August 14, 1972

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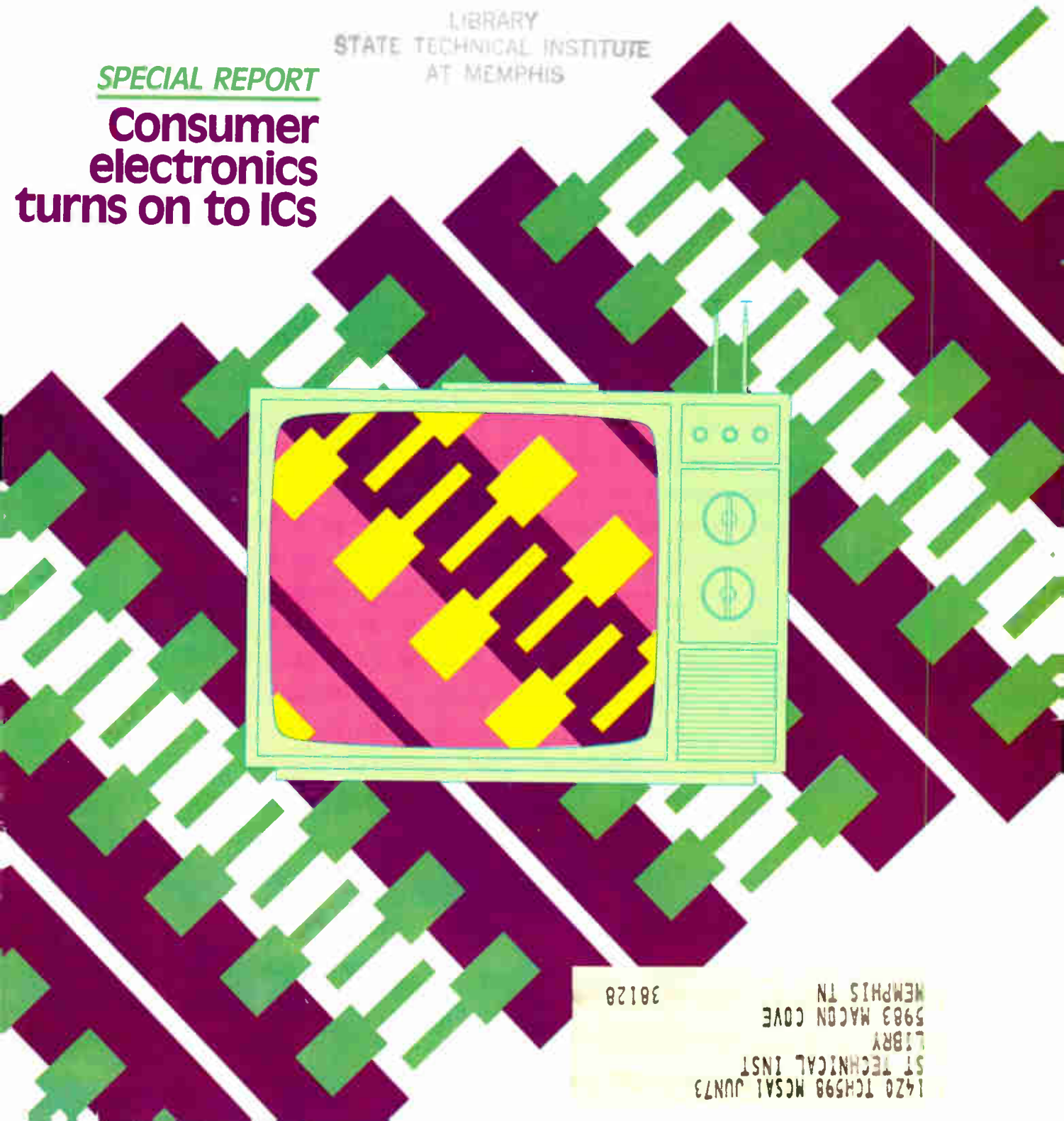
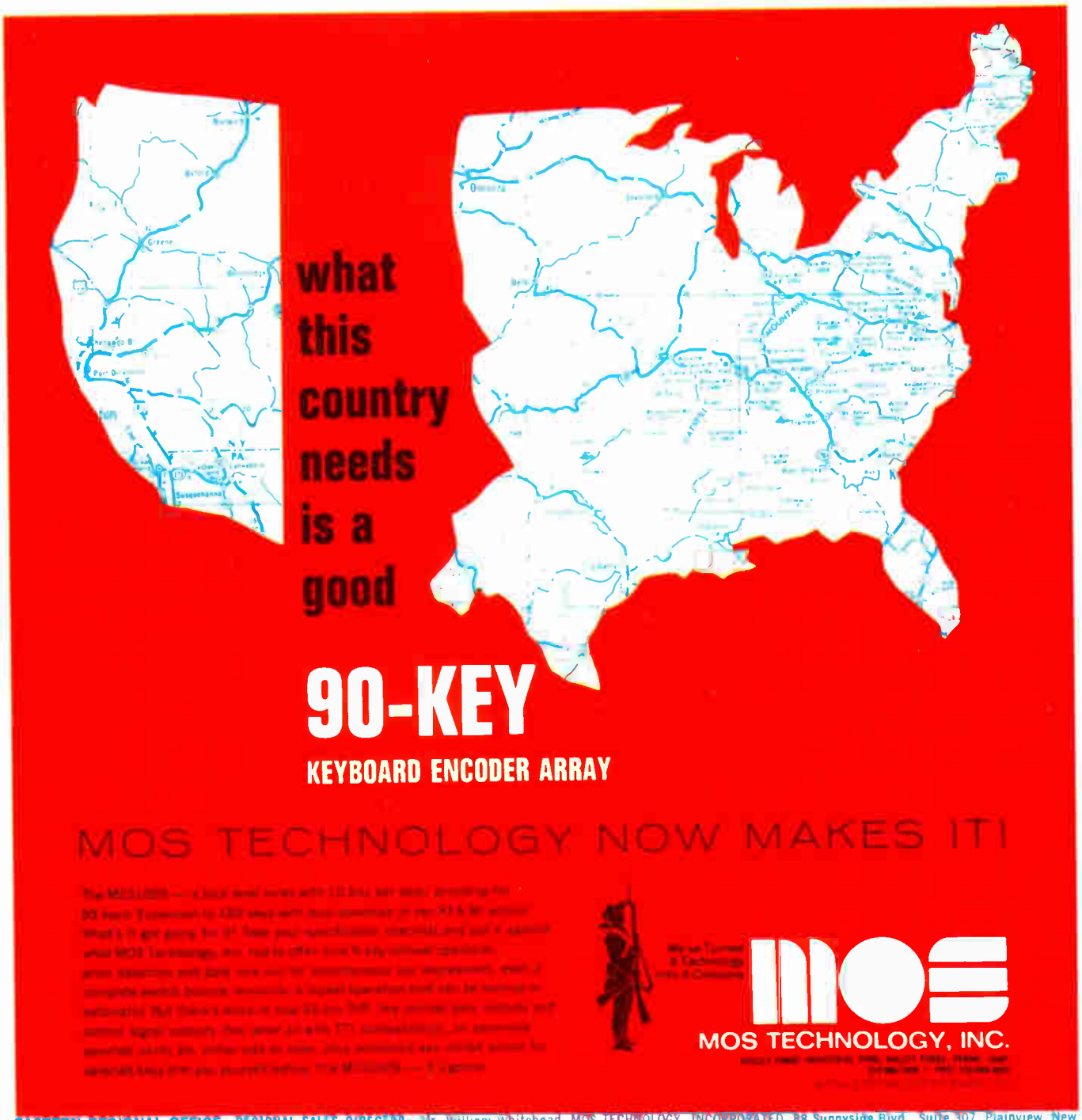
Electronics

SPECIAL REPORT

Consumer electronics turns on to ICs





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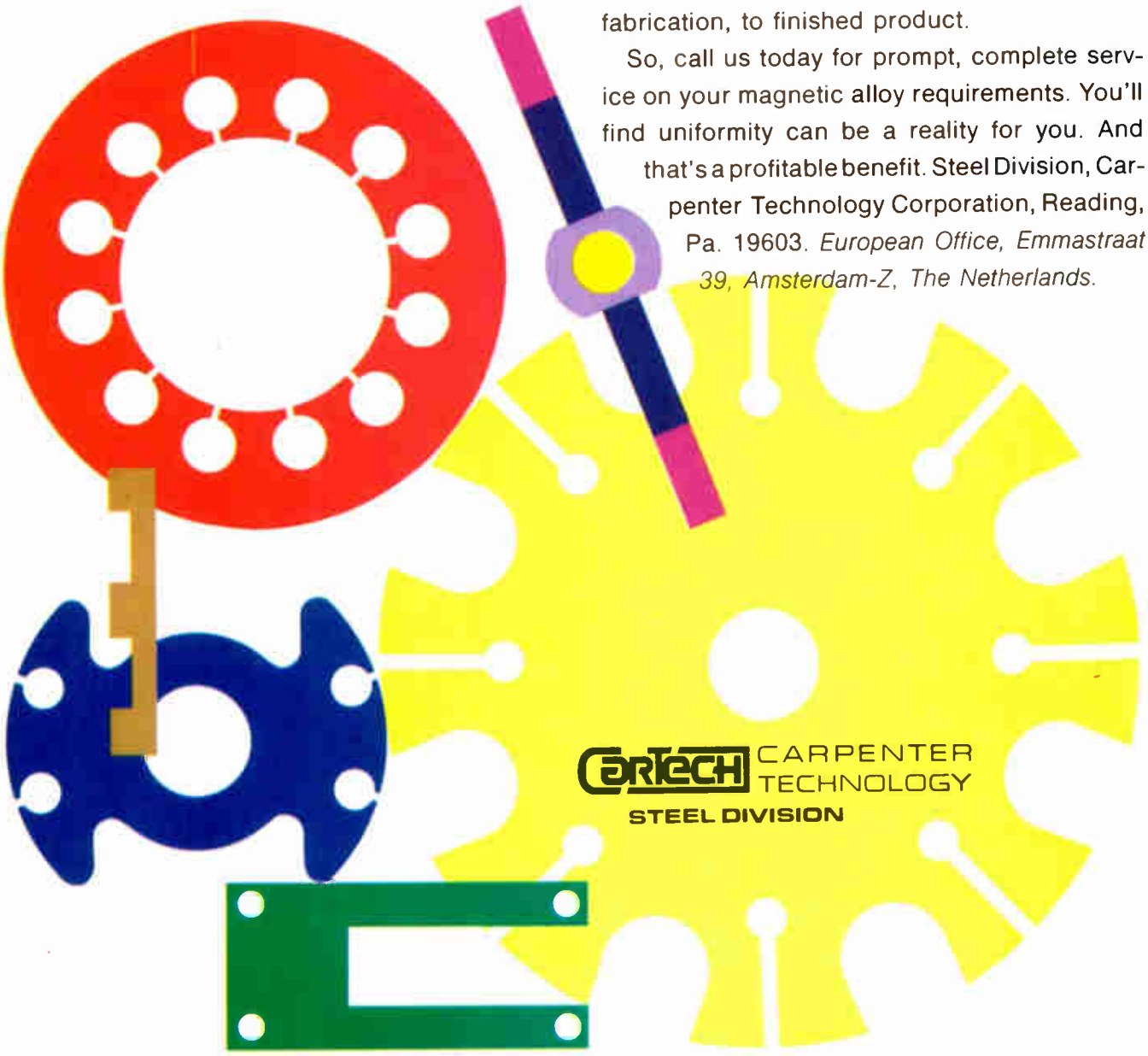

Electronics

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Volume 45, Number 17

Highlights

How Poland is pushing electronics, 69
With the Polish government setting a 20% annual increase in production as the goal for commercial-industrial electronics, computer activity in particular is booming. Radio and radar equipment are other strengths, and monochrome TV tubes may soon find a Western market.

