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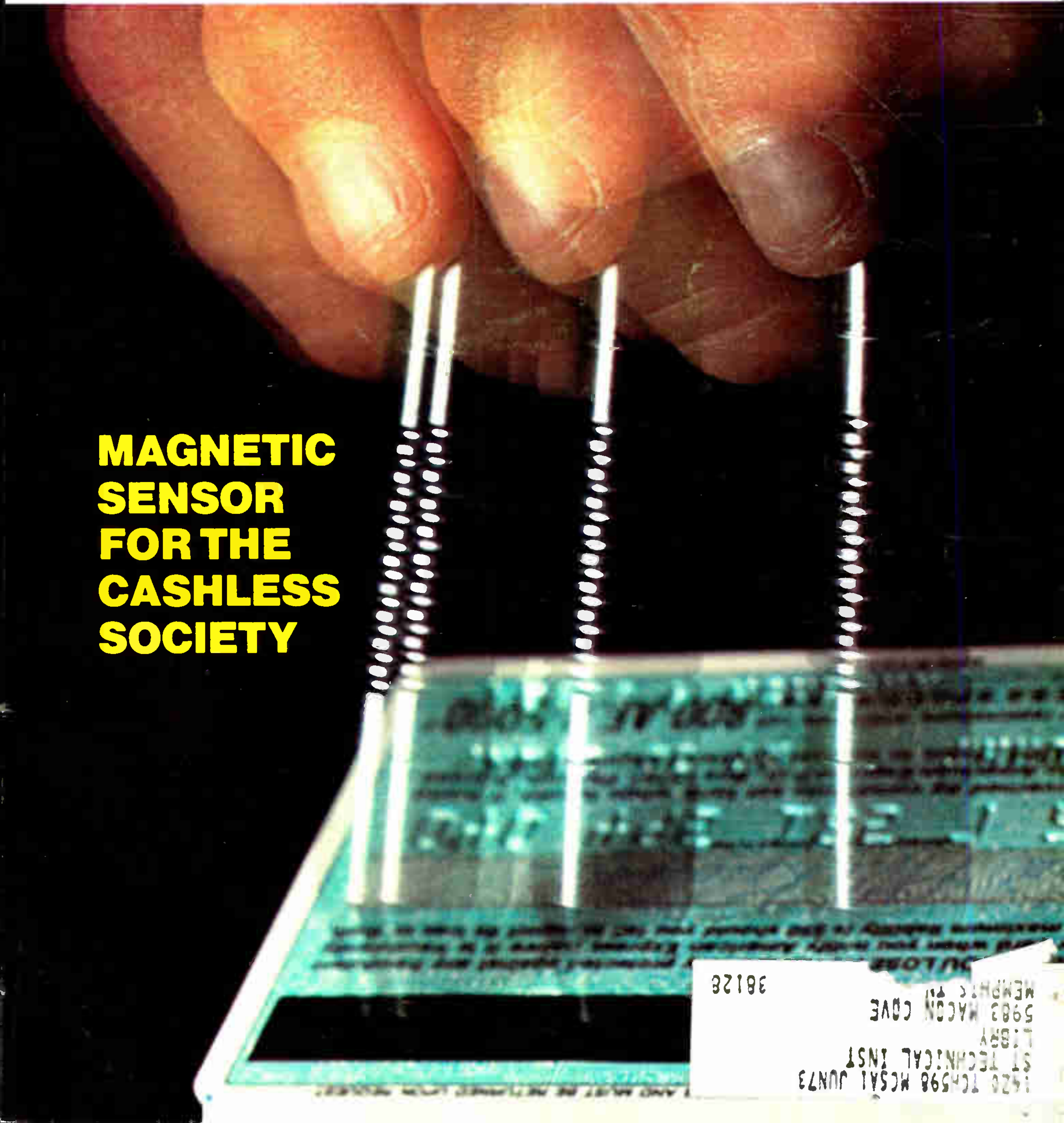

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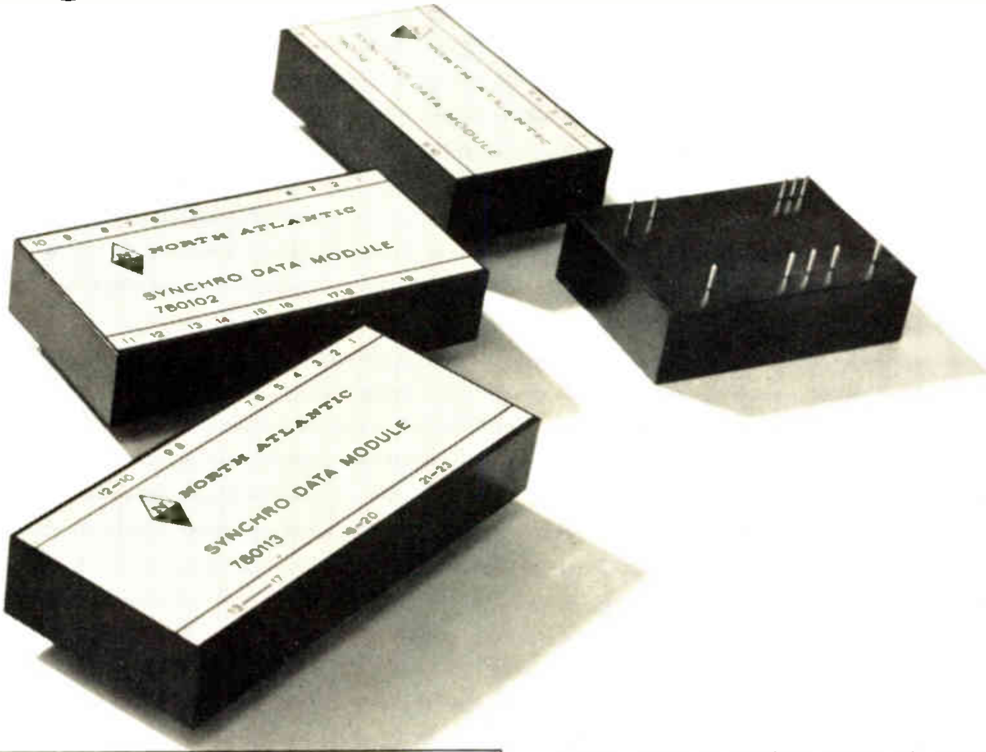

TYPICAL S/D MODULE SETS		
FUNCTION	LINE-LINE	FREQUENCY
S/D or R/D	11.8V	400Hz
R/D	26V	400Hz
S/D or R/D	90V	400Hz
S/D	90V	60Hz

TYPICAL D/S MODULE SETS		
FUNCTION	LINE-LINE	FREQUENCY
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D/R	26V	400Hz
D/S or D/R	90V	400Hz
D/S	90V	60Hz

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Electronics

The International Magazine of Electronics Technology

Vol. 46, No. 3 • February 1, 1973

Highlights

Memory sales are booming, 69
Core systems are still well in the lead, and sales of semiconductor memories won't reach the crossover point before 1976. But both are presently doing better than ever in an expanding mainframe-memory market.

Pluggable DIPs mean easier debugging, 83
Now on the way from socket and package manufacturers are new dual in-line packages that do away with leads and solder mounting. Suspect ICs in this type of DIP can be swiftly unplugged from an expensive printed-circuit board.

How H-P teamed talents with its vendors, 102
First in *Electronics'* new series profiling unusually successful products is the story behind the HP-35, the pocket-sized calculator from Hewlett-Packard that's as smart as a slide rule and faster. Cooperation with vendors Mostek and AMI yielded better-than-spec chip sets.

Painless program controller design, 107
A novel and ingenious method teaches the engineer how to plan and prototype even complex program controllers with a minimum of effort and a maximum of efficiency.

And in the next issue . . .
A microprogramed minicomputer that talks a high-level language . . . a new MOS capacitor . . . an image-storage tube that can help detect hijackers.

The cover
Classic Hall effect is used by Tokyo's Pioneer Electronic Corp. for magnetic sensor that can read price tags at any speed.

Publisher's letter

The shirt pocket of Bill Hewlett, president of Hewlett-Packard Co., was one of the key design constraints imposed on the company's highly successful $395 HP-35 calculator. The HP-35 (see p. 102) is a fine example of the way that high technology must be adapted toward product development today.

Thus, it seemed to us to be a good candidate to kick off a new series—product development profiles—that we will be presenting in the coming year. They will be case histories showing the engineering skill that goes into developing a product that really makes it.

It's instructive to note that, in the case of the HP-35, it took complex and close relations with sophisticated suppliers to get the product into the marketplace on time. We think this will become more and more the rule.

Reading an article about a new technological development or design technique, even in *Electronics*, is only the next best thing to getting details firsthand from the man who did the work. Now we invite you to do both. We've arranged with some of our authors, in this and upcoming issues, to make themselves available for telephone inquiries from our readers about their articles—at a specific time and place.

This is an experiment, an attempt both to close the loop between author and reader and to add another dimension to technical communications. So if you want to clarify some points about digital controller design after reading Chuck Richard's article on page 107, you can talk to Chuck directly about it on the days and at the hours and number specified in the article. We'd also appreciate knowing what you think of the idea.

It's a tradition at *Electronics* to introduce our new staff members. On page 83, you'll find a detailed article on leadless ICs. It's the first technical article authored by Stephen E. Grossman, the most recent addition to our technical staff.

Grossman, who holds a BSEE from the City University of New York and a BA from New York University, has done graduate work at the Polytechnic Institute of Brooklyn. He comes to us after a stint administering system design at the Revenue Controls Systems division of Litton Industries. Before that he worked on the design of high-power microwave amplifiers at Radio Engineering Laboratories, now the Electronics Systems division of the Dynamics Corp. of America.

His experience in equipment design gives him a good perspective on the problems and potential of leadless ICs. "The big factor," he says, "is that the whole industry is tooled up for leaded devices, so these new leadless packages won't move in overnight. And, there's the dog-chasing-its-tail problem. System designers don't want to go leadless until device makers can show a broad array of leadless devices. And the makers don't want to go to market until the designers place large orders. Watch for a few large-volume users to take the plunge and kick off the transition to the new devices."

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Readers comment

Shedding more light

To the Editor: Thank you for the article, "Shedding some needed light on optical measurements" [*Electronics*, Nov. 6, 1972, p.91]. Engineers thus having been educated, perhaps manufacturers' data sheets will become more explicit. Manufacturers now arrange data in such a way as to make it difficult to predict characteristics with light sources other than the one used in specifying the data.

A definition consisting of a radiometric spectral sensitivity curve, plus an absolute value of the point on the curve, would allow immediate comparisons, and a corresponding curve and fixed point for the incident radiation would help the harassed engineer.

J. K. Wood
R. N. Saxby Ltd.
Liverpool, England

Capacitor ratings corrected

To the Editor: In your Engineer's notebook on "Charts find capacitor self-resonant frequency," [*Electronics*, Sept. 23, 1972, p.123], a number of charts are shown for finding the self-resonant frequency of capacitors. It appears to me as if the readings on the mica capacitor chart are incorrect. Should the designation μF have been pF and mF, nF?

D. E. Bawden
Powertronic Equipment Ltd.
Scarborough, Ont., Canada

■ *Reader Bawden is correct.*

Proper PROM precedence

To the Editor: The lead item in "Engineer's Newsletter" [*Electronics*, Dec. 4, 1972, p.115] mentions that a 2,048-bit programable ROM being offered by Harris Semiconductor is the first introduced. However, Monolithic Memories Inc. introduced the first 2,048-bit PROM in mid-1971—18 months prior to the announcement by Harris.

Dale W. Williams
Monolithic Memories Inc.
Sunnyvale, Calif.

■ *We got our firsts mixed up, but we did give MMI due credit in the story on PROMs that appeared on page 115 of our Jan. 4 issue.*

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Wire windings are OUT, conductive plastic is IN for high performance audio controls. With its new Series 300 SLIDELINE™, Duncan Electronics replaces noisy, rough and "grainy" wire elements with smooth, noise-free RESOLON® conductive plastic which actually *improves with use!*

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Duncan Series 300
A sound idea.

40 years ago

From the pages of Electronics, February 1933

Shortly after the new Administration takes hold and the personnel of the Radio Commission is completed, a re-allocation of North American broadcasting stations may be looked for. Pressure from Canada and Mexico for more wavelengths (however unjustified by proportional population figures) will undoubtedly be met by conceding more channels to our northern and southern neighbors. In this re-arrangement, the doom of the U.S. "clear channels," which bring good radio broadcasting to millions in small towns and rural communities, now seems sealed.

When this massacre of the clear channels begins, and the airways on which important broadcasters operate become howling bedlams outside of the immediate neighborhood of the transmitters, the radio industry will have only itself to blame for past apathy. Little or no interest has been displayed by radio engineers or industry organizations. Radio reception in the vast stretches of America has been taken for granted, like the sunshine.

Soon, those who avow to discredit the radio engineer and his "fool theories," will ride high in the political chariots of officialdom. Ignorant, political tampering with the present fairly smooth-running radio machine, will deprive millions in rural communities of good radio. And it will destroy future markets for radio sales.

Gentlemen of the radio industry, wake up!

An X-ray machine built especially for the industrial field for the radiographic examination of thick sections of metal, is rated at 10 ma. and 300 kv. peak for continuous operation and employs the so-called doubling circuit using two kenotron tubes as rectifiers. Condensers are placed in series with the tubes and the high-tension transformer. The condensers serve to boost or double the voltage supplied to the X-ray tube by the high-tension transformer on the useful half cycle.

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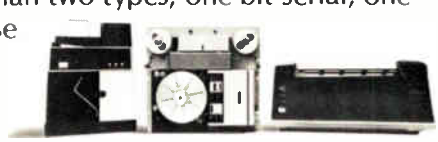

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Centralab perspectives

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Covering Detroit's needs for thick film hybrids is a big order.

Whether you're in autos, computers, music, data processing, business machines, telecommunications or industrial electronics . . . Centralab can now provide the thick film hybrid circuits you need.

Tight schedules. Exacting specs. Volume orders for millions of pieces. Anyone who has supplied the nation's auto manufacturers with component parts knows this is the kind of mission he faces.

Centralab has run this fast track for some years, providing assembly plants throughout the U.S. with thick-film hybrid circuits for Detroit end use. These have included circuits for car radios, stereo tape players, fuel controls, headlight dimmers and dashboard instrumentation such as tachometers and sequential turn controls.

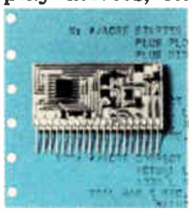
Why Centralab hybrids? Obviously, the auto makers are getting the high performance specs they ordered, and in the enormous quantities they demand.

Hybrids sound good to music makers, too.

Take the specs, for example. Package power up to 4 watts per square inch. Rugged ceramic substrates with special form factors. Compare resistor tolerances as low as ±0.5% and TC of 0 ± 100 PPM/°C and you get an idea of the customized circuitry Centralab thrives on. Capacitor dielectrics range through NPO & N5250 to Hi K. Designs include plastic and glass encapsulated transistors and diodes, as well as chip devices.

Happily, this type of spec is also required in other industries. Manufacturers of musical instruments, sound equipment, radio and TV come regularly to Centralab for custom hybrids. Typical circuits produced are tuner, IF, color and audio-circuitry. Electronic organ manufacturers are using Centralab thick-film circuits for staircasing networks, passive filters, keyers, frequency dividers, amplifiers, MOS protection and tone control circuitry.

Among the fastest growing fields is data processing. Here Centralab has produced such circuits as pull-up networks, voltage regulators, display drivers, one shot, multi-vibrators, hammer drivers and interface devices.

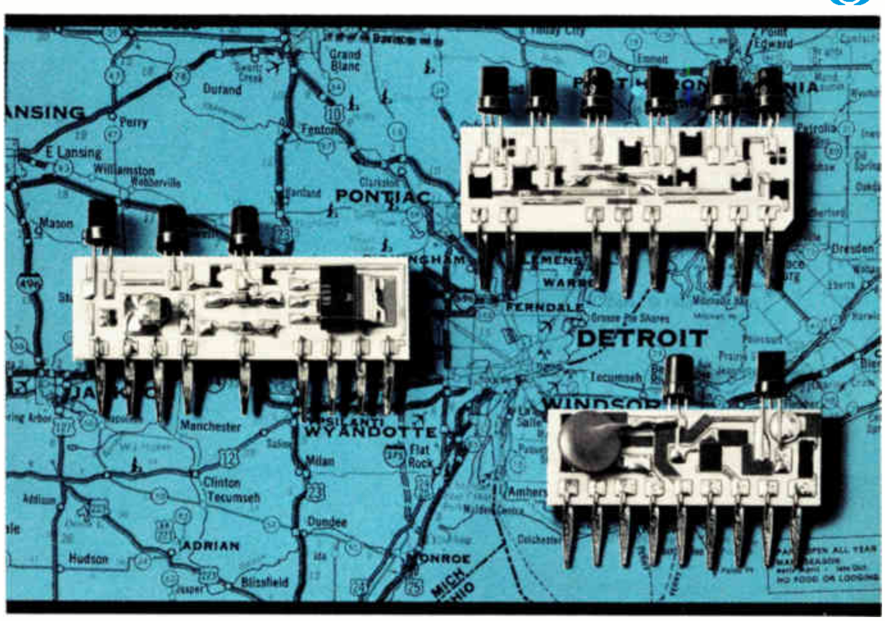


Centralab's programmed for thick-film usage in computers.

Also worth singling out are business machine and point-of-sale equipment manufacturers who specify circuits such as clock drivers, video amplifiers, high voltage bleeders, and motor speed regulators.

The list goes on and on. Telecommunications and the requirements for attenuator pads, passive filters and mixing networks. Industrial electronics and circuits such as motor speed control, solid state switches and frequency control networks.

But you get the idea by now. You set the spec. Centralab will set the precedent. It's virtually that easy when you deal with a leader. If you've a special application for hybrids, or you'd like to consider their adoption in your line, get in touch. Write A. R. Wartchow, Marketing Manager, Electroceramic Products. Ask for Centralab Bulletin No. 1429H.



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PIGS LOOK SLOW.

Strictly as a compiler, our Fortran 5 is probably the slowest on the market. Several times slower than our own Fortran IV.

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Fortran 5 compiles slow and runs fast because its incredibly thorough, multi-pass compiler optimizes "globally"; that is, it examines each program statement, not only internally, but also in terms of every other statement in the program.

The result is amazingly efficient, fast-executing code.

PIGS ARE THE SMARTEST ANIMALS IN THE BARNYARD.

Our Fortran 5 is a compatible superset of almost every other Fortran — IBM level H, ANSI Fortran IV, Univac Fortran V. It includes all their features, plus some.

It's a multi-tasking compiler, so a program can pursue several related but asynchronous tasks simultaneously.

It has an exhaustive set of incredibly precise diagnostics that tell exactly what's wrong and where, in English.

Finally, when it's time to run an application program, Fortran 5 is smart about tailoring a run-time package to include only essentials. That means a program written on a 64K brute might run in only 8K.

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Our Fortran 5 isn't fussy. With all its features, global optimization, and diagnostics, it can turn anybody's Fortran programs into object code as efficient as machine language.

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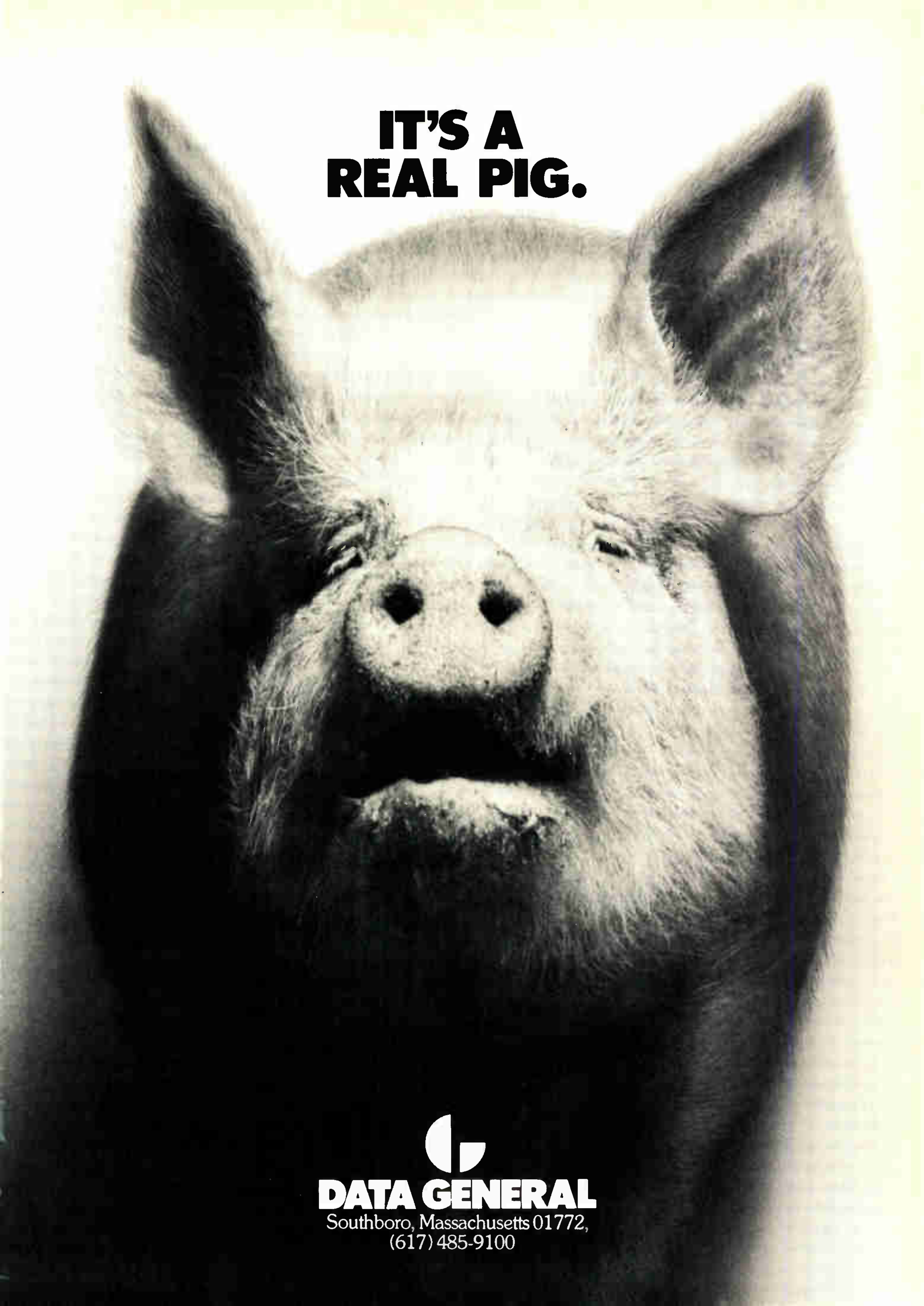
That way, we figured we could hog all your business.

For more information on Fortran 5, write or call any Data General sales office.



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People

RCA's Vonderschmitt to helm solid-state operation

"We think we're at a point where we have a fairly attractive future," says Bernard V. Vonderschmitt with more than some restraint. His caution is understandable, perhaps, for in recently taking the helm at RCA's

Vonderschmitt: The new challenge at RCA is to meet delivery requirements.

Solid State division, Somerville, N.J., as vice-president and general manager, he assumes control of a semiconductor operation that has been in the red since its inception soon after the transistor was invented.

But things are finally looking up for what Vonderschmitt says was a "$100 million business in 1972." The fourth quarter of the year was entirely profitable, "the first total-quarter segment" ever to be in the black. And Vonderschmitt is looking for "continued profit improvement" in the year ahead. This appraisal comes from his great confidence in his division's expertise in complementary metal-oxide semiconductors, linear integrated circuits, and power-device technology, which meet "an extremely broad base" of user applications. So numerous have these become—RCA styles itself as the largest supplier of ICs to the consumer-electronics marketplace with only 10% being sold to the company's other divisions—that Vonderschmitt describes the greatest challenge in his new post as that of meeting delivery requirements. And for a top corporate executive, that's probably the best kind of worry to have.

The slim, baldish, 49-year-old Vonderschmitt comes to his post after a long engineering and management career at RCA. He joined the company first in 1944 as an engineer in component-design projects. Then, after serving as a radar officer in the U.S. Navy, he returned to RCA and worked on deflection-system development for TV receivers.

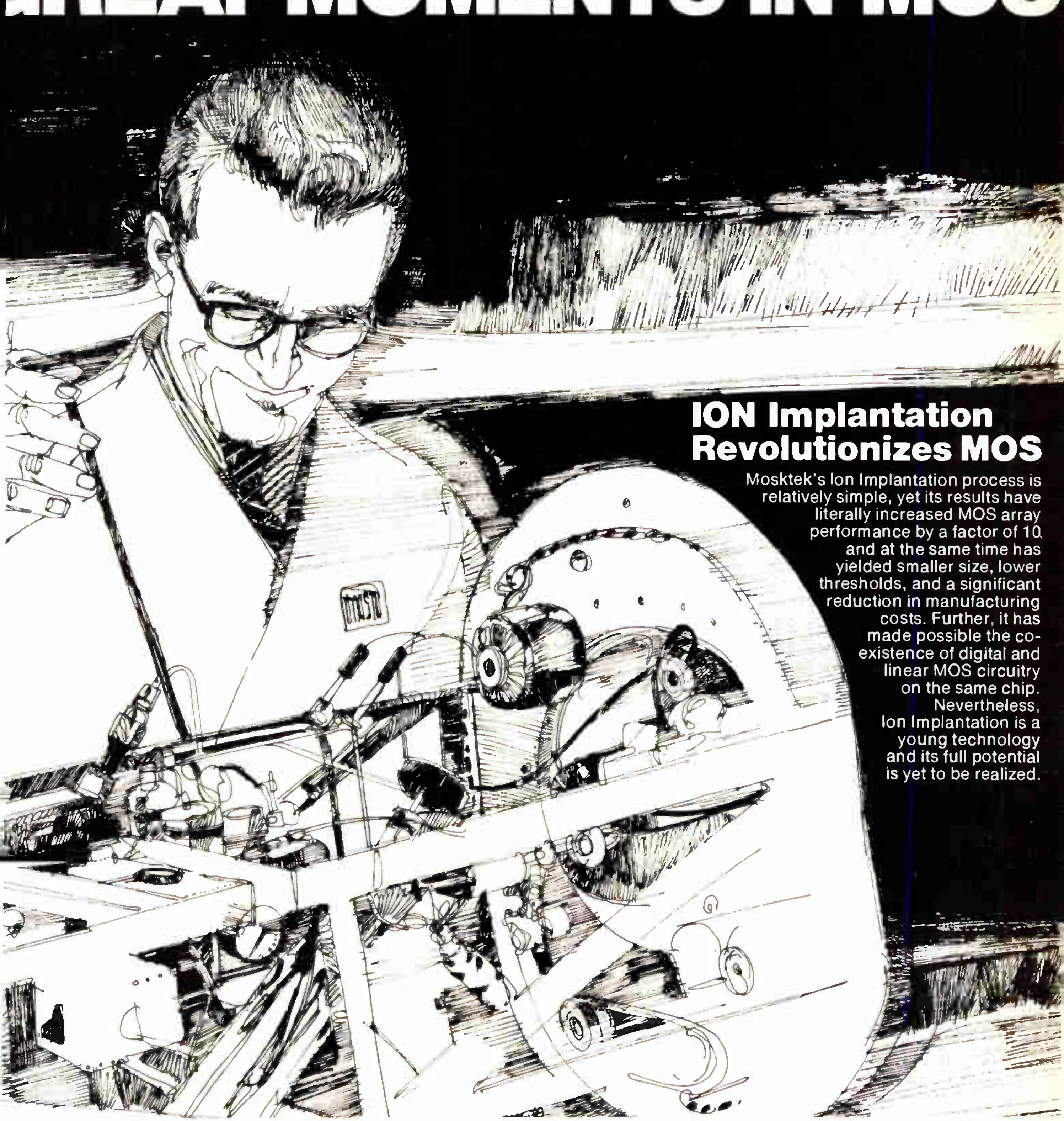
By then holder of an MSEE from the University of Pennsylvania, Vonderschmitt transferred to the former Semiconductor division in 1959 as manager of applications in the Microelectronics department, one of a series of engineering-management positions of increasing importance. In 1971, he was named manager for integrated circuits and later the same year, division vice-president, solid-state integrated circuits. Vonderschmitt looks back on that last job "as the nicest I ever had, primarily because it saw the successful emergence of RCA in the IC area—from both a product and people standpoint."

People motivator. People are an important part of the equation that makes Vonderschmitt go. Many who have worked for him, or who know of him at Somerville, praise his ability to get along with people, to make them, as one put it, "feel he cares about them as individuals." This could come particularly easy for Vonderschmitt because of his basic belief that "you're only as successful as your people's dedication to what they're doing."

Intercon heads for greener pastures

No matter what segment of the electronics industry prospers most, E.W. (Ted) Green thinks his company has a good chance of sharing in the prosperity. Green is the new president of Intercon Systems in Los Angeles, a multifunction computer-and electronics-oriented consulting firm now looking far afield from its past concentration on recruiting execu-

GREAT MOMENTS IN MOS



ION Implantation Revolutionizes MOS

Mosktek's Ion Implantation process is relatively simple, yet its results have literally increased MOS array performance by a factor of 10, and at the same time has yielded smaller size, lower thresholds, and a significant reduction in manufacturing costs. Further, it has made possible the co-existence of digital and linear MOS circuitry on the same chip. Nevertheless, Ion Implantation is a young technology and its full potential is yet to be realized.

AT MOSTEK we were quick to realize the implications of Ion Implantation and we were the first manufacturer to apply it to volume production. The results have been extremely gratifying, both to us and to our many customers who have taken advantage of MOS technology for their products. Unknown just a few years ago, MOS products are now at work in one-chip calculators, multi-function calculator systems, micro clocks and calendar circuitry, organ keyboards and numerous industrial and consumer products. Ion Implantation has made MOS/LSI technology available to virtually all industries no matter how unique their requirements may be. And it's only natural that they turn to a leader to solve their MOS problems. Whether off-the-shelf or customized IC's, Ion Implantation and MOSTEK know-how are both bench marks in Great Moments In MOS.

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MOSTEK

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Circle 15 on reader service card

tives for the electronics industries.

Green says Intercon will concentrate on supplying assistance in finance and marketing to companies that need this help: "We know lots of inventors and engineers with good ideas, but they don't know how to get them to the market successfully." Green hopes to help them by matching them up with major companies looking for new products to sell, or products to produce in their factories. Intercon will also arrange for market research, product planning, business planning, advertising and promotion, documentation, and training.

Green feels that a good part of what his company can offer is the knowledge and contacts he and his colleagues have acquired over the years. He, for example, set up Electronic Memories & Magnetics' end-user memory systems activities as president, but left when EM&M greatly lowered its sights in this field. Before that, he was director of field marketing for Honeywell Information Systems, was in sales for its predecessor, General Electric Information Systems group, and spent almost 20 years at Univac.

Seeking the new, keeping the old. And, while Intercon will involve itself deeply in marketing and financial assistance, it will continue and likely expand its executive-search activities. For the present, Green expects most of the action to be in recruiting, with demand rising in all areas, particularly semiconductors. He notes that the computer and electronics industries are growing and changing so fast that "many good people with fine talent get kicked in the teeth due to politics and mergers. There are many innocent bystanders."

To help in the recruiting, the Penn State graduate is cooperating with search firms in other parts of the country. "Executive search firms have been very jealous of their competition in the past and so haven't cooperated. I think that's very shortsighted," he says. But Green does find cooperation in his own search for relaxation: golfing with his wife and two teen-aged sons.

hp MEASUREMENT NEWS
innovations from Hewlett-Packard

FEBRUARY, 1973

in this issue

World's most powerful desktop calculator

It even talks to you in English.

Where does a calculator stop and a computer begin? That's hard to tell with the powerful new 9830A desktop calculator. This 40-byte system offers computer power with calculator convenience. It uses HP BASIC language, has an alphanumeric keyboard and 32-character display, as well as a built-in 15K byte operating system and a cassette memory. The model 30 is equivalent to a 10K or 12K minicomputer (16-bit words) that stores its compiler in read/write memory. And you can expand the calculator memory with up to 8 plug-in ROM (read-only-memory) modules.

You'll notice part of the calculator keyboard looks like a typewriter.

(Continued on page 2)

Sampling without special controls or training

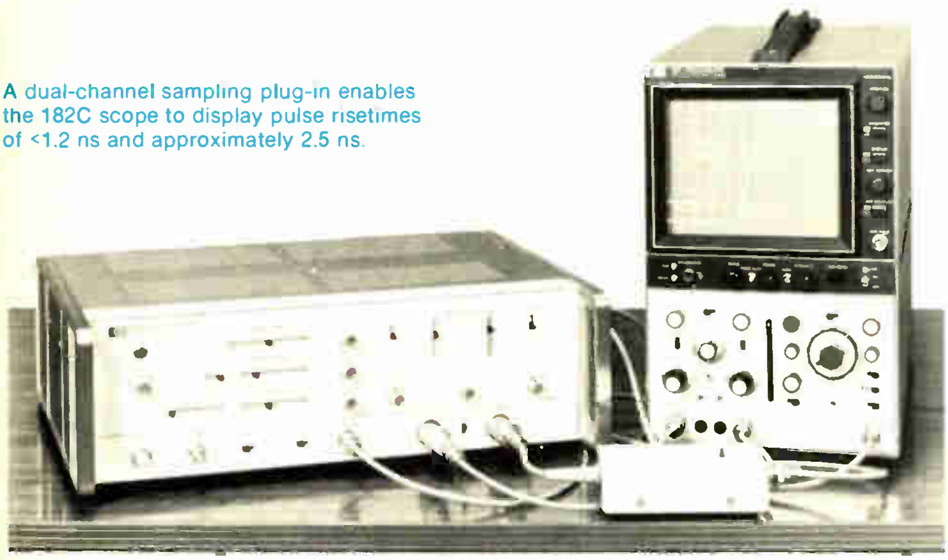
Despite recent advances in the performance of real-time oscilloscopes, sampling techniques still are preferred for viewing repetitive signals with very fast transitions or signals from high frequency components. But previously you needed extensive training to learn the complicated sampling techniques.

Now, HP sampling plug-ins for the 180 series oscilloscopes provide the easiest and fastest low-level, high-frequency measurements available. Because the plug-in looks and operates like a real-time plug-in, you eliminate the special controls and training normally associated with sampling scopes.

Both plug-ins have a 2 mV to 200 mV/div deflection factor. The 1810A plug-in is for 1 GHz applications; the 1811A, for 4 to 18 GHz bandwidths with remote feedthrough sampling heads for accurate high-frequency measurements.

The 1810A costs $1750. The 1811A costs $1700; 4 GHz sampling head, $1100; and 18 GHz sampling head, $2800.

For details, check F on the HP Reply Card.



A dual-channel sampling plug-in enables the 182C scope to display pulse risetimes of <1.2 ns and approximately 2.5 ns.

(Continued from page 1)

That's because the model 30 uses a formal programming language, BASIC, new to the world of calculators. Because BASIC is a combination of algebra and conversational English, it's easy to learn yet powerful enough for your data manipulation and processing.

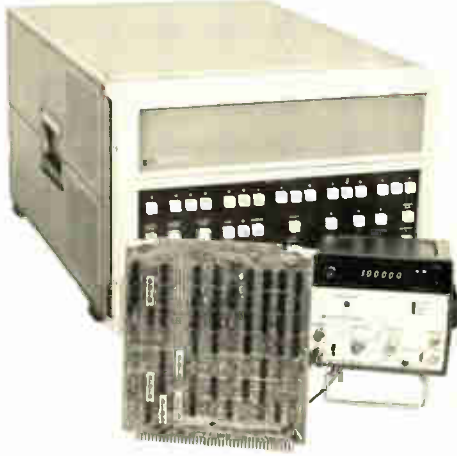
Unique editing features let you delete, modify or correct program lines or individual characters within a line. The calculator even detects your errors and displays an error note.

A new companion high-speed printer matches the model 30's output speed and produces hard copy for reports or your files. This quiet page-width printer can print 330 characters/sec. or 250 lines/minute—that's 33 times better than a teletype at 10 characters/sec. The printer fits on top of the calculator and may be added at any time.

The calculator costs $5975; the printer, $2975.

There's more, including a comprehensive library of programs. For the full story, check P on the HP Reply Card.

New interface transfers 1 megaword/second



HP's universal interface is so fast, you could fill an entire 32K memory in 32 milliseconds.

Instead of designing and building your own minicomputer interface, let the new super-fast HP 12930A universal interface card do it. This single plug-in unit quickly interfaces an HP 2100A minicomputer with external I/O devices that use differential or TTL logic. Included are I/O storage registers, dual channel interrupt logic, and a set of programmable switches to meet exacting interface requirements.

Besides simple plug-in installation, the new universal interface boasts:

- Extremely rapid data transfer (up to 1 million 16-bit words/second) to high-speed mass memories, controllers, and other processors.
- Data transfer up to 500 feet using differential logic.
- Dual-channel operation that lets you transfer data and control/status information simultaneously.
- Successive cycle-stealing when operated through the DMA section of the 2100A minicomputer. This means you can use successive memory cycles for data transfer.

The universal interface is available in three variations: differential or TTL logic (ground true/positive true). Each consists of a universal interface card, priority jumper card and diagnostic software. Price: $800.

For details, check D on the HP Reply Card.

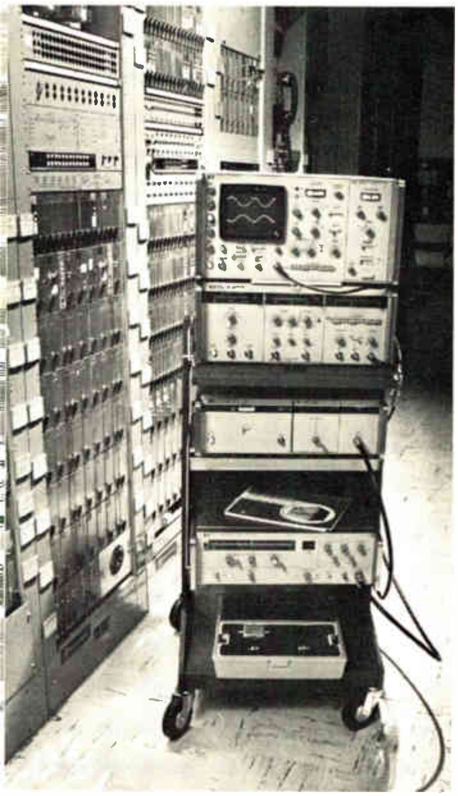
New analyzer troubleshoots microwave links

To realize the full capability of busy microwave radio relay and satellite communication links, it is important that system operators quickly be able to identify, measure and localize the various forms of distortion occurring in a link.

This is precisely the function of the HP 3710 Microwave Link Analyzer (MLA) system. With modulation bandwidths sufficient for color TV or 1800-voice channels transmissions, the basic MLA covers the baseband (BB) and intermediate frequency (IF) link sections. Adding a down converter (RF to IF) and an up converter (BB to RF) extends the MLA's capability to the RF (1.7 to 11.7 GHz) portion of the link.

The MLA system measures such key parameters as group delay and linearity, differential phase and differential gain, plus mod/demod. sensitivity, attenuation and return loss.

Prices for the microwave link analyzer system start around $11,000. *To learn more, check J on the HP Reply Card.*



HP's microwave link analyzer is ideal for optimizing radio relay link performance.

If you're in business, you can't afford to be without it

The new HP-80 pocket calculator—best thing that's happened to business since the credit card.

Last year we developed the popular HP-35 scientific calculator. Now, HP announces another major contribution to personal calculation—the HP-80 computer calculator for business and finance. The pocket-sized HP-80 is preprogrammed with 40 specific financial capabilities; and it can solve more than 100 types of business mathematics problems, many of them in less than 2 seconds.

The HP-80 can be used by managers of all kinds, brokers, bankers, insurance and real estate people, retailers, accountants, executives and sales people. Like the HP-35, the nine-ounce HP-80 fits in your palm or pocket; is battery or ac powered; positions the decimal point automatically; has four operating registers and a storage register; and shows answers on a 10-digit display. The mathematical range is from 10^{-99} to 10^{99}. Yet for all its power, it's as simple to operate as an adding machine.

The HP-80 eliminates the need for cumbersome financial tables and time-consuming interpolation. And it's far more accurate than most tables.

Whatever your business or wherever it takes you, you can take the HP-80, and you should. Price: only $395.

To find out more about the HP-80 and how to get one, check A on the HP Reply Card.

The HP-80 is preprogrammed with the basic four functions (addition, subtraction, multiplication and division) plus 36 separate financial capabilities:

1. Constant storage
2. Selective round-off
3. Percentage calculation
4. Percent difference
5. Square root
6. Power (exponentiation)
7. Running total (summation)
8. Mean (arithmetic average)
9. Standard deviation
10. Number of days between two dates
11. Future date, given number of days
12. Future value of an amount compounded
13. Present value of an amount compounded
14. Effective rate of return for compounded amounts
15. Number of periods for an amount compounded
16. Future value of an annuity
17. Present value of an annuity
18. Effective rate of a sinking fund
19. Effective rate of a mortgage
20. Installment of an annuity, given future value
21. Installment of an annuity, given present value
22. Number of periods for a sinking fund
23. Number of periods for a mortgage
24. Add-on to effective annual rate conversion
25. True equivalent annual rate
26. Linear regression (trend-line) analysis
27. Sum-of-the-years' digits depreciation amortization
28. Rule of 78's finance charge amortization
29. Discounted cash flow analysis
30. Accumulated mortgage interest calculation
31. Remaining principal on a mortgage
32. Accrued interest (360 and 365 day year)
33. Discounted notes (360 and 365 day year)
34. Discounted note yields (360 and 365 day year)
35. Bond price
36. Yield-to-maturity of a bond

And, the HP-80 is a 200-year calendar.

All prices are domestic U.S.A. prices only.

HP graphic displays for OEM systems

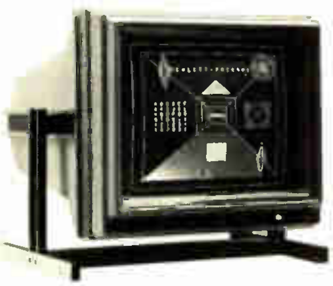
Different size CRTs can be mounted in a modified frame on special order. They range in size from 8 to 21 inches, diagonal measurement (20 to 53 cm).

Need to display computer-generated graphics? The HP 1310A and 1311A displays provide bright, easy-to-see readouts in OEM systems. These high-speed 19 in. (48 cm) and 14 in. (35.5 cm) graphic displays offer unexcelled dynamic performance to meet the broad requirements of varying OEM applications.

Linear writing speed is an unsurpassed 10 in/μs (25 cm/μs) which allows character strokes to be written in less than 100 ns. Maximum slew rate of the electronics is 100 in/μs (2.5 meters/μs), and large-step jump and settle time is 1 μs. This offers tremendous programming simplicity since characters and vectors can be plotted in random fashion from anywhere in the large display area.

Internal construction is modular, rugged, and very servicable. The open-frame construction allows easy mounting in a standard 19-in. (48 cm) rack or in a custom-designed enclosure.

For more information, check E on the HP Reply Card.



The fast and versatile 1310A OEM graphic display. (Computer-generated graphics courtesy of the Boeing Company.)

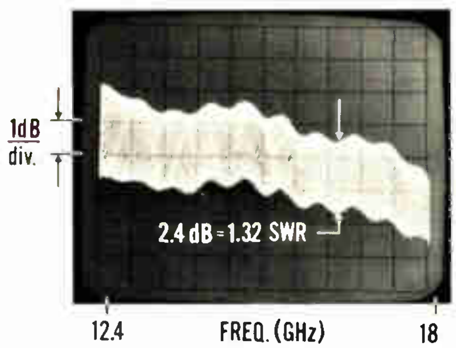
Swept SWR measurements in coax, 1.8 to 18 GHz

Fast yet accurate SWR measurements in coax are now easily made using the HP 817A swept slotted line system and 8755 frequency response test set. The 817A is modified to accept the detectors that are part of the 8755 test set. The result: a measurement system with very broad frequency coverage (1.8 to 18 GHz) and high accuracy (residual SWR < 1.04 at 18 GHz).

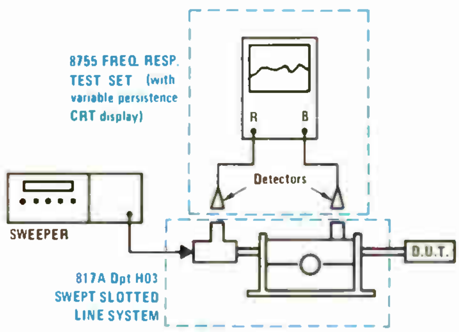
The 8755 test set provides high sensitivity, high stability and high resolution for all-around measurement simplicity and convenience. The test set can also be used for wide dynamic range transmission/reflection measurements over its full 0.1 to 18 GHz frequency range.

The 817A opt. H03 slotted line system costs $1000. A complete 8755 test set with variable persistence CRT display costs $4200.

For details, check O on the HP Reply Card.

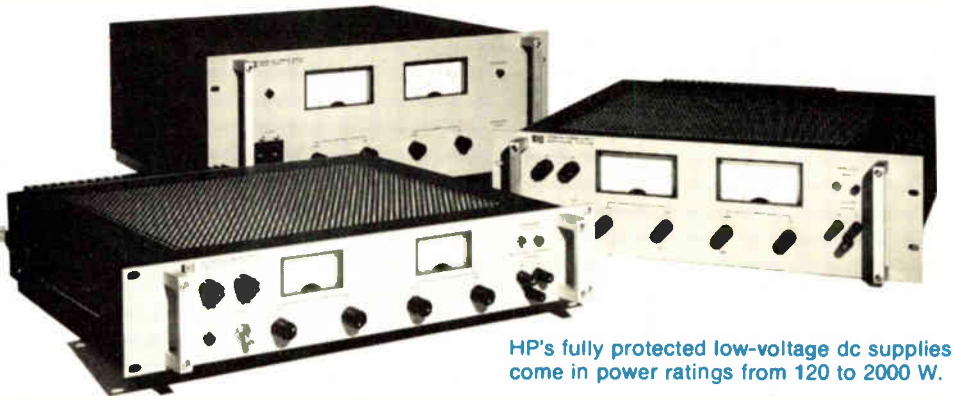


Trace envelope develops as probe is moved along slotted line while frequency is swept. The test device SWR equals the thickness of the envelope.



Simplified diagram of swept SWR test setup.

Fully protected, low voltage dc supplies



HP's fully protected low-voltage dc supplies come in power ratings from 120 to 2000 W.

If your system power requirements call for a dc supply with superior performance and the benefits of built-in overvoltage and overcurrent protection, take a close look at HP's family of low-voltage rack supplies.

These supplies boast load and line regulation of 0.02%, with less than 10 mV peak-to-peak ripple and noise (dc to 20 kHz). Output voltage and current limiting are fully adjustable, while the overvoltage crowbar trip point is adjustable from approximately 10 to 110% of rated output voltage. Other advantages include automatic crossover between constant-voltage and constant-current modes, remote programming, and remote sensing.

This power supply product line includes 13 models (6256B thru 6274B) covering four output voltage ratings: 10 V at 20, 50 or 100A; 20 V at 10, 20, or 50A; 40 V at 3, 5, 10, 30 or 50A; and 60 V at 3 or 15A. Prices start at $410.

For more information, check N on the HP Reply Card.

New data punch formats for any system

Designed for off-line data logging, HP's new 3489A data punch accepts TTL level, BCD coded inputs from measuring instruments, then punches a paper tape that can be fed directly to almost any computer, calculator, or telex system. The punch eliminates tedious and time-consuming manual data transfer between instrument and system.

The 3489A accepts up to 8 BCD digits of measurement data plus 1 BCD digit for range, 1 for function, and 1 bit for polarity and overload. Your computer's format and character codes are preprogrammed on a pin board, so the data tapes punched by the 3489A can be fed directly into your system. A built-in data counter adds a 4-digit number to each data line if you so desire.

Punching speed is 70 characters per second. During unattended operation, the punch, not the measuring instrument, controls the sampling rate.

Price: $3000.

For data punch details, check H on the HP Reply Card.

Now, your measuring system can automatically punch a paper tape for just about any computer or calculator.

Portable tape recorder has many uses

The 3960A portable magnetic tape instrumentation recorder records and reproduces four channels simultaneously using either FM or direct recording on any channel. You can select three tape speeds: 15/16 ips for long-term FM recording of slowly-changing phenomena; 3¾ ips for acoustic evaluation and audio range applications; and 15 ips for vibration studies and other applications that require direct recording response up to 60 kHz or FM up to 5 kHz.

The low-speed performance is outstanding, an important asset to medical researchers and others who record slowly-changing variables. The FM signal-to-noise ratio at 15/16 ips is >46 dB, about 10 dB better than previous recorders. At higher speeds, the FM signal-to-noise ratio is >48 dB. A built-in servo drive minimizes flutter and maximizes tape speed accuracy.

Price: $4285

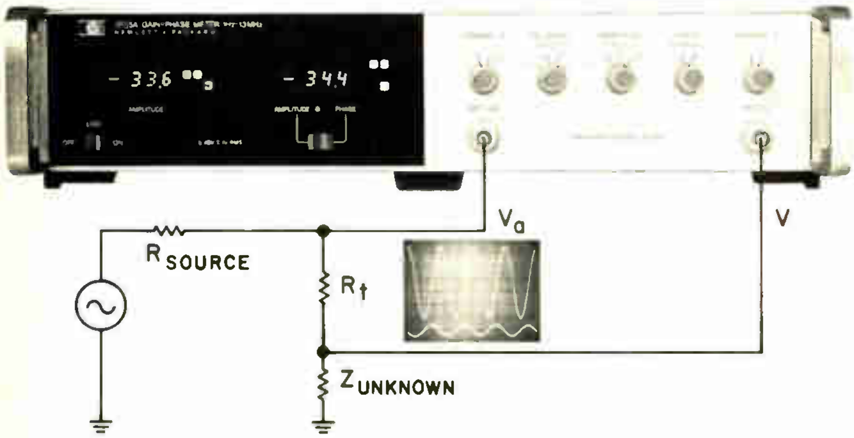
For details, check K on the HP Reply Card.

The 3960A recorder uses ¼-inch tape on standard 7-inch tape reels, which is less expensive than ½-inch or wider tape.

All prices are domestic U.S.A. prices only.

Easier way to measure complex low impedance

Complex impedance measurements at low values present some problems for conventional impedance meters. For example, it's difficult to measure the 20 mΩ impedance of a ground bus using a conventional impedance meter with a 1Ω full scale range; however, you can measure it with a gain phase meter, as shown below:



As long as R_t is much larger than the unknown impedance, voltage V_a will be directly proportional to the constant current flowing through the known resistance and voltage V will vary with the unknown impedance. The voltage ratio of V to V_a will be proportional to the complex impedance. With R_t = 50 Ω, a gain reading of -60 dB on the meter corresponds to 50 mΩ, and a reading of -80 dB to 5 mΩ. All that is needed for calculating impedance magnitude is the value of R_t.

The 3575A costs $2450 to $3150.

For details on the gain phase meter check I on the HP Reply Card. For Application Note 157 on gain phase measurement applications, check R.

Take the mystery out of time interval averaging

"Time Interval Averaging," a new application note, describes our technique for increasing the accuracy and resolution of short time interval measurements. Using time interval averaging, the HP 5326/5327 universal counters can measure intervals as short as 150 ps with resolution to 100 ps (at little or no increase in cost over conventional universal counters that can only measure intervals as short as 10 or 100 ns).

This booklet (AN 162-1) describes when averaging is useful, factors that influence measurement accuracy, and how to verify and evaluate time interval averaging measurements. Other topics include statistics, the need for synchronizers for valid averaging, and simple ways to avoid synchronous repetition rates that could otherwise limit the power of time interval averaging. All major topics are fully illustrated with figures and examples.

For your free copy, mark S on the HP Reply Card.

HP's auto-attenuator for lab and OEM

Broadband programmable attenuators have been optimized for both measurement applications and OEM design usage. The HP 33300 series attenuators (dc to 18 GHz) offer accuracy and repeatability where precision is required. At the same time, the attenuators are fast, compact, reliable and cost-effective for installation in equipment.

At 2/3 the cost of any other programmable attenuator, the 33300 series gives you a broad selection of connectors, ranges and step sizes (1, 6 and 10 dB). Supplied with either 12 or 24V solenoids, simple drive circuitry can be built to fit your needs. Prices start at $665 each in quantities of 1 to 9.

Check G on the HP Reply Card for specifications.

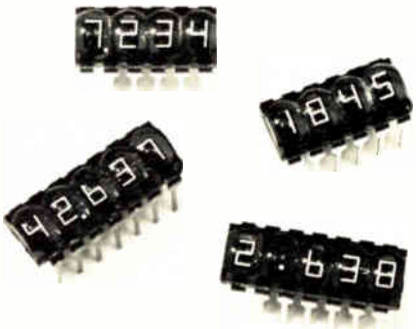
No matter what your application—on the bench or in equipment—the 33300 series programmable attenuators are cost-effective selections.

All prices are domestic U S A prices only

HEWLETT-PACKARD COMPONENT NEWS

Now, choose 3, 4 or 5 digit displays

The 5082-7400 LED clusters are 0.11 inches (.28 cm) high.



A series of small, end-stackable solid-state displays are now available in three, four and five-digit clusters. The extremely low power requirements (typ. 5 mW/digit) make the 5082-7400 series LEDs ideal for miniature battery-powered devices, such as hand-held calculators.

The displays can be plugged into DIP sockets or soldered onto PC boards. They are IC-compatible and designed for strobed operation. Options include either the standard right-hand decimal point or a centered decimal point. Prices:
3-digits (1-33) $12.75 (34-166) $10.50
4-digits (1-24) $17.00 (25-124) $14.00
5-digits (1-19) $21.25 (20- 99) $17.50

For more information, check L on the HP Reply Card.

