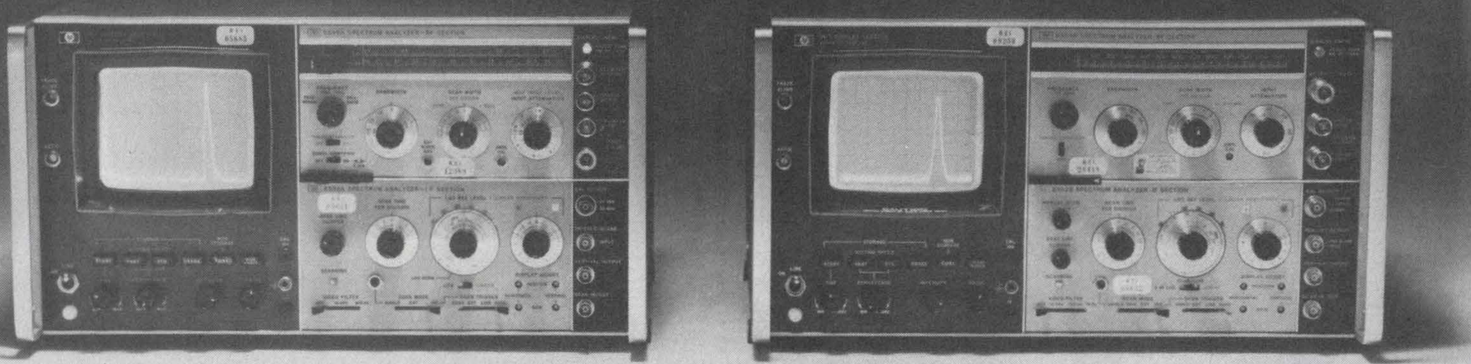

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INFORMATION RETRIEVAL NUMBER 15

APRIL 26, 1975

# Algorithm said to guarantee data security for 100 years

Computer data security may become a problem of the past if a proposed encryption algorithm becomes a standard, as the National Bureau of Standards hopes it will.

The algorithm uses a 64-bit key and codes data in blocks of 64 bits. According to Dennis Branstad, project leader for computer security at NBS, it would take several hundred years to decipher data coded by this algorithm if the key was not known.

Although it was developed by IBM, Branstad notes, the algorithm is being made available to anyone on a nonexclusive, royalty-free basis. It may open up a new market for semiconductor manufacturers, the NBS project leader indicates, because the entire algorithm should be able to fit on one MOS LSI chip. Chip implementation would have several advantages.

As hardware, it would be more efficient than a software counterpart. And, since an integrated circuit cannot be easily modified, an encrypting IC would enhance security.

The coding program can be implemented with MSI TTL, Branstad says, but it would require several hundred packages. The 12,000 to 16,000 gates needed, however, could probably fit on the single MOS chip, he believes.

Semiconductor manufacturers also indicate that the algorithm could fit on a single chip, especially since most of the required logic would be used to form ROMs. Semi makers point out that ROMs traditionally have higher density than random logic devices.

The potential market for data-encryption ICs, Branstad reports, is every computer terminal in use, and he's hoping that such a large market will spur semi manufacturers to develop the IC on their own. But if no one volunteers to do it, he says, the Government will put out a general open bid so that someone will.

The semiconductor industry does not yet have enough information on the algorithm and its potential applications to make any decisions. But based on preliminary data, some manufacturers believe that the data-encrypting chip can be made on a piece of silicon measuring 170 mils on a side. Estimates on the cost of such a chip have ranged from $8 to $50.

## Hot-air printer sears characters on paper

The latest addition to the growing family of nonimpact printers is a device that uses hot air to form printed characters on a sheet of ordinary paper. It will be on the market in two months.

Known as Terminair, the new serial printer is capable of producing 10, 15 or 30 characters per second and is designed to sell for only $900.

The printer was developed by Universal Technology, Inc., of Verona, NJ, and according to John Brady, its inventor, the new device eliminates many of the electromechanical parts used in impact printers. It also does away with the special thermally sensitive paper or ink jets now used in nonimpact printers. But it introduces other electromechanical components: air valves.

Describing how the Terminair unit works, Brady notes that jets of hot air scorch letters and numbers onto ordinary paper. The jets, formed into a print head that consists of a 7-by-9 array, are selectively activated to form all 128 ASCII characters. A small heating element, which can be an ordinary resistor, raises the temperature of air passing through the jets to about 450 F. This is enough to scorch paper lightly and produce a brown character, but not high enough to burn through the paper or to make it brittle.

The system uses compressed air that is stored in a 5 × 2 × 2-in. container. A noiseless compressor connected to the container maintains constant pressure of 15 psi.

Brady reports that the air valves are very reliable, even though they are mechanical, and should last for at least a million operations.

Universal Technology is also developing two hot-air line printers, one operating at 300 lines per minute and the other at 1100 lines. The 1100 line-per-minute printer will be priced at $5000, compared with the $15,000 to $20,000 generally charged for such printers.

The new line printers will be able to produce facsimiles of line drawings and photos, Brady notes. This will be possible because the resolution of the printer will be the same as that of facsimile machines—96 dots per inch.

To produce multiple copies, Brady has designed a special print head that contains a wire in each of the air nozzles. When air passes through the nozzle, it scorches the paper of the original and pushes the wire forward, so that it applies pressure to the copies. Either carbon paper or special pressure-sensitive paper can be used to make the copies.

## Silicon transistor hits 1 W at 8 GHz

A silicon transistor that puts out 1 W at 8 GHz—the highest power yet achieved with silicon at this frequency—has been developed by Texas Instruments.

Heretofore designers had felt that at 8 GHz and above it would be necessary to go to gallium-arsenide field-effect transistors for power applications.

The nearest competitor to the

TI device is a GaAs/FET power transistor, also putting out 1.6 W at 8 GHz. The GaAs transistor has about 9.3 dB of gain, while the Si transistor has 8 dB.

Another feature of the TI transistor is its high collector efficiency of 35%. According to Hantzong Yuan, a member of the TI technical staff in Dallas: "The transistor is composed of four transistor cells sharing a common collector. This technique allows for better thermal spreading and ease of impedance matching. The impedance matching is done inside the transistor package."

The transistor is packaged on a beryllia substrate that is mounted to a copper heat sink. Yuan notes that tests have been made on single cells up to 12 GHz with some useful power out.

"At 10 GHz," he says, "a single transistor cell has given us 220 mW. We feel that the technology might give 1 W at 10 GHz. At 8 GHz, with some more development, we should be able to get up to at least 2 W."

The TI transistor is not likely to be as good at small signal levels as GaAs/FETs, however, Yuan doesn't expect the gain and noise figure to be comparable here.

Further details on the new transistor will be outlined in a paper to be presented May 12 at the 1975 International Microwave Symposium in Palo Alto, CA.

## A polymeric solid made superconductive

Superconductivity has been achieved in a polymeric solid, a material never suspected of possessing such capability.

And while the material is bound by many of the rigid and costly incumbrances that also plague superconductive metals, it's encouraging that the polymeric solid can become superconductive at all—a condition in which electrical resistance completely disappears. If this material can do it, the reasoning goes, then still other materials never put to the test might do the same, and under less stringent conditions.

The polymeric-solid conductivity was discovered by Richard L. Green and G. Bryan Street of IBM's San Jose (CA) Research Laboratory and Laurance J. Suter of Stanford University.

A main problem in rendering a material superconductive is the need to reduce the temperature enough for the phenomenon to take place. This has to be done with liquid helium, which is expensive and difficult to work with. Aluminum, for example, becomes superconductive at 1.175 K, titanium at 0.39 K, tin at 3.74 K, lead at 7.22 K, and niobium germanium at 23.1 K, which converts to a cold −250.18 C.

With more potentially superconductive materials to investigate, one might be found that will superconduct at reasonable temperatures, the discoverers hope. In their tests they used polysulfur nitride crystals—golden in color, fibrous in structure and typically 6 mm long. Structurally the material is composed of bundles of molecular chains, each containing alternating sulfur and nitrogen atoms. In previous tests, carried out at atmospheric pressure, this class of materials had never shown superconductivity.

In earlier studies with polysulfur nitride itself, in which samples were cooled down to 4 K, the conductivity increased but did not become superconducting. When the temperature was pushed down almost to absolute zero (0.25 K) the crystal suddenly switched to the superconducting state.

Success in causing polysulfur nitride to superconduct is particularly significant because of a similarity of structural characteristics hypothesized more than a decade ago by Dr. William A. Little at Stanford University.

In 1964, Dr. Little theorized that an organic polymer with a quasi-one-dimensional structure—a backbone made up of a carbon-based molecular chain with attached side links—could be made to superconduct at temperatures considerably higher than 20 K. Polysulfur nitride is not made up of organic molecules, but it does have a quasi-one-dimensional structure, similar to the backbone of Little's proposed material. As such, IBM says, the new finding may provide an understanding of the nature of superconductivity in quasi-one-dimensional materials and, of course, intensify the search for a higher-temperature superconductor.

## 'Electronic checkbook' a specialized calculator

The pocket calculator has been packaged as an "electronic checkbook"—a thin, eight-ounce, battery-operated machine that makes checking-account transactions and retains in its memory for as long as a year the account's current balance.

The CheckMaster, as it is called by its developer, Mostek Corp. of Dallas, TX, manages to do this because the current to the memory is never actually turned off.

The memory feature could have been accomplished easily with CMOS, says a Mostek spokesman, Don Ward, but to keep costs down "we had to go with our low-cost, p-channel depletion process.

"We had to have a standby current for the memory that would not exceed 100 $\mu$A," he notes.

Mostek proceeded in two ways:

First, a departure was made from the usual data-saving technique of placing the data into a continuously dynamic shift register. Instead, a static, shift-register memory was used. It is clocked only during operations requiring memory access. Use of this type of memory permits the entire circuit to be powered-down during the standby mode, with the sole exception of the 50 static loads in the memory.

The second part of the problem, Ward explains, was to reduce the current required by the memory to an absolute minimum (consistent with speed and leakage considerations). The solution involved use of depletion loads with very high effective resistances.

The CheckMaster will be sold by mail order only, at least until fall of this year, Mostek says. The sale and advertising campaign is being handled by JS&A National Sales Group, Northbrook, IL. The "checkbook with a brain" will sell for around $40.

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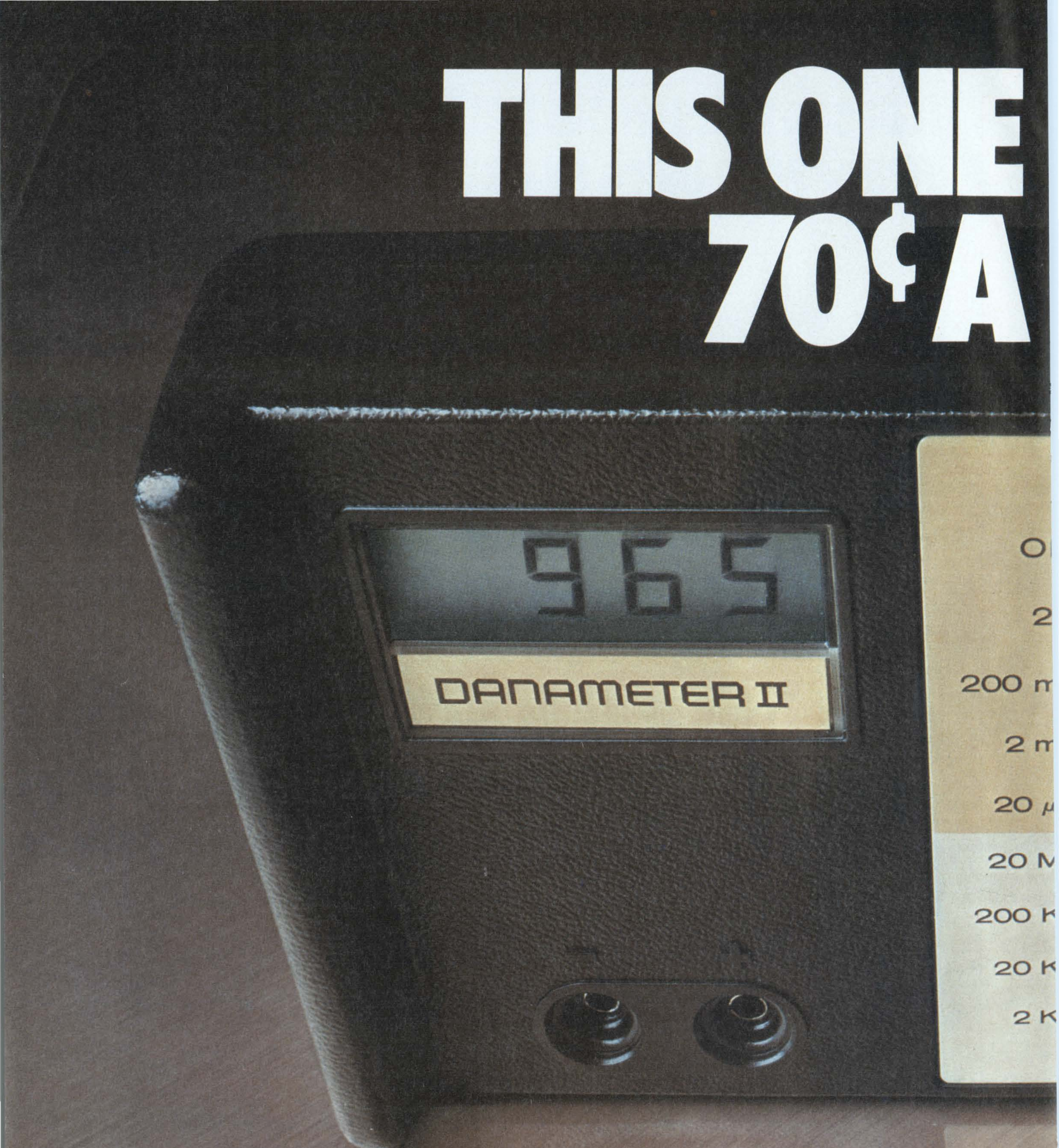


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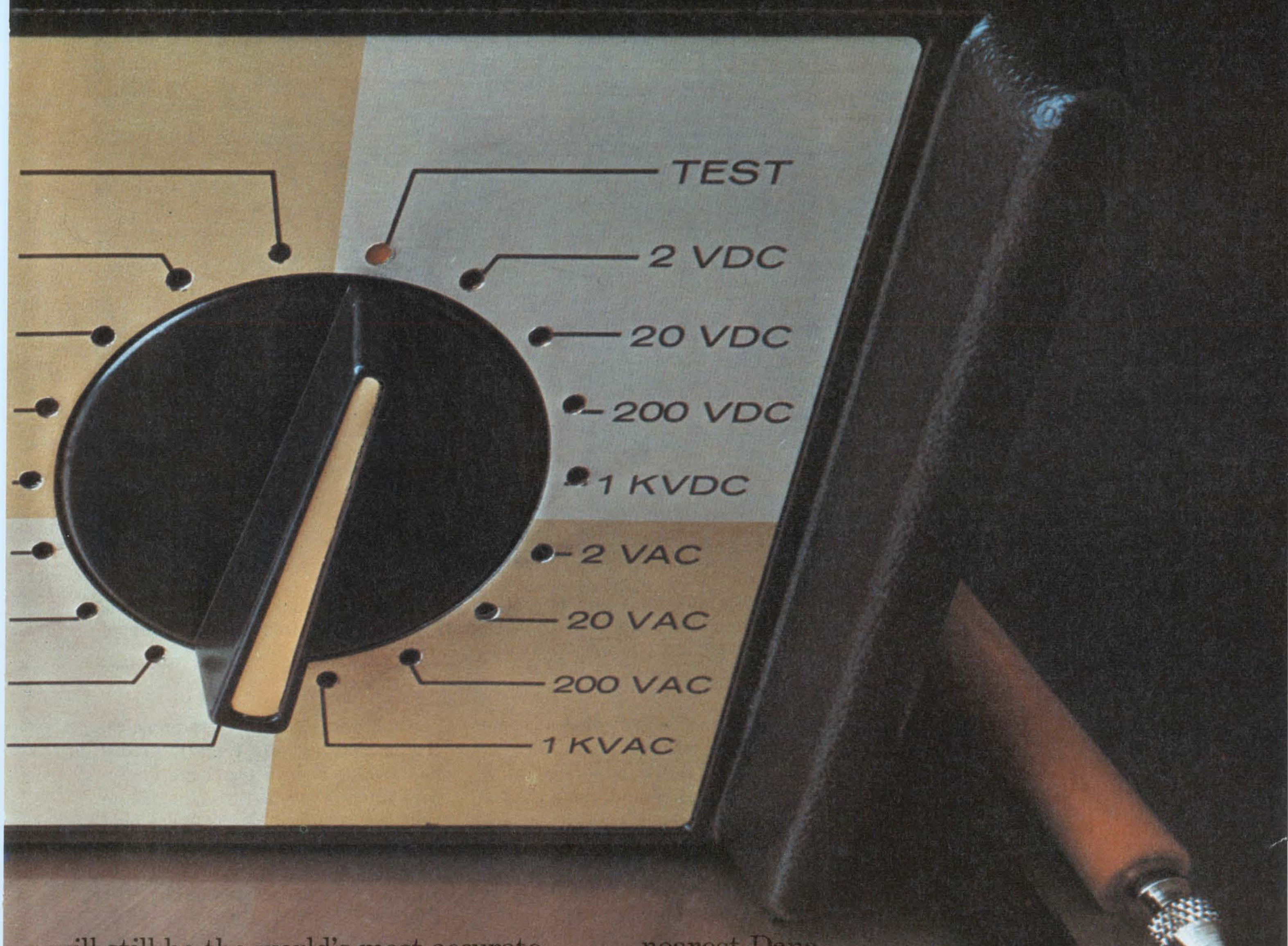


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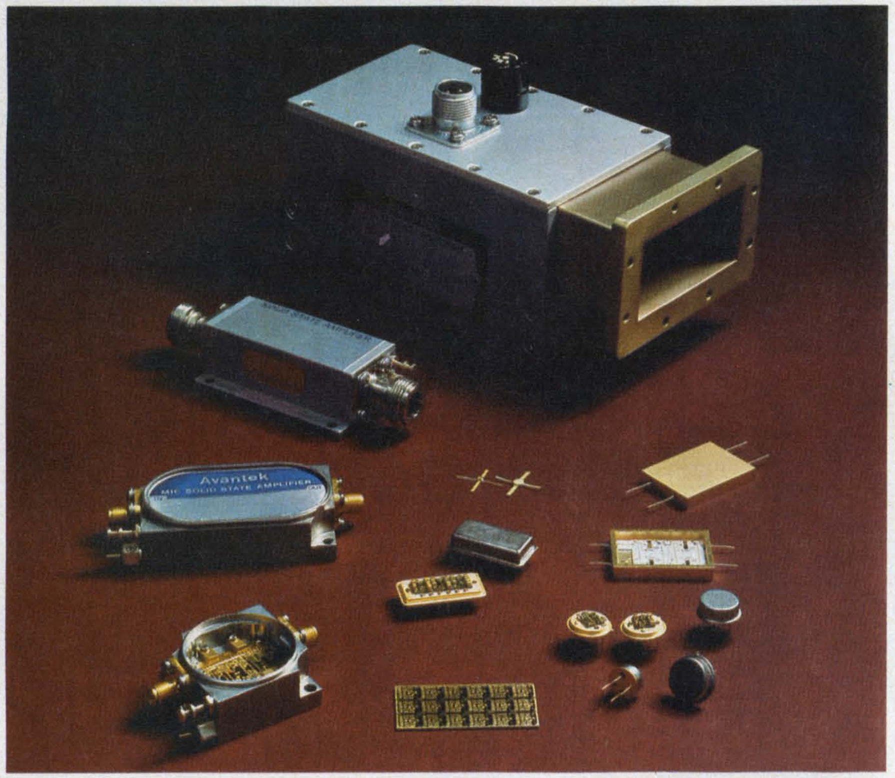
News

# Coax and microstrip packaging edging out microwave waveguide

**David N. Kaye**
Senior Western Editor

Microwave engineers are in danger of losing their nickname—the plumbers. The use of waveguide is on the downswing. All the way up to 40 GHz, coax and microstrip are taking over.

Most microwave devices are now being constructed with integrated-circuit packaging techniques. Microwave transistors and diodes are often used unpackaged, but the packages are getting better all the time. Even TWTs are being constructed with more economical techniques. When getting the heat out is important, heat pipes are making inroads.




**Microwave integrated circuits** come in a wide range of package types. Avantek offers both connector and connectorless packages at frequencies to about 4 GHz. Standard packages are made of welded steel.

### Diode packages get smaller

When a diode package is required, it should have as little effect on diode performance as possible. The effect of the package is to add parasitic reactances that tend to reduce the over-all diode performance.

Hewlett-Packard Associates, Palo Alto, CA, makes a diode package that almost isn't there. Place a beam-leaded diode chip on a tiny ceramic substrate. Attach tiny foil strips to the beams and leave a small drop of epoxy on top of the chip to seal it from the outside world. David Struthers, product marketing engineer at HPA, says: "New diode packages are tending towards beam-leaded chips with convenience features. The current tiny packages are easier to use than an unpackaged beam-leaded chip."

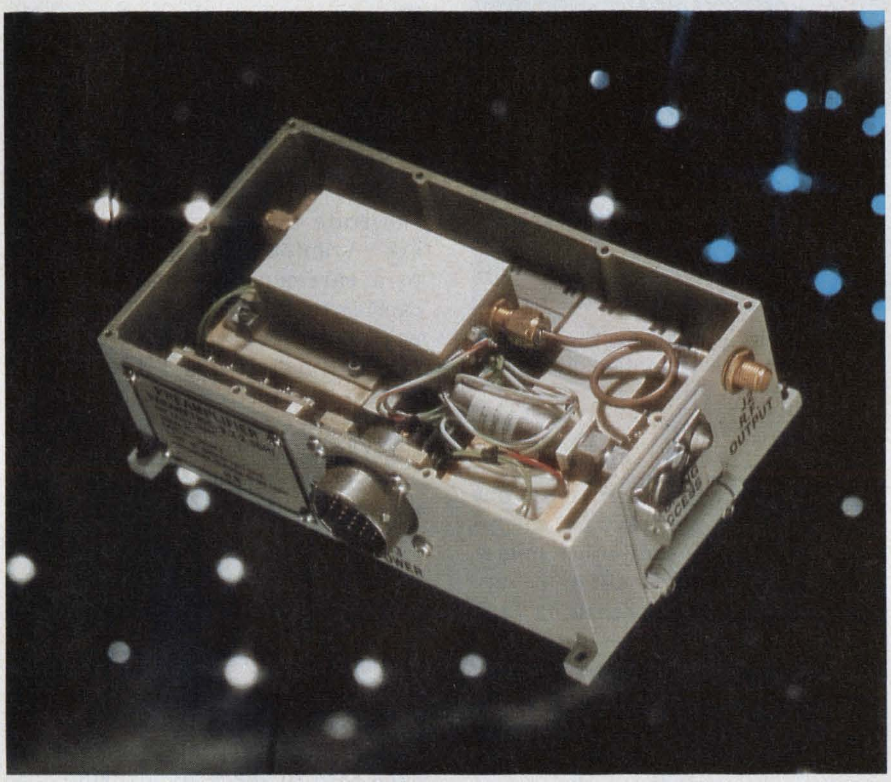
When the application is not small-signal, the packages get larger. When 5 to 10 W must be handled, microwave diodes come mounted on studs.

Impatt diodes generate high thermal densities and usually have some kind of heat sink. Even unpackaged chip Impatts come with a plated-on heat sink on the base that is usually about 4 mils thick and 20 × 20-mils square.

Struthers notes: "A chip Impatt with plated-on heat sink can generate about 2 W at 10 GHz, while the same chip with no heat sink could generate only about 1/2 W at the same frequency." Similar plated-on heat sinks are used by several manufacturers of Gunn diodes.

At millimeter-wave frequencies, the packaging of Impatt diodes has always been a problem. Therefore in the 40-to-100-GHz range Impatts have been used unpackaged in waveguide mounts. Recently, however, packages have been developed for these diodes by the Hughes Electron Dynamics Div., Torrance, CA, and TRW Systems, Redondo Beach, CA. The two packages are similar.

Hughes has the chip mounted on a copper base that is 50 mils in diameter by 10 mils thick. Around the chip is a 30-mil-diam quartz ring topped with a Kovar lid. According to Richard A. John-



**Temperature stabilization** of this Micromega paramp system would normally require a 30-lb heat chamber. With thermal pads, ±1.8 F stabilization is achieved in a 42 oz. package.

son, marketing manager for solid state at Hughes, "the package is virtually as good below 100 GHz as an unpackaged diode."

Dr. John L. Rogers, manager of the arrays department at TRW, says his package is very similar to the Hughes, except for the use of a gold lid and slightly different dimensions for the copper base and the quartz ring. Parasitic capacitance introduced by these packages is only about 0.05 pF.

Johnson of Hughes notes that the next step in package design is to go to a diamond heat sink instead of copper. This should at least double the output power capability of the Impatt diode and, because of the diode's increased dynamic range, should allow the device to be tuned over a much broader bandwidth.

### Transistors in chip form

"More and more users will be buying microwave transistors in chip form," says Richard Lucas, product manager for microwave transistors at Hewlett-Packard Associates. When chips are not used, most small-signal microwave transistors come in a ceramic package that is made in Japan.

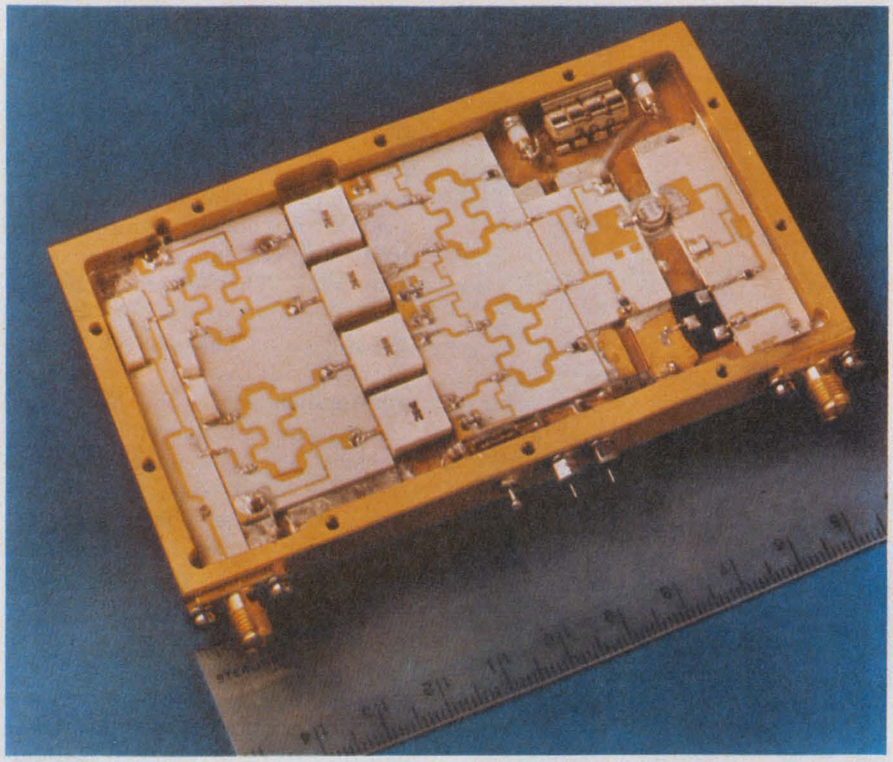
The package starts with an alumina or beryllia square metalized on one side. Then a second piece of ceramic is hot-pressed on top of the metalized surface of the first piece. Leads are brazed onto the metalization at the junction of the two ceramic pieces. The second ceramic is hollow, producing a cavity for placement of the transistor chip. The bottom of the inside of the cavity is plated, and the transistor chip is soldered to the metal. Wires are thermocompression-bonded to the leads, and a metal cap is soldered on. These packages are good up to about 10 GHz. Above 10 GHz, most microwave transistor manufacturers recommend the use of unpackaged chips.

For large-signal microwave transistors, the major trend in packaging has been toward incorporation of internal impedance matching within the package. Some manufacturers of small-signal microwave transistors expect impedance matching to be incorporated within the package as well. However, nobody has yet done this.

Although large-signal microwave transistors all come mounted to a heat sink, it is possible to buy the devices without the sink. Microwave Semiconductor Corp., Somerset, NJ, uses its own transistors without a heat sink. According to Harold Balshem, manager of microwave integrated-circuit engineering: "For good heat transfer, we solder the beryllia substrate of the transistor directly to the microwave integrated-circuit housing. Using this technique, we build power amplifiers up to 4 GHz, with output powers of up to 100 W, continuous or 1 kW pulsed."

Microwave transistors above 8 GHz will likely be gallium arsenide rather than silicon devices. Initially it will be difficult to get GaAs transistors in chip form. This is because GaAs cannot be readily passivated. Thus it is hard to protect the junction against contaminants. Silicon is readily passivated by growth of a natural oxide coating.

In early development at several companies are methods of protecting GaAs chips. Robert E. Brown, manager of microwave sources engineering at Varian Associates, Palo Alto, CA, explains: "We are



**The 91024 S-band MIC power amplifier is offered** in a small package by Microwave Semiconductor. The microwave transistors are mounted directly to the base to give 24 W at 55 C.

working on plastic coating of GaAs chips. However, we are quite far away from a workable solution."

Harry Cook, manager of transistor design at Avantek, Santa Clara, CA, notes: "We are doing something about GaAs transistor contamination but consider the details to be proprietary. However, we are not using a plastic coating."

Much progress has been made in the packaging of stripline resistors and terminations at frequencies up to 18 GHz. Michael Giacalone, microwave engineering manager at KDI Pyrofilm Corp., Whippany, NJ, notes a trend away from coaxial terminations and towards flat terminations. He points out that a 1 × 2 × 1/8-in. structure can dissipate over 100 W. If the heat is spread out over a large surface, the termination is much more efficient than a coaxial structure.

These terminations are made on beryllia substrates. Nichrome is vacuum-deposited on the substrate. Then the terminals and the area to be connected to the heat sink are nickel-plated. The heat sink can be a stud or even the base of a microwave integrated circuit.

More packaging progress has been made in the area of microwave ICs than in any other microwave area. Many different approaches to the packaging are used. The differences lie in the type of substrate used, the way the substrate is bonded to the package, the way devices are bonded to the substrate, the way signals get in and out of the package, and the way the packages are sealed.

## A choice of substrates

Most microwave ICs are constructed on alumina substrates. Alumina is the least expensive of the ceramic substrate materials and can be provided with high degrees of purity and flatness. In cases where surface finish is very important—if thin-film capacitors are to be deposited, say—the substrate of choice is sapphire.

Companies such as Hewlett-Packard and Avantek use sapphire most of the time. When the ICs are designed at high microwave frequencies, it becomes desirable to use a substrate of lower dielectric constant. This allows the line widths to get larger, and the circuit becomes easier to construct. Whereas the dielectric constant of alumina and sapphire are in the vicinity of 9.39 to 9.8, materials such as quartz, at 3.8, and RT/duroid, at 2.35 and 2.20, are more amenable to frequencies in excess of 20 GHz.

RT/duroid is a product of the Rogers Corp., Chandler, AZ. It is a glass fiber PTFE material of high-dimensional stability and low-loss tangent. According to George Archer, microwave product manager at Rogers: "Model 5880 duroid has a loss tangent of only 0.0009. We also produce the material clad with 1/16-in. or thicker aluminum on one side for heat-sinking." Some companies have experimented with duroid microwave ICs as high in frequency as 40 to 60 GHz.

Most companies solder the IC substrate to the base of the package. Avantek solders the substrate to a carrier and then screws the carrier to the package. Some companies use conductive epoxy. And at millimeter-wave frequencies, Stanford Research Institute, Menlo Park, CA, screws down the substrate.

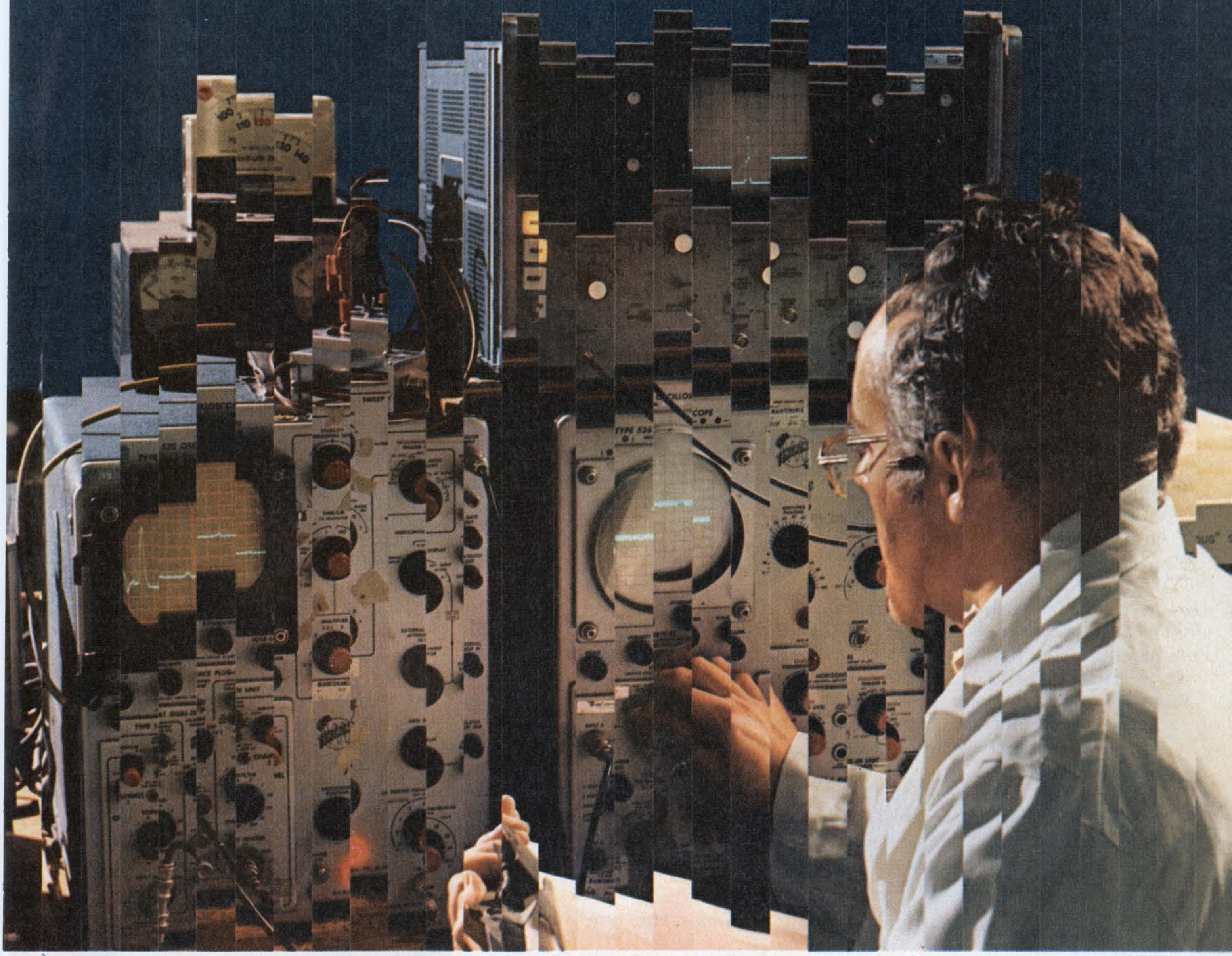
Donald Chambers, senior research engineer at SRI, explains: "We use very thin sapphire substrates up to about 40 GHz. At these frequencies, the bonding of the substrate is very critical, so as not to create any impedance mismatches. So we use several small screws and carefully attempt to get uniform contact across the substrate to the ground plane."

Most devices are soldered to microwave IC substrates. However, recently there has been a move toward the use of conductive epoxies for this purpose. According to Jesse Taub, a consultant with the AIL Div. of Cutler-Hammer in Deer Park, NY: "We have used silver-filled epoxies to bond die to substrates up as high as 60 GHz."

Connectors are one of the major problems in microwave systems. As a result, work is being pursued to develop connectorless packages. Packages of this type have been developed by Avantek and by the Bendix Electrical Components Div., Sydney, NY.

Most microwave ICs have SMA-3.5-mm connectors. Above 18 GHz these connectors degrade rapidly. Work is being pursued to develop precision coaxial connectors that

# Still fighting snap, crackle and pop?



Noise has a way of showing up in circuits. Bendix has a way of preventing it. Filter connectors. Boasting some of the best attenuation curves available, Bendix filter connectors solve a wide range of low-pass filter problems. Small wonder Bendix is first choice in the fight against snap, crackle and pop.

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Bendix

INFORMATION RETRIEVAL NUMBER 18

will be good to 40 GHz. The first of these has been introduced by Maury Microwave, Cucamonga, CA. It is called the MPC-2. Connecting to 0.086 semi-rigid coax, it is a 2-mm dielectrically loaded connector.

Mario Maury, president of the company, reports: "The MPC-2 is good up to 40 GHz, with a maximum VSWR of 1.2:1. Coming later will be the MPC-1—good to 60 GHz. We also make a full line of transitions from the MPC-2 to microstrip or to other connectors."

## Keeping out contamination

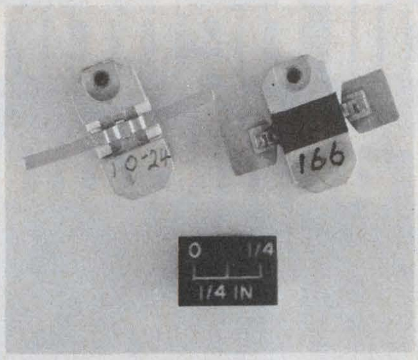
Most microwave ICs are hermetically sealed by a variety of different methods. They include welding, epoxy, screw and gasket and compression. Welding is the most common approach. According to Harry Cooke of Avantek: "Our standard MIC package has been welded stainless steel. We are now moving to Heliarc-welded aluminum."