An automated Olympics—almost, 78
At past Olympic games, human limitations have often slowed the business of deciding on a victor and then announcing him—or her. At Munich this year, however, novel computer programs, computer-controlled displays, and electronic measuring devices will make real-time judgments possible.

ICs catch on in consumer products, 93 (cover)
Suddenly linear ICs are being designed into many more color TV sets, and are about to break through into audio equipment, too. Reliability seems a key attraction to set manufacturers, says this Special Report, conscious as they are of consumerism and high servicing costs.

Functional testing made more informative, 115
Improving fault diagnosis with functional testers is a Special Report that is also the first of an in-depth series on the newly important area of automatic testing. The report's recommendations include eight ways of modifying a complex logic board's design so that it will maximize the tester's diagnostic ability, plus three ways in which the test program itself can be made to pinpoint faults more efficiently.

. . . and in the next issue
Special report on semiconductor memories . . . results of survey of the EE's job status . . . what computers are doing in aerospace.

The cover
The invasion of color TV sets by linear ICs has suddenly surged.

Electronics

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Publisher's letter

Our special report on the application of ICs to entertainment products (p. 93) is one of those pieces that couldn't have been done a year ago, because the breakout just hadn't occurred. But in that year's time some five years of planning came to fruition and integrated circuits began moving into consumer products in a big way.

"The design effort," comments Consumer Editor Jerry Walker, "was kind of a case study in how engineers stay alive by continuing education. The TV companies generally assigned people who came from vacuum tubes and then transistors to learn the ropes in ICs. That sounds easy, but the education process alone took a couple of years, and it still goes on."

Solid State Editor Larry Altman, who collaborated with Walker on this two-part report, adds that the semiconductor engineers had to do some learning, too. Only in their case it was getting a grounding in the basic problems of TV and audio receivers. Sounds like the engineer's familiar concept—synergism.

Two millennia ago, the Greeks used smoke signals and relays of runners to spread the news about who won the various Olympic events.

Today, electronic equipment—from portable television cameras to complex satellite broadcasting systems—will speed the news, indeed the entire action as it happens, to the far corners of the world. And electronics will have another important role: judging the winners.

What's more, electronic techniques will help the press by rapidly retrieving data on past games and victors, will help the show officials by instantly posting results at the Olympic grounds, and will help the athletes by monitoring their physical fitness. You'll find the behind-the-scoreboard story of electronics at the Olympics, by our Frankfurt-based field editor John Gosch, on page 78.

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Readers comment

Automated medicine? Not yet!

To the Editor: I read with interest your "Computer is key to health tester" [*Electronics*, July 17, p.27]. I find it distressing that *Electronics* has joined the ranks of Federal agencies, politicians, and some manufacturers to tout a product that they are really unable to deliver.

Although modular design and disposable parts have been most effective in mechanical and electrical maintenance techniques, our technology and physiology in human anatomy have not reached that point. These techniques belong at present in the office of the quack and on the pages of science fiction.

Except for a few easily measured parameters, we have distressingly little to offer of prognostic significance in the health field, and we seem to be quite ineffective in changing life styles. We should not discard automated medical techniques or multiphasic testing, but to bill them as "health maintenance" is a cruel deception. We have no such technology at this time—by any mechanism. We should explore many pilot projects, but make none our main effort at this time.

James A. Stark, M. D.
Oakland, Calif.

Criticism of NASA clarified

To the Editor: While you quote me accurately in "Washington commentary," [*Electronics*, May 22, p.50], I believe the balance and thrust of my criticism is not accurately portrayed. My main point was that NASA should consider another means of accelerating technology transfer. This involves identification of universal critical problems in delivery of health care that are amenable to technical solutions, followed by a jointly managed project between NASA and mission-oriented Federal health agencies to apply the technology.

I faulted NASA not for errors in its technology transfer program, but for not approaching the subject on a broad scale. I do not believe your editorial reflected this view.

Charles W. Garrett
National Academy of Engineering
Washington, D. C.

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MM74C162/MM64C162/MM54C162	Fully Synchronous Decade Counter	November
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MM4623A/MM5623A	Triple 3-input NAND Gate	Now

NATIONAL

40 years ago

From the pages of Electronics, August 1932

Some significant testimony concerning the radio experiences of the Bell telephone interests was that given by Dr. Frank B. Jewett, president of the Bell Laboratories and vice president of the American Telephone and Telegraph Company, before a Mid-West court last month.

Dr. Jewett reported that research in radio to date has cost the Bell interests about $11,000,000. In addition $5,000,000 to $6,000,000 has been expended for the various radio circuits now in commercial use for telephone communications. Not a single one of these radio circuits comes anywhere near paying its costs, and the combined radio operations represent a loss of from $700,000 to $800,000 a year. Owing to the depression, recent transoceanic phone service demands have fallen; the Buenos Aires link to New York sometimes carries only two phone calls per day.

This experience throws light on other radio operations from a balance-sheet standpoint. It also supports the view long held by Dr. Jewett and the telephone group that if a wire can be put up, wire service will perform more dependably and economically than space oscillations.

Professor E.V. Appleton, King's College, London, suggests that there exist two distinct ionized layers [in the atmosphere]. The upper layer or F region at about 230 km. altitude is produced by ultraviolet light, the lower or E layer at about 90 km. by electrons or atoms thrown by the sun with speed of 1,000 miles per sec. Professor Appleton calls attention to the opportunity of using the eclipse [of the sun on Aug. 31] to shed light into this question.

In consequence of the motions of the moon and the earth, the stream of supposed particles will be interrupted more than an hour before the ultraviolet light is stopped. There would possibly be two radio eclipses, the particle eclipse affecting the E layer, from which the ordinary broadcast waves are turned back and the much shorter optical eclipse affecting the F layer which is reached by 80 m. waves.

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FOUR MODELS

H13A1 H13A2 FOR HIGH SPEED

- Over 10,000 operations possible per second
- Stable within 20% between −55 C. to 100 C.
- $1.35*.

H13B1 H13B2 FOR HIGH GAIN

- 12 mA min. output current
- $1.45*

*Suggested resale price 1,000 lot quantities

GENERAL ELECTRIC

Semiconductor Products Department, Syracuse, New York

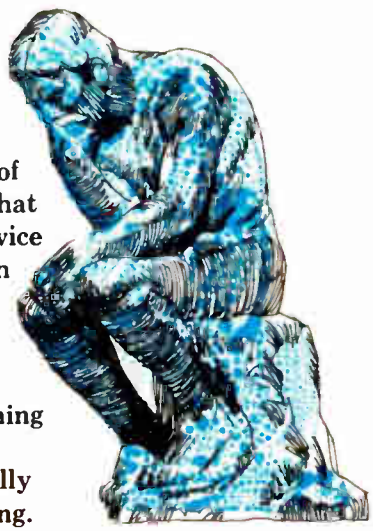
BEST BUY Our No. 1 Goal QUALITY SERVICE VALUE

OUR NO. 1 GOAL: TO MAKE GENERAL ELECTRIC YOUR BEST BUY

Single-Diffused

...better than EpiBase?

We've got both now. Single-diffused, UniBase* power Darlingtons. EpiBase* power Darlingtons. Plus capability to supply discrete power transistors in both technologies. The first to do this.



Great, you say. "Let me have the latest thing so I can edge my competitor's design."

Wait, though . . . not that easy. Unless you understand the basics of both technologies you won't get what you really want — an optimum device matched to true design needs, with the best trade-offs in device characteristics.

More and more engineers are educating themselves before designing in either process. Questioning and comparing to find out which is really better for their application. Probing. Analyzing. Asking.

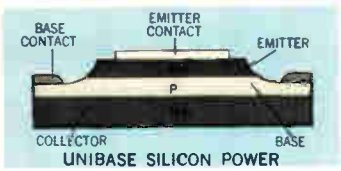
"Are they structurally different?"
"Which is better for high-speed switching?"
"Is there an edge in safe operating area?"
"What are tradeoffs in inductive loads?"
"Which is more applicable to complementary designs?"

If you're satisfied with your supplier's answers, your education, your design, fine. If not, listen.

TAKING THE RIGHT SHAPE . . .

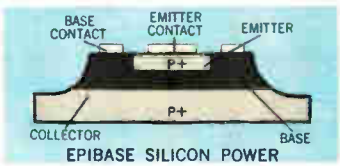
They're different, alright.

Single-diffused, UniBase, is achieved by diffusing collector and emitter into lightly doped P material with the base formed by the undiffused portion of the start material. Emitter and collector are equidistant from opposite chip sides. The deep emitter junction biases off high-current density area and leads to more uniform current distribution throughout the emitter. Result: very good safe operating area . . . with low frequency response due to distributed resistance and longer RC time constants.



UNIBASE SILICON POWER

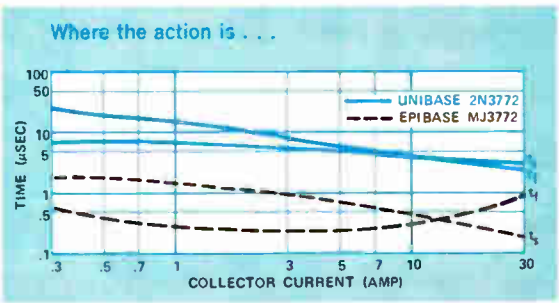
EpiBase offers devices with emitter diffused into an epitaxial base deposited on the collector substrate. The collector voltage depletes into the base region with resulting devices characterized by higher-frequency response and low switching losses with SOA equal to, or better than, UniBase except at or near device BV_{CEO}.



EPIBASE SILICON POWER

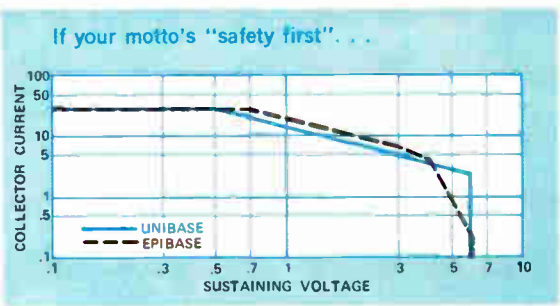
THE TRADEOFFS . . .

A couple. If switching efficiency, f_T or phase shift are your thing, EpiBase wins hands down. Although power-handling and safe area of the two are about equal, UniBase offers an edge in SOA if your design pushes ultimate device breakdown capability. And, while beta-vs.-current curves are similar for EpiBase and UniBase transistors of given chip size, UniBase will exhibit higher sat voltages and slightly lower high-current beta. Again, a result of higher distributed resistance.



Typically, more gain and gain linearity can be had with EpiBase by sacrificing some ruggedness. With EpiBase, it's near-impossible to achieve high f_T and high SOA simultaneously . . . something's got to give.

Conversely, single-diffused offers a bit more SOA but slower action; and gain and gain roll-off figures of merit are only about half or less than EpiBase counterparts.