New low-cost LED for commercial market

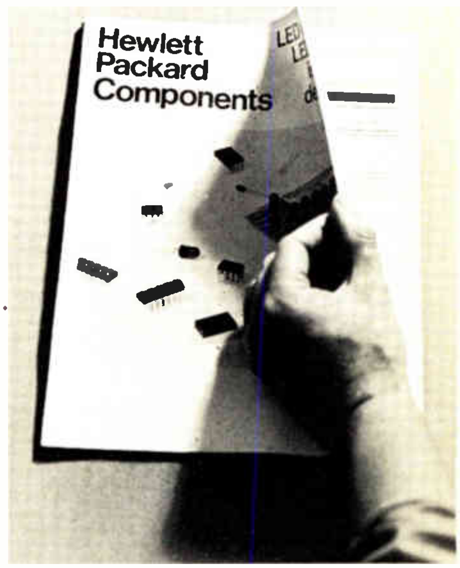
High-volume production and advanced product design have resulted in low-cost LED lamps for the consumer market. Designed for commercial applications, they can be used in TV sets, appliances or automobile instrument panels. These lamps have red diffused lens and 0.8 millicandelas light output (typ).

Price: only 17¢ each in 100K quantities.

For more information, check M on the HP Reply Card.

The 5082-4484 LED is ⅛ inch in diameter (0.3 cm); the 5082-4850, .200 inch in diameter (0.5 cm).

New optoelectronics catalog



Now, you can get a copy of our 1973 Optoelectronics Designer's Catalog. This 48-page book contains complete up-to-date detailed specifications on the entire HP optoelectronics product line—LED displays, LED lamps, high-speed optically coupled isolators, and PIN photodetectors.

For your free copy of this bound catalog, check T on the HP Reply Card.

All prices are domestic U.S.A. prices only.

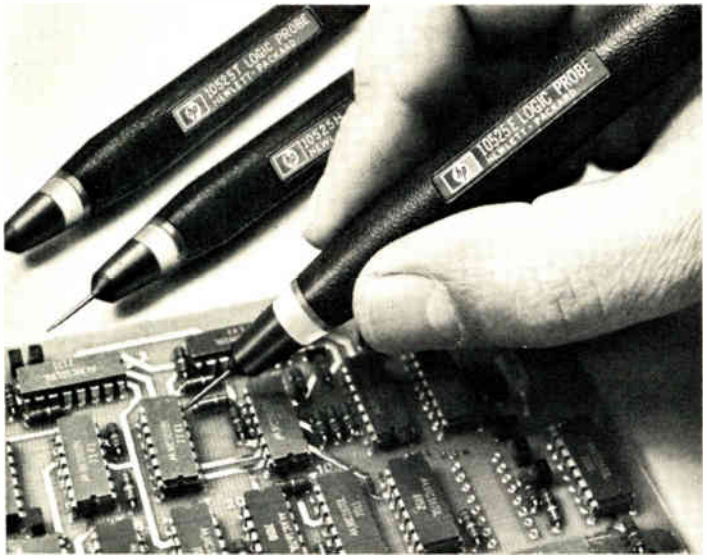
New ECL and HTL logic probes join HP's IC troubleshooters

Two new logic probes bring unique capabilities and fingertip ease to logic troubleshooting: model 10525E is the only probe on the market fast enough to check emitter-coupled logic, while the 10525H probe checks circuits operating in the broad range from 12 to 25 V.

Both probes do everything the time-proven model 10525T does for TTL/DTL circuits—simply touch the circuit node with the probe tip, then read the band of light. A bright light indicates a logic high; no light, a logic low; a dim light, open circuits or voltage between the high and low thresholds; and a blinking light, a pulse train. A single or intermittent pulse is always obvious to the user; the light blinks on for a high-going pulse, or off for a low-going pulse.

When probing in-circuit, the inevitable problem of accidentally touching a high voltage node usually is a potential hazard. Not so; all HP probes will withstand ±200 V intermittently and ±70 Vdc continuously. HP probes also have high input impedance.

Now, HP offers three different logic probes, one for each major logic family.



The 10525E probe is the fastest probe available today, able to capture single pulses as narrow as 5 ns. The logic one threshold is -1.1 V±0.1 V; and logic zero, -1.5 V±0.1 V. With this super-fast, handheld probe, you can solve most of your ECL troubleshooting problems without resorting to complicated test equipment.

The 10525H troubleshoots HTL, HiNIL, MOS, relay and discrete-component circuits. Pulses down to 100 ns are "stretched" for a visual indication. Logic high is anything >9.5 V, while a low state is <2.5 V.

The 10525E ECL logic probe costs $125; the 10525H HTL probe and 10525T TTL probes, $95 each.

For more information on the new IC troubleshooters, check B or C on the HP Reply Card.

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- B. 10525E ECL logic probe
- C. 10525H high-level probe
- D. 12930A universal interface
- E. 1310A, 1311A graphic displays
- F. 1810A, 1811A sampling scope plug-ins
- G. 33300 programmable attenuators
- H. 3489A data punch
- I. 3575A gain phase meter
- J. 3710 microwave link analyzer
- K. 3960A tape recorder
- L. 5082-7400 small LED display
- M. 5082-4850 commercial LED
- N. 6256-6271B low-voltage power supplies
- O. 817A swept slotted line/8755 freq. response test set
- P. 9830 desktop calculator
- R. AN-157 Gain Phase Measurements
- S. AN-162-1 Time Interval Measurements
- T. Optoelectronics Designer's Catalog

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Meetings

Aerospace and Electronic Systems (Wincon): IEEE, Biltmore, Los Angeles, Feb. 13–15.

International Solid State Circuits Conference: IEEE, Marriott, Philadelphia, Feb. 14–16.

Compcon 73: IEEE Computer Society, Jack Tar Hotel, San Francisco, Feb. 27–March 1.

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

IEEE International Convention (Intercon): IEEE, Coliseum and New York Hilton, March 26–29.

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

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

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

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

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

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

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

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

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

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

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CERAMIC

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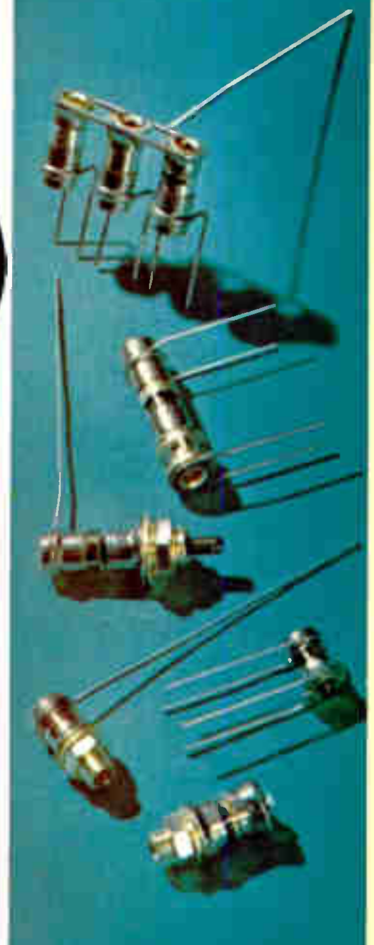
PLASTIC



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Circle 29 on reader service card

Meetings

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

National Aviation System Planning Review Conference: FAA, Washington Hilton, Washington, D.C. May 21–23, 1973.

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

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

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

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

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

International Conference on Communications: IEEE, Seattle, Wash., June 11–13.

Spring Conference on Broadcast and Television Receivers: IEEE, Marriott Motor Hotel, Chicago, June 11–12.

Frequency Control Symposium: Army Electronics Command, Howard Johnson's Motor Lodge, Atlantic City, N.J., June 12–14.

Nepcon and Semiconductor/IC East: Kiver Pub., N.Y. Coliseum, June 12–14.

Design Automation Workshop: IEEE, ACM, Sheraton-Portland, Portland, Ore., June 25–27.

European Microwave Conference: IEE, Brussels University, Brussels, Belgium, Sept. 4–7.

Western Electronic Show & Convention (Wescon): WEMA, IEEE, Hilton and Cow Palace, San Francisco, Sept. 11–14.

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Voltage Rating		Minimum Insertion Loss (dB)			
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	200 VDC 125 VAC	12 to 34	23 to 65	58 to 80	70 to 80
150 VDC	100 VDC	16 to 52	35 to 80	65 to 80	70 to 80
100 VDC	50 VDC	26 to 63	37 to 80	66 to 80	70 to 80

Actual Size

Allen-Bradley
Milwaukee, Wisconsin 53204

Electronics newsletter

LED on sapphire cuts costs, aids MOS integration

The use of sapphire substrates for gallium-arsenide or gallium-phosphide light-emitting diodes may greatly reduce the cost of these displays and provide several significant advantages. Union Carbide Crystal Products division, which supplies sapphire substrates, says the major benefit is at least a tenfold reduction in the cost of the scarce III-V materials from about $80 to $150 per square inch to $4 to $8 with sapphire. C. C. Wang, of RCA's Princeton Labs, who was the first to use a two-stage epitaxial process to grow III-V material on sapphire and spinel, points out the ability also to deposit silicon or germanium on the same substrate. **This makes possible the integration of MOS and LEDs.** Other advantages, says Wang, include the rigidity of sapphire, and its transparency—which means that sapphire could provide a protective cover or that its light could trigger another type of display.

Raytheon regulator undercuts price of competitors

Raytheon Co.'s Semiconductor division, Mountain View, Calif., is going after the market for on-card fixed-voltage regulators, recently dominated by Motorola and Silicon General Inc., with a comparable dual tracking unit that in large quantities will sell for about half the price of the Motorola MC1568 and the Silicon General SG1501. **Raytheon's RC4195, with outputs fixed at +15 and −15 volts—standard operational amplifier voltages, will cost less than $1 in lots of 100,000 or more.** Makers of modular power supplies, electronic organs and modems often buy such large lots, says a Raytheon marketing man. The list prices for small-quantity users will be 10–20% below those at Motorola and Silicon General.

1973 is called the year of the digital clock

Backing its conviction that this is the year of the digital electronic clock, Sperry Information Displays is coming out with a new gas-discharge display ½-inch high that includes the hours, colon, and minutes displays and an a.m./p.m. indicator. The new unit, called SP-151, will sell for $7 each in thousand-unit batches. **In larger quantities, the price would be less than $4, says the company.**

Larry Pond, Sperry's marketing manager, says the gas-discharge display is ideal for clocks because its price is low, size and appearance are good, and its lifetime is longer than that of solid-state units.

'Fastest' TTL RAM to make its bow

What is being billed as the random-access memory with the fastest guaranteed access time of any in the TTL family is about to debut from Monolithic Memories Inc., Sunnyvale, Calif. The 256-bit unit has a guaranteed maximum access time of 50 nanoseconds over the temperature range of 0°C to 70°C. **Zeev Drori, the president, points out that the pivotal words in describing the MM6530 are "guaranteed speed."** "With most parts, including ours," he says, "typical speeds run about half the guaranteed maximum" because RAM builders usually specify typical access times at 25°C.

The unit, which incorporates standard Schottky processing, will be offered with either three-state or open-collector output. A military version also in the works will have a guaranteed maximum access of 80 ns over the range of −55°C to 125°C.

Siemens and CII to cross-market their products

Europe's newest computer alliance has taken its first irreversible step toward total integration of marketing and sales activities. Siemens of Germany and La Compagnie Internationale pour l'Informatique (CII) of France have signed an agreement giving each other full commercial responsibility for each others' products in their respective countries. **Thus, CII salesmen theoretically will be peddling Siemens machines, as well as their own wares, to French customers, and vice versa for the Siemens sales force in Germany.** The agreement will be broadened later this spring to divide up the rest of the world market and bring into the catalog the small computers manufactured by Philips.

Motorola introduces 900-MHz mobile transceiver

The first land-mobile radios to operate in FCC's newly allocated 900-MHz band will be introduced at about $800 in several weeks by Motorola's Communications and Electronics division, Schaumburg, Ill. **Although the commission has not yet given final approval for use of 900-MHz frequencies by land-mobile operators, Motorola marketing plans signal that company's belief in a favorable FCC decision in the near future.** A company spokesman says that crowding of the mobile-radio spectrum in some metropolitan areas is getting to the point where, if new gear is to be sold, it will have to operate in the higher frequency band.

TI's giant computer to go to missile agency

A fourth model of the Advanced Scientific Computer, the giant processor that Texas Instruments has been working on for six years [*Electronics*, April 10, 1972, p. 42] is to be built for the Advanced Ballistic Missile Defense Agency at Huntsville, Ala. **The $3,744,000 contract is for the bare bones of the machine; a choice of options, which will be decided later, may run the price up to around $7 million. Installation is slated to begin in June.**

The first two ASCs have been installed and are working in TI's own facilities—one at Austin, Texas, and the other at Amstelveen, Holland. The third machine, nearly completed and undergoing checkout at the Austin laboratory, is to go to the Geophysical Fluid Dynamics Laboratory of the National Oceanic and Atmospheric Administration in Princeton, N.J., some time this summer.

Addenda

Texas Instruments will be second-sourcing American Micro-systems Inc.'s AMS 6003, a 2,048-bit MOS RAM. Production quantities will be available in June or July, according to TI. The part will be tabbed TMS 6003 . . . And, speaking of 2,048-bit RAMs, **Signetics is the latest semiconductor firm to supply the big p-MOS** parts to Memory Technology, Inc., Sudbury, Mass. MTI will use the RAMs in its 755 and 765 model add-on memories for IBM System/370 models 155 and 165, respectively. MTI will also use them in the MTI 311 memory for Digital Equipment Corp.'s PDP-11 . . . **Finally given the heave-ho** by New York City's Off-Track Betting Corp. is the trouble-plagued computerized betting system installed two years ago by Computer Sciences Corp. [*Electronics*, Jan. 4, 1971, p. 79]. The replacement is a system developed by American Totalisator Co., of Towson, Md., a subsidiary of General Instrument Corp. Also to be phased out with CSC' equipment are the computer services of Control Data Corp.'s Ticketron division.

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Pentagon R&D shakeup set as new managers prepare to take charge

New technology is expected to be pushed into development much faster, and DDR&E may be phased out

The Pentagon is bracing itself for a thorough reorganization of its research and development machinery, one designed to eliminate what the new Deputy Secretary of Defense, William P. Clements Jr., calls the "just unacceptable" lead times of "six, seven, eight, sometimes 10 years" on major weapons systems. Clements ranks the shakeup as his first priority. The 55-year-old Dallas oilman told the Senate Armed Services Committee during his January confirmation hearing, "I think we can significantly reduce paperwork and eliminate layers of decision-making."

The details of what Clements means are contained in the report that the Blue-Ribbon Defense Panel, after probing the Pentagon's management structure and operations [*Electronics,* Aug. 17, 1970, p. 109], submitted to President Nixon in the summer of 1970. Clements served on the panel.

In particular, the report said that "the position of director, defense research and engineering, would be abolished, and his functions reallocated" between two new assistant secretaries for research and advanced technology and for engineering development. Moreover, the panel urged a significant upgrading of the role of the Advanced Research Projects Agency by making it independent of DDR&E and assigning it its own director, plus budgetary responsibility "for all research and exploratory development" carried out under contract or in Federal laboratories.

Takes command. New Deputy Secretary of Defense William P. Clements sees radical changes ahead, especially in military R&D.

Clements, who believes "there is nothing more important than expanding our technological base," supports the panel's recommendations to the hilt, and he is expected to push hard for their implementation.

Impact. The role of DDR&E director, until now the Pentagon's No. 3 man, is expected to be diminished sharply by Clements' strong convictions on the need for change. His strong political ties to the White House are expected to help him establish his position, too, for it is an open secret at the Pentagon that President Nixon broke with protocol by selecting Clements personally as a DOD deputy secretary before the nominee was known to or had met new Defense Secretary Elliot Richardson. As the millionaire chairman of Sedco Inc., an oil pipeline and drilling operation, Clements served as co-chairman with J. Erik Jonsson, former chairman of Texas Instruments, on the Texas branch of the Committee for the Reelection of The President.

While Richardson established himself as a strong manager in the Department of Health, Education, and Welfare, his Boston brahmin background has reputedly given him a more liberal bent than most members of the Nixon cabinet. And his apparent reluctance to take the top Pentagon slot—he seemed only half-joking when he said he received "an offer I could not refuse"—already has the military establishment's rumor mill working overtime on speculation as to how he will work with Clements and a second deputy secretary that he and the more conservative Texan must select. Clements, on the other hand, is strongly aligned with outgoing Secretary Melvin Laird on the issue of countering what they believed to be an ongoing Soviet strategic weapons buildup.

One result of that common philosophy is expected to be a significant escalation in the program to develop the next-generation Trident ballistic-missile submarine with a fiscal 1974 request for funds nearly double the $850 million available in the current budget. General Dynamics Corp. is developing the new 24-missile sub, while Lockheed is working on the Trident I missile.

Change. The prospect that the new Richardson-Clements team will put Trident and other developing systems through a different set of R&D paces is almost certain, however. For example, the Army and Navy's assistant secretaries of R&D are leaving the Pentagon, as is the assistant secretary of defense for installations and logistics. These and other resignations still anticipated are expected to give Clements a strong hand in restructuring the military agency's top civilian management along the lines of the Blue-Ribbon Defense Panel's recommendations.

Many of those were implemented by the then-Deputy Secretary David Packard shortly after the report's completion. These include competitive prototyping and a prohibition of the discredited total-package procurement concept, among others. Still to be widely employed by DOD, however, are such proposals as "design-to-cost," which makes cost a critical element in contractor selection; increased exploratory and advanced development of such subsystems as electronics independently of the weapons systems on which they may be used; increased assurance of maintainability and reliability by means independent of contractor-design proposals; more use of tradeoffs between new weapons systems, and upgrading of existing systems by modifications. □

Jet-engine maker computes work flow

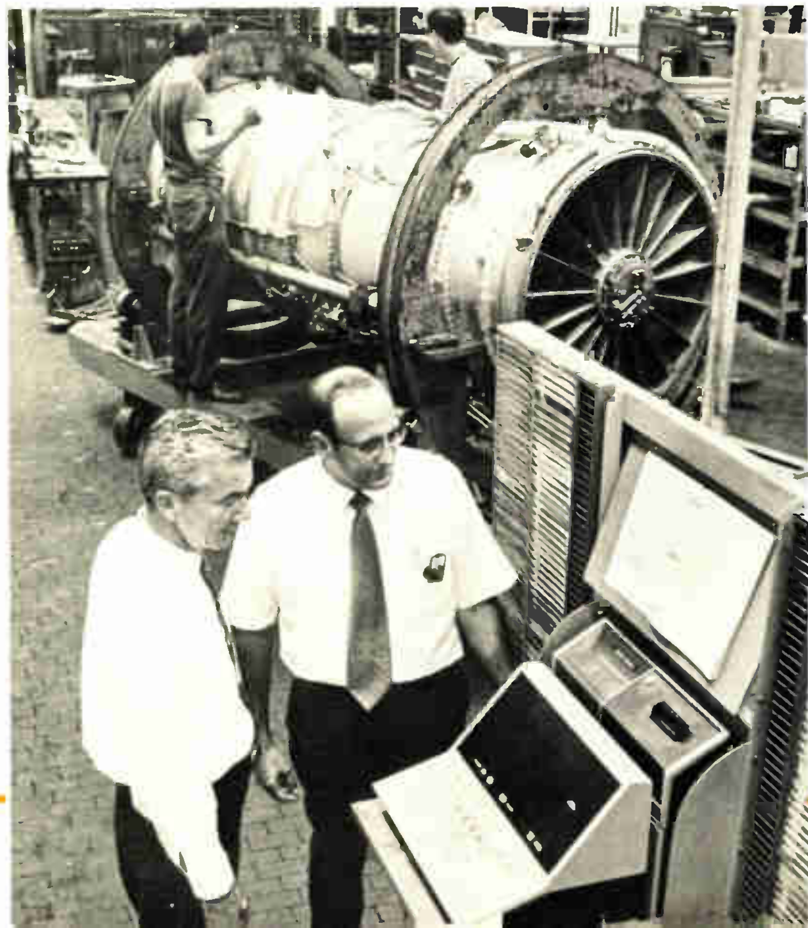
One of the "largest factory data-collection systems in the world" has been introduced by The Singer Co.'s Business Machines group at jet-engine manufacturer Pratt & Whitney Aircraft. "We're able to keep track of our material, our men, and how we're using our machines," says C. Thomas Savary, head of the P&W project team that put the system together. "And it does this without written paperwork."

The Singer installation involves 11 of the company's System Ten computers—with associated processors and disk and tape drives—and more than 600 attendance and job-entry terminals spread around eight major P&W facilities in and around East Hartford, Conn. Overall, the system, which represents a $5 million investment, serves some 22,000 employees and tracks work involving 500 different vendors.

Data is fed in at the remote terminals—from "time clock" units that read employees' badges or from the more complex job-entry units, with up to 40 lighted instructions on a tutorial keyboard, that read punched cards containing data on the parts being worked. Once introduced into the buffered terminals, the data is transmitted to a System Ten processor at 1,200 baud over a pair of twisted wires, or through a remote terminal-scanning system that acts as a line concentrator.

From the processor, data goes at a rate of 9,600 baud to a central IBM 360. There it is batch-processed to produce reports for management by 7 a.m. the next day.

All of the system components were off-the-shelf System Ten units from Singer. The only redesign of any magnitude went into re-orienting the remote data entry terminal to accept badges and cards introduced vertically, rather than horizontally, a P&W requirement. □



Displays

Blue LED display developed at RCA

From the same semiconductor family that made light-emitting diodes famous, RCA's Research Laboratories has produced a bright new offspring—a blue light-emitting diode to go with the red, yellow and green devices already commercially available. The blue LED is a "metal insulating n-type," or MIN, device.

and operates at room temperature.

It is made from gallium nitride, a wide-energy-gap (3.5-volt) material that is transparent to visible radiation, according to Jacques Pankove, program manager at the Princeton, N.J., facility. This transparency means, he points out, that by controlling impurities, a variety of colors can be produced, including the red, yellow and green attainable from other members of the III-V family on the periodic chart of elements, such as gallium arsenide phosphide and gallium phosphide.

Pankove asserts that although his device is still a laboratory development, it could become a product within a year's time "if there's interest." Possible applications include dashboard displays for cars. Until now, blue has been obtained by using compounds such as cadmium sulfide and zinc selenide. The gallium nitride technology is much simpler, Pankove says.

As he describes it, the MIN device is fabricated by vapor-depositing n-type GaN on an insulating substrate such as sapphire. Then an insulating layer of zinc-doped gallium nitride is grown, and a metal connection is evaporated on top. With current through the metal contact, light is emitted back through the layered device and out through the substrate. The whole structure is transparent to visible light, says Pankove. Bias voltages, from 10 volts to 100 volts, depending on doping, have been used, and "quite bright" emissions are attainable with as little as 10 to 30 volts, he claims.

RCA has built lamps with light-emitting diameters, equal to the diameter of the metal contact, of 4 to 10 mils, according to Pankove. Seven-segment units for numeric displays, with each segment about 80 mils long and 4 mils wide, have also been made. Larger displays, depending mainly on the size of the sapphire material, could be made, Pankove asserts.

The power efficiency and brightness of the GaN emitter are perhaps its most unusual and important aspects. Power efficiency—the ratio of radiated light to electrical power input—is 0.1% and comparable to the diodes that emit green light, Pankove says. Light output from the device can be greater than 300 foot lamberts or 10^3 candelas/square meter. In comparison, light from a television screen ranges only between 50 and 100 foot lamberts.

Another feature is that, given certain fabrication conditions, either of two colors can be obtained if the bias polarity is varied. Thus, the same device can emit yellow and red, or blue and green. So far, several blue-emitting devices have operated with no light degradation for several months. □

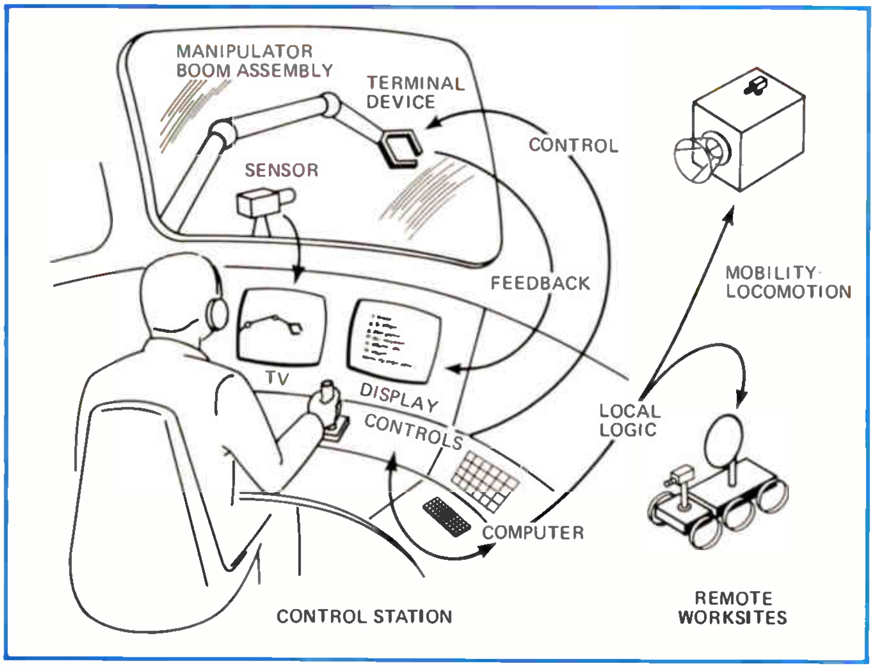
Aerospace

NASA plans man-machine computer interface

When the Russian Lunokhod 2 moon robot nearly ran into its Luna 21 mothership during recent moon explorations, it demonstrated a big problem with remotely controlled space hardware: how can operators know what is going on and respond in time to prevent mishaps? NASA believes that man-machine-computer concepts, called Teleoperator systems, will allow operators on earth or in a vehicle to precisely maneuver hardware via computer control in the alien world of outer space.

One such system is slated for the space shuttle orbiter, which will enable an onboard operator to control the two articulated 40-foot arms that will deliver or retrieve payloads in space. As now conceived, the operator watching a television screen would convey control commands by moving special control handles, which the computer-assisted system would transfer to the arms, much like operating a futuristic crane, says Stanley Deutsch, NASA's director of bioengineering, Office of Life Sciences.

But this operation isn't easy. In a gravityless environment, the arms must touch a payload container exactly right, or they might strike the object so that it would float off into space. Also, the arms' pinchers



Teleoperator system. A remotely controlled cybernetic man-machine system is planned by NASA to augment man's sensory and manipulative capabilities in outer space.

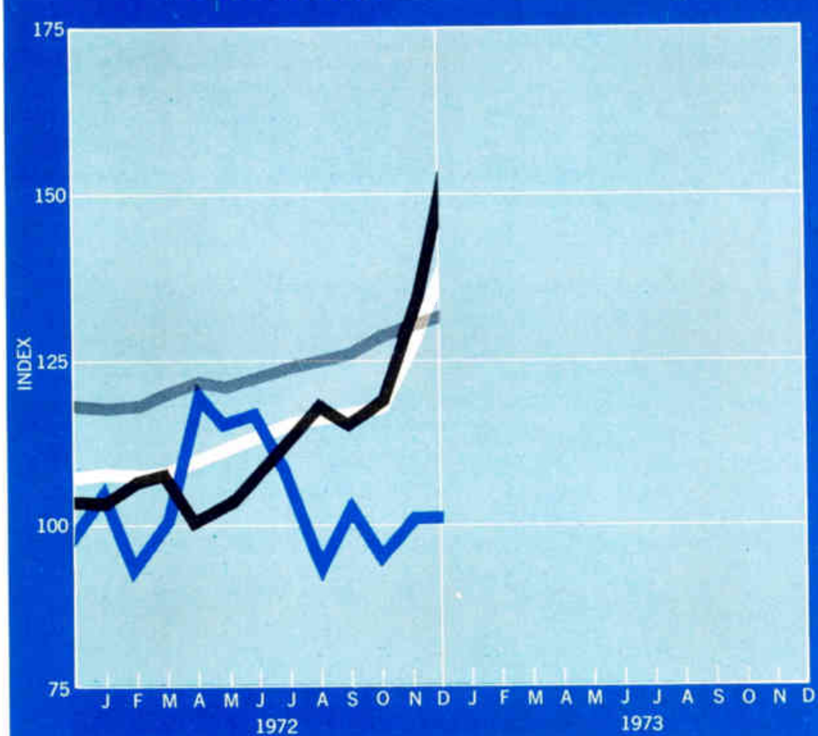
must grip correctly, or they might cause damage. And, since the arms would be manipulating objects outside the orbiter, the operator must be able to coordinate them by watching the operation through a TV console.

NASA is trying to solve these precision mechanical and feedback operations with tactile and force-feedback approaches, based on experiences in prosthetics and television-computer interface techniques. "We have to build in a feel so that the operator will know how near the arms are to an object and how hard he is causing them to grip," observes Carl Janow, Teleoperator program manager. Precision must be high because "we're aiming for two inches of accuracy at the end of the 40-foot arms," comments Deutsch, adding that the arms will have seven degrees of freedom.

For tactile sensing, NASA is studying whiskers, piezoelectric sensors, and small laser arrays to give an operator an indication of arm proximity. Even tools must be selected carefully so that Teleoperator arms can manipulate them. An Allen wrench is fine, for example, but a screwdriver "can't work in space," Deutsch says.

NASA's Manned Space Center, Houston, is performing the space shuttle work, and three other centers are working on other Teleoperator problems. Marshall Space Flight Center, Huntsville, Ala., is exploring a "free-flyer" Teleoperator, which would be housed in remotely controlled space shuttle vehicles to pick up and repair satellites. Jet Propulsion Laboratory, Pasadena, Calif., is presently working on an elementary breadboard planetary explorer. Ames Research Center, Mountain View, Calif., is researching such advanced concepts as computer control for Teleoperator systems, split-controller imaging, and predictive displays. The research is being conducted under a basic fiscal 1973 program budget of $2 million, plus an undisclosed amount of shuttle money. □

Electronics Index of Activity



Segment of Industry	Dec. '72	Nov. '72*	Dec. '71
Consumer electronics	101.8	101.6	99.3
Defense electronics	153.9	135.2	105.0
Industrial-commercial electronics	133.1	131.3	118.8
Total industry	139.2	128.5	108.2

The index climbed 8.3% in December, an amazing 28.7% increase over December 1971's level. All three components of the index contributed to the jump, but most surprising was the defense sector, which rose 13.8% above November's level.

Indexes chart pace of production volume for total industry and each segment. The base period, equal to 100, is the average of 1965 monthly output for each of the three parts of the industry. Index numbers are expressed as a percentage of the base period. Data is seasonally adjusted.
*Revised

Communications

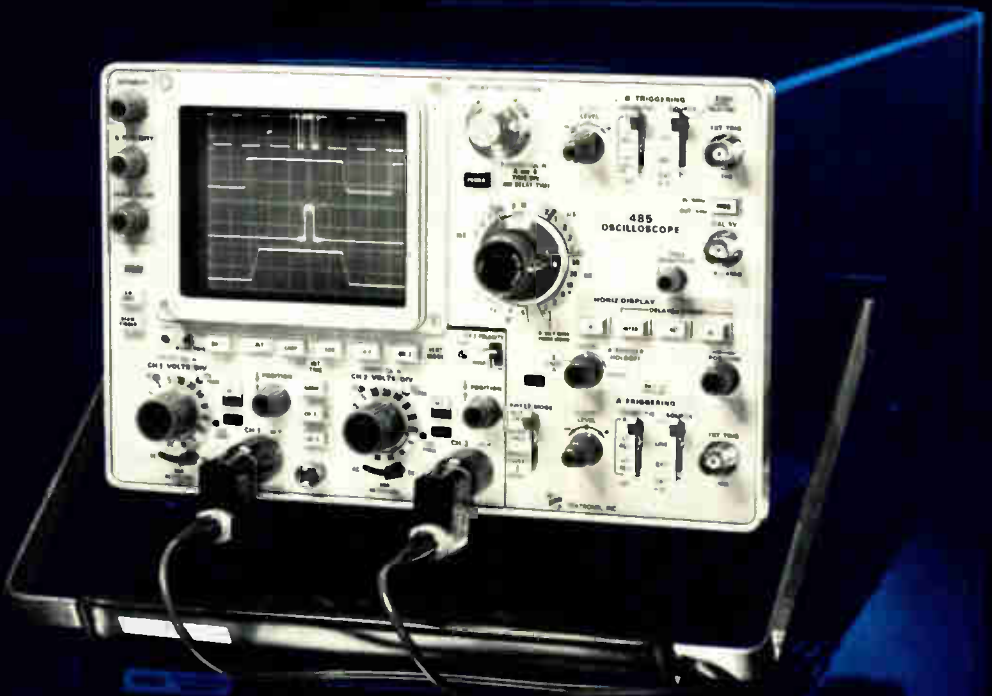
MCI spells out its 4K-Plus push

Although MCI Communications Inc., Washington, D.C. has yet to file tariff proposals with the Federal Communications Commission for a new set of interstate-communications-carrier offerings, the company has issued a price list for four types of services linking 21 cities. These services, dubbed 4K Plus, are scheduled to be on line by 1974.

The 4K Plus services include data, voice, facsimile, and teleprinter communications. They all will travel over the "backbone" microwave systems between the cities served. MCI now merely offers carrier bandwidth between Chicago and St. Louis. This new offering is another step in the evolution of several levels of communications services, each of which comes nearer to providing complete computer-communications systems to the user.

The company's new approach is to get closer to the marketplace by

350 MHz



in a *portable* laboratory oscilloscope that weighs only 23 pounds.

The dual-trace, 350-MHz TEKTRONIX 485 Oscilloscope is the newest addition to the world's most widely used portable family. Many features of earlier TEKTRONIX portables are retained, many others are expanded and a lot of new ones are added. The result is a new product which significantly expands the performance spectrum of portable scopes. Following are some of the features of the 485, an oscilloscope which measures with laboratory precision and carries with small-package ease.

350-MHz Bandwidth at 5 mV/Div—More dual-trace high frequency measurement capability at 5 mV/Div than any other laboratory-quality scope—portable or cabinet.

1-MΩ and 50-Ω Selectable Inputs—Scope circuitry automatically disconnects the 50-Ω inputs when signals exceed 5 V RMS or 0.5 watts to protect your equipment.

Time Resolution to 1 ns/Div—More time resolution than any other portable. And it's direct reading.

A-External Trigger—Just press this button to display the external trigger signal and quickly verify your trigger source or check timing reference.

Alternate Sweep Switching—View intensified waveforms and delayed waveforms at the same time. When you move the intensified zone you always know precisely where you are, and still see the delayed waveform. It saves time and adds operation convenience.

Weight without accessories, just 20½ lb (23 lb with accessories). As much as 30% lighter than other portables which have only 150-MHz bandwidth.

For complete information or to arrange a demonstration, contact any TEKTRONIX Field Office. Our offices are located in or near major cities and industrial centers—worldwide. If you prefer, write Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005. In Europe, write Tektronix Ltd., P.O. Box 36, St. Peter Port, Guernsey, C.I., U.K.

485 Oscilloscope $4200

U.S. Sales Price FOB Beaverton, Oregon

TEKTRONIX®

committed to technical excellence

providing complete customized services, including terminals, modems, multiplexers, error-correction facilities, and the like, for fixed monthly rates. To implement this program, MCI has developed a marketing organization with specialists in each of 13 major industries, from petroleum and finance to transportation and electronics. "Customers will now deal with people who are thoroughly knowledgeable in both the customer's industry and the communications business," says Carl M. Vorder Bruegge, senior vice-president for marketing.

MCI officials say that the FCC holds the key to how fast their new services (and others like them that may be offered by other carriers) will come on-line. For example, it's still not clear if multiple users will be allowed to band together to use the links of a single carrier, such as MCI, to provide reduced user prices—in much the same way that the airlines now enjoy the joint-use services of Arinc's inter-airline data-communications network.

It has been a year since MCI began microwave services between Chicago and St. Louis, and the company says it is expanding both plant and marketing efforts in its bid for what is now more than a $1 billion-a-year business. □

Solid state

Resistors: baked, implanted, or plated?

There seems to be no agreement in sight on whether precision resistors in large-scale linear integrated circuits, digital-to-analog converters in particular, should be diffused, ion-implanted, or fabricated by that old standby technology, thin-film.

Precision Monolithics, Inc., Santa Clara, Calif., is sticking with its special diffusion process, despite the difficulty it had in achieving 12-bit d-a converter resolution. Signetics Corp., Sunnyvale, Calif., has a 10-bit ion-implanted design in pilot production. And Analog Devices, Inc., Canton, Mass., is holding the thin-film fort with a 10-bit converter.

Everyone agrees that ordinary diffusion processes don't give sufficient resistor-matching accuracy for resolutions above eight bits. The error must be halved with each added bit. Most PMI designs, including its operational amplifiers, are based on special processes.

Signetics' aim, however, is to produce both garden-variety op amps and high-precision circuits in the same diffusion furnaces, explains Hans Stellrecht, senior engineer on the DAC project. Ion implantation allows wafers to be completely fabricated, except for precision resistors, and then to be bombarded between the resistor electrodes in separate equipment as the finishing touch. The ions are counted to get precise resistance values.

Stellrecht also argues that implanted resistors are much smaller and better matched than either diffused or thin-film types. When he and Gary Nelson, manager of consumer circuit design at Signetics, describe the DAC at the International Solid State Circuits Conference on Feb. 14-16 in Philadelphia, they intend to prove this point with statistical comparisons of the three competing processes. They can expect some argument. Designers from Precision Monolithics and Analog Devices will be at the session.

The smaller size, Stellrecht continues, means greater design freedom because more circuitry can be put on a chip. Signetics' design has both current and voltage outputs and both reference and multiplying inputs, instead of one of each as in PMI's design. Also, some special feedback techniques were built in to improve temperature stability.

However, the Signetics design is not as fast as PMI's Monodac-02, it doesn't have a sign input, and is three stages shorter. It can be made faster, though, by attaching an extra amplifier to the current output. A bipolar offset input makes the output swing between 5 volts and -5 v, accomplishing much the same end as a sign input.

The Analog Devices AD 560 differs from the other DACs in its use of a thin-film resistor network deposited over the silicon chip. This is said to be far more accurate than diffused resistors. Another basic difference is its use of a forward-biased silicon junction rather than a zener diode for voltage reference. And finally, Analog uses so-called weighted-junction switching. □

Consumer electronics

Electric range has electronic controls

Frigidaire will take the first step toward the computerized kitchen in June when it announces its electric range that for the first time incorporates computer logic in a kitchen appliance [*Electronics*, Jan. 4, p. 30]. "This is the first step toward programing just about anything the housewife wants," says John Weibel Jr., chief engineer for the Dayton-based division of General Motors. "Although we don't think the time is right for the computerized kitchen today, we think it's time to get started."

Frigidaire engineers have replaced separate electromechanical controls for surface units, oven, broiler, clock, timers, and cooking controls by a single electronic system that also includes information

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Functions such as timer and clock, an automatic broil cycle, self-cleaning oven, surface-unit temperature and time controls, and automatic controls for starting the oven, selecting its temperature, and later reducing it to a "hold" temperature that stops cooking are read out on flat-envelope gas discharge tubes from Sperry Information Displays, Scottsdale, Ariz.

"All switches are part of a solid, tempered-glass panel," Weibel says, "We feel that one thing that's attractive to the housewife is cleanability, and there are no knobs, no compressions or holes. The display is mounted behind the glass," he says, "and circuits are printed right on the back of the glass.

All electronics, centered around three MOS LSI chips supplied by American Micro-systems Inc., Santa Clara, Calif., are mounted on a single printed-circuit card behind the glass "touch-control" panel. □

Packaging

AMI's Slam DIP is strong, simple

Where the standard king-sized dual in-line package requires three layers of metalized ceramics and a metal lid, American Micro-systems Inc., Santa Clara, Calif., plans to put most of its MOS LSI arrays into a DIP that is little more than two parts bonded together with epoxy. Yet despite its simplicity, the package is the first specified to meet all hermeticity and reliability requirements of MIL-STD-883. The DIP is called Slam, for single layer metalization.

The chip goes on an alumina substrate carrying a metalized lead frame and either standard DIP pins or plated-edge contacts. After the two-part package is bonded, an alumina lid, shaped like a tiny boxtop, is attached to the substrate with a special epoxy adhesive. The lid forms a hermetically sealed cavity filled with dry air.

While the phaseout of the multilayer package will save AMI money, marketing vice-president Bernard T. Marren says it won't affect circuit prices. He is quick to add, though, that the new package is more reliable than the old because of its simpler construction.

The package is about three times easier to make than the standard one, says James Barnett, manager of packaging development. Also, sealing is less hazardous to sensitive MOS chips because the epoxy sealing temperature is relatively low—200°C. And the assembler has plenty of room to maneuver big chips on the flat substrate, whereas it's hard to get a tweezer and a big chip into a standard cavity. Eventually, Slam could take chips almost four times as large as today's 250-mil-square types, without increasing package dimensions, since eliminating two layers makes room for chips up to 450 mils square. Packages with 40 to 14 pins are being made.

Barnett considers Slam the first successful adhesive-sealed package. It has survived torture tests that Barnett says would destroy DIPs with conventional hermetic sealing.

However, Barnett's group has also developed a metal-sealed Slam for customers who might be leery of adhesive seals before completion of AMI's long-term reliability tests. This version has a Kovar lid soldered to a ceramic ring that is sealed to the substrate.

AMI won't disclose the type of epoxy used, except to call it a "highly cross-linked polymer." Apparently, it is solid—or almost so—when the seal is made, because Barnett insists it leaves virtually no byproducts in the cavity. Even if some got inside, he contends it would not contaminate the chip. "We've covered test wafers with a blob of it and heated them to 350° C without finding any capacitance or voltage drift," he says.

Another secret is the "down-bonding" method. In a standard DIP, the bonded wires go from the chip to a raised metalization, so they can't short on the naked chip edge.

In Slam, the wires curve up and then down around the edge to the lead tips on the substrate. AMI uses aluminum, since it is stiffer than gold, and sets the proper curve with a method it refuses to disclose.

AMI has applied for patents on the design and plans to issue licenses to other semiconductor companies. Right now, the parts are produced for AMI's exclusive use by American Lava Corp., Chattanooga, Tenn., and Kyoto Ceramics Co. Ltd., of Japan. □

Instrumentation

A two-bit story may aid DAC sales

The wolf in sheep's clothing has his electronic counterpart—a monolithic 12-bit digital-to-analog converter that has masqueraded for a year as a 10-bit DAC and will soon emerge at its real length, hoping to gobble up the market enjoyed by hybrid and modular converters. It will also go into a new integrated 12-bit analog-to-digital converter.

Here's the tale told by Precision Monolithics Inc., Santa Clara, Calif. In 1970, PMI developed the first monolithic DAC, the 6-bit Monodac-01. The company decided to double up the design and make an entire 12-bit family with 13 stages (one extra for binary and binary-coded-decimal sign inputs). The designers managed to cram the works on one chip by early 1972. But 12-bit resolution (4,096 output voltage levels) demands an analog output error of 0.01%, which they couldn't achieve.

They did get an output error of 0.05%—enough for 10 bits. So they simply disconnected the two most troublesome stages, and PMI introduced the Monodac-02 as the first single-chip, 10-bit converter last spring [*Electronics*, May 8, 1972, p. 167].

It takes binary plus sign digital inputs (11 bits). The sign inverts the output, giving a grand total of 2,048 output levels. Current output, needed for analog-to-digital converters, was provided on custom units.

Later last year, the logic was modified for two's complement inputs, and the ladder network was rescaled for three-digital BCD inputs. And with the necessary 12-bit accuracy still unattained by late 1972, PMI announced the Monodac-04, the two's complement design with 10 active stages (number -03 being reserved for 3-digit BCD plus sign, which must have 13 stages).

Meanwhile, the PMI staff made changes in the diffusion masks and the diffusion processes in attempts to "tweak in" the 99.99% accuracy required for the 12-bit DAC. They finally made it, last month. In a few months, PMI will start announcing as "new" products Monodac-03, Monodac-06 (12-bit two's complement input), and Monodac-07 (12-bit binary plus sign). Number -05 is a custom design. □

Government electronics

FCC sets study of uhf TV-channel use

The Federal Communications Commission will initiate a computer study this year to determine if spacing requirements for uhf television-channel assignments can be changed to free up spectrum space for land-mobile communications in metropolitan areas. Funds for the study are being made available to the commission in the wake of an April 1970 internal staff recommendation that the study be made to determine if fewer channels could accommodate existing uhf TV stations.

The action has long been supported by the Land-Mobile Communications Council (LMCC), a confederation of 25 groups of equipment manufacturers and private and public users of mobile communications.

The start of the study this year will signal a second successful effort by the LMCC in its struggle with broadcasters to eliminate what the council labels "taboos" that have

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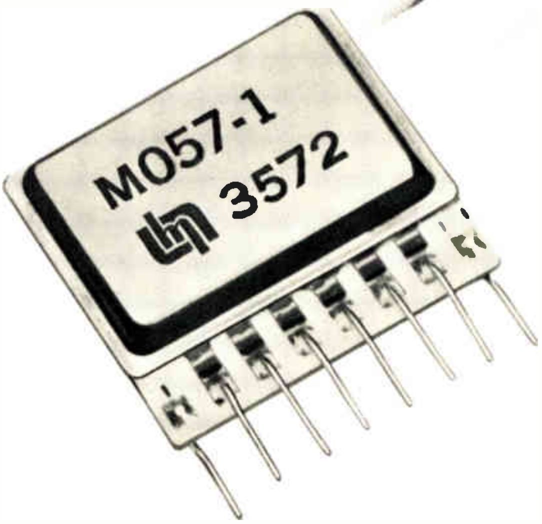

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held many uhf frequencies available for assignment only for television use.

Freeze. The LMCC also wants the FCC to extend its assignment of new two-way uhf radio frequencies to 12 metropolitan areas, in addition to the top 10 cities that attained partial relief in 1970. As a step in that direction, the Council has asked the commission to freeze 44 unused uhf TV channels in the dozen cities "so that the FCC can consider whether more of the uhf spectrum could be used on a shared basis for growing two-way needs."

The requested freeze would not permanently remove the channels from broadcast use, the council stressed. LMCC president Alfred J. Mello of Providence, R.I.'s, Communications department, described the requested freeze as "an initial step in preserving the flexibility for the commission to act in appropriate circumstances to provide necessary allocations for land-mobile use." And he added, "Any channel assignment could be unfrozen to provide necessary broadcast service, should there be no alternative to the use of that channel."

Areas named in the petition for the freeze are St. Louis, Minneapolis-St. Paul, Houston, Buffalo, Dallas, Kansas City, Seattle, Miami, New Orleans, San Diego, Denver, and Atlanta. Mello said the frequency situation in Houston, Dallas-Ft. Worth, Miami, and St. Louis is "particularly acute."

Present receiver technology calls for an FCC reevaluation of the engineering criteria set for the original allocation of channels 14 through 83 for uhf broadcasting, according to the LMCC.

Mello said LMCC has long taken the position that the most reasonable solution to the land-mobile congestion problem would be the nationwide exclusive allocation of frequency space now occupied by uhf channels 14–20 to the land-mobile services. When LMCC requested those channels four years ago, the FCC announced that it would consider only the sharing of some of the channels by two-way radio users and uhf TV in 25 urbanized areas.

"However," Mello pointed out, "the commission acted in 1970 by extending only 'very limited' land-mobile sharing of the band from 470 to 512 megahertz in 10 of the country's major cities." □

Satellites

Marsat effort on new track

U.S. international carriers of record and shipping interests are looking to the U.S. Navy to rescue the drifting commercial Maritime Communications Satellite program [*Electronics*, Jan. 4, p.53]. They hope a projected Navy interim global communications satellite—to be leased from a record carrier—will also provide leased space to shipping interests, notably the owners of large oil-company tanker fleets, who are screaming for ship-shore-satellite service. But successful launching of any operational civilian Marsat program depends on how well it can be navigated through intergovernmental and international conflicting interests.

The Navy has asked Communications Satellite Corp., ITT World Communications Inc., RCA Global Communications Inc., Western Union International and TRT Communications Corp. to submit proposals for operation of a "GapSat" to fill the void between the now expired Hughes' experimental tactical satellite communications program and TRW's operational FleetSatCom due in 1976. Plans call for choosing a contractor for the uhf two-ocean system this spring and launching the system by Sept. 1, 1974.

A way to fill the gap. U.S. record carriers and shipping interests see the GapSat as the earliest and most expeditious way to get maritime communications underway. These interests hope that they can use some space during the Navy's operation and acquire the whole satellite when the Navy switches over to FleetSatCom. The Maritime Administration's (Marad) program

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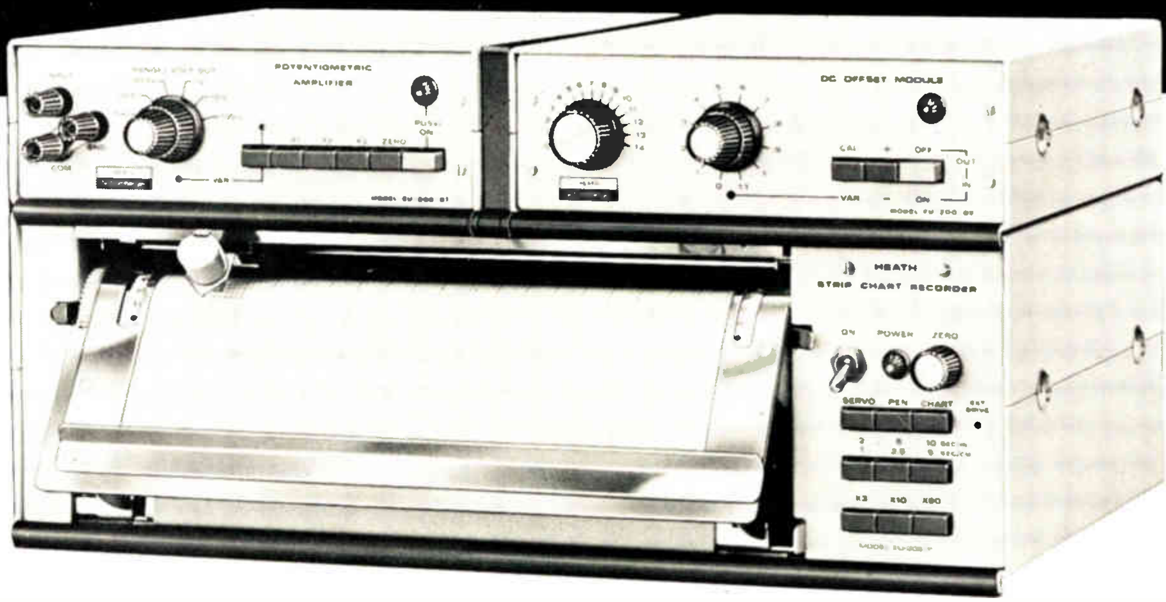

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leading to such a system [*Electronics*, March 27, 1972, p.68] has been slowed because of White House budget cuts, and NASA has dropped communications-satellite work. □

Avionics

Buys could soar if fighter funded

The decision to produce the first 10 Air Force A-X twin turbofan close-support aircraft offers avionics verdors far more long-term selling opportunities than Fairchild Industries' original estimate of $200,000 per plane. The Germantown, Md., company won the competitive flyoff recently against Northrop Corp., Hawthorne, Calif.

Fairchild's first order amounted to approximately $1.4 million per copy with "austere" avionics in each plane. But the Air Force has already developed plans for an A-10B all-weather night-fighter that is expected to double avionics costs. This depends on rushing a follow-on to the initial award through the Congress in the fiscal 1974 budget [see p. 54].

Congressional sources say, however, that Fairchild is "not out of the woods yet." Before the Air Force is permitted to proceed with a buy of upwards of 600 to 720 planes—a production run on which the $1.4 million unit cost is based—there are questions that must be answered for a Congress apparently determined to control soaring weapons-system costs.

Moreover, there are elements of the Congress—supported by the Texas delegation, home of LTV Aerospace Inc.—that are pushing for use of the proven LTV A-7, still in production, for close air support. Congressional sources say that even though an A-7F model, upgraded from the present A-7D, would cost an estimated $3.4–4.0 million, "that will seem cheap compared to what the Air Force has in mind for the A-X to get the same performance."

Indeed, the Air Force, which saw its close air support role challenged by Army helicopters in Vietnam, is expected to have its judgment along with that of the Defense Department challenged in the upcoming congressional session. Two of the questions to be raised concern:

- Real dollar program costs as they have increased from Air Force estimates of more than $2.2 billion for 720 planes, as expressed in 1970 dollars to Congress by Lt. Gen. Otto

News briefs

CDC, IBM, Telex, and Justice

It didn't take Telex Computer Products long to contest the recent pretrial settlement of the antitrust case between Control Data Corp. and IBM, which made IBM's Service Bureau Corp. part of CDC; IBM also paid CDC $60 million. CDC has destroyed a taped index to some 27 million documents that would have been used in the CDC-IBM case. Telex has moved to set aside the CDC-IBM settlement, claiming the destruction violated a court order. The big loser, though, is the Justice Department, which has criticized IBM in a New York court for permitting destruction of the index, needed to prepare the Government's own antimonopoly suit against IBM.

H-P adds business calculator

Hewlett-Packard is marketing the HP-80 calculator for financial use. It's a descendant of the HP-35 in size, electronics, and price of $395.

Univac launches computer

Univac has introduced its smallest member of the 1110 computer family. Although aimed to compete with IBM's 370/155 and 158, the new 1110 1 × 1 is expected to impact Univac's own 1108 and 1106 computers. Named the 1 × 1 because of its one command/arithmetic unit and one I/O unit, it cuts the minimum entry configuration of the 1110 family by about half.

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Electronics review

A-10 avionics

Scheduled for inclusion on the Fairchild Industries' A-10 close-air-support aircraft are the following avionics (with the names of vendors that have been selected):

Communications—uhf/a-m, vhf/a-m, and a high-frequency single-sideband vhf/fm radio, plus intercom for pilot training: Collins Radio Co., which provides radios for the prototypes, is expected to get the nod for these. Navigation and identification—Tacan; General Electric's heading attitude reference system (HARS); Sperry Rand's stability augmentation system (SAS); IFF with selective identification capability using the AIMS system. Fire control and weapon delivery—the Air Force says the A-10 will carry an X-band transponder to operate with ground-based radars, a dual reticle sight with heads-up display, and a laser spot-seeker.