Tom Strouth, a packaging engineer at Teledyne MEC in Palo Alto, CA, says: "We resistance-weld the covers on our packages in a nitrogen-helium atmosphere. We use Kovar packages for temperature stability."

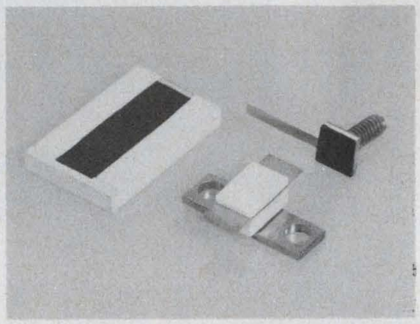
Chambers of the Stanford Research Institute uses gasket and screw sealing but says he is looking into conductive-epoxy sealing of IC packages.

One of the most novel methods of making the hermetic seal is being developed at Watkins-Johnson, Palo Alto, CA. Gary Yasumura, a member of the technical staff, reports: "We are using a new material developed by Ray-Chem, Menlo Park, CA. It is a 50-50 alloy of titanium and nickel. The material has the strange property that it is stiff at room temperature, but when you lower the temperature below some transition temperature, it becomes malleable."

Yasumura makes his IC package with a lip around the edge and a circular opening. He takes a disc of the material that is a little bit oversized for the opening and dips it into liquid nitrogen. Once malleable, the disc is shaped so that it is concave, and it is placed into the IC package opening. As it warms back to room temperature.



**Over 500 W at 4.6 GHz in a p-i-n diode** is tough to achieve. Motorola's wide gold lead is the key.


**Conduction-cooled microwave resistors and terminations** handle up to 100 W. These devices are from Pyrofilm on beryllia substrates.

the disc flattens and applies a uniform pressure against the lip of the package. The pressure is enough to give the package a solid hermetic seal.

Some companies are also looking into thermocompression bonding covers on IC packages for hermetic sealing. This isn't economical unless the volume of the production run is very high.

## Monolithics and mm waves

Microwave ICs have always been hybrid structures. However, there has always been a dream of making them monolithic. Some researchers have been working on a transmission medium that might lead to the development of monolithic microwave ICs. It is called image line, and the process is the reverse of that used in a conventional microwave IC. Instead of metal conductors on a dielectric substrate, dielectric conductors are placed on a metal substrate.

Hughes Electron Dynamics Div. is one group working on the image-line technique. "We are using image line for transceivers at 60 GHz," Johnson reports. "This type of transmission line allows for high-Q circuits to be built at frequencies in excess of 100 GHz."

Since the substrate that Hughes is working with is silicon, it is reasonable to expect that active devices, such as Impatt diodes, may one day be monolithically constructed in the same piece of silicon.

Most millimeter-wave IC work still uses more conventional media, such as a thin sapphire substrate with thin-film gold conductors.

## Use of heat pipes growing

Heat transfer is often a packaging problem, and the solution offering most promise is heat-pipe transfer.

Al Basiulis, engineering manager for thermal products at the Hughes Electron Dynamics Div., notes: "Heat pipes can be used either to transport heat from a device to a sink or as a heat spreader to eliminate hot spots."

Heat pipes have been applied with considerable success to the design of microwave amplifiers, oscillators and TWTs. Edwin L. Kyte, manager of solid-state amplifiers at Varian, is using heat pipes for temperature-stabilization of a Gunn diode amplifier. He says:

"Over a temperature range of 125 C, we can hold the amplifier to ±4 C. Since a Gunn amplifier is only 3 to 4% efficient, the rest of the power is converted to heat by the diode and used to heat a heat-pipe base plate to the maximum temperature of the desired range. The heat pipes spread the heat and hold the amplifier at a stable temperature, without an external power source, as the ambient varies."

In TWTs, heat pipes are used to help remove the heat from the collector of the tube. Heat pads are also being used for temperature stabilization. The Micromega Div. of Bunker Ramo in Westlake Village, CA, uses rubber pads with heating elements in them to stabilize parametric amplifier systems; there is no need for large thermal enclosures. Using this technique, the company has reduced a 30-lb chamber-enclosed paramp system to a 42-oz package. ■■

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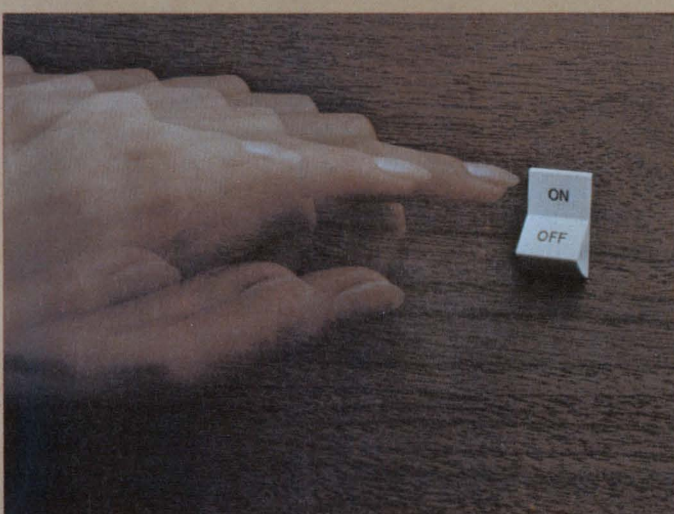
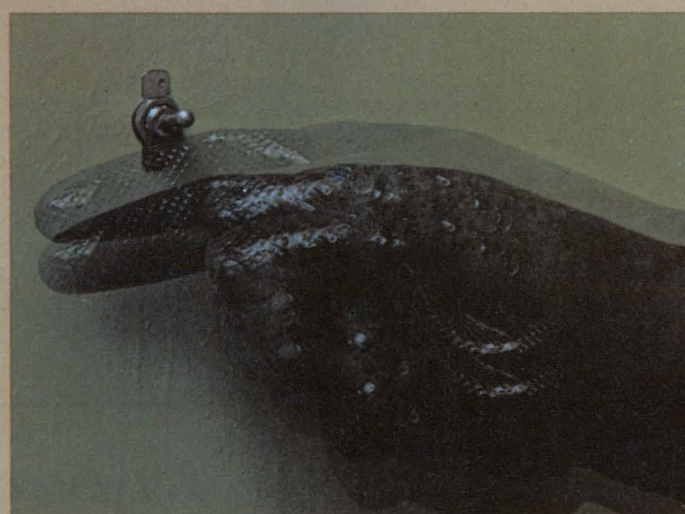
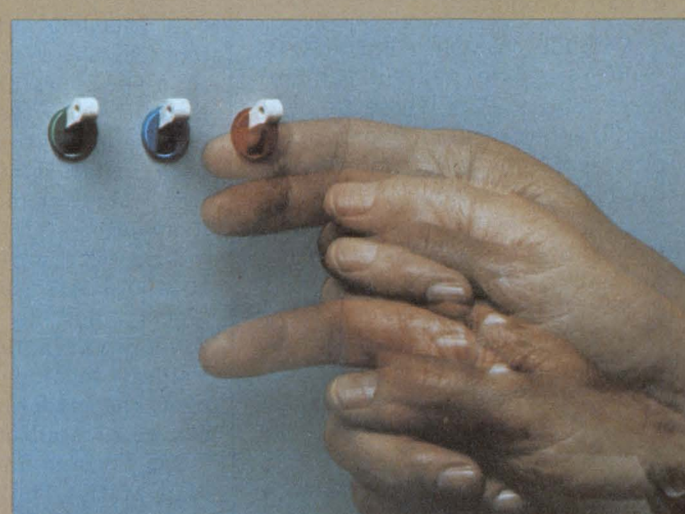




INFORMATION RETRIEVAL NUMBER 19



6169






# Small, nonimpact printer to cost less than $25

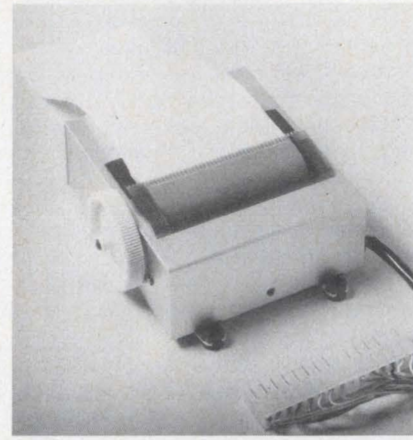
A small, nonimpact printer, using an electrostatic head, has been announced by Panasonic for use in electronic calculators, instrumentation, cash registers and computers. The unit will cost as little as $25 in quantity.

Called the Panaprinter, the unit is small because it eliminates the bulky mechanical equipment usually found in printers such as solenoids and type hammers.

The Panaprinter prints both alphanumerals and arithmetic symbols, based on a matrix structure of 7-row by 5-row dots. The characters are printed by a mechanical horizontal scanning operation of a 7-row-by-one-column head. The unit prints 20 characters per line, at a rate of 2 lines per second.

A voltage supply of −24 V dc is required. The average power amounts to 0.84 watt second per line. The unit operates at 90% relative humidity in an environment of −5 to 45 C.

The Panaprinter weighs 11.7 oz measures 3.54 in. by 1.614 in. by 4.331 in.



**Readout from** electronic calculators, instrumentation, cash registers and computers is printed electrostatically by Panasonic's nonimpact printer.

The only external equipment needed is a driving module, which Panasonic says, the customer will probably want to build himself.

Panasonic says it has announced a similar nonimpact printer for sale in Japan that uses a thermal printing head. ■■

# Airline gets automatic PC tester

A $400,000 automatic test system that can troubleshoot more than 500 types of PC boards used in jetliner navigation communications and control equipment has been installed at the United Air Lines Maintenance Center in San Francisco.

The system—a Honeywell H-2100—tests boards that previously had to be returned to vendors. As a result, says James Valdez, technical support manager, the inventory of spare units can be substantially reduced.

The system includes a central data station and an independent circuit-board tester. The central station can perform simultaneous testing, program development and compilation. The station has its own minicomputer with 24-k memory, as well as foreground and background operating capabilities. Included in the central station is a CRT terminal and keyboard, a 300-line-per-minute printer, a 3.5-Mbit disc file and two 1600 bit/in., nine-channel tape drives.

The circuit-board tester has an independent minicomputer with a 16-k memory. This tester can operate autonomously or with the central data station via a high-speed communications line. ■■

## Low-cost digital setup measures horsepower

A shaft-horsepower measuring system for marine and industrial engines uses low-cost digital techniques that are said to provide improved performance over costly strain-gauge systems. The solid-state system measures up to a few thousand horsepower.

According to Clarence Casper, vice president of engineering for Advanced Electronics Development, Chester, CT, the developer of the system, it has these advantages over the present strain-gauge installations:

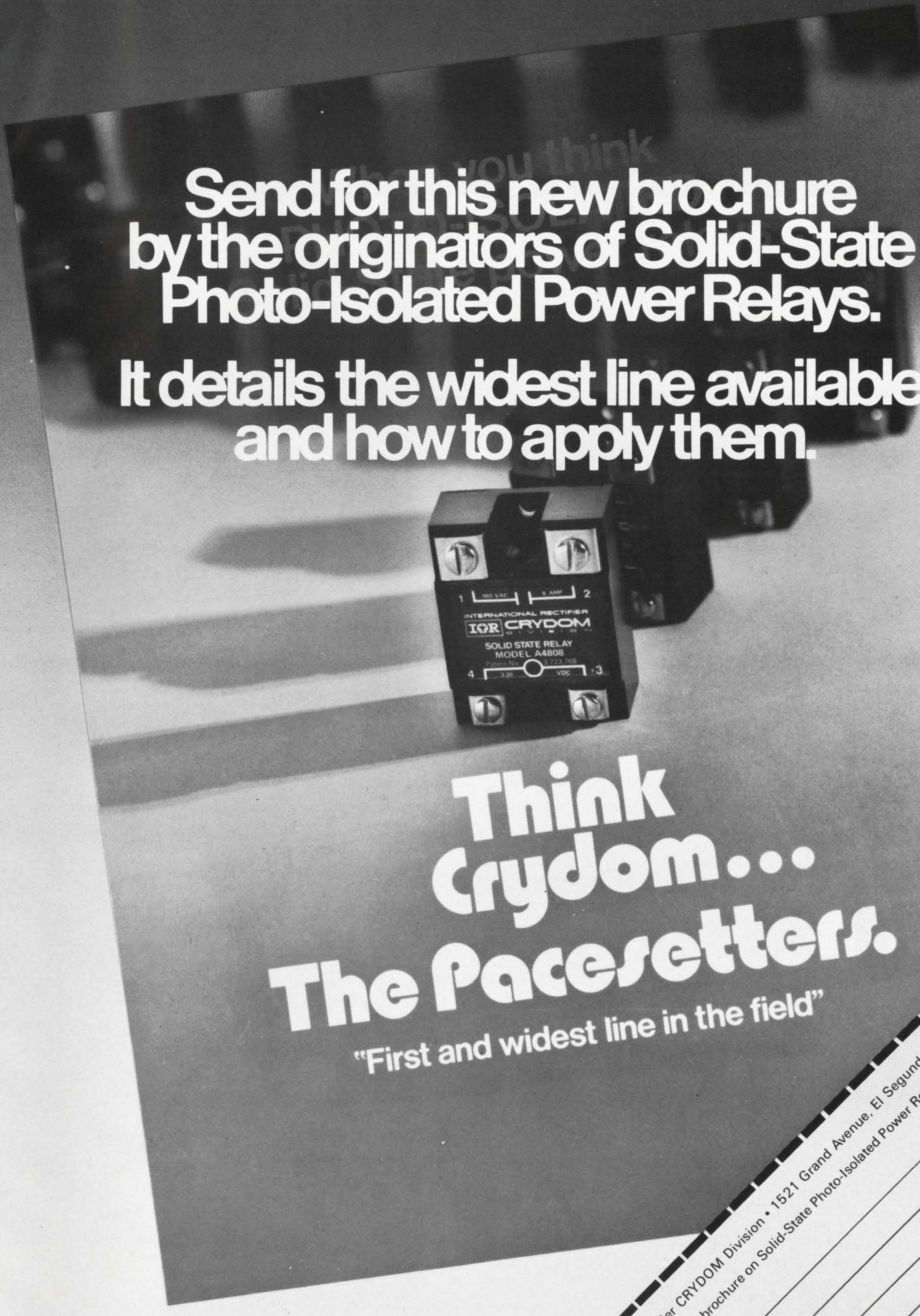
- The cost is reduced from about $20,000 to $1000.
- Exceptionally high noise immunity is obtained through the use of special magneto-sensitive transducers and CMOS circuitry.
- No slip rings are needed, such as those required to pick off strain-gauge signals from the shaft. The rings are a source of noise and other problems in a dirty environment. The new system operates by measuring the twist along a length of the engine-driven shaft, thus obtaining torque. Shaft speed is picked off, and both speed and torque are multiplied to give horsepower, which is displayed directly on a digital panel meter.

The key feature in providing a noise-immune signal to the system is two special magneto-sensitive pickups. These produce a discrete 5-V output compatible with the logic.

Two pieces of magnetic material are bonded to the engine shaft. As the shaft rotates, signals are produced in the two pickups. The magnitude of any shaft twist is obtained by comparison of the difference in time between the two sensor logic outputs. System timing is provided by a special logic one-shot multivibrator that uses a crystal oscillator, a divide-by-n counter and hexidecimal switches for stability and programmability.

Shaft speed is obtained when the output pulses from one of the sensors are counted.

The prototype system has been tested on a marine system, Casper says, and initial tests indicate better than a 5% accuracy. ■■

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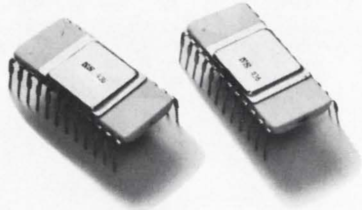

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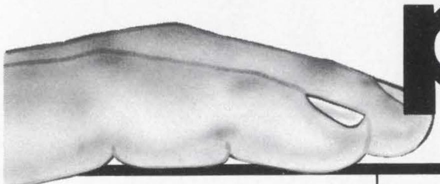
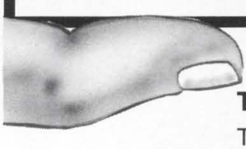


| FREQUENCY (GHz) | 4 GHz | 3 GHz | 3 GHz | 2 GHz | 2 GHz | 2 GHz |
|---|---|---|---|---|---|---|
| $P_{gain}$ (linear) db | 5.0 | 6.0 | 6.0 | 5.0 | 6.0 | 6.0 |
| $P_o$ (sat) W | .7 | 2.4 | 1.2 | 10.0 | 5.0 | 2.5 |
| $P_o$ (1 db comp) W | .5 | 1.8 | .9 | 8.0 | 4.0 | 2.0 |
| $P_o$ (linear) W | .35 | 1.5 | .75 | 6.0 | 3.0 | 1.5 |
| VSWR | ∞ | ∞ | ∞ | 3:1 | ∞ | ∞ |
| PART NUMBER | TRW 54601 | TRW 53602 | TRW 53601 | TRW 52604 | TRW 52602 | TRW 52601 |



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# Washington Report

## Bitter defense-budget battle shaping up

Rising tensions in the Middle East and the stunning defeat of South Vietnamese military forces by the Communists have added intensity to the upcoming battle in Congress over the fiscal 1976 defense budget. Facing those who seek a big cut in defense spending will be such stalwarts as Sen. John Stennis (D-MS), chairman of the Senate Armed Services Committee.

"Because of the uncertainty in the international situation," he says, "some very hard policy decisions would have to be made before any drastic reductions could be achieved this year."

Stennis has notified the Senate Budget Committee that while his committee made significant cuts in defense requests in past years, it would not go along with huge reductions in the new budget.

Obviously among the budget items receiving hard scrutiny is the Defense Dept.'s consolidated telecommunications program of over $3-billion. About one-third of this, says Deputy Secretary of Defense Williams P. Clements Jr., is for hardware. Not included in that total is another half billion for command-and-control facilities and tactical warning systems. The ADP spending for the department will add $2-billion further.

## House bill would give electric cars a push

Electric-car manufacturers are elated over a new procurement bill just introduced in Congress. If passed, the Government would purchase 10,000 electric vehicles and set up a demonstration program involving leasing and field-testing throughout the nation during the next three years. The legislation, drafted by the House Committee on Science and Technology, would authorize $40-million for each of the next three years to the Energy Research and Development Administration, which would operate the program.

Rep. Mike McCormack (D-WA), a sponsor, says the R&D portion of the program would include work in energy-storage systems, control systems and over-all design. Assoicated research would be directed toward urban design, traffic management and environmental studies. Individuals and businesses would have an opportunity to purchase or lease the vehicles.

## Cost overruns found in nondefense projects

Cost overruns, it seems, are not a malady that afflicts only the Dept. of Defense. Reporting on the status of 269 other Federal projects, the General Accounting Office has found that original cost estimates of $76-billion have skyrocketed to $133-billion.

The watchdog agency looked at projects involving $25-million or more and found 59 of them had grown by more than 100 percent. So-called "engineering changes" accounted for 41 percent of the increase on the 59 projects that posted the largest overruns.

The major offender was the Interstate Highway System. The National Aeronautics and Space Administration was relatively clean—23 projects, originally estimated to cost $8.27-billion, had an overrun of nearly $1.9-billion. This estimate was based on the original Congressional authorization.

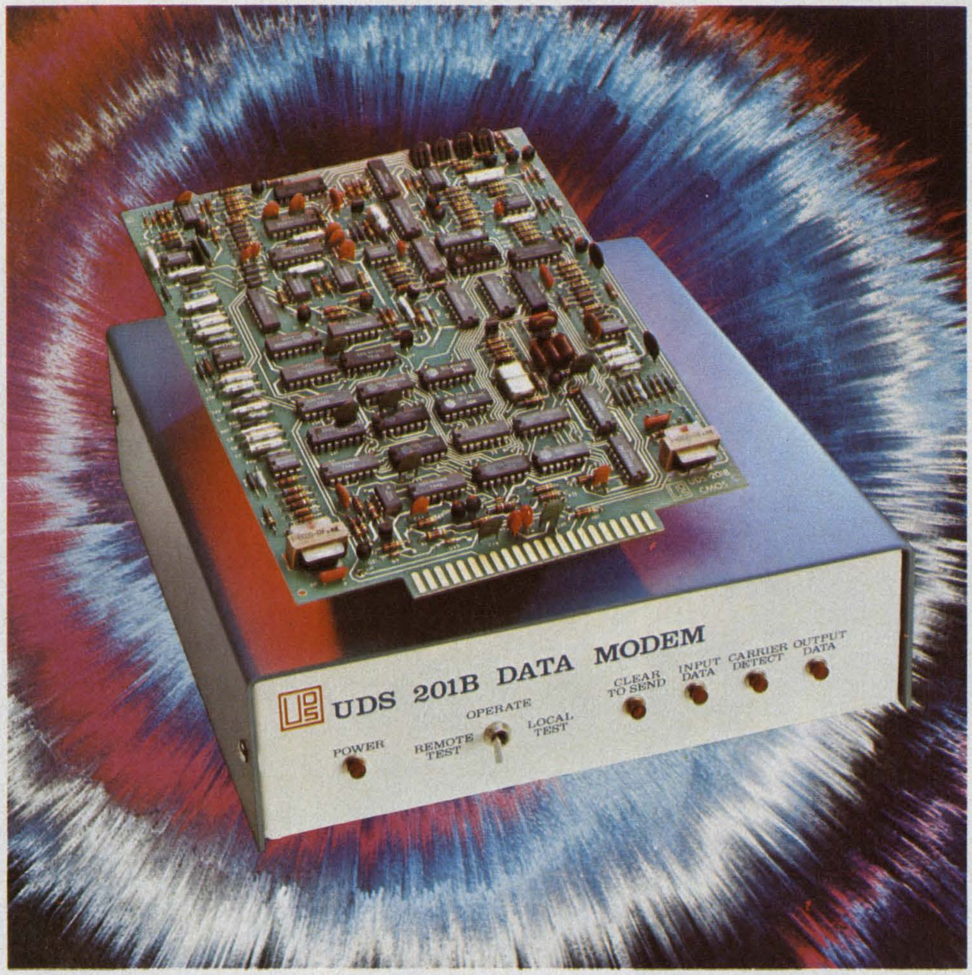
But the GAO also recently pointed its spotlight on the Defense Dept., and if its recommendations are followed, the department will be asking contractors to furnish life-cycle cost estimates with their proposals, including those for prototype competitions. Life-cycle costs haven't figured prominently in the past on major weapon development; however, the GAO concludes that despite the difficulty in making such estimates, they can be done. It recommends that Congress require the data.

## Study examines effects of high-voltage transmission

Faced with the probability that as much as 10,000 miles of extremely high-voltage transmission lines will be in operation by 1990, the Environmental Protection Agency has begun a study of the health and environmental effects that may be involved. Several transmission lines are already operating above 700 kV, and the agency is seeking data and information from the public so it can make an evaluation. Under study are measurement and analytical techniques, electrostatic and electromagnetic induced voltages, electric discharge phenomena and health effects.

In the particular area of electric discharge phenomena, the EPA is asking for comments on the amplitude-frequency distribution of radio-frequency electromagnetic energy, its dependence on operating-line voltage, surface-voltage gradient and the influence of weather.

**Capital Capsules:** The Navy Air Development Center, Warminster, PA, is **in the market for an integrated communication, navigation and identification system** suitable for a wide range of airborne and surface platforms. . . . Users and producers of space-communication technology at 40 GHz and 80 GHz are being sought by the National Aeronautics and Space Administration, which has a program under way **to predict technology developments likely to occur from 1980 to the year 2000.** . . . The Air Force has successfully flight-tested **a new electronic reconnaissance camera system that reduces the time lapse between photography and photo interpretation to about 10 sec.** The system, designated the AN/UXD-1, uses a 4.5-in. return-beam vidicon camera developed by RCA. The pictures, transmitted instantly to ground, are displayed on a TV screen that has 2000-line resolution and are simultaneously recorded on film. . . . **A system analysis of potential over-the-horizon sensor and relay systems is being made** by the Naval Sea Systems Command. The Navy is interested in finding firms willing to participate in the yet unfunded study. The aim is to find out if such systems would be of value to surface ships in tactical situations. . . . The Communications Satellite Corp. (Comsat) is **filing with the Federal Communications Commission** for permission to offer Digital Data Satellite Service in the Atlantic ocean area. Comsat began providing such service between the mainland and Hawaii in mid-January.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Editorial

# To the rear, march!

On public TV's Nova show the other night, Dr. E. F. Schumacher of Intermediate Technology made a great case for going backwards. He argued that technology had gone too far and that, though labor saving might have been a fine goal in the 19th century, it's not so great now. He showed that much of our growing productivity in the past 100 years was based on the low cost of fuel. But now everything's been changed. The object now should be to conserve fuel and increase the use of manpower.

Not only would this alleviate unemployment, he said, especially in the poorer countries, it would help cut pollution in the wealthier lands. More important, this consummation was not merely desirable, it was almost inevitable. That's because the cost of centralized manufacture plus transportation would exceed the cost of local manufacture and distribution, though the latter would be less efficient in terms of units produced per man and per hour.

Hogwash.

Just as history is marked by daily sunrises and sunsets, so, too, is it marked by the frequent appearance of prophets proclaiming that the sky is falling down. Workers in the early days of the Industrial Revolution pitched their shoes into machinery, hoping to destroy what they thought was the cause of their oppression. Scholars at the time assured us that this proved that industrialization was a bad mistake. We'd have to go back to more primitive means of production.

Similarly, in the Nova show, Dr. Schumacher charged that we must go back if we are to survive. Fortunately, technology will move ahead regardless of the "let's go back to the good old days" urgings of Dr. Schumacher and others who will surely follow with similar views.

Should we make less-advanced equipment for those who don't need and can't afford the most sophisticated? Of course, just as we should provide three-digit voltmeters for those who don't need and can't afford four-digit machines. But should we therefore make more primitive technology a goal? Of course not.

In troubled times man has always looked back with faulty memory to a benign past. But never has he solved his problems by pushing technology backward. Throughout history, advancing technology has offered man the wherewithal for improving his lot. If man's social and political institutions weren't ready to accept this bounty, the fault lies there, not with technology.

George Rostky

GEORGE ROSTKY
Editor-in-Chief

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INFORMATION RETRIEVAL NUMBER 27

# Speed microcomputer multiplication

## with a CPU complementary circuit or peripheral multiplier. Here are typical examples that use available ICs.

When required to multiply, microcomputers—LSI microprocessors plus support circuits and memories—may be too slow for a host of real-time control applications. Typically these applications require multiplication times of 5 to 50 μs. Microcomputers need several orders of magnitude longer. But with external circuitry—either a circuit that complements the CPU or a separate, peripheral multiplier—the speed limitations can be overcome.

The complementary-circuit approach requires a microprocessor that can be microprogrammed and has an externally accessible control bus. The circuitry differs from one processor to another. However, the approach yields the highest speed and least hardware complexity.

A separate peripheral multiplier can be used with any LSI processor. But it is less efficient from the standpoints of time and hardware: An 8 × 8-bit multiplier requires nine MSI circuits and at least four clock periods; for a 16 × 16-bit multiplier, these requirements are doubled.

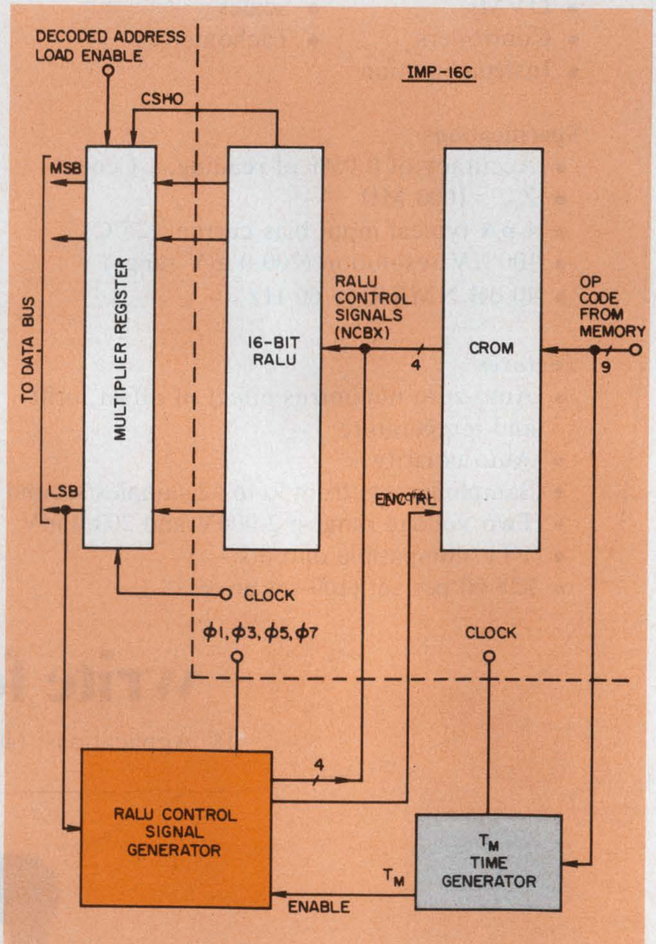
A complementary circuit for National Semiconductor's IMP-16C microcomputer[1] can be built with 16 standard SSI and MSI circuits. And these can be interconnected on a 3 × 4-in. PC board that is mounted piggyback on the microcomputer.

The complementary circuit has been designed around the National unit, because it was the first available 16-bit model. Other models have been announced.

With the complementary circuit, the National microcomputer allows multiplication of two 16-bit unsigned operands in 16 microcycles, or 23 μs, with a 6.5-MHz clock. Thus the multiplication time is reduced by a factor of 30 from the relatively fast 700 μs needed by a conventional macro-software operation. It is reduced by a factor of seven from the 150 μs needed by an optional microprogrammed instruction offered by National.

Speed benefits also result when a complementary approach is used for division or square-root operations, or for multiplication of signed operands. The same hardware technique is used for these operations, but with some increase in ICs.

The design of the complementary circuit for multiplication assumes these three requirements: (1) The basic operation of the microcomputer will not be disturbed or impeded; (2) The additional circuitry will provide the necessary bipolar or MOS interface levels, and (3) No addi-




**1. In this CPU complementary multiplication circuit,** CROM outputs are replaced with special control signals that permit hardware multiplication operations. The additional circuit blocks consist of a time generator, signal generator and multiplier register.

**Hermann Schmid,** Senior Engineer-Computers, General Electric Co., Binghamton, NY 13902.

tional power supplies will be used.

The major blocks of the multiplication circuitry are connected to the RALU (register and arithmetic logic unit) and CROM (control read-only memory) of the IMP-16C (Fig. 1). The external circuitry consists of the $T_M$ time generator, the RALU control-signal generator and the multiplier register (MR).

#### Key microcomputer operations

In a typical microcomputer operation, the CROM receives a 9-bit operational (op) code from memory and processes it into the RALU control signals (NCBX). This time-sequenced 16-bit control word instructs the RALU what to do at each phase of a microcycle. At each clock phase, the four lines determine the following:

- During phase $\phi_1$, which register (or stack) is connected to the "A" bus. The "A" and "B" buses constitute the two ALU input buses.
- During $\phi_3$, which register is connected to the B bus and also whether to complement the A bus.
- During $\phi_5$, which arithmetic logic and control operations are to be performed.
- During $\phi_7$, which signal bus is to be connected to the "R" bus (the ALU output bus) and into which register (or stack) the R bus is to be loaded.

For multiplication, the RALU control signals from the CROM are replaced with separately generated control signals. These are a function of the least-significant MR register bit. The switchover in control signals occurs upon detection of a special multiplication op code—not in the instruction repertoire. The op code simply turns the CROM off and the $T_M$ time generator on.

The time generator provides a period 16 microcycles long for a 16-bit multiplier, and it starts one microcycle after receipt of the multiplication op code. Also, $T_M$ connects the shift clock to the MR register. A function of this register is to

## Digital multiplication: The basics

The use of hardware multiplication to speed microcomputer computations also entails the writing of software. Though not a difficult task, digital multiplication could present problems to designers not familiar with the procedure.

A simple example (top right) will show how to develop a basic multiplication subroutine (bottom right).

Assume that two binary numbers, $X = 13$ and $Y = 11$, must be multiplied. X is called the multiplier and Y the multiplicand. The procedure requires that Y be added to the partial product $Z_i$ whenever the least-significant multiplier bit $X_i$ is 1. When $X_i = 0$, zero is added. After each addition, the partial product and the multiplier are shifted to the right by 1 bit. Thus after multiplication of two n-bit operands, a 2n-bit or double-precision product results.

Most microprocessors perform multiplication sequentially by software. A typical multiplication subroutine consists of three steps:

(1) Initialize,
(2) Loop and
(3) Finalize.

In Step 1, CPU registers AC0, AC2, AC3 are loaded with the operands X, Y and the index n; AC1 is reset to zero. In Step 2, we add Y into AC0 when the LSB of AC0 $\neq$ 0. We omit the addition when the LSB of AC0 $= 0$. The contents of AC0 and AC1 are shifted to the right 1 bit at a time, for each pass through the loop, while the index counter is decremented. In the last step we transfer the double-precision product from AC0 and AC1 to specified memory locations.

```
      Y = 1 1            X = 1 3
      1 0 1 1     x      1 1 0 1

Z0 =  0 0 0 0
     +1 0 1 1
Z1 =  1 0 1 1
        1 0 1 1 ------> SHIFT RIGHT
     +0 0 0 0 0
Z2 =  0 1 0 1 1
        1 0 1 1 ------> SHIFT RIGHT
     +1 0 1 1 0 0
Z3 =  1 1 0 1 1 1
      1 1 0 1 1 1 ----> SHIFT RIGHT
     +1 0 1 1 0 0 0
Z4 =  1 0 0 0 1 1 1

      143 = DOUBLE-PRECISION ANSWER
```

```
OPERATIONS: AC1, AC0 <-- AC0 x AC2
INITIALIZE: AC0 <-- X, AC1 <-- 0, AC2 <-- Y,
            AC3 <-- n
LP: JUMP +2 IF AC0 LSB = 0
    ADD AC1 <-- AC1 + AC2
    RIGHT SHIFT AC1       LSB --> L
    RIGHT SHIFT AC0       L --> MSB
    DECREMENT COUNTER, SKIP IF ZERO
    JUMP TO LP
FINALIZE: STORE AC0 AND AC1 IN MEMORY
```

initially hold the 16-bit multiplier.

At each clock cycle, or microcycle, the multiplier shifts one bit to the right. And as the least-significant multiplier bit (MR−LSB) leaves the low side of the register, the least-significant product bit enters the top side. At the end of $T_M$, the MR register thus holds the 16 low-order product bits.

Use of an external register to store the multiplier operand eliminates the following:

- The need to shift through the "Link" flip-flop (CPU status flag), which would require two microinstructions.
- Testing of the multiplier LSB through software, which would require a conditional branch microinstruction.
- The need to establish, increment and test the index counter, which would require another two microinstructions.

The RALU control signals (NCBX) are generated with simple logic circuits and connected to the NCBX bus during $T_M$ (Fig. 2). Only one transistor, four Tristate MOS buffers and six diodes are needed.

The multiplicand is loaded into accumulator AC2, and the multiplier into the external register. During each microcycle either the content of AC2 (MR − LSB = 1) or zero (MR − LSB = 0) is added to the content of AC0, which is initially zero. In addition the contents of the AC0 and MR registers shift 1 bit right, and the content of the least-significant AC0 stage shifts into the most-significant MR register stage. At the end of the multiplication operation, the most-significant product byte is in AC0 and the least-significant byte in the MR register.

For this design, a macroinstruction loads the multiplier operand into the MR register prior to the multiplication operation. Similarly another macroinstruction causes the 16 low-order product bits to be read out from the register after multiplication.

Obviously the $T_M$ period and the RALU control signals can be extended, so these two operations are performed at the high speed of 1 microcycle each without additional software. But for simplicity, this approach is not used.

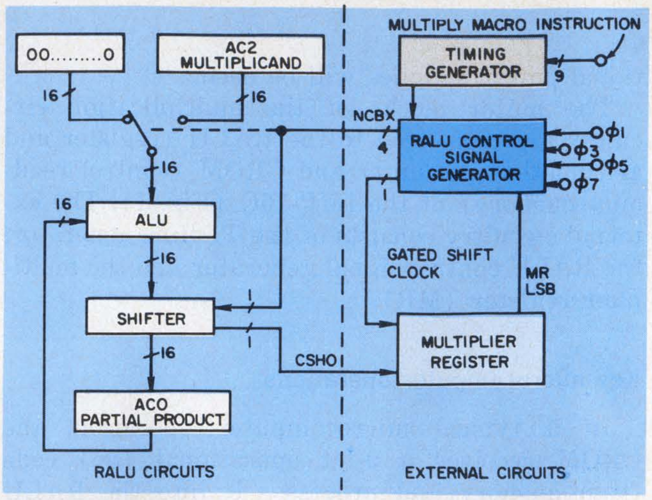
### Control signal pattern easy to generate

To perform a hardware multiplication operation, two pseudo-microinstructions must be generated and then executed. These are the following:

$$(AC0) \leftarrow [(AC0) + 0]\, 2^{-1} \text{ if } MR - LSB = 0 \quad (1)$$

$$(AC0) \leftarrow [(AC0) + (AC2)]\, 2^{-1} \text{ if } MR - LSB = 1 \quad (2)$$

Translated, this means: (1) Add zero to the content of AC0 and shift the result 1 bit right if MR − LSB = 0; (2) Add the content of AC2




2. **The complementary circuit provides alternative** control signals, labeled NCBX, for the RALU. The technique can be used with the IMP-16C because it is a microprogrammable processor.