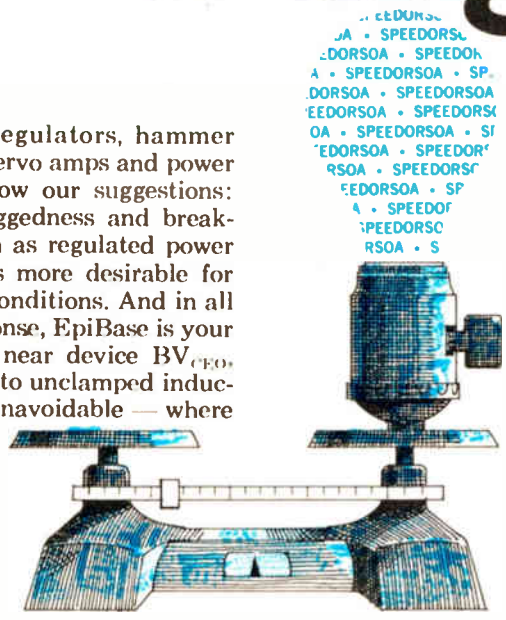


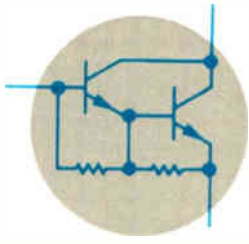
Power Darlingtons

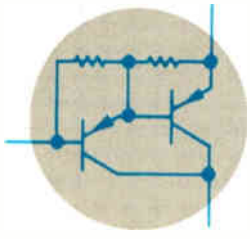
THE APPLICATIONS . . .

Practically everywhere! Commonly, regulators, hammer drivers, inverters, converters, stereo and servo amps and power switching. Which for which? Easy. Follow our suggestions: we've factored in tradeoffs: gain, f_T, ruggedness and breakdown voltage. In many applications such as regulated power supplies for high-speed logic, EpiBase is more desirable for its better response to fast-changing load conditions. And in all circuits demanding higher frequency response, EpiBase is your best bet. Because of that edge in SOA near device BV_{CEO}, UniBase is better where you're working into unclamped inductors — not recommended but sometimes unavoidable — where it must absorb stored energy.

Your Design	EpiBase	UniBase
audio	●	
series pass regulator		●
inverter	●	
unclamped inductive load		●
power switch: slow		●
fast	●	







THE DARLINGTONS . . .

Sounds simple: power integrated circuits consisting of driver, output devices and emitter-base resistors on one monolithic chip. But advantages are revolutionary: super-high gain . . . new levels of efficiency, simplicity, cost-savings . . . direct, logic-to-Darlington interfacing . . . with EpiBase available in both NPN and PNP for complementary symmetry designs. Depending on your conclusions and your needs, your choice will be EpiBase or UniBase Darlingtons.

Draw those conclusions now. Match your design need with an unmatched solid-state power capability. Write us at Box 20912, Phoenix, AZ 85036 — contact your Motorola distributor on prototype or production.

EpiBase or UniBase . . . the choice is yours. But know this. We've got both.

THE SPECS . . .

EPIBASE VS. UNIBASE

PRIME SPECS ON SOME PRIME

. . . NEW DISCRETES

DEVICE	GAIN	FREQUENCY	SAFE OPERATING AREA
EpiBase 2N3055	20 @ 4A	4 MHz	60V/200 mA
vs.			
UniBase 2N3055	20 @ 4A	200 kHz	60V/1.5A
EpiBase MJ3771	15 @ 15A	4 MHz	40V/200 mA
vs.			
UniBase 2N3771	15 @ 15A	200 kHz	40V/3.75A

. . . plus a choice between these discretes

MJ3772 EpiBase and 2N3772 UniBase	MJ6257 EpiBase and 2N6257 UniBase	MJ3773 EpiBase and 2N3773 UniBase	MJ6302 EpiBase and 2N6302 UniBase
2N6253 UniBase		2N6254 UniBase	

. . . NEW DARLINGTONS

DEVICE	GAIN	FREQUENCY	SAFE OPERATING AREA
EpiBase 2N6056	750 @ 4A	4 MHz	80V/100 mA
vs.			
UniBase MJ3521	500 @ 4A	200 kHz	80V/1.4A
EpiBase 2N6283	750 @ 10A	4 MHz	40V/1A
vs.			
UniBase 2N6356	400 @ 10A	200 kHz	40V/3.75A

. . . plus a choice between these Darlingtons

2N6282 EpiBase and 2N6355 UniBase	2N6283 EpiBase and 2N6357 UniBase MJ3520 UniBase	2N6284 EpiBase and 2N6358 UniBase

*Trademark of Motorola Inc.

MOTOROLA POWER
—Technology By Design, For Design

People

Black FCC commissioner seeks to inspire youth

As a minister, banker, lawyer, judge, and television producer, Benjamin L. Hooks combined several roles to become a model of success in his hometown of Memphis, Tenn. Now, as the first black appointed to the Federal Communications Commission, the 47-year-old commissioner hopes he will be a model to inspire black youths across the country to work within the system.

Hooks thinks that kids need to see the right models on television. "If it hadn't been for TV, the black revolution would never have been won," he says, recalling network coverage of the civil rights struggles. "The conscience of America couldn't sleep after that."

However, Hooks fears that since then, black youths have only seen athletes and revolutionaries on TV. "The revolutionaries alone have been given too much coverage. "If my grandson wants to become a revolutionary, that's his decision," Hooks declares. "But I want him to be exposed to other models, such as doctors and lawyers, so he has other roles to choose from."

He makes clear that he seeks no restraints on broadcasting, though he would like to see the roles of blacks on both sides of the camera changed. "Freedom of the press is the best guarantee black people have," he observes.

As "a black man who is a commissioner," Hooks says, he will devote as much time as he can to speaking around the country, encouraging black youths to seek professional and skilled jobs. But, "my first role is to be a good commissioner. I don't plan to be a black commissioner."

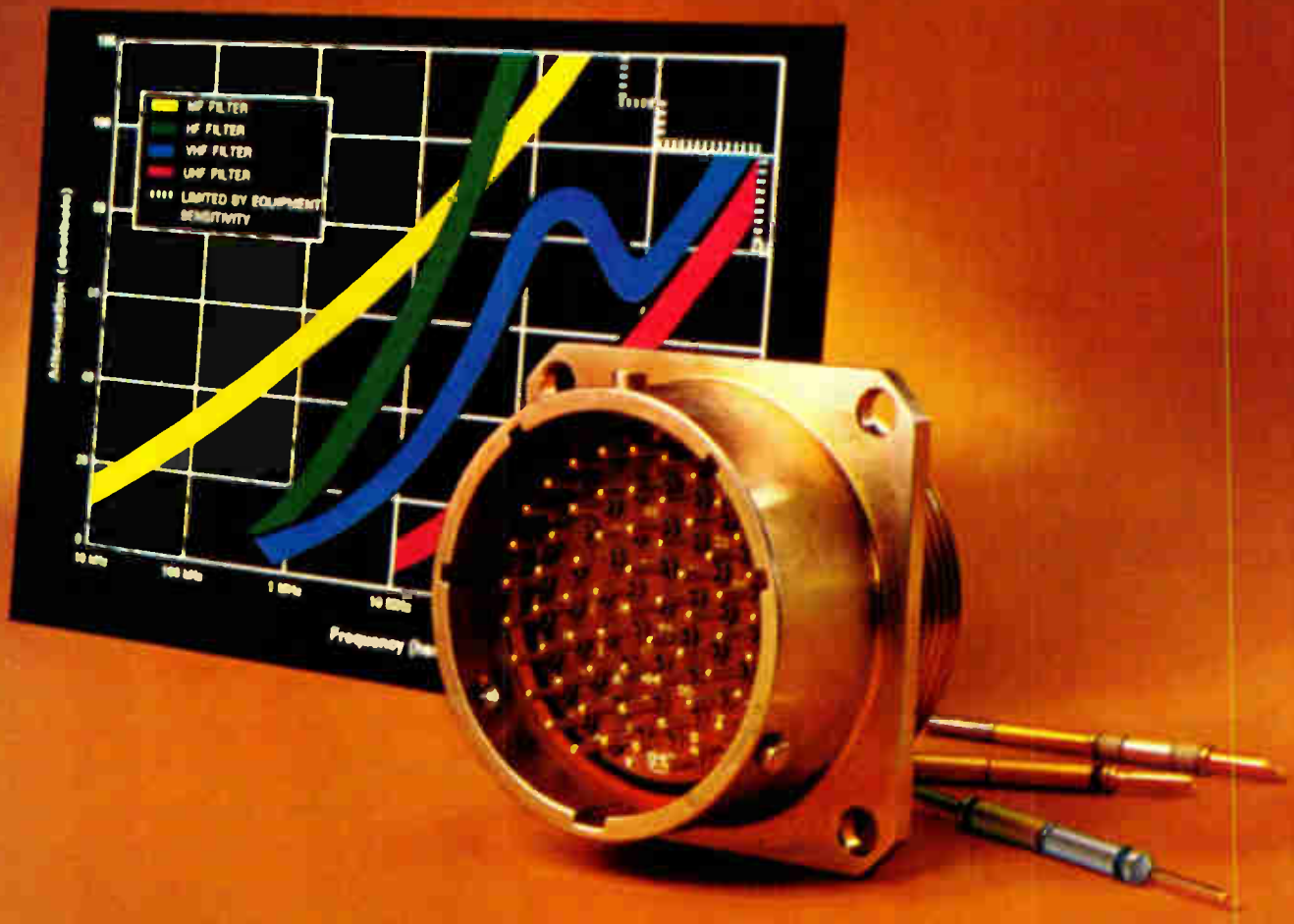
Although interested in innovation, Hooks is steering a cautious course for the time being. As a new commissioner, he says, he has a lot of catching up to do before he can fully exercise his new role on such issues as the domestic satellite decision, which the commission is now being petitioned to reconsider, [*Electronics,* July 31, p. 23]. "I don't have any preconceived notions," he says, but "anyone who is here seven years and works hard is bound to have an impact." And Hooks sounds like a man who will.

Patience, tact vital for consultant: Bolt

If there were such a title, Richard H. Bolt, board chairman of Bolt Beranek & Newman, probably would qualify as dean of the technical consultants. He has been consulting since 1948—first as an individual, then as part of a Cambridge, Mass., company that now is BB&N and includes 350 to 400 professionals. And although its reputation lies mostly in audio and acoustics, BB&N has strong groups working in data processing, data communications, and a

'Bound to have an impact.' Hooks, left, with FCC Chairman Dean Burch after swearing in.

Are you getting static?



Our filter connectors are designed to eliminate interference from your circuits. See those attenuation curves? They are just a part of our selection. We can mix and match filters to solve your low pass filtering requirements. Small wonder Bendix filter connectors are first choice in the fight against electronic noise pollution.

Bendix filters come packaged in connectors intermateable with MIL-C-26482, MIL-C-83723, MIL-C-38999 and MIL-C-5015 connectors. In addition, filter contacts can be packaged to mate with other popular connector types including rectangular in military, industrial and commercial applications. There's sure to be one to meet your attenuation and frequency requirements.

You'll like the price, too.

Delivery? We won't give you any static there, either. Write for our brochure. The Bendix Corporation, Electrical Components Division, Sidney, New York 13838.

Bendix

Circle 15 on reader service card

host of other electronics industries, with contracts from the Defense Department's Advanced Research Projects Agency and others.

Over the years, Bolt has been "offering for sale the professional talents of creative men." But while those talents are often easy to offer, they're often difficult to manage. The client-consultant relationship most often is the sticking point.