For all-weather night operations, the following systems could be added: a uhf direction finder; a vhf omnidirectional range finder and instrument-landing system: Loran C/D, a radar homing and warning and electronic countermeasures.

Glasser of the USAF R&D Office. The program cost estimate included more than $1.5 billion as aircraft flyaway costs from the contractor's plant.

■ The difference between Fairchild's current estimate of $200,000 in avionics costs per plane for the first 10 austere models, as contrasted with repeated Air Force estimates of $110,000 per plane for a long production run. "Costs cannot possibly come down that much, even with a maximum production run, given some upgrading over the years," declares one congressional-committee source. The Air Force, the source believes, "plans to use the old mousetrap again, get its 'cheap' plane into production and then say, 'We've got a great plane here. The country deserves to have it improved.' " □

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"Let's kill all the lawyers!"

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

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

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

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

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

Put the blame, and the burden, on business.

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

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

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

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

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

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

Nevertheless, some things *need* to be said.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

We are no longer ignorant. We are no longer quite so blithe. But the assault continues. Because the insistent, unrelenting pressure of consumer needs, wants, desires and demands continues.

And this, ultimately, is the problem. Not for industry alone, but for the whole of a truly interdependent society. Any major solution to the environmental crisis requires a profound change in the personal expectations, habits, attitudes and actions of millions of individual Americans.

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This is the sixth of a series of editorial messages on a variety of significant subjects that we hope will contribute to a broader understanding.

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John R Emery

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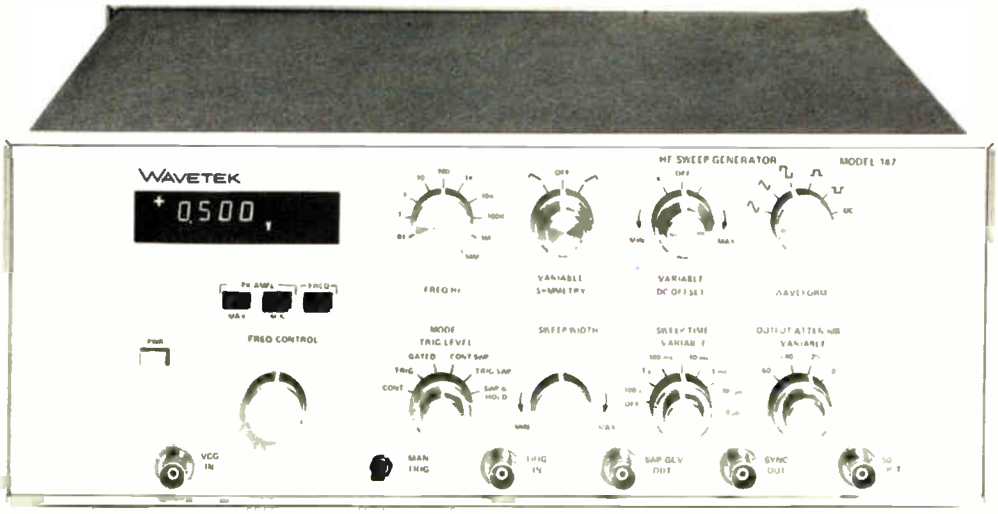

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Circle 58 on reader service card

Washington newsletter

Slight hope seen for loosening IR&D controls . . .

Through the Commission on Government Procurement has **recommended loosening Federal controls on contractor reimbursement for independent research and development** as well as bid and proposal costs, those recommendations are expected to get **shot down quickly by the Congress**, if they get consideration at all. That is the conclusion being drawn on Capitol Hill, where careful note is being made of the **dissenting views of Federal members of the CGP panel.** The commission voted unanimously to support uniform treatment throughout the Government of IR&D and B&P costs, but it split seven to five in favor of (1) allowing such costs "without question as to amount" by contractor cost centers with 50% or more in Government sales and (2) requiring companies with more than 50% in cost-type contracts to submit to a test of the potential relevancy of its IR&D to the funding agency's mission.

The five dissenters—a senator, two congressmen, the head of the General Accounting Office, and former NASA boss James Webb—challenged the "propriety and feasibility" of the two recommendations. They said these could **hike Federal IR&D costs by as much as $100 million**, while the relevancy requirement could penalize small businesses.

. . . as opposition to study spreads in Congress

An initial sampling showed congressional response to the Commission on Government Procurement's report, following public disclosure of its 143-page summary at the end of January, **to be essentially negative.** Reaction to the two-year, $7 million study's **prime recommendation—creation of an Office of Federal Procurement Policy**—was mixed, with questions raised about its placement in the increasingly powerful Office of Management and Budget as well as its enhancement of White House powers. Moreover, recommendations that competition for major systems acquisitions, especially those of the Defense Department, be maintained by a steady funding of "alternative candidates" was **called "nice but unrealistic" by one ranking military economist.**

GAO questions estimated cost of Project Search

Congress' General Accounting Office has rapped the Justice Department for failing to estimate the total cost of a fully operational Project Search, the expanding, computerized, multi-million dollar criminal-history-exchange system run by the FBI and the Law Enforcement Assistance Administration. GAO says that **states "cannot determine whether they will be able, or willing, to meet the financial requirements** of" Search. **GAO also faulted the system's "operational effectiveness,"** concluding that the LEAA and FBI have taken no steps to ensure that entered arrest records are complete. Although the Justice Department contends it's correcting the problems, the office counters that it is still not doing "enough to insure reliable cost estimates."

Addenda

The U.S. Office of Education is about to issue **requests for proposals for a three-year project** to demonstrate how computer-assisted instruction and other **education technology can be cost-effective** and improve instructional quality, with the aid of systems analysis. . . . The Federal Reserve System's **recent public endorsements of electronic banking** will not produce large contracts immediately, being designed to give banks the lead time to plan for such a system. The FRS sees the transition to a full system taking perhaps 10 years.

Washington commentary

For want of a nail

In Japan not long ago, Shigeo Shima, the director of the Sony Research Center, told some visiting editors from *Electronics* a story. It concerned a 1952 visit to the United States by the head of the company that later became Sony. The trip was made to complete a licensing agreement with the developers of the then-new transistor for its manufacture in Japan. When the Americans learned that the Japanese planned to use transistors to build inexpensive radios, recalled Shima with undisguised relish, they were astonished.

Since then, America has been surprised on a number of occasions by the Japanese electronics industries. Now there is evidence that Japan is moving to surprise the United States once more in that segment of technology called PIP—pattern information processing.

If the promise that PIP holds for developing new markets in industrial automation and robotics is realized first in Japan, it will be ironic indeed. Much of what is known of PIP technology was developed first, like the transistor, in the United States. Unlike the transistor, however, most pattern-recognition devices and their applications have been shrouded in a cloak of military secrecy. The reason: PIP is the backbone of America's aerospace intelligence and reconnaissance operations. One consequence of this has been that free exchange of PIP technology is severely limited in the United States. Indeed, there is no available assessment on the state of the American art, much less a measure of the 17 major markets already identified. Apart from manufacturing automation, these include aircraft identification, agricultural crop monitoring, medical imagery, mineral analyses, pollution control, and voiceprint recognition.

Contrasting efforts

The Electronic Industries Association wants to change that and has petitioned the National Science Foundation for a $16,700 grant to conduct just such a study. According to Laveen Kanal, the University of Maryland's PIP specialist who would conduct the study, the funds would be used simply to visit U.S. manufacturers in the field and prepare a report summarizing America's capability and its potential. As a Federal outlay, the amount requested is peanuts. Nevertheless, EIA's Government Products division has got no action on its petition thus far, and, as Honeywell's George Swanlund recently put it to the membership, "the request could be killed completely."

Meanwhile, back in Japan, a seven-year program to develop new PIP applications and related hardware was begun in 1972. It is funded at $100 million. In the opinion of Maryland's Kanal, "unless the United States gets going, it will not only wind up using Japanese pattern-recognition equipment but the related information-processing systems as well." It is an opinion that was widely shared at EIA's small Washington symposium last month on automatic imagery pattern recognition.

Automating autos

Though NASA's Earth Resources Technology Satellite may be America's most widely publicized application of pattern information processing to date, there is growing industrial recognition of its promise. For example, General Motors Corp., which has a PIP research effort of its own, sent an observer to the EIA sessions. GM's man is convinced that PIP's time will come in automobile manufacturing, probably beginning as an inspection tool. "There is enormous money-saving potential in being able to recognize small dents in a car—what we call 'in-pings' and 'out-pings'—before it gets paint. If they can be spotted and corrected before painting, that makes a great deal of difference." The principal reason that PIP is not already in use by auto makers, he explains, "is because it's still a little bit too costly." Yet GM's conviction that pattern information processing has potential gets strong, if silent, support from the fact that the United Auto Workers is also monitoring industry symposia on the subject.

Bring nails

If this is then the case, why cannot industry get its pittance from the National Science Foundation for its beginning study? At a time when there is much despair in Government over America's soaring trade deficit, declining productivity, and threatened technological leadership, it is ludicrous that funds cannot be found to assess what looms as a major new world market. At the moment, EIA's languishing request for $16,700 to make its study seems like the unavailable horseshoe nail which led to the loss of horse, rider, battle and, ultimately, a kingdom. Nevertheless, the message from a national Administration anxious to curb Federal outlays seems clear: those interested in putting together new markets in areas such as pattern information processing had better bring their own nails. **—Ray Connolly**

Godzilla Meets The Linear Monster

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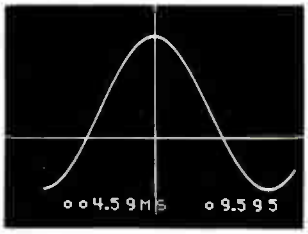

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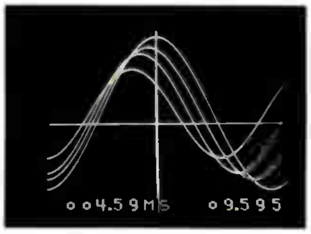
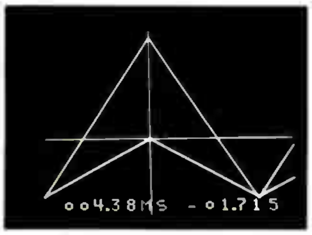
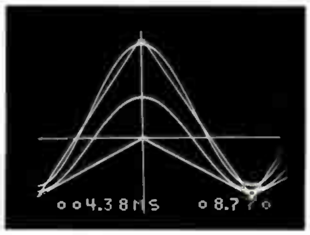


Comparison. Then you can measure and store one, two, or three additional waveforms for superimposed comparison with the standard.



Standards. In another application you may wish to store upper and lower limit waveforms in two memory quadrants . . .



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Merger of European semiconductor makers stalled

Europe's fragmented semiconductor industry, basking in the warm sunshine of a seller's market, is bothered by a nagging feeling that the prosperity may be short-lived. The cycle of zig-zags—that since 1969 has brought periods of big profits, huge losses, and now more profits—is becoming accepted as an ill of the industry.

Ironically, at the same time, the upward swing in orders has helped provoke the downfall of European efforts to pool their resources and at last meet the American giants on their own terms.

The merger effort by semiconductor divisions of Germany's AEG-Telefunken and the Thomson Group of France, finally put on ice last month, is being explained today as "less and less urgent" because orders for everybody are backing up as much as three months, depending on the product.

"We didn't walk out and slam the door," says Thomson executive Philippe Giscard d'Estaing. "But it is clear that rapid creation of a new joint company is not now necessary." "We have set the project aside to think about," adds Thomson president Paul Richard.

Combine. U.S. firms such as Texas Instruments, Motorola, National Semiconductor, and Fairchild can only rejoice at not having to confront the new combine—which would have had sales of $80 million a year at the outset and prospects to reaching $100 million, the level most industry observers accept as the self-sufficient minimum.

Since the collapse, post-mortems have revealed that virtually all the major European semiconductor products manufacturers were invited at one point or another to become partners. But only Thomson and AEG-Telefunken went on to serious negotiations, which would continue for eight months. "I hate to think of the money and man-hours that went into this," says one Thomson official.

Thomson and AEG-Telefunken saw themselves as best-matched anyway, both being diversified companies with consumer products as well as components interests. They felt a full-fledged merger of their semiconductor operations, under the name "Eurosem," was the best route to quick rationalization.

Leak. The talks settled product distribution questions, most of the financial niceties, and the marketing structure. By November, high officials at Thomson were leaking word that Eurosem would be created by the end of the year.

Asked now what caused the about-face, Sescosem director general Olivier Garetta says an unexpected culture clash arose in November over how to run the company. "We felt a strong president was needed, especially in the first years of the operations," he says, to avoid decision-making delays that plagued previous transnational link-ups in Europe.

"The Germans have their way of doing business, which is with a board of directors making joint decisions. We have ours, which allows the president a tie-breaking vote," says Garetta. This disagreement, in light of the improved market, led both partners to "take a break for reflection," before seeking other formulas for cooperation. □

Sweden

Alarm system watches over elderly

For years, specialists involved with the elderly have wanted a simple, inexpensive, passive alarm system for aged people living alone. Now, a Swedish company has developed such a system—and it was given a standing ovation recently when presented at a conference on the aged in Oslo.

A group of researchers—including a professor of gerontology, a doctor, a psychologist and an engineer—studied the problem, and came up with an electronic alarm system, named The Watchman. Now, the unit is being manufactured in the newly established Elektrium Utvecklings AB, which runs the world's most northerly electronics plant. It's located in Kiruna, the Swedish iron ore mining city, about 100 miles north of the Arctic Circle. Elektrium's headquarters, however, are in Luleaa, 75 miles south of the Arctic Circle.

Automatic inputs. The system is ingeniously simple. A control unit is connected to electric switches that are frequently used—such as the bathroom or refrigerator light, the stove, or a bedside lamp. When the switch is turned on, an impulse is transmitted over a separate wire to the control unit, which has an electronic timer built into it. The pulse sets the timer to zero. If the timer is not re-set within a predetermined time—12 hours, say—an alarm goes off.

Included in the system is a special manual alarm button—for bedside use if necessary. There is also a switch that enables the system to be turned off if the person goes away from the house for a long period. The system starts operating again automatically as soon as an electric switch is turned on.

One extra device that can give a sense of added security to many people is a sensor that would signal if the electric stove were left on. In its simplest form, the hardware costs about $60—and it will cost roughly $40 to make the installation. □

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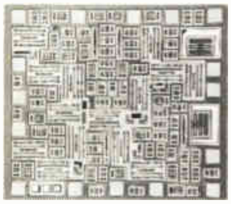

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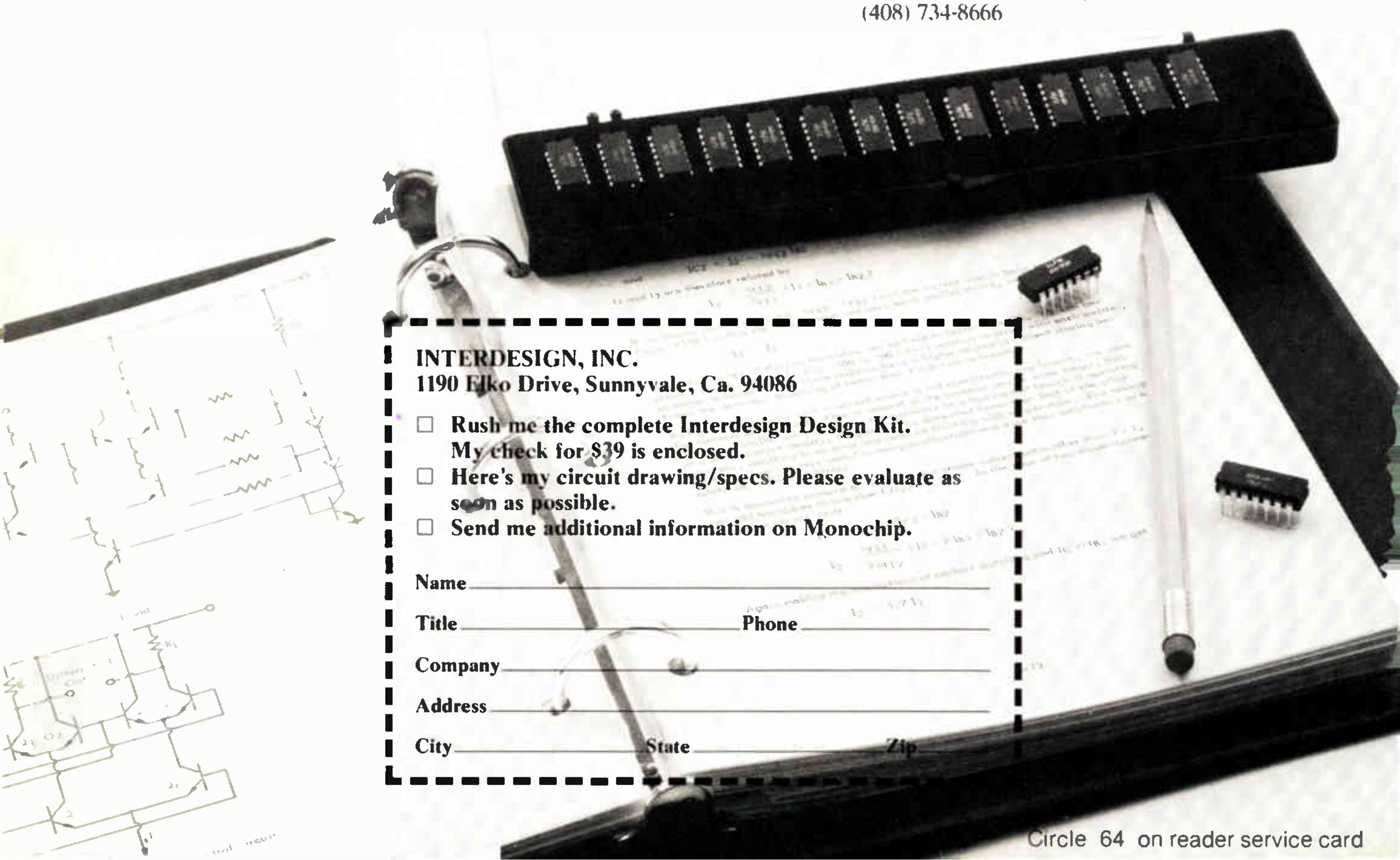

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Circle 64 on reader service card

European calculator makers are hurting

Japanese competition in electronic calculators is tightening the squeeze on the Europeans, forcing a French calculator off the market just after Philips withdrew and Facit of Sweden cut back [*Electronics*, International Newsletter, Nov. 20]. **Schneider Radio-Television has killed off the Exactronique, which was selling at the rate of about 6,000 units a year and held about 15% of the French market.**

A Schneider official cites Japanese competition, incompatibility with Schneider's consumer-oriented products, and low profits as main reasons for dropping the Exactronique. He denies that Philips, which controls the largest block of stock at Schneider Radio-Television, imposed the decision in coordination with the October closing of its own electronic calculator manufacturing plant in Bremen, West Germany. "We are grown-ups here," the Schneider official says. "We make our own decisions."

10 nations join new air-traffic safety group

In an admirable display of cooperation, flight safety engineers from nine European countries and Israel have recently formed an organization known as the International Federation of Air Traffic Safety Electronics Associations, the IFATSEA, for short. Some of the goals of the federation are to make recommendations to individual government on **how to improve air traffic safety, to exchange operational know-how and technical information and, eventually, to swap personnel** between member countries. Other goals are to elevate the status of the flight safety engineering profession and to further its image in the public's mind. According to the Association of German Flight Safety Engineers, a member of IFATSEA, Canada, Australia, and New Zealand are expected to join the 10-member federation soon.

Marconi markets Omega receiver, with minicomputer

International plans to have four transmitters in the Omega very-low-frequency navigation chain working on full power by autumn this year is fostering development of new receivers. In England, Redifon Ltd. recently introduced a marine receiver, and now Marconi Co. has an airborne system. Following a concept initiated by Northrop Corp., **Marconi's receiver is integral with a minicomputer, which has an alterable read-only memory containing the correction factors that have to be applied continuously to receive and process the Omega signals.** The pilot has to punch in only the date and the time at switching on—all correction and updating are automatic. There is digital read-out of normal navigation data.

Marconi believes that aviation authorities will certify it as accurate enough on the longest ocean routes, making a qualified navigator unnecessary. In this respect it will be on a par with inertial systems, and one up on doppler systems. At $40,000 installed, Marconi's entry is a lot cheaper than an inertial system. Thus Marconi maintains that it can be sold as original equipment, although at present major airlines are leaning towards inertials. **But the biggest initial outlet is retrofit in long-distance charter transports,** where operators would like to dispense with a qualified navigator and don't want to pay for inertial retrofit.

West German railroad completes freight data network

West Germany's federal railways, one of the country's biggest single computer users, has just completed the last link in what it calls a nation-wide "data bridge" for freight-charge calculations. This EDP network now includes some 225 computers installed at 45 freight yards, all tied to a large data-processing center at Frankfurt. The network, said to be unique in Europe, enables the railways to **automatically determine all national and across-the-border transport charges** and other data pertaining to freight shipments. The computer scheme replaces older methods, in which freight costs were manually calculated at individual freight yards.

Color TV exports from Japan climb 15%

Japan's color TV exports exceeded $325 million last year for the first time, according to estimates by industry sources. The number of sets exported have increased about 15% from 1971 to some 1.8 million units. **Japanese producers of color TV sets had originally expected a drop of 30% to 40% in their 1972 exports** in view of the U.S. economic slump and the impact of the yen's revaluation in December 1971. But the American economy recovered faster than expected and exports to Western Europe rose more than four times.

Meanwhile, Japan's tape recorder exports last year are estimated to have been about 36 million sets worth about $1.1 billion. This represents a four-fold increase in volume and a three-fold increase in value. Exports to the U.S.—the largest single market for Japanese tape recorders—rose about three times in volume and about two times in value. **Much of the increase was fueled by the highly popular and relatively new category of popularly priced radio-recorder combinations.**

Japan readies 1973 budget

Electronics projects figure prominently in the draft for Japan's 1973 budget. **Subsidies from the Ministry of International Trade and Industry for promotion of electronic computer development totals $39.67 million,** of which $36.33 million is for three industrial groups developing main frames and the rest for peripheral equipment.

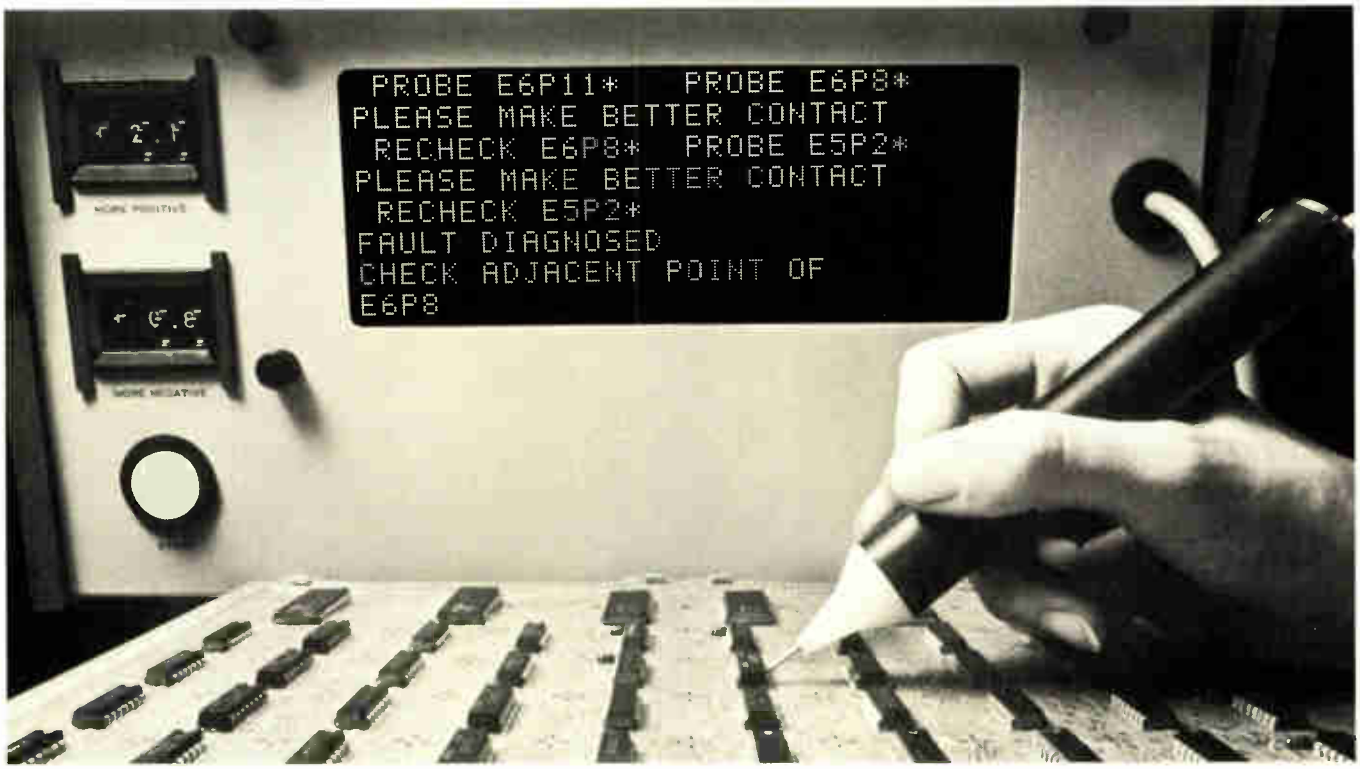
Other MITI projects include $5.43 million for continuation of a pattern-processing project, $670,000 for the first year of a $16.67 million project for exchange of information between vehicles and group stations to reduce automotive congestion, and $4.56 million for development of electric automobiles.

The Ministry of Posts and Telecommunications gets **about $4 million for development of communications and broadcasting satellites** and for development of repeater electronics and antennas for communications satellites. Approval is to be granted Nippon Telegraph and Telephone Public Corp. for a budget of $3.98 billion, which includes installation of 29 computers for subscriber services applications, electronic exchanges, undersea cable system development, and large-capacity transmission systems.

Electronics-related development projects approved for the Japan Defense Agency include $3.5 million for air-to-air missiles, $3.63 million for electronics for a supersonic close-support jet, and $1 million for airborne antisubmarine electronics. **Approval of development is the big battle because up to now funds for procurement always were forthcoming once development was approved and successfully completed.**

Circle 67 on reader service card

Anyone can find fault with the Teradyne L100.



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Core memories are still on top

The booming memory market is still overwhelmingly dominated by cores; semiconductor units will not draw even before 1976

by Paul Franson, Los Angeles bureau manager

A few facts seem lost in all of the noise about semiconductor memories replacing cores in computers. For one, cores still hold 90% of the sockets in traditional mainframes outside the IBM captive market. Also, both cores and semiconductors are enjoying unparalleled growth, which, though limited by capacity, is expected to continue through at least 1976. After that, semiconductors should overtake and pass cores—a bit later than many semiconductor people had predicted.

One reason the semiconductor takeover has been slower to come than the chronically optimistic semiconductor houses had predicted is that the present standard semiconductor memory, the 1,024-bit p-channel metal-oxide-semiconductor memory, doesn't appear to be the part for mass mainframe storage. Users are looking for the 4,096-bit n-channel product, just now appearing in sample quantity, to solve their demands for low cost and high speed. While fast semiconductor storage is finding widening use in mainframes, core is being used more and more for massive bulk storage that is itself encroaching on traditional, but slower, electromechanical memories. Semiconductors are also uncovering applications in which cores have never been used: smart terminals, calculators, and some peripherals are examples.

The total random-access-memory market is sizable, with estimates putting it at $300 million, excluding IBM. In 1973, between 30 billion and 40 billion bits are expected to be sold, with cores now accounting for 90% of shipments. By 1976, however, the ratio should change dramatically: in a market for 90 billion to 100 billion bits, semiconductors and cores will split 50-50. Semiconductor usage is doubling each year from its present low base, with core rising at 15% to 20% annually. The growth rates will slow, but even core is expected to grow in number of bits through at least 1976.

Present large-quantity prices-per-bit at the systems level are typically 0.7 to 1 cent for core, and 1 to 1.7 cents for semiconductors. Costs are higher if power supplies and enclosures are included, but they're dropping, in any case.

Robert Lowry, president of Technology Marketing Inc., Costa Mesa, Calif., designers of custom computer systems, says the large-volume core user can purchase a complete 600-nanosecond system of 8,192 bits by 18 words for about 1 cent per bit, or buy core stacks and assemble the electronics for under 0.5 cent per bit. Buying raw cores at 0.1 cent and stringing them brings the cost down 0.1 cent, and the company that makes its own cores can end up paying as little as 0.35 to 0.38 cent.

These figures, which also are quoted by others, explain why such large core users as Data General Corp. of Southboro, Mass., and Digital Equipment Corp. of Maynard, Mass., have recently set up their own plants to manufacture cores. "Data General should be able to pay off its half-million-dollar investment in a year by making a billion cores," says Lowry. A Data General spokesman agrees: "Don't look at us as being committed to cores. We are committed for two years, and the facility will pay for itself by then." Similarly, Graham Tyson, president of core maker Data Products Corp.,

Observers. Watching the memory battle are TI's Jerry Moffitt, MOS marketing manager (right), Data Products' R.D. Miller, marketing vice-president (below), and Ampex' Thom Harleman, manager of marketing.

says, "We paid off our last capital expenditure for cores in 28 weeks."

Ampex's Computer Products division in Marina del Rey, Calif., and Electronic Memories and Magnetics (EM&M), Hawthorne, Calif., are the two largest core producers, each shipping about 200 million bits per week, with Ampex probably ahead. After them come Data Products, Mountain View, Calif., with 125 million a week; Fabri-Tek, Minneapolis, Minn., with 70–80 million a week; and Lockheed Electronics, not necessarily in that order.

Semiconductor memory costs are much harder to pin down. Figures that are confirmed by users, however, come from Intel Corp. in Santa Clara, Calif., which developed the 1103, the most popular 1,024-bit MOS memory. Mike Markkula, Intel's U.S. marketing manager for components, says "Minicomputer guys are paying about 0.4 cent per bit for 1,024-bit RAMs. On top of this, the other systems costs are from 0.7 to 1 cent per bit." Memories being ordered (but not built) today, he says, are somewhat cheaper, with the semiconductor part at about 0.3 cent per bit.

Markkula says that 350,000 1103s are being shipped per month, and with other 1,024-bit parts (Advanced Memory Systems 6002, Mostek 4006, and National Semiconductor 5260), 10 billion bits will be shipped in 1973. He also feels that the 1,024-bit RAM will reach a peak in 1977, with the 4,096-bit RAM passing it in 1976.

The great 1103 race. Intel and Canada's Microsystems International Ltd. (MIL) are jockeying for first place in 1103 business, with MIL probably ahead. Behind them in 1,024-bit MOS memories come Advanced Memory Systems, Mostek, Texas Instruments, and a host of others.

The most popular semiconductor memory after the 1,024-bit MOS unit is the 256-bit bipolar RAM, which now has 20% of the market, according to Jerry Moffitt, MOS marketing manager at Texas Instruments in Houston, compared to 70% for the 1,024-bit MOS RAMs. Fairchild Semiconductor is biggest here, with Intersil, Intel, Motorola, National and TI also shipping.

Most experts don't see the 1,024-bit MOS RAMs reaching the 0.1-cent-per-bit chip cost level required to cause a really strong movement away from cores. That honor seems destined to fall to the 4,096-bit n-channel RAM now being introduced by various companies, which project systems costs of 0.5 cent by 1976. Intel and Mostek first showed parts last year, and MIL has introduced a product. But the big RAMs are not expected to have a major impact until 1974, says Phillip Harding, director of marketing for the Electronic Memories division of EM&M.

Who uses what. Semiconductor memories are now used only in some IBM equipment and a few minicomputers, but most new major mainframes are being designed around semiconductor storage. At Honeywell Information Systems in Waltham, Mass., for example, a spokesman says that all new product development is committed to semiconductors. However, HIS, like NCR but unlike all the other major computer makers, has no core capability.

At Digital Equipment Corp., the largest minicomputer company, vice-president Andrew Knowles says that DEC is shipping more machines with semiconductor memories than ever, but core shipments are growing even faster. He attributes the growth to the fast-growing demand for small computers, which still use cores, and to the higher cost of semiconductors.

Among other companies, Control Data Corp. is still holding out for cores. However, according to Curtis W. Fritze, vice-president for corporate planning, if forced to choose, CDC "tends toward the more sophisticated bipolar memories. Eventually they will provide an order of magnitude cost advantage over cores," he says. And Univac hasn't decided whether to go with semiconductors or the plated-wire memories it has been using.

At Varian Data Machines, Irvine, Calif., Warren Sullivan, director of product management, says only 20% of the orders for the Varian 73 are for the more expensive but faster (330 nanoseconds versus 600 ns) semiconductor memory, but he expects that to change to 50% before long. Sullivan says that users are buying more memory in general.

Improvements expected in semiconductor RAMs include, besides the higher density and lower cost expected from the 4,096 n-MOS chips, easier-to-use, lower-power chips. MIL expects to have an eight-chip 32,768-bit memory module in a single 1.5-by-2-inch dual in-line package by the fourth quarter.

Tape and stacks. Meanwhile, among the major improvements in cores in recent years are the tape method of making cores used by Lockheed and Data Products Corp. of Mountain View, Calif., and the substitution of planar "stacks" for the earlier three-dimensional ones. Core makers are continually stuffing more cores on one board, and sharing drive and sense circuitry among more cores.

Common are 8,192-bit mats, with work being done in 16,384 bits. R.D. Miller of Data Products points out that, in the core business, twice as many bits does not mean an automatic doubling in price. Instead, doubling the bits usually costs only 20% to 25% more.

Smaller cores are also in the works, as are improved materials, like the Ampex TIN (temperature independent) core that eliminates temperature-compensating circuitry. Ampex also has reduced kiln time from 8 hours to 45 minutes, and improved yields from 20% to 80% over past years. All core makers are taking advantage of dropping semiconductor prices; only part of the system cost is in the cores. And more exotic developments yet may lie in store. Thom Harleman, manager of marketing at Ampex Computer Products division, points out, "It's been known for some time that it's possible to store more than one bit in each core, but the uniformity of present cores allows us to do things that weren't practical before."

Still, there seems to be a limit to how far core prices can drop. Richard Egan, marketing vice-president of Cambridge Memories in Concord, Mass., referring to today's larger mats with their longer sense lines, states, "I think the string is running out on core memories. The handwriting is on the wall." □

Government electronics

Navy to pick tactical MLS

Kearfott, competing with Bell for Marine Corps scanning-beam microwave landing system to be selected by year-end, uses stationary structure

by Alfred Rosenblatt, New York bureau manager

After the Marines have cleared a jungle airstrip, they need an instrument-landing system to guide in the combat jets under Category II landing conditions: ceiling 100 feet and runway visibility to 1,200 feet. The way things stand now, a heavy ILS would have to be transported on the ground to the strip, but the Navy Electronics Command is working to change that.

The Navy is funding work on a new compact, lightweight, man-transportable microwave landing system that can be dropped to remote areas and set up in minutes. The Ku-band MRAALS—for Marine Remote Area Approach Landing System—will be the first tactical system that can handle Category II landings.

Two companies, both with scanning-beam approaches, are working on 11-month contracts that will lead to a competitive fly-off, scheduled for the last quarter of the year. One, the Textron Corp. Bell Aerospace division, Buffalo, N.Y., has been awarded $475,000; the other, the Singer Co. Kearfott division, Little Falls, N.J., has a contract for somewhat under $700,000.

Usually at this juncture in a technical runoff, competitors are reluctant to talk at all about their design approaches. This is certainly true of Bell. And Kearfott hasn't said a word since late last September, when the awards were made, but now it is willing to talk—at least to a point—about what it regards as a breakthrough in ground-station design for instrument-landing systems. The system is probably so different from what Bell has in mind that talking about it will not matter, says George Henf, program manager, now that designs are "pretty well settled in to meet the delivery target date."

Kearfott is relying on stationary energy-radiating structures instead of on the two nodding or rotating antennas—one for azimuth data, and the other for elevation—generally used in a scanning-beam system. "We use only one moving part—a rotator with two sets of four feeds each—and sequence the energy automatically for proper interlacing in the elevation and azimuth apertures," Henf explains. "Synchronization between the two beams is no problem because it's machined into the antenna so you can't lose it."

Pop-up. One set of horns presents energy to a localizer reflector that pops up atop the ground station package to produce a 2° azimuth fan beam. The other set has its energy rerouted through a pillbox and out the front of the station for a 2° elevation fan beam. Right now, the system operates with the equivalent of five scans per second and could probably go as high as 30 per second, impossible for mechanically rotating antennas, says Henf.

Scanning systems similiar to this one are certainly not new. On tracking radars, for example, they're used with signal nulling techniques to lock onto targets. But because scanning radars rely on signal nulls,

From the air. Kearfott's Ku-band MRAALS deployed in scaled-down mockup without DME antenna. Azimuth reflector is at top, elevation beam is projected through vertical supports

The FAA and MLS

On the civilian MLS front, concept-definition studies from six industrial teams are being evaluated by the Federal Aviation Administration. The decision is imminent as to who will push on into the next feasibility definition phase, in which up to four contractors may be chosen [*Electronics*, July 5, 1971, p 21]. Four of the proposals involve scanning-beam systems—from AIL division, Cutler Hammer Inc., with Collins Radio; Texas Instruments with Thomson-CSF; Raytheon with Sperry Phoenix; and Bendix Corp. with Textron's Bell Aerospace division. The remaining two studies employ dopoler-scan approaches—from Hazeltine Corp. with Marconi of Canada, and from ITT Gilfillan with Honeywell Inc.

Ultimately, the development program could take as long as five years, cost $50 million, and lead to commercial buys in the late 1970s and 1980s.

the actual pattern of the signal in space—that is, whether it's distorted or not—is not important. Unfortunately, signal integrity is vital in scanning-beam landing systems, which have each position of the beam coded. Pattern distortions here are troublesome, if not downright dangerous, because the data encoded on the beam enables an aircraft to locate itself with respect to the ground station.

Package deal. According to the Navy requirements, MRAALS, ready to be dropped from an aircraft, must weigh less than 80 pounds, and be contained in a single package that's part of the station structure itself. Henf says the Kearfott package resembles a card table. Setup time in the boondocks is said to be less than 10 minutes.

By way of comparison, Kearfott's Ku-band Talar (tactical landing approach radar) fixed-beam microwave landing system for civilian use, which is certainly not meant to be airdropped, weighs 60 lb, but its traveling case weighs a whopping 130 lb. And the Navy's own ground-based AN/TRN-28 scanning beam landing system, developed by AIL division, Cutler-Hammer Inc., has two transmitter-antenna units, each weighing some 500 lb.

In operation, MRAALS will cover ±20° in azimuth, and 0° to 20° in elevation. Glide slopes are to be selectable in the aircraft from 3° to 12°, and the signals are to be compatible with the AN/ARA-63 receiver/decoder systems. Usually, the glide slope is permanently set by physically aligning the station on the ground; the new system need only be aligned with the vertical.

MRAALS will also contain an L-band distance measuring transponder, operating in a Tacan (tactical air navigation) mode, as part of the ground station. Airborne distance-measuring equipment (DME) will also be provided. Kearfott is calling on Hoffman Electronics Corp. to supply the ground-based and airborne DME, a digital indicator, and an airborne DME interrogator.

Bell Aerospace, on the other hand, is tackling the job alone. But other than saying that it has some "cute concepts" for the MRAALS antenna, a company spokesman declines to give any details of the design. The company is relying, he points out, on its previous experience in military programs. This includes experience in its role as prime contractor for the Navy's Ka-band AN/SPN-42 automated carrier landing system, and distance-measuring equipment for a target-locating system aboard an Army helicopter. Unlike an ILS, the SPN-42 derives steering signals on shipboard computers and transmits them to the aircraft.

Features. Other operating features of the Kearfott system include a peak output power, using a magnetron, of 2.5 kilowatts, with a power consumption of less than 200 watts. Range information is transmitted up to 40 nautical miles, while the limit for azimuth and glide slope data is 20 miles. Except for the power tube, the unit is of all-solid-state design, and that includes the L-band DME. Mean time between failures is calculated at 1,000 hours. Internal power conditioning and distribution systems will operate from either 28 v dc or 45 to 420 hertz ac power. □

Commercial electronics

Computers switch traffic signals

Cities from Baltimore to Chula Vista, Calif., automate intersection control; fast-growing market is estimated at $100 million in 1973

by William F. Arnold, Aerospace Editor

Traffic engineers have been looking hungrily at electronic traffic-control systems for years, hoping that someday those systems would prove to be the ultimate weapon against jams and snarls. That day appears to be just around the next curve, now that the digital computer is moving into the fight to speed the weary commuter home in his car. In what promises to be a big market, automated traffic-control systems that control signs and signals according to traffic demand are going to work in more and more municipalities.

Even differences of opinion about hardware—some experts say the minicomputer's lower price and flexibility make it ideal and others prefer the large computer's capacity—haven't slowed the action.

"There must be 40 cities or so actively engaged in these traffic systems in one form or another," says Juri Raus of the Federal Highway Administration. Raus is program manager, urban traffic control system/bus priority system, Office of Research. Rockne Lamber, manager of computer systems and software for the Econolite division of Altec Corp., Anaheim, Calif., an equipment supplier, estimates the 1973 market to be about $100 million, half of it in computers, and growing at 20% to 30% a year. Another supplier, Sperry Rand's Systems Management division, forecasts $200 million worth of business over the next five years, says Harold Whalen, marketing manager, traffic and transportation systems.

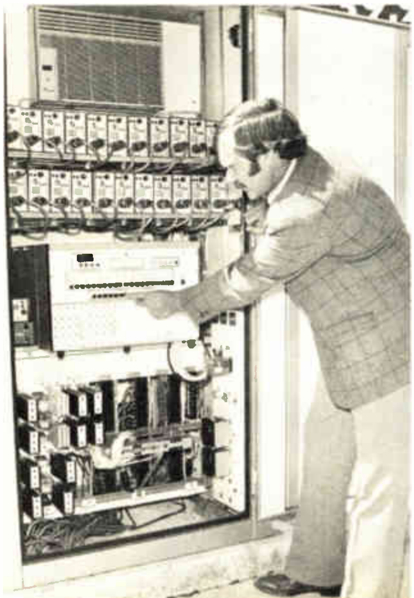
Cities big and small are turning to computer systems. After a hot industry contest, Baltimore recently selected TRW Systems group to build a mammoth 900-intersection system, costing "in excess of $3.8 million," reports Hugo O. Liem, transit traffic commissioner. If expected Federal approval of 50% funding is received, the three-year job will begin this year. The city plans to install the 1,000 pavement-embedded vehicle detectors and new controllers for traffic signals to pare costs, he says.

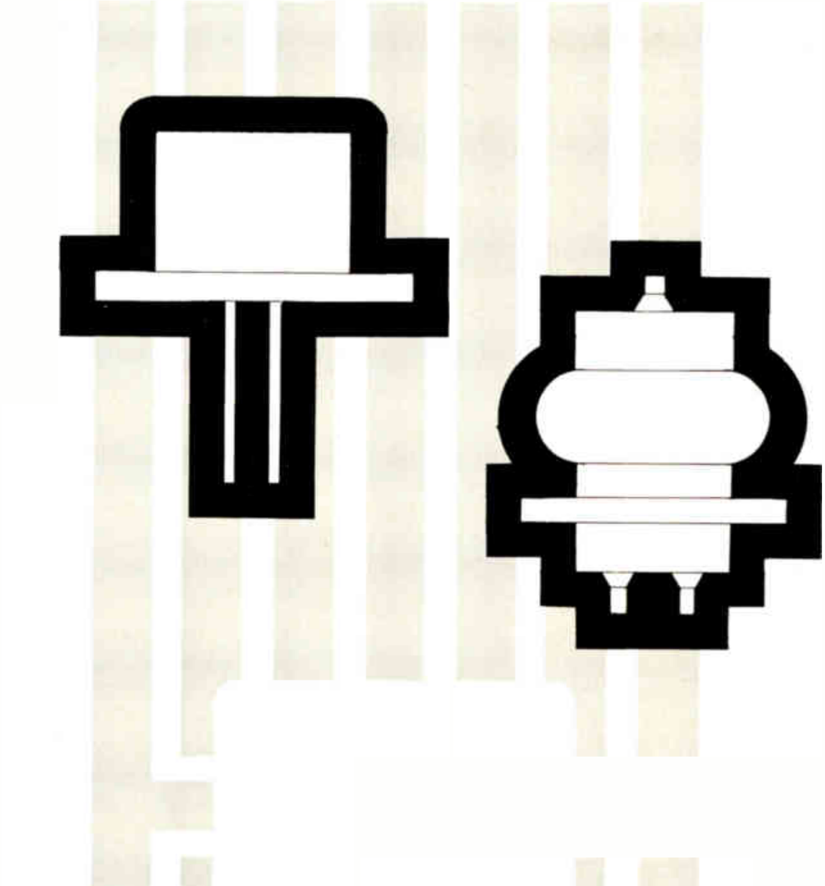
In Washington, D.C., the Federal Highway Administration late last year unveiled the urban traffic-control system (UTCS), a $5 million operational testbed built by Sperry Rand. UTCS controls 112 intersections of the downtown area, and it is to be turned over to the nation's capital after evaluation. "The development here will provide guidelines," says the highway agency's Raus. "The intent is to try to reduce the development costs for cities."

Two for L.A. In the Los Angeles area, well known for its almost total reliance on the auto, one large system is working, and a second is to be opened soon.

In operation is the area freeway surveillance and control project. Run by the state division of highways, it covers a 42-square-mile triangular area of the incredibly busy Santa Monica, San Diego, and

Merrily they roll along. Heavy traffic moves freely in Campbell, Calif., at intersection controlled by Eagle Signal's ET-800 controller. At right, William G. Wren, director of public works, inspects the unit. It's believed to be the first minicomputer to control a single intersection.





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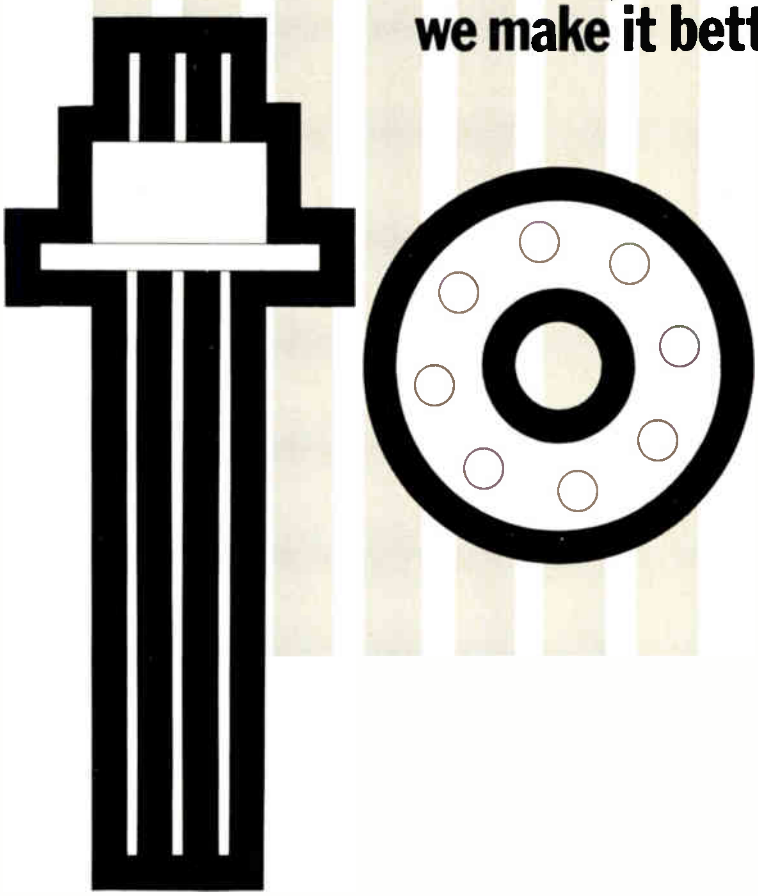

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Harbor freeways, monitoring 700,000 vehicles a day and 56 interchanges. Inductive loops embedded in the pavement every three miles per lane feed about 900 sensors; these telemeter data to a Xerox Information Systems Group Sigma 5 computer. Sampling each sensor every 15 seconds, the computer analyzes the data to spot slowdown or breakdown and alert highway patrolmen and change traffic-condition signs. TRW, Econolite, and System Development Corp. are involved in the program. The state highway department coordinated the $1.5 million project and provided 40% of the funds. The U.S. provided the rest.

The other big Los Angeles system is TRW's $1 million Safer (for systematic aid to flow on existing roadways). It is designed to improve traffic flow by controlling 112 intersections on South Bay area streets on a real-time basis, which makes it unique. Other systems using computers change flow on the basis of predetermined programs, but this system, in effect, has an infinite number of patterns, says M. R. Stanford, project engineer for the Los Angeles County road department. Its funding is 71% Federal, 22% county, and 7% state.

The layout. The system includes a Sigma 5 computer and display board in another part of the county, voice-grade telephone connections to 10 intersections, and lines from there to the individual intersections and about 400 road sensors. Communications flow through 1,200-bit-per-second modems.

TRW is doing the work on a contract which is to provide half its fee on completion, then the rest on the basis of performance in improving traffic flow up to 15%.

Small cities join. But such systems aren't being used only in big cities. Econolite also is putting in minicomputerized traffic-control systems at 43 intersections in Chula Vista, Calif., and 15 intersections on an artery in Pomona, Calif., all using a Ling Electronics LDP-1800 computer with local controllers and telemetry. Econolite has delivered one to the city of Los Angeles for an intersection, and 50 to the state to replace standard controllers. Built around Data General Nova minis, these are stand-alone systems for each intersection.

Among the other cities installing systems are Shreveport, La., Worcester, Mass., Denver and Boulder, Colo., and Oklahoma City. The last-named uses a System Development Corp. traffic-actuated computerized signal (Tracs) system [*Electronics*, Oct. 23, 1972, p. 29]. Other companies competing in the automated-traffic field include the Automatic Signal Division of Laboratory for Electronics, Computran, IBM, and Eagle Signal division of the E. W. Bliss Co.

In traffic systems, "the offsets are important," says the FHA's Raus. By this, he means the timing of lights at adjacent intersections to ensure desired flow. With the UTCS in Washington, for example, "we can change the offset patterns to get what we want." Besides being able to change the electromechanical relays in the signal boxes, the UTCS also has a built-in fail-safe system, Raus explains. "When a detector fails, the computer waits until the next green light before dropping it off-line," he says. "It will turn back on with electromechanical operations."

Although Sperry integrated the UTCS, there is no Sperry equipment, Raus says. "Because Sperry was acting as systems manager, everything was on a best-buy basis." He adds that, for example, "we felt that the Sigma-5 was the best computer, so Sperry bought Sigma-5s."

The UTCS can give its operators a variety of performance parameters on the display board, on console cathode-ray tubes, and on printouts. Among these measures are numbers of vehicles per hour, numbers of cars delayed at intersections, and average vehicle speeds at each intersection. The UTCS, which also incorporates a bus-priority system, employs 79 leased pairs of telephone lines, 112 intersection controls, 500 vehicle detectors, and 144 bus-detector lines, Raus says.

Raus describes the UTCS in four basic parts: the detectors, detector and controller communications, computer system, and displays and controls. Dual Sigmas with sufficient capacity to control the entire network are the heart of the system. The computers, one of which does bus-priority computations, share the memory of 65,536 32-bit words.

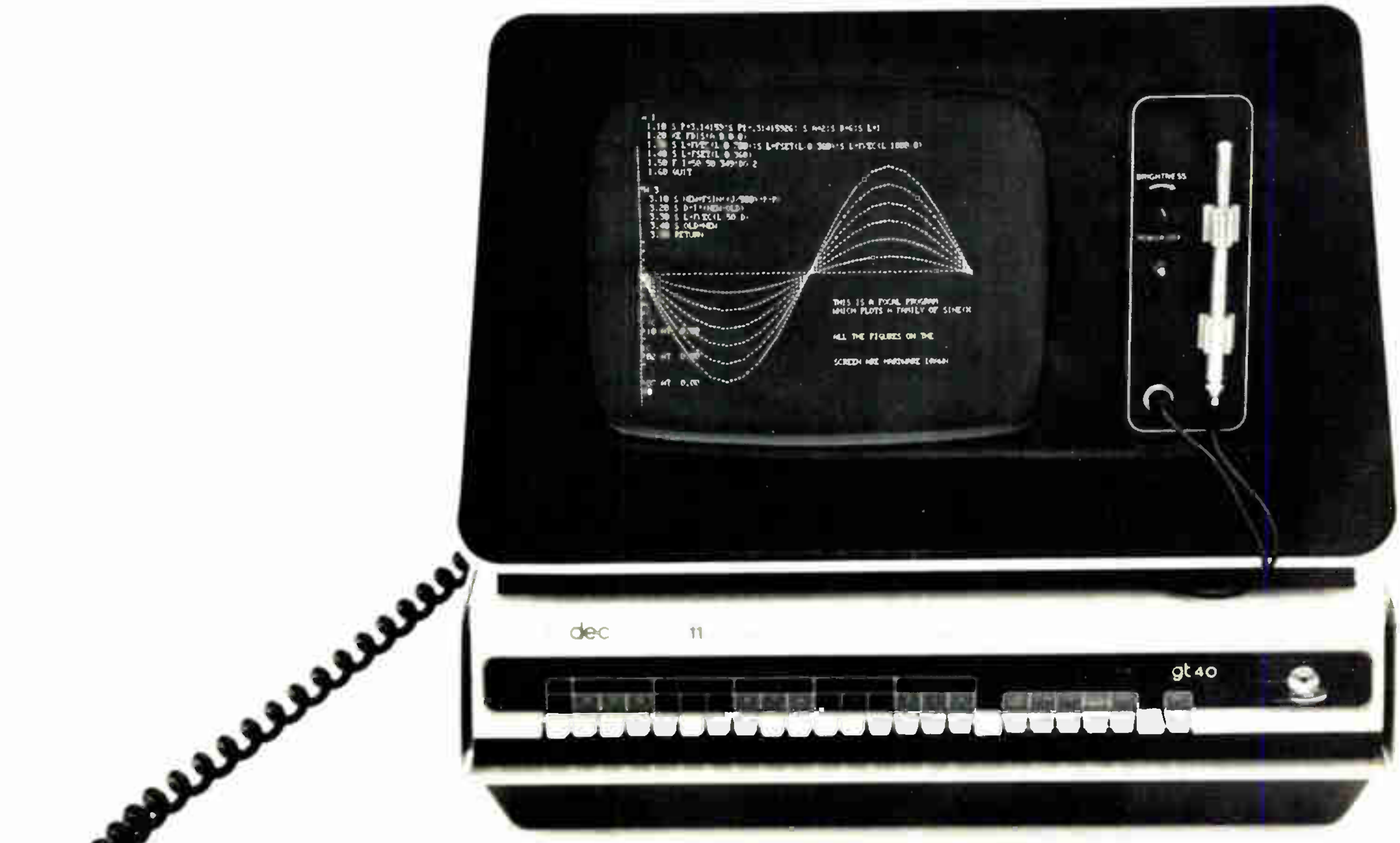
The display equipment includes a traffic-control panel, an illuminated wall map, and an alphanumeric CRT, permitting the operator to exercise all the necessary control and monitoring functions, Raus says. The supervisor can examine the over-all operation of the network or study in detail the operation of a particular intersecton, and he can control all aspects of the system.