## Table 1. Command codes for the RALU

| ALU functions | |
|---|---|
| NCB (1), (0) @ T5 | Function |
| 11 | AND |
| 10 | XOR |
| 01 | OR |
| 00 | ADD |

| Control functions | |
|---|---|
| NCB (3), (2) @ T5 | Function |
| 11 | None |
| 10 | R-bus control |
| 01 | Shift left |
| 00 | Shift right |

| A, B and R-bus addresses | |
|---|---|
| NCB (2) (1), (0) | Address |
| 111 | ZEROS |
| | FLAGS, STACK |
| 110 | R1 |
| 101 | R2 |
| 100 | R3 |
| 011 | R4 |
| 010 | R5 |
| 001 | R6 |
| 000 | R7 |

| R-bus control | | |
|---|---|---|
| I/O NCB(3) @ T7 | BYTE (SININ @ T5) | R-bus value |
| 1 | 0 | Output of shifter |
| 1 | 1 | Output of shifter |
| 0 | 0 | Output of I/O mux |
| 0 | 1 | Value of sign input on SININ @ T7 |

## Table 2. RALU signal patterns that permit unsigned multiplication

| | Time period | NCB3 | NCB2 | NCB1 | NCB0 | Operation |
|---|---|---|---|---|---|---|
| Multiplier MR − LSB = 0 | $\phi_1$ | 1 | 1 | 1 | 1 | (A bus)←0 |
| | $\phi_3$ | 1 | 0 | 1 | 1 | (B bus)←AC0 |
| | $\phi_5$ | 0 | 0 | 0 | 0 | SHIFT RIGHT, ADD |
| | $\phi_7$ | 1 | 0 | 1 | 1 | (AC0)←(R bus) |
| Multiplier MR − LSB = 1 | $\phi_1$ | 1 | 0 | 0 | 1 | (A bus)←(AC2) |
| | $\phi_3$ | 1 | 0 | 1 | 1 | (B bus)←(AC0) |
| | $\phi_5$ | 0 | 0 | 0 | 0 | SHIFT RIGHT, ADD |
| | $\phi_7$ | 1 | 0 | 1 | 1 | (AC0)←(R bus) |

to the content of AC0, then shift the result in AC0 1 bit right if MR − LSB = 1.

The two pseudo-microinstructions can now be translated into the required RALU control signals with the code definitions in Table 1. The result is a truth table (Table 2) that yields these logic equations:

$$NCB0 = \phi_1 + \phi_3 + \phi_7$$
$$NCB1 = \phi_{1S} + \phi_3 + \phi_7$$
$$NCB2 = \phi_{1S}$$
$$NCB3 = \phi_1 + \phi_3 + \phi_7,$$

where $\phi_{1S}$ denotes the clock phase, $\phi_1$, switched by the multiplier LSB.

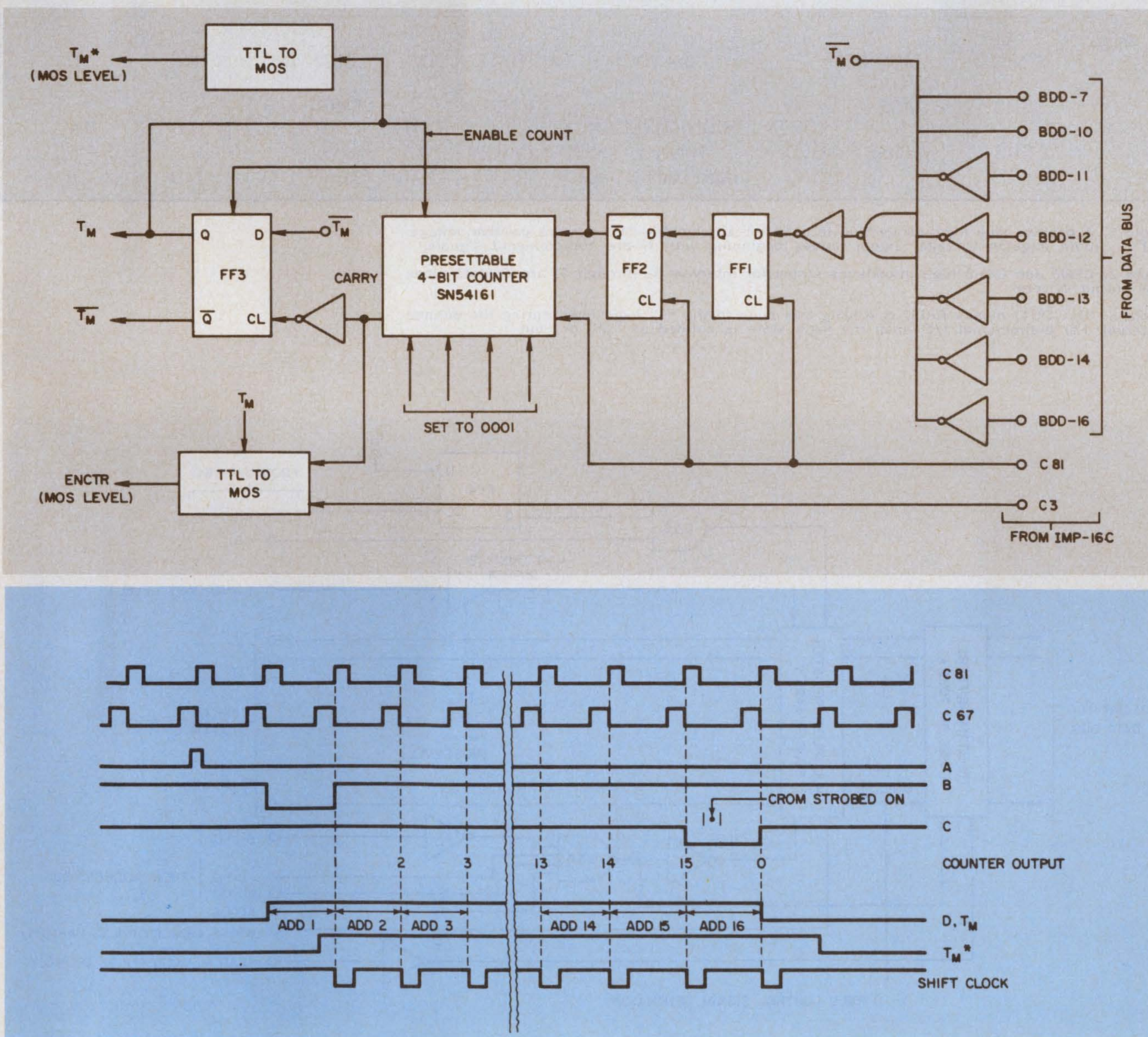
### The problem: Interfacing and timing

Implementing these logic equations in either TTL or MOS levels would be a cinch. However, the RALU and CROM have both types of inputs and outputs, even though the chips use MOS techniques. The outputs may be either the standard pull-up/pull-down types, open collector or Tristate.

As shown in Table 3, some of the RALU control signals perform different functions within the eight time periods of 1 microcycle. For example, CSHO (carry-shift-zero) accepts a carry input during period $T_5$ and outputs the shift pulse during $T_8$. Also, the NCBX signals are always driven to logic ZERO during even clock phases.

The timing of these signals is very critical. For example, the carry output signal (CSHO) is guaranteed to be available only during the last 70 ns of $T_8$. Similarly the pseudo-NCBX signal cannot be delayed by more than 85 ns from the start of the clock phase.

Consequently logic levels, impedances and the




3. **The 16-clock $T_M$ period** is generated when the multiplication op code is detected. FF2 provides an inverted pulse that presets the counter to 0001. Unless otherwise indicated, TTL circuits and levels are implied.

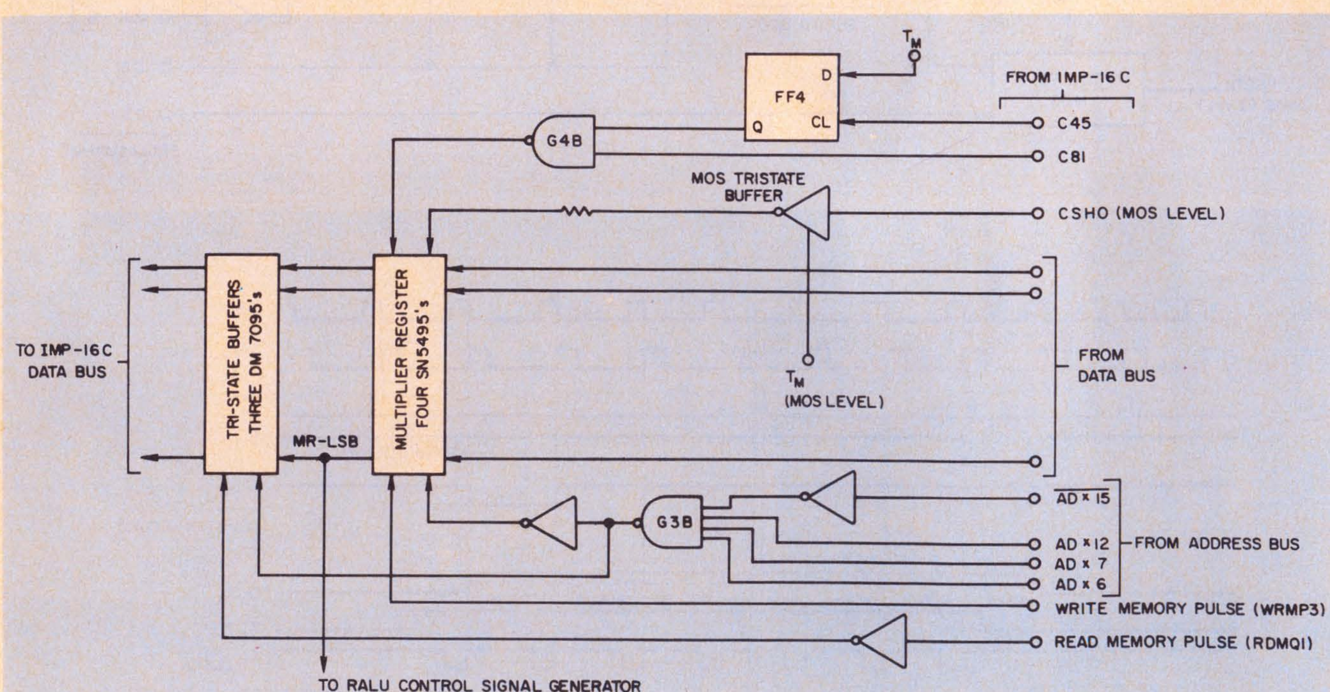
# Table 3. Critical timing for the RALU

| Signals | Logic levels | T1 | T2 | T3 | T4 | T5 | T6 | T7 | T8 | Pin function | Pin No. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Clocks** | | | | | | | | | | | |
| $\phi_1$ | MOS | | | | | | | | | IN | 2 |
| $\phi_2$ | MOS | | | | | | | | | IN | 1 |
| $\phi_3$ | MOS | | | | | | | | | IN | 23 |
| $\phi_4$ | MOS | | | | | | | | | IN | 22 |
| **Command** | | | | | | | | | | | |
| NCB(0) | MOS | $\overline{A0}$ | "0" | $\overline{B0}$ | "0" | $\overline{ALU0}$ | "0" | $\overline{R0}$ | "0" | IN | 21 |
| NCB(1) | MOS | $\overline{A1}$ | "0" | $\overline{B1}$ | "0" | $\overline{ALU1}$ | "0" | $\overline{R1}$ | "0" | IN | 19 |
| NCB(2) | MOS | $\overline{A2}$ | "0" | $\overline{B2}$ | "0" | $\overline{CTL0}$ | "0" | $\overline{R2}$ | "0" | IN | 18 |
| NCB(3) | MOS | $\overline{STACK}$ | "0" | $\overline{COMP}$ | "0" | $\overline{CTL1}$ | "0" | $\overline{I/O}$ | "0" | IN | 20 |
| **Data** | | | | | | | | | | | |
| DATA(0),(1),(2),(3) | TTL | R BUS (OUT) | | A BUS(OUT) | | "1" (OUT)[3] | | DATA INPUT | "1" (OUT) | I/O | 17, 5, 4, 7 |
| **Control** | | | | | | | | | | | |
| FLAG | TTL | ← FLAG → | | ← "1" → | | | | | | OUT | 16 |
| **Misc** | | | | | | | | | | | |
| SININ | MOS T5 TTL T7 | ← Don't Care (DC) → | | | | BYTE | DC | SIGN | DC | IN | 10 |
| CSH0 | MOS | "1" (OUT) | HIGH IMPEDANCE[2] | | | CARRY (IN) | "1" (OUT) | $\overline{SHIFT}$ I/O | | I/O | 14 |
| CSH3 | MOS | OVCEN (IN) | HIGH IMPEDANCE | | "0" (OUT) | CARRY (OUT) | "1" (OUT) | $\overline{SHIFT}$ I/O | | I/O | 11 |

Note 1. A positive true logic convention is used for all signals—"1" = more positive voltage, "0" = more negative voltage. Signal names beginning with N are complementd signals.

Note 2. CSH0 and CSH3 high impedance states for intervals $T_2$ through $T_4$ are Tristate mode for output drivers.

Note 3. "1" (OUT) means RALU is driving this node to the "1" logic level during the defined interval. For bidirectional I/O lines the logic state is defined as "in" or "out."




4. **The external multiplier register** first stores the multiplier operand, then shifts it right 1 bit per microcycle, and then injects the least-significant partial product bits. After 16 microcycles, the register contains the 16 LSB double-precision product. The multiplier register employs four 4-bit universal shift registers.

timing of all signals to and from the IMP-16C play a critical role in the hardware multiplication operation. The problem is aggravated by the fact that the speed required—a 6.5-MHz clock—is beyond the capabilities of most available standard SSI and MSI/MOS circuits.

To bridge this interface gap, one MOS-to-TTL and four TTL-to-MOS converters are needed, all of which must switch in less than 50 ns. The MOS-to-TTL conversion is relatively simple; it can be accomplished with a standard CMOS inverter. The TTL-to-MOS—+5 to −12 V—converters require capability to AND two TTL-input signals and to have an open-collector output that pulls low.

The NCBX line drivers present another interface problem. The signals must have MOS levels, and they must be connected to the bus only during $T_M$. Yet they must switch in less than 50 ns. The Motorola MC 14502 strobed hex inverter provides three-state output, the +5 to −12 V levels and the high speed.

## The solution

The timing generator is initiated when the multiplication op code appears on the data bus (Fig. 3). Data bits 7, 10, $\overline{11}$, $\overline{12}$, $\overline{13}$, $\overline{14}$ and $\overline{15}$ are ANDed at the data input of a two-stage shift register (FF1 and FF2), which is clocked with the leading edge of clock period $C_{81}$ (waveform A). The Q output of FF2 is thus an inverted pulse, exactly 1 microcycle wide and starting 1 microcycle after the decoded op code is clocked into FF1 (waveform B).

The inverted pulse presets the 4-bit counter to 0001 and FF3 to Q = 1. Thereafter the counter increments with every $C_{81}$ pulse until count 15 is reached and a carry is generated (waveform C). The trailing edge of the carry pulse resets the FF3 Q output and the period $T_M$ back to zero (waveform D). Thus the $T_M$ interval is exactly 16 microcycles wide. To produce the clock pulses for shifting the MR register, $T_M$ is reclocked with $C_{45}$ and gated with $C_{81}$.

The enable control pulse (ENCTL) is produced by gating $\phi_3$ with the carry pulse, but it is connected to the ENCTL line only during $T_M$. Its purpose is to turn the CROM back on so it will fetch the next instruction and continue with the macro program. The three flip-flops, FF1 to FF3, are reset by the system clear pulse, SYCLR, to ensure that they are in the reset state following power turn on.

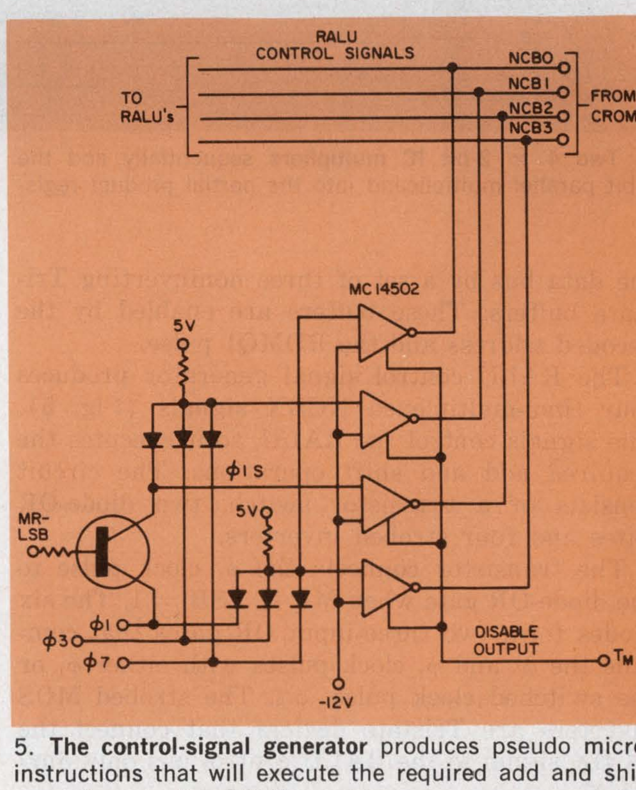
A 16-bit parallel-in/parallel-out register that shifts to the right is used to store the multiplier (Fig. 4). Its functions are to store the multiplier operand, to shift it 1 bit right every microcycle and to shift the low-order product bit on the CSHO line into the register. After 16 microcycles, the register contains the 16 least-significant bits of the double-precision product.

The register employs four 4-bit universal shift registers and three Tristate hex buffers. The multiplier operand is loaded into the MR register prior to the actual multiplication operation (before $T_M$), with a macro STORE instruction that addresses the register as if it were another memory location. The use of specific memory addresses for peripheral devices has an advantage: The access is faster, and all memory-reference instructions can be used.

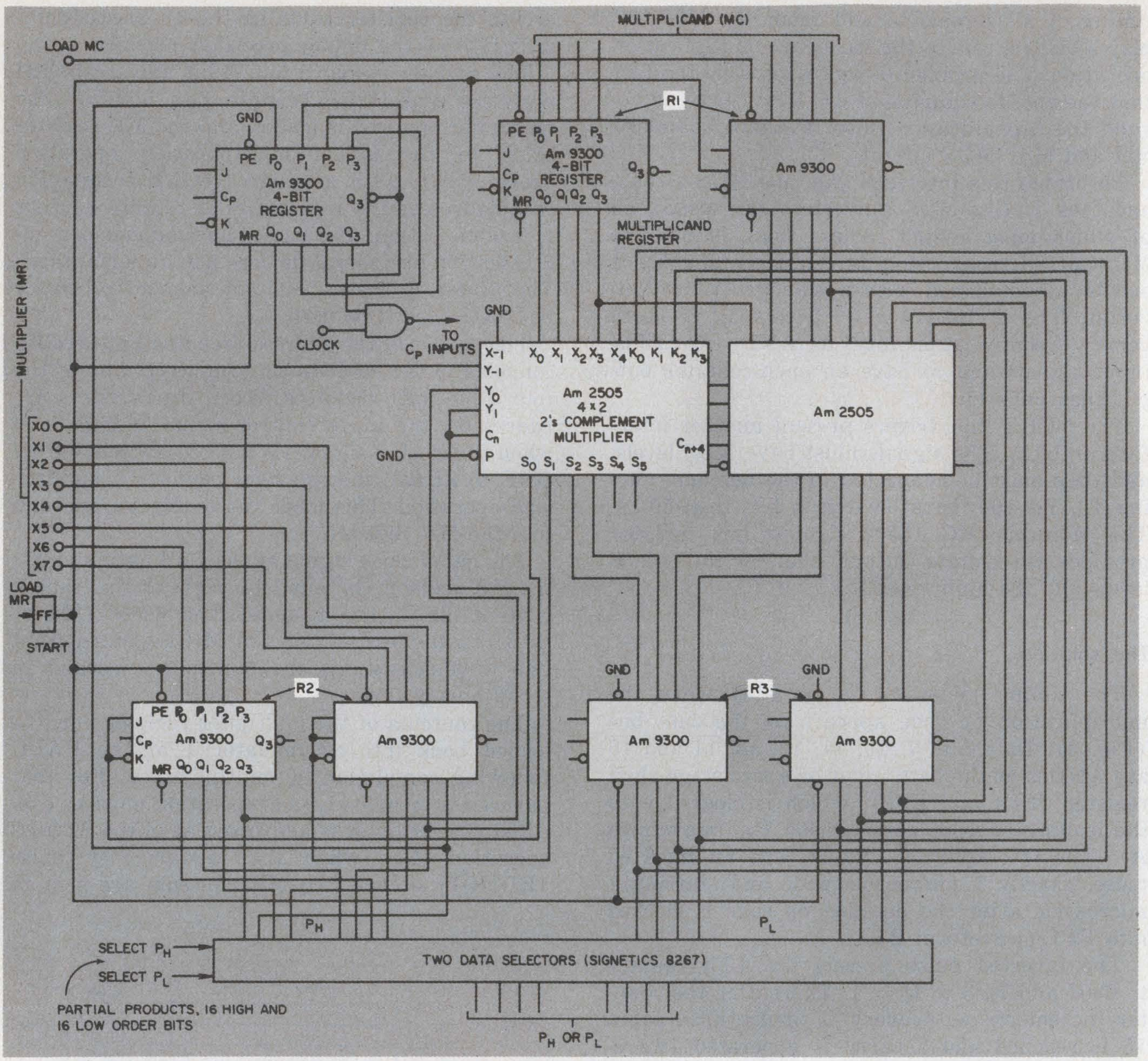
The output of the address-decoding gate (G3B) connects to the mode-control input (pin 6) of the four 4-bit shift registers. When the registers are addressed, the mode control signal is high, and when the clock-2 signal (WRMP3) switches from ONE to ZERO, the registers perform a parallel-load operation. This loads the multiplier operand into the MR register.

The gated clock signal at the G4B output shifts the MR register content 1 bit right at the leading edge of the $C_{81}$ timing pulse. The signal (MR − LSB) on the least-significant MR register output line thus constitutes the multiplier operand in serial-binary form.

The contents of the multiplier register must be loaded back into accumulator 1 of the RALU following completion of multiplication. For that purpose, a memory LOAD operation must be executed. The register is addressed as in the STORE operation. But when the read-memory pulse (RDMQ1) occurs, the MR contents are sent to




5. **The control-signal generator** produces pseudo microinstructions that will execute the required add and shift operations in the RALU.




6. **Two 4 × 2-bit IC multipliers** sequentially add the 8-bit parallel multiplicand into the partial product register. Control of the operation is provided by the two least significant multiplier bits.

the data bus by a set of three noninverting Tristate buffers. These buffers are enabled by the decoded address and the RDMQ1 pulse.

The RALU control signal generator produces four time-multiplexed NCBX signals (Fig. 5). The signals control the RALU, so it executes the required add and shift operations. The circuit consists of a transistor switch, two diode-OR gates and four strobed inverters.

The transistor connects the $\phi_1$ clock pulse to the diode-OR gate when MR − LSB = 1. The six diodes form two three-input OR gates that combine the $\phi_3$ and $\phi_7$ clock pulses with either $\phi_1$ or the switched clock pulse, $\phi_{1S}$. The strobed MOS inverters are Tristate devices that connect the NCBX signal to the RALU control bus only during $T_M$.

Though peripheral multipliers can be built with a number of available MSI ICs, only serial-parallel (rather than all-parallel) multipliers are cost and speed-compatible with microprocessors. The 4 × 2-bit IC multiplier[2] in Fig. 6 is an example.

The 8 × 8-bit peripheral multiplier consists of three single-length registers, a 2 × 8-bit multiplier, an output data selector and some addressing and control logic. Register $R_1$ holds the multiplicand, while register $R_2$ holds the multiplier. Double-precision products are stored in registers $R_2$ and $R_3$.

At the start of multiplication, the multiplicand and multiplier are loaded into registers $R_1$ and $R_2$, respectively. During an operation the multiplier is shifted out, 2 bits at a time, and the empty locations are filled with partial product bits.

The two Advanced Micro Devices multipliers provide a 2 × 8-bit product during each clock cycle. Under control of the two least-significant multiplier bits, the multiplicand is added with appropriate weights to the eight LSBs of the partial product. The result is then stored again in the partial-product register.

The multiplier operand and the eight most-significant partial product bits are separated into odd and even parts, each of which is loaded into one 4-bit shift register. A shift of two places can thus be obtained with one clock pulse, with each register providing one least-significant bit as an output.

Four shift operations are needed to execute 8 × 8-bit operations. This means that the basic multiplication execution time is four clock periods. Since these MSI circuits easily can operate at a clock rate of 4 MHz, the complete multiplication can be performed in 1 μs.

### Extending the technique

The technique can be extended easily to handle 16-bit multiplicand and multiplier operands and a 32-bit double-precision product. In the latter case, however, the length of all registers and of the actual multiplier must be doubled. Similarly the execution time also increases by a factor of two, since eight shift operations must be performed now.

To use a peripheral multiplier in a microprocessor system, the multiplier must operate through the data bus and be treated like any other peripheral. When multiplication is performed, the microprocessor addresses a multiplier register and specifies whether the data are to be stored or fetched.

In a typical operation, the register would first store the multiplicand and multiplier operands and then fetch the high and low product bytes. This necessitates two output and two input operations, or four macroinstructions, and this would require much more time than the actual multiplication.

In the National IMP-16, each I/O operation requires approximately 10 μs. Consequently the total multiplication execution time would be 40 μs. And for a complete 16 × 16-bit peripheral multiplier, with all the address decoding and control logic, approximately 18 MSI and eight SSI integrated circuits are required. ■■

**References**

1. IMP-16C Application Manual, 4200021B, National Semiconductor Corp., Santa Clara, CA, 1973.

2. Ghest, R. C., "A Two's Complement Digital Multiplier," Application Note, Advanced Micro Devices Corp., Sunnyvale, CA, 1971.

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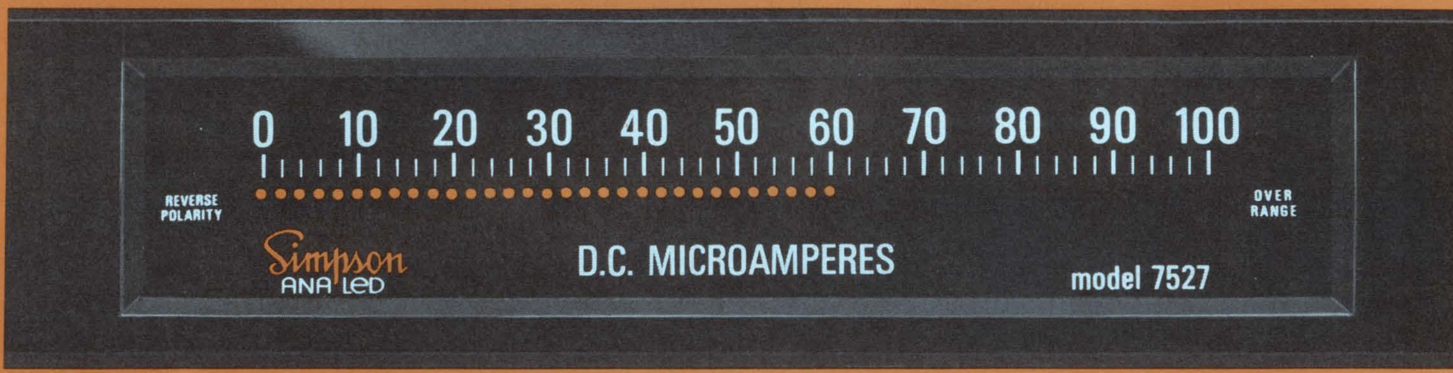


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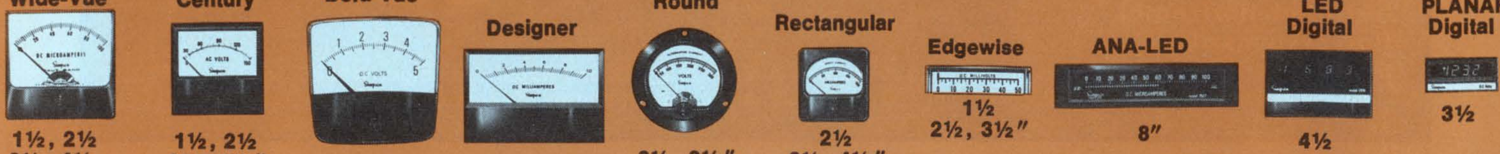

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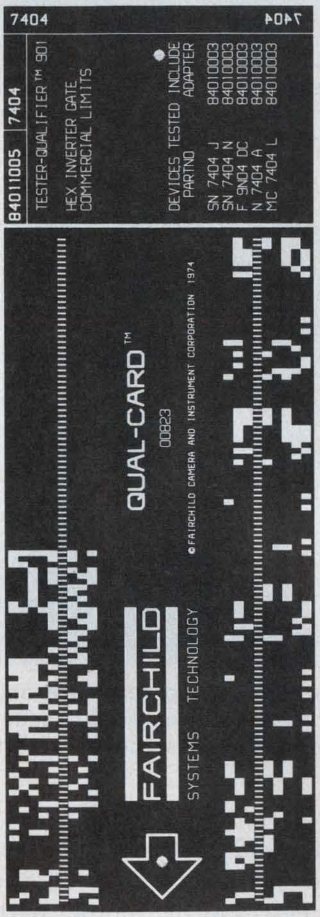


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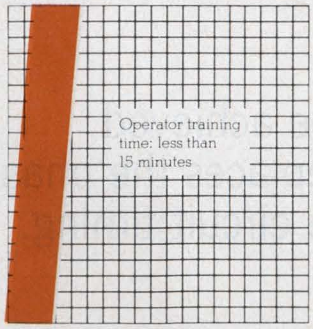


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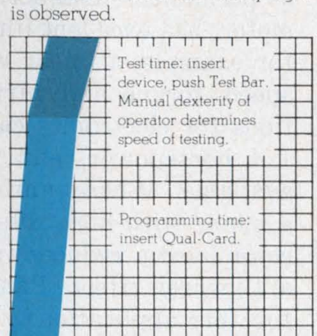


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We've added a new option to the Qualifier 901: A digital readout (DRO) for first level analysis of voltage and current. More than expanded function, there's the true beauty of simplicity in the DRO option. Analysis as simple and foolproof as Qualifier 901 go/no-go testing.

Actually, there are two uses for the DRO. One is to monitor voltage levels of the +15 and −15 power supplies — from which analog voltages and currents are derived to be applied to the device. A reading is taken at the reference point of the system to indicate if the supplies are operating and properly adjusted.

The main function of the DRO option is to measure and digitally display the voltage or current of a device on test in a FAIL condition.

Let's pick up the analysis procedure from the last step of go/no-go testing. A red light indicates FAIL condition. The Qualifier 901 is in the STOP and FAIL mode, and on PROTECTIVE OVERRIDE. The operator pushes the START switch.

Qual-Card programming takes over. The program searches out the first failure and stops. An indicator lights opposite the appropriate pin number on a grid display.

The operator turns a pin selector rotary switch until the two digit display matches the pin number lit on the grid display. That's all. The FAIL pin is correctly identified.

Purposefully, there are no pin identification numbers for the positions of the selector switch. The Qualifier 901 is a universal tester and pin numbers change from device to device, up to the 24-pin capacity. Pin selection, a confusing and error-prone task if left to the operator, is processed simply by Qual-Card programming.

Once the pin numbers are matched, the operator turns to the function range switch, and selects the appropriate parameter that should be measured, whether voltage or current.

To emphasize: the DRO option automatically converts from the fixed rotary positions of the pin selector via a microprocessor to actually map the pins of the device. The DRO tells the operator which pin he's on — not vice-versa. There is no way to test the wrong pin.

The DRO option: analysis as foolproof as go/no-go testing.

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INFORMATION RETRIEVAL NUMBER 31

# **Motor control by PLL** can be achieved with a microprocessor. Software replaces the phase detector, and the internal clock provides the circuit timing.

Microprocessors can offer important advantages in phase-locked loops for dc motor control. Though unusual, this all digital technique proves straightforward and effective for these reasons:

- The fixed cycle time of the processor is derived from a crystal-controlled clock. Use of this consistent timing provides the system accuracy.
- A digital PLL that uses pulse-width modulation performs a count-and-compare function. The processor's arithmetic and branching capabilities are admirably suited to perform these tasks.

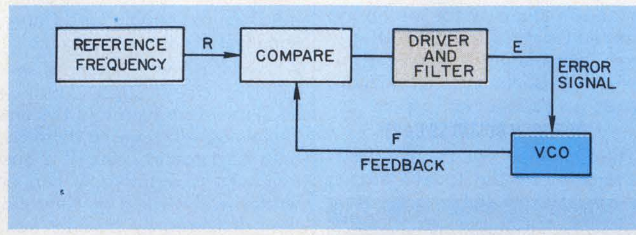
A phase-locked loop consists of a reference frequency generator, phase comparator, loop filter and voltage controlled oscillator (Fig. 1). The circuit places the VCO frequency into step with the reference frequency. The loop begins to correct whenever the output phase drifts away from that of the reference. An error-correcting voltage, computed by the phase comparator, causes the VCO phase to realign with the reference.

### Motor becomes the VCO

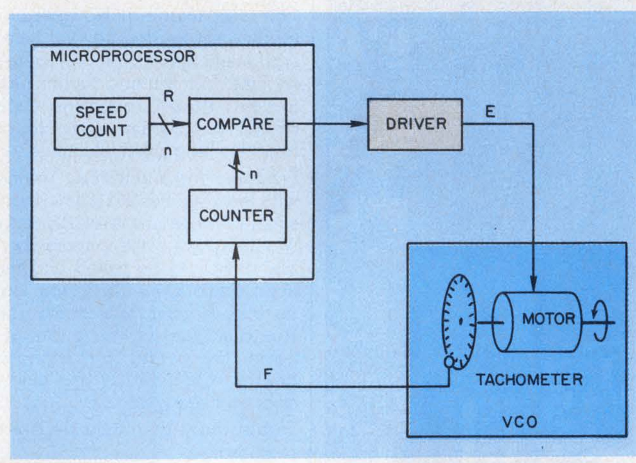
Substitution of a motor-tachometer for the VCO extends the circuit to motor control. As with the nonmechanical counterpart, the design calls for two operating modes: vernier in-lock and out-of-lock. In the first situation, the VCO (or motor) is merely out of phase with the reference but at the correct frequency or rotational speed. Low-duty-cycle dc pulses provide the needed correction. But when the output frequency is very different—as when the load on the motor changes suddenly—the circuit applies a gross error-correction voltage to alter the speed as quickly as possible.

With the microcomputer approach, the processor computes reference and error signal to better than 0.1%—thanks to crystal-derived timing and the consistent time intervals of all software instructions (Fig. 2).

**Howard A. Raphael,** Product Manager, Microcomputer Systems, Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051.



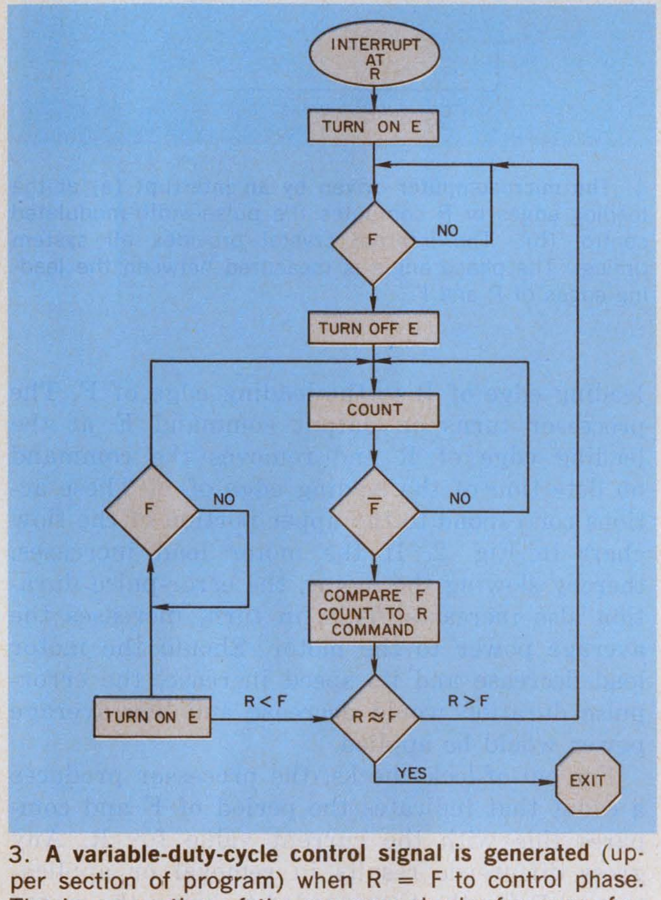

1. **A conventional phase-lock loop** makes the VCO frequency track that of a reference. For use with motor control, the VCO block is replaced by a motor-tachometer; comparator operation is not changed.




2. **A microcomputer furnishes the speed reference** and also performs phase and frequency comparisons under program control. Motor inertia provides the necessary loop filter.

The motor, tachometer and motor driver replace the VCO and the low-pass filter of the conventional electronic PLL. A dc motor with a permanent magnet stator, or a Hall-effect motor, has excellent linear VCO characteristics—for example, a linear relationship exists between speed, torque and current. Most motor applications for electronics call for ratings of less than 1/4 horsepower, and these motors are readily available. Where uniform velocity is required, a motor with high rotor inertia is desirable. The rotor inertia reduces variations in speed through a flywheel effect. Pancake motors are excellent for this application.