Pinch. "Two things we want in our consultants are patience and tact. Some clients approach us with a partial solution; this can place our man in a pinch if he has his own strong ideas—and especially so if our ideas are really superior. So our men often must not only tactfully steer clients toward what we feel are the best solutions, but also help our own sometimes temperamental creative types meet clients halfway."

One of the best ways to avoid this conflict in the first place is to "get in early," says Bolt. "We like to get in at the definition and talk stage." Bolt figures that this protects the firm against clients committed to one way of doing a task—say an acoustician who has designed a hall, but afterward finds that it needs electronic reinforcement for speech or music. "We can nearly always improve hall acoustics electronically, but often this is not enough. If the project has gotten enough publicity, our name is attached to it, and we endanger our reputation."

Tightwire. Thus, Bolt must not only look out for sticky situations, but also manage a group of highly intelligent men who are often as high-strung as race horses. "We have had a few clients so angry with us it was frightening," he says, "and in each case the cause was a personality clash. We have fired BB&N men because of fuzzy thinking and some, unfortunately, because they were emotionally disturbed. A few brilliant men, unable to come to conclusions, lead clients down long and costly paths.

"On the other hand, clients often won't let us alone—you can get calls every day. It can reach the point where a consultant is afraid to hear the phone ring." When that happens, his efficiency falls off.

MEASUREMENT NEWS
innovations from Hewlett-Packard

AUGUST edition

in this issue

Now, automate your calibration lab

New fast-writing storage scopes

Precision power supplies? Exactly!

New multimeters with multi-innovations

A new multimeter that tests itself and a new low-cost "clam-shell" DMM that can be several meters in one have joined HP's growing line of solid-state LED instruments.

The 3490A multimeter performs its own diagnostics and trouble-shooting. Automatic self-testing checks the meter's readiness, reduces your calibration time, reduces the required verification standards, and lets you quickly isolate possible troubles from the front panel.

The 3470A digital measuring system is really five compact modules that snap together. In seconds, a digital voltmeter converts to a multimeter, to a battery-operated field instrument, or to a digitizer with BCD output.

(For both stories, please turn to page 3.)

Compact OEM peripherals for mass storage

The 7900 disc drive (top) and 7970 tape transport (underneath) are compact, flexible peripheral memories.

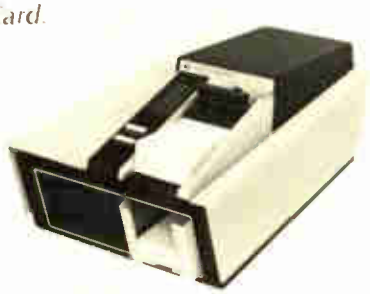
Besides data products and computer systems, HP has developed high-quality disc, tape and card peripherals for original equipment manufacturers. Now, OEMs can select the storage capacity, speed and I/O hardware that they need to complement their own systems.

The 7900A disc drive is an ultra-fast, random-access, moving-head dual-disc memory. The compact design is ideal for small and medium-sized computers. Average seek time is less than 30 ms; and the data capacity is five million bytes on-line (with unlimited shelf storage). A new single-cartridge version, 7901A, is now available for low-cost, random-access data base applications. Both disc drives are fully compatible.

For a versatile, compact tape drive, consider the 7970 family. There are over 200 configurations from 9-track PE and 7/9-track NRZI to a single unit that reads multiple-density 7- and 9-track NRZI as well as 9-track PE tapes.

For card input, the 2761A-07 optical mark reader handles punched and marked cards at the rate of 200-250/min. Reading time is 190 ms/card.

For more information on these OEM products, check T on the HP Reply Card.



The 2761A-07 optical mark reader

New microwave test set for production, lab, field

In a typical production test application, the 8755L large screen display shows forward- and return-loss response of components.

Our new 8755 series frequency response test set gives you accurate swept displays of characteristics from 100 MHz to 18 GHz. Use it for those basic insertion gain/loss and return loss (VSWR) measurements. The 8755 features high sensitivity (−50 dBm), high resolution (better than 0.05 dB), and a full 60 dB dynamic range with only 10 mW of RF drive, which means it's compatible with your solid-state microwave sweeper (e.g., HP 8620 series).

Production testing and incoming inspections are accurate and easy with the 8755 test set. Fewer controls mean simpler operation. Outstanding stability means less recalibration and greater confidence in results. This broadband test set is ideal for testing active and passive circuits, coax and waveguide. It's also immensely useful in the lab.

Because the solid-state system is rugged and compact, it's a natural for field tests of antennas and cables. The detectors can be placed as far as 200 feet away from the test set.

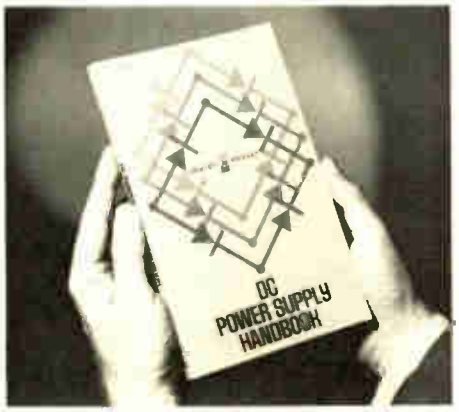
A typical system consists of analyzer, detectors, modulator, and HP 180 series scope display and costs approximately $3200.

For details, check M on the HP Reply Card.

All you ever wanted to know about dc power supplies

How can ground loops in multiple loops be avoided? What's the difference between a constant voltage/constant current and a constant voltage/current limit power supply? How do you measure power supply performance? Questions like these are answered in the 138-page *DC Power Supply Handbook* (AN-90A).

Choosing the right power supply for your application is easier, too, with HP's *DC Power Supply Selection Guide*. Both general and special-purpose power supplies are listed by voltage and current in tabular form. This 40-page booklet also contains performance data, operating features, and outline drawings with dimensions.



If you would like copies, check O and P on the HP Reply Card.

New HP self-testing DMM improves reliability

Now, HP introduces a new concept in digital multimeters: self-testing. The 3490A multimeter provides 5 ranges of dc measurement (0.1 V to 1000 V), 4 ranges of ac measurement (1.0 V to 1000 V, 20 Hz to 250 kHz), 6 ohms ranges (100 Ω to 10 megohms), and the exclusive self-test function. For readability and reliability, the five-digit display uses HP light-emitting diodes.

Measurement capability is unsurpassed. The 3490A uses a dual slope integrating technique and is fully guarded, providing excellent noise immunity at 5 readings/sec. on all dc ranges. It detects average ac and displays rms at the rate of 1 reading/sec. All six resistance ranges provide true 4-wire ohms measuring. Maximum current through the unknown is 1 ma, and there is built-in over-voltage protection in case you inadvertently apply a high voltage to the ohms terminals.

With self-testing, the 3490 is calibrated and ready for any measuring task.

There are 16 front-panel tests, each of which interrogates an internal parameter and displays the results. You merely compare the readout with the proper values on an instruction card. Logic tests, ratio amplifier offset, reference voltage—the multimeter checks them faster than you can.

Price: $1650

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

Diverse uses for compact strip-chart recorder

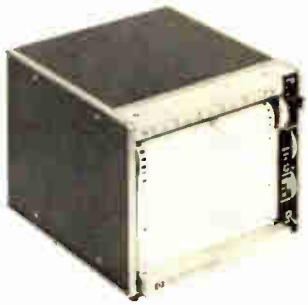
Smoke stack monitoring, soil analysis for mineral content, oceanographic research, and automobile exhaust emission tests—they all use a 680 strip-chart recorder to graph final output. Since 1961, this compact recorder has proven itself highly accurate in specialized industrial applications as well as in general laboratory use.

With a 5-inch (12 cm) writing width, the recorder has multi-range input, multi-speed chart transport, full-range zero set, electric pen lift, and full-tilting chart magazine. You can choose standard (English) or metric scaling, and electric writing is optional.

This popular recorder also has a popular price: only $900.

For details, check H on the HP Reply Card.

The "tried and true" 680 recorder weighs only 11 lbs. (5 kg) and fits into a rack mounting space 7 inches (178 mm) high.



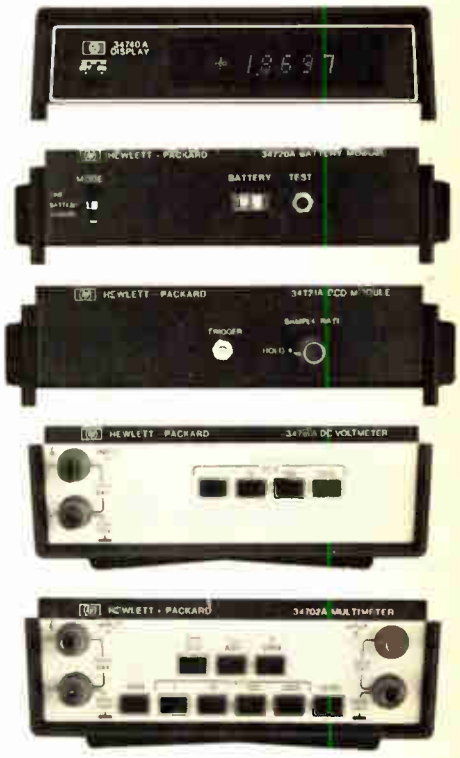
New 'clam-shell' DMM can be several meters

More than just a multimeter or a dc voltmeter, the new 3470 measuring system features versatile snap-together modules that you can configure in minutes. The same system can be a bench instrument in the lab and, five minutes later, a test device in the field. And it couldn't be easier:

- Start with the four-digit solid-state display.
- Snap it on top of the multimeter module and it's a digital multimeter with 4 full digits plus 100% overranging. It has 4 ac and dc ranges from 1 V to 1000 V full scale and 6 ohms ranges from 100 Ω to 10 megohms.
- Or, snap the display and dc section together for a dc voltmeter from 1 V to 1000 V full scale. Dc accuracy is ±0.03% of reading +0.01% of range on all four ranges.
- For portability, merely add a battery module between the display and the bottom section. Immediately, your system converts to 6 hours of continuous measuring on rechargeable batteries.
- Need BCD output? Simply take out the battery and insert the BCD module for the center section. Nonisolated BCD output can be used to drive printers and other devices.

It's as economical as it is easy. Modules start at $150.

For prices and full details, check D on the HP Reply Card.



More precision and power in four new dc supplies

A 6115A precision power supply is used to calibrate the dc voltmeter section of an HP multimeter.

If you need a low-cost calibrator, a systems reference supply, or a high-performance lab supply, consider one of HP's four new precision power supplies.

These new 40-watt supplies feature output voltage accuracy of 0.025% plus 1 mV, with 5-minute cold-start warmup. Two supplies (6114A and 6115A) use four-digit pushbutton switches for fast and accurate voltage setting, with a fifth-digit vernier providing 200 μV resolution. The other two supplies (6104A and 6105A) are designed for applications where the supply is programmed remotely.

Models 6104A and 6114A provide 0-20 V at 0-2 A and 20-40 V at 0-1 A. Models 6105A and 6115A provide 0-50 V at 0-0.8 A and 50-100 V at 0-0.4 A. These supplies also feature constant voltage/constant current operation, front-panel mode indicator, built-in overvoltage protection, high speed, and remote programming capability. In addition, there are full voltage and current metering and auto-tracking, series, or parallel operation.

Prices: 6104A, $440; 6105A, $455; 6114A, $525; and 6115A, $540.