Minicomputer controllers. Next-generation traffic control system processors will probably be minicomputers, say some. Campbell, Calif., a city of 30,000, bought an Eagle Signal ET-800 mini for its busiest intersection, reports William Wren, public works director. Wren says that the system has reduced delays in traffic, and it has reduced accidents.

Roy Matthews, assistant traffic engineer for the California Division of Highways in Sacramento, says that the minis tested by his agency have reduced accidents and delays. He concurs that the main advantage of the minis is their flexibility. □

Past is prologue

Some measure of the progress being made by electronic traffic-control systems can be estimated by what has happened in the Los Angeles area. There, a freeway system is operating, and a city-street system is to start soon. This is a radical change from the attitude only five years ago, when Los Angeles found such systems wanting [*Electronics*, April 15, 1968, p.157]. Then, a 28-signal system on Sunset Boulevard was switched back to time clocks after a two-year trial, as were systems on three principal east-west arteries. The problem, said one city engineer, was that the computer, on the basis of insufficient data, would change signal patterns for the main artery, as well as all cross streets, as often as every four or five minutes at peak periods.



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digital

Circle 77 on reader service

Consumer electronics

TV makers intensify quality quest

Manufacturers, goaded by consumerism and competition, try new technologies and shuffle engineering departments to exploit solid-state reliability

by Gerald M. Walker, Consumer Electronics Editor

The already competitive television manufacturers' world is turning to a new emphasis on reliability, once formerly associated mostly with big aerospace projects. Spurred by intense Japanese competition, setmakers are converting to solid-state design in color-TV receivers and reorganizing their engineering departments to increase the sophistication of their approach to reliability. In fact, hardly a company has not revamped its engineering procedures or organization—a couple more than once—since the advent of solid-state components, especially since the extensive application of linear integrated circuits began.

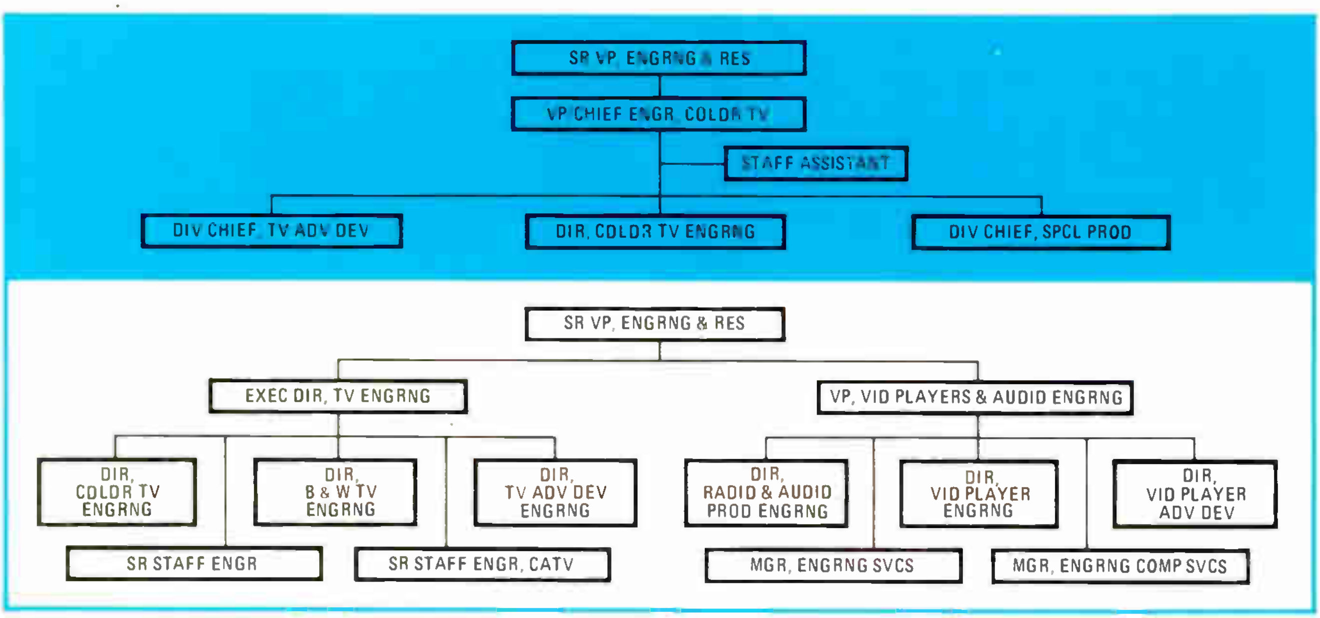
Some companies, such as Zenith Radio Corp., Chicago, and Magnavox Corp., Fort Wayne, Ind., have shifted personnel and changed titles. Others, including GTE Sylvania's Entertainment Products group, Batavia, N.Y., have boosted engineers higher on the organization chart. But for most, including RCA Consumer Electronics division, Indianapolis, Ind., Philco-Ford Corp., Philadelphia, and the General Electric Co. TV Receiver Products department, Portsmouth, Va., the changes have meant, as with their competitors, new approaches to design and quality assurance, but without organizational switches.

These changes were made partly to open channels for applications advice from semiconductor suppliers, a move Motorola's Consumer Products division in Chicago made very early in leading the industry toward solid-state receivers. Other important goals were:

- To react to the increased pressure on reliability created by the consumerism movement and intensified by a marketing gamble to extend warranties. The one-year warranty has forced a number of alterations in engineering procedures to try to weed out part failures before they cause expensive repair bills.
- To keep up with Japanese competition, which, although blunted by yen revaluation, is still largely a price-performance battle. Such Japanese firms as Hitachi, Matsushita, and Sony have large consumer-product research and development efforts, and American engineering departments have been scrambling to keep pace.
- To prepare for such other television innovations as the more complex ICs, new in-line gun tubes and, for some, possible expansion into home video players. Engineering departments have always had to anticipate innovations, but today the stakes are higher than in the past.

At RCA Consumer the new direc-

Two from one. Zenith split TV design organization into two parts (bottom) to push solid state and development of video players.



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Circle 79 on reader service card

tion involves a computer-based reliability-prediction program. Organized in August 1971 as a separate entity, a 12-man product-analysis and control group has stored in a time-shared computer a history of field failures, quality-control data from incoming inspection, and supplier-performance information. The objective was to provide a base for predicting reliability, as well as identifying failure mechanisms or individual parts.

M. H. Glauberman, director of engineering for the Consumer Electronics division, says that the group has come a long way in establishing in-house confidence in its predictions and thereby gaining cooperation from product designers.

A typical example of how the computer program helps is in deciding whether to install a transistor without a heat sink at 25 cents, the same transistor with heat sink for 35 cents, or another transistor with a higher rating but without heat sink at 40 cents.

Pressure. The program stresses another aspect of the move to solid-state design. There's more pressure on the engineer to design for reliability because engineering-related failures have become more important than production-related failures since the advent of the one-year warranty (excluding picture tube) in 1970. For example, the analysis and control group discovered that field failures attributable to manufacturing and quality deficiencies, that is, assembly-line mistakes, were 90% during the first 90 days of TV receiver use. However, in the first year, 50% of all failures were from design stresses, attributable to engineering mistakes. And in the first five years of use, 80% of the failures were directly related to design stresses, the responsibility of the engineering, rather than the production department. Thus, during the 90-day warranty period, the onus for living up to performance was on the production line. Now, one-year warranties have shifted the major burden to the engineer.

At General Electric in Virginia, the arrival on the scene of solid-state technology has also prompted formation of a separate evaluation group to predict product reliability and to track failure mechanisms for specific parts.

"Eventually we expect to transfer more engineering to the component suppliers," comments Donald Garrett, manager for design engineering, "But in the meantime, we had to get IC competence; just to learn to specify." GE also went to the lot-tolerance-per cent-defective (LTPD) mode of incoming inspection rather than the more-familiar acceptable-quality-level (AQL) technique. Since the vendor has a greater burden to achieve acceptance of parts under LTPD than AQL, he must take greater pains to control his processes.

Philco-Ford devised a computer model to simulate performance of every component in its 1973 line of solid-state chassis. Here, too, the idea was to use computer projections to isolate possible end-product failure in the predesign stage. The company has previously used computer-aided design programs in development of other consumer products, but this color-TV line represented the most extensive CAD program to date.

The pressures of longer lead time for designing solid-state chassis, of reliability during extended warranties, and of bringing on new products were all part of the changes in the Zenith engineering department late last year. Last spring, when George Schupp became engineering vice-president, he observed that application of ICs and development of home video players represented his major challenges. This view was borne out in less than a year, when Schupp was appointed vice-president for video-player and audio engineering and Leonard Dietch, formerly director of color-TV engineering, was made executive director for television engineering. Thus, Zenith divided into separate jobs the two major engineering challenges that Schupp had identified.

Says Schupp: "The problem facing engineering is reliability. The computer spits out analyses of failures so we can knock them off one by one. These techniques are not the ultimate. As technology changes, engineering must be able to change, and this has not always been recognized in consumer electronics." □

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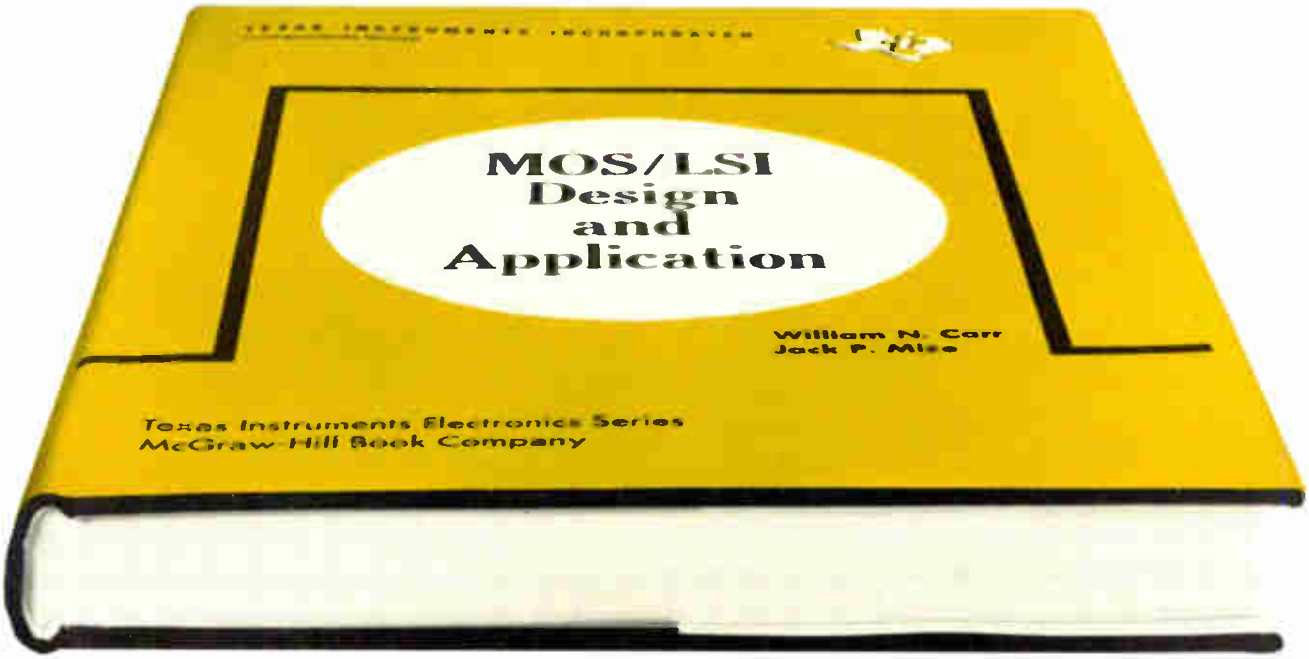

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Leadless, pluggable IC packages reduce fabrication and repair costs

Device and socket makers team on new packaging technique that eliminates both leads and solder mounting to give promise of lower device prices, cheaper on-line debugging, and streamlined field-maintenance practices

by Stephen E. Grossman, *Packaging & Production Editor*

☐ Both socket and package manufacturers are tooling for production of leadless, pluggable, dual in-line package systems to join the edge mounts already being used by several equipment builders. The new packages eliminate the problem of breaking or bending beyond repair the slender, vulnerable leads of traditional DIPs (Fig. 1). Yields are therefore increased at each step, from the start of device fabrication, right through to shipment of a fully operational printed-circuit board with the integrated circuits installed. Proponents also point out that the new packages eliminate the delicate and time-consuming job of unsoldering defective ICs from expensive pc boards. Therefore, pluggability speeds both in-house and field debugging, since a suspected device can be quickly and safely replaced by one known to be good.

Both device manufacturers and users have recognized the benefits of the leadless, pluggable approach. Tom Dyer, program manager for custom LSI at Fairchild MOS Products division, Mountain View, Calif., phrases it strongly: "The really key argument for going leadless and pluggable is the horrible cost now encountered with soldered, leaded ICs in arriving at a clean [debugged] pc board."

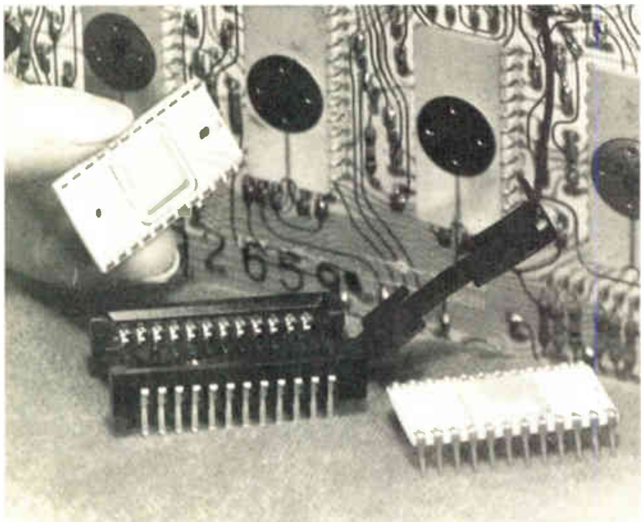
Another advocate of leadless packaging is Bob Foster of Xerox Corp., Rochester, N.Y., who lives closely with next-generation design, producibility, and field-service considerations. Says Foster: "Leadless LSI packaging offers promise for the large-volume user. The main advantages will accrue in both the manufacturing and field-service areas. Another advantage will develop in field revision. With some forethought at the design stages, including selection of pluggable, leadless ICs, such field revisions may be accomplished without the expensive scrapping of numerous pc boards. The breakthrough is awaiting the initiative, incentive, and direction from the major users—and in reality, this appears to be a year away."

But despite what proponents claim are obvious advantages of leadless devices, universal acceptance is still a long way off. In the first place, cost reductions are not directly obvious. And secondly, users now have a heavy investment in the ubiquitous conventionally leaded DIP.

Tom Dyer at Fairchild reports: "We are prototyping for a number of people, but quantities are preproduction." However, Richard Grubb, vice-president of marketing at Augat Inc., Attleboro, Mass., believes that the conventional dual in-line device with leads has a lot of staying power. Says Grubb: "The configuration has been so well received that we know that's the way the industry is going, and it will be locked in for some time. There is just a host of packages coming out with the dual in-line lead configuration."

Go the route?

As in most design decisions, whether or not to go pluggable and leadless requires careful scrutiny of the technological and economic factors. Going leadless means ridding the fabrication sequence of the cost of the lead frame, the cost of lead attachment, and the losses that result in device manufacturing from lead defects alone. These losses occur during device manufacture, testing, shipment, and handling. Yield losses as high as 20% have been cited. Such a figure is not surprising, since each lead of the ceramic package is but a slender member that will bend or break in the event of mishandling. Merely sliding such devices through han-



1. Leadless contenders. Burndy's face-contact receptacle and du Pont's companion substrate are representative of leadless IC packaging, rivaling the traditional dual in-line device with leads.

TABLE 1 – GALLERY OF LEADLESS PACKAGE RECEPTACLES

Type	Manufacturer	Contacts: Number	Contacts: Material	Contacts: Plating	Contacts: Contact Interface Resistance	Contacts: Normal Contact Force	Device Insertion Force	Life Cycle[1]
Edge-mount	AMP, Inc. Harrisburg, Pa. 17105 (717) 564-0101	40[3]	Beryllium-copper or stainless steel	Gold 30 μin. on contact area) over nickel[4]	9 milliohms avg contact resistance	40 g min	10 lb	100 min
	Texas Instruments Metallurgical Materials Division Attleboro, Mass. (617) 222-2800	40	Copper alloy	100 μin. wrought gold over 300 μin. nickel	4.5 milliohms max constriction resistance	50 g min	10 lb max	100
	Cinch Connectors Elk Grove, Ill. 60007 (312) 439-8800	64	Beryllium-copper	50 μin. gold over 50 μin. nickel or cupro-nickel plated	1.8 milliohms avg contact resistance[8]	Not available	10 lb max	100 min
	Winchester Electronics Division of Litton Systems Oakville, Conn. 06779 (203) 274-8891	40	Beryllium-copper	30 to 45 μin. gold over nickel plate	14 to 20 milliohms contact resistance[9]	Not available	8.5 lb	500
Dual in-line side-contact	AMP	40[5]	Beryllium-copper	Gold (30 μin. on contact area) over nickel	9 milliohms avg contact resistance	40 g min	4 to 6 lb	100 min
Dual in-line face-contact	Amphenol Industrial Division Chicago, Ill. 60650 (312) 242-1000	40	Beryllium-copper	20 μin. gold min over 50 μin. nickel min	5 milliohms[7]	50 g min	Zero	50
	AMP	40[5]	Stainless-steel	Gold (30 μin. on contact area) over nickel[4]	9 milliohms avg contact resistance	40 g min	Zero	100 min
	Burndy Corp. Norwalk, Conn. 06856 (203) 838-4444	40[5]	Copper-based alloy	Tin-alloy plate	5 milliohms max constriction resistance	150–300 g	Zero	40 min

Notes
1. Insertions and withdrawals
2. Dimensions are rounded off
3. Also available in an 80-contact version
4. Stainless contacts may be obtained with a tin plate.
5. Also available in 24- and 28-contact versions.
6. Height (0.40 in.) with cover closed includes 0.020-in. stand-off.

dling tubes is bound to cause some losses.

If the leaded device is destined for a socket, it will be subject to plugging and unplugging and will encounter a number of chances to be damaged or destroyed. A 40-lead device requires 15 pounds to insert. At insertion, a lead may buckle because of misalignment with its pin socket, or the lead may break off.

A principal deterrent to going pluggable is the wide-spread apprehension regarding contact system reliability. At the heart of this matter are the durability of the contacts and the stability of the contact resistance across the contact interface.

Contact resistance is the ohmic value of the film resistance on each of the mating contacts plus the constriction resistance, as it is called by contact specialists. (See "Which resistance?" p. 87). The constriction resistance of a so-called "good" gold-to-gold contact ranges from 0.5 to 5 milliohms. But most system designers agree that the exact value is not nearly so important as over-all contact-resistance stability. Stability of the contact resistance depends on how much contact degradation occurs from repeated removal and replacement of the device and from exposure to hostile environments.

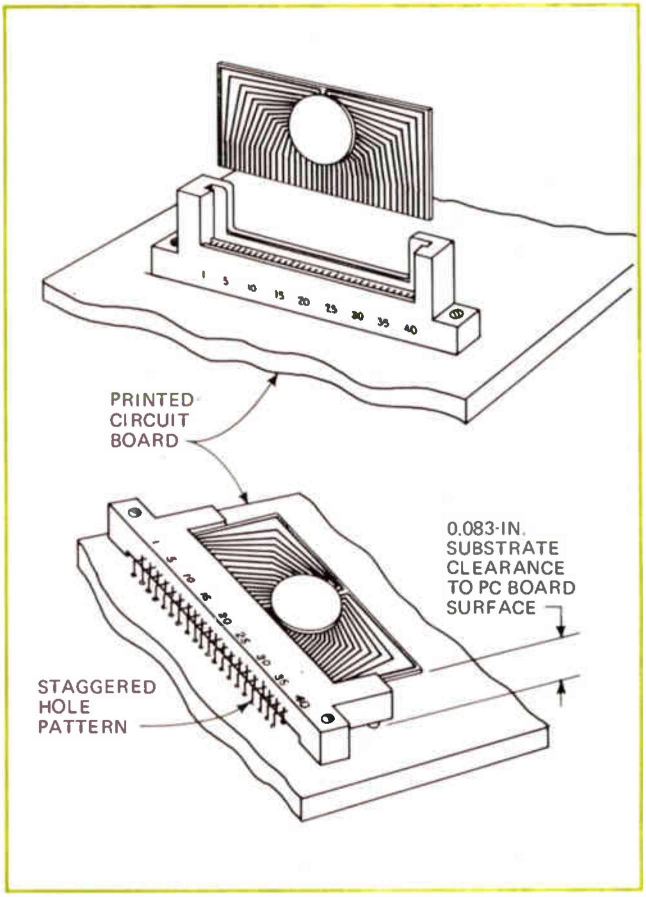
Proponents of going both leadless and pluggable say

Body Dimensions[2]	Body Material	Manufacturers of Companion Packages (See Table 2)
2.73 x 0.25 x 0.80	Glass-filled nylon	Metceram, Kyocera
2.90 x 0.25 x 0.82	Glass-filled nylon	Kyocera, Metceram
2.45 x 0.88 x 0.24	Glass-filled polyester thermoplastic (self-extinguishing)	Metceram
2.65 x 0.30 x 0.67	Glass-filled phenolic	Metceram
2.12 x 0.83 x 0.23	Glass-filled nylon	Plessey, du Pont, American Lava, SCS, Kyocera, National Beryllia, U.S. Electronic Services
2.05 x 0.80 x 0.40[6]	Glass-filled nylon	American Lava, du Pont, Metceram
2.50 x 0.78 x 0.38	Glass-filled nylon	American Lava, Kyocera, U.S. Electronic Services
2.30 x 0.79 x 0.26	Thermoset material	du Pont, U.S. Electronic Services

7. Calculated value of constriction resistance.
8. Measured with probes immediately adjacent to the contact interfaces.
9. One ampere test current.

that substituting a leadless IC package and a companion socket for a soldered leaded device will yield an over-all cost reduction, despite the fact that a 40-lead socket costing 40 to 80 cents will be added. Their reasoning is based on two factors. The price of the package is reduced by elimination of the lead frame, and the yield will rise at each step of the fabrication process: package assembly, handling, device assembly, device testing, shipping, equipment assembly, and debugging (see "Some economics of going leadless," p. 86).

The leadless IC-package systems divide into two general categories: edge-connect and dual in-line (Table 1).



2. Two postures. Texas Instruments sockets for edge-mount substrates are designed for stand-up (high-density) or prone (low-profile) mounting. Price is about 40 cents in production quantities.

The first edge-connect to be developed, was introduced by Texas Instruments Metallurgical Materials division, Attleboro, Mass., working in conjunction with Coors Porcelain Co., Golden, Colo., and American Micro-systems Inc., Santa Clara, Calif. [*Electronics*, Sept. 13, 1971, p. 106]. The TI device is a 40-termination, single-line edge-mount connector, which can be mounted either vertically or horizontally (Fig. 2). In the vertical position, the assembly closely resembles the socket-mounted pc board and enables high packaging density at the sacrifice of profile. The contacts are on 0.050-inch centers, with staggered solder contacts on 0.100-in. centers. Substrate thicknesses of 0.035 to 0.044 in. can be accommodated. Texas Instruments employs contacts made of copper-nickel-zinc alloy with a 100-microinch wrought-gold stripe metallurgically bonded in the contact area.

Tests are encouraging

Because the edge connector is a close cousin of the pc connector, the reliability of its contact interface has been questioned. Consequently, Texas Instruments investigated reliability and performance.[1] Following 100 repeated insertion and withdrawal cycles, TI found constriction resistance changed little and remained between 1.0 and 4.5 milliohms. Contact force at the end of the test cycles still exceeded a 45-gram minimal value. Better than 50% of the original gold remained on the contacts. Similar connectors are being marketed by AMP

Economics of going leadless

The following is a yield analysis based on an assumed yield loss of 10%, due to leads alone:

1. Assume that a 40-lead device costs $8 to make.
2. Also assume that the 10% fallout occurs at final test and inspection. So if one starts with 1,000 devices, 900 are marketable.

Each marketable device costs $8 × $1,000/900 = $8.89. If leadless, each device would cost:

8 × 1,000 = $8.00
− .20 value of unused lead frame
+ .80 value of leadless socket
$8.60

Going leadless therefore, saves $8.89 − $8.60 = $.29 at the device-fabrication level.

The savings in this example are probably conservative because there have been reports of yield losses of 20% due to leads alone. The price of 80 cents for a leadless socket is approximate for a gold system; 40-lead tin-alloy sockets are being quoted at about 40 cents each.

Finally, the ultimate cost to the user will depend on how much of the savings is passed on to him.

Inc., Harrisburg, Pa., and Winchester Electronics division, Oakville, Conn.

Another edge-mount package and connector pair is being marketed by Metalized Ceramics Corp., Providence, R.I., and Cinch Manufacturing Co., Elk Grove Village, Ill. (Fig. 3). The 64-line version provides 32 leads to a side on 50-mil centers. Metceram's package is constructed of layers of metalized "green" or unfired alumina tape, laminated and high-temperature-fired to produce a monolithic ceramic body, complete with dice-attach cavity and lead fingers. No metal lead frame or seal ring is required. An alumina screened dielectric layer protects lead runs on the rear of the package. The basic package is designed for a single chip, but Metceram is prepared to provide custom multichip hybrid versions.

One of the problems of the edge-mounted systems is the lack of symmetric metalized fan-out about the die cavity. This means that the connections to some of the wire-bond pads are long. This may be objectionable in certain high-speed switching applications.

Face-mount, side-contact

AMP, working with Fairchild and Kyocera International Inc., Sunnyvale, Calif., devised a face-mount side-contact dual in-line socket (Fig. 4). Since contact is made along the sides of the package, no metalization of the contacts is required on top, and so the surface can be laid out to accommodate the larger chips (300 mils square or more).

The latest version of AMP's side-metalization receptacle requires an insertion force of about 6 pounds [*Electronics*, Jan. 4, p. 132]. About 2 pounds of force is required to dislodge the package. An optional snap-in hold-down strap may be used for high vibration requirements. The price for AMP's socket, with a thermoplastic polyester body, is 40 cents to 60 cents in production quantities.

Others tooled for a side-contact, dual in-line package are listed in Tables 1 and 2.

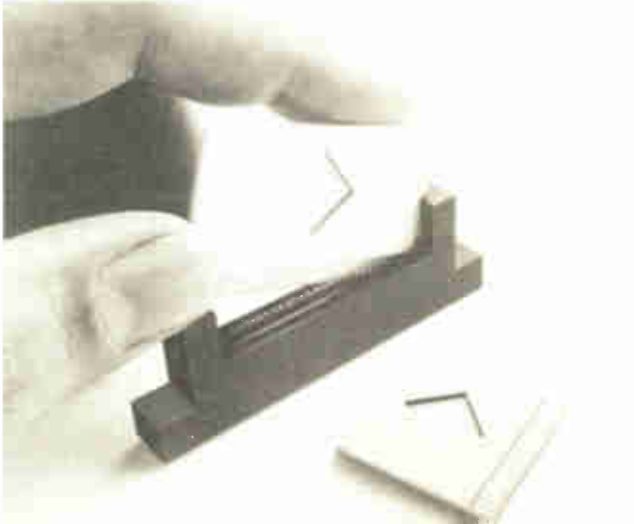
Go tin?

While most of the leadless designs center on innovations in packaging geometry, Burndy Corp., Norwalk, Conn., mounted a substantial research effort in quest of a reliable base-metal contact system that would do away with gold. Gold accounts for 30% to 50% of the cost of a gold-contact socket, and currently, gold prices are hovering at about $70 an ounce. When prepared for plating, gold costs an additional $5. Working in conjunction with E.I. duPont de Nemours & Co., Wilmington, Del., Burndy developed a face-mount, face-contact dual in-line socket using tin-alloy contacts. The key to the reliability of the contact interface is a gas-tight connection, which prevents entry of air that could degrade the connecting interface.

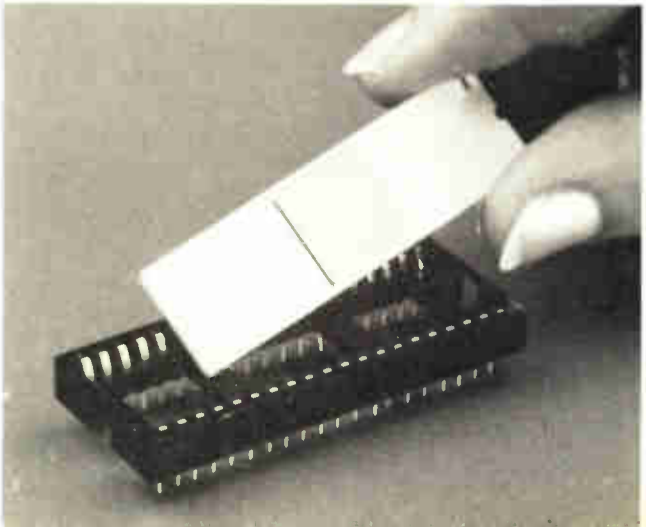
The tin-alloy contact technique is an extension of work done on wire-wrapped posts. Experience here indicated that wire, wrapped about a tin post, broke through the brittle oxide formed on the post to make the gas-tight connection.

While the gold-to-gold contact attempts to avoid plastic deformation, the tin-alloy technique deliberately seeks it. Each chisel-tipped contact in the Burndy socket

3. Pint-sized. Metceram's edge-mount package is marketed in both a 64-pin, 1.7-by-1-inch version and a 40-lead, 1.08-by-0.95-inch version. Cinch makes a companion socket for the 64-pin version.



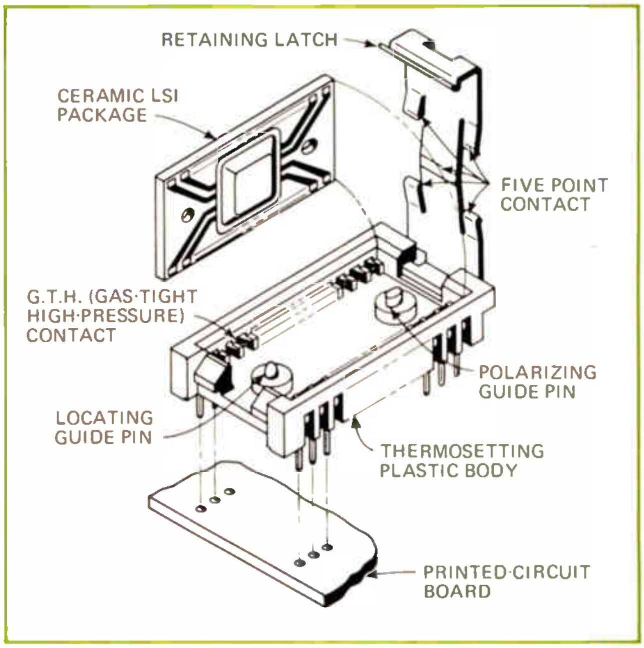
4. Side-contact. AMP's socket serves as a receptacle for a package, developed by Fairchild, which metalizes the edges for electrical connection. A hold-down can be inserted for high-vibration use.



penetrates the corresponding solder pad on the device package and displaces the brittle surface oxides, thereby forming the gas-tight connection (penetration is about 0.5 to 1 mil). Contact pressure ranges from 150 to 300 grams. A force of approximately 15 pounds is required to snap the package retaining clip into place. Contact resistance remains below 2 milliohms for at least 40 replacement cycles. In contrast, a good gold-to-gold connection runs about 0.5 to 5 milliohms and a wire-wrapped connection about 0.5 to 0.8 milliohm. The contact is rated at 3 amperes (10°C contact rise).

As for environmental tests, after temperature cycling over the range of −55°C to +125°C, Burndy reports that no significant degradation of performance was noted when tests exposed the engaged contact to nitric acid, which attacks tin alloys, and ammonium sulfide, which attacks copper. Such results have led Michael D. Lazer, of Burndy's Advanced Development Laboratory, to claim: "Our tin-alloy system is as good as a good gold-to-gold connection and enables the fabrication of the lowest-cost separable connector."

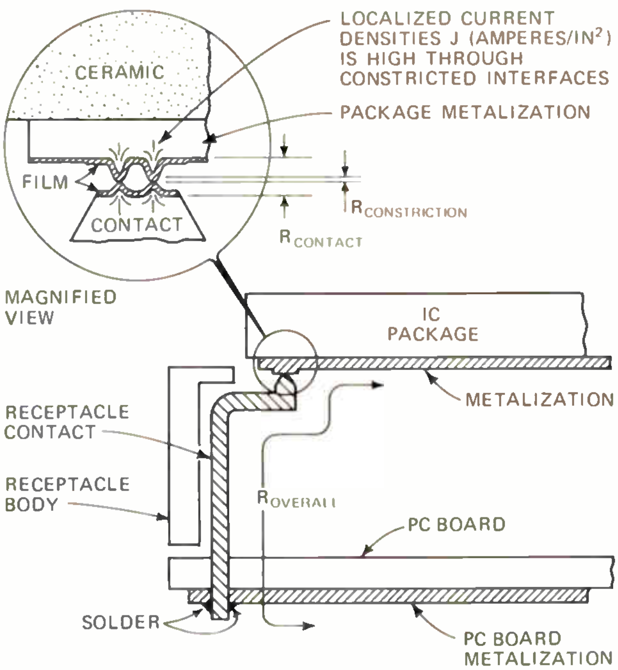
Throughout the history of tin-alloy contacts, instances have been reported that tin from one contact has cold-welded to its mate so that, upon separation, plate was stripped from one of the contacts. Says Lazar: "You al-



5. Gas-tight. Burndy's receptacle with chisel-tipped tin-alloy contacts and du Pont's package enable a 40-line price of approximately 40 cents for the socket and 58 cents for the substrate, in volume.

Which resistance?

When connector people discuss contact interface resistance, there is often no telling just which resistance they have in mind. There are at least three components of interface resistance that are reasonably agreed on: constriction resistance, contact resistance, and over-all resistance:



Constriction resistance

When the surface of a pair of contacts mate, the true connecting interface is merely a small fraction of the gross contact area. Because the surfaces are not microscopically smooth, they contact at a number of localized points termed asperities (A spots). This total contact area is, in part, dependent on deformation (plastic and elastic). The resistance measured across this interface is called constriction resistance.

A relationship for evaluating constriction resistance R_c is:

$R_c = K\rho P^{1/2}/F^n$
K = constant for surface roughness $lb^{(n-1/2)}$
ρ = bulk resistivity (ohm-in.)
P = contact pressure causing plastic flow (psi)
F = force normal to the contacting interface (pounds)
n = constant exponent for the surface (determined experimentally)

Constriction resistance is commonly measured by a pulse technique, or by a non-linearity technique.[2,3] The value of this resistance at an IC contact interface is typically 5 milliohms or less.

Contact resistance

If the contact is coated with any contaminating film, then the contact resistance is the resistance of the film in series with the constriction resistance. Sometimes the term contact resistance includes a certain amount of the bulk materials on both sides of the contact interface. A representative value for contact resistance, which includes constriction, film, and bulk resistance, is 30 milliohms. For comparison 1 inch of #20 A.W.G. annealed copper wire has a resistance at room temperature of 0.87 milliohm. For further discussion of contact resistance, see reference 4.

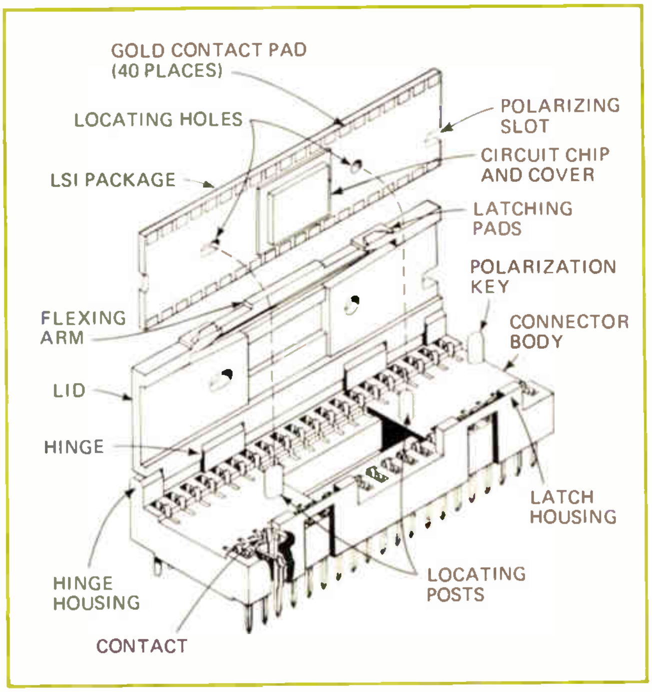
Over-all resistance

The term over-all resistance usually includes the resistance due to connections with the outside world (metalization on the substrate and copper on the pc board).

TABLE 2 — LEADLESS PACKAGE ROSTER

Type	Mating receptacle	Package manufacturer	Number of contacts	Dimensions[1] (inches)	Die cavity (inches)	Construction	Contact metalization
Edge-mount	AMP, Texas Instruments & Winchester	Coors Porcelain Co. Golden, Colo. 80401 (303) 279-6565	40	2.00 x 1.00 x 0.04	0.270 dia.	Co-fired Laminated Alumina	60 μin. gold
		Metalized Ceramics Corp. (Metceram) Providence, R.I. 02904 (401) 331-9800	40	2.00 x 1.00 x 0.04	0.270 sq.	Screened Dielectric Alumina	80 μin. gold
		Kyocera International, Inc. Sunnyvale, Calif. 94086 (408) 736-0606	40	2.00 x 1.00 x 0.04	0.270 sq.	Single-layer Co-fired Alumina	60 μin. gold
	Cinch	Metceram	64	1.70 x 1.00 x 0.04	0.270 sq.	Two-layer Laminated Alumina	80 μin. gold
Dual in-line side-contact	AMP	American Lava Corp. Chattanooga, Tenn. 37405 (615) 265-3411	40	2.00 x 0.59 x 0.08	0.300 sq.	Laminated Co-fired	60 μin. gold
		E.I. duPont de Nemours & Co. Wilmington, Del. 19898 (302) 774-7672	40	2.00 x 0.59 x 0.06	0.200-0.310 sq.	Alumina Substrate, Thick-film Construction	Thick-film metalization
		U.S. Electronic Services Corp. Clifton Heights, Pa. 19018 (215) 626-5200	40	2.01 x 0.58 x 0.08	0.300 sq.	Metalized Plastic	60 μin. gold
		National Beryllia Corp. Haskell, N.J. 07420 (201) 839-1600	40[2]	2.00 x 0.52 x 0.10	0.225 sq.	Ceramic-glass Laminated Co-fired	100 μin. gold
		Kyocera	40	2.00 x 0.58 x 0.08	0.250 sq.	Multilayer Co-fired Alumina	60 μin. gold
		Plessey Ceramic Division Frenchtown, N.J. 08825 (201) 996-2121	40	2.00 x 0.57 x 0.08	0.250 sq.	Pressed Alumina	100 μin. gold
		SCS Corp. Garland, Texas 75040 (214) 272-5481	40	2.00 x 0.59 x 0.10	0.275	Dry-pressed Alumina	60 μin. min. gold
Dual in-line face contact	AMP	American Lava	40	2.00 x 0.50 x 0.06	0.240 sq.	Laminated Co-fired	60 μin. gold
		Kyocera	40[3]	2.00 x 0.50 x 0.06	0.240 sq.	Multilayer Co-fired	60 μin. gold min
		U.S. Electronic Services	40	2.01 x 0.52 x 0.08	0.250	Metalized Plastic	60 μin. gold or 60-40 solder
	Amphenol	American Lava	40	2.00 x 0.56 x 0.04	0.200 x 0.220	Single-layer Alumina	60 μin. gold
		American Lava	40	2.00 x 0.56 x 0.06	0.220 x 0.240	Three-layer Alumina	60 μin. gold
		Metceram	40	2.00 x 0.59 x 0.08	0.320 sq.	Multilayer Co-fired Alumina	80 μin. gold
		du Pont	40	2.00 x 0.59 x 0.06	0.200-0.310	Alumina Substrate Thick-film	Thick-film metalization
	Burndy	du Pont	40[3]	2.02 x 0.59 x 0.06	0.200-0.310	Alumina Substrate Thick-film	Thick-film metalization
		U.S. Electronic Services	40	2.01 x 0.59 x 0.06	0.275	Metalized Plastic	60-40 solder

Notes:
1. Dimensions are rounded off
2. Also available in 24-contact version.
3. Also available in 24- and 28-contact versions.



6. Planar plug-in. Amphenol's receptacle, teamed with an American Lava Corp. package, has gold-to-gold face-contact system. User selects single or multilayer substrate with chip-up or -down mounting.

ways have some cold-welding when two contacts are contamination-free and are in intimate contact under pressure. What is really crucial is do you have actual transfer of materials? We believe we have no transfer in our nonwiping, gas-tight high-pressure technique." Burndy's 24-, 28-, and 40-lead packages are priced at about 1 cent a lead.

Despite Burndy's use of tin alloy, which enables the company to offer a low-cost receptacle, the current version requires 15 pounds to close the lid. This means that the pc board will also be subjected to this force, and it may have to be supported during insertion.

DuPont is marketing leadless packages for Burndy's sockets that have chip cavities ranging from 200 to 310 mils square, and construction is similar to their lead-frame-last series with leads. The body is 95% alumina, and the user can opt for metallurgical, glass, or adhesive seal. Thick-film construction enables independent selection of chip bond, seal, and lead metallurgy. The package may be purchased either in planar form or with a chip cavity depth of 15 mils. Price for a 40-lead package is about 58 cents in volume.

The Amphenol Industrial division, Chicago, working with American Lava Corp., Chattanooga, Tenn., has developed face-contact sockets for 40-mil-thick dual in-line, single-plane chip-down packages and 60-mil multilayer chip-up and chip-down packages. Termed planar plug-in connectors, the two variations use the same connector body and contacts. Only the lids differ. The glass-filled nylon device is a one-piece assembly with a snap-lock lid—metal hinge pins are not used.

Round and oblong locating posts perform two functions: they provide partial polarization, and they align the plated contact pads on the substrates with the contacts of the connector. The over-all ceramic-package dimensional tolerances may be relaxed because they are not necessary for contact alignment. A polarization key, offset about the longitudinal center line, in conjunction with the proper corresponding notch in the package, determines whether mounting will be chip-up, or chip-down. Pads mounted on the bottom of the receptacle raise it 20 mils off the board so that solder does not bridge the pins, spaced 100 mils apart. A contact preload of 50 grams sets a lower limit on the contact pressure.

When the cover is closed by a force of about 4 pounds, each contact deflects vertically a minimum of 12 mils. The cantilever construction provides for a horizontal cleansing wipe of 10 mils. Individual contacts can be replaced in the field (contact retention force is one pound minimum).

A unique feature of the design is its end-for-end and side-by-side stackability. In other words, no lateral space around the perimeter of receptacle is required for the lid to be raised. Closed-package height is approximately the same as that of a package plugged into a conventional DIP socket. Pin spacing is the same as that of conventional sockets, 100 mils between contacts and 600 mils between rows.

The Amphenol socket contacts the existing pad areas on the top or bottom surfaces of the ceramic package—that is, the pads formerly employed to braze the lead frame become contact pads.

American Lava is marketing three ceramic packages that mate with the Amphenol face-mount, face-contact receptacles. A single-layer version with a screened alumina insulation layer provides maximum economy. This device requires "down-hill" bonding and a cup-shaped lid. ("Down-hill" describes the attitude of a wire joining a chip to a single-layer substrate. Die-attach and metalization are on the same plane; consequently, each wire comes down-hill from the pellet to the wire pad on the substrate.) Contact pads are on the top of the substrate.

A second model has three-level construction for conventional wire bonding and sealing; contact pads again are on top. And finally, a three-level structure is available with contacts on the bottom so that normal lead orientation can be maintained with regard to lead No. 1 placement. Forty-lead versions are available; other versions are undergoing development. Sizes of die cavities are specified in Table 2.

AMP also has a face-mount, face-contact receptacle that houses top- or bottom-metalized substrates. Mechanical and electrical characteristics are similar to those for the face-mount, side-connect socket, except that nylon clamps, fastened by self-tapping screws or plastic cams, secure the package in the receptacle. In one version of this connector, the nylon hold-down has windows so that a package mounting seven-segment light-emitting-diode displays may be accommodated. □

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Hall-effect magnetic sensor reads data at any speed

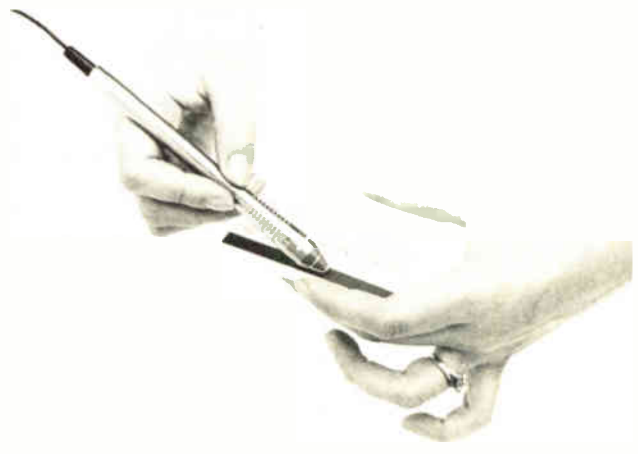
Thin-film technology makes possible micrometer-thick sensor that can be guided by hand to read densely packed recorded data, thereby eliminating the need for constant-speed mechanism and uniform head-to-track spacing

by Masayuki Murai, Data Products and Devices Division, *Pioneer Electronic Corp., Tokyo, Japan*

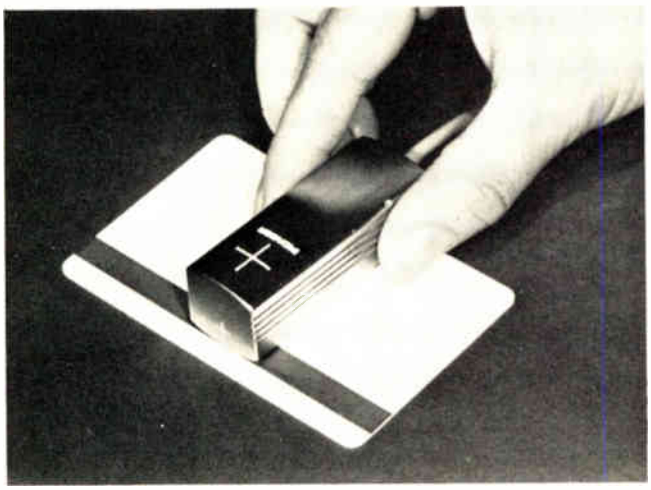
☐ For a number of years, the electronics industries have been developing devices that can read price tags, credit cards, and similar documents as a vital first step to the long-awaited computerized, cashless, checkless society. Some optical readers are available to read color-coded data, but they can be misled by stains. A conventional magnetic head could be used, but that would require the reading medium, such as a hand-held wand, to be moved at exactly the right distance from the magnetic code at exactly the right speed—obviously an unrealistic demand for a manual operation.

Variations in distance or speed of magnetic reading heads produces signals that are distorted, low in amplitude, or otherwise unsatisfactory. But if these obstacles could be overcome, such a reader would also make possible reading of higher-density digital magnetic tape than has been feasible in the past. Some designs of magnetic recording heads have overcome the constant-speed requirements, but only at the cost of sophisticated circuits to compensate for the distortion.

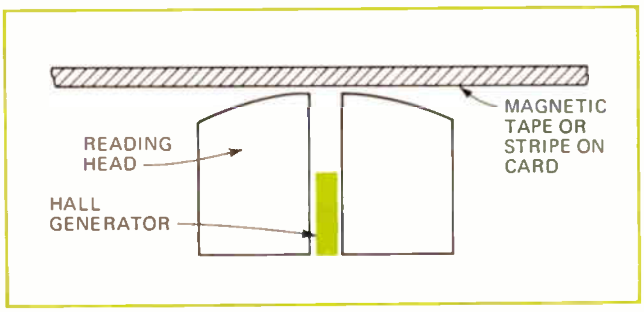
Now, however, the classic Hall effect, which is relatively immune to speed variations and relatively uncritical of the distance to the magnetic recording medium, has been teamed with thin-film semiconductor technology to produce a read head that is suitable for such equipment as hand-operated wands like those in Figs. 1 and 2 to read price tags for point-of-sale devices. The sensor is a micrometer-thick deposit of indium antimonide in a 2½-μm gap between two ferrite pole pieces (Fig. 3). Fabricated right on one of the pole pieces in much the same way as a hybrid integrated circuit, the Hall-effect sensor is recessed well into the gap. The top can be filled with sapphire-hard glass, which protects



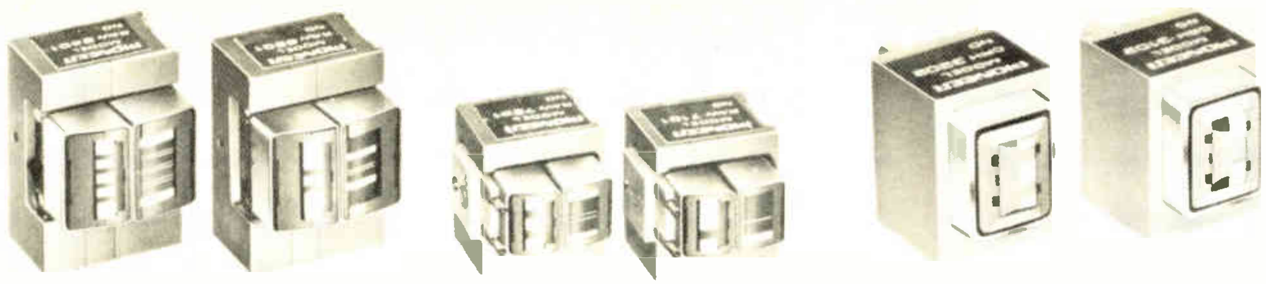
1. Digisensor wand. This Hall-effect probe was developed for reading magnetically encoded merchandise labels and price tags in point-of-sale applications, as well as for the credit-card application shown here. The thin-film Hall-effect head is in the "pen point," which has a circular gap around its tip. The head is insensitive to variations in reading speed, unevenness of the coating on the magnetic stripe, card warping and other factors that in a conventional coil-wound head would be likely to produce a lot of inaccuracies.



2. Another wand. This probe, another in Pioneer's "Digisensor" line, has the same type of Hall-effect head as would be used in a cassette tape drive. Its maximum output is as high as that of a tape head when it is perpendicular to the magnetic material being read.



3. Hall-effect head. This cross section of the type of head used in the wand of Fig. 2 shows the open magnetic circuit and the Hall generator. The head is recessed into the gap to protect it from wear and to permit front electrode connections.



4. Read heads. Recently developed Hall-effect heads include four multitrack cassette read/write heads (left) and two heads for magnetic credit-card readers (right). The multitrack heads combine coil-type recording heads and Hall-effect heads in the same block, closely enough that they may be used as high-density read-after-write heads. The combination minimizes crosstalk problems.

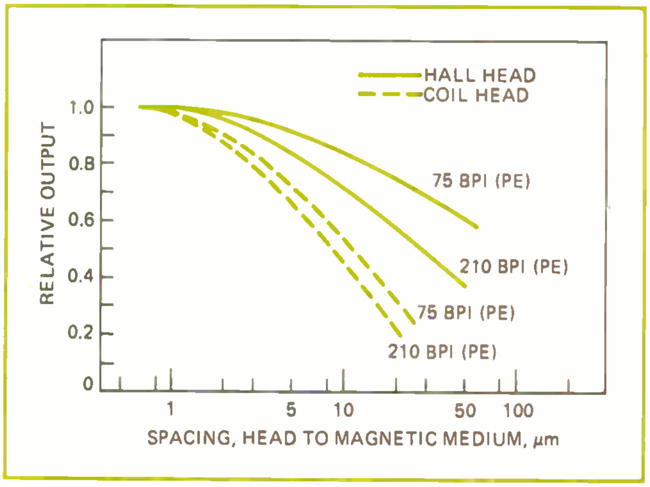
the edges of the ferrite parts from chipping.

Unlike the conventional coil-wound reading head, the sensor can put out a strong digital signal under practically any reading conditions. Because it is so thin, the sensor is highly sensitive. It has a very long life and can tolerate surface irregularities in the magnetic medium, as well as other imperfections.