Any first-order servo requires a feedback




3. **A variable-duty-cycle control signal is generated** (upper section of program) when R = F to control phase. The lower portion of the program checks for gross frequency error by counting for the duration of clock pulse F and comparing the count with the command value.

path. In this case it is from a digital tachometer attached to the motor shaft. The tachometer resolution—the number of pulses in a revolution per unit of time—should be sufficient to monitor the intended speeds. For high speeds, a coarse track of 100 to 1000 pulse per revolution suffices. For slow speed, 1000 pulses are appropriate.

One popular form of optical tachometer makes use of a rotary disc with transparent sections of equal size plus a light source and phototransistor. But be sure that the unit you choose provides a symmetrical pulse train.

The conventional low-pass filter is omitted (Fig. 2). Instead motor inertia serves to reduce (filter) incremental variations in the motor-control signal that cause speed pulsations.

To perform the comparison function between the feedback and reference, the microcomputer must compute the frequency of the tachometer feedback signal, which is proportional to the motor velocity, and compare it with the reference frequency. This is done by counting the duration of one of the tachometer signal periods. Since the tachometer signal has a 50% duty cycle over the speed range of interest, counting over half the period will suffice.

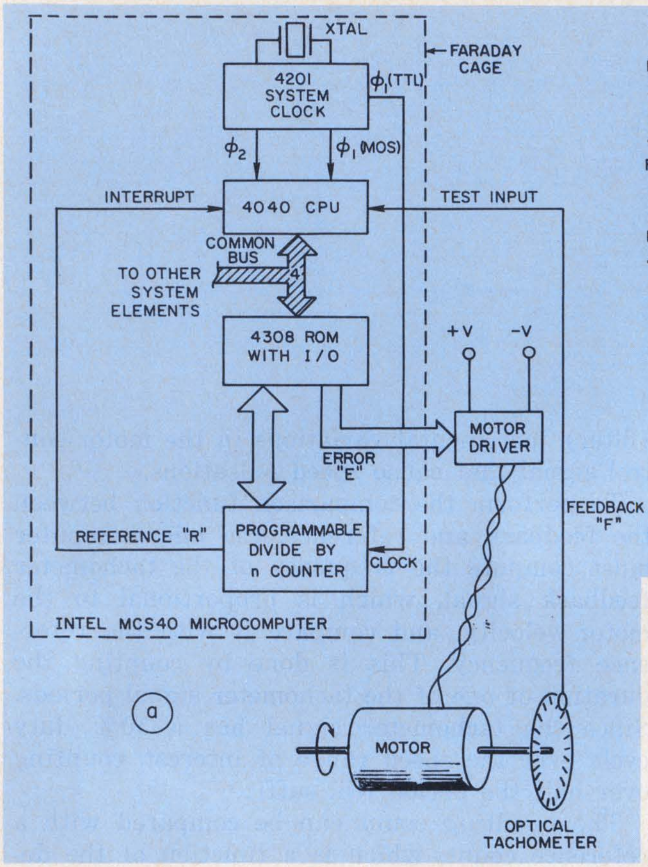
The resulting count can be compared with a reference count, which is a function of the desired speed. If the count is larger than the reference count, the motor is running too slow and power must be applied. If the count is less than the reference count, the motor is running too fast and power must be reduced.

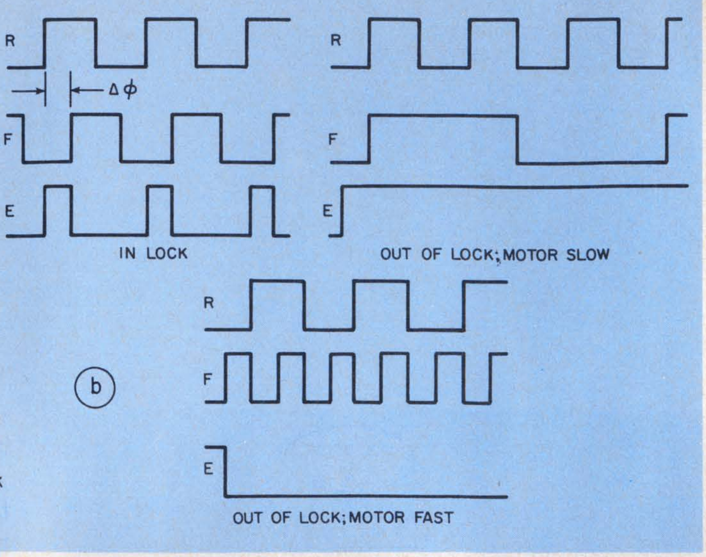
### The processor uses a dual strategy

A count tolerance establishes the boundary between in-lock operation and gross error correction for the out-of-lock condition. Periodic bursts of full power of a prescribed rate keep the motor in step with the reference. Large differences between reference period and tachometer output period result in the application of full output power or none to the motor, until the difference again falls into the tolerance band (Fig. 3). By this means, the motor is brought into phase-lock as quickly as possible. The loop responds to changes in reference frequency at a rate that corresponds to the signal bandwidth of the motor.

A dedicated series of microinstructions implements the strategy (Fig. 3).

The computer cycle time and number of instructions used limit the maximum speed at which the processor can maintain synchronization. The speed limit depends on the microcomputer used, since cycle times vary. Typical figures are 200 ns for bipolar chip sets, 2 μs for NMOS device sets, and 5 to 10 μs for PMOS microcomputers. If you operate a motor at, say, 600 rpm or 10 rps and the tachometer provides




4. **The microcomputer driven by an interrupt** (a) at the leading edges of R computes the pulse-width-modulated control (b). The internal crystal provides all system timing. The phase angle is measured between the leading edges of R and F.

100 pulses per revolution, the response frequency is 1 kHz, a period of approximately 1 ms. Since the processor computes only during half of this period, the self-imposed program duration is 500 $\mu$s. A microcomputer with a cycle time of 200 ns could execute 2500 instructions. If the microcomputer has a cycle time of 10 $\mu$s, only 50 instructions can be executed within the time frame. Since computing for the PLL is done during one-half of the reference period, the other half can be used by the processor for other system tasks. This analysis assumes that a uniform phase difference is acceptable between an arbitrary reference and the feedback signal.

### Implicit or explicit reference?

The explicit-reference technique is one of two suitable for implementation with a microcomputer. An external reference source, such as a series of programmable counters, furnishes a clock train that the motor locks onto. With the implicit scheme, the processor calculates the desired rotation period, then forces the motor to conform. No phase angle is used.

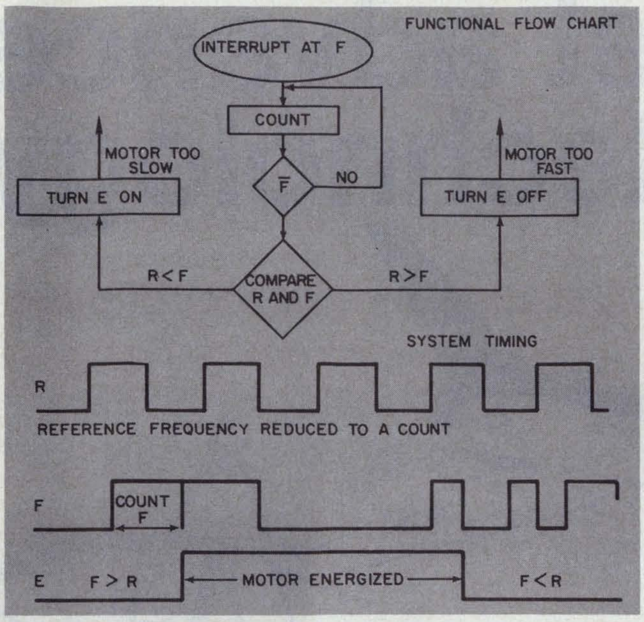
First consider the explicit technique (Fig. 4a). The clock signal or reference clock is labeled R and that of the feedback clock F. Speed synchronization occurs when $f_R = f_F$, although a phase difference may exist between the two signals. This phase difference is measured from the leading edge of R to the leading edge of F. The processor turns on output command E at the leading edge of R and removes the command on detection of the leading edge of F. These actions correspond to the upper portion of the flow chart in Fig. 2. If the motor load increases, thereby slowing the motor, the error-pulse duration also increases. This, in turn, increases the average power to the motor. Should the motor load decrease and its speed increase, the error-pulse duration would decrease and less average power would be applied.

For out-of-lock checks, the processor produces a count that indicates the period of F and compares this with the current value for R. Any gross difference results in removal or application of E for the time needed to bring the motor into lock (bottom half of Fig. 2).

To calculate the count, the processor executes a software loop with a fixed number of instructions. Each execution of the loop takes a small, but fixed, interval of time. The loop is executed only while F is present. The number of executions, as counted by an increment-by-one instruction in the loop, equals the period of F.

It is unlikely that the counts for F and R will ever agree precisely. Therefore a tolerance is used so that F equals R plus or minus a count of n, where n is small relative to a count of 1/2 F or R. The resolution of the tachometer count and the response to changes of load on the motor determine what value to use.

For example, if a motor with a high rotor-inertia load is used, the load will provide a flywheel effect to reduce speed pulsations; hence




5. **If the only concern is motor speed,** an internally computed reference can be compared with the tachometer period. The operation resembles that of the PLL circuit in an out-of-lock condition.

the motor speed will always be within a very narrow count of R for a generally static load. If the motor has low inertia, precise synchronism will be harder to maintain. Hence a wider tolerance is desirable. If $T_R > T_F$, indicating that the motor is going too fast, power is removed until F gets back in tolerance. If $T_R < T_F$, indicating the motor is going too slow, full power is applied to the motor to bring its speed into tolerance.

A continuous error-correction signal is not necessary to obtain synchronous speeds for motors with large internal inertia. Once a specific speed is achieved, the flywheel effect of the motor absorbs any variations in load or energy input. Without need to correct for phase, the free-running reference clock becomes unnecessary. Only the reference frequency count is required to maintain speed.

The F signal half-period value is counted and compared with the reference count. If $R < F$, the error signal is applied. If $R > F$, the error signal is removed (Fig. 5). The alternate application and removal of energy must not cause the motor to pulsate. To change speed with this scheme, simply change the reference count, and a different comparison is in effect. Changes in direction are also easily initiated by alternate applications of positive or negative potential to the motor. ■■

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# **Cool through turbulence** with lightweight wire-mesh transpiration panels. They conserve space, take almost any shape and provide quiet operation.

A gas, such as air, passes through a porous-metal heat sink. The gas cools the sink and its attachments. Turbulent flow that results from the tortuous passage of gas through the porous metal produces a high heat-transfer coefficient to the gas.

The technique is known as transpiration cooling. The turbulence breaks up stagnant boundary layers of laminar flow that impede heat transfer to the cooling medium.

Though this technique of porous-metal heat transfer is well-established in aeronautical engineering, it is only now beginning to make inroads in the electronics industry. In electronic assemblies, components are mounted on panels made of layers of wire mesh. The layers are bonded together by a sintering process to provide the equivalent of porous-metal air channels.

### Wire-mesh panels create turbulence

The mesh openings are staggered for maximum turbulence. A typical wire is 0.025 in. in diameter, and the mesh has 0.1-in.-sq. spacing—about the dimensions of window screening. Six layers of the mesh are about 1/8-in. thick. A high-emissivity coating applied to completed mesh panels improves radiation heat transfer.

Copper mesh is usually used in electronic assemblies because of its high thermal conductivity. But for high temperatures, stainless-steel mesh is more durable. Material with high thermal conductivity is desirable to reduce the temperature differences between the cooling gas and components mounted on the mesh.

Transpiration panels can be fabricated into many shapes and sizes. The basic sheet form (Fig. 1) is usually 20 × 45 in. and 1/8 to 1/2-in. thick. This can be cut and shaped to almost any geometry. The more familiar extruded-fin heat sink, on the other hand, is limited by its mechanical rigidity and bulk.

A section of a 10-layer wire laminate offers six times the cooling surface of an extruded smooth fin of equal envelope dimensions (Fig. 2). The heat-transfer surface is included within the bulk of the laminate. However with a solid fin, the space required is that taken by the bulk of the fin and the air space alongside it, but only the outer surface of the fin is heat-transfer area.

An important advantage of transpiration cooling is that it allows easy optimization of the space requirements. To improve laminate conductivity, thicker laminate can be used; to increase convection heat transfer, a tighter mesh can be selected. However, the size of the cooler can remain the same.

With extruded-section heat sinks, the preponderance of metal may provide a low thermal resistive path, but there also is a shortage of convection surface. And the relationship between bulk and surface is hard to change.

By contrast, transpiration panels consist largely of voids, thus their density is low—about 0.1 $lb/in^3$, compared with 0.3 $lb/in^3$ for solid copper. They are typically 25% smaller and about 35% lighter than conventional finned heat sinks. Finished panels are easily incorporated into cooling assemblies, with blowers and components readily arranged for convenient air ducting and efficient space allotment (Fig. 3).

The panel configuration lends itself to easy fabrication of structural walls and case enclosures—so called cold-wall cooling. Also, the panels provide excellent shielding against electromagnetic interference.

An extra bonus is noise-free operation. The low-velocity gas flows quietly through the mesh-metal passages. Also, the baffling action of large-area diffusion reduces noises normally generated by fans or blowers. Use of low air velocity is possible, because the technique attains turbulence by maximizing air-passage obstruction. More conventional air cooling requires far greater velocities for the same degree of turbulence.

Low air velocity and large cooling surface are associated with a low Reynolds number—a dimensionless number that can be defined in pipes and channels as

$$R_N = \frac{Lv\rho}{\mu}, \text{ or } \frac{\text{impulse forces}}{\text{laminar viscous forces}}$$

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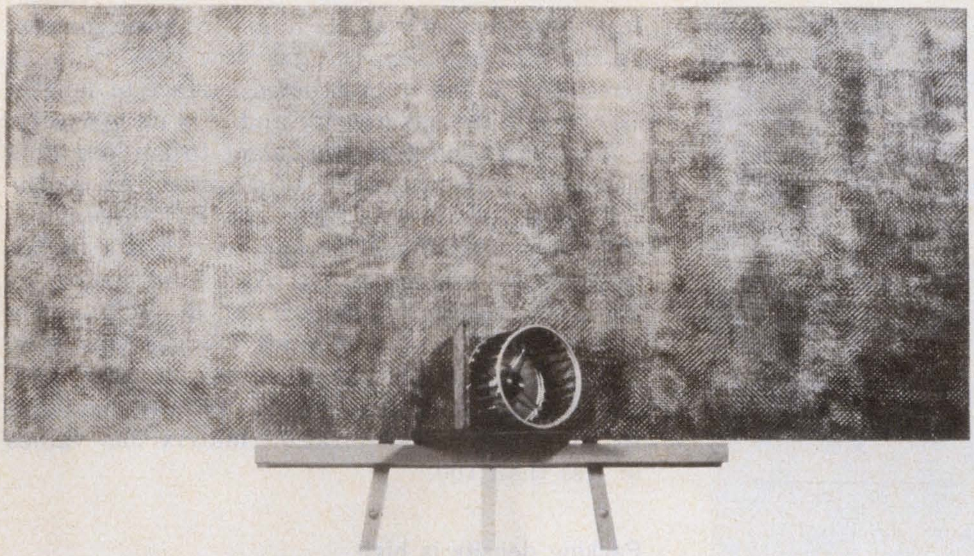
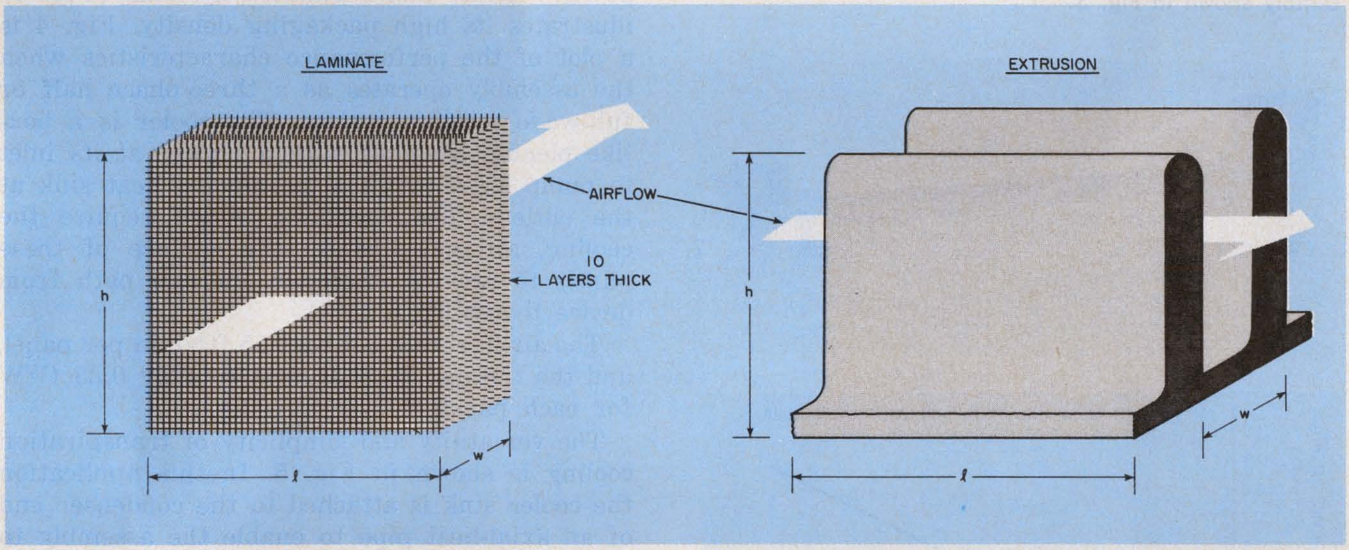
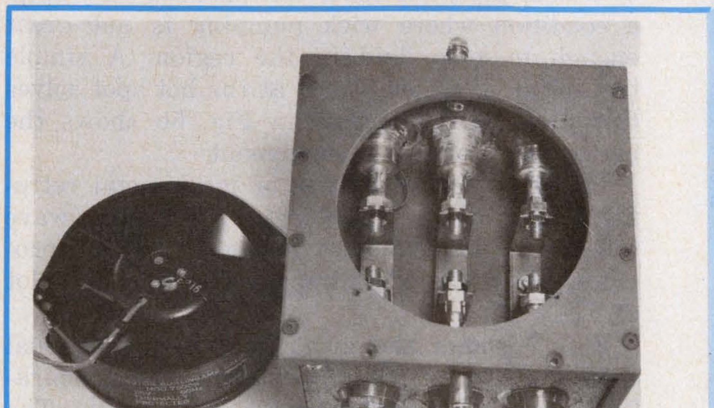


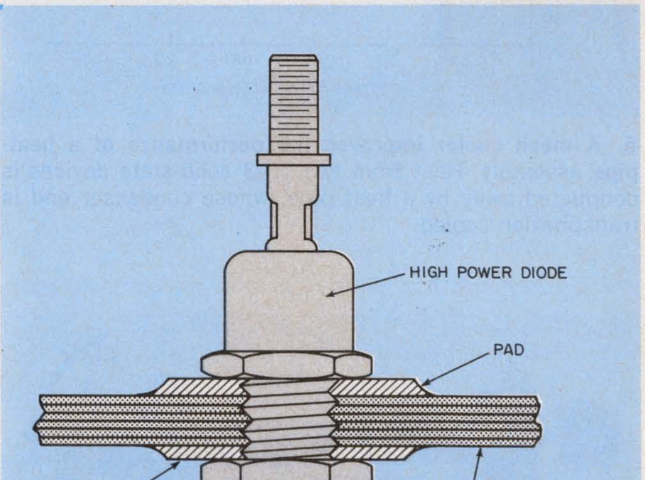
1. **Transpiration panels** consist of several staggered layers of wire mesh—copper is strongly suggested—sintered together. Basic panel laminates are usually 20 × 45 in. by 1/8-to-1/2-in. thick, and they can be cut and shaped to almost any configuration.

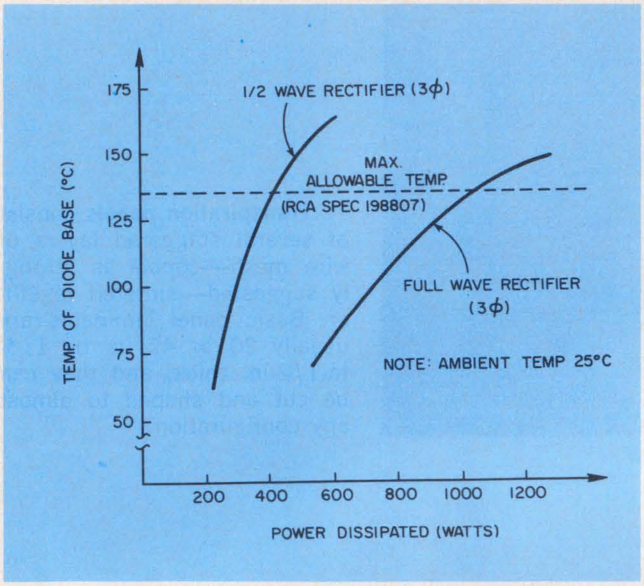



2. **The cooling surface of a laminated panel** is at least six times greater than that provided by an extruded fin with equal space requirements. And turbulent flow in the panels further increases heat transfer.

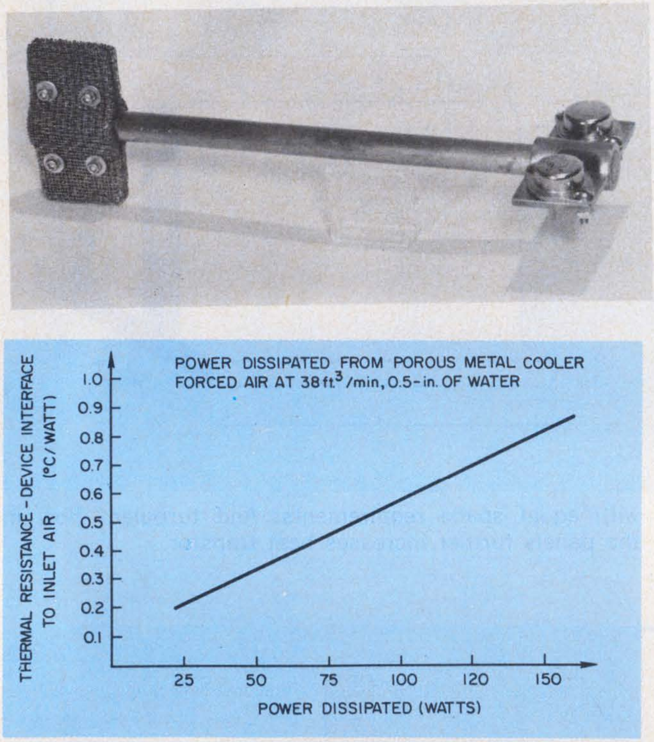


3. **In this three-phase, full-wave power-rectifier assembly,** six power diodes are mounted on panels that provide low thermal resistance to the cooling air. A half-wave unit would need only three diodes and a single panel.






4. **The cooling performance** of the power-rectifier assembly shown in Fig. 3.




5. **A mesh cooler improves the performance of a heat-pipe assembly.** Heat from two TO-3 solid-state devices is conducted away by a heat pipe, whose condenser end is transpiration-cooled.

6. **A transpiration cooler is easily retrofitted** to a traveling-wave tube. Its performance curve is similar to that of the cooler shown in Fig. 5.

in a more general way, as in a wire-mesh matrix. In the pipe equation the gas flow velocity, v, is parallel to a flat, unobstructed surface of length, L, and $\rho$ is the gas density and $\mu$ is its viscosity.

The transition from turbulent to laminar flow depends on the critical $R_N$ of a system. Above the critical $R_N$, the flow is turbulent. But fortunately the transpiration matrix surfaces create turbulence at low values of $R_N$. And fluid-mechanics engineers associate low critical $R_N$ with easily attained good mixing at quiet, low-gas velocities.

The familiar smooth-fin-extrusion heat sink usually has a critical $R_N$ of several thousand in air, but the transpiration matrix has values of less than 100.

## Packing density is high

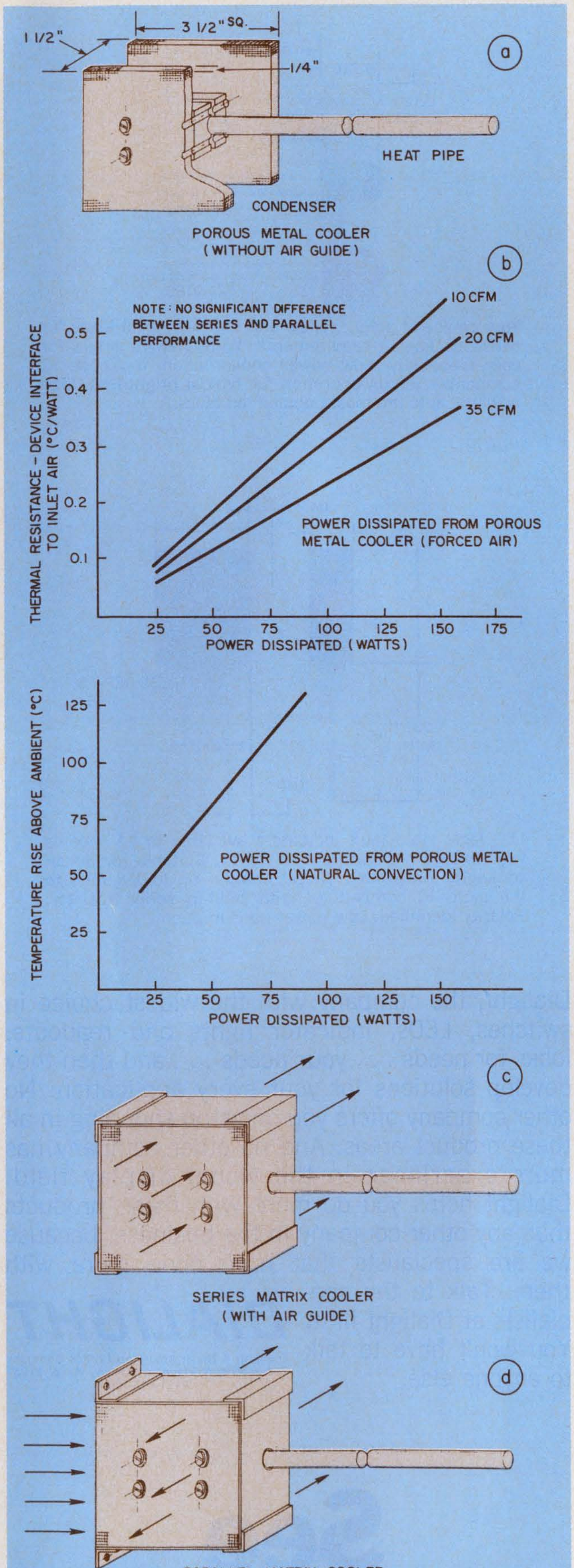
The transpiration-cooling assembly for a high-power rectifier and regulation systems (Fig. 3) illustrates its high packaging density. Fig. 4 is a plot of the performance characteristics when the assembly operates as a three-phase half or full-wave rectifier system. The cooler is a box-like plenum chamber with a blower at its inlet to pump air through a mesh-panel heat sink at the outlets. The rectifiers, which require the cooling, are mounted on the surface of these panels to provide minimum thermal path from device to cooling air.

The air-flow rate is about 55 ft$^3$/min per panel, and the thermal resistance is roughly 0.25°C/W for each panel.

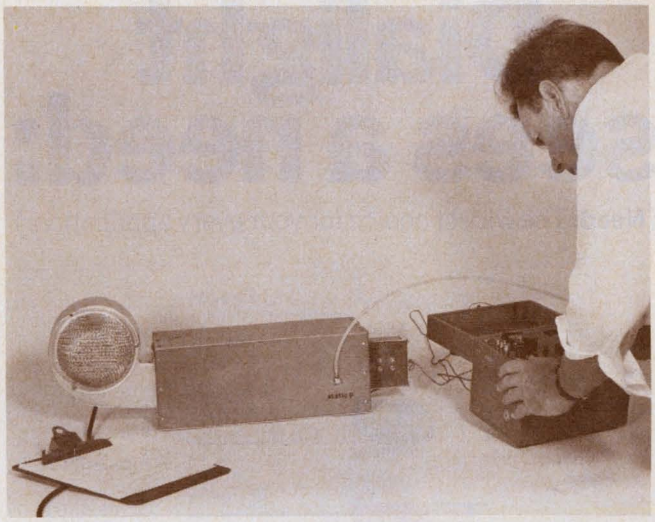
The versatility and simplicity of transpiration cooling is shown in Fig. 5. In this application the cooler sink is attached to the condenser end of an axial-heat pipe to enable the assembly to operate more effectively near the limit of its transport capacity. This technique prevents hot spots. At either the evaporator or condenser end of a heat pipe, hot spots can produce "dry-out," a condition where wick pumping is not great enough to keep fluid in the region. A simple transpiration cooler placed at the hot spot solves this problem. The graph in Fig. 5b shows the performance of this arrangement.

In Fig. 6 a small length of mesh-metal retrofitted around the collector to a traveling-wave tube—a technique similar to that in Fig. 5—provides the cooling effect approximated by the plot of Fig. 5b.

Fig. 7 shows the geometry and operational characteristics of a high-performance transpiration cooler for high-capacity heat pipes. The cooler panels are shown in Fig. 7a without air ducting. Forced air is ducted in series through the two mesh-metal sinks in Fig. 7b. In another arrangement (Fig. 7c), air enters between the two sinks and flows out in parallel. There is little difference in performance between these




7. **A high-performance condenser configuration** for a heat pipe (a). There is no performance difference (b) between series (c) and parallel (d) air-flow patterns.



8. **Test duct for transpiration coolers** provides controlled, filtered air flow to allow measurement of component temperatures with a thermocouple. The blower housing contains a washable air filter.

two configurations.

The performance of the same cooler with natural convection is also shown in the curves. This depicts what can be expected in the event of fan failure. Clearly a significant amount of heat is dissipated simply by chimney effect.

The mesh-metal heat sink has such a high heat-transfer rate to air that the chimney effect is particularly effective if the system is oriented to take advantage of natural air movement. The normal upward convection movement of lighter heated air must be allowed to take place easily; the cool heavier air must be able to displace it. Clearly, vertical open-end ducting can greatly enhance the effect.

### Dirt problems easily avoided

Of course, air pumped into a transpiration cooler should be first filtered to remove lint and other contaminates. Transpiration-panel openings are fairly large, and particles to 150 $\mu$ easily pass through. However, without a filter, a panel can soon become matted with lint and dust.[1] Many types of air filter arrangements are possible. Fig. 8 shows a washable filter mounted directly to a blower housing.

But don't try to use metal-filter materials as cooling panels. Some engineers, in an attempt at a short-cut, have tried powder-metal filter stock instead of a copper-mesh panel. Filter stock will not work very well because it is usually made of bronze, which has low thermal conductivity. Experience has shown that the most satisfactory material is a bonded copper-wire laminate. Michigan Dynamics Inc. of Detroit custom fabricates such copper-mesh bonded panels. ■■

**Reference**

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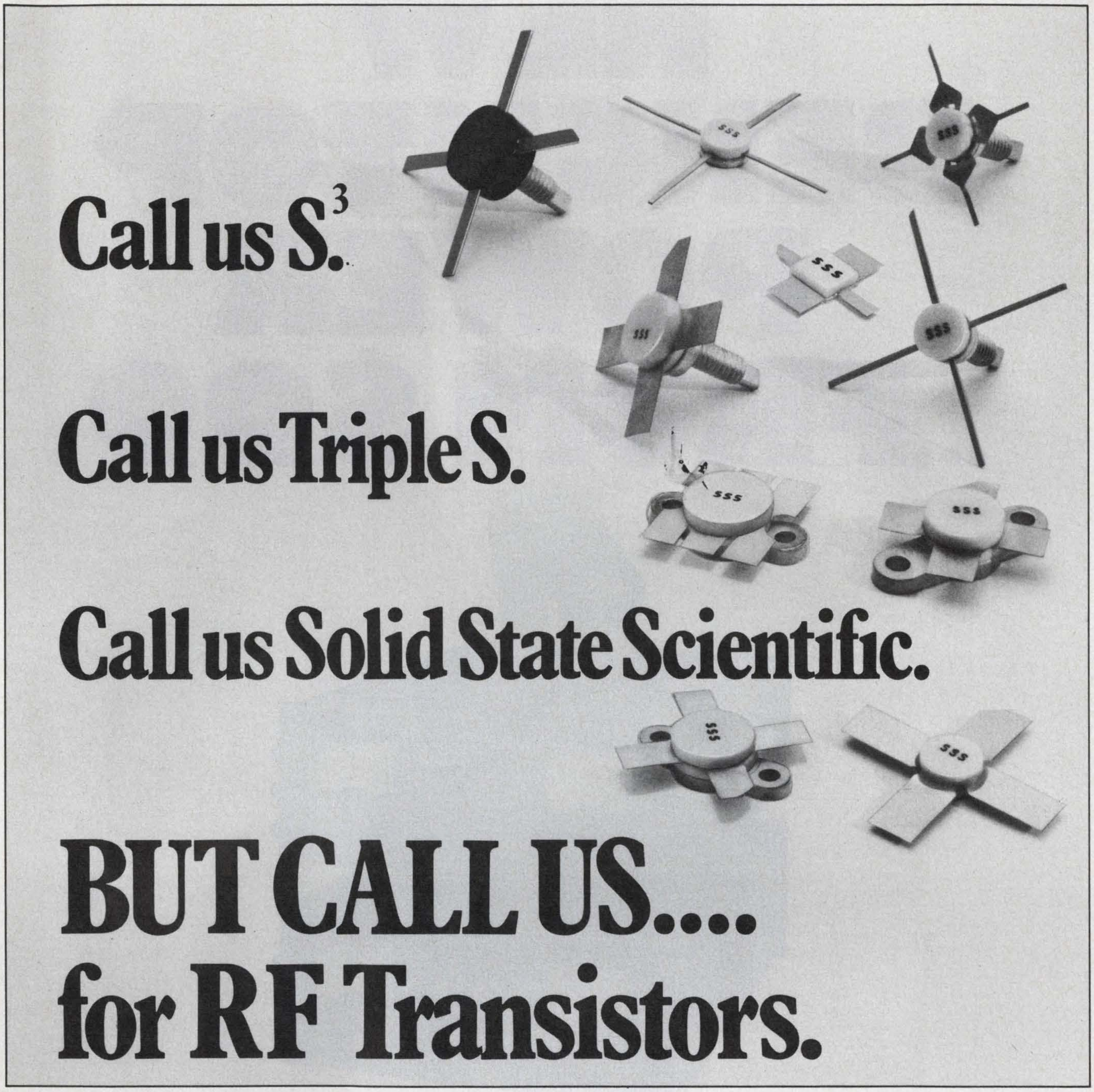
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| 0-32 | 0.35 | 99 | K32S35 |
| 0-32 | 0.6 | 120 | K32S60 |
| 0-50 | 0.35 | 120 | K50S60 |

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INFORMATION RETRIEVAL NUMBER 37

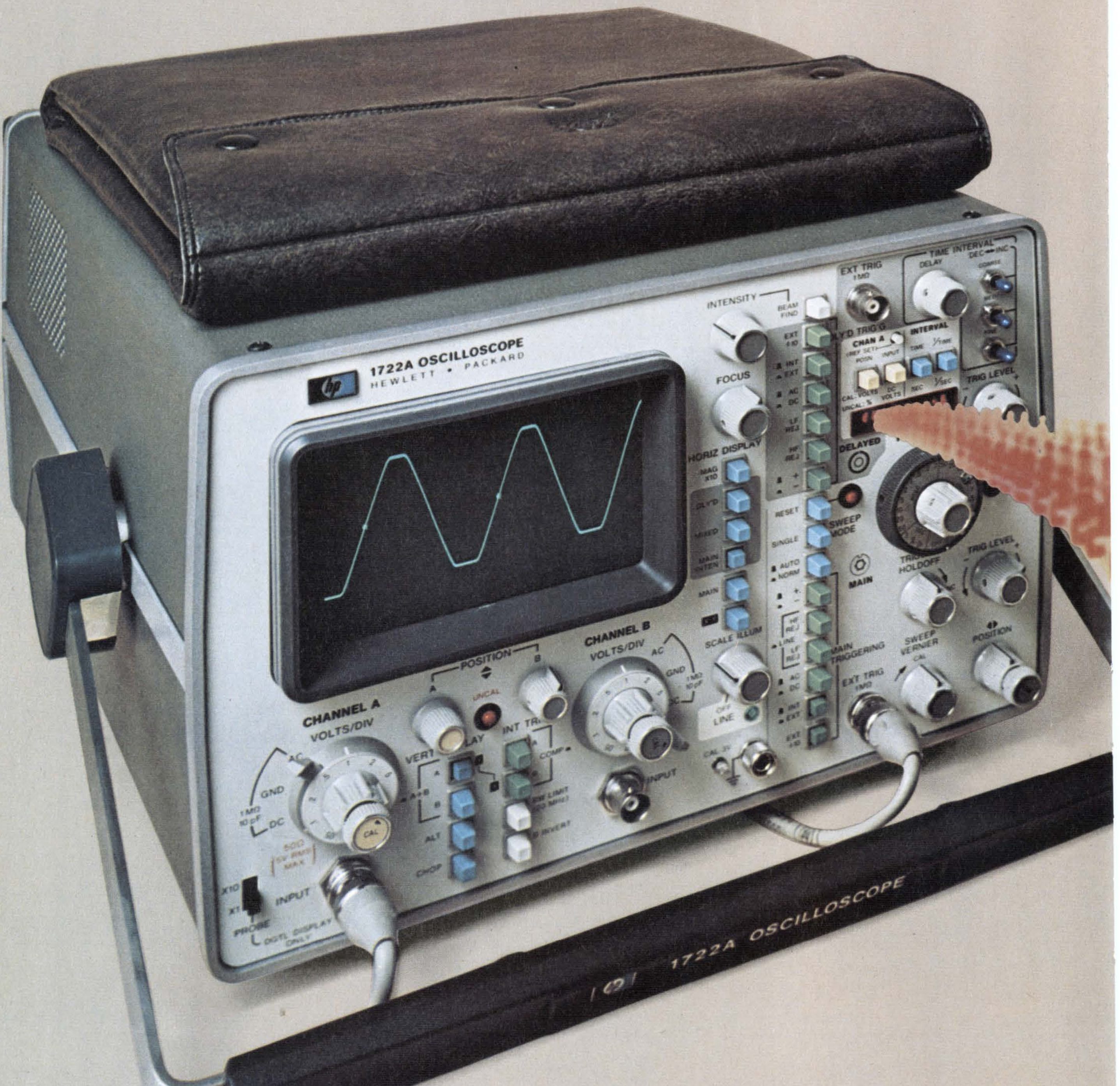
# Electronic Design presents the 'top-ten' winners

The following pages display advertisements of companies who won our "TOP TEN" contest with outstanding ads in the January 4 issue. The contest attracted thousands of readers who attempted to match their ratings of the 10 most memorable advertisements with the "recall-read" and "recall-seen" scores from ELECTRONIC DESIGN's regular Reader-Recall survey.