For power supply specifications, check I on the HP Reply Card.

HP videotapes make inexpensive, individual, on-the-job service training a reality.

HP videotapes: a better way to learn

When planning a training program —for beginners or for experienced staffers—consider HP's library of quality videotapes. This new medium offers:

- More information in less time.
- Higher retention, even higher than with live lectures.
- Convenience. Your "instructor" is available anytime, anywhere.
- Flexibility. You can organize seminars for 100 people or view the tape alone for refresher purposes.
- Economy. For just the initial cost, you use a videotape over and over. Executives and engineers don't have to interrupt projects to teach a seminar.

The HP library covers three categories: tutorial, "how to use," and service/maintenance tapes. Our most popular tutorial series is *Practical Transistors*, a 15-program course for electronic service technicians. The "how to" topics range from *How to Use HP Instruments* to *BASIC Programming*. Service/maintenance tapes cover many areas from adjusting oscilloscopes to servicing computers. Tape format is usually EIAJ half-inch, but other formats are available including cassette. You can also order Sony cameras, video recorders and monitors from HP.

For a complete index and price list, check U on the HP Reply Card.

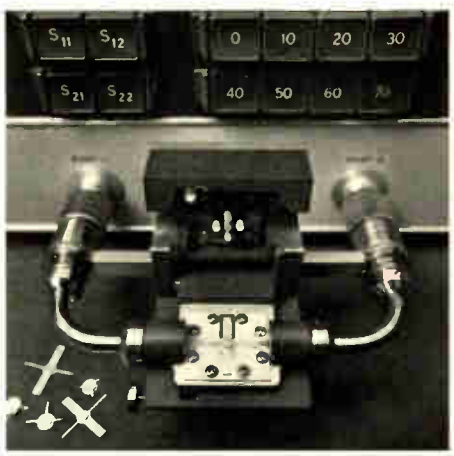
Get microwave design data quickly, accurately

To save hours of work while producing more accurate and thorough microwave designs, you need the 8410S network analyzer. In minutes, this complete system measures key network parameters, such as: phase, gain, attenuation, impedance, return loss, reflection coefficient, and s-parameters. You can quickly characterize active and passive components—even stripline devices—from 110 MHz to 40 GHz. The system has >60 dB dynamic range with 0.1 dB resolution and 360° phase range with 0.1° resolution.

Even a taxing chore like characterizing microwave transistors can be done quickly and effectively, using our precise yet simple transistor fixtures, pushbutton-controlled test sets, and bright CRT display of results. Many system functions are readily programmable to further speed the measurement process.

Full systems start at $11,745.

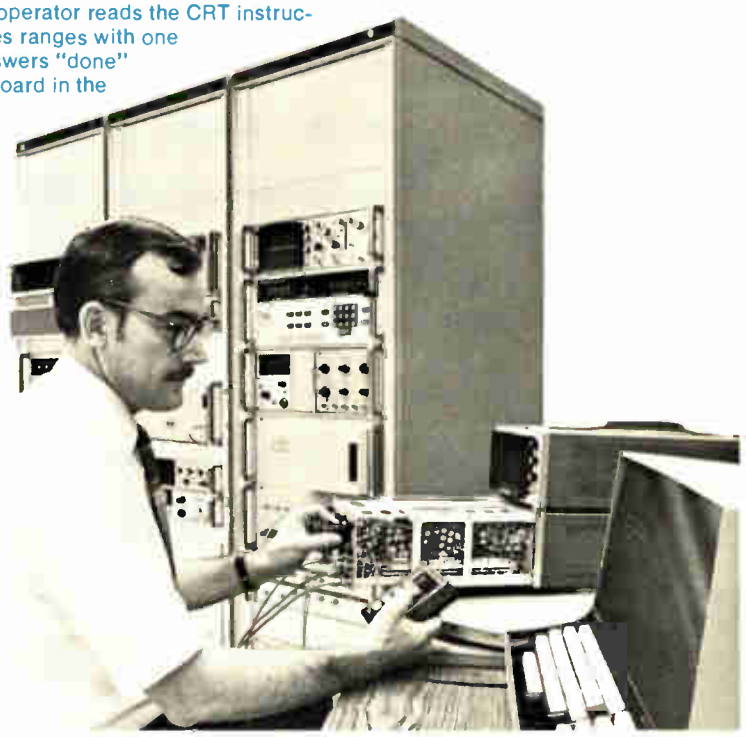
To learn more about solving tough microwave measurements, check K on the HP Reply Card.



With this stripline test fixture, merely drop in a stripline microwave device or transistor and let the 8410S do the work.

New instrument calibration system reduces costly overhead

Calibrating a sweep-time plug-in for a scope, the operator reads the CRT instructions, changes ranges with one hand and answers "done" with the keyboard in the right hand.



Now, there *is* a way to calibrate today's proliferation of complex instruments, to beat spiraling labor costs, to reduce training costs, and yet to increase efficiency—all without raising the operating budget. How? With an HP 9550A automatic instrument calibration system.

Whether you calibrate HP instruments or others, this automated system covers oscilloscopes, plug-ins, voltmeters, multimeters, test oscillators, amplifiers, DVMs, and low-frequency generators. The system calibrates to manufacturer's recommendations and for the instrument's intended use.

HP has developed almost 50 application programs for calibration. You can adapt or convert these to other workloads by modifying the program. Should you need to write a special program from scratch, the system language is ATS-BASIC, a conversational language that any skilled technician can easily learn.

The calibration system uses a 16K core and a mass memory disc for flexible information storage and fast access. This combination makes it easier to convert programs and parameters, as well as being more economical. (Saving two minutes on each calibration by having fast access is worth about $10,000 each year.)

HP quality instruments and reliable hardware provide a precise calibration-quality stimulus, dc to 1300 MHz.

The 9550A system optimizes man-machine capabilities. An HP 2100 computer handles programming and switching the stimulus, pacing test sequences, measuring and data keeping. The operator makes connections, adjustments, and control checks and decides whether anomalies are within tolerance or if he should rerun a certain test sequence. For the past year and a half, we've used the 9550A instrument calibration system on our own instruments at the HP Customer Service Center.

Because the 9550A is a modular system, you can also add digital test units or programmable scopes to handle other lab applications. Instrument calibration systems range from $125,000 to $175,000.

To learn more, check N on the HP Reply Card.

A scope for all seasons (or any environment)

You probably won't use your oscilloscope under water, but it's reassuring to know that an HP portable scope (1700B, Option 300) operates in virtually any environment. This 35-MHz scope is dustproof, weatherproof, shockproof, and with slight modifications, waterproof. You get laboratory quality and accuracy even when external conditions are less than perfect.

Take the rugged case; fill it with a weight equivalent to the scope; raise it 30 inches off the ground, then drop it onto concrete 14 times—it's still watertight. Use the scope on shipboard without concern about corrosive salt spray. Send it up in an airplane; the scope operates between −40° and +55° C at altitudes up to 10,000 feet. The 1700B, Option 300 is reliable in a chemical plant, refinery or dusty environment; contaminants won't get inside the instrument. The key to environment-resistance is low power consumption and low heat buildup which eliminates the need for vent holes in the case.

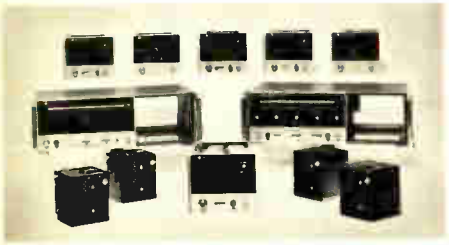
An optional internal battery pack enables the scope to operate anywhere without ac or dc power lines. Yet you get laboratory qualities such as 10 ns risetime, 10 ns/div sweep speed, and 10 mV/div minimum deflection factor.

Price: $2600

Interested? Just check B on the HP Reply Card.

Should you accidentally drop your scope overboard, don't worry. It floats.

Solid-value, solid-state microwave sweepers



Choose from our family of mainframes, RF plug-ins and modules . . .

. . . for a high-value solid-state sweeper only 5 inches (12 cm) high.

High performance and attractive pricing are two features of the HP 3620 series solid-state sweepers. And there's a wide selection so you can choose the configuration that best suits your needs.

Start with the mainframe. The economical 8620B has start-stop and ΔF sweeps, stable CW and versatile modulation. The more sophisticated 8620A provides remarkable latitude in operating modes, exceptional frequency resolution, plus remote programming capability.

For flexible RF coverage, there are new wideband VHF/UHF plug-ins (3-350 MHz and 10-1300 MHz) plus microwave units extending to 18 GHz. For most frequency ranges, you can choose either single-band plug-ins or get multiband operation by combining RF modules in a single drawer (e.g., 0.1–6.5 GHz or 5.9–12.4 GHz).

All versions give you high sweep linearity, accurate frequency calibration, low residual FM, low spurious content—and a low price. The 8620A mainframe costs $1,450; the 8620B, $975; and RF units range from $1,375 to $2,950.

For details, check L on the HP Reply Card.

Two new x-y recorders designed for the lab

Two new general-purpose x-y recorders will withstand all sorts of abuse and rough handling and still give you laboratory quality, speed and accuracy. Both the 7044A and 7045A are contained by a rugged aluminum mainframe which eliminates the need for critical mechanical adjustments, yet provides desired durability.

Both the 7044A (pictured here) and 7045A boast an accuracy of ±0.1% of full scale.

The 7044A operates at medium speed with a slewing speed of 20 inches/sec. The faster 7045A has a slewing speed of 30 in/sec. and acceleration of 3000 in/sec² on the y axis and 2000 in/sec² on the x axis. Input ranges for both instruments are from 0.5 mV/in. to 10 V/in.; input resistance is one megohm on all ranges.

Both recorders use a servo-actuated ink pen. The writing area is 10 by 15 in. (25 by 38 cm) which means you simply use 11 by 17 in. or standard European A3 size paper. Metric calibration is available with either recorder at no extra charge.

Prices: $1350 for the 7044A; $1675 for the 7045A.

For more on these new x-y recorders, just check J on the HP Reply Card.

New storage scopes show nanosecond transients

Now, you can view fast rise, low rep-rate or single-shot signals without having to photograph them. The HP 184 A/B oscilloscopes combine fast writing speed and new storage surface processing to produce a bright display of hard-to-capture signals.

Storage writing speed is greater than 400 cm/μs. The FAST mode automatically switches the CRT display to a high-writing speed, reduced scan and maintains a fully calibrated display. The reduced graticule is superimposed on the center of the normal graticule. This lets you see signals such as a 16-bit computer word directly, without using a camera. With storage, you can retain the display for 5 minutes from FAST mode or over 30 minutes from the standard mode.

In variable persistence mode, match persistence to the signal speed. Thus, a slowly-moving dot becomes a complete trace and meaningful waveform for study.

Several plug-ins complement these new scopes and let you tailor sweep, bandwidth and sensitivity to specialized applications. The cabinet style 184A costs $2200; rack style 184B, $2275.

For more on these new storage scopes, check A on the HP Reply Card.

A single-shot TTL digital word with a 10 ns noise pulse shows up readily on the 184 display.

Microwave measurements—quickly and reliably

For the most accurate, reliable frequency measurements of CW signals in the shortest time, the heterodyne converter is unsurpassed. For equal resolution, counter gate time is up to 500 times shorter than with a transfer oscillator. Now, there are four easy-to-use plug-in converters (up to 18 GHz) for HP 5245, 5246 and 5248 counters.