Using thin-film wiring, the film can be etched into arrays of sensors so that many read heads can be packed into a multitrack block no wider than high-density magnetic tape (Fig. 4) in order that the device can be readily adapted to reading digital magnetic tape. Density as high as 30 tracks per inch of tape width is feasible. Therefore, with the development of high-density digital recording techniques, it's no longer necessary to depend upon mechanics for reliability of cassettes, recorders, and other electronic devices.

In one application, the increasing use of digital magnetic tape cassettes in recent years frequently has been accompanied by great effort in mechanical design of cassette drives to ensure that the tape in the cassette moves past the read/write head at constant speed. The complexity of some of these designs make it appear that they come from the brain of the late Rube Goldberg.

More recently, cssette-drive design has discarded constant speed and put more sophistication in electronic circuits to compensate for the irregularities caused by speed variations. Use of Hall-effect heads in such drives would eliminate the need for much of the electronic sophistication, not to mention mechanical complexity.



5. Spacing loss. The Hall-effect head tolerates wide gaps between the head and the magnetic medium. This allows it to tolerate irregularities in the surface being read, as well as gaps, and allows considerable head wear before sensitivity drops appreciably.

Hall vs gauss

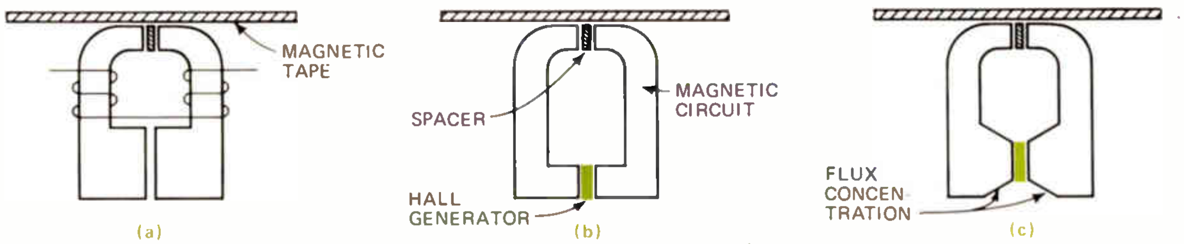
Under normal conditions, the performance of a Hall-effect head and a coil-wound head are comparable. In the Hall-effect head, thin-film sensors generate an electromotive force of about 7 millivolts when reading a standard saturated tape, while the output of a typical channel in a multitrack Hall-effect head is about 2.5 mv with a noise level of about 2.5 μV. Coil-wound heads do as well—under normal conditions.

But when conditions are not normal—as when the tape slows down, or bounces momentarily off the head because of an external shock or a dust particle on the tape—the coil-wound head's signal deteriorates sharply. Since the signal is the differential of the recording waveform with respect to time, it depends on the motion of the magnetic flux. The flux may be moved past the head too slowly to generate an adequate output because of an incremental motion of the tape or because of a steady motion at low speed that is required to read very densely recorded data at a usable rate. On the other hand, if a densely recorded tape is advanced too fast, the waveform's differential nature and the very short time between its peaks may cause loss of data unless special tapes are used.

Furthermore, in many machines, read and write heads are combined in a single structure. These heads have two sections, or gaps, for each track of recorded data; the gap that the tape or other medium crosses first writes the data on the tape, and a few milliseconds later, the written data crosses the other gap, which reads it and returns it to the source, where it is checked for accuracy. Such two-gap heads are necessarily very compactly built, and as a result of their compactness, crosstalk is severe. To record at high density, the writing gap of the combined head uses high-intensity fast-rising pulses. The nearby reading part of the head picks these up, and the pickup is difficult to attenuate without greatly degrading read sensitivity. In fact, the read output can fall below the noise level when the tape moves slowly.

A Hall-effect head suffers none of these problems because its output amplitude is affected only by the magnetic-flux density. Other factors in the Hall voltage equations [see "Lorentz and Hall started it all," p. 94] are constant, and the tape velocity isn't involved at all.

Thus, the tape speed can be high, low, or variable without affecting the output amplitude. The output



6. Configuration dilemma. A coil-wound head usually has a wide-faced gap in the rear (a), which seems to be a good place to put the Hall generator (b). However, the Hall generator requires both a low reluctance, and thus wide faces, and a concentration of flux, and therefore narrow, tapered faces (c). This dilemma cannot be resolved with conventional head shapes, and requires a completely new approach.

waveform also truly reproduces the recording waveform, not its differential. In a high-speed, high-density application, the output pulses are well defined, and specially processed tape is not usually necessary to overcome data dropout problems.

Because the signal output is consistently high, any crosstalk in a read-after-write application can be easily attenuated at all speeds. Furthermore, because the thin-film multichannel Hall-effect reading heads are tiny, they can be mated with the recording heads in one small structure to minimize the time between writing and reading.

Another important advantage is that the Hall-effect head, because it contains no inductors, can be considered a simple resistor. The amplifier's optimization is therefore simpler because the read amplifier doesn't have to be designed to cope with the inductive load presented by the coil-wound head.

Again, design innovations in the thin-film head makes it relatively insensitive to the distance between the magnetic recording medium and the head. Figure 5 shows this characteristic in terms of typical spacing loss of a Hall-effect credit-card reader and a coil head at densities of 75 and 210 bits per inch.

Design dilemmas

At the beginning of the development effort, several design dilemmas had to be overcome. The most important of these were:

- The best head shapes do not concentrate magnetic flux in the way that a Hall-effect generator requires it.
- The best shapes for Hall-effect generators cannot be used in the best head configuration.
- The thin, high-sensitivity generators also produce large noise voltages.

The first dilemma is created by the configuration of the coil-wound heads used in most tape systems, which have been built by well-advanced techniques. A Hall-effect head would be built most simply if it could have similar shape. A coil-wound head is shaped like a distorted ring (Fig. 6a), with an air gap that interrupts the otherwise continuous flux path. To detect densely packed individual binary digits or the highest recorded analog frequency, this front gap must be very narrow, but to divert the magnetic flux through the winding instead of across the gap, its reluctance must be high. Therefore its faces are also narrow. For easy assembly, coil-wound heads usually have a second gap opposite the first one; because this gap should have low reluctance, it is built with wide faces. (These faces may be in contact, but that doesn't make the reluctance zero because the contact is not as intimate as a continuous mass would be.)

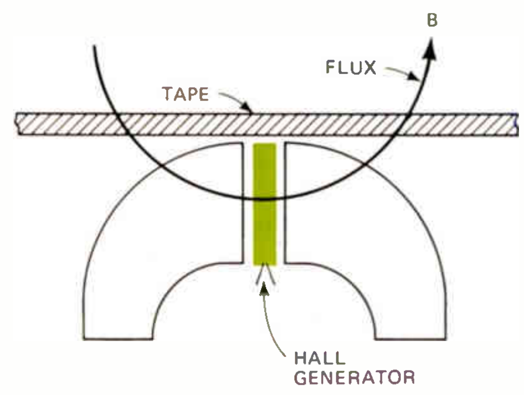
If the Hall-effect head is to have the same configuration as the coil-type head, the Hall generator should be placed in the rear gap (Fig. 6b). However, the Hall voltage is proportional to the reluctance of the front gap and inversely proportional to the sum of the reluctances of both gaps:

$$V_H = kR_{fg}/(R_{fg} + R_{rg})$$

In this equation, k is a constant of proportionality. Thus, the Hall voltage approaches its maximum value if the reluctance of the rear gap is made as small as possible, approaching zero, as in the coil-wound head; but [as shown on p. 94] the Hall voltage is also proportional to the flux density, which calls for a flux concentration and therefore an increase in R_{rg}. By tapering the faces of the gap (Fig. 6c), this increase can be achieved without widening the gap appreciably, but it nevertheless adversely affects the sensitivity of the head.

An alternative is the simple front-gap design (Fig. 7). This structure is more or less horseshoe-shaped instead of ring-shaped, a better shape because the magnetic flux is to be directed through the front gap, with the Hall generator in it, instead of away from the front gap, to pass through a coil.

But the simple front-gap design brings up the prob-



7. Simple front-gap design. Here the Hall generator is brought close to the tape, while the horseshoe-shaped pole pieces act as an open magnetic circuit and concentrate the magnetic flux in the generator and perpendicular to it, if the gap is narrow. But the design leaves no room for an electrode at the top of the generator.

Lorentz and Hall started it all

More than a century of research has gone into the Hall-effect head. The basic phenomena involved—the effects of magnetic fields upon the motions of charged particles and electric conduction—have been studied in various laboratories since 1870.

First came the Lorentz force, named after Hendrik A. Lorentz, who won the Nobel Prize in 1902 for work in magnetics and radiation. This force, exerted by a magnetic field on a charge carrier when the latter moves perpendicular to the field, changes the path of the carrier. The force, at right angles to the magnetic field and to the original motion, is defined by the vector expression:

$$\mathbf{F} = -e(\mathbf{E} + \mathbf{V} \times \mathbf{B})$$

where e is the charge on the carrier, E is the electric field, V the electron velocity, and B the magnetic-flux density.

The Lorentz force, exerted on the electron in a vacuum, causes it to move along a semicircular path as shown below, left. If the cathode weren't in the way, the electron would move in a complete circle. The magnetron tube uses this effect.

In a semiconductor, an electron moves in a series of arcs, shorter than semicircles, as shown below, center. The net motion is inclined away from the electric field, creating a current in a direction opposite to the electron motion. The inclination, or Hall angle, is

$$\theta = \tan^{-1}\mu B$$

where μ is the mobility of carriers in the semiconductor. If μ is constant, the electromotive force is a measure of the field.

In a vacuum, the Hall angle is 90°; in a semiconductor, it is the average of the inclinations of the paths of a great many electrons over a substantial period of time. It is less than 90° because each electron bumps into impurities and the crystal lattice, stops, and then starts up again.

The current, at an angle to the electric field, has a component parallel to the field and one perpendicular to it. The perpendicular component is accompanied by a voltage across the semiconductor—the Hall voltage.

Hall generators. The practical use of the Hall effect is in a sensor made of a thin semiconductor plate with current and voltage electrodes mutually perpendicular to the magnetic field, as shown below, right. Several factors determine the magnitude of the Hall voltage:

$$V_H = [R_H I_C B/d][f(1/w)] \times 10^{-8}$$

where R_H = the semiconductor's Hall coefficient, a function of the charge carrier density and the charge per carrier;

I_C = control current in amperes;
B = magnetic flux density in gauss;
d = thickness in cm; and
f(1/w) = a geometry factor, ideally 1.

This equation shows that with a given semiconductor and controlled current, thickness must be minimized to make the sensor sensitive to B.

Modern history. Marvin Camras, of Armour Research Institute of Chicago (now Illinois Institute of Technology Research Institute), in 1952 was the first to apply the Hall effect to playback heads. Others in the United States, West Germany, and Japan began working on the technique at about the same time.

Siemens-Halske AG, of Munich, Germany, made the first commercial Hall heads. Much later progress has been made, but the thickness problem has limited applicability of heads made with bulk semiconductors. (Incidentally, coil-wound heads were also first made in Germany, by E. Schöller, in 1932.)

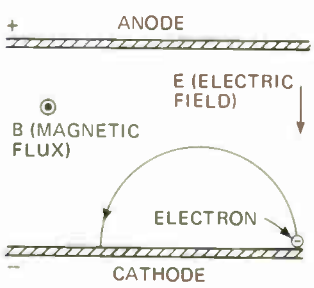
Thickness became the limiting factor because of the relationship:

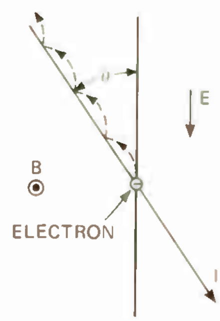
$$V_{H(max)}/B = (2R_H \mu \Delta T k/d)^{1/2}$$

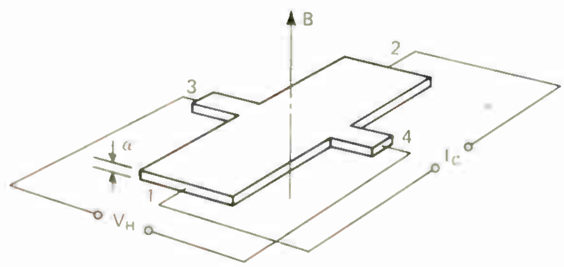
where T is the allowable temperature increase and k a heat-transfer coefficient.

R_H and μ are parameters of the semiconductor material; InSb and InAs have the highest known values. Temperature increase due to the Joule heating effect in semiconductors prevents the control current from being very large. Thus the thickness is the only truly variable parameter.

Pioneer Electronic Corp. began a research project in thin-film Hall generators in 1967. Four years later, the indium-antimonide element was successfully developed and reported in a paper to the Japan Institute of Electronics and Communications Engineers. The company is now manufacturing the thin-film heads commercially for numerous applications.



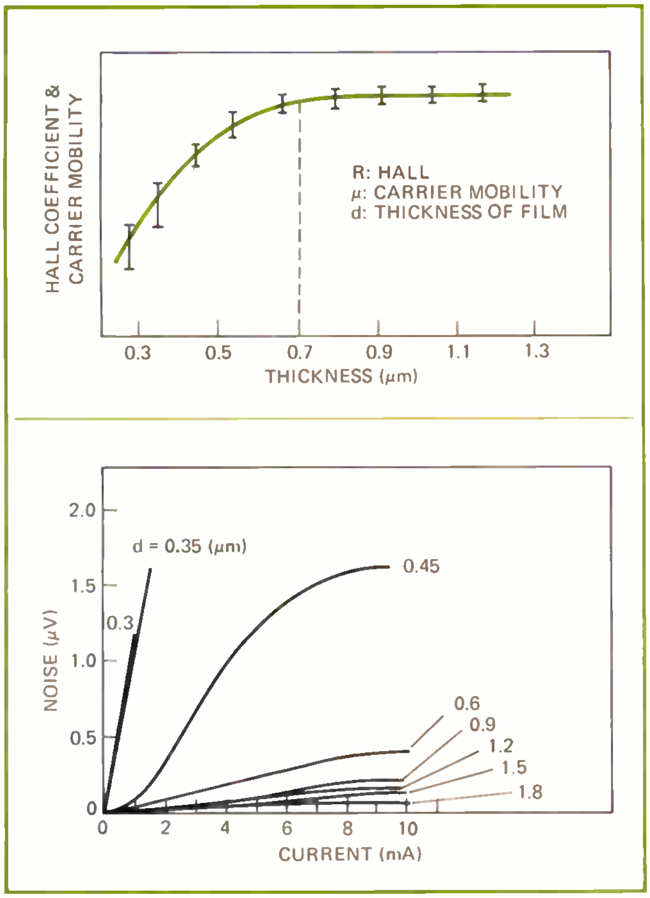




lem of generator shape. The generator, or plate, must be very thin and as close to the top of the gap as possible so that the maximum magnetic flux passes through it. But in this position, it is subject to wear. The best materials for Hall plates are indium antimonide and indium arsenide, but both are relatively soft.

Also, in the ideal Hall configuration [see above], one of the electrodes should be attached to the plate at the exposed end of the plate, but it cannot be put there because the moving magnetic medium is close to the head, if not in actual contact.

Various plate shapes without front electrodes have been tried. But most of them have unbalanced outputs, poor channel separation in multitrack designs, less sen-



8. How thin is too thin? The semiconductor film composing the Hall generator must be at least a micrometer thick; otherwise the Hall coefficient and the carrier mobility decrease rapidly (top) and the noise voltage sharply increases (bottom). These effects are the result of the thin film's irregular crystal structure.

sitivity than the ideal configuration, high noise voltages, and other disadvantages. Wear further degrades their performance.

Synergistic solutions

A solution to these dilemmas is a thin-film plate with a good Hall coefficient and a thickness of 1 μm. This is inserted in a ferrite structure with a front gap only about 2.5 μm wide. Since the structure is an open magnetic circuit, the flux is concentrated in the single gap and is perpendicular to the plate. The Hall generator mounted in the structure is so sensitive that it can be recessed deep enough in the head to allow a front electrode to be connected and a wearing-surface glass to be inserted in the top of the gap.

Recessing the generator in this way slightly degrades the output, but the loss is not serious. The recess depth is not critical—there is a leeway of tens of micrometers, while manufacturing tolerances of 10 μm can be held easily. The design also retains immunity to spacing loss, noted in Fig. 5. If necessary, the head surface can be ground down to optimize the recess depth.

Thus, each aspect of the solution reinforced the others and helped make possible production of the heads at reasonably low cost.

Single-crystal plates have a more nearly linear Hall voltage than do deposited films, and therefore, from purely a physics standpoint, would be better in a head. But it isn't practical to laminate a bulk single-crystal element into a gap less than 2 to 5 mils wide, whereas the thin film can be deposited in a gap only 2.5 μm—0.1 mil—wide. Besides, in a production environment, the bulk crystals would have to be machined; machining would damage them and cause severe performance losses. And surely some valuable crystals would be lost or broken, increasing production cost.

Film on ferrite

The remedy is to use a thin film of indium antimonide. While its carrier mobility isn't as good as that of the bulk material, it approaches half the bulk value if the film is at least 1 μm thick. The mobility and the Hall coefficient actually level off at about 0.7 μm, as shown in the top part of Fig. 8, while the noise generated by the passage of current through the film remains insignificant for thin films 0.9 μm or more in thickness, but it skyrockets for films under 0.5 μm (Fig. 8, bottom). With the total gap width of 2.5 μm, the 1.0-μm film leaves about 1.5 μm for substrate preparation, electrodes, and a coating to protect the Hall elements from scratches and other handling damage during head assembly.

During deposition, the granularity of the film must be well controlled for good linearity and low noise. The difference between a good film and a poor film is indicated in Fig. 9. The film at the left has too great a variation in crystal sizes. Its thickness is uneven, and, if pressure were applied to the large crystal (6 μm high and 20 μm in diameter), the stresses in the film would cause more noise and might fracture the film. The one at the right, though it looks more ragged, actually has an almost uniform height.

Making the crystal grains smaller reduces the mobility somewhat. However, these properties, in combination with the benefits of minimum thickness, are more than adequate for magnetic heads.

Two types of ferrite are suitable—manganese-zinc and nickel-zinc. They have the necessary magnetic properties, and since they are also dense and hard, they are good head surfaces. However, like all other ferrites, they give off by-products when heated to deposition temperatures. These by-products would make the film unstable, so they must be eliminated by pretreating the ferrite—depositing a thin layer of a nucleating agent.

9. InSb films. In these vacuum-deposited films, shown x 10,000, the one at left has higher mobility but also higher noise than the other. Furthermore, pressure on the large crystal in the left photo creates a stress that in turn generates more noise and might even fracture the film. All-around performance of film at right is better.

Also, MnZn has low electrical resistivity, requiring an insulating substrate coating of silicon oxide or aluminum oxide. NiZn doesn't need this insulating coating, making it more useful for very-narrow-gap designs.

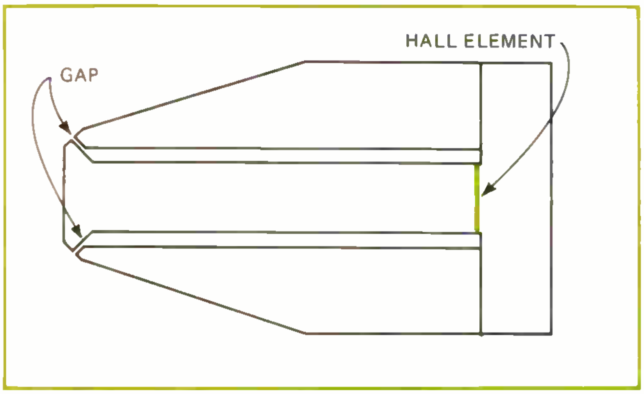
In fabrication, the ferrite surface is first polished to a smooth finish with diamond dust. (Rouge and similar abrasives would give a more mirror-like finish, but cannot be used because they would contaminate the surface.) Then, if the substrate is MnZn, a 1-μm-thick layer of insulation is sputtered on. Next, a thin nucleating agent is deposited to promote uniform crystal size.

Then, the working layer of InSb is deposited for about four minutes while the substrate is heated to about 480°C, the crystallizing temperature. An electrode coating of aluminum or gold on chromium and a protective coating complete the film. The InSb and subsequent layers are shaped to form a single element or several of them for a multitrack head which is shaped by a deposition mask or by photoetching, depending on the complexity of the plate design. Both methods provide Hall plates down to about 2 mils square.

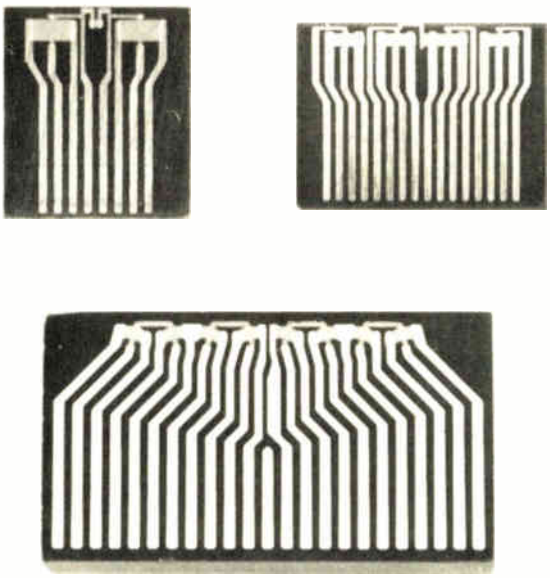
Elements for two-, four-, and eight-channel heads are shown in Fig. 10. The eight-channel array, designed for ¼-inch tape, goes into a block about 0.5 by 0.6 by 0.6 inch. Hall heads as compact as 30 in-line channels, each of which independently reads a channel on a 1-inch tape, are feasible.

At the point of sale

In the expected cashless society of the future, applications will be developed that only Hall-effect reading heads can handle. For example, the clerk at a local emporium will record a customer's purchase by passing over the price tag a magnetic wand similar to the prototypes, called Digisensors, shown in Figs. 1 and 2. In addition to the price, the wand will also pick up such information as stock number, size, and color, which can also be used for inventory purposes. This data will be fed to a point-of-sale terminal, and a distant computer will handle billing details. Or the purchase may be paid for on the spot by using a credit card in a reader.



11. Circular-gap head. Shown in cross-section, this is one type of head configuration for card- and tag-reading wands. The angled, circular gap allows the user to rotate and tilt the reader as he pleases and still get a constant output.



10. Sensor arrays. These thin-film arrays are for multitrace read heads, reading two, four, and eight channels respectively. With the sensors oriented as shown here, the plane of the tape is horizontal and its path is perpendicular to the page.

In such an application, variations in the speed with which the clerk passes that wand over the tag and in the distance between the wand and the tag must be tolerated. These irregularities will arise because the tag or card may be plastic-covered or warped and because the operator's hand is likely to waver while moving the wand. Yet none of these irregularities or any of a host of others should result in any bit dropout—otherwise, the customer might go home with an electric mixer and be billed only for an eggbeater.

The "penpoints" of these magnetic wands may have either straight gaps or gaps especially configured for the application. The circular-gap design shown in cross-section in Fig. 11, which is still experimental, allows omnidirectional reading over wide angles. However, it is not as sensitive as the straight-gap head used in the Digisensor in Fig. 2. This wand reads a 1-mm track. With a 3-V dc input, reading data recorded at 75 bits per inch, its minimum output is 2 mV peak-to-peak. The output drops to about 40% of its maximum value when the wand is tilted 20 degrees from the vertical position.

Another innovation being considered is a swivel mount for the penpoint. This would keep the read head perpendicular to the magnetic recording while the user holds the handle at the most comfortable reading angle.

Perhaps the next step will be to mount an integrated line amplifier, transmitter, or decoder in the handle of the wand. Then the Hall effect could perform such services as helping the blind keep up with the news. A braille-like code printed in magnetic ink in the margins of an ordinary newspaper or magazine could be read with the pen, translated into an audio signal, and fed into an earplug. □

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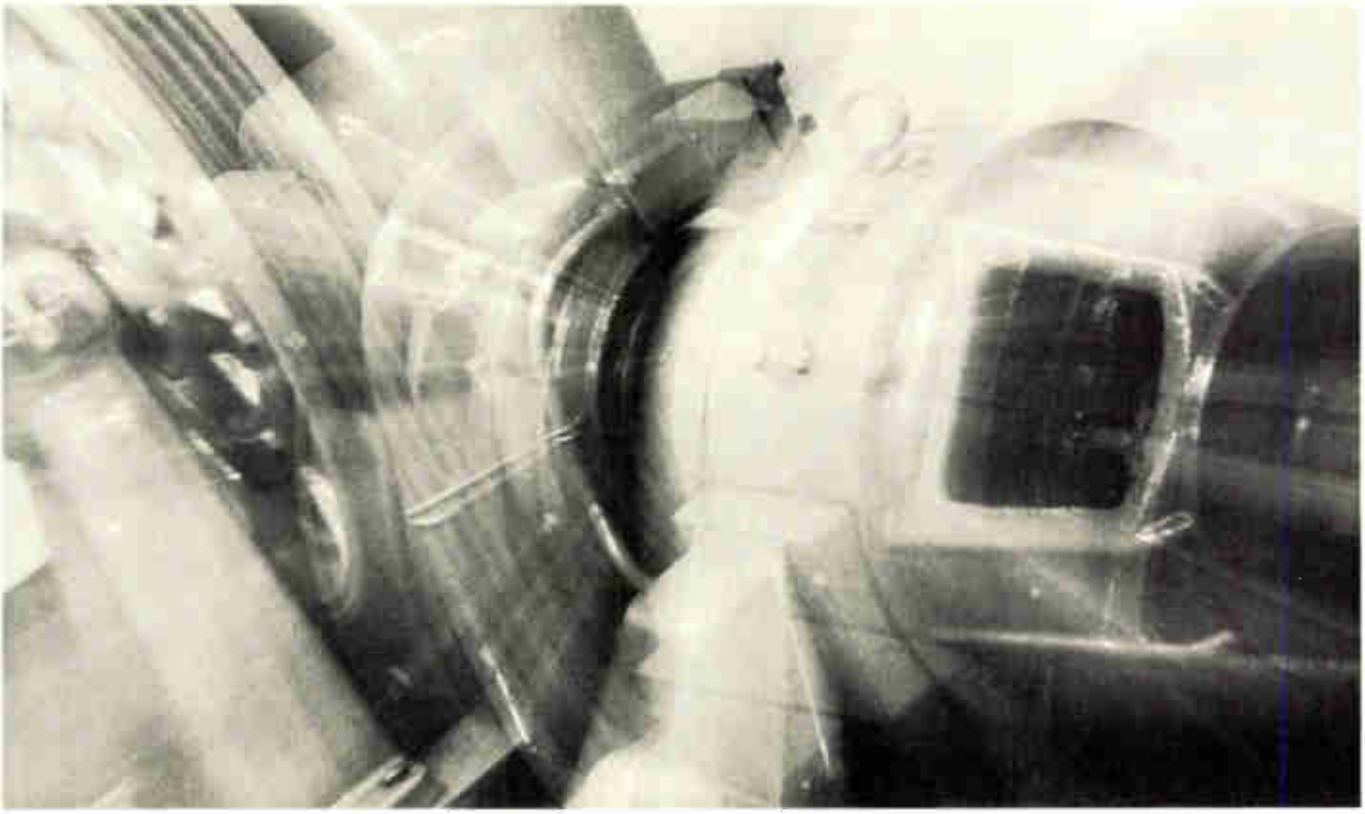

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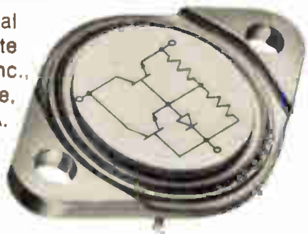


TRW® SEMICONDUCTORS

Programable monostable is immune to supply drift

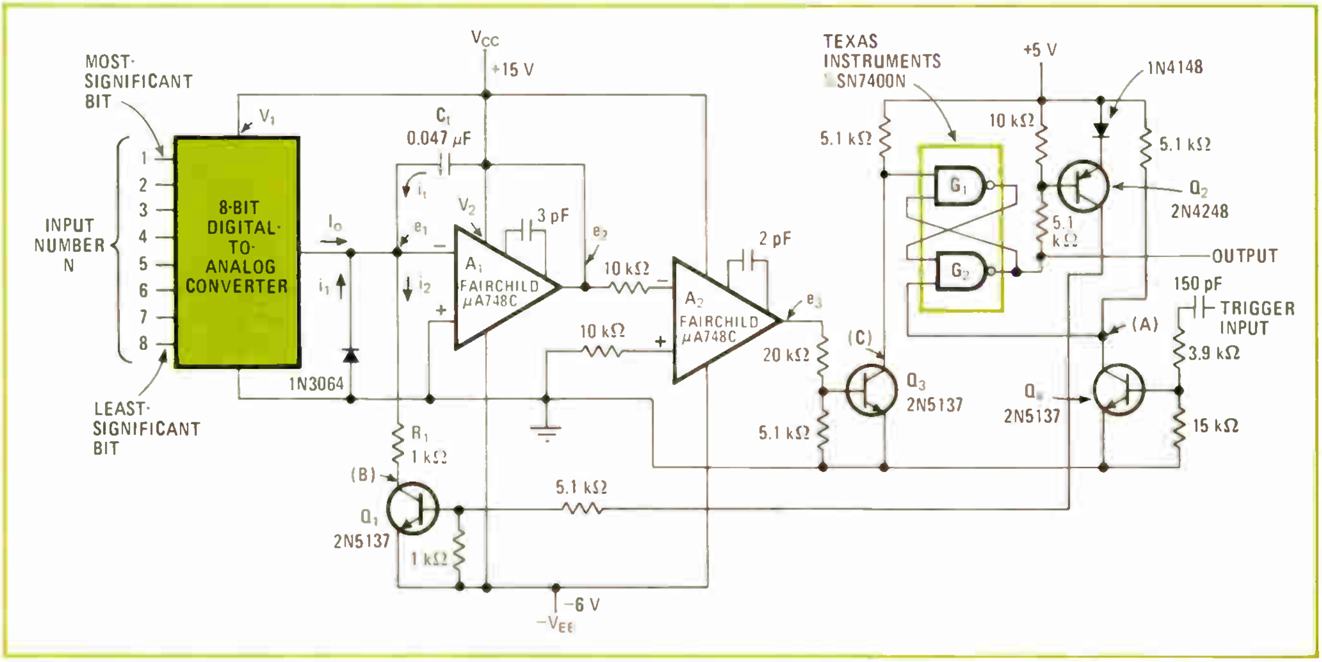
by Mahendra J. Shah
University of Wisconsin, Madison, Wis.

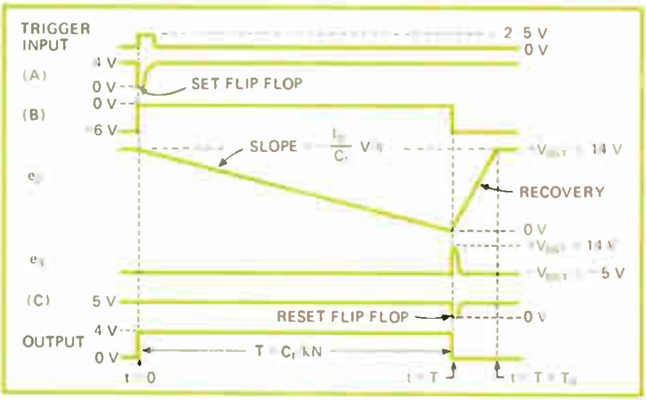
A monostable multivibrator with an output pulse width that is digitally programable is, for all practical purposes, independent of power supply variations. The circuit's output pulse period varies only −0.0055% for a 1% change in the positive supply voltage and only +0.0031% for a 1% change in the negative supply voltage. The monostable is useful in computer-controlled test systems and real-time control systems where digitally controlled pulse width or time delay is needed.

The circuit consists of a low-cost eight-bit digital-to-analog converter (one that does not have an internal reference), an integrator, a comparator, a flip-flop, and the necessary set-reset circuitry. Amplifier A_1 and capacitor C_t form the integrator, amplifier A_2 is the comparator, and NAND gates G_1 and G_2 make up the flip-flop. Transistors Q_1 and Q_2 allow the integrator's output voltage to be reset to the positive saturation voltage of amplifier A_1, while transistors Q_3 and Q_4 enable the flip-flop to be set and reset.

Initially, the monostable's output is low, transistors Q_1 and Q_2 are fully on, and transistors Q_3 and Q_4 are off. Voltage e_1 is at (minus) the forward voltage drop of the diode at the converter's output, voltage e_2 is at $+V_{SAT}$, and voltage e_3 is at $-V_{SAT}$. The current, i_t, flowing through timing capacitor C_t is zero and:

Voltage-stable one-shot. Digitally programable output pulse width of monostable multivibrator drifts less than 0.005% for 1% change in either positive or negative supply. The table shows that product of input number N and output period T is nearly constant over broad range of values. Amplifier A_1 acts as integrator, amplifier A_2 is comparator, and gates G_1 and G_2 are set-reset flip-flop.





INPUT NUMBER N	OUTPUT PERIOD T	PRODUCT N x T
1	70.5 ms	70.5
2	35.0 ms	70.0
4	17.2 ms	68.8
8	9.0 ms	72.0
16	4.45 ms	71.2
32	2.20 ms	70.4
64	1.10 ms	70.4
128	0.56 ms	71.7
255	0.28 ms	71.4
000	2.5 s	0.0

$i_2 = i_1 + I_o$
where I_o is the output current of the d-a converter.

When a trigger input is applied at $t = 0$, it is differentiated, and transistor Q_4 is momentarily turned on fully. This sets the flip-flop, the monostable output goes high, and transistors Q_1 and Q_2 turn off, making currents i_1 and i_2 zero. Now current i_t is equal to $-I_o$, causing voltage e_2 to become a linear ramp that descends from $+V_{SAT}$ towards $-V_{SAT}$ at a rate of $-I_o/C_t$ volts per second. Voltage e_1 is maintained at virtual ground.

Once voltage e_2 reaches zero at $t = T$ (where T is the monostable pulse width), the comparator (A_2) output switches from $-V_{SAT}$ to $+V_{SAT}$. Transistor Q_2 now turns fully on, resetting the flip-flop and causing the monostable output to go low.

Transistors Q_1 and Q_2 then turn fully on, producing a reset current of:
$i_t = V_{EE}/R_1 - I_o$
This current causes voltage e_2 to rise linearly towards $+V_{SAT}$ at a rate of $(V_{EE}/R_1 - I_o)/C_t$ volts per second. Voltage e_2 reaches $+V_{SAT}$ at $t = T + T_R$, where T_R is the monostable recovery time:
$T_R = V_{SAT}C_t/(V_{EE}/R_1 - I_o)$
The monostable is now ready to accept the next trigger.

The output current for the d-a converter is given by:
$I_o = kV_1N$
where k is a constant that equals 0.68 micromho, V_1 is the converter's supply voltage, and N is the binary input number. The monostable pulse width can be written as:
$T = V_{SAT}/(I_o/C_t) = (V_2 - 0.5\ v)/(I_o/C_t)$
where V_2 is the integrator's positive supply voltage. Substituting for current I_o in this equation yields:
$T = (V_2 - 0.5\ v)C_t/kV_1N$
Since V_1 and V_2 are 15 v—a much higher voltage level than 0.5 v—this equation can be approximated by:
$T = C_t/kN$
which indicates that T should be very nearly independent of the power-supply voltage.

The table in the figure shows the product of N × T to be almost constant over a range of input numbers. □

Getting power and gain out of the 741-type op amp

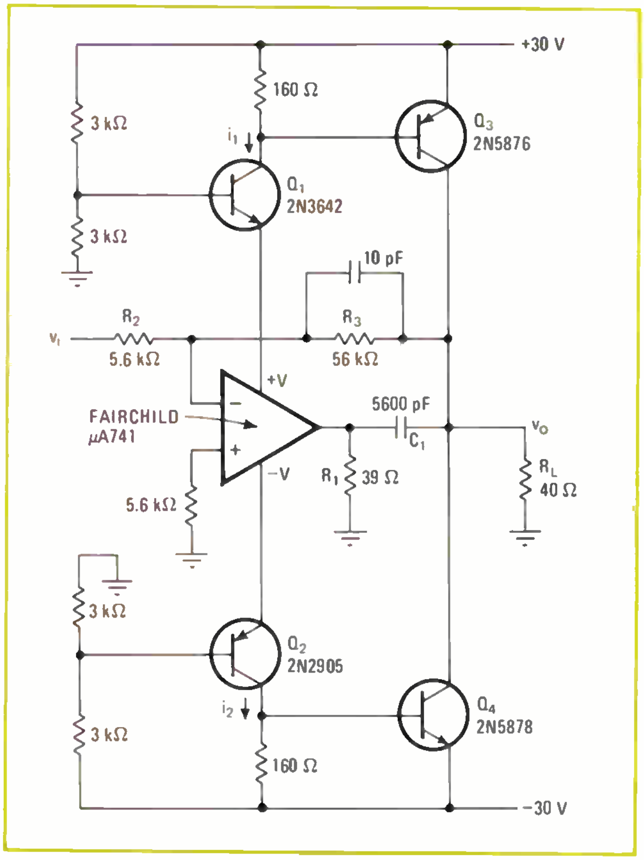
by Pedro P. Garza, Jr.
General Electric Co., Apollo and Ground Systems, Houston, Texas

The popular 741-type operational amplifier can be used as the basis for a high-voltage power amplifier that is capable of delivering 22 watts of peak power at an output voltage swing of 60 volts. Voltage gain for the amplifier is 10, and its frequency response is flat from dc to 30 kilohertz.

Most integrated-circuit op amps are not designed to accept more than 36 v across their power pins. Here, therefore, transistors Q_1 and Q_2 protect the 741-type op amp by maintaining a 30-v differential across the device's power pins. The base of transistor Q_1 is biased at 15 v by the voltage divider network formed by the 3-kilohm resistors, while Q_1's emitter is at 15 v minus its base-emitter voltage drop. The biasing arrangement for transistor Q_2 is similar.

Since a 39-ohm resistance (resistor R_1) is connected to the op amp's push-pull output, substantial currents will be drawn by the device. Currents i_1 and i_2, which appear at the collectors of Q_1 and Q_2, are used to generate the base drive voltage for the power-output stage, made up of transistors Q_3 and Q_4. The power-output stage has a wider frequency response than the 741-type op amp. The negative feedback path through capacitor C_1 provides a frequency roll-off characteristic similar to that of the op amp, thus assuring unconditional stability.

The resistance ratio of resistor R_3 to resistor R_2 determines the amplifier's voltage gain. If the op amp's input-offset voltage is nulled out and resistors having tolerances of ±0.25% are used for R_2 and R_3, the power amplifier's linearity error will be within 0.4% over the output voltage range of +29.8 v to -29.8 v.



Power amplifier. Widely used 741-type op amp is heart of 22-watt power amplifier that supplies 60-volt output swing. Transistors Q_1 and Q_2 keep peak-to-peak voltage across op amp's power pins at 30 V so that device's 38-V rating is not exceeded. Using low-value load resistor (R_1) at op-amp output produces currents (i_1 and i_2) large enough to drive output power stage of transistors Q_3 and Q_4.

Output voltage swings of more than 60 v are possible if transistors with higher collector-base breakdown-voltage ratings are used along with higher power supply voltages. □

Solid-state dpdt switch provides current reversal

by Don DeKold
Santa Fe Junior College, Gainesville, Fla.

When the dc current flowing through a load is periodically reversed, the alternating square-wave voltage developed across the load has a peak-to-peak amplitude that is twice the magnitude of the power-source voltage. A circuit that provides periodic current reversal is useful for driving loads that otherwise might become polarized by the steady passage of a unidirectional current.

Dc-to-ac inverters may be used for periodic current reversal, but they usually require a power transformer of relatively large size and weight. Additionally, these circuits frequently have sizable standby currents because they generally contain saturating transformers, making them inefficient under light load conditions.

The solid-state circuit in the diagram solves these problems. It acts as a double-pole double-throw switch that periodically reverses the current through its load resistor, R_L.

Transistors Q_1 and Q_2 are the active elements in an ordinary astable multivibrator. They alternate between saturation and cutoff at the multivibrator's basic pulse-repetition rate. Transistors Q_3 and Q_4, which are driven by transistors Q_1 and Q_2, respectively, also alternate between saturation and cutoff, but are 180° out of phase with Q_1 and Q_2.

The load-driver section of the circuit is made up of four Darlington pairs, labeled transistors Q_5 through Q_8 in the figure. A single pnp pair, such as the one designated transistor Q_5, is connected in complementary fashion to an npn pair, such as the one identified as transistor Q_6. Each Darlington pair is an output stage that is either saturated or cutoff, depending on the operating state of transistors Q_1 through Q_4.

Diagonally opposite output stages (such as transistors Q_5 and Q_8) are switched on at the same time as the two other diagonally opposite pairs (transistors Q_6 and Q_7) are switched off. This condition holds for half of the multivibrator's period and reverses for the other half, as indicated by the table.

The circuit's efficiency is very high because practically all of the supply voltage is applied across the load during each half of the operating cycle. The transistor states change at the pulse-repetition rate of the multivibrator, producing an alternating current through the load. In effect, the circuit is a solid-state double-pole double-throw switch that is toggled at the frequency of the multivibrator. If the multivibrator stalls or does not start when power is applied, both transistors Q_1 and Q_2 will saturate, cutting off the other devices and preventing any load current from flowing.

With the components shown, the circuit supplies an alternating current of 1.6 amperes to a 24-volt load. Standby current is about 25 milliamperes, and the multivibrator frequency, which is unaffected by loading, is 57 hertz. If desired, a heavier load can be driven, since the type HEP245 and HEP246 transistors are rated at 3 A. The supply voltage, of course, may be any value that does not exceed device-breakdown voltages.

Operating frequencies in the kilohertz range can be achieved by merely decreasing the values of the two multivibrator capacitors. If a higher output voltage is wanted, the circuit can directly drive a step-up transformer, but arc-suppression diodes must be placed across each output stage. Loading of the output must never short either terminal to ground. □

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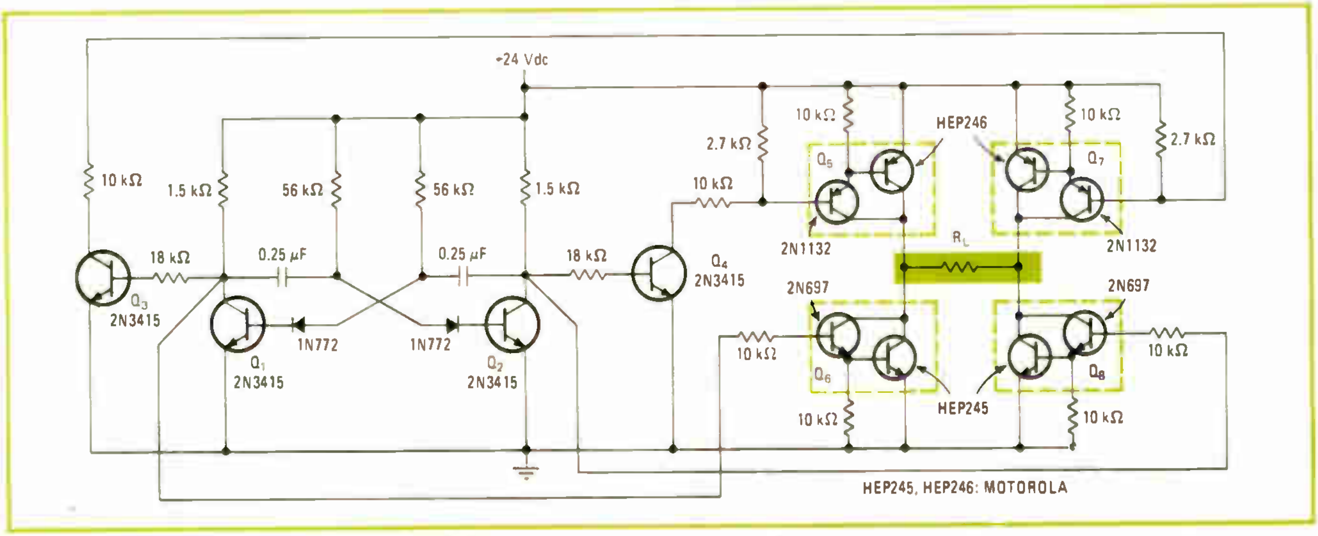
OPERATING CYCLE

FIRST HALF	SECOND HALF
Q_1 ON, Q_2 OFF	Q_1 OFF, Q_2 ON
Q_3 OFF, Q_4 ON	Q_3 ON, Q_4 OFF
Q_6 OFF, Q_7 OFF, Q_5 ON, Q_8 ON	Q_6 ON, Q_7 ON, Q_5 OFF, Q_8 OFF



Current-reversal switch. Solid-state circuit periodically reverses load current, making amplitude of square-wave load voltage twice the level of supply voltage. Operating frequency is determined by astable multivibrator formed by transistors Q_1 and Q_2. Four Darlington pairs, labeled transistors Q_5 through Q_8, make up the output stages. Diagonally opposite pairs are on while the other two pairs are off.

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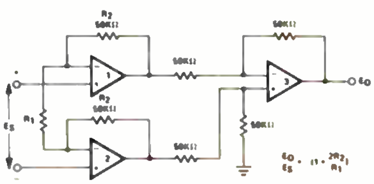

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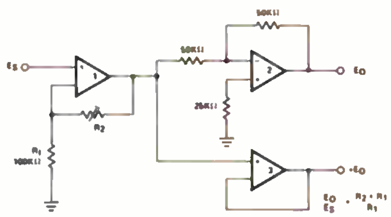

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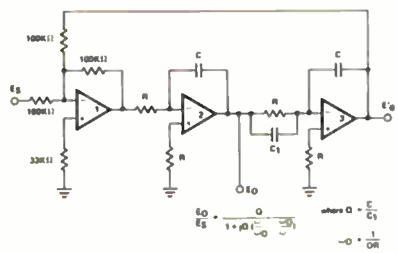

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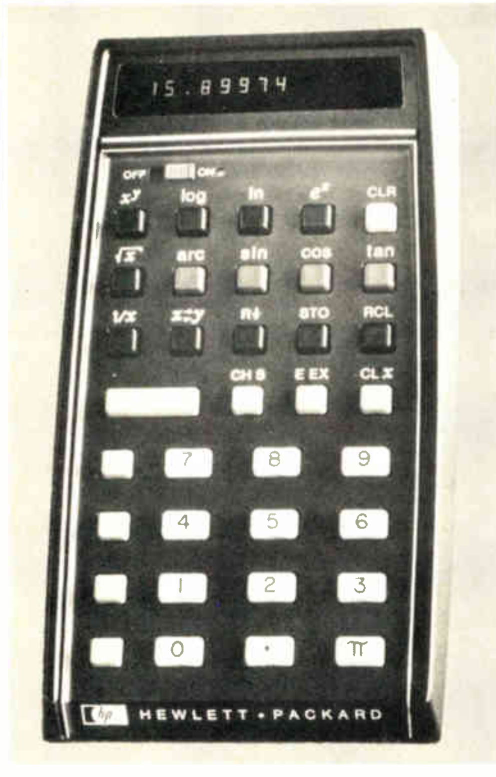
Product development profile

The HP-35: a tale of teamwork with vendors

When the company president wanted a scientific calculator that would fit into his shirt pocket, Hewlett-Packard got into a new business, with a lot of help from its MOS suppliers

by Gerald M. Walker, *Associate Editor*



☐ For a shirt-pocket calculator, the HP-35 has already piled up enough charisma to get a spot on a TV talk show—if it could talk. Fortunately for the Hewlett-Packard team of designers and the vendors they brought in to help, company president William Hewlett did not ask that the little calculator talk. He did, however, set the basic objectives for the HP-35 which were to provide its personality.

Like any popular new star, it has had both triumphs and tribulation. The first triumph was for the designers, who got it to the market in less than a year and a half. The second has been a sales success of more than 50,000 units since the machine went on sale a year ago. While the first version has been aimed at the engineer and scientist, another model, the HP-80, has recently been announced for financial and accounting applications.

The tribulation was an embarrassing discovery late last year of a programing error, since corrected, in the LSI memory. Discovered by a user, the error triggered a recall letter to customers, but because the probability that the error would foul up a calculation is very small, not many units have been returned for alteration.

The idea for the HP-35 was originally conceived in March, 1968, when the company introduced the HP-9100A calculator, a table-top, programable machine for scientific and technical uses. At that time Bill Hewlett wondered if the next calculator developed couldn't be a tenth the size and cost of the 9100A. (It could.) Later he refined the goal to be a battery-powered, hand-held unit capable of being carried in his shirt pocket. (It can be.)

Work had begun in earnest at the Advanced Products division by the fall of 1970, a critical year to be thinking about the hand-held calculator market. At the time, Japanese manufacturers dominated the business-type field, and the first signs had appeared of a consumer market pitting U.S. and Japanese companies in a price battle. Nevertheless, H-P debated whether its first entry should go after the business-machine trade. But by the time that design plans were under way, H-P had decided to stay in the scientific market more familiar to it.

Hewlett had presented a small machine with a tall order to fill. To be a scientific/engineering calculator, the 35 had:

- To perform trigonometric, logarithmic, exponential, and square-root functions, as well as the standard four math functions of other hand-held calculators.
- To have a full two-hundred-decade range, allowing numbers from 10^{-99} to $9.999999999 \times 10^{+99}$ to be represented in scientific notation.
- To have a 15-digit display.

Finally, with all these added functions, it required a different type of keyboard if every key and contact was to be fitted into a limited space.

Far and away the greatest challenge presented by the HP-35 was the design and development of the necessary metal-oxide-semiconductor large-scale integrated circuits. These consist of three identical instruction read-only memories, an arithmetic-and-register (A&R) chip, and a control-and-timing (C&T) chip. On top of the requirements for high density and high speed imposed by the scientific nature of the machine was the need for low power imposed by its size and portability. Four hours of battery operating time was the goal, yet the shirt-pocket size of the calculator limited the 35 to few and small batteries.

Thomas M. Whitney, section manager for the HP-35, recalls, "To get the right function density we went to a totally serial design, which reduced interconnections both internal to the chip and between chips. The complex algorithms to compute transcendental functions require many multiplications, which forces a high clock rate. To get a 1-second-maximum computation time for any function, we felt a 200-kilohertz bit rate could do the job."

Help from outside

At this point, the design team made an important decision: to have the MOS design done outside. Hewlett-Packard has some experience in MOS, but the high-density, low-power circuit design was too demanding for it to tackle in the short time Hewlett had allowed for completing the task. This decision created a textbook case of successful vendor relations with the two MOS LSI suppliers eventually chosen for the HP-35: Mostek Corp., Carrollton, Texas; and American Microsystems Inc., Santa Clara, Calif. Each company took a different approach to meeting the MOS requirements, yet the result more than satisfied H-P's specifications.

Whitney points out that one of the requirements for vendor selection was that the firm have a low-threshold process for production. He also avoided companies that had plans to market their own calculators, to dodge any conflict of interest.

After preliminary discussions, seven companies were asked to quote: one dropped out because the part could not be offered to other buyers; two said it couldn't be done with the three-chip partitioning demanded by H-P; and four submitted bids. Mostek and AMI were selected on the basis of a combination of past performance and H-P's belief that the ion-implanted, p-channel MOS process, which they both proposed, was the best route to low-power, high-density chips.

Two vendors were chosen in an effort to insure rapid development, a dual supply source, and competitive prices, says Whitney. Once H-P had picked the suppliers, relations with them were remarkably free. Both were allowed leeway to rework the logic diagrams and the performance specs. And for relaxing its attitude toward vendor suggestions, H-P was rewarded with better-than-spec chip performance.

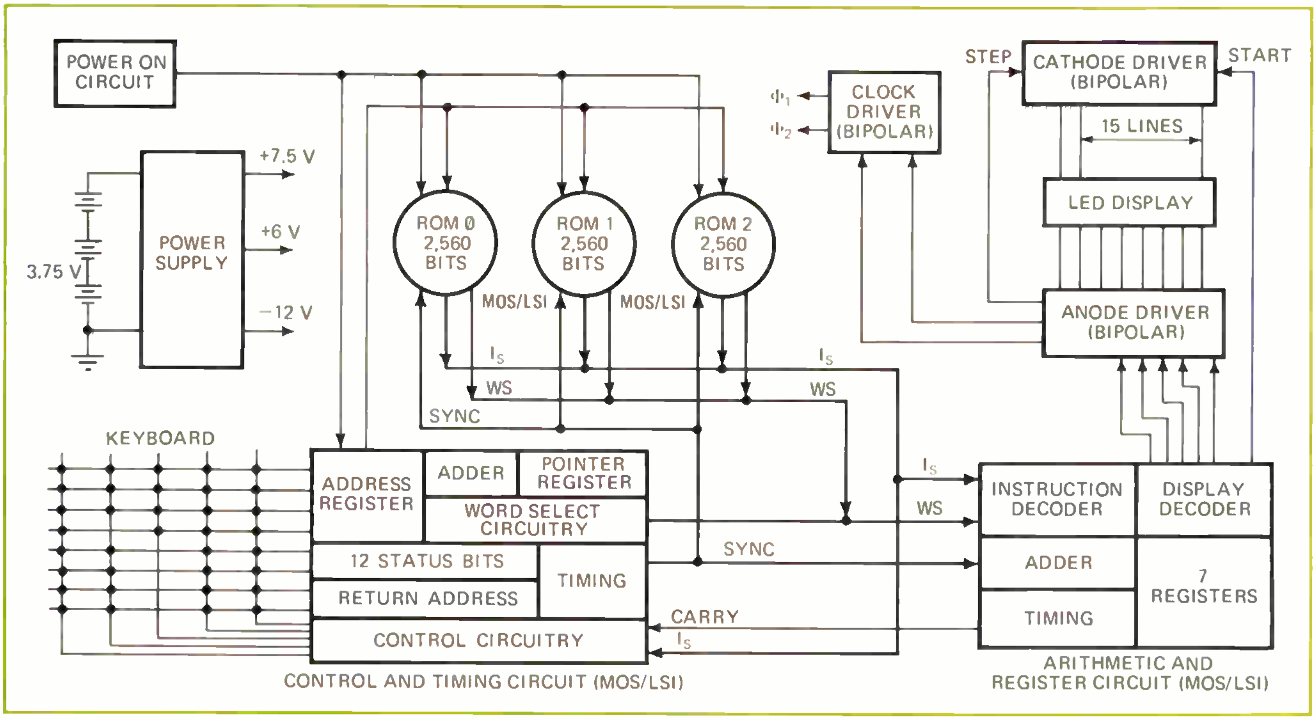
The degree of freedom permissible in vendor relations was a touchy subject, particularly in view of the time crunch imposed by Hewlett's direct interest. The issue was how much the LSI developers should be allowed to change H-P's original logic design. On the one hand, if a supplier thoroughly understood the requirements, he might be able to suggest improvements. But on the other, there was danger of slowing the project while the engineers wrestled over differing viewpoints or else bogged down production schedules with

Product development profiles

Of the hundreds of high-technology products introduced each year, many fail to catch on, many are moderately successful, and a few are outstanding hits in both their conception and ultimate acceptance.