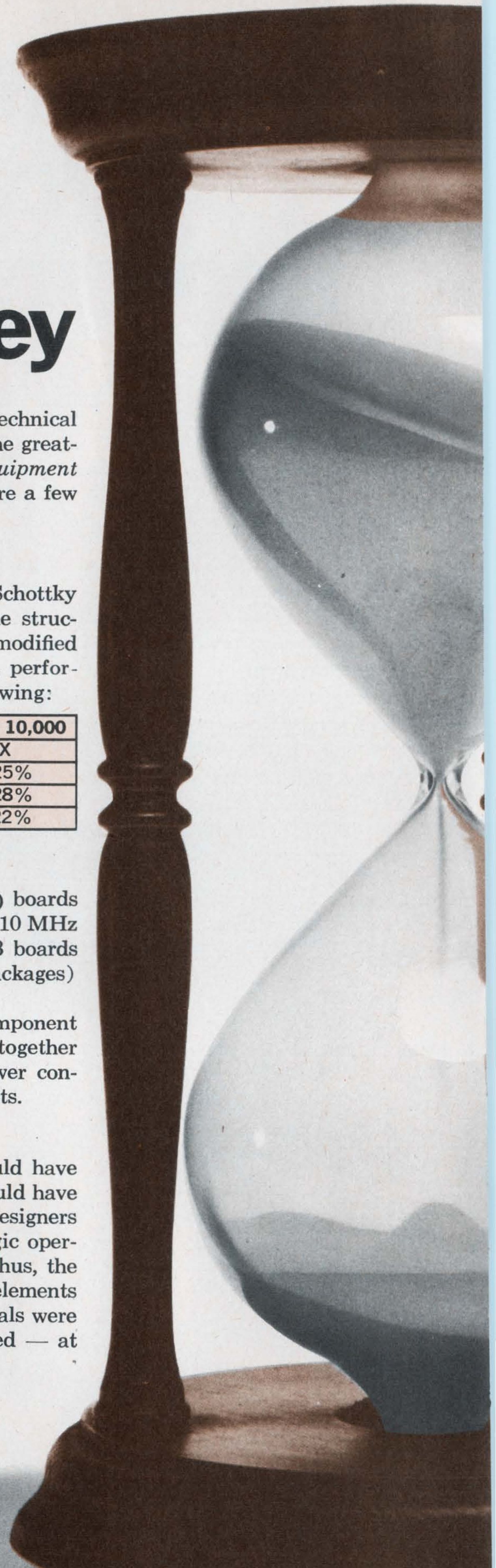
Winning advertisements combine attractive colors, tasteful design and well-written copy. The result: impact. Here are the winning companies in order of highest Reader-Recall score received:

1. Hewlett-Packard, Colorado Springs Div.
2. Tektronix, Inc.
3. Motorola Semiconductor Products
4. Robinson Nugent
5. Duncan Electronics
6. Litronix
7. Intel
8. Hamlin
9. Motorola Semiconductor Products
10. Bourns

# Meet the first scope with a microprocessor.



# Time is money



An old proverb states "Time is Money." Today's technical jargon might express this as: The logic which does the greatest work per unit time, per dollar, *can reduce equipment costs*. Naturally, we feel the logic is MECL. Here are a few actual case histories illustrating just that.

**Case 1.** A processor was designed in three ways: A. Schottky TTL, performance level X; B. MECL 10,000, same structure, performance 2X; C. MECL 10,000 architecture modified to exploit ECL speed and other design advantages, performance level X. The design team discovered the following:

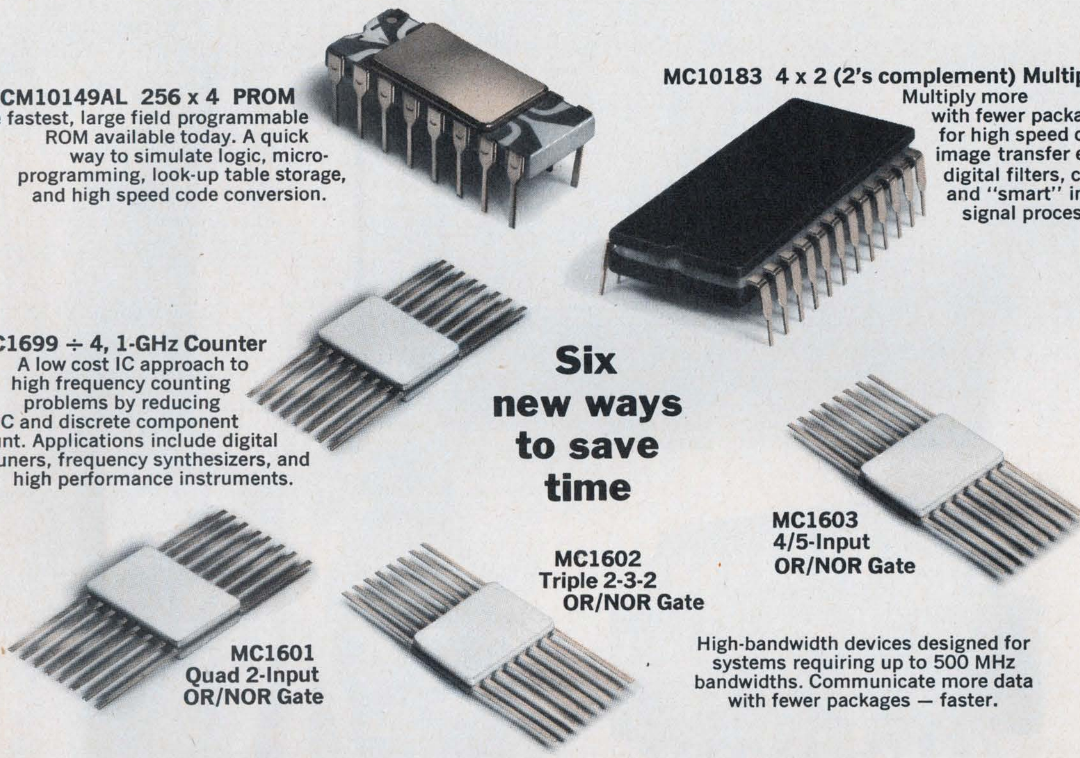
| | TTL (Schottky) | MECL 10,000 |
|---|---|---|
| Performance | X | X |
| Package Count | Y | Y-25% |
| Power Consumption | P | P-28% |
| TOTAL SYSTEM COST | Z | Z-22% |

**Case 2.** Existing equipment used 3 TTL (7400 series) boards (~100 packages each) to process 9 input lines of 2 to 10 MHz data streams. The system was redesigned and the 3 boards replaced with *one* MECL 10,000 board (~100 packages) which worked more than 3 times faster.

Design results: A. A small saving in basic IC component costs; B. A huge reduction in system complexity, together with increased reliability, smaller size, reduced power consumption, lighter weight, and reduced assembly costs.

**Case 3.** A memory system was designed which would have required high performance NMOS memories and would have used TTL control logic. In analyzing the system, designers realized that delay time subtracted from control logic operation could be added to NMOS cycle time specs. Thus, the use of cheaper, lower performance NMOS memory elements were combined with ECL control circuits. Design goals were met and the same level of performance was obtained — at reduced cost.

# MECL saves time



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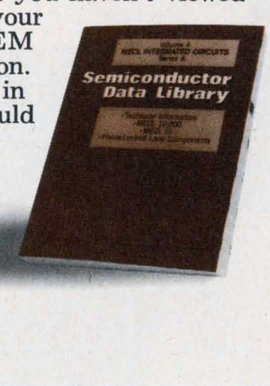
For device specifications, write to Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036. And if you haven't viewed the MECL seminar, call your Motorola distributor or OEM sales office for a presentation. "Time is Money." Invest in a MECL evaluation. It could return a handsome profit.




INFORMATION RETRIEVAL NUMBER 39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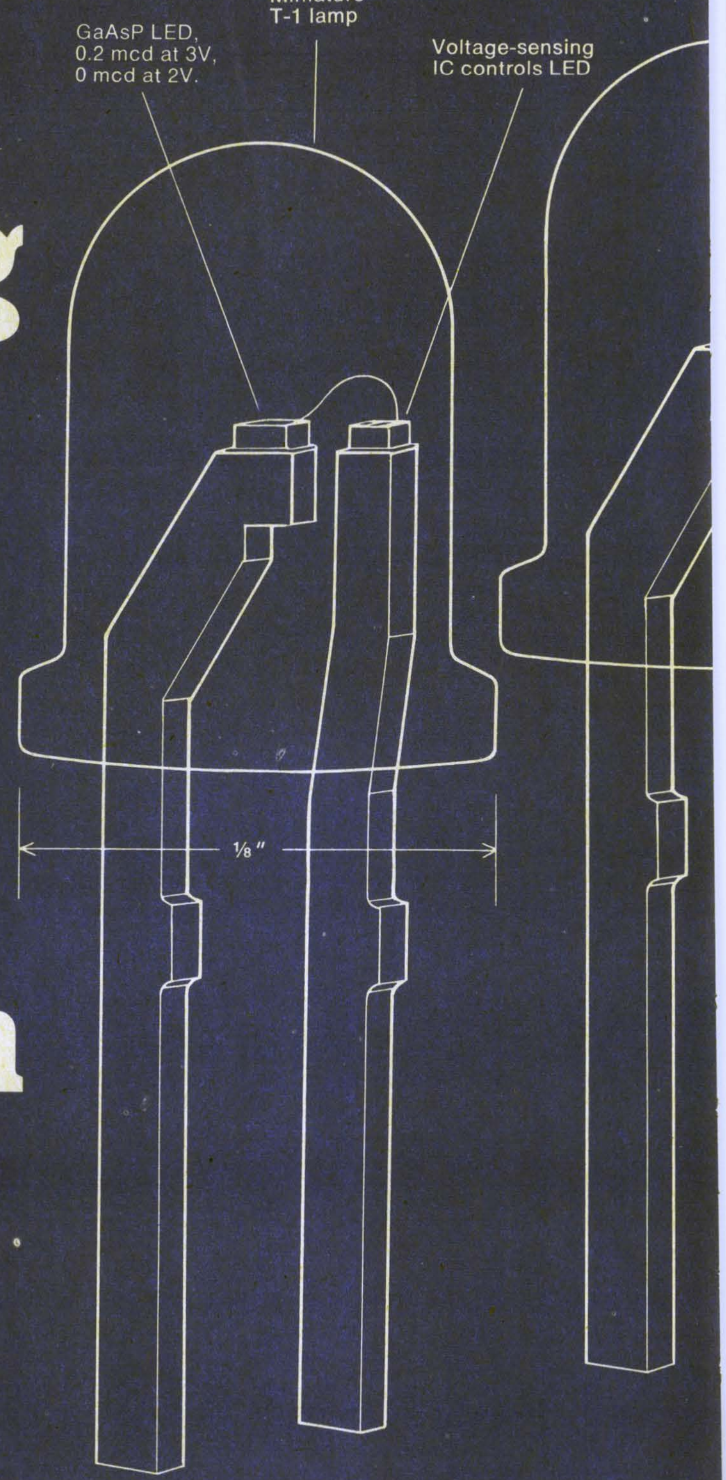
Get the **high reliability** that eliminates trouble. RN DIP sockets make contact with the wide, flat sides of your IC leads. This provides **100% greater surface contact** for positive electrical connection.

# Announcing the Battery Status Indicator– a new LED/IC combination



Dead batteries! Everyone hates 'em. And most battery powered equipment—cameras, tape recorders, calculators—don't warn you until it's too late.

Now Litronix—the world's largest manufacturer of LEDs—introduces the RLC-400 Battery Status Indicator. It's a red GaAsP warning light and voltage-sensing IC combined in one little T-1 lamp package. The light is on at 3V, off at 2V.

One of the nation's most prominent camera manufacturers uses it. Any battery-powered device that uses it may acquire an important competitive advantage at low cost.

The Litronix Battery Status Indicator will cost you only 60¢ in quantities of 1000. And you keep production costs down because you don't have to test, assemble and inventory several components.

If you need a warning light that goes on and off at different voltages, get in touch with us. We may be able to help you.

You can get a free sample of the Battery Status Indicator by writing us on your company letterhead. Or if you want more information quick, contact Litronix, 19000 Homestead Road, Cupertino, California 95014. Phone 408-257-7910. TWX 910-338-0022.

**No wonder we're No. 1 in LEDs**

# litronix

INFORMATION RETRIEVAL NUMBER 41

# The fastest single clock 4K NMOS RAM operates on the least power.

# It's the only one with a second source.

There's just no doubt about it. Motorola's new MCM6605L NMOS 4K RAM is the coolest in operation, and the fastest single clock design available.

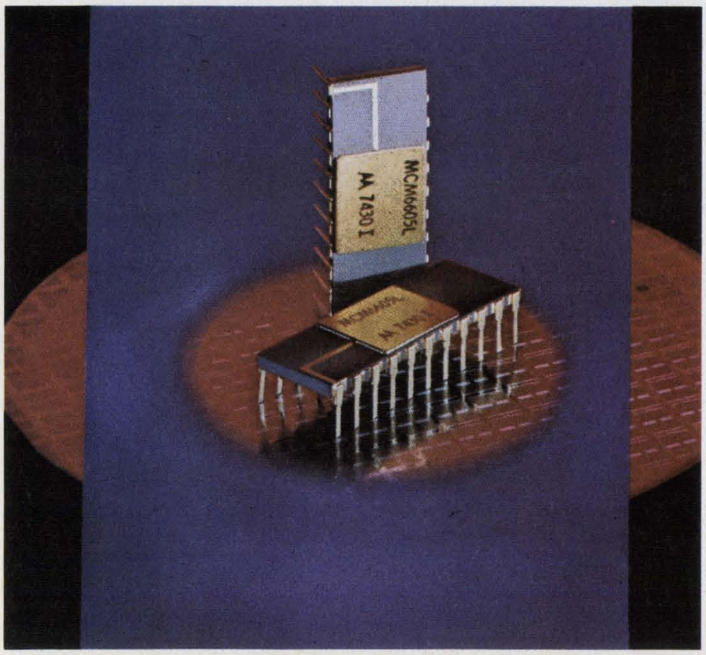
The tables tell the story. One makes device vs. device comparisons and the other shows what the differences mean in system applications.

It's a good idea to have a questioning attitude in this day and age, so we've provided the system power equations. Apply them to your own system size requirements, to any hypothetical system, or simply check the accuracy of our demonstrated figures. Go ahead, prove to yourself that the MCM6605 has the lowest system power requirements by a wide margin.

Results of these comparisons are significant for several reasons. The most obvious is probably the smaller battery required for battery back-up for non-volatile operation. Reduced cooling requirements and the ability to operate with smaller, less expensive standard power supplies are also important factors.

**4K NMOS RAM COMPARISON**

| Device | MAX $I_{DD}$ (Active) (mA) | MAX $I_{DD}$ (Standby) (mA) | $V_{DD}$ (Volts) | Number of refresh cycles/2 ms | Memory access time (ns) | Memory cycle time Read/Write (ns) |
|---|---|---|---|---|---|---|
| **MCM6605** | 36 | 0.020 | 12 | 32 | 210 | 370/490 |
| **MK4096P** | 30 | 1.0 | 12 | 64 | 350 | 500/500 |
| **TMS4030** | 41 | 0.5 | 12 | 64 | 300 | 470/470 |
| **2107A** | 34 | 0.1 | 12 | 64 | 300 | 500/700 |




**THE EQUATIONS FOR POWER**

1. Active memory system power:

$$P_D = M\left(\frac{MCT}{SCT}\right)(I_{DDA})\ (V_{DD}) + (N\text{-}1)\ (M)\left[\left(\frac{MTC}{T}\right)(I_{DDA})\ (V_{DD}) = \left(\frac{T\text{-}MCT}{T}\right)(I_{DDS})\ (V_{DD})\right]$$

2. Standby memory system power with refresh:

$$P_D = (N)\ (M)\left[\left(\frac{MCT}{T}\right)(I_{DDA})\ (V_{DD}) + \left(\frac{T\text{-}MCT}{T}\right)(I_{DDS})\ (V_{DD})\right]$$

Where: $N = \frac{\text{System word size}}{4096}$

$M$ = Number of bits

$MCT$ = Memory cycle time

$SCT$ = System cycle time

$T$ = Period between refresh cycles = $\frac{2\text{msec}}{\#\text{ of ref cycles}}$

$I_{DDA}$ = Active $I_{DD}$

$I_{DDS}$ = Standby $I_{DD}$

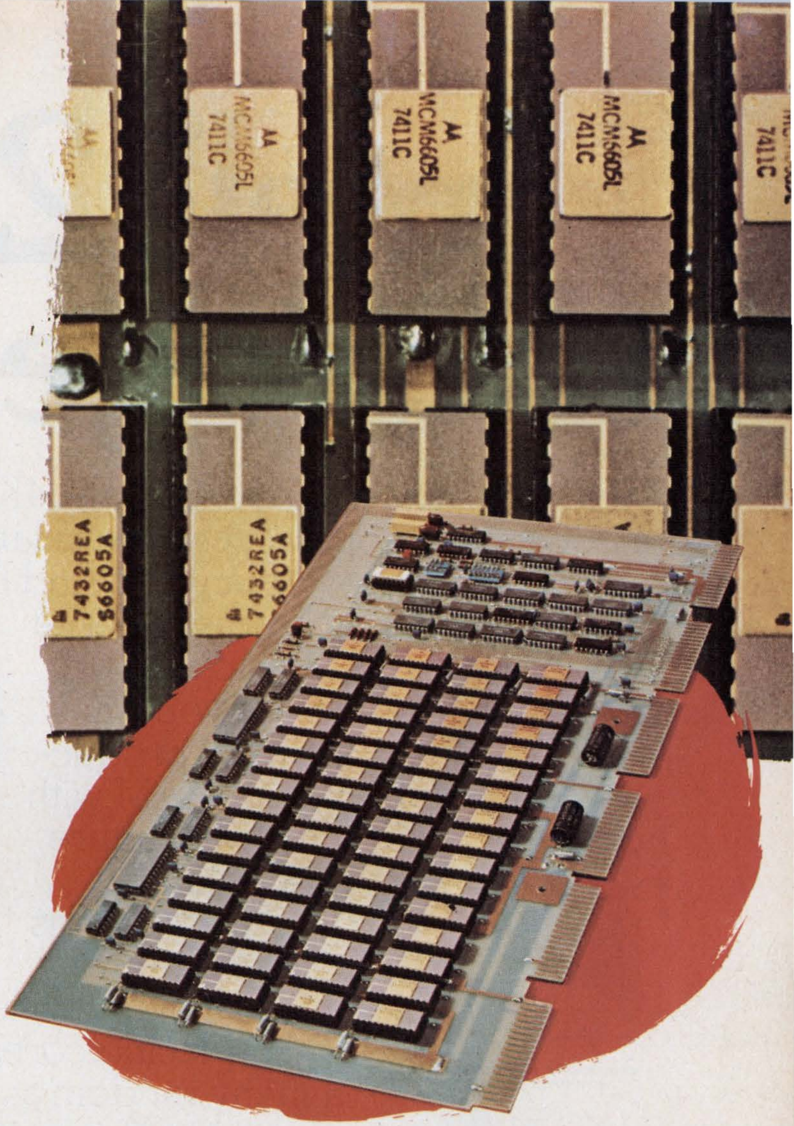
There are subtleties involved, too, such as the number of refresh cycles required, which can significantly increase standby power. But the best way to illustrate is with the tables. All pertinent dc parameters are taken directly from the most recently available data sheets of the manufacturers, themselves.

## Plenty of MCM6605 Advantages

**Speed:** The device comparison table tells it all. With an access time of 210 ns and read/write cycle times of 370/490, none of the major competitive devices are as fast.

**Optimized Pin-Outs:** Voltages are on the corner pins, an advantage for several reasons. It's easier to lay out the PC board, and the larger allowable bus lines make line impedance lower, very important in dynamic memory systems because of the high dynamic surge currents. Bypassing is easier, too, which reduces the capacitance required.

**New Interface Parts designed for 4K RAMs:** Motorola circuit designers have recognized the unique interface requirements of NMOS memory systems. The first in a new family of interface devices is the MC3459, a Quad NMOS Memory Address Driver. The MC3460 Quad NMOS Memory Clock Driver will follow.




## Only the MCM6605 Has a Second Source

Mere pin compatibility isn't interchangeability. As the photograph of an operational 16K by 16 bit add-on PDP-11 memory system demonstrates, the 6605 type RAMs supplied by AMI are direct, electrical, plug-in replacements for Motorola's MCM6605. No other 4K NMOS RAM has that type of second source. No other.

NMOS MEMORY SYSTEM COMPARISON

| Memory System Organization | 32 K Words X 8 Bits | | | 256 K Words X 32 Bits | | |
|---|---|---|---|---|---|---|
| Semiconductor* Memory | MCM6605 | MK4096 | TMS4030 | MCM6605 | MK4096 | TMS4030 |
| Memory cycle time | 490 ns | 500 ns | 470 ns | 490 ns | 500 ns | 470 ns |
| Memory system cycle time | 600 ns | 600 ns | 600 ns | 600 ns | 600 ns | 600 ns |
| System power Active | 3.0 Watts | 3.4 Watts | 3.8 Watts | 18.6 Watts | 45.1 Watts | 39.2 Watts |
| Standby (with refresh) | 0.23 Watts | 1.13 Watts | 0.85 Watts | 7.4 Watts | 36.0 Watts | 27.2 Watts |

**2107A comparison is not shown because the write cycle time is not fast enough to meet the chosen system cycle time.*

## Where to use the MCM6605

The MCM6605 will go just about anywhere there is a memory system. It's ideal for large main memories, for small main RAM memories, for microprocessors used with smart or POS terminals, and as a small buffer memory. We've indicated its application in add-on memories, and the MCM6605 can even be used as erasable ROM for debugging microcomputer system programs. How's that for usefulness.

At this time, the MCM6605 is available only from the factory on orders placed through a Motorola Sales Office.

Applications and additional technical information is now available on request from Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, AZ 85036, or by circling the reader service number. Your reward will be well worth your effort. MCM6605 . . . the fastest single clock 4K NMOS RAM. It has the lowest power requirements and it is the only one with a second source.

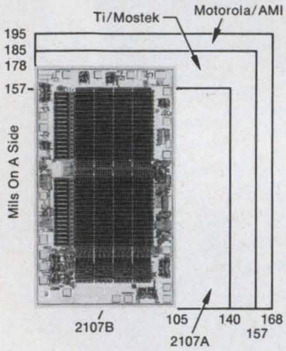
**MOTOROLA MOS**

*— for the advantage in memory systems.*

INFORMATION RETRIEVAL NUMBER 42

# Intel's 2107B. The the edge on speed,

Intel's new 2107B n-channel 4K RAM, with a 200 nanosecond access, is available now in production quantities. And because the 2107B chip is almost as small as a 1K RAM chip, we can assure you it is the most producible 4K RAM with the lowest future cost potential.



4K RAM CHIP SIZE COMPARISON WITH INTEL'S NEW 2107B.

The 2107B is already being shipped in quantities and replacing cores in many random access memory applications. Because of its low cost, it's also being used in serial memory applications. Intel distributors now stock two types: the basic 2107B accesses in 200 ns and cycles in 400 ns; the 2107B-4 runs at 270 ns access and 470 ns cycle times (all worst case from 0 to 70°C).

Our advanced, single-transistor cell design eliminates critical clock tolerances, special substrate voltage levels and double clocks. Like the 2107A, the 2107B has a single clock with solid ±1V margins, operates on standard −5, +5 and +12V supplies, and comes in the industry standard, 22-pin configuration

# new 4K RAM with price and delivery.

for single-clocked, fully decoded, 4K dynamic RAMs. These new 4K RAMs improve your speed while reducing your system overhead costs by as much as 300% whether you're using 1K dynamic RAMs or core. Typical overhead is only .05¢/bit. To further reduce system overhead, both the three state output and all inputs are TTL compatible. Intel also offers a low cost 3235 quad clock driver designed to drive the 2107B. And economical battery backup can be implemented because of the 2107B's low standby power.

| INTEL'S NEW 2107B 4K RAM FAMILY | | | |
|---|---|---|---|
| PART | MAX. ACCESS TIME (ns)[1] | MIN. CYCLE TIME (ns)[1] | AVAILABILITY |
| 2107B | 200 | 400 | Now |
| 2107B-4 | 270 | 470 | Now |
| 2107B-6 | 350 | 800 | Now |

[1] (All worst case from 0 to 70°C.)

The smaller die size of the 2107B means higher yields, lower cost and a more producible product. In comparision, competitive 4K RAMs are 55% to 75% larger than the 2107B.

Yet, the 2107B is processed with Intel's standard n-channel silicon gate MOS technology. The same process Intel has been using to produce high performance memory products with for over 3 years.

So put the 2107B or 2107B-4 in your memory system. You'll gain the edge in Speed, Price and Delivery right now, and for the future. Write Intel for 4K RAM family details. Or buy these new 4K RAMs from stock at Intel distributors: Almac/Stroum, Cramer, Hamilton/Avnet, Sheridan Sales, Industrial Components, and L. A. Varah.

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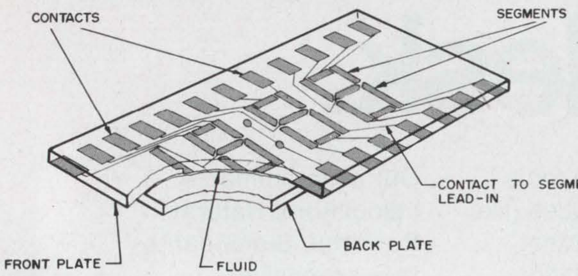
# The case for Liquid Crystal Displays

## Dynamic Scattering or Field Effect

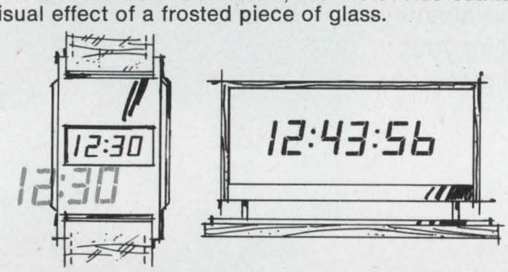
**Liquid Crystal Displays;** light emitting diodes; incandescent and fluorescent displays and "Nixie" tubes are becoming solidly established in circuit design as the trend to digital readout continues. The design engineer faces an unusually formidable task in determining the type of display most suitable and practical for his product. We make liquid crystal displays — dynamic scattering **and** field effect.

**The display of the future?** Our displays are as sandwiches of two glass plates, spaced typically about .0005″ apart with a nematic liquid crystal solution between them and hermetically sealed at the perimeters.




**How they work.** When the liquid is not electrically excited, its long cigar-shaped molecules are parallel to one another in a position perpendicular to the plates. The liquid appears transparent. When an electric current is applied, ion activity of the molecules leads to turbulence causing the liquid to scatter incident light. Depending on the type of nematic liquid used, either a dynamic scattering or field effect display results.

**Dynamic scattering.** We use a nematic liquid crystal solution in our dynamic scattering displays. This nematic liquid crystal is conductive, has negative dielectric anisotropy, and is oriented in either a homeotropic or homogeneous alignment. In either case the liquid is clear in the absence of an electric field. When an electric field is induced, the molecules scatter, giving the visual effect of a frosted piece of glass.




**Field effect.** These displays also utilize a nematic liquid crystal but with a different molecular orientation. The molecules are arranged in a helical stack, like a spiral staircase. The liquid is also sandwiched between two polarizers which are at right angles with each other. When current is applied the molecules rotate 90° so that they become perpendicular to the front polarizer. Light that passes through them is not rotated and therefore is absorbed by the rear polarizer. The result is a dark image on a light background. The image also can be reversed — light on dark.

**Producing an image** — digital or other — simply requires a conductive surface the shape of the desired image on the front glass plate. Current flowing from the conductive image through the liquid crystal to the common ground back plate causes the liquid to change from clear to a frosted appearance in the current-carrying areas.

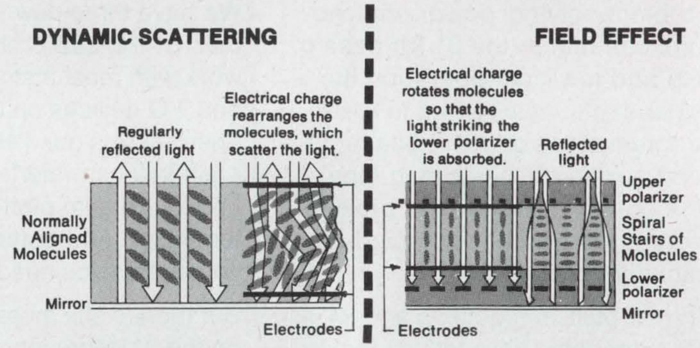
The images almost always are in the form of seven segments formed on the front glass with transparent oxide and each with its own electrical lead. Energizing the proper segments produces the desired numerals. Lead-ins connect the segments to external contacts on the sandwich (display).

**Consider the advantages**. Liquid crystal displays have a number of distinct advantages. Simplicity is the reason for several of these. The elements are few and passive — very little can go wrong with an LCD and this means reliability and long life.

Simplicity means low cost too — lower than that of most similar displays. Packaging costs are low because LCD's can be driven directly by MOS and C/MOS circuits. Very narrow character widths are possible and still provide a good viewing angle — 60 degrees in many cases.

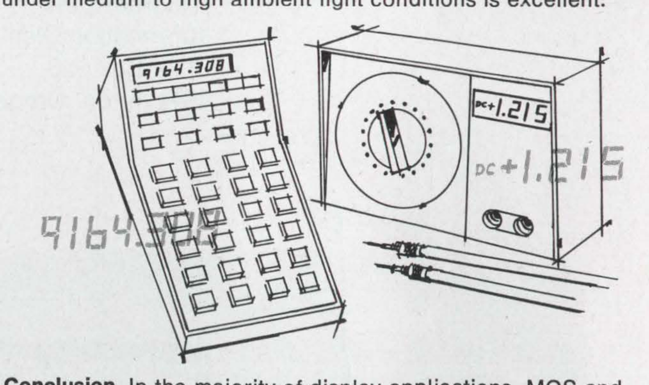
Low power consumption makes LCD's a logical choice where power limitations rule other displays out. They do not generate light as do other displays so use no power for that purpose. Watch type field effect LCD's use only 3μW. for example with all segments energized at 7 Volts.

LCD's offer the greatest flexibility of any display type. Several standard displays, dynamic scattering or field effect, are immediately available from Hamlin's stock. Special displays with virtually any type of image can be produced with surprisingly low preparation or "tooling" cost. Because of the LCD's simplicity, lead time on specials is only a matter of weeks.




**A few limitations.** LCD's have limitations too. Operating temperature range is one. Liquid crystals slow down and may even cease to function at temperatures below 0°C. Above 50-60°C, crystals go into solution and will not function properly. But extremes do not damage LCD's. Once the temperature returns to normal, operation is automatically resumed.

LCD's are somewhat difficult to read under low ambient light conditions. (Side or back lighting can remedy this.) Visibility under medium to high ambient light conditions is excellent.




**Conclusion.** In the majority of display applications, MOS and C/MOS compatibility, reliability, flexibility and low power requirements are important considerations. No other display can match the liquid crystal display on these jobs. They could be the display of the future.

And that's the case for the LCD. For specifications, and application data, write Hamlin, Inc., Lake Mills, WI 53551 • 414/648-2361. Or dial toll-free 800-645-9200 for name of nearest representative. (Evaluation samples are available at moderate cost.)

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1054


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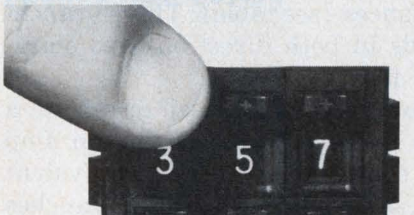


Simple, fast, precise. Push the PLUS button to increase; the MINUS to decrease. Rated life is 100,000 operations per decade.

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Large, easy-to-read numbers enable fast, "squint-free" data entry and information readout.


## ACCURATE

You get what you set with the 3680 . . . every time. The unique Bourns design integrates precision laser-trimmed cermet resistor technology with a positive pushbutton detent action. The result is resolution of output of 1 part in 1000 discrete steps, and dependable repeatability of ±0.1%.

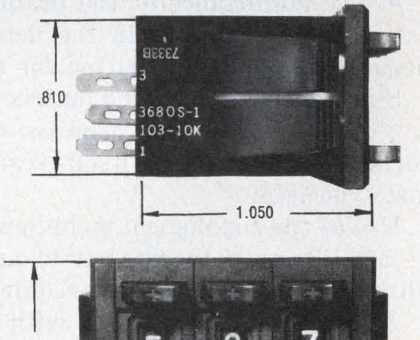
## COSTS LESS TO INSTALL

Snap-in mounting cuts installation time, eliminates mounting hardware. Integral bezel covers irregular panel cut outs and minor edge blemishes. Terminals match the AMP Series 110 receptacle . . . or can be soldered in the standard fashion.

## FEATURES AND SPECIFICATIONS

**• stable built-in cermet resistance elements • 100 PPM/°C tempco • 2 watts power rating • standard resistance range (3 decade unit) 5K ohms to 1 megohm • ±1.0% resistance tolerance • resolution 0.1%.**

## COMPACT SIZE

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# Apply topological graphs

to active-filter analysis. The graphs offer fast and accurate solutions to the circuit's node equations.

A topological flow graph will analyze active filters. This graphical technique will find transfer functions without the need to write and solve many equations simultaneously. And it is one of the fastest and most accurate techniques known. With other methods, such as the Mason signal-flow graph, the user must first write the network equations.

The topological flow graph[1,2] represents the node equations of the circuit. Network solutions are obtained through simple geometric manipulation of the graph.

### Topological graph depicts circuit

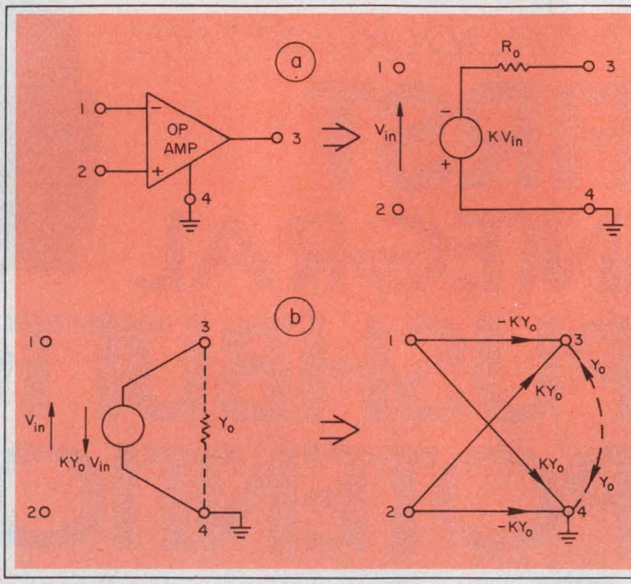
For node equations, the source currents and voltages are given; the node voltages are unknown. Information contained in the node equations is related to the topology (interconnection of branches) in the network. For the matrix of node equations:

- The sum of the admittance values of the branches connected to node i is the same as the term at the intersection of the i-th column and row.
- The admittance of the branch between node i and node j appears in the determinant as the negative of the term written for row j, column i.

Since operations on the matrix can furnish network voltage solutions, similar operations—performed on the graph itself—can also solve for node voltages.

Use of the topological technique allows analysis of any linear network, but to apply it to active filters, an op-amp model is required.

A conventional op amp with finite gain and nonzero output resistance is used first (Fig. 1). The voltage source is converted to an equivalent current source (to facilitate topological operations), from which the topological representation is taken (Fig. 1b). Arrowheads shown on the four solid branches signify that signal transmission is in one direction.




1. **The topological graph** of an op amp starts with the equivalent circuit (a), which is transformed to a current-source equivalent (b). This model is valid for infinite input impedance and finite output impedance.

Passive circuit elements are described by their operational admittances (see table). These branches have arrowheads in both directions—to signify bilateral signal flow.

To obtain the over-all topological graph of a circuit, retain the nodes but replace the op amp and associated components with equivalent branches (Fig. 2a, b). Note that parallel branches are combined by algebraic addition of their admittance values at each node. Since the noninverting terminal is grounded, you can also eliminate the branch between nodes 4 and 5 to simplify the diagram further (Fig. 2c).