Tuning is easy. Just dial upwards in frequency until the level meter needle indicates "tuned," then add the dial and counter readings for your answer. Constant bandwidth cavities ensure that tuning is consistent over the entire range. HP converters give the most reliable answers—there are no spurious responses.

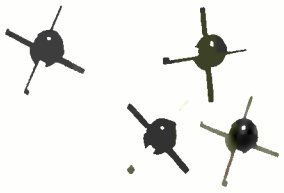
Converter prices are as follows: (50–512 MHz) $675; (0.15–3 GHz) $925; (3–12.4 GHz) $2,200; and (8–18 GHz) $2,300.

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

The heterodyne converter provides rapid, reliable resolution of CW and heavily-modulated signals.

hp COMPONENT NEWS

New Schottky ring quad double-balanced mixer



Its small size makes the ring quad ideal for microstrip applications.

This monolithic array of Schottky diodes features wideband operation to 2 GHz, tight diode match and temperature tracking, low conversion loss, and a compact mechanical package. Typical characteristics are: 4 dB conversion loss at 1 GHz and V_F of 0.4 V at I_F=1 mA.

Designed for high-volume low-cost applications, these devices provide diode circuit functions in double-balanced mixers, AM modulators, pulse modulators, phase detectors and low-power limiters requiring wideband operation and small size. The 5082-2830 ring quads are available from stock.

Price: $3.90 each in 1K quantity.

For details, check G on the HP Reply Card.

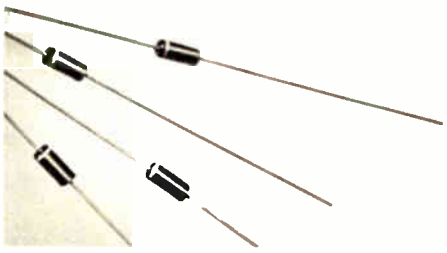
Low-cost PIN diodes for industrial electronics

HP's expanded series of PIN diodes cover the frequency spectrum from RF to above 1 GHz. Types 5082-3080 and 5082-3081 are ideally suited for constant impedance EGC circuits in bi-directional CATV trunk and line extender amplifiers, where operation with extremely low distortion down to frequencies of 5 GHz is required.

The 1N5767 is a general-purpose PIN diode for low-cost switching, attenuating, and modulating. A minimum effective carrier lifetime of 1 μs extends the useful frequency range below 10 MHz. The 5082-3077, with minimum effective carrier lifetime of 100 ns, has similar applications in the UHF frequency band.

Prices in quantities of 1000: 5082–3077, $1.80 each; 5082–3080, $1.65 each; 5082–3081, $1.80 each; and 1N5767, $1.95 each.

For data sheets and Application Note 936, check S on the HP Reply Card.



Two component kits for engineers, designers

Two popular kits are available so that you can try HP components in your design or development project. The 5082-0050 Schottky diode kit features 24 diodes (8 each of 3 different types) together with supporting literature. Price: $8.40.

The 5082-0051 communications kit contains a transistor and several PIN and Schottky diodes for amplifiers, AGC and mixer/detector applications. It's a $34 value for $19.40.

To find out how to get your kit, check F on the HP Reply Card.

Diode fits military specifications

Now, Schottky diode type 1N5711 qualifies to military specification MIL-S-19500/444. This specification applies to both JAN and JAN TX devices. Stock to four weeks delivery. Prices:

	JAN 1N5711	JAN TX 1N5711
1–99	$1.95	$6.95
100–999	1.45	5.95

To learn more, check C on the HP Reply Card.

New logic probe and logic pulser aid IC troubleshooting

Together the pulser and probe form an IC logic stimulus-response test set that's only the size of two pens.

At last, you can inject logic pulses between TTL and DTL gates without unsoldering or trace cutting. Simply touch the new 10526T logic pulser to any in-circuit node, press the pulse button, and a 300-nanosecond pulse is "stuffed" into inputs and outputs. If the node is high, it is pulsed low instantaneously; if low, it goes high—all automatically. The ability to source or sink up to 1 amp, typically, ensures a pulse into even the hardiest loads.

Another addition to the IC troubleshooting line is the new three-state 10525T logic probe. Besides detecting TTL highs and lows, the new probe detects bad levels and open circuits. Single pulses as narrow as 10 ns and pulse trains to 50 MHz rep rate are also indicated. (No wonder so many engineers and technicians reach first for their logic probe when digital troubleshooting.)

Combine the unique stimulation capabilities of the logic pulser with the response monitors—the logic probe and the 10528A logic clip. The pulser injects pulses into logic gates; the probe monitors the output. Shorts to ground or Vcc are detectable with the pulser and probe. (Opens are detected by the probe itself.) Attach the logic clip to flip-flops, counters, decoders, shift registers, and other MSI chips; then monitor exact operation 14 or 16 pins at a time with the pulser providing clock, reset, clear or transfer pulses.

You can buy these three troubleshooters separately or all together in a convenient low-cost kit. The 10525T logic probe and 10526T pulser cost $95 each; the 10528A logic clip, $125. The 5015T troubleshooting kit contains all three for only $285.

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

The 5015T logic troubleshooting kit packs complete stimulus/response capability into a single package . . . at a 10% discount.

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West—3939 Lankershim Boulevard, North Hollywood, Calif. 91604, Ph. (213) 877-1282.
Europe— Post Office Box 85, CH-1217 Meyrin 2, Geneva, Switzerland, Ph. (022) 41 54 00.
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MEASUREMENT NEWS
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1

☑ I'd like Literature ☑ Please contact me about:

- ☐ A. 184 A/B storage scope
- ☐ B. 1700B, Option 300 "environment-proof" scope
- ☐ C. 1N5711 Schottky diodes
- ☐ D. 3470A snap-together multimeter
- ☐ E. 3490A self-testing multimeter
- ☐ F. 5082-0050, -0051 component kits
- ☐ G. 5082-2830 double balance quad mixer
- ☐ H. 680 strip-chart recorder
- ☐ I. 6104/05/14/15 precision power supplies
- ☐ J. 7044, 7045 x-y recorders
- ☐ K. 8410 network analyzer family
- ☐ L. 8620 sweepers
- ☐ M. 8755 frequency response test set
- ☐ N. 9550A instrument calibration system
- ☐ O. DC Power Supply Selection Guide
- ☐ P. DC Power Supply Handbook
- ☐ Q. Heterodyne converters for HP counters
- ☐ R. Logic pulser, logic probe
- ☐ S. Low-cost PIN diodes
- ☐ T. OEM peripherals — tape drive, disc, and card reader
- ☐ U. HP videotapes

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☑ I'd like Literature ☑ Please contact me about:

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For fast response, please use the above Reply Cards to request information on any Hewlett-Packard product described in the foregoing issue of MEASUREMENT NEWS.

Please note that you can choose two types of HP response:

- ☑ Literature (You will receive more information on a product, such as data sheets or other relevant literature.)
- ☑ Please contact me. (You will receive product information *and* a follow-up call by an HP Field Engineer. He'll discuss general or specific applications, answer questions, or provide other information as requested.)

If both the Reply Cards on this page have been used, contact your nearest HP field office or one of the regional offices listed on the preceding page. Or write directly to the Hewlett-Packard Company, 1601 California Avenue, Palo Alto, California 94304.

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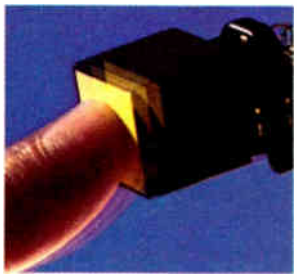
Press here to save on lighted pushbutton switches.

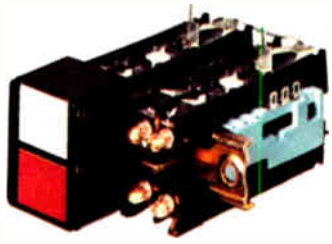
buys all the switch you need.

Oak's Series 300 gives you good looks and a small price-tag in lighted pushbutton switches. Plenty of switching performance for most jobs, without paying a premium. Even the Series 300 Split-Legend/4 Lamp Switch is less than $1.60 (normal latch, 2P2T, glass alkyd insulation, no engraving, less lamps.)



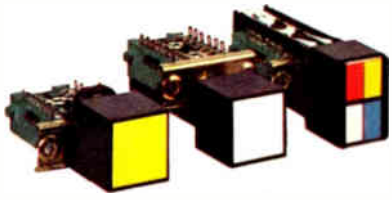
Built to take it.

Series 300 is built for reliable performance and long life. Applications galore —bank terminals, calculators, and copy equipment.



Modular design.

Single-legend/single-lamp, split-legend/4-lamp, and single-legend/redundant lamp switches have snap-on lamp holders. Plus replaceable legend plates, lens caps, and button assemblies. Front-panel relamping, too, without special tools on all types.

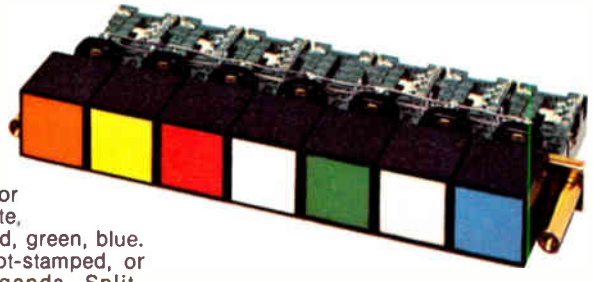


Three versions with switching up to 4P2T.

Choose from single, dual, or four lamp display as well as non-lighted type. One to twelve station, momentary, interlock, alternate action, or any combination available on the same switch bank. Lockout feature available for all types. Power Module 3A125VAC. Lighted indicators are identical in size and appearance, but without switching.

Gang them up by the dozen.

Order up to 12 switching stations on a single channel, any switching mix, with convenient panel-mounting studs. Color selection: white, lunar white, yellow, amber, orange, red, green, blue. Choose silk-screened, hot-stamped, or engraved-and-filled legends. Split-legend switches can be specified with any two, three, or four colors on insertable legend plates.



Write for our Series 300 Brochure

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digital
PDP-8e

Meetings

First National Conference on Remotely Manned Systems: NASA, Caltech. Ramo Aud., Caltech, Pasadena, Calif., Sept. 13-15.

Western Electronic Show & Convention (Wescon): WEMA, Convention Center, Los Angeles, Sept. 19-22.

Engineering in Medicine and Biology: IEEE, Americana, Bal Harbour, Fla., Oct. 1-5.

International Symposium on Remote Sensing of Environment: U. of Michigan, Willow Run Labs, Ann Arbor, Oct. 2-6.

U.S.A. & Japan Computer Conf.: AFIPS, IPSJ, Tokyo, Oct. 3-5.

Ultrasonics Symposium: IEEE, Statler Hilton, Boston, Oct. 4-6.

National Electronics Conf.: NEC, Regency Hyatt O'Hare, Chicago, Oct. 9-11.

International Conference on Cybernetics and Society: IEEE, Sheraton, Washington, D.C. Oct. 9-12.

Conference on Display Devices: IEEE, United Engineering Center, New York, Oct. 11-12.

Eascon: IEEE, Marriott Twin Bridges, Washington, D.C., Oct. 16-18.

The Business Equipment Show: McCormick Place, Chicago, Oct. 16-20

International Conference on Computer Communications: IEEE, ACM, Hilton, Washington, D.C., Oct. 24-26.

Nerem: IEEE, John B. Hynes Civic Auditorium, Boston, Nov. 1-3.