These product "stars" are not just accidents, but the result of anticipating a need, designing to fit the need, and timing the introduction. This article launches a continuing series that will examine the evolution of exceptional electronic products to show how they were designed and developed. Each installment will attempt to tell how such a product came together.

The HP-35 calculator illustrates one of the major effects of integrated-circuit technology—the increasing interdependence of customer and vendor in getting a job done. Other articles in the series will cover components, instruments, and complete systems.



1. Insides out. The HP-35 block diagram above shows the MOS LSI circuits manufactured by Mostek and AMI—three ROMs, a control and timing circuit, and an arithmetic and register circuit. Three bipolar ICs developed by H-P drive the LED display. H-P also makes the keyboard.

vendor changes that in turn would require design alterations by the customer.

In this case, AMI chose to work within the H-P logic diagrams by adapting to the requirements. Mostek chose to suggest changes to optimize its own production scheme for meeting the power requirements. Each company claims to have the better approach. Both had problems, fortunately on different portions of the design, so that between the two of them, first delivery dates were met and the first prototype had a mixture of parts from the two vendors.

The first chip AMI produced successfully was the control-and-timing circuit, while it was the last Mostek completed. Mostek's arithmetic-and-register chip worked the first time, while AMI had to redo its version. Neither had trouble delivering the ROMs. Production models are either all-AMI or all-Mostek because the two suppliers' chips don't really run well together. Though the parts are the same electrically, the different locations of the precharge make it impossible for the Mostek A&R to operate with the AMI ROMs. (Actually, H-P did not specify that the chips be compatible in all respects, though this could have been done if the demand had been made.)

Another important decision made by H-P was to develop a computer simulation program to check the system design and the MOS circuits. It was felt that two or more months could be saved using the computer simulation approach rather than a breadboard because engineers could work in parallel, rather than serially on a breadboard.

H-P used a general-purpose simulation program to check out each gate, each circuit, and each chip (apart from the ROM), and finally all the chips together, including the ROMs. Each MOS circuit is designed as a network of gates and delay lines. For each gate output, an algebraic equation was written as a function of the gate inputs. This produced a large set of algebraic equations to be evaluated every clock time. A printout was available so the operation of any of the gates or delay outputs could be checked as if with an oscilloscope probe.

The general-purpose simulation program was too slow to handle the algorithms on the ROMs. For these, H-P used a higher-level simulation in which only the input/output functions of each subsystem within the ROM had to be specified. If anything went wrong, it was possible to stop the program and step through it to find the trouble. Changing a punched card or two then fixed the problem.

Thanks to the simulation programs, it was possible to set up patterns for testing the completed ICs. A complete test pattern was generated by running a program and recording all the inputs and outputs on tape for final test of the IC. Nevertheless, H-P found many errors in the first ROM programs, in some cases because the simulation did not exactly duplicate the hardware. Reprograming fixed the simulation. Other minor errors in the algorithms have been found since, requiring additional alterations.

Perhaps the biggest benefit to Mostek as a supplier was that Hewlett-Packard was not only flexible in accepting suggestions for changes, but had done its homework in MOS design. Says Robert J. Paluck of Mostek, "H-P consulted its own MOS facility and learned what the MOS designer wants to see on the logic diagram—it's different from TTL, and engineers used to TTL usually don't know how to produce the logic diagram. We had to redesign only to optimize the circuit. H-P is an exception in this respect, they gave us what we needed to optimize the logic and power supply." Paluck feels that if Mostek had gone ahead without questioning the H-P logic design, the end product would have required twice the power with larger chips than actually proved necessary.

AMI AND MOSTEK CHIP SIZES COMPARED

Circuit type	Final size (mills) AMI	Mostek
Instruction ROM	116 x 108	126 x 134
Arithmetic and register	138 x 167	156 x 200
Timing and control	163 x 169	150 x 212

What Mostek did

Mostek engineers took the H-P award as more than a routine contract, and planned accordingly. They set up three concurrent projects under the direction of a program manager—design and layout of the three MOS chips, construction of a hardware system simulator, and construction of a computerized production tester. An MOS design engineer assumed full responsibility for each circuit's logic, electrical implementation, and layout, and eventually for its transition into production.

"A hardware simulator of the calculator was built to verify that the proposed MOS designs were not only logically correct, but also capable of properly interfacing with the peripheral circuits," Paluck reports. "A Mostek systems engineer was assigned to understand the entire calculator operation and construct a node-for-node simulator, implemented with TTL elements. This breadboard would not only help insure system success but also would be used to check out and characterize prototype parts. At the same time the Mostek test equipment group began the design and construction of a PDP-11 computer-controlled tester for the three chips."

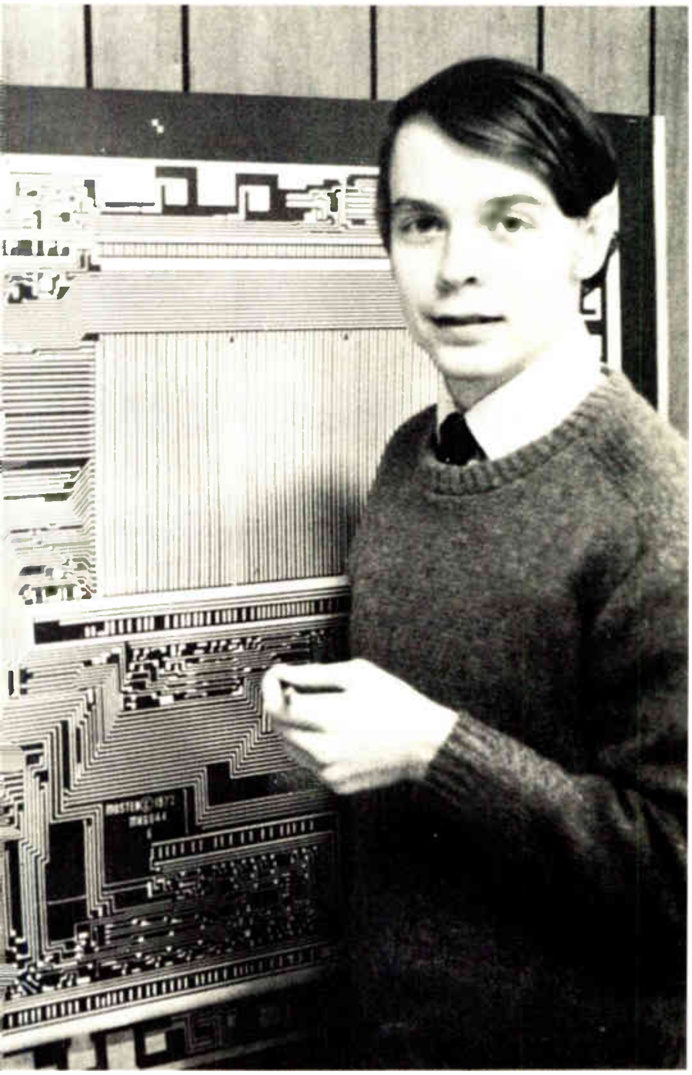
One of the reasons for these elaborate preparations was that the Mostek design team was apprehensive about H-P's computer simulator. "The first time a program is used, a computer simulator always has bugs. Sometimes it may call out an error that doesn't exist, or worse, or pass a chip that has errors due to a programing fault," Paluck comments. Thus, while H-P felt it could save two or more months by using the simulator, Mostek was of the opinion it could head off six man-months of program debugging by building the breadboard.

In giving Mostek the go-ahead to optimize the logic designs, H-P at the same time made it clear that the vendor would have to take complete responsibility for the success or failure of its alterations. In practice, however, the working relation between the two engineering groups was not as threatening as the language of the contract might have implied. Most of the communication about changes was by phone followed by documentation for H-P to check. This approach paid off.

One change achieved in this way concerned a portion of the design for the decode section of the ROM chip. Though H-P's design called for 24 loads, that is, 24 gates for burning up power, Mostek was able to cut these to four units of power consumption. In the A&R chip, Mostek cut the bit time to output, reducing the 18 levels of logic in the H-P diagram to 12 by minimizing the number of circuit paths. "To reduce power, aid in minimizing layout, and meet timing specifications, propagation paths to output buffers were reduced, look-ahead logic was added to slow paths, and various decoding and counter techniques were changed," Paluck states. Mostek also made allowance (as did AMI) for keyboard bounce, which can completely destroy accuracy in calculations.

Transforming the logic into an electrical circuit followed. This required development of several special circuits, in addition to the logic gates, flip-flops, and output buffers. For instance, an internal clock generator that reduced the area of one chip was designed to extend, attenuate, and regulate the external clocks.

Caveat vendor. Robert Paluck, Mostek team leader, explains that H-P allowed leeway in changing logic designs, but at Mostek's risk



Another problem was integrating both the random logic and 400 bits of memory on the A&R chip. Mostek solved this with a high-packing-density shift register. After completing a composite drawing of the masks used in the MOS fabrication process, all the critical parts and individual circuit elements were simulated with the aid of the company's MOS transient analysis program. The composite was then ready for generating the artwork for the actual integrated circuit.

The first instruction ROM turned out to have a layout error necessitating a change in the masks and a new run of material. "On the second try the circuit operated perfectly, with a power dissipation of only 3 milliwatts, a value 10 times less than was originally quoted," says Paluck.

The first A&R chips worked on the first try. Power dissipation for this circuit was 20 milliwatts, 10 mW below the original estimate. On the other hand, Mostek ran into electrical and layout problems in the C&T circuit which required two iterations to repair.

Paluck remarks, "The breadboard was used extensively during the check-out of this chip. With it we were able to override internal erroneous signals that might have masked possible problems in other sections of the logic." The final version of the C&T circuit dissipates 50 mW.

Mostek ran into more difficulty when starting to ship production quantities. The computerized tester was taking time to check out, but again the hardware simulator saved the day by filling in as a slow, yet thorough tester. The computerized tester was in full swing by February, 1972, for all five of the calculator chips.

AMI's approach

"We took a different approach from Mostek," comments Andrew M. Prophet, manager of digital products at AMI. "We took H-P's logic and turned it into a circuit layout. One of the things we have learned is to keep the chip as small as possible, thus, all of the layout was done by hand."

However, AMI did not take H-P's logic diagrams without question. To check them out, the company used a

Satisfied supplier. Andrew Prophet of AMI feels the MOS chip size and low power proved value of ion-implantation process.

logic simulator. "The purpose is to simulate the customer's logic and make sure what we have in MOS is the same as what they had in software," Prophet explains. At this point specs were also checked against the customer's original. AMI originally had some question about the number of chips specified by Hewlett-Packard that needed to be clarified.

For both vendors, the hardest of the H-P chip set specs was the call for 250-mw power dissipation. But while Mostek's prime target was to hit that spec by being conservative about speed and size, AMI's basic concern was to meet the speed spec by conservative handling of the power-dissipation requirement.

AMI's final parts run at about 100 to 120 mw, considerably higher than Mostek's. Nevertheless, Prophet feels that AMI made the correct tradeoffs on this score. Prior to the H-P contract, AMI had only produced about 10 chips with the low-threshold, ion-implanted process. As a consequence there was some question about the final speed of the parts, and since there is a fixed speed-power relation for a given process, the level of power dissipation was also kept flexible—though the engineering team knew that it could come in under the specified 250 mW. The result, Prophet confirms, "is that our power is slightly higher than Mostek's, but our devices are faster."

Chip size is another design tradeoff that concerned AMI as well as Mostek. The rule of thumb is that the smaller the chip, the better the yield and thus the less expensive it is to make the part. Prophet is satisfied with the final chip sizes, which are smaller than Mostek's.

He adds that now that AMI knows more about the ion-implantation process, "we could redesign the H-P chips to consume less power." Ultimately the differences in size and power dissipation between AMI and Mostek chips boil down to the types of gate used. AMI employed NOR structures, which are smaller than the AND/NOR structures used by Mostek but entail a larger number of nodes so that the power dissipation is higher.

Unlike Mostek, AMI used its standard tester for the finished products, a machine called PAFT (for programable automatic function tester). PAFT was originally built to AMI specs.

And H-P did the rest

While Mostek and AMI were racing to turn around the MOS LSI chips in the shortest possible time, Hewlett-Packard had tackled other critical parts of the 35. H-P's Whitney concedes that even though H-P had to work on a multichip, plastic package for light-emitting diodes; low-power, high-current bipolar display drivers; a new type of keyboard; and the power supply, "in the end we were waiting for MOS parts." One reason is that most of these other major parts were manufactured internally, so "top priorities could be established and overtime authorized as necessary."

For the display, H-P developed a magnified five-digit LED cluster which saves both power and cost and comes in an easy-to-install 14-pin package [*Electronics*, Jan. 17, 1972, p. 64]. The 35 uses three clusters. Since LEDs are more efficient if pulsed at a low duty cycle, energy is stored in inductors and dumped into the diodes, allowing a high degree of multiplexing.

H-P also developed and manufactured special bipolar anode and cathode driver circuits for the display. The anode driver generates the two-phase system clock signals, as well as drive signals for the segments; it decodes the data from the A&R chip and inserts the decimal point; it sends shift signals to the other axis of the multiplex circuitry, and it reports low battery voltage by turning on all decimal points as a warning that only 15 minutes of operating time remain. The cathode driver contains a 15-position shift register, which is incremented for each digit position.

Since the HP-35 design started from the outside package—president Hewlett's shirt pocket being the fundamental specification—a considerable amount of planning was necessary to fit 35 keys, an on-off switch, and a 15-digit display into the front panel. The magnified LED clusters helped solve the size problem for the display. The keyboard, which was to fit into an area about 2.5 inches by 4.5 in., had to deviate from the usual ¾-in. center-to-center key spacing. Reducing the size of each key, however, made it possible to compromise on 11/16-in. center-to-center spacing for the numeric keys and ½-in. spacing for the various function keys.

Two printed-circuit boards carry all of the circuits. One holds the specially designed spring mounts for the keyboard and the LED display, and the other has the remaining electronic components. A series of pin connectors attaches the two boards.

"In terms of customer response," Whitney notes, "the HP-35 is the most successful H-P product ever introduced. The price is a tenth that of the 9100, with 1/80 the volume in size." And in terms of Bill Hewlett's shirt pocket, H-P's engineers and vendors are glad to report an excellent fit. □

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All together. Thomas M. Whitney, H-P section manager, points out that the MOS suppliers bettered the original specs for power dissipation and helped meet size and cost goals for the chips. Another helper: president Hewlett, "the behind-the-scenes project leader."

An easy way to design complex program controllers

With less than a handful of functional integrated circuits, an engineer can use a general method to readily put together a logic program controller to direct even the most involved operations

by Charles L. Richards, *Seaco Computer Displays Inc., Garland, Texas**

☐ When an electronics engineer needs to design a complicated program controller, he may well experience a sinking feeling—it could mean a return to the textbooks to relearn the techniques of transfer tables, combinational and sequential logic, and component minimization. But a new general design method relieves the engineer of these burdens and allows him to configure and prototype even an extremely complex logic controller with a minimum of effort, time, and cost.

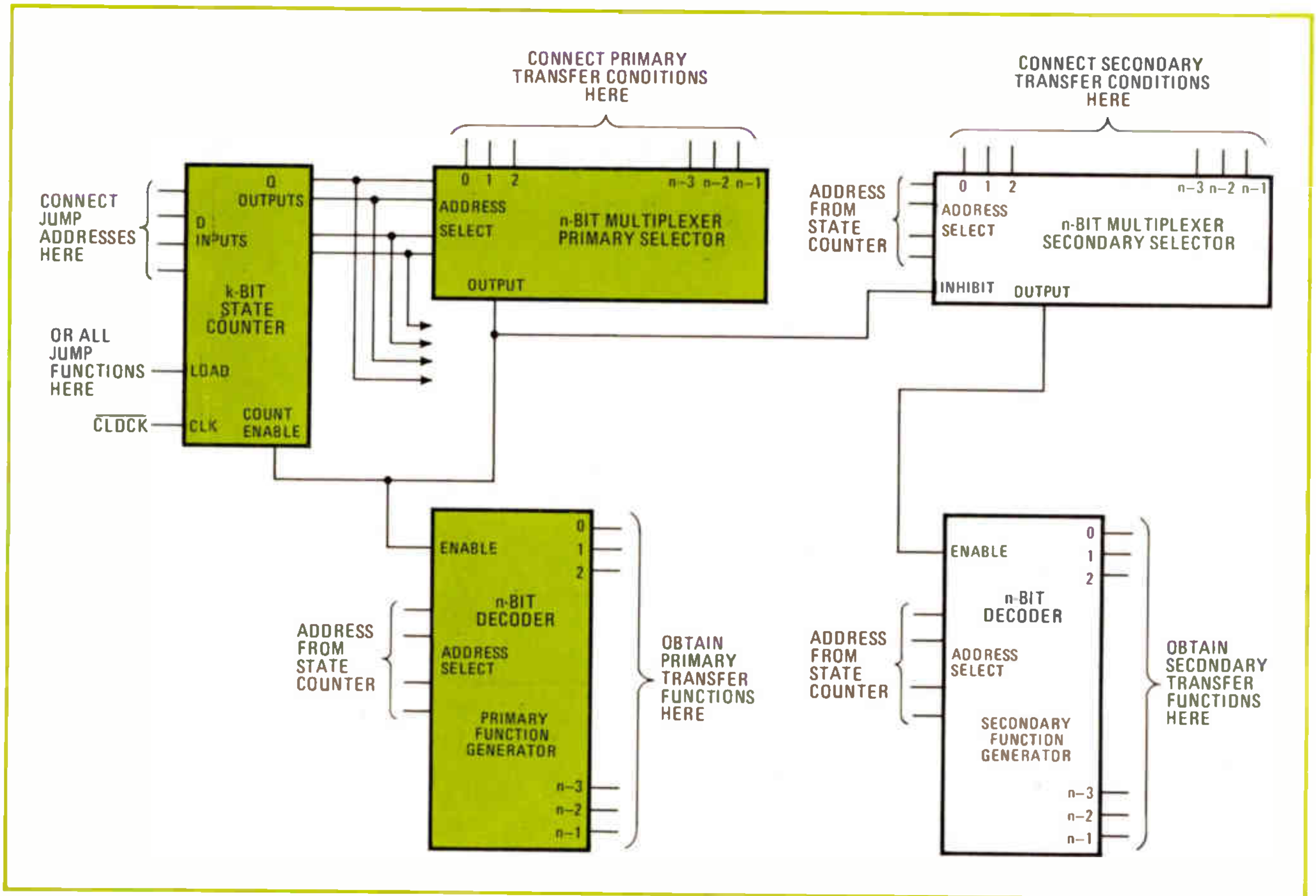
What's more, the generalized approach applies not only to straightforward sequential controllers, but also those that implement nonsequential YES-NO and multiple-choice decisions. That is, a controller can be made to index one state (or step) at a time, or to jump forward or backward to any predetermined state, or to choose which input condition out of many in the same state is to cause it to either index or jump.

In fact, the method is so easy to learn and apply that an engineer using it for the first time was able to design

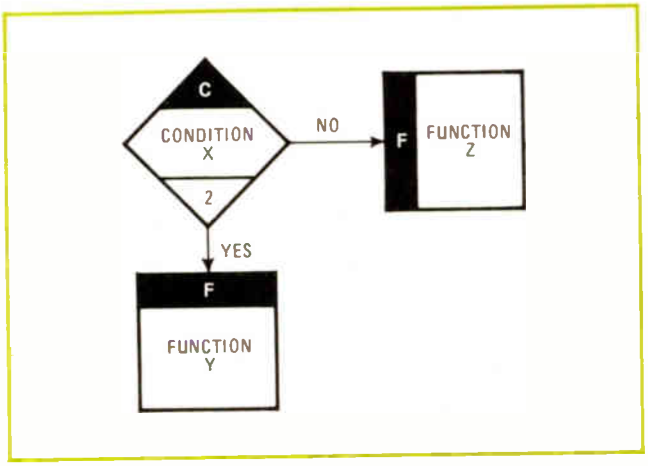
Closing the loop

Readers wanting to discuss this technique further with the author can call him on Feb. 12, 13, or 14, between 7 and 10 p.m. CST at (214) 272-9458.

1. Key logic elements. The state counter, multiplexer, and decoder, in color, are the main devices needed to produce a sequential controller that indexes from one step to the next. Adding secondary devices permits both nonsequential and priority control actions.



*Now with Texas Instruments Incorporated, Dallas, Texas



2. Transfers defined. Diamond denotes transfer condition, while rectangle denotes transfer function. One function is the action initiated by a transfer condition of YES, while a transfer condition of NO can initiate the other transfer function.

and prototype a controller involving 54 different states, with many states having five decision levels. The controller required 178 integrated circuits, had no logic errors, and worked perfectly the first time power was applied.

The three integrated circuits shown in color in Fig. 1 form the kernel of the logic-program controller. These primary devices are a k-bit state (or step) counter, an n-bit multiplexer, and an n-bit decoder. Here, n, the number of controller states, equals 2^k. For an eight-state controller, the three IC devices in plastic dual in-line packages cost about $12, even when bought at their maximum, single-unit prices.

By adding another multiplexer and decoder, shown at the right of Fig. 1, to handle secondary input conditions, the controller can be made to perform condition-priority and nonsequential—or jump—operations. Appropriate jump addresses are fed back to the primary state counter through AND and NAND gates. More complicated program control can be obtained simply by adding more multiplexers and decoders.

Flow diagram tells all

The design process starts with a statement relating the controller's inputs to the output actions to be initiated by the inputs. The sequence of events can be represented by a flow diagram of the individual states in the over-all program. The diagram can be readily converted to a group of logic-state equations, which then clearly tell how to connect the inputs and outputs, including address jumps.

To explain how the generalized controller can be applied to three applications of varying complexity, it is necessary to define the terms transfer condition and transfer function. These are shown symbolically as the diamond and square in Fig. 2.

The diamond-shaped box represents the transfer condition, which concerns a YES or NO decision. The number in a diamond is the state (or step) number for that transfer condition. The transfer condition can be implemented physically by such two-state devices as a thermostat switch, a flip-flop, or a pulse.

The transfer function, denoted by the rectangles in Fig. 2, is an action that is started or stopped by the transfer condition. As examples, the transfer function can gate a digital counter or start a motor. As shown, a YES transfer condition initiates one transfer function and a NO another transfer function.

Furthermore, depending on the controller's application, the transfer conditions can be either independent of or dependent on the transfer functions. In a dependent case, for example, the transfer condition might trigger a transfer function that starts a count of 1,000 events. The occurrence of the 1,000th count then serves as the next transfer condition. In an independent case, the next transfer condition might be an input from a timer occurring 500 milliseconds after the count starts, whether or not the count has reached 1,000.

1. Designing an eight-state sequence controller

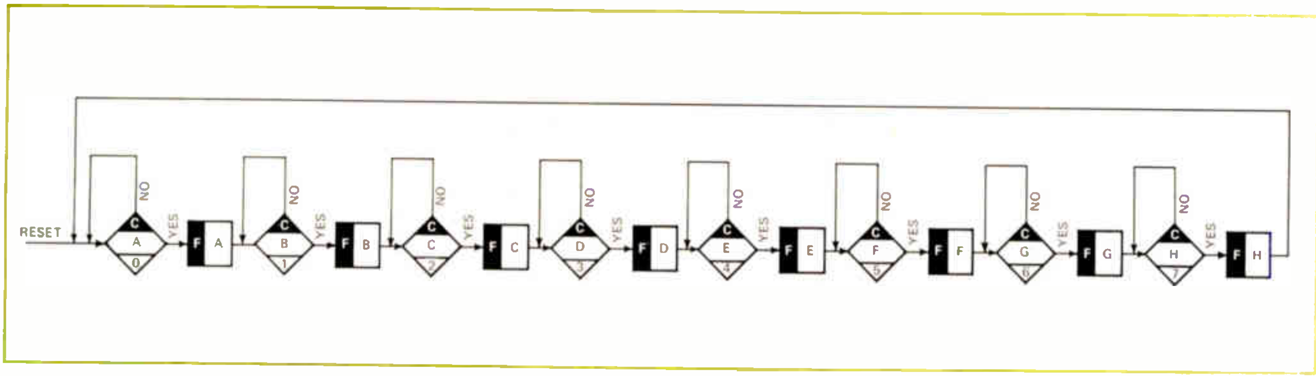
Probably the simplest program controller is one that sequences from one step to the next. Figure 3 contains the flow diagram for an eight-state sequence controller. Transfer functions are not required from any NO conditions, so NO-outputs are simply symbolically looped back as a condition input. The corresponding logic equations are:

FUNCTION A = (STATE 0) (CONDITION A) Δ
FUNCTION B = (STATE 1) (CONDITION B) Δ
FUNCTION C = (STATE 2) (CONDITION C) Δ
FUNCTION D = (STATE 3) (CONDITION D) Δ
FUNCTION E = (STATE 4) (CONDITION E) Δ
FUNCTION F = (STATE 5) (CONDITION F) Δ
FUNCTION G = (STATE 6) (CONDITION G) Δ
FUNCTION H = (STATE 7) (CONDITION H) Δ

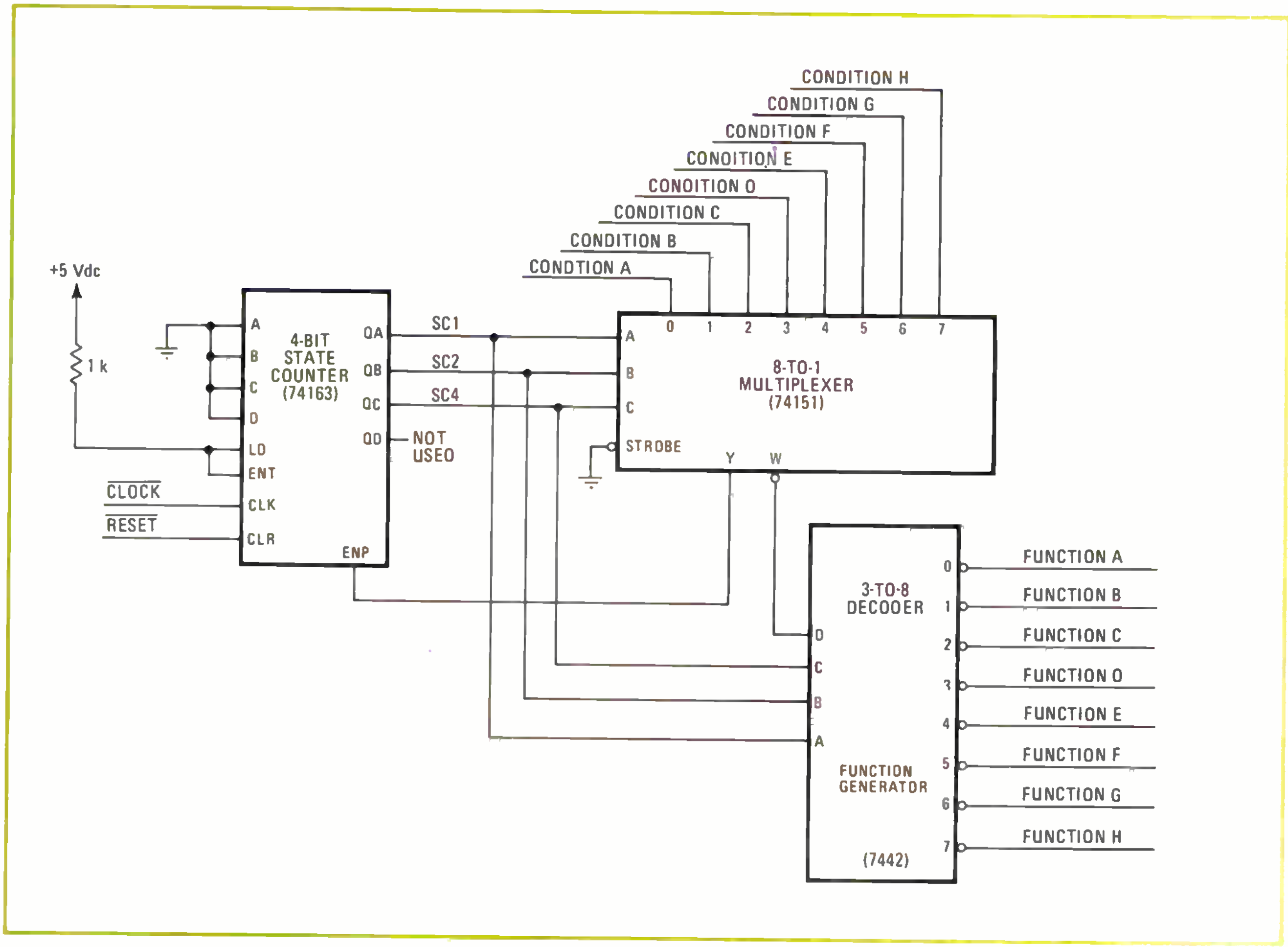
In logic convention, the product of two terms means that an output will occur TRUE when each term is TRUE. That is, for example, FUNCTION A becomes TRUE when both STATE 0 and CONDITION A are TRUE. Thus, the sequence of events is for the controller to remain TRUE in STATE 0 until CONDITION A becomes TRUE, at which point the controller initiates FUNCTION A and steps to STATE 1. Then the controller remains TRUE in STATE 1 until CONDITION B becomes TRUE, initiates FUNCTION B, and steps to STATE 3. When the controller reaches STATE 7, it remains there until CONDITION H becomes TRUE, initiates FUNCTION H, and steps to STATE 0—ready for a new cycle. In the equations above, the delta denotes on increment, or step, to the next state.

This eight-state sequence uses commercial integrated circuits. As shown in Fig. 4, the state counter is a type 74163 four-bit counter. But only three bits are used in this application, since k = 3 provides the eight state addresses, binary 000 to 111, corresponding to the 0 to 7 states. The counter's outputs address the 8-to-1 multiplexer (type 74151) to select the corresponding transfer condition and address the 3-to-8 decoder (type 7442) to select the corresponding output transfer function.

For example, when the counter in Fig. 4 outputs 101, the counter thus simultaneously addresses STATE 5. That is, it addresses CONDITION F of the multiplexer and FUNCTION F at the decoder.



3. Flow diagram. Succession of transfer conditions and transfer functions represents the actions needed for the particular application. Here the task is simple sequence control, in which the controller indexes from one step to the next in prescribed order.

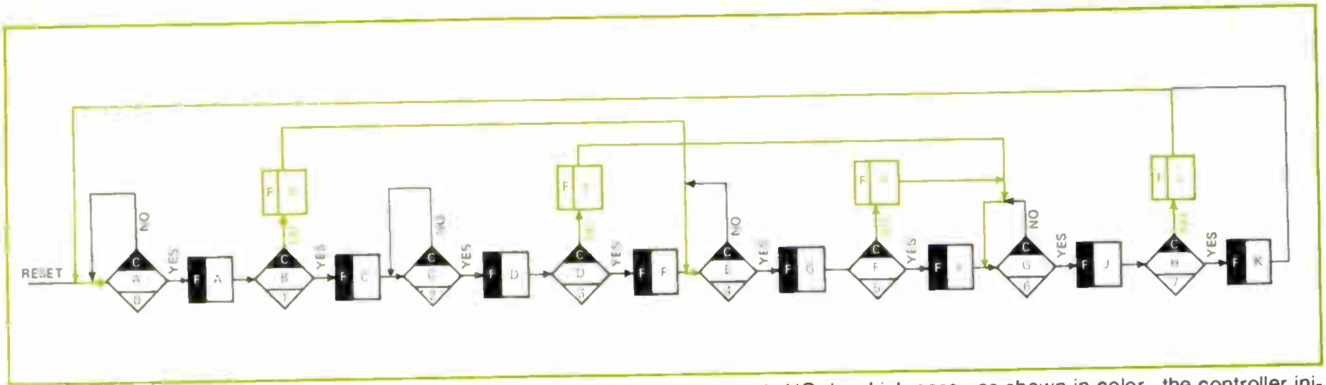


4. Sequence controller. In a step-by-step sequence controller, which can be implemented with as few as three IC packages, the multiplexer's Y-output enables the counter to increment the state address for the multiplexer and decoder to yield the required function.

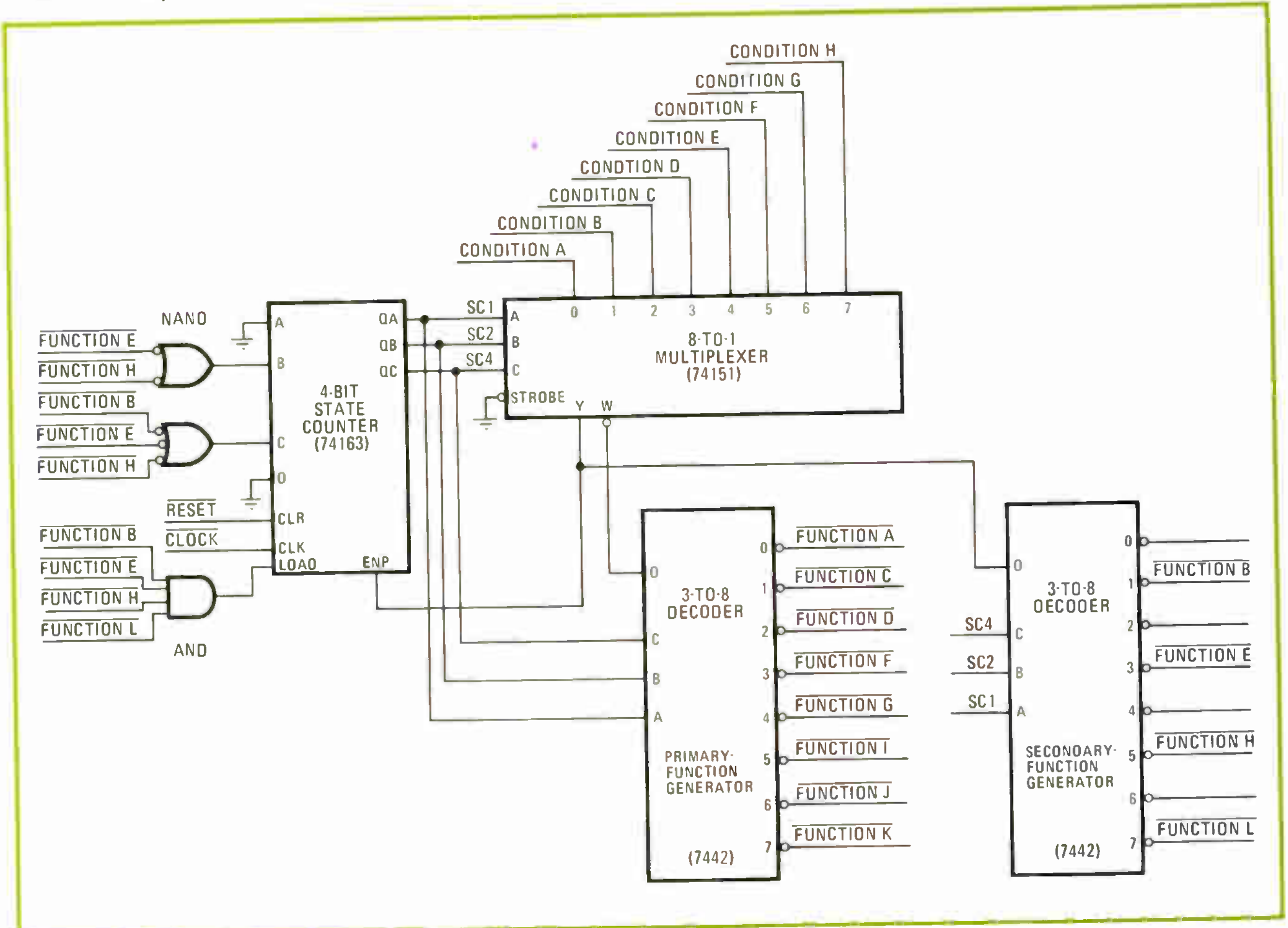
Assume the counter has been RESET to binary 000, corresponding to STATE 0 in the flow chart. This count on the multiplexer's address inputs gates the status of CONDITION A from the multiplexer's input to its complementary Y and W outputs. As long as CONDITION A is NO, the Y output is low and the W output is high. The low Y signal inhibits the counter's ENABLE-P INPUT, so the counter cannot increment even when a CLOCK pulse is present. The W output connects to the decoder's most-significant-bit output (D) which, if high, inhibits the decoder's 0 to 7 outputs. But when multiplexer output W goes low it enables the decoder output addressed by the state counter.

When CONDITION A becomes YES, two things happen: the multiplexer's Y output goes high and allows the state counter to increment on the next CLOCK pulse; and the W output goes low and enables the decoder, addressed to 000, to produce a low output on line 0, thus yielding a signal to initiate FUNCTION A. (Here, a low-voltage output is defined as a TRUE FUNCTION A.)

When the next CLOCK pulse occurs, the state counter increments to 001 (or STATE 1), FUNCTION A goes back high, and the multiplexer's 001-address then gates CONDITION B through the multiplexer, but FUNCTION B from the decoder appears only when CONDITION B becomes YES and the counter increments to the next state. In this



5. Decide and jump. Controller executes steps in sequence unless a condition is NO, in which case—as shown in color—the controller initiates a secondary function and jumps to a new state. Inputs to state counter establish address for multiplexer and decoder.



6. Generating jumps. Adding a secondary decoder (function generator) provides the outputs for the secondary conditions, shown in Fig. 5, which are also fed back to the state-counter's inputs through gates to produce the new jump address for the multiplexer and decoders.

manner, the controller steps through to STATE 7 (111), and when CONDITION H becomes YES, FUNCTION H is generated, the state counter steps to STATE 0 (000), and the controller is ready for the next cycle of operation.

Note in Fig. 4 that the address inputs for the state counter are grounded. The reason is that in this application the required state-by-state indexing is carried out by a CLOCK pulse each time a selected YES condition drives the multiplexer's Y output high to ENABLE the counter. (In more complex controllers, the counter's inputs are addressed according to program requirements, as will shortly be explained.) Simple as it is, however, the sequence controller can prove useful, for example, where eight conditions must be performed in prescribed order to insure safe and proper operation of a production machine.

2. Designing a nonsequential alternate-function controller

More complex, and certainly more realistic, is a program controller that must trigger one transfer function when a condition is YES and another function if the condition is NO. Also required is that the controller sequence to the next state if the condition is YES or jump to a nonsequential state if NO.

Figure 5 contains the flow diagram for a controller that can perform these YES-NO decisions and nonsequential jumps. Here, for example, when it is in STATE 1 and CONDITION B is YES, it will initiate FUNCTION C; but when CONDITION B is NO, it will initiate FUNCTION B and jump to STATE 4. The logic equations, developed from inspection of the flow diagram (Fig. 5), are:

$\overline{\text{FUNCTION A}}$ = (STATE 0) (CONDITION A) ⦣
$\overline{\text{FUNCTION B}}$ = (STATE 1) $\overline{\text{(CONDITION B)}}$ → 4
$\overline{\text{FUNCTION C}}$ = (STATE 1) (CONDITION B) ⦣
$\overline{\text{FUNCTION D}}$ = (STATE 2) (CONDITION C) ⦣
$\overline{\text{FUNCTION E}}$ = (STATE 3) $\overline{\text{(CONDITION D)}}$ → 6
$\overline{\text{FUNCTION F}}$ = (STATE 3) (CONDITION D) ⦣
$\overline{\text{FUNCTION G}}$ = (STATE 4) (CONDITION E) ⦣
$\overline{\text{FUNCTION H}}$ = (STATE 5) $\overline{\text{(CONDITION F)}}$ → 6
$\overline{\text{FUNCTION I}}$ = (STATE 5) (CONDITION F) ⦣
$\overline{\text{FUNCTION J}}$ = (STATE 6) (CONDITION G) ⦣
$\overline{\text{FUNCTION K}}$ = (STATE 7) (CONDITION H) ⦣
$\overline{\text{FUNCTION L}}$ = (STATE 7) $\overline{\text{(CONDITION H)}}$ → 0

The horizontal arrows in the equation point to the required jump state, as determined from the application flow diagram.

Here, the complement (FALSE) of a function—denoted by the ban over, for example, $\overline{\text{FUNCTION A}}$—must actually be interpreted as the initiation of the required function so as to be internally consistent with the voltage-level convention of the devices in this particular controller. In these devices, a TRUE logic level means a high voltage level; a FALSE logic level means a low voltage level. Thus, the equations above are logically consistent with their electrical circuit (Fig. 6).

This implementation is substantially similar to that of the simple sequence controller, except for the addition of the secondary decoder to develop the nonsequential addresses for those transfer functions generated by the four NO conditions. Also required are NAND gates to drive the state counter to the correct state address and an AND gate to LOAD that address into the counter. If, in Fig. 5, all conditions go YES in sequence, then the operation is the same as that for the previous sequence controller.

Suppose, though, the controller has sequenced through to STATE 3, CONDITION D, which if YES initiates $\overline{\text{FUNCTION F}}$. However, if CONDITION D is NO, the flow diagram indicates the controller should jump to STATE 6, CONDITION G. Referring to Fig. 6, all transfer conditions are inputted through the 8-to-1 multiplexer, with the particular condition gated through the multiplexer (transfer-condition selector) depending on the address produced by the state counter. Also, depending on the counter's state address, the primary decoder will produce one primary function, or the secondary decoder one secondary function. Here, secondary function B occurs at STATE 1, E at STATE 3, H at STATE 5, and L at STATE 7. Thus, the controller uses the secondary decoder's 1, 3, 5, and 7 outputs.

The primary and secondary transfer functions initiate the desired external actions mandated by the particular application. A YES primary condition will cause the controller to index to the next state. But the secondary functions are fed back as inputs to the state counter to generate a jump address and to load the state counter with that address.

Connecting jump addresses

As shown in Fig. 5 and by the logic equations, the required address jumps are:

Function B → 4; E → 6; H → 6; L → 0

These state numbers are obtained by addressing the state counter's binary-weighted inputs. The counter's highest-ordered input (D) is permanently set to low level, or binary 0, by grounding, since the A, B, and C inputs can yield the required eight state addresses.

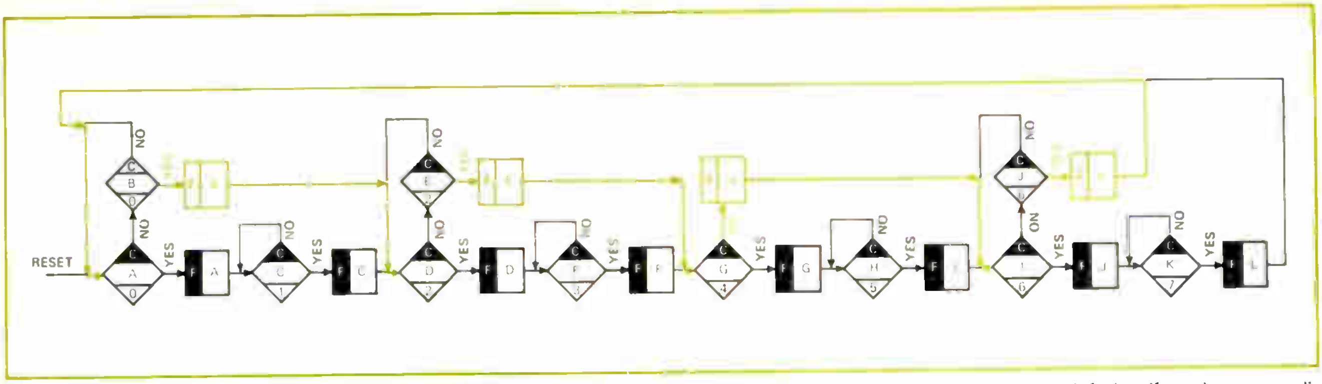
In Fig. 6, these addresses are developed through two NAND gates. $\overline{\text{FUNCTION B}}$ inputted to one NAND gate puts a high-level signal on the counter's C input and generates the 100 which is the jump-to-STATE 4 address applied to the multiplexer and decoders. And $\overline{\text{FUNCTION E}}$ is fed through both NAND gates to activate the B and C inputs to generate 110, the STATE 6 address. The 0 jump address occurs simply when there are no input signals on the NAND gates. Note that since only even-numbered jump addresses are used, the state counter's A input is permanently grounded. In applications requiring odd-numbered addresses, the A input would also be accessed through a NAND gate by the odd-numbered functions.

All secondary-decoder jump outputs serve as inputs to an AND gate that in turn connects to the state counter LOAD input. Because of the voltage-level convention, the AND gate actually performs an OR logic function. Therefore, whenever any jump function appears at the AND gate inputs, the counter's A, B, or C inputs LOAD the counter to set up the jump address at its output.

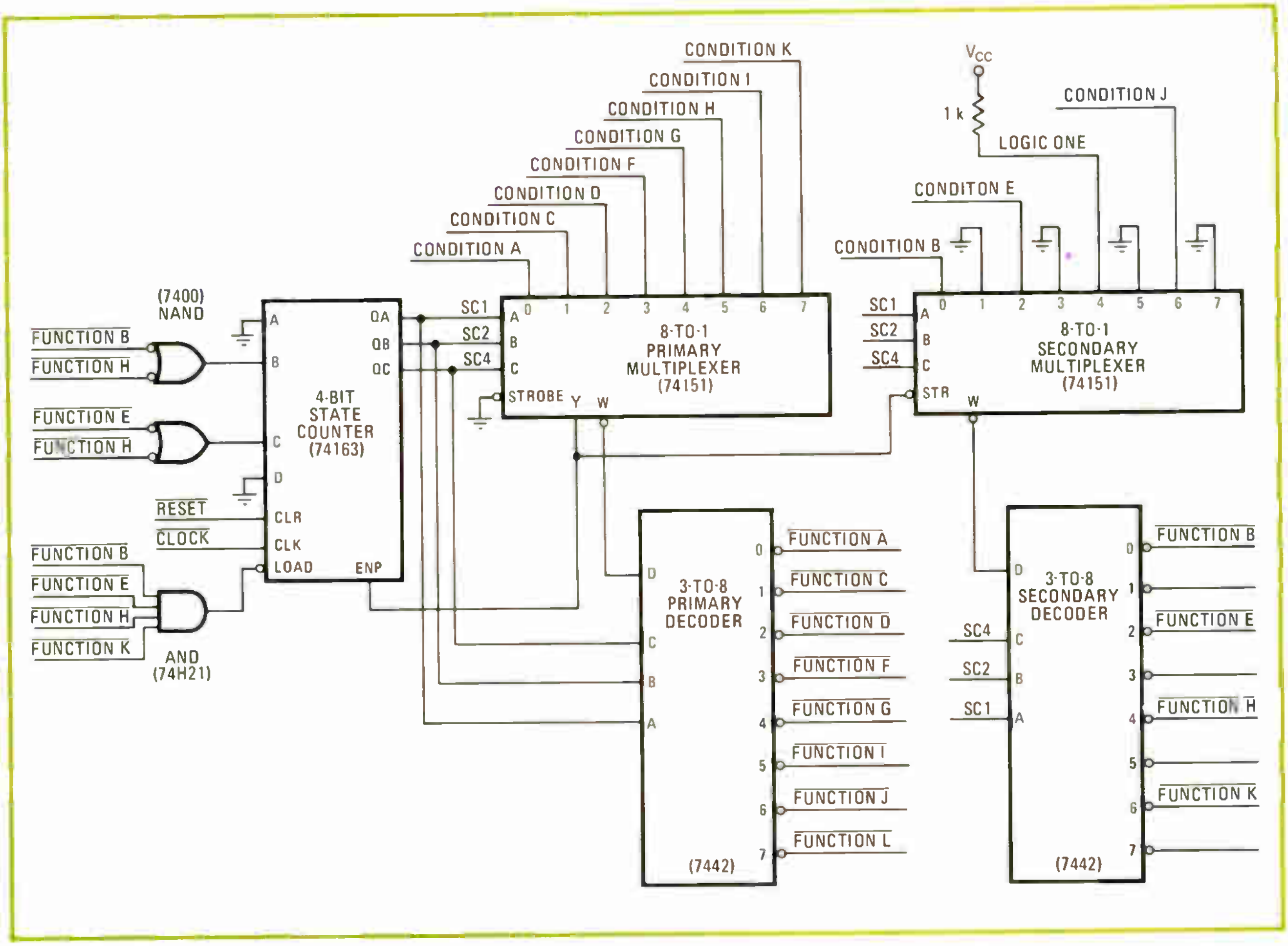
A few other electrical connections are required. The multiplexer must enable the primary function generator for primary (YES) decisions or the secondary-function generator for secondary (NO) decisions. This is accomplished by connecting the multiplexer's Y-output to the D (inhibit) terminal of the secondary decoder and the W output to the D terminal of primary decoder. The Y output also connects to the counter's ENABLE-P terminal.

Assume the controller state counter has been RESET to STATE 0. As long as CONDITION A is NO, the secondary-function generator's 0 output is low—but this output is not used. When CONDITION A becomes YES, the primary-function generator's 0-output goes low to generate $\overline{\text{FUNCTION A}}$. At the same time the multiplexer's Y output goes high to drive the state counter's ENABLE-P input and, on the next CLOCK pulse, the counter increments to STATE 1. Here, as shown in Figs. 5 and 6, if CONDITION B is YES, the primary-function generator is enabled, because W is low, to produce $\overline{\text{FUNCTION C}}$, and, because Y is high, the state counter increments to STATE 2 on the next CLOCK. However, if CONDITION B is NO the low Y signal on the secondary-function generator's D terminal enables that decoder to yield $\overline{\text{FUNCTION B}}$. And the counter must jump to STATE 4. Therefore, $\overline{\text{FUNCTION B}}$ gets fed to the counter's C input through the NAND gate, and to the LOAD input through the AND gate. Thus, the next CLOCK pulse loads the counter to a count of 100, or STATE 4.

In this manner, the controller will either index to the next state or jump to a prescribed state. As shown in



7. Priority control. Flow diagram indicates controller must give first priority, at any state, to primary conditions, at left, but if a primary condition is NO and secondary condition—in color—is YES, then controller initiates secondary function and jumps.



8. Dual decision. Adding a secondary multiplexer, upper right, provides gating of secondary, or low-priority, inputs, with the primary multiplexer's enable and inhibit outputs choosing whether to give priority to primary or secondary transfer conditions.

Fig. 5. initiation of $\overline{\text{FUNCTION L}}$ will bypass $\overline{\text{FUNCTION K}}$ and reset the controller to STATE 0. but if CONDITION H is YES. the controller will first initiate FUNCTION K and then increment to STATE 0.

3. Designing a nonsequential priority-condition controller

Consider now any application in which, at one or more states, two input conditions exist and the program controller has to choose which condition will initiate the next function. Thus, the controller must follow a set of priority rules. This controller is slightly more complex, electrically, than the previous two examples, but is still easily put together with standard ICs.

In STATE 0 of Fig. 7, for instance CONDITION A could represent a thermostat switch which, if closed (YES) initiates FUNCTION A and indexes the controller to STATE 1. But if the thermostat is open (NO), then CONDITION B should be implemented. Here CONDITION B could be a timer input. In STATE 0 the controller is to give first priority to the temperature input, but if the temperature does not close the thermostat, then after some elapsed time the controller will operate through CONDITION B and jump to STATE 2. And if the temperature and time are both YES, then the controller is to obey the move dictated by the priority assignment, CONDITION A. Figure 7 includes eight high-priority conditions—A, C, D, F, G, H, I, and K—and three low-priority conditions—B, E, and J—at STATE 0, 2, and 6 with jumps to, respectively, STATES 2, 4, and 0. Also a jump is needed to STATE 6 when CONDITION G, at STATE 4, is NO.

Inspection of the flow diagram (Fig. 7) leads to the following logic equations, which indicate the connections between the devices making up the controller (Fig. 8). Again the delta means index to next state, and the horizontal arrow means jump to the indicated state.

$\overline{\text{FUNCTION A}}$ = (STATE 0) (CONDITION A) Δ
$\overline{\text{FUNCTION B}}$ =
(STATE 0) $\overline{\text{(CONDITION A)}}$ (CONDITION B) → 2
$\overline{\text{FUNCTION C}}$ = (STATE 1) (CONDITION C) Δ
$\overline{\text{FUNCTION D}}$ = (STATE 2) (CONDITION D) Δ
$\overline{\text{FUNCTION E}}$ =
(STATE 2) $\overline{\text{(CONDITION D)}}$ (CONDITON E) → 4
$\overline{\text{FUNCTION F}}$ = (STATE 3) (CONDITION F) Δ
$\overline{\text{FUNCTION G}}$ = (STATE 4) (CONDITION G) Δ
$\overline{\text{FUNCTION H}}$ = (STATE 4) $\overline{\text{(CONDITION G)}}$ → 6
$\overline{\text{FUNCTION I}}$ = (STATE 5) (CONDITION H) Δ
$\overline{\text{FUNCTION J}}$ = (STATE 6) (CONDITION I) Δ
$\overline{\text{FUNCTION K}}$ =
(STATE 6) $\overline{\text{(CONDITION I)}}$ (CONDITION J) → 0
$\overline{\text{FUNCTION L}}$ = (STATE 7) (CONDITION K) Δ

Here again the logic equations show that the required function results when the corresponding decoder output goes low, to be consistent with device electrical levels.