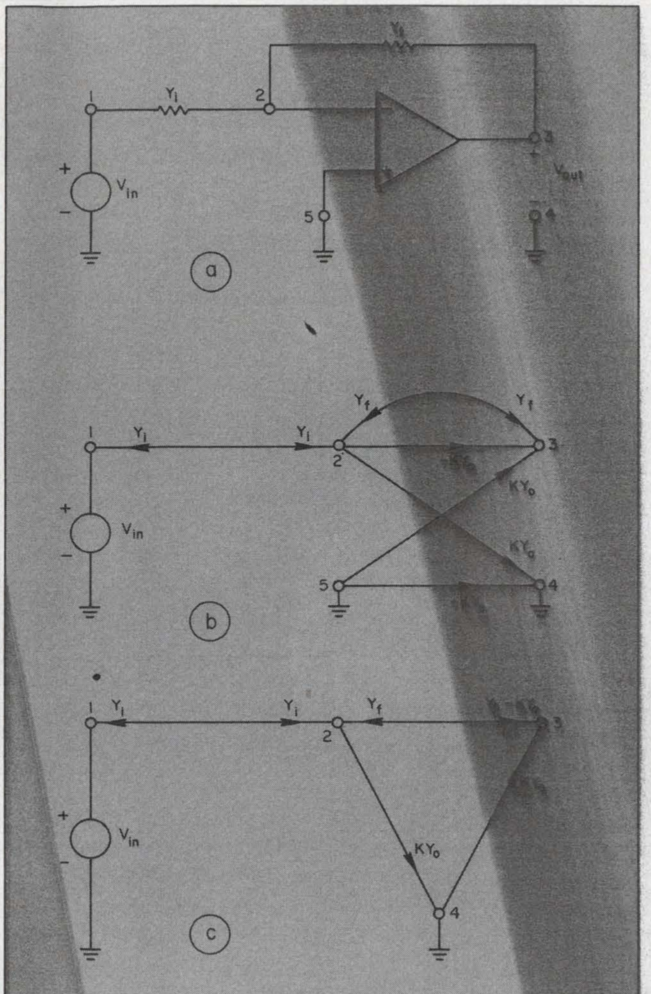
The formula

$$\frac{V_{out}}{V_{in}} = \frac{P_1 \Delta P_1 + P_2 \Delta P_2 \cdots + P_n \Delta P_n}{\Delta} \quad (1)$$

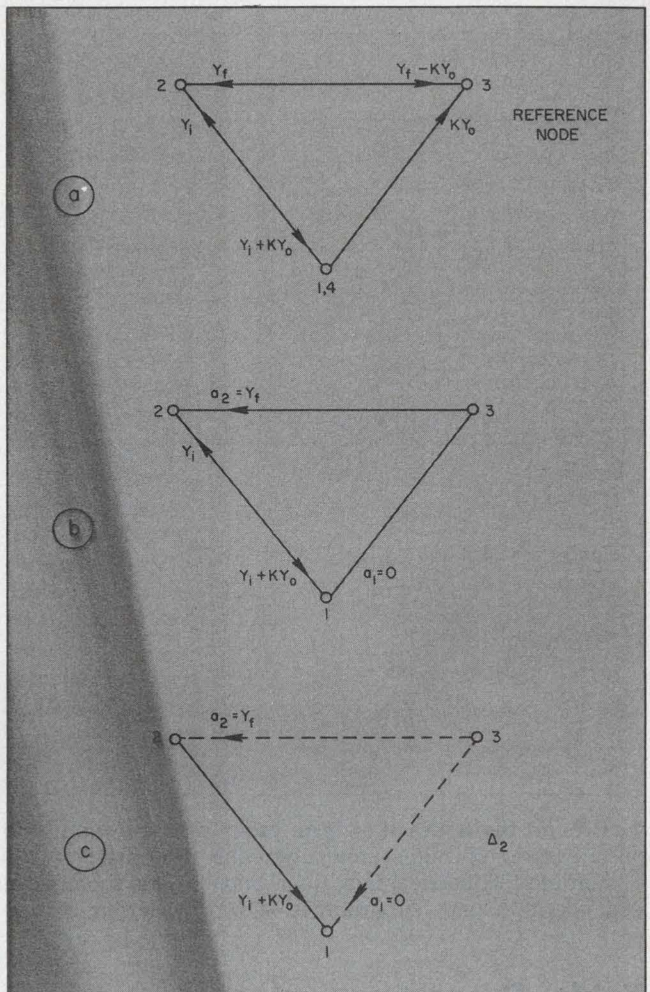
evaluates the transfer function between any pair of nodes. The numerator terms refer to the various paths from the input node (node 1) to the output node (node 3) that do not pass through the ground node.

Values $P_1$, $P_2$ $\cdots$ $P_n$ are obtained through the multiplication of values along branches of the

**John A. DeFalco,** Section Head, Honeywell Information Systems, Inc., 300 Concord Rd., Billerica, MA 01821.




2. **Use of the op-amp equivalent** and passive-circuit representations helps model active filters (a, b). The algebraic addition of parallel branch admittances simplifies the final topological equivalent (c).




3. **These transformations provide** the graphic solutions. Node 3 is selected as the reference, and arrowheads directed to node 3 are removed. The single remaining branch and coefficients provide the circuit determinants.

n paths that lead from input to output. In the circuit of Fig. 2,

$$P_1 = Y_i\ (Y_f - KY_o)$$

Also, $P_1$ is the only path in this case.

### Subgraphs help evaluate determinant

The terms labeled with a $\Delta$ represent various determinants. Their evaluation involves the entire graph (for the denominator) and various subgraphs (for the numerator). The graphs that correspond to the $P_i$ are those in which all nodes along path i are shorted to ground. Any path that passes through all nodes except ground has a $\Delta P$ equal to one.

The one path in the circuit of Fig. 3 passes through all nodes; so $\Delta P_1 = 1$ and

$$\text{Numerator} = Y_i \cdot (Y_f - KY_o) \cdot 1.$$

The denominator corresponds to a graph in which independent voltage sources are shorted and independent current sources are opened (Fig. 3a). To start, select a *reference node*—preferably the one with the largest number of, and most complicated, branches. This is node 3. Remove (ignore) arrowheads directed to this node; call all branches that leave the reference node *reference branches*. Also designate their respective admittance values as $a_1$, $a_2$, etc.

To evaluate $\Delta$ use

$$\Delta = \Sigma a_i\ \Delta_i + \Sigma a_i\ a_j\ \Delta_{i,j} + \Sigma a_i\ a_j\ a_k\ \Delta_{i,j,k} \cdots + (a_1\ a_2\ a_3 \cdots a_m)\ \Delta_{1,2,3..m} \quad (2)$$

Only two terms exist: $a_1$ and $a_2$. But $a_2 = 0$, since there is no arrow that points away from node 3. In this case Eq. 2 reduces to

$$\Delta = a_1\ \Delta_1 + a_2\ \Delta_2 + a_1\ a_2\ \Delta_{12}.$$

Since $a_2$ is zero,

$$\Delta = a_1\ \Delta_1 = Y_f\ \Delta_1$$

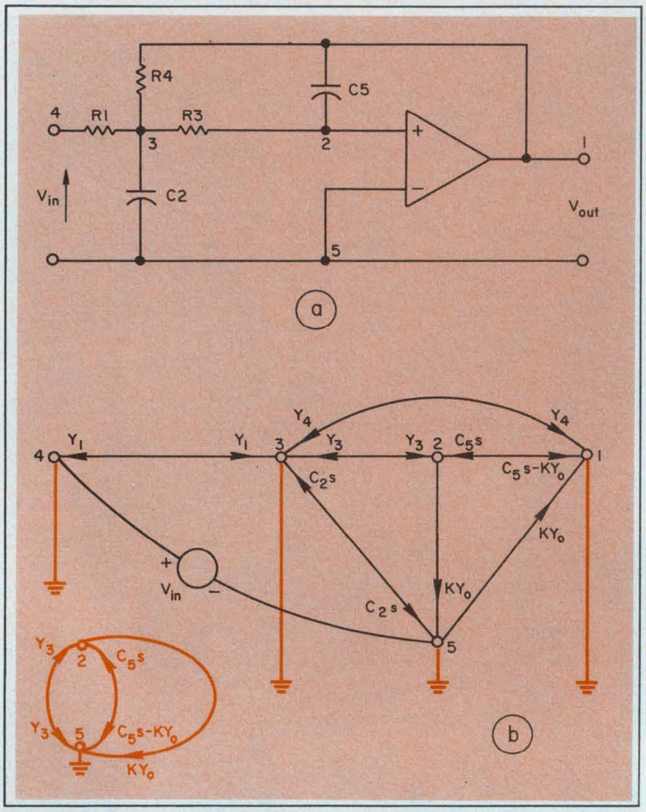
To obtain the subgraphs for the various $\Delta$s in Eq. 2, remove the reference branches and all arrowheads that point toward the subscripted node (Fig. 3c). In this instance a single branch remains with value $Y_i + KY_o$, so for the denominator

$$\Delta = Y_f\ (Y_i\ KY_o)$$

and the gain (from Eq. 1) is

$$\frac{V_{out}}{V_{in}} = \frac{Y_i\,(Y_f - KY_o)}{Y_f\,(Y_i + KY_o)} = \frac{Y_i\,Y_f - Y_i\,KY_o}{Y_f\,Y_i + Y_f\,KY_o}.$$

In the ideal case the op amp has zero output




4. **Ground the nodes that form paths** between input and output to obtain numerator subgraphs. The circuit (a) is a multiple-feedback active filter and (b) its topological equivalent. A path subgraph is shown at bottom left.

## Table. Branch equivalents of passive components

| ELEMENT | EQUIVALENT |
|---|---|
| RESISTANCE R | G ← → G; G=1/R |
| CAPACITANCE C | Cs ← → Cs |
| INDUCTANCE L | 1/Ls ← → 1/Ls |

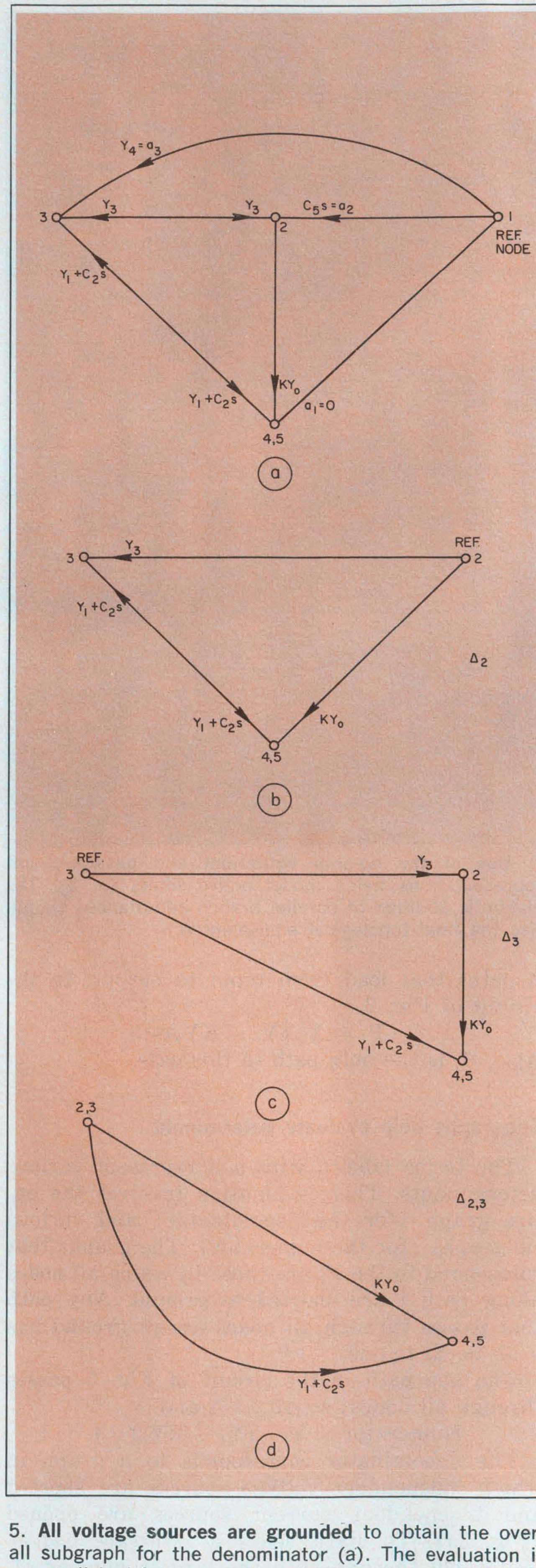
impedance $Y_o = \infty$ and infinite gain. Divide numerator and denominator by $KY_o$; let $KY_o$ approach infinity. And

$$\frac{V_{out}}{V_{in}} \frac{-Y_i}{Y_f} = \frac{-R_f}{R_i},$$

the familiar op-amp gain equation. Only terms multiplied by $KY_o$ will be retained in the ideal op-amp equations, and only these terms need be used in the graph operations.

### Evaluation of two-pole filter is easy

A more complicated network, representative of a two-pole low-pass filter, will illustrate the capabilities of the method (Fig. 4a). As seen from the network graph, there are two paths $P_1$ and $P_2$ between input node 4 and output node




5. **All voltage sources are grounded** to obtain the overall subgraph for the denominator (a). The evaluation is accomplished from separate subgraphs (b, c and d) each of which may have a separate reference code.

1. These paths pass through nodes 4, 3, 2, 1 and 4, 3, 1, respectively. And their values are

$$P_1 = Y_1 Y_3 (C_5 s - KY_o)$$
$$P_2 = Y_1 Y_4.$$

The first path involves all nodes so the corresponding determinant $\Delta P_1$ is 1. Path $P_2$ does not pass through node 2; the graph for $\Delta P_2$ is formed by the shorting of all nodes on $P_1$ to ground (heavy lines in Fig. 4b). Only three branches remain, all in parallel (bolded), so

$$\Delta P_2 = Y_3 + C_5 s$$

for the sum of the branch admittance at node 2. (The result would be the same for the sum of values at node 5.) The numerator value is now obtained:

$$\text{Numerator} = Y_1 Y_3 (C_5 s - KY_o) + Y_1 Y_4 (Y_3 + C_5 s).$$

In more complex cases, application of Eq. 2 will evaluate subgraphs such as $\Delta P_1$ and $\Delta P_2$.

To evaluate the denominator, short the input voltage source to ground. Use node 1 as the reference. Three reference branches remain, one of which has zero value. The denominator equation has the form

$$\Delta = C_5 s \Delta_2 + Y_4 \Delta_3 + Y_4 (C_5 s) \Delta_{2,3}.$$

To form the subgraphs for $\Delta_2$, $\Delta_3$ and $\Delta_{2,3}$, remove all reference branches. Then delete all arrowheads directed toward the subscripted node (s). In addition superimpose all multiple nodes, such as those designated by $\Delta_{2,3}$. These steps are shown in Fig. 5b.

The determinant rule, Eq. 2, is reapplied to subgraphs $\Delta_2$ and $\Delta_3$ with their respective reference nodes 2 and 3 to give

$$\Delta_2 = KY_o (Y_1 + C_2 s) + Y_3 (Y_1 + C_2 s) + KY_o Y_3$$

and

$$\Delta_3 = Y_3 KY_o + 0 + Y_3 (Y_1 + C_2 s).$$

Determinant $\Delta_{2,3}$ is simply the parallel combination of two branches, so

$$\Delta_{2,3} = KY_o + Y_1 + C_2 s.$$

And the resultant transfer function is

$$\frac{V_{out}}{V_{in}} = \{Y_1 Y_3 (C_5 s - KY_o) + Y_1 Y_4 (Y_3 + C_5 s) \; [C_5 s (KY_o (Y_1 + C_2 s) + Y_3 (Y_1 + C_2 s) + K_3 KY_o) + Y_4 (Y_3 KY_o + Y_3 (Y_1 + C_2 s)) + Y_4 C_5 s (KY_o + Y_1 + C_2 s)]\}.$$

As $KY_o$ is allowed to be infinite, we get the transfer function for an ideal amplifier; namely,

$$\frac{V_{out}}{V_{in}} = \frac{-Y_1 Y_3}{C_2 C_5 s^2 + C_5 (Y_1 + Y_3 + Y_4) s + Y_4 Y_3}.$$

Practice with the method will improve the speed of problem solving. Additional analysis examples are given in the references. ■■

**References**


1. Robichard, L. P. A., "Signal Flow Graphs and Applications," Prentice Hall, Englewood Cliffs, NJ, 1962.

2. DeFalco, J. A., "Speed Network Analysis with Topology," *Electronic Design* No. 7, April 1, 1969, pp. 56-61.

## Ideas for Design

# Two-phase clock generator and driver synchronize the 8080 microprocessor

The applications data for the 8080 microprocessor do not describe a clock generator and driver circuit. Suitable generator and driver circuits are shown in Figs. 1 and 2. Together they provide a two-phase nonoverlapping high-level clock to the microprocessor, with a minimum clock period of 500 ns. TTL-level clock outputs also are available for use by other circuitry.

The frequency of a 20-MHz crystal oscillator is divided by five and then by two in a 7490 counter. The counter outputs are decoded to provide the Phase-1 and Phase-2 TTL clocks (Fig. 1).

The TTL signals then drive a National MH0026 IC, which provides an output swing from ground to +12-V with a fast rise time. A 91-Ω resistor to the diode at pin 3 supplies a −0.7-V bias to the driver circuit, which improves the noise margin of the high-level outputs (Fig. 2). The two 47-Ω resistors provide series damping. This driver circuit should be placed near the processor to keep the leads short and reduce ringing.

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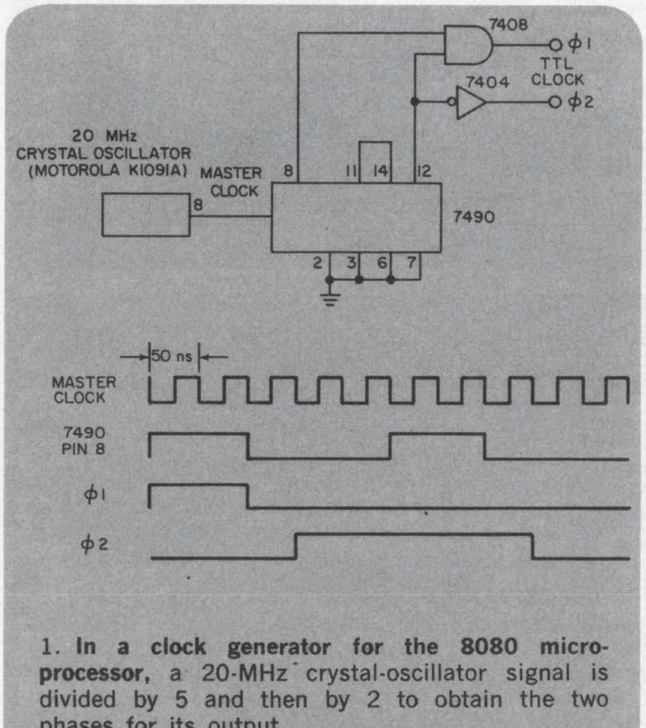
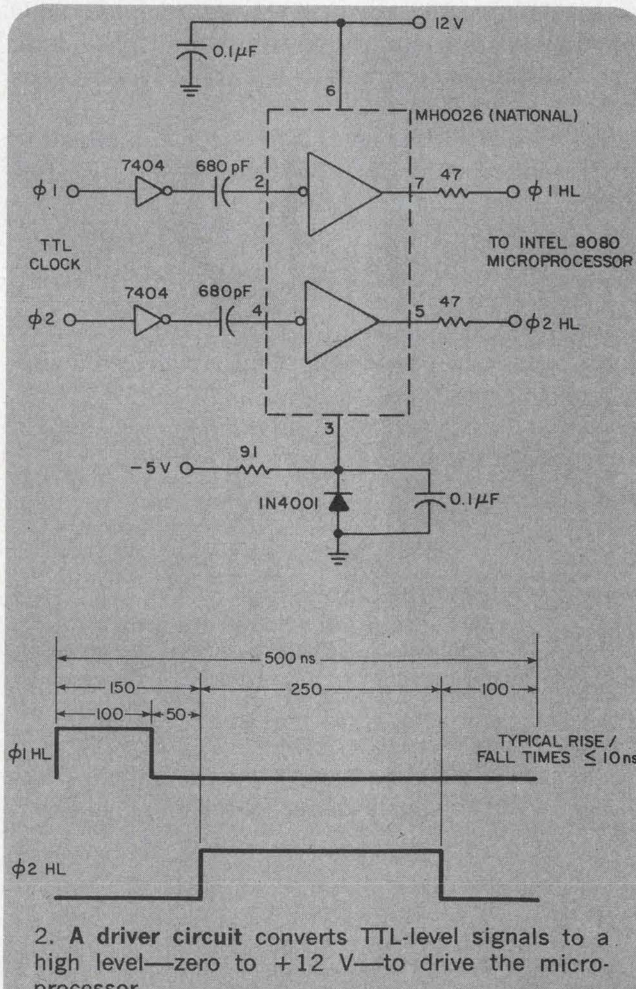



1. **In a clock generator for the 8080 microprocessor,** a 20-MHz crystal-oscillator signal is divided by 5 and then by 2 to obtain the two phases for its output.




2. **A driver circuit** converts TTL-level signals to a high level—zero to +12 V—to drive the microprocessor.

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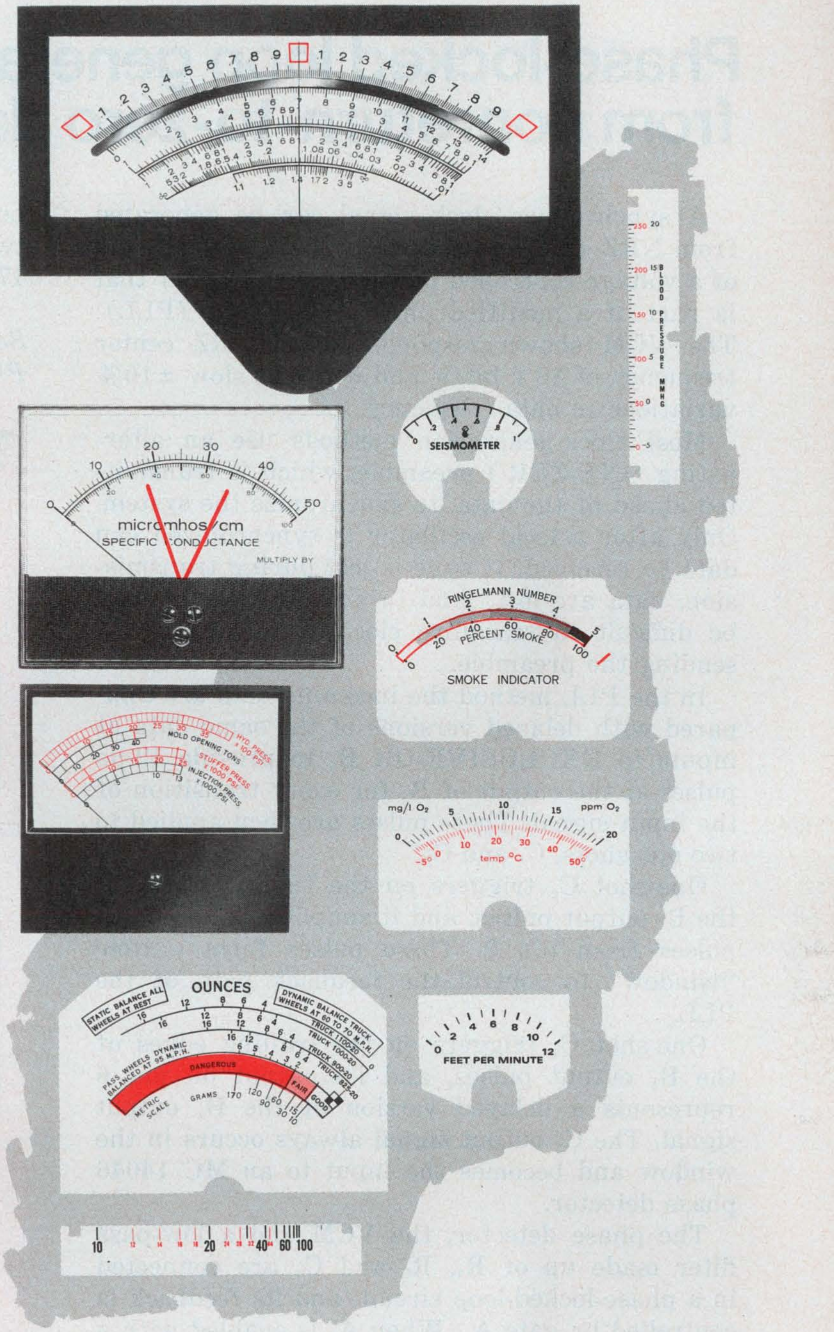


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INFORMATION RETRIEVAL NUMBER 54

# Phase-locked loop generates clock from nonreturn-to-zero data

A synchronous clock signal can be generated from NRZ (nonreturn-to-zero) data with the aid of a voltage-controlled multivibrator (VCM) that is part of a modified phase-locked loop (PLL). The VCM shown responds to an NRZ center frequency of 16 k bit/s, and it tracks slow ±10% variations in data frequency.

Most clock-generation methods use an alternating ONE-ZERO preamble, which is transmitted ahead of the data, to synchronize the system. Only after a local oscillator is synchronized can data be received. If sync is lost during transmission, data are lost. And in such systems it may be difficult to reacquire clock sync without resending the preamble.

In the PLL method the incoming data are compared with delayed versions of the same data at inputs to EXCLUSIVE-OR $B_1$ to provide 12-μs pulses at the output of $B_1$ for every transition of the input signal. These pulses are then applied to two one-shots, $C_1$ and $C_2$.

One-shot $C_2$ triggers on the leading edges of the $B_1$ output pulses, and it supplies 22-μs output pulses from pin 9. These pulses form a time "window" to control the feedback path of the PLL.

One-shot $C_1$ triggers on the trailing edges of the $B_1$ output pulses, and its output on pin 6 represents a delayed version of the $B_1$ output signal. The $C_1$ output signal always occurs in the window and becomes the input to an MC 14046 phase detector.

The phase detector, the VCM and a low-pass filter made up of $R_4$, $R_5$ and $C_4$ are connected in a phase-locked-loop circuit, and its feedback is controlled by gate $A_3$. When $A_3$ is enabled with a LOW signal on pin 13, the PLL tracks the NRZ input signal transitions. However, when $A_3$ is disabled, the PLL provides clock output at the last frequency tracked.

This circuit was successfully tested with NRZ data from a pseudorandom-bit generator. Though the VCM was initially synchronized to the data stream with a preamble—an alternating ONE-ZERO format of an 8-kHz square wave preceded the data—this approach is not necessary if data loss is permissible. The circuit can lock onto the raw NRZ data. The lock-on time to NRZ only is about 10 ms, compared with 8.2 ms for 65 cycles of a square-wave preamble.

The lock-on time is a function of the low-pass filter characteristics of $R_4$, $R_5$ and $C_4$. A change in the filter can shorten the lock-on time, but at the expense of output stability. The filter component values in the figure are a compromise between stability and lock-on time for the 13.4-to-17.6-kHz passband.

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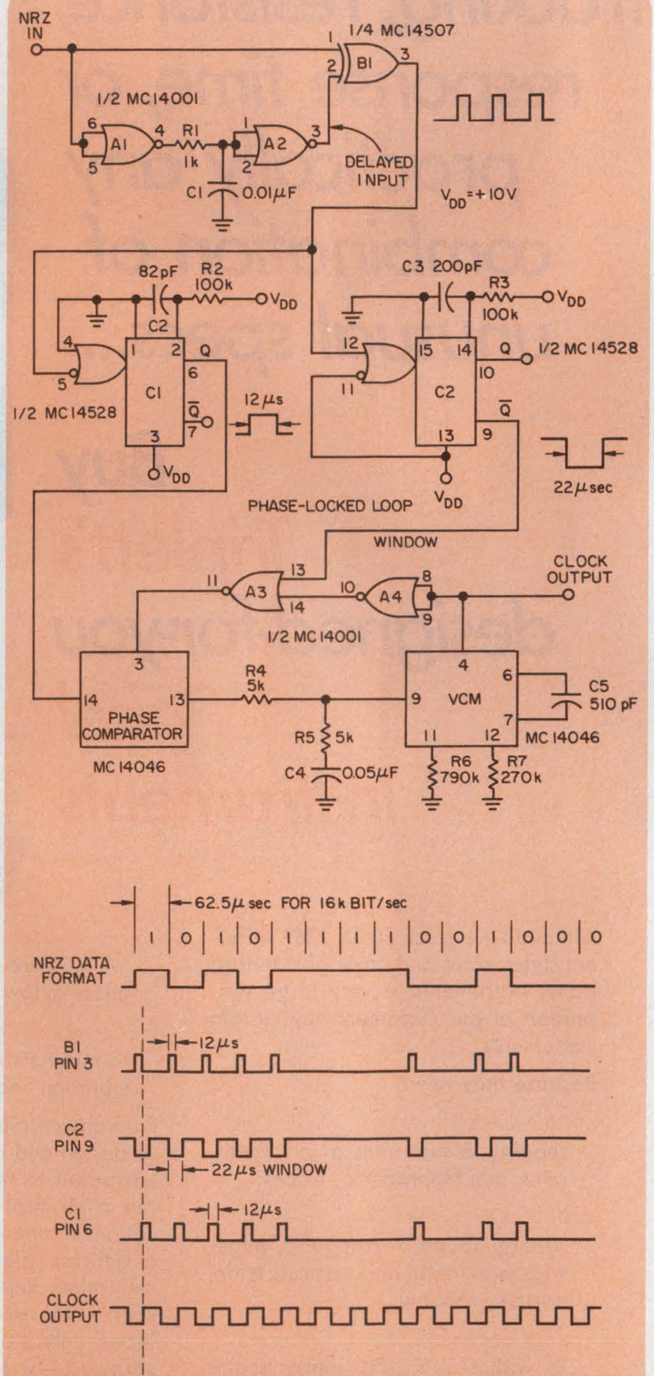


**Phase-locked-loop circuit generates** a synchronous clock signal from raw NRZ data and maintains a clock output even with temporary interruptions of the data.

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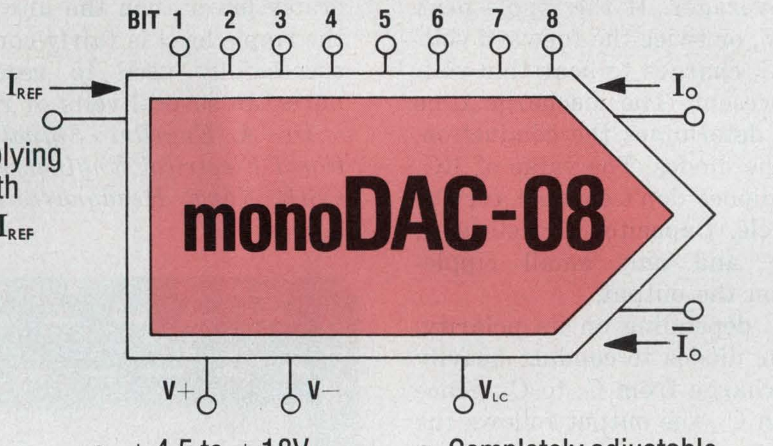


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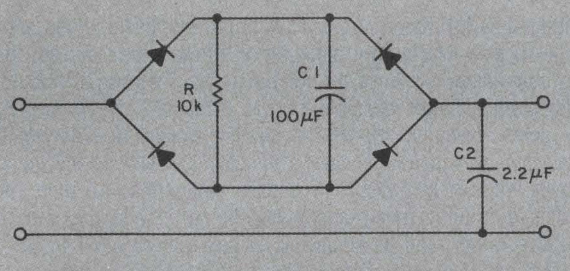
INFORMATION RETRIEVAL NUMBER 51

# Passive low-pass filter recovers signals buried in high ripple

The nonlinear, passive filter circuit (Fig. 1) can reject ripple or other unwanted but fairly steady voltage without appreciably affecting the rise time of a signal. The filter consists of only seven components: a four-diode bridge, two capacitors and one resistor.

The circuit has characteristics similar to two peak-detecting sample-and-hold circuits in tandem with a voltage averager. If the ripple peak level exceeds about 1 V, or twice the forward voltage drop of a diode, $C_1$ charges to near this voltage with no signal present. The discharge time constant of $RC_1$ then determines the conduction, or aperture, time of the diodes. The value of $RC_1$ is chosen so that the diodes don't conduct for the period of a ripple cycle. Capacitor $C_2$ acts as a signal-hold capacitor, and only small ripple-voltage steps appear on the output.

A step-signal input, depending on its polarity, causes two of the four diodes to conduct heavily and rapidly transfer charge from $C_1$ to $C_2$. Since $C_1$ is much larger than $C_2$, the output follows the input with little delay.




1. **A low-pass filter for recovering signals** from high levels of ripple voltages uses only seven low-cost components.

Component values are chosen for best compromise between ripple suppression and response time. For example, Fig. 2 shows the filter response for a 6.5-$V_{pp}$, 143-Hz sine wave superimposed on a 4-$V_{pp}$, 14-Hz square-wave signal. The rise time of the output is very fast, and the ripple is suppressed by nearly 40 dB. This circuit works well even when the signal level is considerably lower than the unwanted ripple, provided the ripple level is fairly constant. The circuit was successfully used to recover millivolt signals buried in several volts of ripple.

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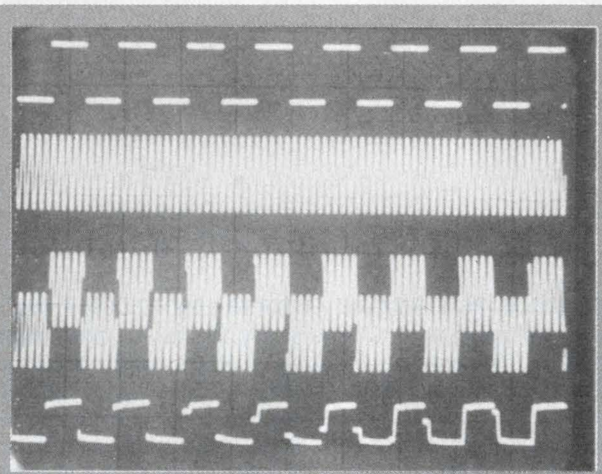


2. **A 4-$V_{pp}$, 14-Hz square wave (a) is recovered** from a superimposed 6.5-$V_{pp}$, 143-Hz sine-wave ripple signal, (b and c) with 40-dB suppression of the ripple and little deterioration of the square-wave rise time (d).

---

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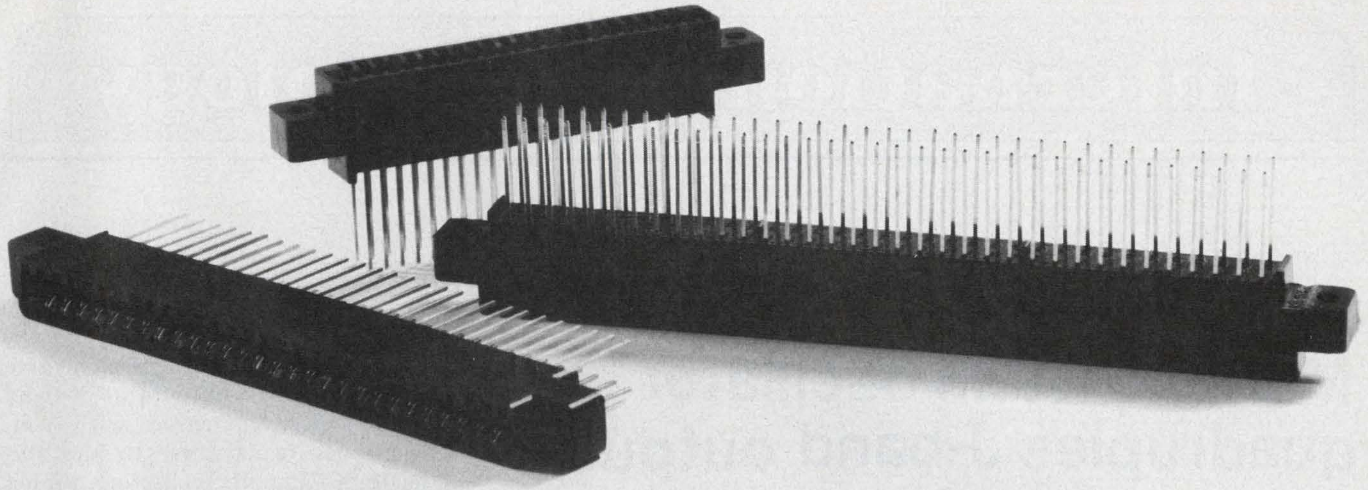

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INFORMATION RETRIEVAL NUMBER 52

# Multiple Gunn oscillator quadruples J-band output

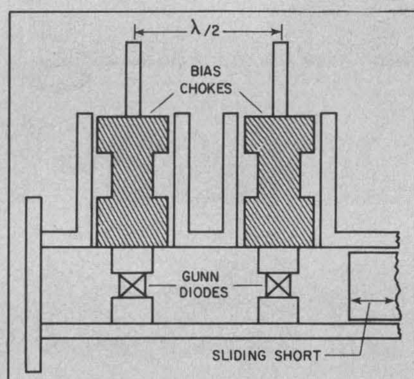
The power output of Gunn-diode oscillators in the J-band (16 GHz) has been quadrupled by researchers at Plessey Co.'s Allen Clark Research Centre in England. Their solution is a new waveguide-cavity oscillator design that uses four Gunn diodes in an additive-power arrangement.

The researchers report that while a single diode can produce as much as 30 W at X band, its power declines to about 10 W in J band. To compensate for this, a two-diode and a four-diode structure were developed.