International Conference on Magnetism and Magnetic Materials: AIP, IEEE, et al., Hilton, Denver, Nov. 28-Dec. 1.

International Electron Devices Meeting: IEEE, Washington Hilton, Washington, D.C., Dec. 4-6

The Fluke problem solver

The DVM you put together an option at a time, anytime

Because we use single main frame construction with all options field installable, you can configure the Fluke 8200A anyway you want when you buy it or anytime you want to change it. It's Fluke's way of giving you total flexibility for minimum money. It's one of the reasons Fluke has moved to DVM leadership in a scant two years.

Here's what you get for just $995: ☐ 4½ digits with 60% overranging for ±16000 count resolution ☐ Autoranging and autopolarity on all functions ☐ Switched input filter ☐ Full 1000 volt guarding ☐ ±0.01% accuracy ☐ Fluke's unique recirculating remainder* A to D conversion which combines low parts count and low power consumption to provide higher reliability.

To the basic unit you can add: ☐ Two ranges of millivolts, giving you autoranging from 1 microvolt resolution up to 1200 volts input ☐ Six ranges of ohms measurement, providing autoranging from 10 milliohms to 16 megohms ☐ Four ranges of ac volts ☐ Four ranges of true rms ac volts ☐ Isolated 4-terminal, real-time ratio measurement.

A real systems DVM too: ☐ Speeds up to 400 readings per second with full accuracy after only a 500 microsecond look at the input ☐ Isolated and buffered data output for digits, range, functions and polarity—with status flags ☐ Isolated remote control for continuous or buffered input commands ☐ Isolated and buffered printer output.

Ask for Fluke's 8200A Application Bulletin No. AB-10 for systems designers.

The 8200A's single main frame and field-installed options let you configure the most cost-effective 4½ digit DVM on the market.

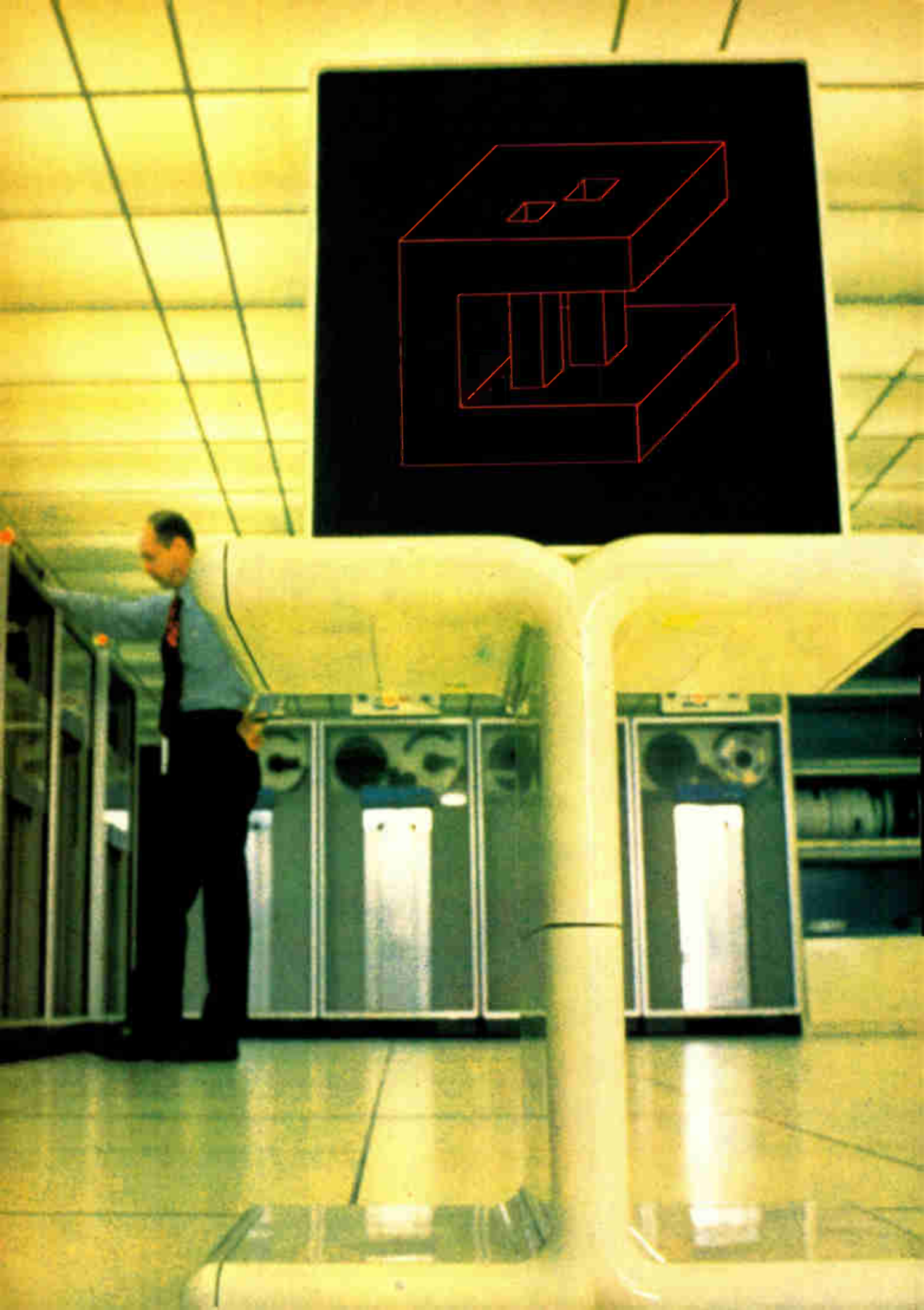
To arrange a demonstration or get complete information, call your nearby Fluke Sales Engineer or contact us directly.

*Patent pending

Fluke, Box 7428, Seattle, Washington 98133. Phone: (206) 774-2211 TWX: 910-449-2850. In Europe, address Fluke Nederland (N.V.) P.O. Box 5053, Tilburg, Holland. Phone: 13-670130. Telex: 884-52337. In the U.K., address Fluke International Corp., Garnett Close, Watford, WD2,4TT. Phone: Watford, 33066. Telex: 934583.

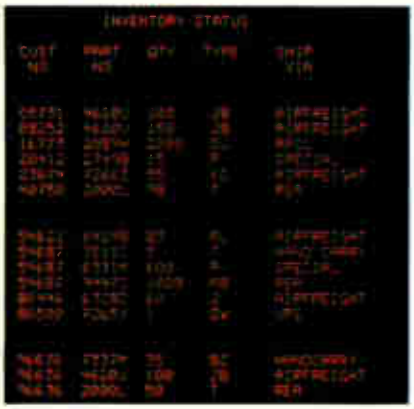
FLUKE

Circle 31 on reader service card



You've got the kind of an organization that demands instant, high-impact, full spectrum visual communication.

We've got Digivue.



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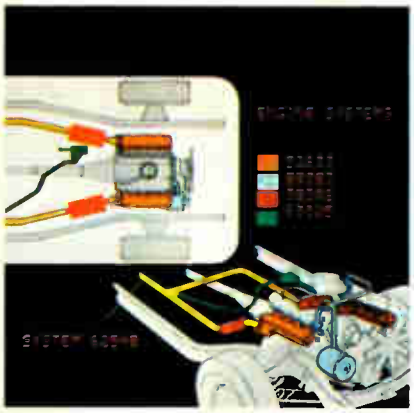

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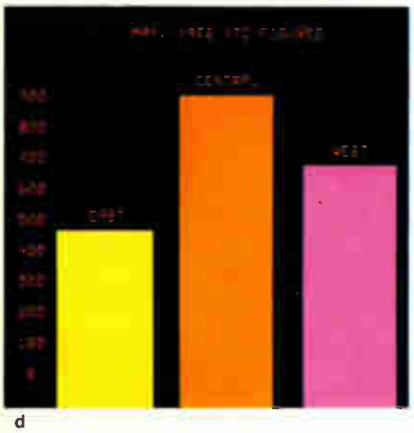

d

Communicate. That's the watchword for the Seventies. And that's just what Digivue® Display/Memory units do—with impact, immediacy and memorability.

Digivue Display/Memory units deliver computer-generated alphanumeric or graphic information at microsecond speeds. And a Digivue Display/Memory unit is a digital plasma display device—the space age display system that's a technological giant step beyond the cathode ray tube.

Inherent memory, selective write/erase, drift-free images, rear-projection capability, design adaptability, hard copy printout potential—that's Digivue.

Digivue Display/Memory units are now available in three different sizes: A 256 x 80 addressable line panel at a resolution of 33 lines per inch; a 256 x 512 addressable line panel at a resolution of 50 lines per inch; and a 512 x 512 addressable line panel at a resolution of 60 lines per inch that offers an active display area for up to 4,000 characters.

If you need fast, multi-purpose visual communication with impact—in a business, school, hospital, transportation center—we've got what you need. Digivue Display/Memory units.

Call or write: Jon Klotz, Marketing Manager
Electro/Optical Display
Business Operations C,
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P.O. Box 1035, Toledo, Ohio 43601
(419) 242-6543.

Communication with Digivue units begins at a data processing center like the one pictured on the opposite page, where computer-generated information is directly addressed to Digivue units at various locations.

a/*A Digivue unit in a shipping department relays the day's orders by catalog number, type, quantity and method of shipment. Digivue's inherent memory allows instant retrieval of this information without refresh requirements at any time.*

b/*A Digivue unit on the desk of a financial vice president transmits a twelve-month cost projection. Terminal manufacturers note: Digivue's slim panel depth allows for high-styled consoles and attractive, unobtrusive placement in an almost limitless variety of situations and locations.*

c/*Digivue units help a sales training class with assembly techniques for a new product line. Because Digivue panels are transparent, rear-projected graphics in every color of the rainbow deliver high-impact visuals no CRT system can even come close to.*