Generating priorities

In Fig. 8, the high-priority conditions are the same as the primary conditions used in the previous examples, and they are gated through the multiplexer generating the high-priority transfer condition. Another multiplexer generates the low-priority transfer conditions. Again two decoders are used, one to output the high-priority functions, the other the low-priority functions. Since this application also requires nonsequential jumps, the jump addresses are obtained by the same procedure of feeding back appropriate secondary (or low-priority) output functions through NAND gates to the state counter. And the presence of any one of these jump functions and the AND gate (operating in an OR mode) loads the address into the state counter. As in the preceding example, the addresses developed by the state counter drive the multiplexers and decoders.

Of particular interest in this example is how the devices are connected so that they properly assess the required priority (if any) in a given state, and enable or inhibit the associated integrated circuits. The Y output of the primary multiplexer connects to the state counter's ENABLE-P terminal to provide sequential indexing when needed. This Y output also goes to the STROBE terminal of the low-priority multiplexer, which inhibits the low-priority transfer-function selector (multiplexer) any time the selected high-priority transfer condition is TRUE. As in the preceding example, when a multiplexer's W output, the complement of Y, is low, it inhibits the function output of the related decoder.

Consider now some of the alternative actions provided by this program controller that choose and implement a function depending on the priorities assigned to two conditions at a given state. Assume the controller has been RESET to STATE 0. Here, the high-priority (primary) multiplexer is addressed to select CONDITION A and the low-priority (secondary) multiplexer to select CONDITION B.

If CONDITION A is YES (or TRUE), three things happen: the Y output of the primary multiplexer ENABLES the state counter to index to the next step, the W output of the same multiplexer removes the inhibit on the D terminal of the primary decoder and thus generates the addressed $\overline{\text{FUNCTION A}}$; the Y output, connected to the STROBE terminal of the secondary multiplexer, inhibits— through that multiplexer's W output—the secondary transfer-function generator (decoder). As required, the controller generates $\overline{\text{FUNCTION A}}$ and steps to STATE 1.

However, suppose the controller is in STATE 0 and that CONDITION A is NO and CONDITION B is YES. As shown in Fig. 7, the controller in this situation is to initiate $\overline{\text{FUNCTION B}}$ and jump to STATE 2. Since CONDITION A is NO, the low-priority transfer-function generator is enabled, resulting in $\overline{\text{FUNCTION B}}$ appearing on output line 0, as required. Furthermore, this function is fed back to the state counter's NAND gate which enables input-terminal B to a 100 address so the controller jumps to STATE 4, as required.

For the case where CONDITION A and B are both YES, the controller is to give priority to, and react to, CONDITION A only. This action is the result of the high Y output of the primary multiplexer inhibiting the secondary multiplexer and thus preventing CONDITION B from being gated through to the decoder. Therefore, the controller ignores CONDITION B and the primary Y output enables the state counter to increment to STATE 1. Of course, if CONDITIONS A and B are both NO, the controller stays in STATE 0.

In some states, as for example STATE 3, the controller is required to step to STATE 4 only when a condition (here CONDITION F) becomes YES. Because the secondary multiplexer and decoder are inhibited, the controller indexes in the same manner as in the sequence controller in the first example.

Even without having to make a priority decision, this controller can also perform YES-NO nonsequential jumps, as is required at STATE 4. Here, the controller is to generate $\overline{\text{FUNCTION G}}$ and step to STATE 5 if CONDITION G is YES, or generate $\overline{\text{FUNCTION H}}$ if CONDITION G is NO. In the YES, or primary condition, the primary multiplexer inhibits the secondary multiplexer, so the controller simply generates $\overline{\text{FUNCTION G}}$ and goes to STATE 5. If CONDITION G is NO, the controller must initiate $\overline{\text{FUNCTION H}}$ and jump to STATE 6. To accomplish this, a YES condition is permanently connected to input 4 of the secondary controller, shown as the logic one connection in Fig. 8. Being in STATE 4, with the secondary multiplexer enabled through its STROBE connection and the secondary decoder enabled through its D input, the controller can then "gate" this permanent YES condition through the multiplexer and decoder to generate $\overline{\text{FUNCTION H}}$, as required. Furthermore, this output is fed to the B and C NAND gates to produce the 110 corresponding to the required jump address of 6. □

Engineer's notebook

Approximating waveforms with exponential functions

by Robert G. Durnal
Systems Development Division, Westinghouse Electric Corp., Baltimore, Md

Many engineering applications require generating a waveform that matches a characteristic curve of some device or physical law. Some examples of such waveforms are hyperbolic ground-range radar sweeps, fast automatic-gain-control functions, and automatic light-level compensation waveforms for television cameras. The most useful and easily generated waveform for approximating such functions is the decaying exponential. And using the graphical exponential approximation technique demonstrated here permits an accurate fitted curve to be obtained in less than two hours.

To illustrate the technique, an approximation will be developed for a typical waveform—a logarithmic voltage function that must be generated to compensate a particular process. The function is:

$V = 2 \log_{10}(t_{max}/t)$

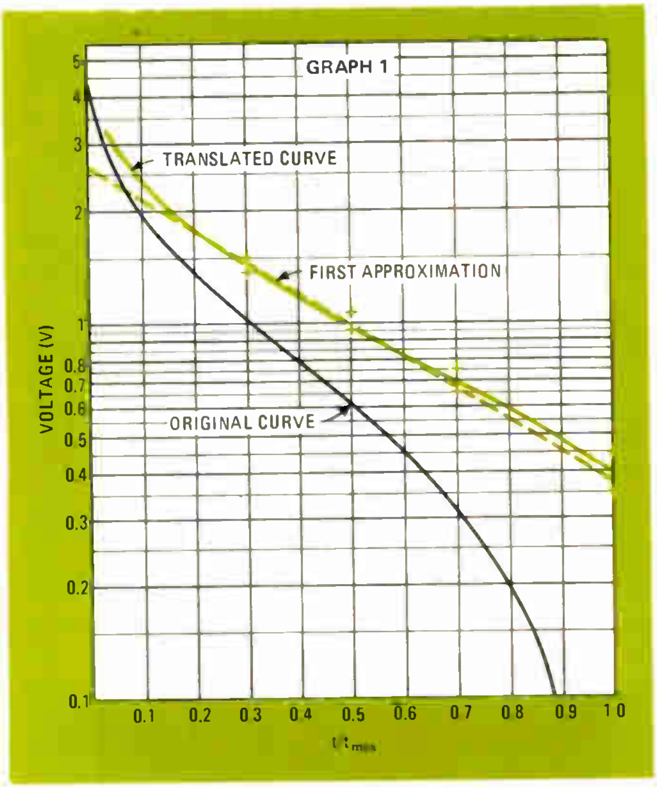
Voltage V must be accurate to within 0.05 volt for values of time t between t_{max} and 0.25% of t_{max}. The curve should be plotted on semilogarithmic graph paper be-

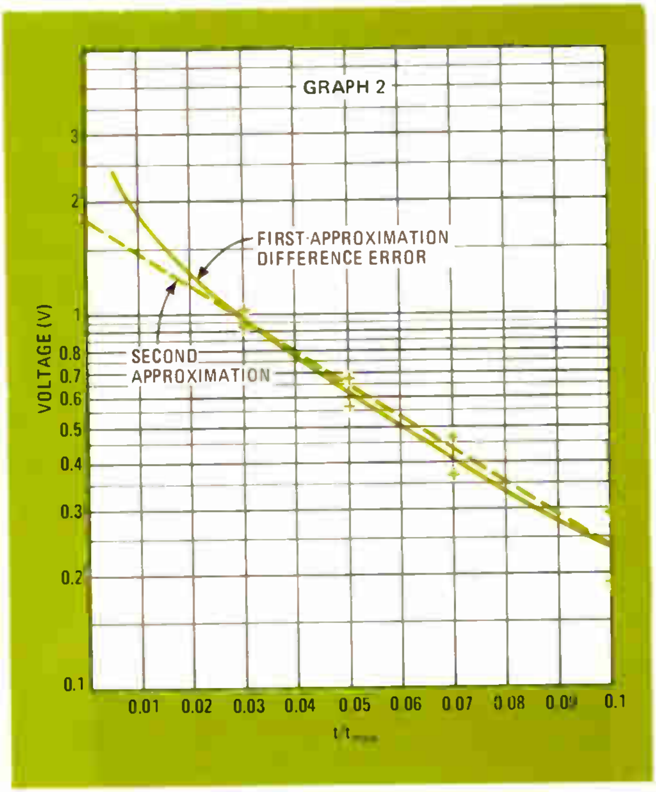
TABLE 1: ERROR IN FIRST APPROXIMATION

t/t_{max}	Translated curve (V)	First approximation (V)	Difference error (V)
0.05	3.002	2.384	0.618
0.1	2.40	2.162	0.238
0.2	1.798	1.777	0.021
0.3	1.446	1.460	0.015
0.4	1.196	1.200	0.005
0.5	1.002	0.987	0.015
0.6	0.844	0.811	0.033
0.7	0.710	0.667	0.043
0.8	0.594	0.548	0.046
0.9	0.492	0.450	0.041
1.0	0.400	0.370	0.030

TABLE 2: ERROR IN SECOND APPROXIMATION

t/t_{max}	Translated curve (V)	Second approximation (V)	Difference error (V)
0.005	5.002	4.233	0.769
0.01	4.400	4.053	0.347
0.02	3.798	3.735	0.063
0.03	3.446	3.468	−0.022
0.04	3.196	3.240	−0.045
0.05	3.002	3.047	−0.045
0.06	2.844	2.880	−0.037
0.07	2.710	2.737	−0.027
0.08	2.594	2.612	−0.018
0.09	2.492	2.502	−0.011
0.1	2.400	2.405	−0.005





cause the decaying exponential, the function to be used to approximate voltage V, can then be drawn as a straight line.

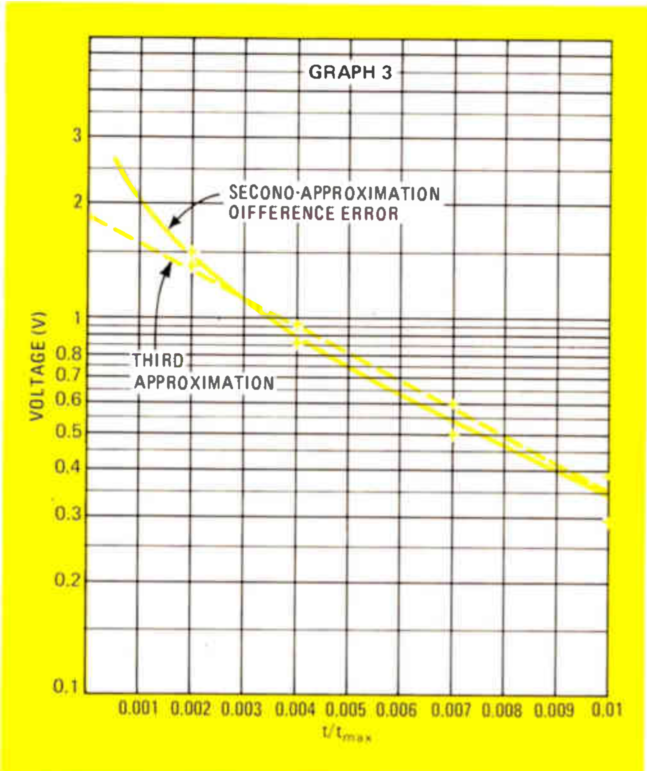
Voltage V is plotted as a solid black curve in Graph 1. It can be seen by inspection that this curve is inflected—the direction of curvature reverses at the midpoint. Inflected curves are difficult to generate with a series of straight-line approximations, which is the method to be used here.

The difficulty can be removed by simply adding a constant along the entire curve of voltage V. The value of the constant is not critical, but if it is too large, the curve will flatten out. (As a rule of thumb, the constant can be one-half to two-thirds the value of the curve at the inflection point.)

Graph 1 shows, as a solid color line, voltage V translated by adding a constant offset voltage of 0.4 v. In this case, the right-hand portion of the translated curve is nearly linear. The envelope of the ±0.05-v limits is represented by crosspoints (shown in color on the graph) to aid in choosing the approximation curve.

TABLE 3: OVER-ALL ERROR

t/t_{max}	Translated curve (V)	Third approximation (V)	Difference error (V)
0.0015	6.0500	5.833	0.217
0.002	5.798	5.696	0.102
0.0025	5.622	5.573	0.049
0.003	5.446	5.450	−0.004
0.004	5.196	5.236	−0.040
0.005	5.002	5.050	−0.048
0.006	4.844	4.887	−0.044
0.007	4.710	4.744	−0.035
0.008	4.594	4.619	−0.025
0.009	4.492	4.507	−0.015
0.01	4.400	4.408	−0.008



The first approximation should cover the greatest possible range of voltage V. Larger errors can be tolerated for higher values of t/t_{max}, since the tolerance band is wider for the rightmost section of the curve than for the leftmost. Additionally, the first approximation should be drawn below the translated curve to avoid negative difference errors (between the translated and approximation curves), which are difficult to plot.

As shown in Graph 1, the first approximation is drawn for a best fit graphically within the restrictions already cited. The exponential function of this first approximation can be written as:

$$V_1 = 2.63\exp(-t/0.51t_{max}) - 0.4$$

where the voltage intercept is 2.63 v, the added constant is 0.4 v, and $V_1 = 2.63/e$ (here, e represents the base for the natural logarithm) when $t/t_{max} = 0.51$.

Table 1 lists the voltage levels of the translated curve and the first approximation curve for several values of t/t_{max} from 0.05 to 1.0. The difference error between these two curves is computed and then plotted (Graph 2) for values of t/t_{max} between 0.01 and 0.1, where the error is largest. Again, the ±0.05-v limits are inserted as an approximating aid.

When the difference-error curve is approximated, care must be taken not to disturb the accuracy of the first approximation. Therefore, absolutely zero error is introduced at $t/t_{max} = 0.1$ by locating the straight-line second approximation at the same point as the first-approximation difference-error curve. The best fit for the second approximation is then determined graphically. Voltage V can now be expressed as a sum of two exponentials and a constant:

$$V_2 = 2.63\exp(-t/0.51t_{max}) + 1.8\exp(-t/0.05t_{max}) - 0.4$$

where V_2 is the entire second approximation. The leftmost portion of this approximation, which is shown in Graph 2, has a voltage intercept of 1.8 v.

Table 2 shows the voltage levels of the translated curve and the second-approximation curve for values of t/t_{max} between 0.005 and 0.1. The difference errors between these two curves are within the allowable limits (of ±0.05 v) when t/t_{max} is greater than 0.01. The second-approximation difference error curve, therefore, is plotted (Graph 3) for t/t_{max} from 0.001 to 0.01.

The same graphical technique can now be used to arrive at a third approximation for the leftmost portion of voltage V. The accuracy of the second approximation is preserved by making the difference error equal to zero at $t/t_{max} = 0.01$. The best fit for the third approximation of voltage V yields:

$$V_3 = 2.63\exp(-t/0.51t_{max}) + 1.8\exp(-t/0.05t_{max}) + 1.88\exp(-t/0.006t_{max}) - 0.4$$

Table 3 gives the difference errors between the translated curve and the third straight-line approximation curve. The desired accuracy of ±0.05 v is now met for the specified 400:1 time range—from $t/t_{max} = 0.0025$ to $t/t_{max} = 1.0$.

The circuit needed to produce voltage V, therefore, must consist of three exponential generators and a constant voltage. □

Built-in LED display decoder simplifies digital-clock logic

by James Blackburn
University of Western Ontario, London, Ont., Canada

Many solid-state readouts are supplied with their own built-in decoders, which can simplify the logic needed to produce a blanked display. For example, the Hewlett-Packard Co. type 5082-7300 numeric light-emitting-diode indicator accepts four-line (1, 2, 4, 8) binary-coded-decimal logic inputs. An input of 1000 generates a "1" display, while the complement of this signal (0111) results in a blank display. Therefore, the Q and $\bar{Q}$ outputs of a flip-flop can cause H-P's LED display to show either a 1 or blank.

This property is particularly useful in simplifying the logic required for a digital clock to make the transition from 12:59 to 1:00. Obviously, 13:00 must be inhibited in favor of a reset to 1:00. Since modulo-10 counters have integral reset-to-zero functions, the least-significant digit of the hours display must be reset to 1 indirectly. Additionally, the hours' most-significant digit must be blanked, causing the clock display to be 1:00.

Because of the display's built-in decoder, the desired reset-to-1 operation can be accomplished with only five dual-input NAND gates and one J-K flip-flop. The flip-flop drives the most-significant digit of the hours display.

When the time is 12:59, the flip-flop is in the 1 state, and the decade counter's A and B outputs are high while its BD_i, C, and D terminals are low. At the end of the next minute, a negative transition occurs at the counter's A_i input. Its A output then goes low and is inverted by gate G_1, causing input BD_i to go high so that the display reading should be 13:00.

Both inputs to gate G_2 are now high, producing a low at its output, which is inverted by gate G_3. The two inputs to gate G_4 then go high, causing the flip-flop to reset to the 0 state and the decade counter to reset to zero. This generates a blank at the most-significant digit of the hours display, and, because of the inversion at gate G_1, all is generated at the least-significant hours digit. The clock display now shows 1:00 as the time.

The transition from 13:00 to 1:00 occurs so quickly that the clock display indicates only a transition from 12:59 to 1:00. □

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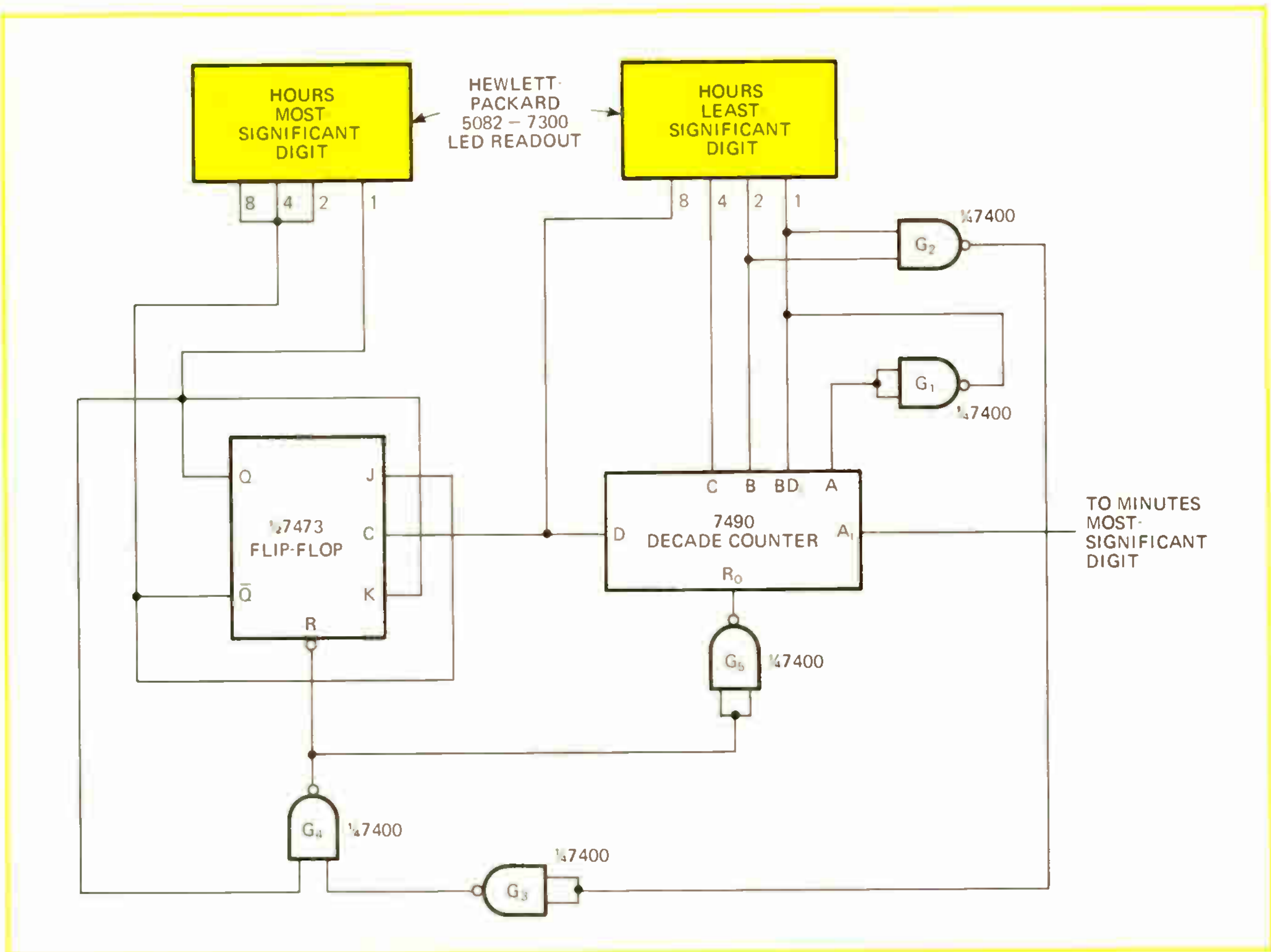
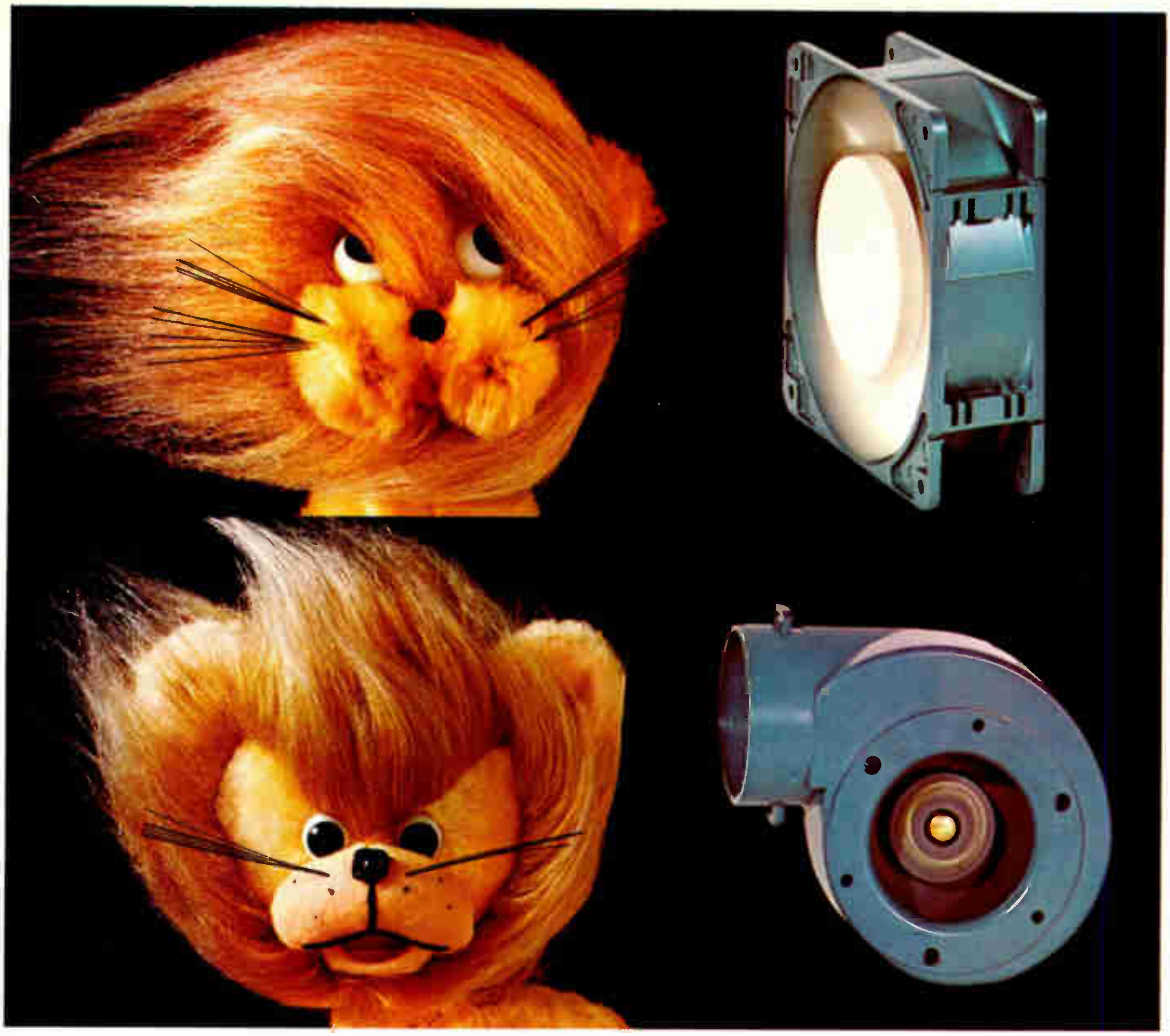
Digital clock display. Because of its built-in decoder, Hewlett-Packard's solid-state readout reduces the logic required to blank a clock's display when making the transition from 12:59 to 1:00. The complement of the signal that blanks the readout produces a 1.





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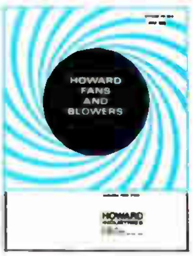

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Engineer's newsletter

Double duty saves one

If you can **eliminate a passive component by letting your active device do double duty,** you save not only the price of the component but board space as well. For example, in a typical astable multivibrator, where you need two capacitors and two transistors, **one of the capacitors can be eliminated** by using a programable unijunction transistor instead of one of the bipolars. The PUT acts as a gated switch for charging and discharging the single capacitor.

Making noise? Go digital

Using digital techniques to generate noise instead of the old heated resistor and high-gain op amp method looks like **a good way to increase bandwidth and not spend a whole lot of money** doing it. Take a high-speed shift register, connect it as a maximum-length, pseudo-random, sequence generator, and then pass the digital output through a low-pass filter. Since it's best to cut the filter off at about one-tenth the register clock rate, by using one of the new 500-MHz ECL registers, **this method can give you a noise generator with a bandwidth of 50 MHz.**

Think serial in process control

If your process control specs permit you leeway in the controller's operating speed, you might consider processing data serially rather than using the voguish parallel approach. **It's slower, but it's cheaper, since you need fewer logic functions.** And by storing information in one dimension, **every storage site can be used.** Besides, if you're transmitting into a data line, you'll have to get into serial form anyway.

New magnets for TWTs

A new magnetic compound with four times the strength of today's magnet material is turning on builders of high-performance TWTs for the military. **The material is samarium cobalt,** and is distributed here under the name of Hi-Corax by Hitachi Metals America, White Plains, N.Y. Its **small size and powerful focusing strength** give TWTs the edge over old tubes. The only rub: it presently **costs over over 10 times more** than magnets made with the popular Alnico 8.

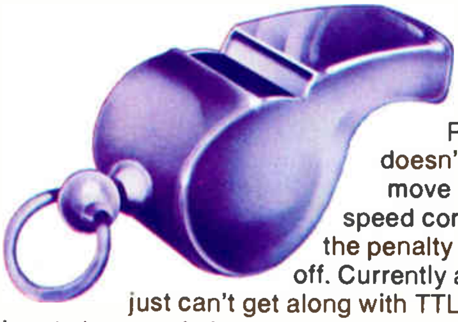
Hand inserter puts terminals in their places

Inserting terminals into circuit boards for prototypes might well be a least-favorite occupation for many engineers and technicians, but a new hand inserter promises to ease the chore considerably. **You simply press the terminal with the tool until the spring in the tool trips,** forcing the terminal into a hole in the prepunched board. The spring-actuated inserter from Vector Electronics, Sylmar, Calif., can be adjusted to give optimum pressure. Various types of terminals can be accommodated, and **the small insertion heads can perform on crowded boards.**

Production line goes to the convention

Here's your chance to roll up your sleeves and learn first hand what it takes to **turn your prototype design into a production model.** On March 26–29, the Manufacturing Group of the IEEE will sponsor a do-it-yourself booth at the International Convention in New York's Coliseum, where a designer, working on a simulated production line, **can actually assemble on a pc board and test his own pulse generator.** You get to keep what you build, whether it works or not.

No-hitch Schottky Comparators



Compatible multi-function plug-ins: more speed – more output – more profits in the end.

Really bugs you, doesn't it? Make your move into ultra high speed comparators—and the penalty whistle goes off. Currently available parts just can't get along with TTL levels, and input characteristics are much too stringent.

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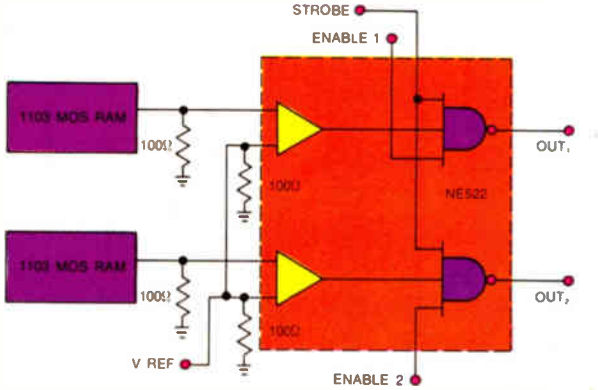

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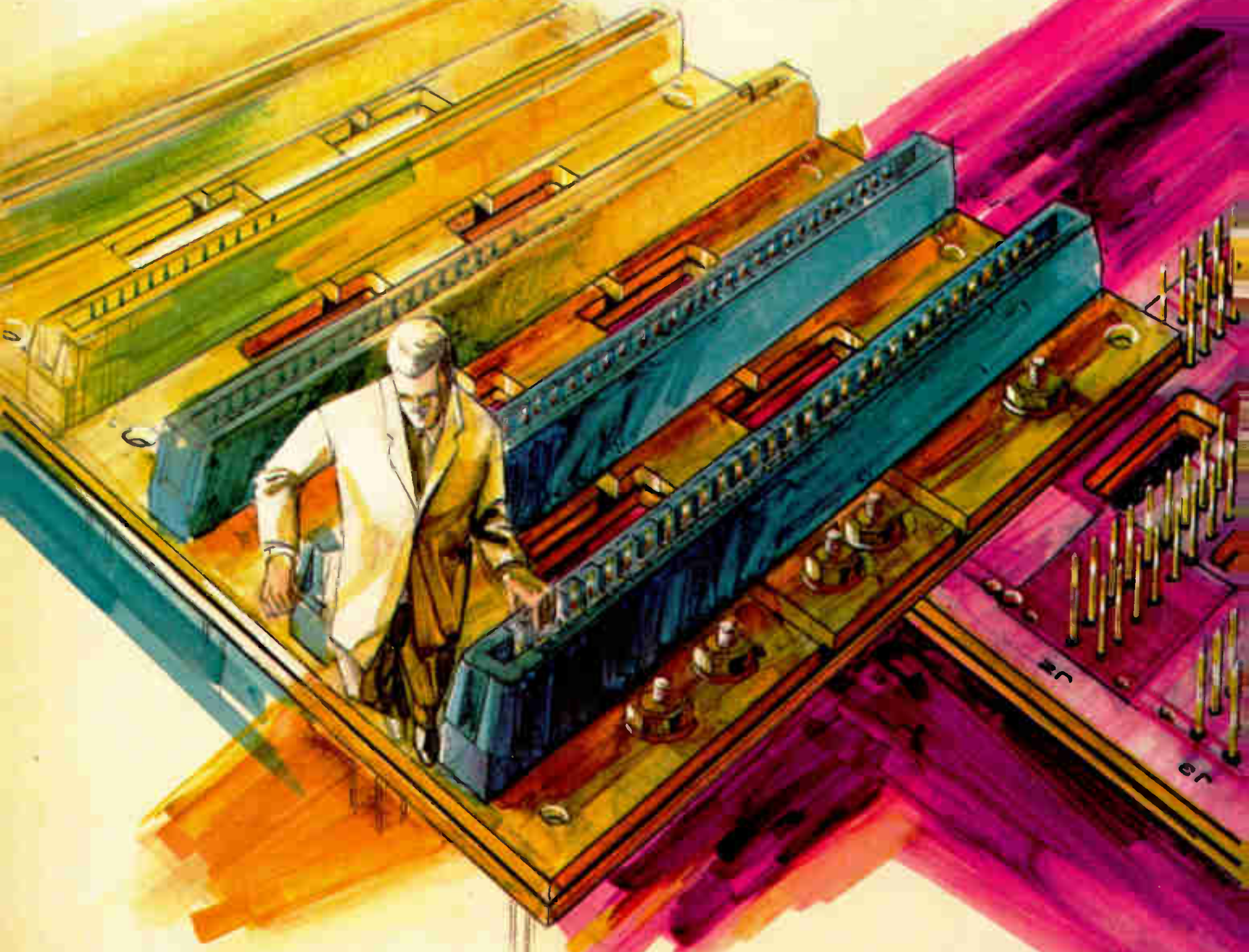

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Solid-state camera uses photodiodes

Image-sensing system for character recognition, industrial controls, and measurements is designed around 50-by-50 array of MOS devices

by Stephen Wm. Fields, San Francisco bureau manager

Most electronics companies working toward solid-state image sensing are counting on the promise of charge-coupled or bucket-brigade devices to make the solid-state camera a reality [*Electronics*, Jan. 18, p. 162]. But the first solid-state camera to go into production uses neither. Instead, it has an array of MOS photodiodes.

Designated the LC600 series, the camera is built by Reticon Corp., Mountain View, Calif. It is intended for noncontact sensing in a variety of measurement, identification, and control applications.

The camera contains a complete optical system, a photodiode array—either a linear array of 64 to 512 photodiodes or an area array that measures 50-by-50 photodiodes. It also has scanning circuitry to interrogate each diode in sequence and determine whether the light intensity is above or below a preset level and input/output circuitry that enables the camera to be used with very simple external electronics chosen to fit the particular application. Only moderate light levels are required to operate the camera, provided there is reasonable contrast between the background and the object to be measured.

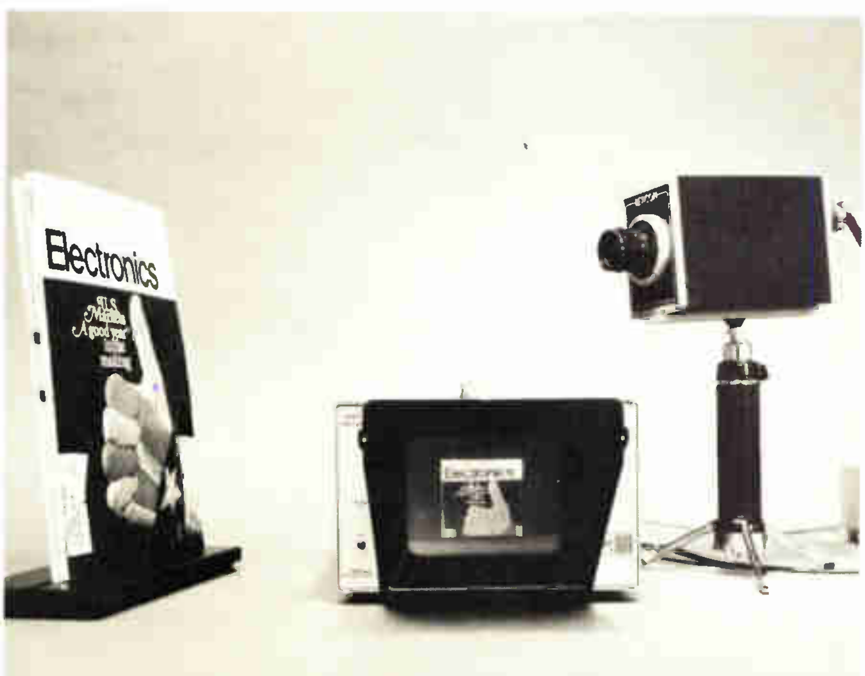
Direct drive. In the simplest form of system, all that is needed besides the camera are a power supply and a display. If the camera contains the 50-by-50 array, for example, all that is required is ±15 volts at 100 milliamperes, +5 V at 1 A, and a CRT display. The camera has three output lines—X,Y, and Z or intensity—and these can drive the display directly. In such a setup, the camera is acting as a solid-state vidicon with a 2,500-point resolution. But according to John J. Rado, Reticon's president, "this is not the primary application for the camera," although it provides Picturephone quality or better.

According to Rado, in many OCR applications the output pulse train of the camera will be fed to a signal-processing system. This method would be used, for example, in text reading, where the signal-processing equipment would be looking for lines and edges and then, after determining what the character was, would enter it into a system.

Another application is in detecting defects. "Castings, for example," says Rado, "are often treated with a chemical that will show up cracks and other defects. With the LC600, an automatic assembly-line operation could be set up with the camera detecting the presence of the chemical in the defect. The detection of the fault could then trigger a machine to remove the bad casting from the line."

Choice of array. The heart of the camera is the photodiode array. The camera is available with either linear arrays of 64, 128, or 512 photodiodes, or with a 32-by-32 or the 50-by-50 area array (which measures 250 by 250 mils). The choice depends on the application. In systems where the object to be viewed is moving at a constant speed, the linear array could be employed. It can also be used in measuring systems—systems that assess how full a

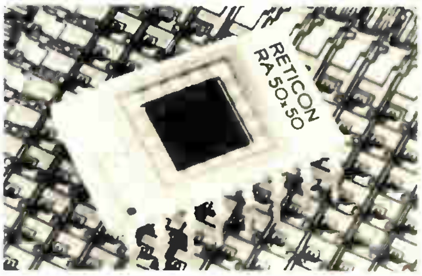
Image sensing. The families of solid-state cameras now being developed offer promising applications in facsimile, optical character recognition, and low-resolution television.



New products

tank is or how long a bolt is, for example. The area array is employed in applications where the object to be viewed is not moving at constant speed, or where viewing in more than just the X direction is required, as with the example of the casting-fault detector.

The camera itself measures 4 inches high, 2.8 in. wide, and from 6 to 10 in. deep, depending on the electronics. The X "standard" version contains the lens (any one of 10 types of vidicon or enlarger lenses is



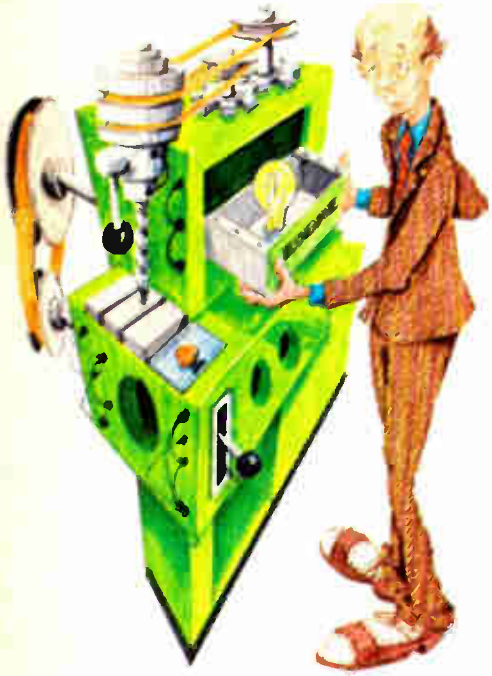
available), the photodiode array (which contains the scanning circuits and the first driver stage), and several circuit cards. These contain the final driver stage, the video stage, a charge-amplifier sample-and-hold circuit, which puts out a series of "boxcar" pulses that can be fed to an a-d converter to digitize the display, and the sweep and interface circuits. The latter can be as complex as is called for by the design. In fact, says Rado, "you could put a complete data processing system such as the Intel MCS-4 inside the camera case, and it could connect directly to a printer." An application would be in length-measuring, where the camera would look at an object and print out its length.

Accurate tool. Rado points out that unlike vidicon cameras, the Reticon system has geometric accuracy. Each diode position is precisely defined, and this, combined with the digital nature of the device, makes it an accurate measuring tool.

Samples of the LC600 camera are available from stock. The price ranges from $1,200 (for a camera with the 64-element linear array) to $4,900 for a camera with the 50-by-50 area array.

Reticon Corp., 450 Middlefield Rd., Mountain View, Calif. 94040 [338]

What the industry taught us about cheap OEM minicomputers.



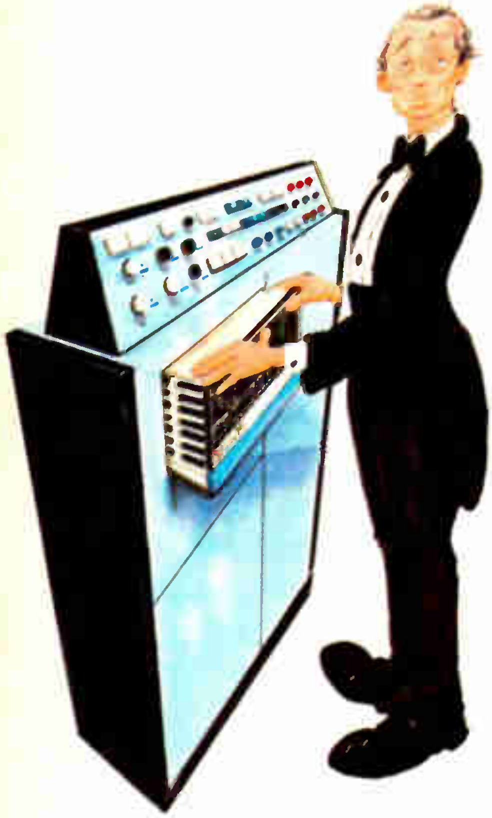
Stripped for action.

Here's a familiar approach. El Cheapo II. In reality, it's the good old Mod X stripped of all the stuff that made the old Mod X good. Instructions. Memory. I/O facilities. Everything. But it's cheap. It's really cheap. Only the hum remains.

Dressed to kill.

Here's the same machine in disguise. Now it's hiding behind all the things you have to hang on it to make it work. Like a power supply and a memory and some sort of I/O kluge so your system can talk to it.

Also hidden, of course, is the cost. And it isn't so cheap any more.



Introducing the $3600 Interdata Model 74. What you need is what you get.

Here's a new approach.

A $3600* general-purpose OEM minicomputer with the much-copied third generation architecture of the Interdata New Series family of minicomputers.

And that $3600 — lowest in its class — includes hardware multiply/divide, 16 general registers, directly addressable 8KB core expandable to 64KB, an 80-ns solid-state Read-Only-Memory and a multiplexor that provides an I/O system for communicating with up to 255 peripheral-oriented device controllers.

We've even made the display panel optional because most OEMs don't need it. And what you need is what you get.

At $3600, maybe we'll teach the industry a thing or two.

INTERDATA

2 Crescent Place, Oceanport, New Jersey 07757 (201) 229-4040. Atlanta — (404) 288-7000. Boston — (617) 890-0557. Chicago — (312) 437-5120. Dallas — (214) 238-9656. Detroit — (313) 356-5515. Houston — (713) 783-1850. Los Angeles — (213) 640-0451. Palo Alto — (415) 969-1180. Washington — (703) 525-4806. Toronto — (416) 678-1500. United Kingdom — Uxbridge 51483. Sydney — NSW 439-4155. West Germany — 0811/160031. Tokyo — 270-7711.

*Basic 8K8 Model 74 list.
With OEM discount, quantity of 18 — $2,520.00.

Instruments

Generator has DVM and counter

3½-digit unit provides multiwaveform output from 0.0005 Hz to 10 MHz

A common sight on workbenches is a function generator, used with a counter for accurate frequency determination and with a digital voltmeter or scope for an accurate indication of output level. This

inconvenience may become a thing of the past with a new wide-range sweep/function generator that includes a frequency counter and a peak-reading digital voltmeter.

Wavetek's new model 147 has a multiwaveform output from 0.0005 hertz to 10 megahertz with 3½-digit light-emitting-diode display. The display can be switched to read frequency, positive peak amplitude, or negative peak amplitude. The peak values are more meaningful for the various waveforms than rms values would be, and this output helps eliminate the need for a scope to determine this information.

The frequency in the free-running mode is set in decades, then by coarse and vernier controls on one knob, with frequency readings provided instantly, even for very low values. Output waveforms are sine, square, triangle, positive-pulse, negative-pulse and dc-voltage. Symmetry is adjustable from 1:19 to 19:1, and the 147 provides sawtooth or ramp output. The frequency can also be controlled by an external voltage, with a 5-volt signal excursion giving a frequency change up to 1,000:1.

Output potential is 30 V peak-to-peak into an open circuit or 150 milliamperes into a short circuit, and impedance is 50 ohms. An 80-dB attenuator is provided with maximum step deviations of ±0.25 dB for each 20-dB section. At low frequencies, the instantaneous output voltage can be read; this is especially useful for ramp outputs. Dc offset of ±10 volts is provided.

In addition to free-running and external frequency controls, the model 147 can operate as a sweep generator. Starting point and sweep width can be set and read accurately with the counter. Sweep frequency is adjustable, and operation can be continuous or triggered.

Counter display variation is ±0.2% ±1 digit from 10 kHz to 10 MHz and 0.3% down to 0.01 Hz. Time symmetry is 99.5% from 10 Hz to 100 kHz. Amplitude readout deviation is ±5% of full output from 1 Hz to 10 MHz. Display is of the 50-ohm terminated voltage. Sine-wave frequency response is to within 0.2 dB to 1 MHz.

Sine-wave distortion is less than 0.5% from 10 Hz to 100 kHz, with triangle linearity greater than 99% from 0.0005 Hz to 100 kHz, and amplitude symmetry is ±99% about ground on symmetrical waveforms. Square-wave rise and fall times for a 50-ohm load are less than 30 nanoseconds. The generator is priced at $1,295.

Wavetek, P.O. Box 651, San Diego, Calif. 92112 [351]

Frequency counters cover 1 Hz to 200 MHz

A line of frequency counters is designated SM-110 series. The 110A operates from 1 Hz to 200 MHz and offers separate 1-megohm and 50-ohm inputs, 10-mV input sensitivity and a 1-MHz-crystal time base, stable to 7.5 ppm/year. The SM-110B provides range, inputs, and sensitivity identical to the SM-110A and also includes such features as a temperature-compensated crystal-oscillator time base of only 1 ppm/year and remote programing capability. The SM-110C, in addition to these features, includes a 600-MHz prescaler for high-frequency input for uhf measurements.

Price of the A model is $495; the B, $625; and the C, $795.

Heath/Schlumberger Scientific Instruments, Benton Harbor, Mich. 49022 [356]

Recording system provides two 40-mm analog channels

Accepting a range of industrial and biomedical plug-in signal conditioners, the model 220 general-purpose recording system provides two 40-mm analog channels and two event channels. Features of the unit include a full-width response of up

to 40 Hz, 10 divisions at 100 Hz; rectilinear trace presentation; pressurized ink writing; 99.5% linearity enforced by a servo pen-positioning system; and four pushbutton-selected chart speeds of 1, 5, 25, and 125 mm/second.

Gould Inc., Instrument Systems Division, 3631 Perkins Ave., Cleveland, Ohio 44114 [357]

Industrial panel meter offers internal stable reference

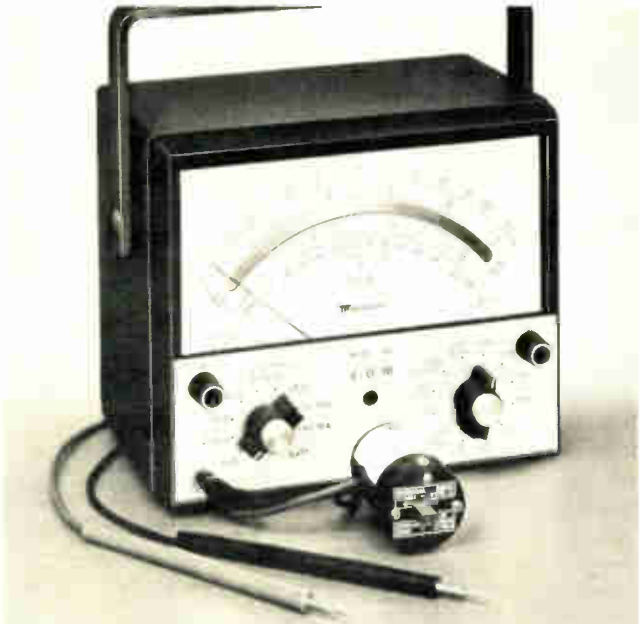
The series 3000B general-purpose digital panel meter is designed specifically for industrial system applications. The display is updated five times per second. Input semiconductor devices and stable internal reference and converter components provide a solid zero

over a 0 to 50° C temperature range without adjustments. Price is $198.

Electronic Research Co., 7618 Wedd Ave., Overland Park, Kan. 66204 [358]

Leakage adapter is for medical, commercial uses

A portable ac current leakage adapter designated the model 60-413 permits measurement checks of those small amounts of leakage current between patient and connected instruments that are often undetected in hospitals and geriatric centers. The unit can also be used to



measure leakage current in commercial applications. The unit measures from 10 μA full scale to 30 mA full scale, and resolution is 0.2 μA on the lowest VOM range. Accuracy is to within ±4% full scale. The unit, for use with the model 801 multimeter, is priced at $30.

Triplett Corp., Bluffton, Ohio 45817 [359]

Microwave

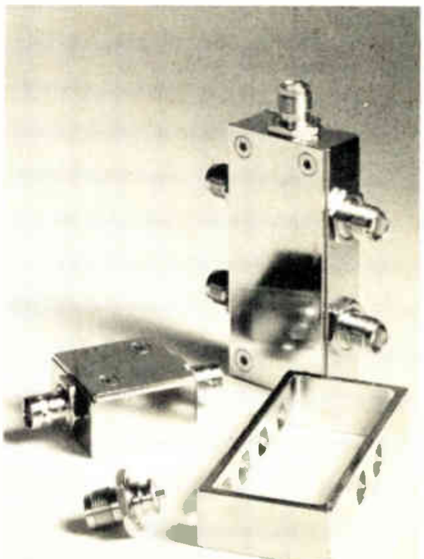
Package line is standard

8 configurations offered, with user's choice of four connector types

Integrated-circuit makers have the advantage over their radio-frequency and microwave counterparts; once they make a circuit, there is usually a low-cost package to put it in—the DIP, for example. Until now, building microwave hybrid circuits, a strip transmission-line device, or any other of a number of rf or microwave circuits, required custom-packaging the end-products.

Now the Modpak electronics-packaging system, manufactured in eight standard configurations with up to four connectors and four feedthroughs, is being offered. The user has his choice of any one of four connector types—BNC, TNC, type N, or SMA. Prices range from $9.75 to $14.75, whether the quantity is one or 500. While this is higher than prices for plastic dual in-lines, it is low for microwave packages.

Developed by Modpak, which specializes in microwave subassemblies, these packages anticipate many of the prototyping and breadboarding problems facing microwave engineers. There are simple clips for mounting on pc boards, stripline circuits, or hybrids. D-holes for all connectors and feedthroughs are prepunched to save a great deal of time. Modpak packages allow access to both sides of any circuit, in contrast to competing packages, which usually are die castings with the centers milled out but with a bottom surface remaining. And since the Modpak line was designed for rf and microwave applications, the company can give VSWR data on every package-connector combination it builds. And Modpak is promising 72-hour delivery on standard and two weeks on custom units.



Each Modpak is a nickel-plated aluminum extrusion with circuit-board mounting chips and nickel-plated aluminum covers. There are standoffs in the bottom cover, to which the top cover is bolted.

If one of the eight standard configurations and sizes doesn't fit a customer's requirements, Modpak designs to custom specifications. Custom-order forms are included in the company's 16-page catalog. The set-up charge is waived, and the user pays for a blank case ($11.50), connectors ($3.75 each), and feedthroughs ($2 for standard types, and $3 for filter feedthroughs). That's for one to 24 units, but on custom orders, Modpak gives 10% off as order size passes the 25, 50, and 100 levels.

Modpak, an Adams-Russell Company, 32 Green St., Waltham, Mass. 02154 [401]

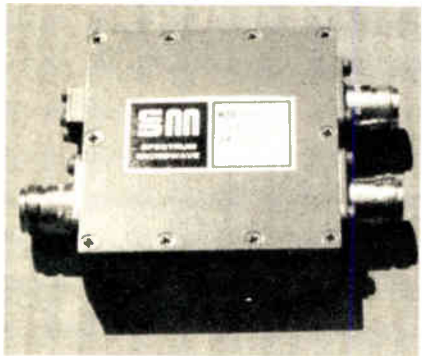
Limiter protects sensitive instruments from overload

Sensitive microwave instruments can be protected from overload damage by a limiter, designated model 11693A, which typically introduces frequency response variations of less than ±0.5 dB from 100 MHz to 12.4 GHz. Limiting action begins at signal levels of around 5 mW; even with applied levels of 1 W continuous-wave or 75 W peak, the output from the limiter stays below 100 mW. The limiter can also be connected at the input of an instrument that is looking at signals from an antenna, such as a spectrum analyzer or receiver, and the limiter will not constrict the dynamic range of the spectrum analyzer. Price of the limiter is $200, and delivery time is two weeks.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [403]

Power-splitter handles 10 W continuous-wave power

The model 1500-3SP power-splitter which can also be used as a power-combiner, is furnished with a load termination for 10 watts of continuous-wave power. The unit, sealed

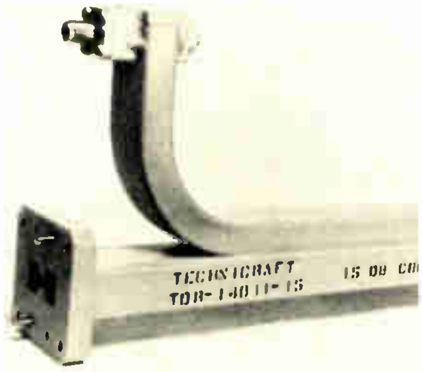


for outdoor all-weather use, has a center frequency of 1.5 GHz. Bandwidth is 100 MHz minimum. Other specifications include a coupling of 3 dB ±0.5 dB, a VSWR of 1.25:1 maximum, insertion loss of 0.2 dB maximum, and isolation of 18 dB minimum. Price is $275.

Spectrum Microwave Corp., 328 Maple Ave., Horsham, Pa. 19044 [404]

Waveguide coupler covers 7.5 to 18.0 gigahertz

A broadband double-ridge waveguide coupler, called the WRD750D24, covers the band from 7.5 to 18.0 GHz. High 35-dB minimum directivity permits less than 1.035 residual in return-loss-measurement systems. The unit is constructed of aluminum with an SMA-coupled output port and features a mean coupling of 10 dB. Twenty- and 30-dB models are also avail-



able. Price is $800.