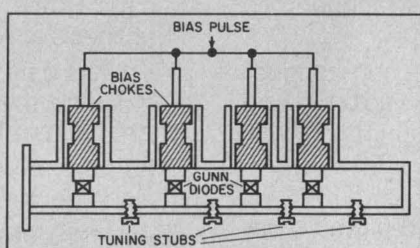
Two Gunn diodes in the waveguide structure (Fig. 1) give a pulsed output of 22 W. The diode separation is one-half the waveguide wavelength at the operating frequency.

The four-diode oscillator (Fig. 2) produces about 45 W and is tunable over a 1-GHz bandwidth by use of tuning stubs in the high-field regions between the diode locations. With the four diodes, however, device separation has to be experimentally altered to compensate for variations in the waveguide impedance.

The combined four-diode current is in the region of 30 A at a voltage of 25 V, which presents problems in producing a short rise-time output pulse.




1. **Two Gunn diodes in a waveguide** structure provide 22-W pulsed output.




2. **Four-diode oscillator** produces about 45 W and is tunable over 1 GHz.

The Clark solution is use of the pedestal approach, in which a low-current pulse brings the diodes to a point just below switching threshold. At this point, a fast voltage increase produces an abrupt rise time—and a clean output pulse—without need for additional high-current input.

## A new active device for X-band operation

A new transistor that is reported to operate at five to 10 times higher frequencies than standard microwave transistors has been developed in the Dept. of Engineering at Cambridge University, England. Known as an Impistor, the device uses an Impatt diode as the collector structure.

Impatt multiplication is combined with Impatt negative conductance to give the improved performance, according to the researchers. Impatt diodes alone give superior power outputs at X-band frequencies, compared with conventional transistors. In the Impistor's Impatt collector region there are avalanche zones between the collector and the emitter and there are drift zones near the collector contact.

In contrast with bipolar transistor biasing, the Impistor's base-collector region is biased into breakdown, usually with the base grounded. Very small emitter current is required if the emitter is reverse-biased with a grounded base.

## Fast switching reported with MESFET structure

A gallium-arsenide MESFET structure with a switching rise time of 35 ps has been developed at the Institut fur Halbleitertechnik at Aachen, West Germany. The fast-switching property, the researchers report, comes from the low transconductance and upper and lower saturation of the transistor-transfer characteristic.

A normally off MESFET was fabricated on an insulating chromium-doped gallium-arsenide substrate. The epitaxial layer was vapor-phase-grown ($n^-/n$), and an undoped $n^-$ region was operated as a buffer layer. A special etching technique—a combination of chemical etching and dc sputter—permitted adjustment of the channel thickness to within 100 A.

The transistor was tested at 300 K and it was found that, even at a high forward bias of 600 mV, the gate current was limited by the channel current and the diode was not destroyed. When the switching behavior was tested, the input step had a rise time of 60 ps, whereas the output into a 50-Ω load resistance rose in 35 ps.

# 5 reasons why the Keithley model 168 should be your number 1 digital multimeter

**1.** Autoranging. All you do is connect the signal to the two-terminal input and push the function you want. The 168 takes it from there to save you time.

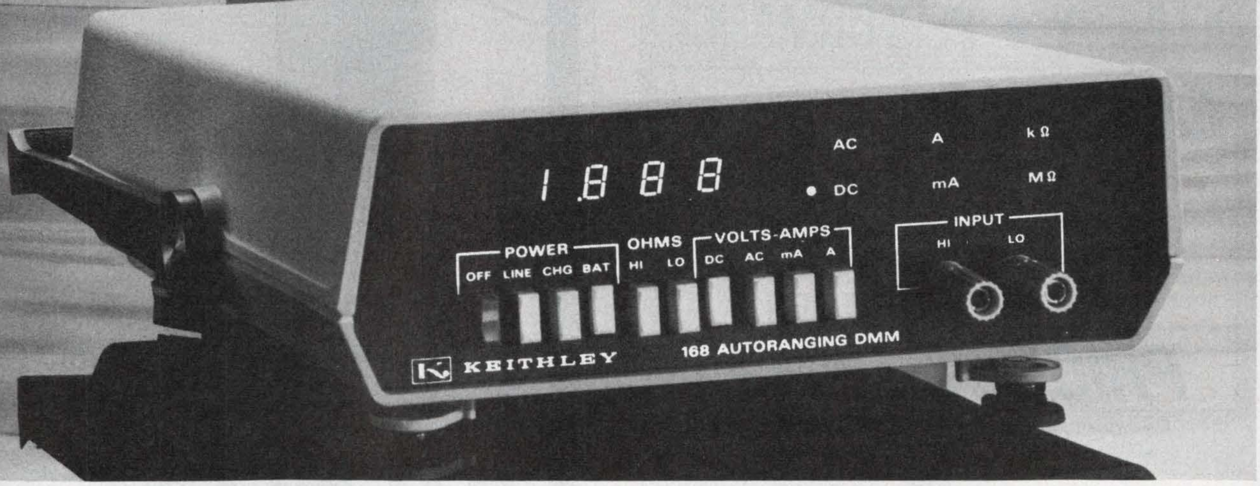
**2.** 5 Functions. Dc voltage from 100μV to 1000V, ac voltage from 100μV to 500V, ac and dc currents from 0.1μA to 1A and resistance from 100mΩ to 20MΩ.

**3.** Hi-Lo Ohms. Select ranges with 1-volt drop for turning on semiconductors or 100 millivolts for keeping them off.

**4.** Full 1-Year Guarantee. It's a Keithley, no less. And that means all specs including accuracy are guaranteed for a full year. Maintenance is easy too.

**5.** Low Price. Only $315 puts the Model 168 in your hands. A complete line of accessories gives the 168 even more versatility.

The Model 168 Autoranging DMM will make your job easier . . . and that should make it your number 1 choice. Send for full details or phone (216) 248-0400 for a right-away demo.

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INFORMATION RETRIEVAL NUMBER 53

# IC circuits in plastic DIPs provide the reliability of hermetic packages

*RCA Solid State Div., Route 202, Somerville, NJ 08876. (201) 722-3200. See text.*

Instead of chasing after the elusive hermetically sealed plastic package, as most other IC manufacturers have done, RCA has attacked the major plastic-package failure modes and claims to have achieved a breakthrough in reliability. In tests by both RCA and the Army, the new chip-processing techniques have reduced failure rates by a hundredfold to levels achieved with truly hermetically sealed packages.

The usual aluminum metallization for intra-chip connections was replaced with a trimetal process and this was combined with silicon-nitride passivation. RCA concentrated on these five causes of failure:

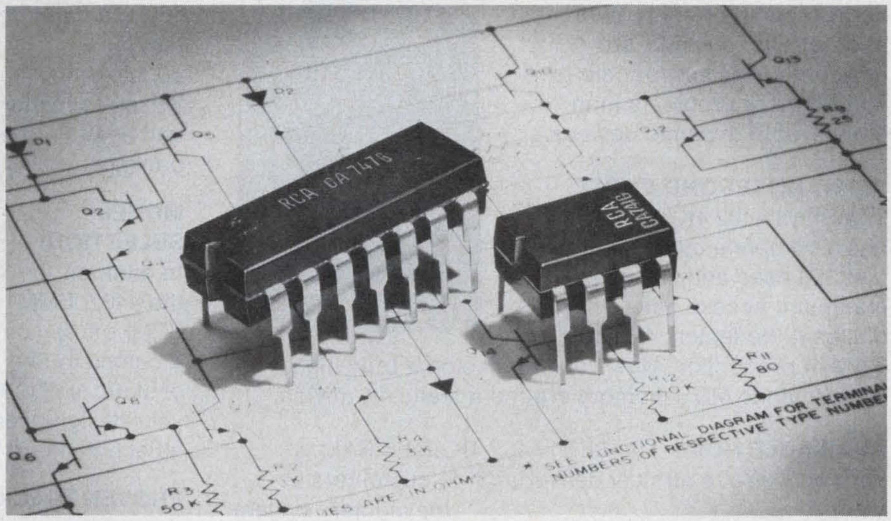
1. Purple plague. Intermetallic compounds that form between gold bond wires and the aluminum metallization cause brittle joints.

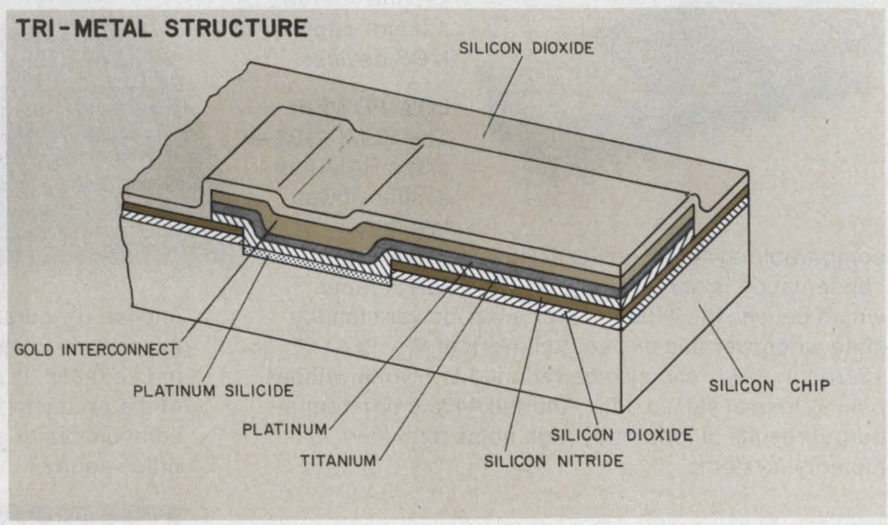
2. Electrolytic corrosion. Moisture that seeps into plastic packages converts aluminum to aluminum oxides, especially when bias voltages are present. The oxides are nonconductors, and open circuits and failure of the device soon follow.

3. Electromigration. High temperature that is often accompanied by mechanical stress and high current density causes a transport of mass in the direction of electron flow in aluminum. Thin sections soon become open-circuited.

4. Aluminum-silicon reactions. Silicon that dissolves into the aluminum at ohmic interfaces produces electrical shorts.

5. Poor step coverage. Microcracks or thin areas that often occur with aluminization result in






high current densities and eventual failure.

RCA says its titanium-platinum-gold combination overcomes these problems. And silicon-nitride passivation, it adds, protects the silicon substrate from moisture and other contaminants.

Gold is the primary conductive material. This eliminates purple plague, since gold metallization now is attached to the usual gold bond wires in place of aluminum. Also, gold is noncorrosive and far less susceptible to electromigration than aluminum.

Low ohmic contacts to the device's silicon junctions are made with platinum nitride. A titanium layer is then used for good adher-

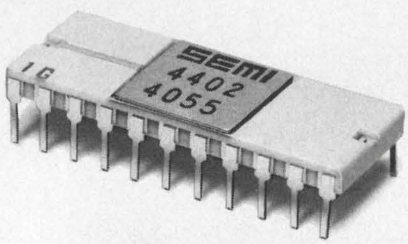
*(continued on page 99)*

# 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.

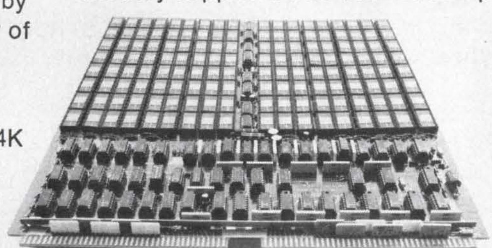
**PERFORMANCE TESTED:** Like all SEMI NMOS components, the 4402 4K static RAM must meet our own tough test standards, since we use it in our memory systems — for example the MICRORAM 3400N. With our reputation riding on its performance, you may be sure the acceptance standards are high indeed. In fact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

**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.

| 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.

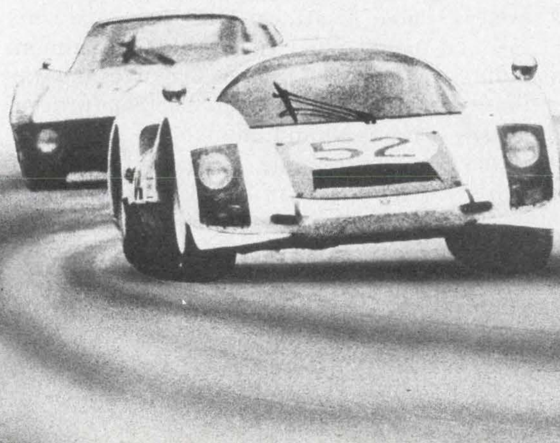
**PROVEN TRACK RECORD:** At EMM we've been making memory components and systems since 1961. Unlike memory suppliers who market components only, all EMM components are all performance proven in our own systems. When you buy from EMM, you get the benefit of the unusually high acceptance standards we impose 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 59



(continued from page 97)
ence to the platinum-nitride contact area and also to the silicon-nitride surfaces. Platinum between the titanium and gold acts as a diffusion barrier. Finally the gold interconnect pattern on the platinum provides high conductivity and excellent bond and step coverage (see illustration).

In this so-called hermetic-chip process, RCA follows the usual production process until the final oxidation step, where the silicon-nitride layer is applied to seal the junctions. A standard masking operation is used to open contact windows. Then platinum is sputtered over the wafer and sintered in the contact areas to form platinum silicide.

Titanium and platinum layers are sputtered sequentially on the surface of the wafer. The gold interconnect pattern is applied to the platinum layer with standard photoresist techniques. And a gold layer is electrolytically plated on the platinum interconnect paths through this resist mask. In the final step, as in the aluminum method, application of a silicon-dioxide layer protects the completed wafer during handling.

RCA has run a series of tests to establish the reliability of these "hermetic-chip" packages. On samples from four lots that total 250 units in a standard 15-V reverse-bias test at 85 C and 85% humidity, all devices survived for 5000 h. By contrast, RCA says, aluminum-metallized ICs began to fail at about 600 h under the same conditions, with 100% failure usually occuring within 1500 h.

In "pressure-cooker" tests, where the devices were operated at 30 lb/in$^2$ and 121 C, 230 units survived for 250 h and 50 for 200 h, RCA reports. Equivalent aluminized circuits showed an average of greater than 25% failures after 250 h, the company says.

In addition, the Army has been evaluating RCA's plastic devices since March, 1973, at its tropical test center in Panama. In seashore, salt-air environmental tests, 16 devices operated continuously for 14,232 h without failure in test racks that were protected only by wooden louvered enclosures, RCA reports. The failure rate was calculated to be less than 1%/1000 h, with a 90% confidence level.

In concurrent reverse-bias tests in 47 units at an inland jungle site—in similar louvered enclosures—the devices operated continuously also for 14,232 h, according to RCA. Here the failure rate was calculated to be less than 0.32%/1000 h, with a 90% confidence level.

The new ICs are priced the same as RCA's conventional aluminized plastic-packaged devices. Six standard linear circuits are now available from stock, identified by suffix "G". They include the CA741G and CA747G widely used op amps and four other circuits: the CA324G quad op amp, CA-339G quad voltage comparator and CA3724G and CA3725G high-current npn transistor arrays.

Other devices are to follow, including both new circuits and circuits currently in RCA's product line.

CIRCLE NO. 301

## Super solvent unsticks super glues

*Edmund Scientific Co., 380 Edscorp Bldg., Barrington, NJ 08007. $4.25/oz: Stock No. 42, 225; stock.*

Now users of the super glues can unglue their mistakes. A solvent quickly and safely releases the hold of super glues to allow re-alignment of work that has been incorrectly bonded. The solvent will get fingers unstuck, dissolve super glue bonds from skin (even eyelids), clothing, tools and instruments. It is said to be safe for external use on humans.

CIRCLE NO. 304

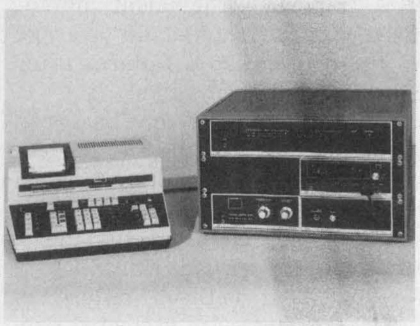
## Pure-metal anodes reduce sludge problems

*Litton Industries, 4201 Wrightwood Ave., Chicago, IL 60639. (312) 235-1601.*

New Ultrapure anodes have been developed for plating PC boards, copper wire, bus bars, terminals, eyelets and other electronic parts. According to Kester engineers, Ultrapure's special processing eliminates oxide inclusions, trapped gasses and sulphur and metallic contamination. No bagging is required, since there is a minimum of sludge and flaking.

CIRCLE NO. 305

## Measurement system includes calculator



*Keithley Instruments, 28775 Aurora Rd., Cleveland, OH 44139. (216) 248-0400. 90-120 days.*

System 1—a calculator-based data-acquisition, control and measurement family—embraces a series of plug-to-plug compatible instruments, interfaces, other hardware, and software. The system allows the user to attain on-line measurement and computation capability with nearly the sophistication of a minicomputer system, but at a fraction of the total cost.

The heart of the System-1 family is a full-function, fully programmable calculating unit (PCU) with a paper-tape printer and controller. The PCU is integrally tied to an interface that permits direct connection of the company's digital multimeters, scanners, electrometers, nanovoltmeters and other instruments and peripherals. Provision is also made to connect to other manufacturers' instruments, with Keithley's guidance to ensure proper interfacing.

In its most sophisticated form, System 1 can control up to six DMMs and provide up to 180 channels of low-level voltage (microvolts) or low-level current (picoamps) input. The PCU itself has a memory of 512 words, expandable to 4 k. Additionally, mag-card storage is standard.

Communication with any instrument in the system is through simple keystrokes. Most of the commonly used mathematical functions, including logarithms, exponentials and trigonometric and statistical functions can be implemented and programmed by depression of a key. Another keystroke enables a program to be stored quickly on a magnetic card for further use.

**CIRCLE NO. 302**

## $295 buys 100-MHz, 7-digit counter/timer

*Data Precision, Audubon Rd., Wakefield, MA 01880. (617) 246-1600. $295.*

Available for just $295, Model 5740 is a 7-digit, 100-MHz counter/timer designed to measure frequency, period average, elapsed time and total events. The unit measures frequency from 5 Hz to 100 MHz; single period (sine wave) time from 1 μs to 0.2 s; period average with 1-ns resolution to 99,999.99 μs; event counting (totalizing) from 0 to 9,999,999; and time interval (stop watch) measurement covering 0 to 99,999.99 s (27.8 hrs). Sensitivity is 10 mV from 5 Hz to 20 MHz, rising linearly to a high-frequency of 50 mV rms at 100 MHz.

**CIRCLE NO. 306**

## Microwave power meter gets 'high marks'

*Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 93404. (415) 493-1501. $1800; 8 wks.*

Model 436A digital microwave power meter has built-in firmware "intelligence" to switch automatically among its 5 power ranges, to translate its reading into watts, dBm or dB relative, as desired, to locate the displayed decimal correctly, and to recognize which of several possible sensors is connected, and to calibrate its display accordingly. Instrumentation uncertainty is less than 0.5% of reading. Power and frequency range depend on sensor used and range from 100 kHz to 18 GHz in a power range from −30 to +35 dBm.

**CIRCLE NO. 307**

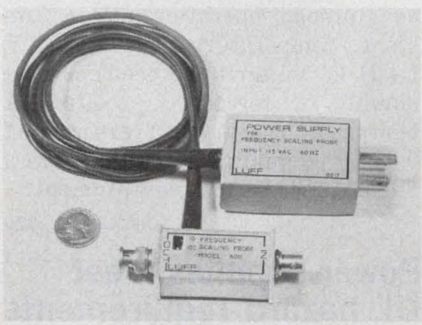
## Single-slope DPM dissipates 3 W


*Data Technology, 2700 S. Fairview St., Santa Ana, CA 92704. (714) 546-7160. $189; stock to 30 days.*

Though it is classified as a 3-1/2-digit instrument, Model 3362 6000-count DPM has a full 1 through 5 readout in the first position thereby providing 4-digit accuracy for measurements such as shaft rotation (over 360 degrees), temperature (up to 500 C) and similar applications. The unit has a conversion time of 60 ms max. The repetitive read rate is set at 4 readings/sec but can be increased to 8 readings/sec with an external resistor.

**CIRCLE NO. 308**

## Scaling probe extends counter range to 0.6 GHz

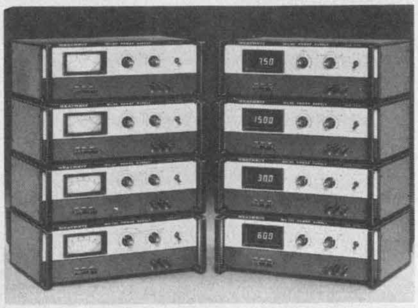



*Luff Research Associates, P. O. Box 449, Jackson Heights, NY 11372. (212) 429-5900. $325; 4 to 12 wks.*

Model 600 frequency scaling probe is a miniature assembly (2.5 × 1.5 × 1 in.) that attaches directly to a counter and extends the counter's frequency range to 600 MHz. The probe has a built-in switch that allows the input frequencies to be divided by either 10 or 100 and an extremely sensitive input amplifier that allows measurements typically to better than −30 dBm to 600 MHz. Power is supplied by a wall plug assembly with a 6-ft cord to the probe.

**CIRCLE NO. 309**

## Lab supply offers choice of readout



*Heath Co., Benton Harbor, MI 49022. (616) 983-3961. Analog kit, $169.95; Digital kit, $219.95; stock.*

Eight laboratory power supplies from Heath are the first in their price range to offer a choice of analog or digital readouts. The digital models (3-1/2 digits) offer two-decade autoranging to provide high resolution at low voltage and current settings.

Available in both kit and assembled form, the 2700 series operates in both constant-current and constant-voltage modes, which function independently of each other. And the units are true constant current not simply current limiting.

Adjustment of two front-panel controls is all that's needed to get exactly the voltage and current that is required. If one supply doesn't deliver the needed output, two or more units can be connected in series or parallel—with no loss of regulation.

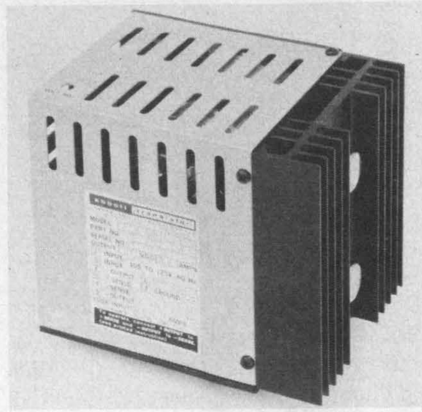
Load regulation is ±0.05% +1 mV for voltage, and ±0.1% +3.5 mA for current. Line regulation is specified at ±0.05% +1 mV for voltage and ±0.10% +1 mA for current. Any of four output ranges are available: 0 to 75 V at 10 A, 0 to 15 V at 5 A, 0 to 30 V at 3 A, and 0 to 60 V at 1.5 A.

The analog readout supplies can be field calibrated to ±3% for voltage and current. And built-in standards in the digital versions allow calibration to within ±1.0% for voltage, and within ±1.5% for current. If lab standards are used, units can be calibrated within ±0.5% for voltage and ±1.0% for current.

Remote programming and sensing are standard in the 2700 series, as is output protection.

**CIRCLE NO. 303**

## Modular supplies are rugged



*Abbott Transistor Labs, 5200 W. Jefferson Blvd., Los Angeles, CA 90016. (213) 963-8185. $104 to $131; stock.*

The RN2.5 family provides 2.5 A at various voltages between 4.5 and 37 V dc. Line and load regulation are 0.1% and ripple is less than 0.02%. Standard features include short-circuit protection, input transient protection and remote error sensing. High reliability, with a predicted mean time between failure (MTBF) of more than 75,000 hours, is typical of these units. Anodized aluminum case construction permits sustained full-load operation at an ambient temperature of +160 F (+71 C) without the need for heat sinking or forced air cooling. A temperature coefficient of 0.03%/°C guarantees stability in a fluctuating thermal environment.

**CIRCLE NO. 320**

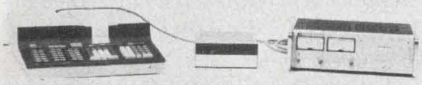
## Power supplies meet UL hazard requirements

*Power-One, Inc., 531 Dawson Dr., Camarillo, CA 93010. (805) 484-2806. $29.95; stock.*

Two new supplies are UL approved (Class 2) for use in hazardous environments. In the event of a catastrophic regulator or component failure, the transformer is protected and will not overheat or burn. Listed as a recognized component under UL478 and UL114, Model B12-1.7 S113 and Model B24-1.2 S113 deliver 12 V, 1.7 A and 24 V, 1.2 A, respectively. These IC-controlled units have line/load regulation of ±0.05%, with current limit/foldback built-in. OVP is an option. Input power is 115/230 V ac.

**CIRCLE NO. 321**

## Standard interface weds digital power sources

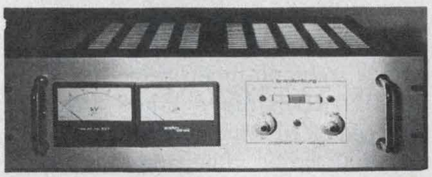


*Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. $2300 to $3550; 1-8 wks.*

Four of the company's existing digitally programmable voltage sources (6128C-6131C) and two digitally programmable current sources (6140A, 6145A) now can be ordered with Option J99 for compatibility with the Hewlett-Packard Interface Bus (HP-IB). The factory-modified units are designed to be connected through an ASCII-to-parallel converter, Model 59301A, to the company's programmable calculators. All J99-equipped units feature isolation between digital inputs and analog outputs, internal storage of digital data, digitally programmable current latch (on voltage sources) or voltage limit (on current sources) and analog input (both ac and dc) to modulate output.

**CIRCLE NO. 322**

## High voltage supplies span 3 to 60 kV

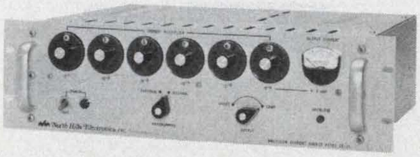


*Brandenburg Ltd., 930 London Rd., Thornton Heath, Surrey CR4 6JE, England.*

A line of high-voltage power supplies features high stability (10 ppm) at voltage outputs ranging from 3 to 30 kV and 6 to 60 kV. The units measure 14 × 5.25 × 19 in. The output, which is via a removable connector at the rear, is controlled by 10-turn helical potentiometers. This gives a continuously variable coarse and fine adjustment. The fine control permits resetting to within 20 ppm. Two 3-in. scale analog meters indicate output voltage and current; a digital readout is optional. The units operate from standard line power at temperatures between 32 and 95 F.

**CIRCLE NO. 323**

## Current source holds to 5 ppm per 100 h

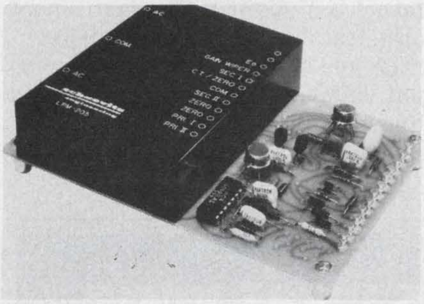


*North Hills Electronics, Glen Cove, NY 11542. (516) 671-5700. $1695; stock-30 days.*

Ultra-stable dc current source, Model CS-31, features long-term stability over 100 hours of 5 ppm, with output capability of 0 to 2 A at 60-V compliance. A six-decade, direct reading Kelvin-Varley voltage divider permits current setting with a resolution of 1 ppm of full-scale. Remote programming may be achieved by use of an external K-V divider. The instrument also features 0.01% absolute accuracy and 2-ppm regulation of output current over specified load and line variations.

**CIRCLE NO. 324**

## LVDT signal conditioner powered by ac line

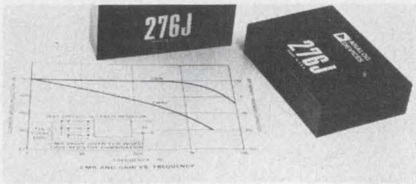


*Schaevitz, P.O. Box 505, Camden, NJ 08101. (609) 662-8000. $164 (unit qty); stock.*

The LPM series of signal conditioning modules is designed to condition linear variable differential transformer outputs. The modules operate from conventional ac line voltages and all that is required for a complete measurement system is the ac power, an LVDT, and a readout. Use of a passive diode demodulator makes phase adjustments unnecessary. Output is proportional to LVDT displacement, and the output is a low impedance, ±5-V-dc signal which can drive meters, high response recorders, or other dynamic indicators. An internal oscillator delivers a nominal 3-V-rms LVDT excitation. Some other specifications include frequency response from dc to 100 Hz (within ±1 dB), minimum input of 50 mV results in a ±5-V-dc output, and nonlinearity and hysteresis is less than 0.1% of full scale.

**CIRCLE NO. 325**

## Isolation amplifier designed for medical use




*Analog Devices, Rte. 1 Industrial Park, P.O. Box 280, Norwood, MA 02062. (617) 329-4700. $49 (100-up); stock.*

The Model 276J medical isolation amplifier is optimized for patient monitoring equipment. The unit surpasses the patient safety current limits proposed by UL, AAMI and other regulatory agencies. The input circuit design limits input fault currents to 10 μA during amplifier failure. The isolator also limits ground leakage currents to under 0.01 μA/V ac between input and output and to the power common while providing full defibrillator protection. The 276J has only 8 μV pk-pk of input noise, a high, 115 dB (minimum), common-mode rejection ratio, when measured at 60 Hz, with a 5-kΩ source imbalance and a high, 50 MΩ in parallel with 20-pF, common-mode input impedance. The amplifier has a ±0.5-V input signal range; a 1-kHz, 3-dB frequency response; a 0.2% nonlinearity; and a ±0.015%/°C gain tempco. The gain is optimized for 3 V/V to maximize signal gain while ensuring that skin-electrode potentials will not saturate the isolator. The 276J is packaged in a 3.5 × 2.5 × 1.25 in. (89 × 64 × 32 mm) module and operates over 0 to 70 C.

**CIRCLE NO. 326**

## Active filters designed for audio frequencies

*Siemens Aktiengesellschatt, D-8000 Munchen 1, Postfach 103, West Germany.*

Active RC filters operate in the audio frequency range up to approximately 20 kHz. The desired filter parameters, such as frequency, Q-factor and gain, are set by laser trimming of specific resistors with tolerances better than 1%, the maximum temperature coefficient of the RC filter is 40 ppm/°C. This temperature coefficient means that the frequency does not change by more than 0.2% for temperature changes of 50 C. Filters are available over a range of 100 Hz to 1 kHz with a Q of 100 and up to 10 kHz with a Q of 50. Various types of operational amplifiers can be used. So far ICs TAA 861, TAA 761 and TBA 221 have been used.

**CIRCLE NO. 327**

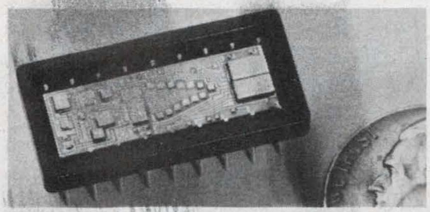
## Hybrid instrumentation amp has 300 MΩ input Z

*National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. (408) 732-5000. From $12.10 (100-up); stock.*

The LH0037 instrumentation amplifier uses three operational amplifiers and a precision, laser trimmed thin-film network. It has a high, 300-MΩ input impedance, and a common-mode rejection ratio of 100 dB. Only a single resistor is needed to set the gain over a 1 to 1000 range. The amplifier operates over ±5 to ±22 V and is housed in a 12-pin, TO-8 hermetic can.

**INQUIRE DIRECT**

## D/a converters operate at CMOS power levels

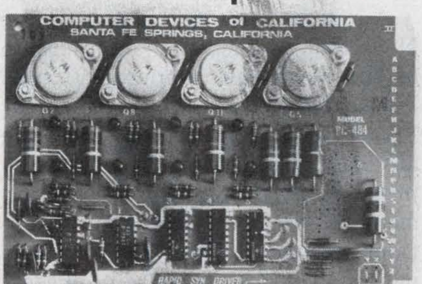


*Micro Networks, 324 Clark St., Worcester, MA 01606. (617) 852-5400. $129 (1 to 24); 2 to 5 wk.*

Two 12-bit CMOS compatible d/a converters are available in 18-pin DIPs. The MN370 has a bipolar output of −10 to +10 V. The MN371 has a unipolar output of 0 to 10 V. Both units are complete with output operational amplifier and an internal reference supply. The total power dissipation for either device is 60 mW typical and 90 mW max. The MN-370 and MN371 are available for operation over the full military temperature range of −55 to +125 C ("H" Models) and still guarantee linearity of ±0.5 LSB max. over the entire temperature range. In addition, both converters are available screened 100% to the Class B requirements of MIL-STD-883.

**CIRCLE NO. 328**

## Multimode motor driver delivers 4 A/phase




*Computer Devices, 11901 Burke St., Los Angeles, CA 90670. (213) 698-2595. $83; stock.*

The Model PC-484 is a bidirectional driver capable of three different modes of excitation: single mode, dual mode, and half-step mode. This capability enables engineers to evaluate the motor exciting one winding, two windings or alternating between the two. Excitation modes can be selected by simply grounding pins Y or Z. This selection can be accomplished either before or during operation of motor.

**CIRCLE NO. 329**

## Parallel processor extends Nova speed

*Educational Data Systems, 17981 Sky Park Circle, Irvine, CA 92707. (714) 556-4242. $2600; 60 days.*

A microprogrammable processor, called the Micro-N, executes microprograms in parallel with that of the Nova CPU. Typical speeds for four-word floating point operations are up to 100 times faster than a Nova 1200 that uses software routines. The processor occupies one slot in any Data General Nova computer or DCC D-116. One or more Micro-N's can operate on the data channel in parallel with the standard CPU of the Nova. Each accesses macros and data from Nova core via the data channel.

**CIRCLE NO. 330**

## Line switch is directed by a stored program


*Multiplex Communications, 123 Marcus Blvd., Hauppauge, NY 11787. (516) 231-5350. See text: 4 to 6 mos.*

A stored program directs a unit called the Automatic Data Switch. The device interconnects any number of lines, from 10 up to 256. It can be used as a local telegraph switching exchange, a data line concentrator or as a local data intercom system. The switch can also function as a computer line switch, time-share concentrator, or as a real-time circuit switch. System expansion is facilitated by additional modules and line terminators. A diagnostic facility displays program status and monitors line voltage and current. The basic 10-line system is available for less than $13,000. 100-line systems are less than $500/line.

**CIRCLE NO. 331**

## High-quality serial printer does 30 char/s

*Interdata, Terminal Products Corp., 2 Crescent Place, Oceanport, NJ 07757. (201) 229-4040. See text; May.*

Digital stepper motors and a "Carousel" print cup combine to give high print quality at 30 char/s. The impact printer features a built-in microprocessor that is an integral part of the electromechanical system. The processor controls the stepper motors that move the print head, position the carousel and feed the paper. And the unit prints up to 132 char/line. For graphics use, the processor interprets ASCII control characters to move the paper up and down or slew the print cup at 600 steps/s with 0.01-in. increments. Vertical increment is 1/48-in. The barebones unit accepts 8-kit parallel ASCII input. A barebones printer sells for $1478 (50 qty) while a complete ASCII terminal costs $2009. The print cup, which is capable of 1M character impressions, costs $8.75 to replace.

**CIRCLE NO. 332**

## Nova 830: a lower cost option to the 840

*Data General, Route 9, Southboro, MA 01772. (617) 485-9100. See text; 30 days.*

A systems-oriented computer, the Nova 830, is a lower-priced version of the Nova 840 computer. It uses high-capacity 32 kbyte core memory (1 $\mu$s) to permit large system size at moderate price. A Nova 830 processor with 128 kbytes of main memory, memory management option, power supply and console panel all in a 10-1/2-in. chassis with 10 additional slots available for system memory and I/O interfaces costs $23,150. The Nova 830 has the same facilities as the faster Nova 840—full hardware-protected dual operations, standard dual-processor/shared disc operations, memory mapping with 2-kbyte boundaries and support of 256 kbytes of memory in one processor. The Nova 830 also supports Data General's operating systems, high level languages, utility programs and program development aids. A single 830 supports 30 time-shared terminals.

**CIRCLE NO. 333**

## Low-cost column printer uses electro-discharge


*Harry Gocho Enterprises, Copal Div., 56-01 Queens Blvd., Woodside, NY 11377. (212) 779-5252. See text.*

A sample of the SF-30 electro-discharge printer costs $85. Its capabilities include 2 line/s speed, and 11-digit width (5 × 7 dot-matrix). The unit supplies timing and start signals: one a 0.4-V pulse, the other a switch contact.

**CIRCLE NO. 334**

## Digital LSI modem can perform at 4800 bit/s

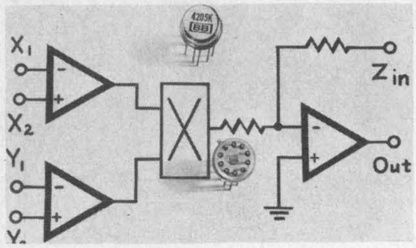
*Microelectronics Div., Rockwell International, PO Box 3669, 3430 Miraloma Ave., Anaheim, CA 92803. (714) 632-2321.*

A 4800/2400 bit/s modem based on MOS/LSI circuits is available from Rockwell International Corp. The half-duplex modem, for use on voice-grade telephone line, uses digital modulation and demodulation techniques and includes adaptive equalization. The modem provides phase coherent, suppressed-carrier, double-sideband modulation on two quadrature carriers. Two amplitude levels are used for the 2400 bit/s rate and four levels at the 4800 bit/s rate. A phase-locked-loop corrects jitter. Complete initialization is achieved without any preamble or start up. Automatic equalization, timing, carrier phase and agc are learned from the data signal alone. Even after major line disturbances, there is no need for the receiver to call for retransmission of a preamble to relearn the channel. Rockwell's Microelectronic Device Div. develops custom MOS/LSI modems that range from 1200 bps to 9600 bps for equipment manufacturers.