Technicraft Division, Tech Systems Corp., 401 Watertown Rd., Thomaston, Conn. 06787 [405]

SMA-type termination offers VSWR of 1.15 to 18 GHz

A coaxial SMA-type termination, designated the T180M, measures 0.42 inch long. Maximum voltage-standing-wave ratio from dc to 18 GHz is 1.15, and readings below 1.10 are typical VSWR from dc to 10 GHz is 1.05 maximum. Maximum power input is 1.0 watt, and temperature range is from −54°C to +125°C. Price is $15.

Engelmann Microwave, Skyline Dr., Montville, N.J. 07045 [406]

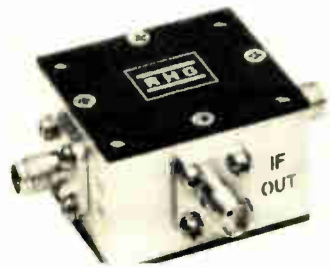
Schottky detector is for broadband applications

Designed for all broadband applications requiring high-voltage sensitivity and small size, the model 7705B-M19 Schottky detector operates over the frequency range from 0.01 to 30.0 gigahertz. The unit has an open-circuit voltage sensitivity of 1,000 mV/mW minimum over the frequency range of 0.1 to 20 GHz and of 1,500 mV/mW from 1.0 to 12 GHz. High sensitivities are available for narrower bandwidths. The device measures 1.17 in. in length and 0.247 in. in diameter. Price ranges from $95 to $125, depending on quantity.

Microwave Associates, Burlington, Mass. [407]

Double balanced mixer covers 1 to 18 GHz

Using Teflon-Fiberglass substrates with beam-lead Schottky diodes, the model DM1-18 double balanced mixer covers 1 to 18 GHz, and is usable to 26.5 GHz. Applications are in surveillance, radar, and communi-



cations receiving systems. Specifications include an isolation of 20 dB, noise figure of 10dB and an i-f range of dc to 300 MHz with dc to 2.3 GHz available. Price is $595.

RHG Electronics Laboratory Inc., 94 Milbar Blvd., Farmingdale, N.Y. 11735 [408]

Amplifier delivers 1 W at 1 dB compression

The model LWA1020 in a solid-state linear class A amplifier operating over the range from 1 to 2 GHz. The unit delivers 1 watt at 1 dB compression with a signal gain of 30 dB. Gain is 30 dB, and gain flatness

is ±1 dB. The modular unit has a noise figure of 10 dB maximum and a power input of +20 Vdc at 960 mA. Price is $1,950.

Microwave Power Devices Inc., Adams Court, Plainview, N.Y. 11803 [409]

The wraps are off—and the new Macrodata MD-500 general-purpose LSI test system is now a reality!

We designed it, we produced it, we field-tested it — and now it's ready for you. It's the world's finest and most versatile, general-purpose, LSI test system. We call it the MD-500. With both hardware and software modularized for your selection — at last you can have a system that's built the way *you* want it. Now you can put together in one general-purpose system the functions you need for your applications.

The MD-500 tests both MOS and bipolar devices up to 64 channels at data rates as high as 10 MHz, and DC parametric tests are conducted independently or simultaneously with high speed functional tests at the user's option. It tests random logics, RAM's, ROM's, and shift registers — both synchronous and asynchronous devices, as well. And instead of a single pattern storage medium, it offers the user a choice of one or more of the following: a serial data simulator; a bipolar RAM buffer; and Macrodata's exclusive MD-104 microprogrammable multiprocessor for algorithmic pattern generation. All this provides you a testing capability well beyond that of other existing systems with limited hard-wire pattern generators.

Also, in the tradition of being first with such innovations as random bit masking, channel masking, I/O in a single clock period, error delay counting, and galloping 1's and 0's, etc., Macrodata now adds such other exclusive new features in its MD-500 as — Initial Vector Compare, Random Vector Compare, and Deterministic Vector Compare.

But that's not all. Instead of just a major and minor loop, the MD-500 offers up to 256 loops, nested in any fashion. And the MD-500 software system offers multi-station operation — up to two parallel stations and up to four active stations, plus a test compiler station. Programs may be compiled on line while other stations are testing, without test interruption. The test pattern data base and programs are independent of each other . . . you can program off the front panel . . . and, in addition, you can even talk to a single bit.

Why wait for the me-too-ers to say — "Oh yes, we have that too"? Macrodata — the company the others are following — has it all now in the MD-500. Send for your free copy of the MD-500 brochure.

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Circle 131 on reader service card

The $4,000 graphic terminal

for when you need more than one

When you need a multi-terminal graphic display system, remember this price. It is the price of the most cost effective system you can get.

And it includes all the system hardware.

Low-cost, daylight viewable TV monitors are refreshed by a common disc memory and video generator. One memory and generator can drive up to 16 high resolution terminals—each with an independent display.

Or drive as few as 4 terminals and the system cost works out to just under $6,000 each.

But if you don't need a keyboard, or if you want to use a different TV monitor, OK. You can buy only the video generator and whatever accessories fit your application.

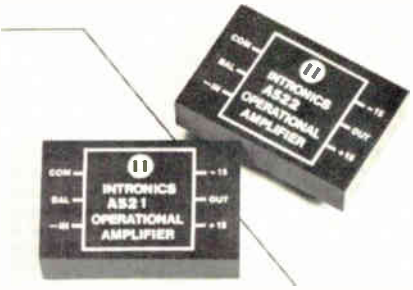
These systems have all the capability you need. There are over ¼ million individually addressable points in the graphic display, and you can selectively erase any rectangular area of the screen. Write 51 lines of 85 alphanumeric characters. You can even combine channels for color or gray scale displays.

And because the displays are disc refreshed, you will not overload your CPU.

So when you need more than one graphic display terminal, call your Data Disc representative or contact us at 686 West Maude Avenue, Sunnyvale, California 94086; 408/732-7330.

DATA DISC

Circle 134 on reader service card

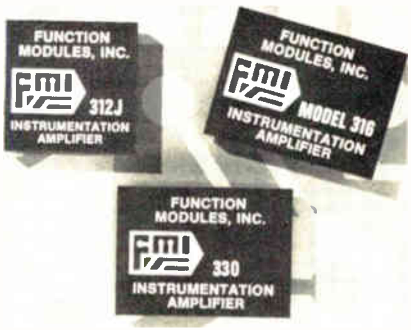


cuitry to achieve wide-gain bandwidths of 100 MHz. Price is $59 for the 521 and $69 for the 522.

Intronics, 57 Chapel St., Newton, Mass. [389]

Amplifier gain adjusted by one external resistor

Three instrumentation amplifiers are designated the models 312, 316, and 330. The gain of each is ad-



justed over a wide range by varying one external resistor. For other than no gain, no external trimming is necessary, even on common-mode rejection. The model 312 has an FET input stage and a high input impedance. The model 316 is a general-purpose unit with a gain range of 1 to 1,000, and the model 330 offers a common-mode input of ±250 V and can be used for industrial control systems. Price ranges from $35 to $69.

Function Modules Inc., 2441 Campus Dr., Irvine, Calif. 92664 [387]

Power source controls current to within 1%

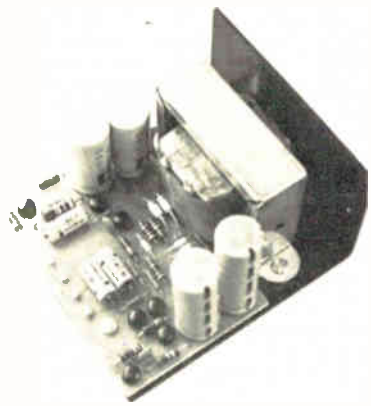
A series of constant-current dc power supplies designated SCC-120-3 is designed to control current to within 1%. Typical applications include equipment for resistive measurements, and circuits incorporating lamps or light-emitting diodes.

Specifications are: an input voltage of 115 vac ±10%, adjustable current range of 0.1 to 3 amperes, and an open-circuit voltage of 40 vdc. Price ranges from $125 for one unit to $106.26 for 100 pieces.

Standard Power Inc., 1140 W. Collins Ave., Orange, Calif. 92667 [388]

Power supplies are for small MOS, logic systems

Designed for small MOS or op amp and logic systems, a series of dual- and triple-output regulated power supplies provides typical outputs of ±12 V at 0.5 A, +5 V at 1.2 A/−12 V at 0.5 A, and +5 V at 3.2 A/+12 V at 0.5 A. Features include current limiting, floating output and regulation and ripple compatible with MOS, TTL and linear systems. Price



ranges from $29.95 to $49.95.

Viking Electronics Inc., 721 St. Croix, Hudson, Wisconsin [390]

At Statham we've tamed the component test fixture!

It's a thrilling three-ring act! Components, test fixture, test chamber — all working together smoothly. Because . . . at Statham we've tamed the test fixture! Made it behave — cooperate — do just about anything we ask.

We make test fixtures that cooperate fully with our Statham SD Series Temperature Test Chambers.

Standard off-the-shelf fixtures test a broad range of electronic components, including DIPs, TTLs, T05-T018, and other multilead devices with front-panel switches for individual readout.

The operating range of our standard test fixtures is -65°C to +150°C. Extended ranges are available to +300°C.

All Statham test fixtures feature high unit capacity, quick loading, ease of accessibility — and are designed to ensure low electrical leakage rates and low thermal gradients.

Do you have unusual design needs? We will make test fixtures to meet your specifications.

It doesn't matter how tough or complicated your requirements are. Statham will make the test fixture you need.

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TELERAY 3300

The low cost, silent Teletype* replacement

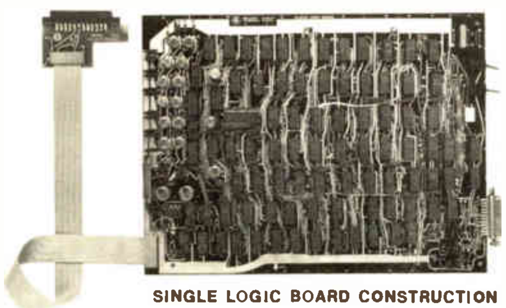
Do all the CRT Teletype replacements look alike to you?

There's a big difference inside.

The TELERAY 3300 has *all* the terminal's logic on one *single*, highly-integrated circuit board. Not only does this design bring the cost down, but it gives you one-circuit-board replacement maintenance. And, that's not all. All 106 integrated circuit chips on the single logic board are *plug-ins*. Check the others for this feature! In our 20 years of experience in electronic product design, we've learned to build things truly maintainable.

The TELERAY 3300 displays up to 24 lines of 40, 72 or 80 characters each. The keyboard, available separate or attached, generates 64 graphic characters plus control characters. Data retrieval is at rates from 110 to 2400 Baud. Switchable half or full duplex. Interface is RS-232-C, TTL and 20 ma current loop. Desk top cabinet or chassis mount. 50/60 Hz models available.

Use TELERAY 3300 anywhere you'd use a Teletype.



SINGLE LOGIC BOARD CONSTRUCTION

TELERAY 3300

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For prices and details call (612) 941-3300

RESEARCH INC

BOX 24064 MINNEAPOLIS, MINNESOTA USA 55424

No. 112

Packaging & production

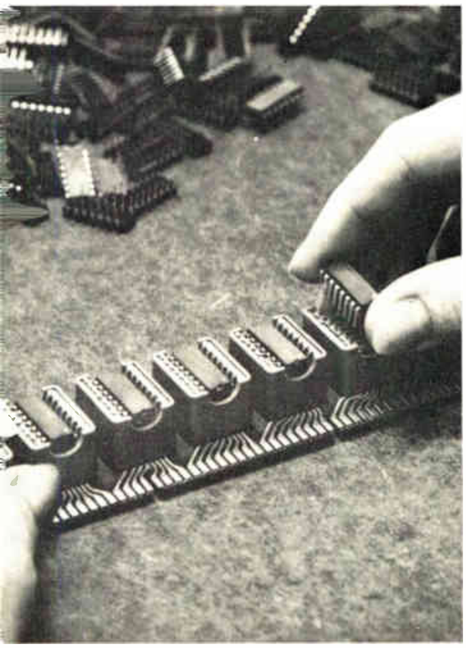
IC socket offers wide entry

Test unit with flared contacts speeds device insertion and minimizes damage to leads

Burn-in and testing of integrated circuits call for specialized sockets, designed for both ruggedness and prevention of damage to the ICs. With these requirements in mind, Loranger Manufacturing Co. has developed a series of sockets, available in 14- through 40-lead dual in-line configurations. The socket, which permits burn-in that conforms to Military Standard 883, has a flared entry so that devices with bent or misaligned pins can be inserted without "fishing" for the entry holes.

The leads are spaced 400 mils between rows so that the socket will accept both standard dual in-line and side-brazed packages. A ⅛-inch-square groove down the center of the socket (not visible in the illustration) permits easy removal of the device by merely inserting a rod under the IC, which then pops out.

Unlike zero-insertion-type sockets, the Loranger unit has a wiping contact to ensure adequate cleansing of the leads at the time of insertion. The socket (shown gang-mounted) has side ribs between the contacts to prevent damage and lateral misalignment of the contacts. The socket will withstand temperature cycling from −65 C to +300°C continuously. The body is molded epoxy, and the contacts are beryllium with 50-millionths of an inch of gold-plating over 100-millionths of an inch of nickel understrike.



In 1,000-piece lots, price for the 14-lead type is $1.10 each.

Loranger Manufacturing Corp., P.O. Box 948, Warren, Pa. 16365 [391]

Radial-lead preformer handles 1,800 units an hour

A completely adjustable radial-lead preformer can process radial-lead components accurately and efficiently at rates exceeding 1,800 per hour, according to the maker, Manix Manufacturing of Feasterville, Pa.

Designated T-Kut, the portable, lightweight, 110-volt machine will handle all components, including transistors, diodes, rectifiers, capacitors, and resistors.

Interchangeable jaws have adjustments for cutting, bending, and standoff dimensional change. The radius of crimp is also variable, as well as the distance that the leads may extend below the board. The design of the T-Kut ensures that delicate microcircuitry is protected during the lead-forming operations, the company says. Air- and electric-powered models to process other types of components are also available. Prices for the machines start at $1,250.

Manix Manufacturing, Feasterville, Pa. [339]

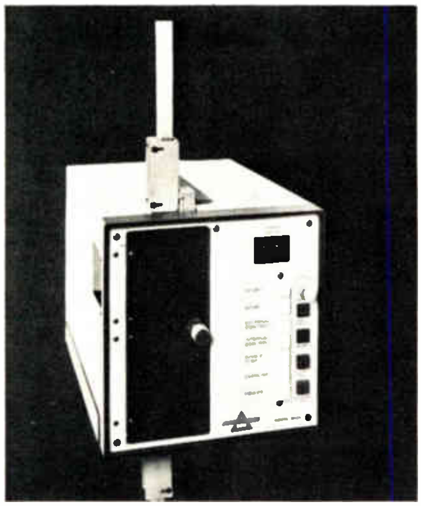
Mask comparator measures to within 8 microinches

A mask comparator measures to within an 8-microinch accuracy the registration of patterns on related photomasks. Users view the working pattern superimposed over the master pattern or a multilayer pattern. Deviations appear in contrasting colors. Three high-aperture objectives for magnifications up to 320× are provided.

Opto-Metric Tools Inc., Dept. JR, Rockleigh, N.J. 07647 [393]

DIP handler processes to 7,000 devices per hour

An automatic dual in-line package handler is capable of processing up to 7,000 devices per hour. The model 8020 will process 8-, 14-, 16-,

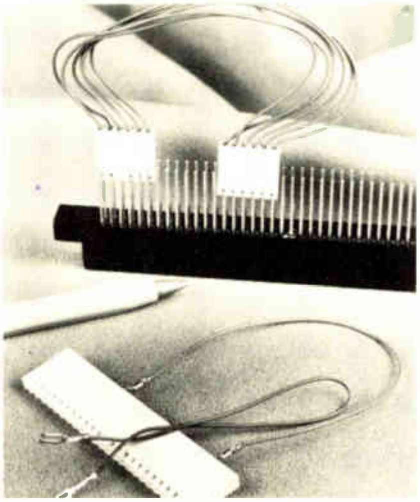


or 18-pin DIPs directly from the manufacturer's packing sleeve, through a test station and back into the packing sleeve. Rejects are ejected into bulk. The unit links with all IC testers and accepts every manufacturer's single- and dual-stick packaging sleeves. Price is $3,050.

Delta Design, San Diego, Calif. [394]

Strip connectors mate with square, round posts

Jumper strip connectors are available in strips of two to 25 contacts, and they mate with 0.25-inch square or round posts. The series 221 devices intermate with most pin types, including wire-wrapped and dip-solder tails. The units are suitable for back-plane interconnection, in addition to applications in multilayer pc boards, socket panels, and printed-circuit connector panels. They are



particularly suited for data-processing equipment.

Amphenol Industrial Division, 1830 S. 54th Ave., Chicago, Ill. 60650 [395]

DIP sockets are available in three configurations

For flexibility in mounting and termination options, a family of DIP sockets, called A-OK, are available in three configurations. The W-type sockets press-mount directly into a drilled board. L-type sockets provide annealed beryllium-copper terminals that may be bent, twisted, or cut for any mounting method, and the type-U devices allow wire-wrapping on the same side of the board as components, eliminating board flipping during wiring.

Robinson-Nugent Inc., 800 E. Eighth St., P.O. Box 470, New Albany, Ind. [396]

Microwave oven cures photoresist in seconds

The model QK600GP microwave oven cures photoresist from 10 to 100 times faster than conventional methods, and developing times are typically 2 to 10 times faster than other means. The unit operates from 110 v at 60 Hz, and it offers high and low power levels. A digital timer provides timing range of 0 to 999.9 seconds with repeat accuracy to within ±0.05 second. Price is $1,575. An optional adapter permits the chamber to be purged with inert gases.

Sage Laboratories Inc., 3 Huron Dr., Natick, Mass. [397]

Tool inserts 8- to 16-pin DIPs in less than 4 seconds

A tool developed for the manual insertion of 8- to 16-pin DIPs in sockets and holes in printed-circuit boards is called the DIP-Sert/16. Operators can mount DIPs in less than 4 seconds per package, compared with manual-insertion times of 1½ to 2 minutes per package by other methods. After insertion, lead tension holds the packages securely

in place during soldering. Price is $2.94.

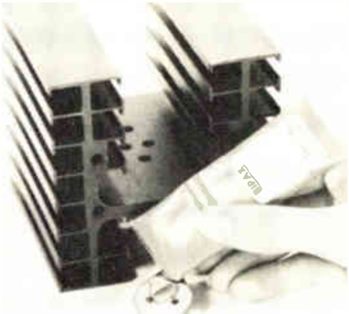
Scott Industries, Paramount Bldg., N. Chelmsford, Mass. 01863 [399]

Fracturer is for ceramic substrates, wafers

An automatic fracturer is designed for ceramic substrates and semiconductor wafers. The devices are transported on a moving belt and the operation is completed in seconds. The part is rotated 90°, and the action is repeated to complete fracture in both directions. The unit will accommodate a range of materials and sizes. Price of the model 105 is $1,750.

Mechanization Associates, 147 E. Evelyn Ave., Mountain View, Calif. [400]

New products/materials



A two-part thixotropic epoxy adhesive system is for staking transistors, diodes, ICs and other heat-sensitive electronic components to printed-circuit boards, radiators, and heat sinks. The material is called Tra-Bond 2151, and it mixes to a smooth paste with slump-resisting body. It cures overnight at room temperature into a hard, rigid formulation that creates thermally conductive, yet electrically insulating bonds to a variety of materials.

Tra-Con Inc., Resin Systems Division, 55 North St., Medford, Mass. 02155 [476]

An electrographitic grade, number 2089, helps eliminate cracks in silicon-carbide coatings on semiconductor boats and other parts where the high-temperature capabilities of graphite need to be augmented with increased oxidation and/or wear resistance. The substrate material closely matches the coefficient of thermal expansion with refractory carbide coatings, such as silicon carbide.

Stackpole Carbon Co., Carbon Division, St. Mary's, Pa. 15857 [478]

A thermally conductive, electrically isolating silicone pad for mounting power semiconductors or other devices requiring electrical insulation, in addition to high heat dissipation, is called Cho-Therm. The material consists of inorganic fillers dispersed in a silicone binder and is configured in sheets or die-cut forms; it can also be molded into special shapes as desired. Two formulations are available: one with a thickness of 0.012 inch and the other with a thickness of 0.020 inch.

Chomerics, 77 Dragon Ct., Woburn, Mass. 01801 [480]

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New literature

Indicator lights. The SIND series of industrial indicator lights is described in a one-page data sheet available from Shelly/Datron, 1562 Reynolds Ave., Santa Ana, Calif. 92707. Circle 421 on reader service card.

Microprograming. Debugging microprogramed systems is the topic of a four-page applications note being offered by Signetics Memory Systems Inc., 740 Kifer Rd., Sunnyvale, Calif. 94086. The leaflet explains specifically how flaws can be removed from memories. [422]

Surface waves. Dynamic Research Corp., 60 Concord St., Wilmington, Mass. 01887. A six-page data sheet describes methods for generating wave masters with the option of changing the weighting function without changing the interferometrically divided grating. [423]

C-MOS. A technical bulletin outlining the advantages of using C-MOS in automotive applications has been released by Solid State Scientific Inc., Montgomeryville, Pa. 18936. The bulletin discusses chip-design techniques and provides data on some circuits now being implemented in automotive electronic systems. [425]

Substrates. National Beryllia Corp., Greenwood Ave., Haskell, N.J. 07420. A data sheet on Berlox K-150 substrates provides dimensional and fabrication standards, as well as thermal and electrical properties of the material. [426]

Antennas. Channel Master, Ellenville, N.Y., has published a catalog of antennas, accessories, and electronic-reception aids. The 48-page book contains information on products for indoor and outdoor vhf, uhf, and fm applications. [427]

Temperature measurement. A handbook and catalog, containing tables and listing instruments and other products pertinent to temperature measurement, is available from Omega Engineering Inc., Box 4047, Stamford, Conn. 06907 [428]

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HOME SECURITY

Will it be chains and bolts, electric eyes—or muscle?

It was 8:55 p.m., a Friday. The stranger had cased the house and seen its owners depart at 8:40, the man wearing a black coat, and his wife, a long skirt, indicating they would not be right back. The stranger slipped to the rear patio windows. Quietly and easily he cut a pane of glass and within seconds was inside the house. He took two steps in the dark, and froze. A table lamp had snapped on. The intruder spun about. He was alone. A piercing alarm wailed in the night. The man, his eyes glazed, stood still for a moment, then fled—into the arms of approaching squad car officers who had been dispatched by the station desk man who, in turn, had been alerted by a red flash on his residence-signal console.

Such is the action pictured by vendors of the newest electronics in the home protection business—which is currently ticking off receipts faster than a suburbanite can say, "Help—police!" "It's a true story—it's going on more and more in towns like this," says Police Chief John Orr of Ridgewood, N. J., a haven for New York commuters. "I go for the electronics—within limits."

Under a quick cloak of darkness, as it were, the home protection business has boomed since 1965. Sparked by drug-related violence and burglaries (the latter up 70% in five years), the industry has produced a maze of wires and hardware. A homeowner can spend from $500 to as much as $2,000 for a "perimeter" alarm system which signals when a window or door is opened—or $100 for an ultrasonic space alarm which picks up anything moving within its 300 sq. ft. field of detection. A do-it-yourselfer can buy kits to cut most prices in half.

But profusion hasn't meant that all wires have been soldered to the right connections. Malfunction is common, and stories about alarms triggered by the cat and sirens that wouldn't turn off make the rounds at local police stations. Unhappily the young home protection industry—on top of having to experiment with new electronic tricks—is having to contend with some fly-by-nights and quick-buck artists with a yen for the bankrolls of jittery suburbanites and city apartment dwellers. Some legitimate companies have even unwittingly employed as alarm installers men who later turned out to have police records and were as clever at foiling the electronic gadgets after dark as they were at installing them.

All this can lead a homeowner to wonder whether he might be better off buying a loud-barking dog. But despite short circuits in the gadgetry, crime prevention specialists and insurance companies give the new electronics a strong vote of confidence. Speaking of alternatives, most of these pros make it quite

This PERSONAL BUSINESS section is written by McGraw-Hill editors to give you helpful information on the better management of your leisure time and money. Personal Business covers everything from taxes and investments to education and travel. We feel that today, more than ever, personal-business planning is of prime concern to businessmen and professionals.

clear that they vastly favor electronics, or dogs, over the amateur's use of guns. "Don't become weapons-minded when you think of home protection—it can be very dangerous," says Stanley Schrotel, a top industrial security specialist and former Cincinnati police chief.

How much ought one spend on electronics? This may depend on the degree to which personal safety is a problem in the neighborhood, and the value of art works and other high-ticket items that need protection.

A perimeter alarm by American District Telegraph Co. or Westinghouse averages $1,500, installed. In this system, sensors are embedded in window and door frames and connected to an alarm console which is signaled if the sensors are moved. The console sets off an alarm on the premises, or signals police or private security agency over a leased wire or by an automatically dialed phone. Automatic dialers cost $200 to $400, installed, and leased wires, $10 to $25 a month.

A simplified version of a perimeter system is a Magnavox unit with two window or door sensors which signal a small console by radio. Since it is not wired to the sensors, the console can be hidden anywhere, thus thwarting discovery of the alarm ($170). Simpler yet, and less costly, is an alarm-door-lock which is triggered by tampering ($50 range). ADT offers a clever twist on the idea—a push-button lock that sets off an alarm and alerts police if the buttons are not pushed in proper sequence.

Second best is scaring off a crook once he is inside. For this, Magnavox sells an ultrasonic space detector that looks like a small stereo component, while 3-M offers one disguised as a dictionary ($100 range). This is the device that, upon sensing movement in a room, sets off a blare of light and sound.

"Some electronic items on the market are cheaply made, and don't work properly at all," says Ridgewood's Chief Orr. "Those that are too sensitive sometimes get upset by power line surges and set off false alarms. Not to mention tripping by members of the family. But the idea of connecting with the local police station is fine. We find that this works—especially when the intruder is not alerted."

In affluent Scarsdale, N. Y., another commuter bedroom community, over 700 of the town's 5,000 private homes have alarm systems tied into the police station. The gadgetry pays off; the burglary rate has remained level while in some surrounding areas it has curved upward at about 30% a year. Scarsdale Police Chief Donald Gray favors the electronics—even though over 90% of the town's home emergency signals turn out to be false alarms.

Aware of abuses in the business, the Scarsdale town council has passed an ordinance requiring licensing of alarm companies, fingerprinting their employees, and the use of interior space detectors as a backup for perimeter protection in police-connected systems.

Unfortunately, the abuse-awareness in Scarsdale is exceptional. Before investing in a system, a homeowner is wise to check with local police, an insurance company, and someone who has used the system. While homeowners are unable to get insurance rebates, as do commercial owners, some insurers note that a reliable alarm system will help keep some coverages in force in areas where crime rates are high.

A safe piece of advice is to consider only systems listed by Underwriter's Laboratories; the choice is wide—there are hundreds. Another idea is to read Mel Mandell's new study of home security, *Being Safe* (Saturday Review Press). Much hinges, of course, on obvious measures: buying good door and window locks; using bright lights inside and outside the house, and, of course, keeping neighbors informed of long weekends and trips away from home.

At what time of day or night need a home be protected? The answer is, of course, at all times—and the notion that most burglaries occur from midnight to dawn is entirely false.

"Hits in the late afternoon, after high school is out, seem to be on the increase," says Chief Orr. "The phoney delivery man or meter reader can turn up at any time of day. And lately, most 'b and e's' (breakings and entries) seem to be in the early evening, from dusk until eleven o'clock—they case houses where people are out for dinner or a show. Few hits are made in the middle of the night."

Supporting such statements are statistics from the International Assn. of Chiefs of Police. In the past five years, says IACP, night-time residential burglaries increased nearly 90%—and daytime breakings and entries, 108%

The need for home protection in daylight and early evening hours makes the use of complex electronics all the more difficult. Simple devices such as automatic timers that turn lights and radios on and off may be needed to supplement more intricate systems. Something must be done, and part of it by the individual homeowner. Only 19% of reported burglaries are solved by the police.

Biter—or barker?

"For home protection you can't beat a loud-barking dog," says Chief John Orr, longtime head of the Ridgewood, N.J., police department which safeguards the homes of many affluent New York City commuters. "Houses that have them rarely get broken into." Many policemen agree. They note, too, that the barkers are oftentimes more effective and reliable than complex electronics. "A member of the family can't accidentally 'trip' the family pet," Orr says. "And a dog is cheaper."

There is debate, however, on what kind of dog is best. Some policemen insist that the common, ordinary loud barker is a safer bet for a family than a professionally trained "guard" dog that can literally tear an intruder limb from limb.


Ron Appelbe

K-9 Corps' ex-Capt. Haggerty and pupil.

"It's too dangerous for the average family," says Stanley Schrotel, a top crime specialist and former Cincinnati police chief. Schrotel, an attorney, is particularly aware of the legal liabilities that can arise from owning a guard dog, and he and others who specialize in protecting property (Schrotel is now head of security for the Kroger Co., of Cincinnati) tend to place guard dogs for the home on a par with hand guns.

The not-so-average family that deems itself capable of controlling such a dog, nonetheless, will find a growing number of trainers in a business that has been fattened by the national crime scare.

In the New York area, former Capt. Arthur Haggerty, who once headed up the Army's K-9 Corps and has for 18 years trained and sold German Shepherds and Dobermans to protect business property and a limited number of private apartments and houses, opts for the German Shepherd type for home protection. "Just any big dog, like a Husky or Great Dane, won't do the best job," says Haggerty. "It takes a police-bred animal, and one that's placid to start with. If the dog has the right temperament and training—and proper handling by its owner—it's safe. It won't hurt a member of the family under normal circumstances." The cost, incidentally, of having your own dog trained: $350 to $750.

Keeping home coverage up to snuff

The bank mails a checking-account statement every month. The dentist's nurse sends a reminder for a check-up twice a year. The IRS makes April a month to remember with its Form 1040. But the average homeowner's insurance policy rarely gets attention more than once in three years—when the agent calls to renew it.

Even then, the process has become so routinized that the average householder cannot tell you, off the top of his head, what's covered, what isn't, for how much or how little. An impartial national survey not long ago showed that, in the light of what inflation has done to replacement prices of most things—from restoring a room after a fire to replacing stolen furniture—the majority of U. S. householders are under-insured.

If you haven't done so in the past year, now is as good a time as any to dig out your homeowner's policy and compare its coverage with your family's current requirements. Here are some checkpoints to consider:

■ Scope of perils covered. If yours is a "basic" homeowner's policy (the industry's HO-1), your property will be protected against 11 perils, ranging from fire or lightning, windstorm or hail, to explosion, riot, vandalism and, of course, theft. If, after examining your policy, you feel you also need coverage against the damage of plumbing freeze-ups, water or steam leakage, falling objects and the weight of ice or snow, you may consider stepping up to a "broad" homeowner's policy (HO-2)—it guards against 18 perils. Of course, "comprehensive" homeowner's (HO-5) goes even further, protecting against nearly everything except cataclysms such as earthquake, landslide, flood, tidal water or tidal wave, and war and nuclear radiation.

■ What is covered and for how much? Typically, homeowner's insurance covers the basic dwelling (including attached garages and additions), other structures (detached garage, guest house, tool shed, etc.), personal property on and off the premises, and liability for injury or damage to others. Note that an extra garage that you might rent out will be included in the coverage, but any other buildings used for commercial purposes or rented or leased to others will require additional coverage.

The *amount of coverage on your basic dwelling* is all-important under homeowner's insurance, since it governs other important elements of a policy. If a $40,000 house, for instance, is insured for its full value, up to $20,000 (50% of the dwelling's coverage) is the limit on personal property recovery. The ceiling on appurtenant structures is $4,000 (10%), and up to $8,000 (20%) is allowed for additional living expenses should you and your family be forced to live for a time in a hotel and eat in restaurants. Using those percentages, a policyholder can quickly judge whether he's adequately covered.

Insurance companies generally require that in order to qualify for *full payment* in any *partial* loss under homeowner's insurance, a dwelling be covered at least to 80% of replacement value. The difference between that and 100% is for the homeowner to choose. Although insurance companies are rarely called upon to pay off total value (even in the worst fires, the foundations generally survive in useful shape), carrying less coverage shrinks the auxiliary benefits; in the $40,000 house example, dropping coverage to $32,000 would mean cutting personal property coverage to $16,000 (50%) and the other benefits proportionately.

In deciding whether your present insurance is adequate, remember that it is *replacement* value that you must cover. This is not necessarily the same as *market* value of a property, which also includes value of the land, landscaping and any out-buildings. A rule-of-thumb that claim adjusters follow is to measure the square footage of the house and multiply by local per-foot cost of building (any professional builder or real estate man can tell you what it is in your area).

It is vitally important that homeowner's coverage be at least 80% of the current cost to rebuild the house. If it falls below that percentage, the insurance company is not bound to fully restore damaged portions of the building. It can simply depreciate the value of the damaged property on the basis of its age, and pay you accordingly. To get the repair job done, you would have to dig into your own pocket for the remainder. That can be an increasingly large bite as building costs rise; a recent survey shows that, in three years time, these costs have jumped 31% in eastern states, 25% in the midwest, and 20% in the west.

Certainly, if anything of value has recently been added to the family furnishings, such as an antique or two, an inherited oil painting, say, or new and expensive furniture, the time is ripe for an inventory. Figure up your total replacement cost and weigh it against your coverage. Wisest choice is to consult an insurance man on "floaters" and separate insurance on objects of high value.

Note, too, that it's also smart to photo-graph such objects in their customary place in your home, and file the pictures away with bills of sale, appraisals or other proof of value. Such foresightedness can save time and perhaps many dollars if claims of loss ever have to be filed.

Liability insurance is included in the homeowner's package, typically $25,000 to cover a single mishap, $500 for the medical expenses of others, and $250 to cover physical damage to the property of others. By today's standards in most parts of the U. S., these are minimums, not maximums, of coverage. If yours are this low, they deserve special attention.

■ Trimming your premiums. Homeowner's coverage is generally considered an insurance bargain, but meeting today's protection demands can boost premiums. One type of cost-cutter to explore are *deductibles*. Indeed, most forms of homeowner's policies include a $50 deductible—when a loss occurs, the owner pays the first $50, collecting the rest from his insurer. (This is the so-called "disappearing" deductible; when a loss exceeds $50 the insurance company generally absorbs some of the deduction until, at $500, it pays the whole loss up to the limits of the policy).

Particularly for owners of large, expensive properties, higher deductibles—say of $100, $250 or even $500—can materially cut premiums.

■ Shopping for coverage is another way to cut costs. While relative hazards and property values determine much of your insurance premium, another factor is the casualty experience of the company that writes it—if it has had a lot of homeowner claims, its homeowner premiums will likely be higher than those of a company that has had fewer pay-outs.

Shopping, however, should not take precedence with older homeowner customers—unless they feel they are really being had. Insurance industry insiders say that the best arrangement, despite a few dollars difference in premium, is to carry your homeowner's coverage with the same agent who has your life insurance and other policies. "It gives you a great deal more leverage," one industry veteran notes, "when it comes to getting any claims handled quickly and favorably. It's worth a few dollars extra."

Nowadays, insurance companies also offer packaged homeowner-type coverage for people who rent or lease their dwelling place. Such policies, of course, do not cover the premises, but they do protect against the usual hazards to the personal property of the tenant.

That coverage, as with homeowner's, extends to losses incurred while away from home. Most standard policies set a limit of $1,000 on any one theft. If you're in the habit of carrying expensive photographic or sports gear it is smart to be sure your loss exposure is covered.

Collector's choice: maps, manuscripts and Mr. Gwinnett

If a true autograph collector is given his choice between a signed letter by Winston Churchill and the signature of one Button Gwinnett, he'd take the Gwinnett. Although hardly so well known as Britain's wartime Prime Minister, Mr. Gwinnett did sign the Declaration of Independence as a representative from Georgia. But then he went home and, within eight months, died. He left so few autographs behind that a good one today might bring over $50,000. The Churchill might bring hardly more than $1,000.

"Also," says a Boston dealer in these collector's items, "chances are that Gwinnett's signature will continue to increase in value as much as 15% a year."

Indeed, collectors are paying more attention to—and more money for—American autographs, maps, documents and rare pieces of literature as investments of the money-hobby type. American items have proven to be fast appreciators and liquid in trade. Edgar Allan Poe's *Tamberlaine* seemed to cap the market for American literary items in 1945 when it brought $15,000 at auction. "A first edition of Poe's poem, depending on its condition, could easily bring twice that now," says an expert at Sotheby Parke-Bernet.

Reasons for the increasing prices are two-fold: The numbers of important private collections is steadily growing, and universities, libraries and museums are buying and "hoarding" American historical material.

Top choice of collectors are "autograph letters, signed" (known simply as ALS's to the initiated) of men prominent in the formation of America. "Letters, signed" (LS)—signed but not written in the hand of the author—are less valuable. An ALS of George Washington, for instance, recently topped $20,000 at a New York auction.

Other Presidential letters that are highly valued are those of William Henry Harrison (signed while in office, which was only one month), Abraham Lincoln, Thomas Jefferson, John Adams, John Quincy Adams, Ulysses S. Grant, Andrew Johnson and Zachary Taylor. More recent but still quite rare because of his frequent use of the "autopen" to mechanically sign documents are autographed letters of John F. Kennedy. Depending on its content, a letter of the late President's is worth anywhere from $500 to $5,000. Other important figures to collect are Benjamin Franklin, Alexander Hamilton, Gen. Anthony Wayne, and just about any of the military men prominently involved in the War of 1812 and the Civil War.

Although their husbands' signatures demand more, top prices are paid for letters signed by First Ladies, particularly those of Abigail Adams and Dolly Madison. A personal letter of Jacqueline Onassis will easily bring $300 to $500, depending on the message.

While autographs of historic figures remain high, those of literary people tend to fluctuate. Rarity is again the clue—a letter signed by Melville may sell for $1,000 while one by Henry James will go for $200, or one of Longfellow's, for only $50. Longfellow, presumably, wrote more letters than Melville. Always in demand are the manuscripts and signatures of Thoreau, Dickens, Washington Irving, Emerson, Whitman and Hawthorne, among others.

The "innovative" authors of the 20th Century are now in demand—$400 is usually the asking price for an autograph of Hemingway, Faulkner or Steinbeck. Five years ago, such authors would have brought one-half if not one-third that amount. The value of James Joyce's autograph has risen dramatically in the past three years, having doubled if not tripled. The 100 autographed first editions of Ulysses sold for $1,500 to $2,000 in 1967; the 1971 price was $5,000.

Robert Tollett, head of the Collector's Gallery at Manhattan's B. Altman & Co. department store, sees a rising interest in the autographs of composers, artists, Nobel Prize winners and notable scientists. An ALS of Mozart or Sir Isaac Newton, for instance, can now command between $5,000 and $10,000, depending on condition and content. Beginners, it should be noted, need not be scared off by all those high prices, however. A recent sale at Altman's, for instance, featured along with a $2,000 "Benjamin Franklin" the more contemporary signature of former Chief of Staff Matthew B. Ridgway—at only $5.

Female personalities are also high in demand, notably authors Willa Cather and Virginia Woolf, actresses Sarah Bernhardt, Jean Harlow and Greta Garbo, artist Grandma Moses, and any of the Queens of England. Autographs of history's villains are also collected: John Wilkes Booth is valued at $300 to $500, Lee Harvey Oswald, at $500 to $1,000—and a note written by Adolf Hitler can bring $1,000 to $1,500.

Authenticity and fair prices are the prime concern of inveterate collectors, and most agree there's no substitute for trading with reputable dealers. Among names commonly mentioned are New York's David Kirschenbaum, Philadelphia's Charles Sessler, Los Angeles' Doris Harris, and San Francisco's Warren Howell.

Because the major portion of them are printed, historical documents are more available and generally less expensive. But there are exceptions. Most notable recent sales have involved the log written by the co-pilot of the Enola Gay, the plane which dropped the atom bomb on Hiroshima—$37,000—and the original document on which votes were counted for Andrew Johnson's impeachment—$8,750. Also, Lincoln's draft calls for individual states of the Union sell for about $6,000 apiece.

Another field of collecting that's gaining favor is antique maps. Single-issue maps made of the American colonies in the 18th Century and before are particularly popular, as are the maps of the states made during the Civil War.

The name of the cartographer often determines the value of a map. The works of John Speede (1552-1629), early British mapmaker, are considered the rarest, most beautiful, and most in demand. Choice items include the charts of Abraham Ortelius (1527-1598), the Flemish "father of the modern atlas," and Jan Jansson (1596-1664), who published atlases in Amsterdam. As collector items, though, the cartographers don't rival Button Gwinnett's scarce autograph. About $200 buys a top-quality map.

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CIRCLE 708 ON READER SERVICE CARD

The times they are a-changing in London town

In Kensington Road, the high street of a chic quarter of London where Sir Winston Churchill used to live, a wrecking crew has been bashing away at an elderly but stately townhouse, making room for a new block of high-rise apartments. A sign on the gate warns: "Danger—Demolition in Progress." An indignant graffitist has scratched out "demolition" and scrawled in its place, "VANDALISM."

That is the way a lot of Londoners—and not a few visitors—feel about what is happening to their beloved city. Skyscraper office buildings now loom above the trees and automatically "urbanize" once-pastoral parks. Huge, ultra-modern apartment buildings diminish their Victorian neighbors. Even Piccadilly Circus, which defied the Blitz, will shortly succumb to the wrecking ball of progress—unless a worthy band of preservationists—(including comedienne Hermione Gingold) succeeds in blocking a multi-million-pound redevelopment plan.

The school of thought that London must never change in ways that might make Dr. Johnson feel out of joint—or that are too "American"—is clearly on the defensive. What is happening is the latter-day Twentieth Century, arriving somewhat late and in a hurry—and it shows in London's skyline.

Further, the pace can only be accelerated by Britain's entry, finally, last month into the Common Market (continental shippers are already pressuring for wider, straighter, less Olde English-y streets and roads for their trucks).

But before you shout "VANDALISM," rest assured that London, survivor of 20 centuries, is quite capable of coping with this one. The city on the Thames, despite its share of modern-day urban growing pains, remains one of the most civilized of civilized capitals. The West End theater district, raffish as it may seem in parts, is safe to prowl at the latest hour. So, even, is most of sinful Soho. London's fabled bobbies still rule the streets with moral suasion, not guns. And, somehow, London cabbies have escaped the neuroses that seem to plague their New York counterparts.

Of course, that worthy institution, the pub, is still very much part of the London scene—and still the best place in town for an inexpensive lunch or sociable drink. But here again, the new Continental influence of Common Market membership may shortly be felt. A government-sponsored committee has proposed that Britain's peculiar drinking hours (closed from 3 to 5:30 p.m., for instance) be eased, and that pubs take on more of a "cafe" existence, catering to the whole family, including the children. London publicans, backed by their "regulars," are already marshalling strength to resist.

Most abrupt effect of Common Market membership will be felt April 1, when a new value-added tax (VAT) replaces the current "purchase" tax, emulating EEC taxation. It means a somewhat higher tax bite for visitors on hotel and restaurant tabs—perhaps as high as 10%, compared to the currently prevalent 3%. Car hire (but not other forms of transport) will also be nipped. But some things, such as jewelry, cameras and leather goods, now taxed at a thumping 27½% rate, will actually become cheaper.

Actually, the tourist demand for hotel space is responsible for much of the new look of London—particularly from Americans, who have been arriving nearly 1.6-million strong in recent years. The rush has inspired a hotel-building boom—and more new peaks in the London skyline.

Last year nearly 8,000 new hotel rooms came on the market, and by mid-summer this year another batch of hotels with 14,000 more rooms will be completed. To the dismay of visitors expecting Edwardian comforts and good, old, bed-and-breakfast English hospitality, the new hotels simply offer (let's face it) all the familiar comforts of home. The success of Hiltons around the world, after all, indicates that this is what Americans want. London is simply trying to please.

English hospitality on the grand scale, of course, is still widely available—at Claridge's, the Savoy, the Ritz, Connaught, Dorchester and other elite London hotels. Booking at the older hotels, including those well below the Connaught's level, however, can be sticky—even in what used to be the off season. While the rooms at some of the new unknowns may go begging, established hotels had some trouble this past season with over-booking. An African dignitary last October became so incensed when he found his pre-booked room occupied by someone else, he took the next plane back to Africa, leaving a trail of bitter comment along the way.

If you should arrive to find your room occupied (and it can always happen) the best advice is to turn to one of the several London booking services. Five can be reached by free telephone at the London airport. A favorite of veteran business travelers is HOTAC (for Hotel Accommodations); it has a reputation for wide choice and reliability. For those wanting to book ahead, about 20 London hotels have representatives (check the phone book) in major U. S. cities, American Express books for about a dozen, and, in New York, British Hotel Bookings (667 Madison Ave.) can set you up in any of a range of accommodations.

For the Londonphile distressed by all the newness, there are always freshly kept relics—Dr. Johnson's house, for instance, a step or two off Fleet Street—and the museums. Indeed, an ideal antidote might be a visit to one of the lesser ones, the 160-year-old house of the architect Sir John Soane (13 Lincoln's Inn Fields). Upstairs, an attendant will gladly turn back the folding walls to reveal the original Hogarth paintings of *The Rake's Progress*. They graphically announce just what a brawling, wenching, drunken, thieving and often wretched place good old London used to be.

Commercial spires of 20th Century leave their mark on the face of old London.

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CIRCLE 709 ON READER SERVICE CARD

A kid's allowance: the start of money management

"Dad, may I have $3 for the movies?" With Dads who remember when movies were not only X-free but cost just 50 cents, such pleas for cash are putting a brittle edge on many a father-son relationship. Mothers, too, with 1973 prices jarring their nerves, grumble over an escalating commercialism that "shovel the walk" or "help with the dishes" seems to inspire in their youngsters.

In most homes with kids under, say, eighteen, the shrinking dollar is adding its two-cents-worth to the age-old family conflict over that weekly sum of money called the allowance.

Most children receive their allowances in one of two ways: Money is provided for personal expenses (treats, gifts, movies, etc.) on a regular basis, with school lunch money and bus fare meted out separately; or daily cash is provided in a routine manner—within reason—with a special allowance doled out now and again for weekend events and occasional minor splurges. Few families, it seems, have ironclad rules—and that may be all the better.

The educators and psychologists approve of any really sensible plan, so long as it is consistent with the family's financial status *and* is followed consistently. Beyond this, the experts stress the idea that it is the parents' attitude toward money that not only dictates how the kids' allowances are distributed, but—more importantly—how the kids handle their cash once they get it.

Long before a child clamps his fist over his very own coins, he learns something about them and the role they will play in his life. Indeed, say the pros, whether he holds his money tightly in hand, loathe to spend too much, or lets it jingle through his fingers, will depend on the habits, viewpoints and motivations of his elders. "A youngster absorbs the competence and confidence of his parents concerning money," says a Columbia University psychologist, "—or their attitude of anxiety about it. And this kind of basic education is taught and learned long before the 'allowance' stage."

A child of 5 to 7 should be given a nickle or dime occasionally to buy a candy bar, or such, on his way home from school. One child psychologist offers this rule of thumb: Never give more money than the child is able to manage. And for children just starting school, the planning of expenses should be limited—a coin or two once or twice a week is sufficient.

A child of 8 or 9 is beginning to learn the value of money. His independence is increasing and with it the necessity of having some money of his own to spend. In order to learn, the child must have a fixed amount, perhaps 50¢ to a dollar, given each week. Guidelines should be set for the use of the allowance with enough leeway so that the child can use or misuse the change as he wishes. The pocket money should not be so tightly budgeted that a child has no options for what he wants now versus what he wants in the future. He can hardly develop a "savings" concept if there is no excess that permits it.

The obvious—and too prevalent—mistake is to be so generous that a child feels he can have almost anything he wants.

Specific allowances for different ages are difficult to judge because so much depends on the parents' money and attitudes toward money and the allowances given others in the neighborhood. Family discussions should cover the child's needs and desires and what the allowance should cover. Ideally, say the pros, "periodic reviews" should be scheduled to find out if a raise is in order and to resolve any budgeting questions that might arise. This, they admit, is a fancy way of saying that wrangling over the subject

can be lessened, even avoided, if the parents take the lead in opening the topic for discussion, remembering that most kids will almost always want more and more.

The psychologists caution that allowances should parallel family income, and should be in line with general practice among most families in the area living on a similar scale. "The kid who gets more than his peers," says the Columbia specialist, "will probably misuse the money, and what's worse, feel guilty about it."

Conversely, a higher-income businessman who gives his son little or no spending money demonstrates, not an old-fashioned, productive frugality—as he may think—but an unreasonable attitude toward money, and is instilling that feeling in his child. The child, note the psychologists, can end up with an extreme feeling, one way or the other—that of a miser or a spendthrift. Over and above this, the youngster might also feel—quite seriously—that he is being somehow excluded by his father.

Child guidance people offer some highly flexible ground rules:

In the pre-teen years, a weekly stipend should cover lunches, transportation, movies, and the like. Later on, when buying clothes and attending dances and sports events become major preoccupations, a monthly allowance is justified. The hope, of course, is that the monthly sum will further teach the art of budgeting and deciding between necessities and luxuries—here again, though, the habits of the parents will ring out loud and clear.

The monthly allowance should continue through college years and cover the cost of laundry, books, supplies and recreation. Some psychologists feel that a college student who is truly motivated in his studies doesn't need the "push" afforded by working for his expenses, even during the summer months. Others have decided that summer jobs are quite a valuable experience—with the money applied to a big purchase or a holiday vacation, or more likely, to tuition.

A youngster on a monthly allowance should be encouraged to put some aside for deposit in a savings account. Checking accounts are usually practical when a child starts earning his own money. The procedure should be explained fully, along with the benefits and pitfalls. Credit cards may also be an educational possession—*if* the child understands how to handle them and assumes responsibility for the charges.

Monetary rewards should never be attached to good grades or behavior. Motivation toward learning, not grades, is the important thing, and bribery will only lead to unnatural pressures for money, perhaps even cheating. Likewise, an allowance should not be taken away or reduced for disciplinary reasons. The child will put a dollar sign on accomplishments and mistakes, and the educational purpose of the allowance will be lost.

Children should not be paid for chores that are considered a part of family cooperation. Helping with the dishes, or walking the dog should be a scheduled job for a child. However, when a special request or extra money is asked for, a paying job might be assigned. Washing windows or cleaning up the attic are two examples of chores that might warrant payment.

Healthy, wealthy and wise

by Joseph Wiltsee

Cash flow: fast-math, trusty unitrusts, sick bay protection

Mini-calculator: numbers by the fistful.

In buying a *fast-math pocket calculator*, don't be confused by the rapidly growing array of brands. If in doubt, stay with a solid, known name, and—if you're a novice—keep in mind these points: (1) Be sure the calculator will display at least eight digits. (2) Look for a CE (clear entry) button—it lets you erase a faulty entry among a long string of numbers. (3) If you plan heavy use, get a machine with rechargeable batteries and plug-in cord—throwaway batteries may give out after 30 minutes or so. (4) Get a machine with a low-battery warning signal. (5) For heavy use, get one with a "K" (constant) key—it locks a first digit into the machine, letting you repeatedly multiply or divide by that number. (6) Consider a machine with a floating decimal—not needed for working expense accounts or household budgets, but providing a required measure of accuracy for many complex calculations . . . Price: $80 to $130 for utility models, up to $400 for specials.

Estate Planning Dept.: *The "unitrust"*—a new twist on an old idea—is being talked about more these days among leading planners. At least check the idea with your family lawyer. It differs from the usual trust in that all income and all principal are combined, with the proviso that the beneficiary receive a fixed percentage of the total fund value each year. The trustee uses all income first, of course, before he dips into principal . . . Irving Trust Co. (New York) advises that the unitrust can often profitably be set up *now*—by trust agreement—instead of later on, by will. *It can be revocable, too, and this sweetens the whole idea, say the pros.*

If you have an *individual health insurance policy* bought some time back, be aware that rising hospital costs (staggering lately) may have vastly overridden the adequacy of policy payouts. A number of insurance companies are now selling coverages with riders that, in effect, give you cost-of-medical-service increases. May be a specialized inflation-hedge worth looking into.

Words of warning to save you time and money

Taxes. The Commissioner of Internal Revenue, Johnnie M. Walters, warns against sharpies in the tax return business—1040 preparers that too frequently understate taxes due so that they look good in the eyes of clients. Walter pulls no punches in his effort to steer the average taxpayer away from "dishonest and incompetent preparers" that victimize both taxpayer and Treasury. One suggestion: Have your company's accountant suggest a good man.

Travel. The new one-week airline tours to Europe costing $300 to $500 per person include airfare, hotel room, and such extras as theater tickets and breakfasts. We recommend them as a *first-rate travel bargain.* But—and this is important—book a month in advance, at least, so that you can make a good hotel selection. If you don't, you can wind up in a location that may be far from what you want. Especially important in London, Paris and Rome.

Hot-stove league at Mt. Snow.

Liquid investment. A survey by J. K. Lasser, the tax people, indicates that more Americans than ever are now investing in Scotch whiskey. They buy warehouse receipts before storage, and hold four years for capital gains. Lasser warns that the four-year outlook is today very shaky, *despite all contrary propaganda.*

The Broadway beat: There's an oasis of theatrical glamour in the very heart of Manhattan's show biz section—it's Shubert Alley, between 44th and 45th. Now, a pleasant and lively new spot called Ma Bell's is right on the Alley. Ask for a "cream sickle": Shake with ice 1 oz. each lemon juice, orange juice, vodka, gin, and creme de cacao; strain or serve on the rocks . . . *Apres ski:* From the bar at Snow Lake Lodge, Mt. Snow, Vt., try a "dirty bird": Shake with ice 1½ oz. each vodka, Kahlua coffee liquor, and heavy cream; strain.

February 1, 1973

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