**CIRCLE NO. 335**

INTEGRATED CIRCUITS

## Multiplier/divider has 1% accuracy

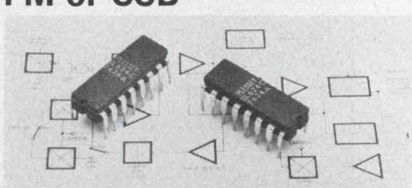



*Burr-Brown, International Airport Industrial Park, Tucson, AZ 85734. (602) 294-1431. $16 to $31.50 (100); stock to 2 wks. (small quantity).*

Laser trimmed and self-contained, a new series of IC multiplier/dividers needs no adjustments or external components to meet its guaranteed accuracies of 1% (4205K and 4205S) and 2% (4205J). And the units have differential inputs for flexibility in choosing algebraic sign for the operations of four-quadrant multiplying, dividing and square rooting —all of which the 4205 does without additional amplifiers. Other features include a 25-V/μs slew rate, 1-MHz bandwidth and overload recovery time of 3 μs. Harmonic distortion reportedly remains low for frequencies well above 100 kHz.

**CIRCLE NO. 336**

## Demodulate AM, FM or SSB

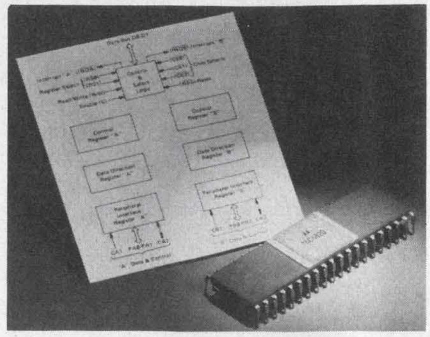


*Plessey Semiconductors, 1674 McGaw Ave., Santa Clara, CA 92705. (714) 540-9979. $4.44 (stock).*

The SL624 IC can perform as a synchronous detector for AM, a quadrature detector for FM, and a product detector (with built-in oscillator) for SSB or cw. The IC can be completely switched to implement different modes, or two ICs can be used to reduce switching costs. Usable at frequencies to 30 MHz, the SL624 operates from voltages of 9 to 12 V, and it requires about 20 mA at 12 V. The circuit comes in a standard 16-pin ceramic DIP.

**CIRCLE NO. 337**

## Interface peripherals to microprocessor



*Motorola Semiconductor Products Inc., P.O. Box 20924, Phoenix, AZ 85036. (602) 244-3466. $28 (1-24).*

The MC6820 Peripheral Interface Adapter (PIA) provides a means of interfacing peripheral equipment to the company's MC-6800 microprocessor. Data flow between the processor and a PIA by means of an 8-bit bidirectional bus. Data transfer between the PIA and a peripheral occurs on 16 I/O lines organized as two 8-bit bi-directional busses. Each I/O line may be individually programmed to act as either an input or output of the PIA. The six registers in the PIA are accessible to the processor via its bidirectional data bus and as standard memory locations. The PIA comes in a 40-pin DIP.

**CIRCLE NO. 338**

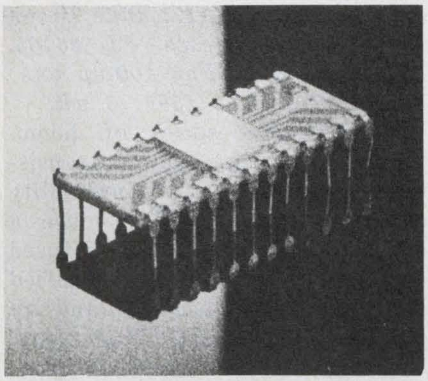
## Darlington arrays allow 600-mA peak

*Sprague Electric Co., 347 Marshall St., North Adams, MA 01247. (413) 664-4411.*

Three high-voltage, high current Darlington transistor arrays in DIPs consist of seven silicon npn Darlington pairs on a common monolithic substrate. All units feature open-collector outputs and integral suppression diodes for inductive loads. Allowable peak inrush currents reach 600 mA, or a suitable level for driving tungsten-filament lamps. The type ULN-2001A is a general-purpose array that can be used with standard logic circuits. The Type ULN-2002A has been specifically designed for use with 14-to-25-V PMOS circuits. The Type ULN-2003A has a series base resistor to each Darlington pair, and thus allows operation directly with TTL or CMOS operating at a supply voltage of 5 V.

**CIRCLE NO. 339**

## Bipolar PROMs have byte structure

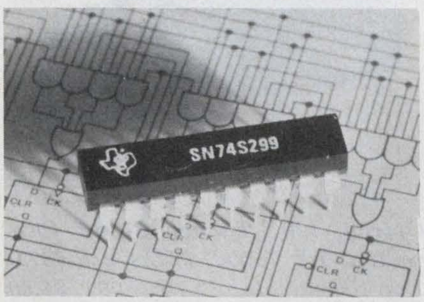


*Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. (408) 739-7700. $60 (100).*

Two byte-organized bipolar PROMs, the 2-k bit 82S114 and the 4-k bit 82S115, feature typical access times of 35 ns. The 82S114 holds 256 eight-bit words, while the 82S115 holds 512 bytes. Other features include buffered address lines, on-chip decoding, on-chip storage latches, three-state outputs and input currents less than 100 $\mu$A.

**INQUIRE DIRECT**

## 70-MHz, 8-bit SR reduces board space




*Texas Instruments Inc., P.O. Box 5012, M/S 308, Dallas, TX 75222. (214) 238-3741. $5.60 (100); stock.*

A 70-MHz parallel-access, 8-bit Schottky-TTL shift register—the SN74S299—provides the equivalent of two 16-pin SN54S/74S194 or one 24-pin SN54/74198 universal shift register in a single 20-pin package. With pin-row spacings of 0.300-in., the new 20-pin register can reduce PC board area requirements by 40% and 55%. The bidirectional register has full parallel access for loading or reading, with shift right, shift left, hold, and clear modes of operation controlled from two function-select inputs.

**CIRCLE NO. 340**



**INFORMATION RETRIEVAL NUMBER 69**



**INFORMATION RETRIEVAL NUMBER 70**

DISCRETE SEMICONDUCTORS

## Ultraviolet photodiode has low impedance

*ITT Electro-Optical Products, 7635 Plantation Rd., Box 7065, Roanoke, VA 24019. (703) 563-0371. $875; 30 to 60 day.*

A 1.25-in. diameter ultraviolet sensitive biplanar photodiode, type F-4115, uses a magnesium fluoride entrance window. The cesium telluride photocathode is formed on a solid metal substrate, which assures a low impedance characteristic. This feature, in conjunction with the close spaced mesh anode, makes the diode useful as a fast, relatively high current laser pulse receiver. Due to the solar blind characteristic of the photocathode and its associated magnesium fluoride entrance window, the diode should find applications involving the detection of UV in the presence of high ambient visible radiation.

**CIRCLE NO. 341**

## Transient suppressor handles up to 60 kW

*General Semiconductor, 20001 W. Tenth Pl., Tempe, AZ 85281. (602) 968-3101. $79 (100 up); stock to 4 wk.*

The 60KS200C TransZorb is a high power surge suppressor. The TransZorb suppressor has been designed around the Navy's MIL-STD-1399 (Interface Standard for Shipboard Systems, Electrical Power, Alternating Current). It is rated for 180-V peak voltage and has a maximum clamping voltage of 335 V at 180 A. The unit has a maximum surge power of 60 kW for 40 $\mu$s and 350 kW for 1 $\mu$s.

**CIRCLE NO. 342**

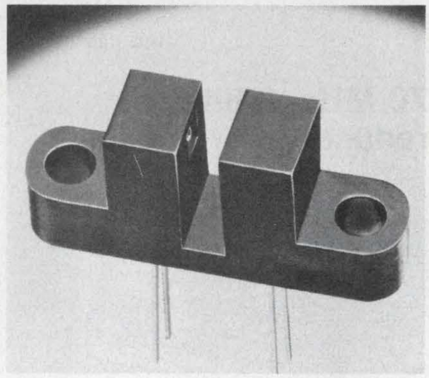
## Power transistors handle up to 30 A

*Solitron Devices, 1177 Blue Heron Blvd., Riviera Beach, FL 33404. (305) 848-4311. For 100-up lots: $3.75 (58); $4.50 (59); 3 wk.*

The 2N6258 series of homogeneous base npn power transistors has a peak current capability of 30 A. The transistors use a 0.284 × 0.284 in. single-diffused chip. The transistors are identified as the 2N6258 and 2N6259 and are packaged in JEDEC TO-3 cases. Typical features of the 2N6258 include $V_{CEO}$ greater than 80 V, $V_{CBO}$ of 100 V and a minimum gain of 20 at 15 A. The 2N6259 offers a $V_{CEO}$ greater than 150 V, a $V_{CBO}$ of 170 V and a minimum gain of 15 at 8 A. Both devices offer typical $I_{S/B}$ greater than 250 W/s and a $\Theta_{J\text{-}C}$ of 0.5 C/W.

**CIRCLE NO. 343**

## Optical interrupters use infrared light beams

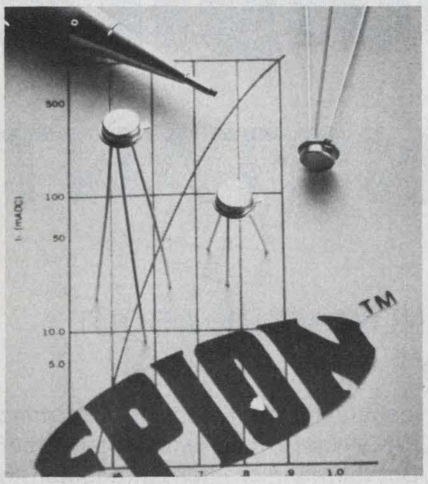


*Optron, 1201 Tappan Circle, Carrollton, TX 75006. (214) 242-6571. For 100-up lots: $1.70 (800), $1.80 (803); stock.*

The OPB 800 and OPB 803 optically coupled interrupter modules consist of a GaAs infrared LED coupled with a silicon photosensor in a plastic housing. The OPB 800 with a phototransistor sensor has a typical unblocked output of greater than 0.75 mA with a LED input of 20 mA. Typical output of the OPB 803 with a photo-Darlington sensor is 3 mA with an input of 10 mA. Both units have a high resolution aperture for shaft encoder or strobe bar applications, an infrared transmitting filter for applications in high ambient light applications and alternate pin separation to fit standard DIP sockets.

**CIRCLE NO. 344**

## High speed rectifiers handle currents to 1.5 A




*Solid State Devices, 14830 Valley View Ave., LaMirada, CA 90638. (213) 921-9660. $1.98 (100-up); stock.*

Ion-implanted 1-A silicon rectifiers have reverse recovery speeds of less than 10 ns. The diodes are available with voltages to 150 V. They have a capacitance of 20 pF maximum at 0 V, and can operate at temperatures from −65 to +200 C. Low threshold voltages of 300 mV at 1 mA and 900 mV maximum at rated currents to 1.5 A are available.

**CIRCLE NO. 345**

## P-i-n and limiter diodes come with carrier choice

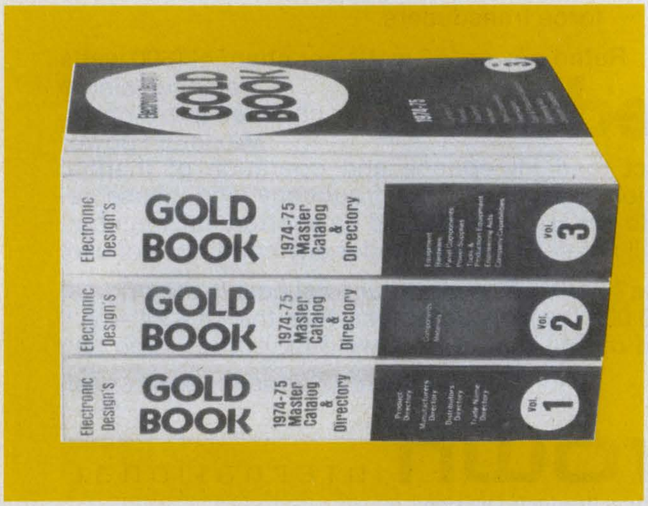
*Alpha Industries, 20 Sylvan Rd., Woburn, MA 01801. (617) 935-5150. From $4.50 (1 to 9); 10 to 30 day.*

A line of p-i-n and limiter control diodes is designed for hybrid microwave circuits. The devices are available in basic chip form or mounted on a choice of standard carriers. The hybrid carrier choices include LID, mini-strip and post configurations. Chips are mounted on the carrier using a high temperature gold-germanium solder preform. Typical p-i-n diode characteristics of the CSB-7000 series include: $V_B$ min at an $I_R$ of 10 $\mu$A is 50 to 200 V, $C_T$ at a $V_R$ of −50 V ranges from 0.13 to 0.45 pF and a $T_s$ at an $I_F/I_R$ of 0.05 that spans 3 to 100 ns. Characteristics of the CLA-3100 diode limiter series include: a $V_B$ min of 25 to 70 V, a $C_T$ of 0.15 to 0.3 pF, and a $T_s$ of 3 ns.

**CIRCLE NO. 346**

# Electronic Design's

# YOUR OWN INSTANT




## 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** | **NUMBER OF ENGINEERS** |
| **TELEX** | **NUMBER OF EMPLOYEES** |
| **CABLE ADDRESS** | **DOLLAR VOLUME** |
| **FACSIMILE EQUIPMENT (make and call number)** | **KEY OFFICIALS** |
| **QPL DESIGNATION** | **SALES OFFICES** |
| **FEDERAL STOCK CODE NUMBER** | **FOREIGN OFFICES** |
| | **U.S. & FOREIGN REPS** |
| | **U.S. DISTRIBUTORS** |

## 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.

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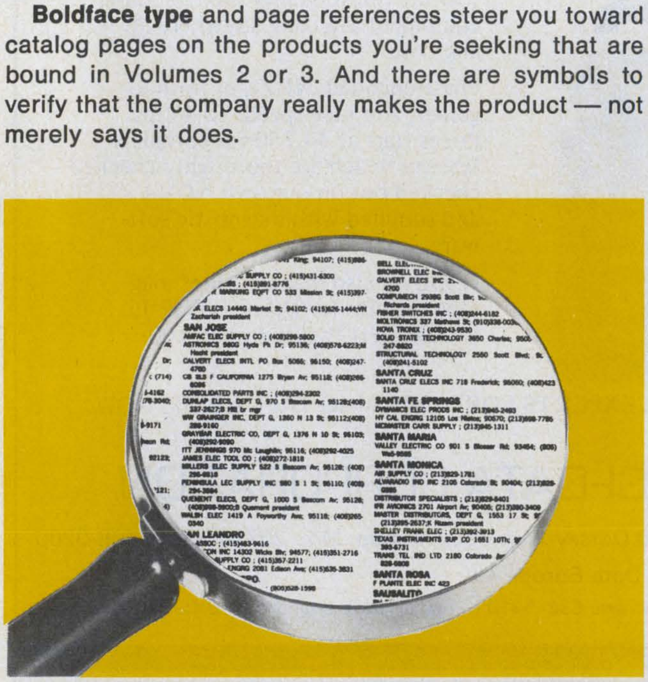
Check the Geographical Section of the GOLD BOOK's *Distributors Directories.* You enter the section by state, then find your city — or one nearby — and the distributors located in that city. You can then go to the Alphabetic Section to find the complete address, zip, and phone. In most cases annual sales 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.*)

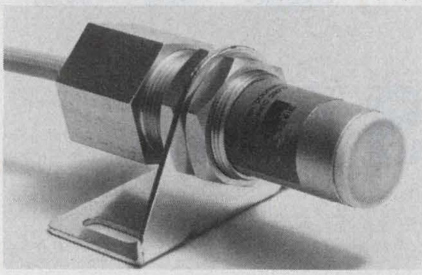


## LOOKING FOR A FOREIGN REPRESENTATIVE?

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.)

COMPONENTS

## Proximity switch senses all metals

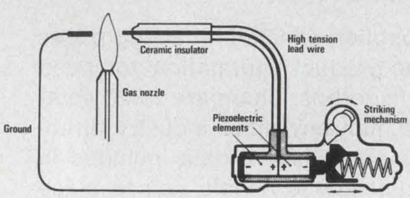


*Eldec Corp., 16700 13th Ave. W., Lynnwood, WA 98036. (206) 743-1313. $75 (100 up); 30 days.*

An all-metal-sensing proximity switch, Model 8-250, fits a standard 1/2-in. conduit for easy adaptation to material handling and machine-tool applications. The unit is said to withstand extremely harsh environments. The sensing distance is 0.320 in. on steel with a repeatability of ±10%. Response time is 10 ms. The operating temperature range is −40 to 180 F. The unit can switch 1 A.

**CIRCLE NO. 347**

## Piezo element ignites commercial gas units

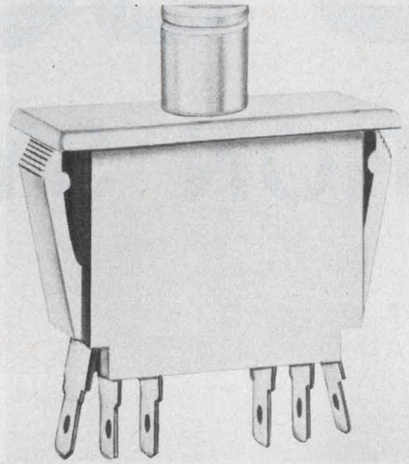



*National Instrument Co., Inc., 4119-27 Fordleigh Rd., Baltimore, MD 21215. (301) 764-0900.*

A piezoelectric gas igniter designed for original equipment manufacturers is available in seven different models. The gas igniter replaces dangerous, troublesome pilot lights. It is actuated automatically when the gas cock of the appliance is turned on to generate a high-voltage, low-amperage current that produces an electrical discharge into the gas stream. The gas ignites every time, without failure, according to the manufacturer. A spring-loaded striker hits the convex-shaped surface of a lead-titanate-zirconate ceramic piezo element. Rated life is 50,000 to 100,000 ignitions. Any type of commercially available gas, including natural gas, manufactured gas, propane, butane, etc., can be ignited.

**CIRCLE NO. 348**

## Snap-action switch features short button

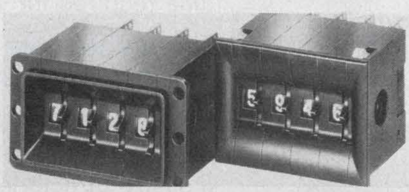


*Cherry Electrical Products Corp., 3600 Sunset Ave., Waukegan, IL 60085. (312) 689-7702. $0.78 (200 up); stock to 5 wks.*

The Cherry E79-40A DPDT snap-action switch has special molded-in, serrated, spring-lock clips that facilitate snap-in panel mounting. Also featured is a short button that depresses flush with the top of the switch housing. This makes the switch ideal in door applications. The standard unit is rated at 10 A, 1/3 hp and 125/250 V ac, and the line also includes units with gold crosspoint contacts for low-energy switching applications.

**CIRCLE NO. 349**

## Thumb switch needs no assembly hardware

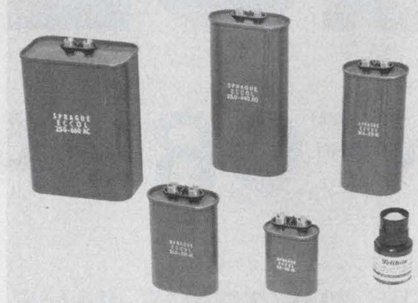


*Inter-Market Inc., 1946 Lehigh Ave., Glenview, IL 60025. (312) 729-5330. $2 (500 up); stock.*

ImLec, Series SM, subminiature thumbwheel switches assemble with built-in snap studs. The new design eliminates the need for threaded rods or bands. Front or rear-mounted, the switches are 0.312-in. wide with 10, 11 or 16-position wheels, and they have decimal or BCD boards with single or double-pole configurations. Minimum life expectancy is one-million detents in either direction. Units are 100% electrically and mechanically tested before shipment.

**CIRCLE NO. 350**

## Capacitors free of toxic PCB



*Sprague Electric Co., 347 Marshall St., North Adams, MA 01247. (413) 664-4411.*

ECCOL capacitors have been designed to meet industry needs for nontoxic, PCB-free (polychlorinated biphenyl) capacitors. They exhibit essentially identical electrical performance characteristics to those of the long used askarel capacitors. Their operating life and readability are also equivalent. Even the size of ECCOL capacitors is similar to previous designs, except for a slight increase in case height. The capacitors are available in a wide range of capacitance values from 1 to 55 μF, with four voltage ratings from 300 to 660 V ac.

**CIRCLE NO. 351**

## Numerical display readable at 60 ft.


*Info-Lite Corp., 46-10 104th St., Corona, NY 11368. (212) 476-1287. $14.75: no logic (100 digits); 2 to 4 wks.*

Series 68032 numerical readouts are 2-in. high and can be viewed at 60 ft. The units are supplied with the number of digits desired and with an anti-glare, blackout front panel, bezel and color filter ready to snap into a panel cutout. Message modules, ± sign, colons and decimal points may be integrated into the package. Standard snap-in decoder-driver and memory logic packs are optional. T-1-3/4 light sources for each segment are dual redundant (lamps and logic) are socket mounted and accesible from the front for simple field servicing.

**CIRCLE NO. 352**

# PERSONALIZED TRANSFORMERS

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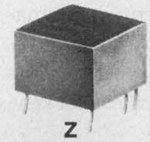
Pulse, isolation, matching, converter, etc.

**No matter what specs.**
Tough electrical, environmental, or both.

**No matter what package.**
DIP, substrate, header, conventional, or . . ?



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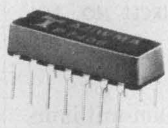
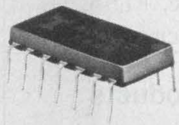


DIP



special

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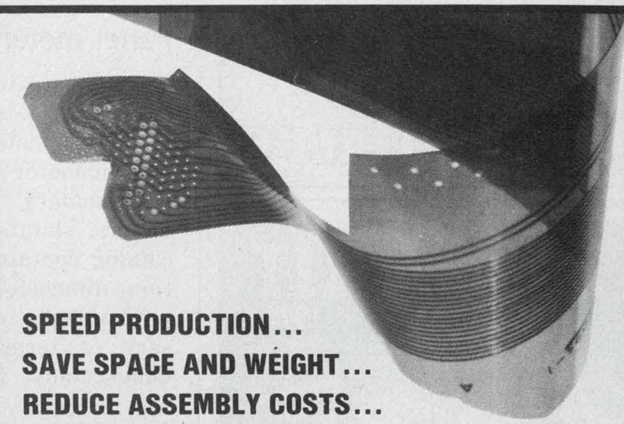

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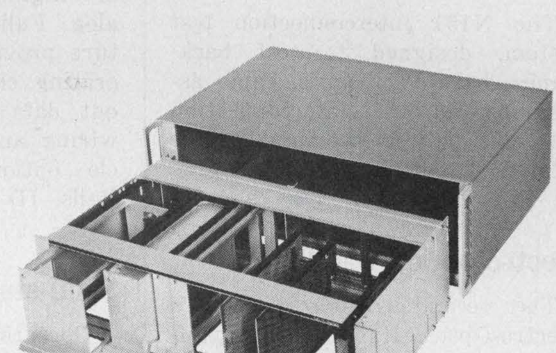

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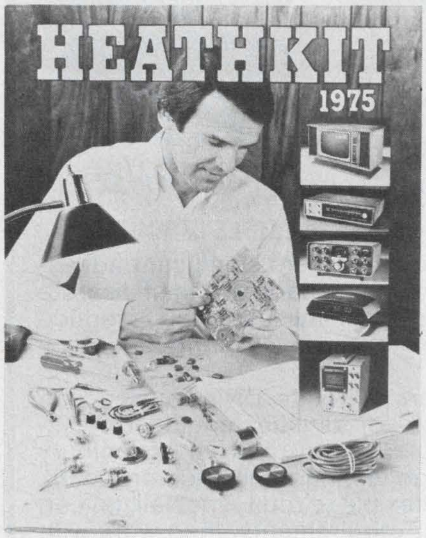
INFORMATION RETRIEVAL NUMBER 76

# New Literature




## Electronic kits

The 1975 Heathkit catalog describes over 350 kits for virtually every do-it-yourself interest—TV, radios, stereo and four-channel hi-fi, marine, R/C modeling, home appliances, automotive, test instruments . . . and more. Heath Co., Benton Harbor, MI

**CIRCLE NO. 353**

## Interconnection test system

The N151 interconnection test system, designed to test backplanes, bare PC boards, cable assemblies and other interconnection networks, is described in a 17-page catalog. Teradyne, Boston, MA

**CIRCLE NO. 354**

## Electro-optics handbook

The second edition of RCA's Electro-Optics Handbook is available at $4.95. This 256-page handbook provides reference material with dozens of tables, charts and graphs. RCA Commercial Engineering, 415 S. Fifth St., Harrison, NJ 07029

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## Microcomputers

Two pieces of literature describe two of the company's microcomputers—the MicroPac 80, a desktop microcomputer, and the MicroPac OEM. PCS, Flint, MI

**CIRCLE NO. 355**

## Panel meters

An illustrated panel meter catalog and price supplement describes frequency meters, elapsed-time meters, ac motor-load indicators, edgewise meters, meter relays, pyrometers, shunts and resistors. The catalog contains ordering information, dimensional drawings, an interchangeability guide and a glossary of terms. General Electric, Schenectady, NY

**CIRCLE NO. 356**

## VOMs

The XL series volt-ohm-milliammeters are featured in a four-page flyer. Simpson Electric, Elgin, IL

**CIRCLE NO. 357**

## Thermoelectric products

Temperature control devices for applications such as microscopy, aerospace, IC wafer probing and diffusion furnace controls are covered in a 24-page catalog. The catalog contains model equivalent tables and metric and temperature conversion tables. Cambridge Thermionic, Cambridge, MA

**CIRCLE NO. 358**

## Switchlights

Low-cost, 2 Form C, dual wiping, general-purpose switchlights are highlighted in a six-page catalog. Fully illustrated, the literature provides key dimensions, operating characteristics, panel cutout data and lists the terminal wiring and quick-connect receptacle options. Clare-Pendar, Post Falls, ID

**CIRCLE NO. 359**

## Solid-state cameras

Operation of cameras based on self-scanned linear arrays of photodiodes is described in an eight-page catalog. Integrated Photomatrix, Mountainside, NJ

**CIRCLE NO. 360**

## Solenoids

Seventy-two colorful, information-packed pages feature solenoids, including long-life tubular solenoids, general-purpose solenoids and first generation tubular solenoids. Guardian Electric, Chicago, IL

**CIRCLE NO. 361**

## Rotary switches

An eight-page brochure describes 1-5/16-in. diameter rotary switches—Type F—and contains circuit diagrams of the standardized 30°, 36°, 45°, 60° and 90° configurations. Oak Industries, Switch Div., Crystal Lake, IL

**CIRCLE NO. 362**

## Heat-shrinkable tubing

Thermofit heat-shrinkable SFR tubing is described in a data sheet. Raychem, Menlo Park, CA

**CIRCLE NO. 363**

## Hybrid microcircuits

A 20-page brochure features practical advice on electrical characteristics, packaging techniques and design of custom hybrid microcircuits. NEC Microsystems, Fort Lauderdale, FL

**CIRCLE NO. 364**

## Display monitors

"Display Monitors," a 20-page booklet, is designed to help OEM buyers choose the right monitor for their system. Tektronix, Beaverton, OR

**CIRCLE NO. 365**

## Digital instrument course

The first two parts of a course in digital techniques offer an in-depth understanding of digital circuits and the mathematical theory behind them. Both Digital Instrument Course, Part I, a 60-page soft cover book and Digital Instrument Course, Part II, a 64-page soft cover book are $3.50 each. NY state residents add 7% tax. Philips Test & Measuring Instruments, 400 Crossways Park Dr., Woodbury, NY 11797

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## Rare gases

An 8-page brochure describes ultra-high-purity rare gases used in epitaxial growth processes. Purity levels are claimed to exceed 99.9999% in such gases as arsine, phosphine, silane and ammonia. Details are provided on specialized instrumentation and analytical techniques used to obtain purity data. Three H Corp., Wanamassa, NJ

**CIRCLE NO. 366**

# Design Aids

## Power tubes

Power grid tubes are listed in a 24-page selection guide according to the principle mode of service for which they are rated, rather than in alphanumeric order. The tube types are tabulated in descending order of the most significant tube parameter. EIMAC, div. of Varian.

**CIRCLE NO. 367**

## Ceramic capacitors

Technical information on temperature compensating disc ceramic capacitors including temperature characteristic curves, temperature coefficient charts and curves, dimensional information and testing specifications are provided in a four-page guide. Murata Corp. of America.

**CIRCLE NO. 368**

## English/metric converter

An English/metric converter in slide rule form contains conventional conversions of length, weight, area and volume. The converter has a slide rule chart showing the relationship between square millimeters, AWG and MCM size, circular mils, ohms per 1000-ft and ohms per kilometer for stranded tinned copper conductor at 20 C. Continental Wire and Cable Corp.

**CIRCLE NO. 369**

## Electrolytic capacitors

A quick guide to MIL style CSR91 nonpolarized solid-electrolytic capacitors abstracts data from MIL-C-39003 in an easy-to-use format. Sprague Electric.

**CIRCLE NO. 370**

## Optoelectronics guide

The Optoelectronics Status Guide lists numeric arrays, single numeric digits, LED lamps, opto-couplers, display dice and accessories. National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051

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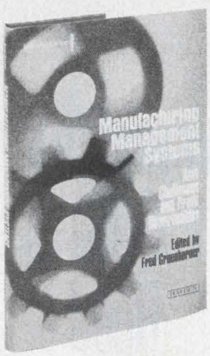


By crystallizing the results of the 1973 Informatics/UCLA Symposium, this book offers a powerful blend of technical and managerial expertise for enhancing the overall success and profitability of today's manufacturing management systems. Some of the nation's top industrial and technical leaders speak freely and in depth of their organization's objectives and specific operations, as well as their personal strategies and methods. You'll find the newest computerized tools available to manufacturers . . . crucial managerial skills for directing progressive systems . . . the tact and care needed for the sensitive human problems of system implementation, and more. **#5940-x, 160 pages, $10.50.** Circle the Info Retrieval No. to order a 15-day exam copy. When billed, remit or return book. No obligation.

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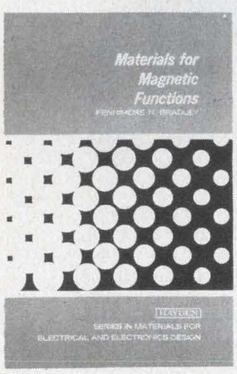


## MATERIALS FOR MAGNETIC FUNCTIONS

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This valuable reference provides a thorough background as well as practical design techniques for the materials needed for magnetic functions. Included in its exhaustive coverage is detailed treatment of key parameters of about 30 classes of ferrite materials relating processing to costs and design trade-offs . . . and equally thorough coverage of about 40 classes of both conventional and exotic magnetic metals and processes. The book focuses on design problems encountered in a wide range of permanent-magnet applications . . . pinpoints design problems in nearly 30 categories of electromagnetic devices . . . and concludes with coverage of environmental influences such as corrosion, magnetic field, temperature, stress, etc. 360 pp., 6 x 9, illus., cloth, $17.20. **Circle the reader-service number to order a 15-day examination copy.**

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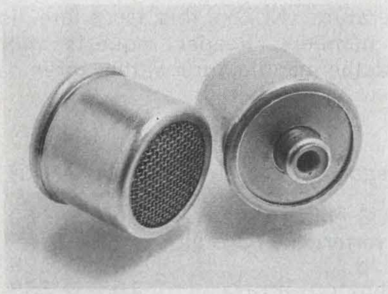

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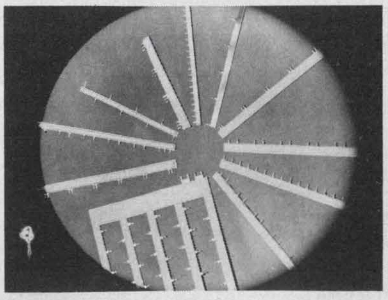

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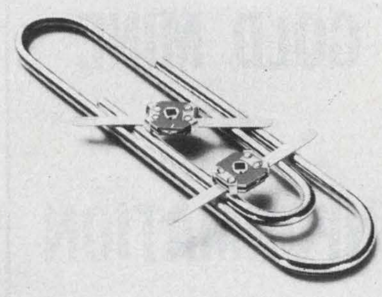

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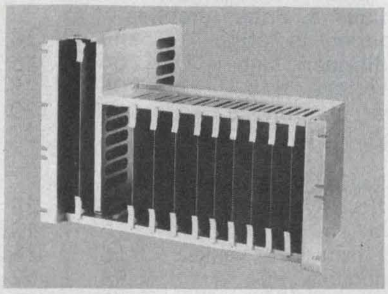

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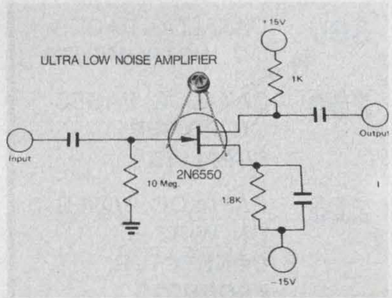


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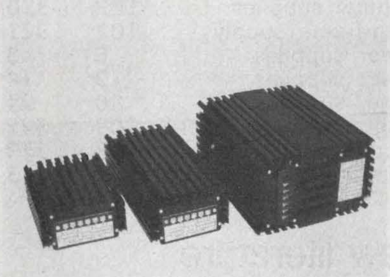

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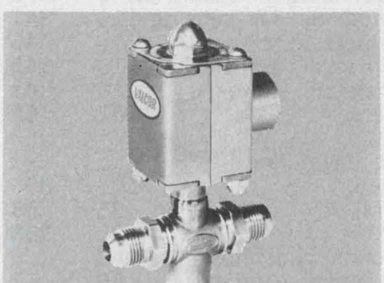

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# Product Index

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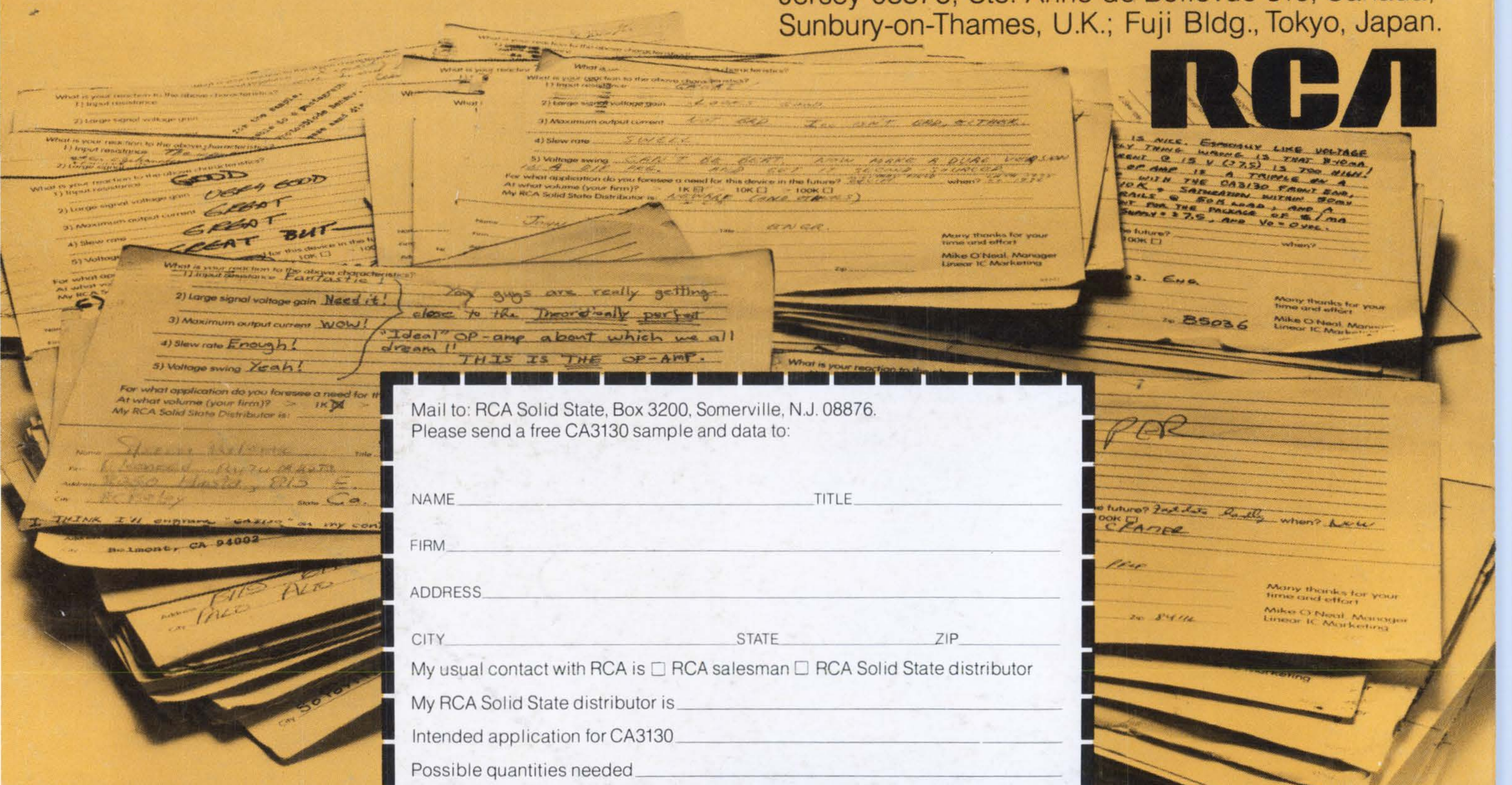


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