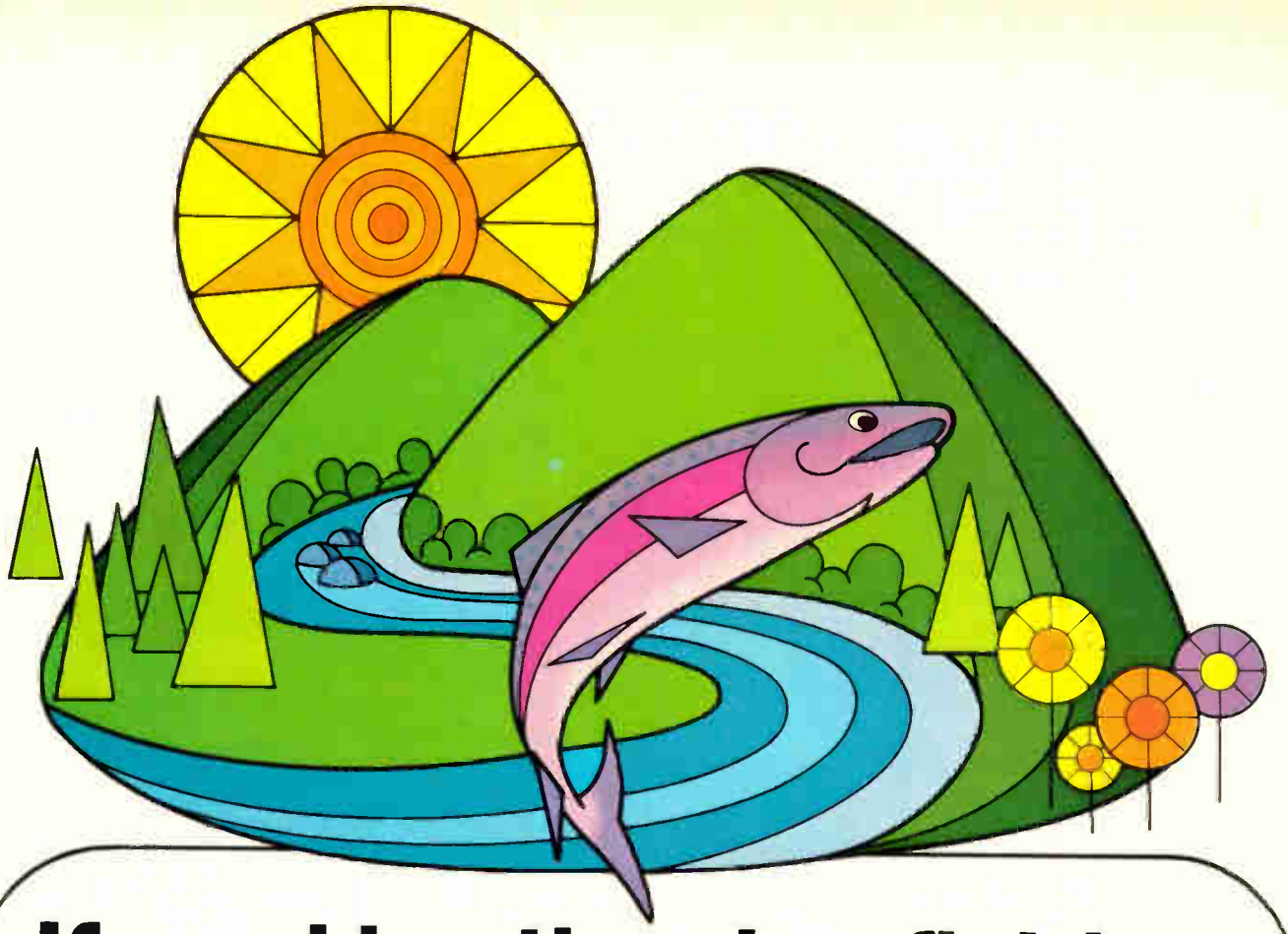
d/*With the help of a Digivue unit, a busy executive secretary prepares information for an important meeting—utilizing a combination of rear-projected graphics and computer-generated alphanumerics.*

Digivue

Display/Memory Units

Owens-Illinois

Circle 33 on reader service card



If you'd rather be fishing

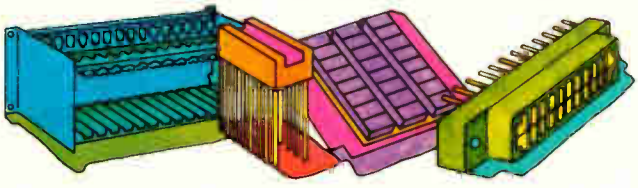
Let SAE solve your packaging problems.

Wouldn't you rather be up to your hip boots in a trout stream than up to your neck in packaging problems? Then turn over component selection, packaging, and systems assembly to us. You go chasing the Rainbow.

Only SAE provides a complete packaging service in your choice of three systems: Plug-in, Planer, and Dipstik™.

We manufacture all the hardware for card cage plug-in systems, including PC cards, card files, card guides, connectors, sockets, enclosures, mounting and bussing.

Rather go planer with logic panels? We have everything: panels, mounting hardware, sockets, peripheral items.



Or try our unique Dipstik. It gives twice the IC density as PC methods, and eliminates a lot of hardware.

Whichever method you select, we can supply the components for you to assemble yourself. Or, we'll pick the parts, do the assembly, and let you do the wiring. Or, we'll provide everything: components, assembly, and Wire-Wrap®. So, call us in . . . and you can go out fishing!

Free bumper sticker for your desk. Tell the world you're a fisherman. If not, tell us what you are. Maybe we have a bumper sticker to match. Anyway, we'll send a new brochure showing how we can relieve you of systems packaging snarls. Write us:

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Inselek adds speed to static memory

The elusive combination of high speed and low power in a static device has been achieved in a 256-bit random-access memory by Inselek Co. of Princeton, N.J. **Indeed, the new memory may have the lowest speed-power product of any standard part available.**

Using silicon-on-sapphire technology, Inselek's memory has an access time of only 35 nanoseconds and dissipates only 0.4 milliwatt per bit, in contrast to about 2 mW per bit for a bipolar memory of comparable speed. **The SOS fabricating system yields a packing density four times higher than the equivalent bipolar structure.**

Inselek is adding the 256-bit part to its 64-bit static memory already in production. Also, the company indicates it's about to announce a 1,024-bit static device with equally impressive speed-power specs.

Philco replaces wiring with logic in phone exchange

Relying on techniques developed for its military switching systems, the Communications and Technical Services division of Philco-Ford Corp. has produced its first commercial product—a programable electronic private automatic branch exchange (EPABX). **Hard-wired logic is replaced by software in the Philco-Ford unit,** which has a capacity of 512 lines.

Two redundant processors—each with roughly the over-all capability of a minicomputer but without arithmetic functions—are at the control system center. A great variety of functions—such as call-forward and call-back, abbreviated dialing, traffic statistics recording, conferencing, class-of-service marking, and even adding new extensions—can be handled simply by reprograming. Another feature is that the system uses silicon-controlled rectifiers, instead of pnpn switches or reed relays, to replace the electromechanical cross-point switches of the conventional PABX.

Radio Shack to sell TI calculator under own label

The Tandy Corp. of Fort Worth, Texas, will sell the first private label handheld calculator from Texas Instruments through its chain of 1,300 Radio Shack stores. **The calculators will retail for $129.95—$20 less than TI's own Datamath brand** [*Electronics*, July 3, p. 44]. The eight-digit machine, with its light-emitting-diode display, is similar to Datamath, but will run either on penlight or nickel-cadmium batteries and has an ac adapter. But it cannot multiply or divide by a constant.

Datran delays naming supplier, gets fresh money

Data Transmission Co. appears to have slipped its schedule for naming a microwave system supplier for its nationwide switched digital data network, **increasing industry speculation that the parent company, University Computing Co. of Dallas, is having difficulty pulling together the required financing.** Having earlier reported plans to name a contractor by the end of June [*Electronics*, May 22, p. 49] and later changing the date to mid-July [*Electronics*, June 5, p. 36], Datran management at the company's Vienna, Va., headquarters now says only that it will "commit to construction before the end of the year." Negotiations are in progress with four suppliers identified only as "both foreign and domestic." The company will not confirm earlier reports that Nippon Electric Co. is one of those that has offered to supply equipment with financing.

Meanwhile, **University Computing has lived up to its earlier pledge to sell some of its own holdings to back Datran** [*Electronics*, March 13, p. 34]. UCC chairman and founder Sam Wyly has agreed to sell UCC Communications Systems Inc. to Harris-Intertype Corp., Cleveland, for about $20 million in cash.

Fluke to sell $299 multimeter

John Fluke Mfg. Co. is entering the low-cost digital multimeter field with its model 8000A 3½-digit machine. The new meter, which will sell for $299, incorporates two technological innovations: **it uses a voltage-to-frequency conversion scheme and a custom linear LSI chip** that combines both bipolar and MOS transistors.

Surveillance business expected to increase

Looking for the industrial and police surveillance market to open up, MOS Technology Inc. of Valley Forge, Pa., says it's getting into production with silicon targets for low-light-level vidicon tubes. **Agreements have been signed to supply the targets to two vidicon manufacturers.** The targets, 1-inch square and containing some three-quarters of a million ion-implanted p-n diodes, are of the type supplied either separately or in finished tubes by companies such as RCA, Texas Instruments, and Hughes Aircraft. With silicon targets that can better withstand overpowering light levels, the vidicons are more rugged and electrically faster than vidicons with photoconductive targets.

Some 3,500 silicon vidicons were sold last year, an MOS Technology spokesman says. And he expects their use to increase "considerably," particularly in anticrime surveillance applications that don't require extremely high-quality, and therefore expensive, devices.

Swedish firm buys share of calculator maker

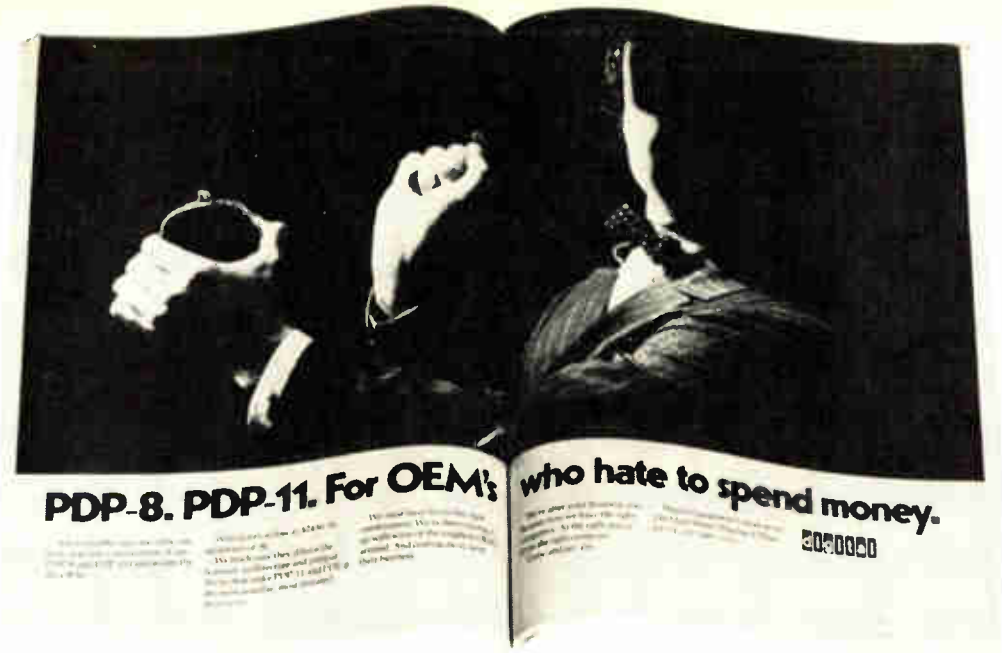
Swedish office-machine maker Facit AB has bought into Lago-Calc, the Woodland Hills, Calif., calculator maker. No details on the deal were available. **The Swedish company plans to stop selling Japanese-made desktop machines now that it has the U.S. manufacturing capability.** As for Lago-Calc, it previously had taken over financially pressed International Calculating Machines, formed as a subsidiary of Electronic Arrays Inc.

Since 1965, Facit has been selling machines made by Sharp of Japan under its Facit and Addo-X labels in the U.S., Europe, and other markets.

Western Union orders 3 satellites from Hughes

Western Union has contracted for three satellites from Hughes Aircraft Co. at a cost of $20.7 million. **The order is the first for a domestic communications satellite system, for which Western Union is one of eight competitors.** The company's move indicates that it is confident of being named one of up to four operators of such systems under the FCC's "multiple entry" policy [*Electronics*, July 3, p. 72].

The three Western Union satellites will be identical, except for antenna coverage, to the ANIK I being built by Hughes for the Canadian Telesat system. ANIK I is a 75-inch-diameter spin-stabilized craft. The American satellites, due for first orbit in 18 months, will carry 12 transponders each. **Still to be ordered by Western Union are seven earth stations, bringing total system cost to more than $68 million.**



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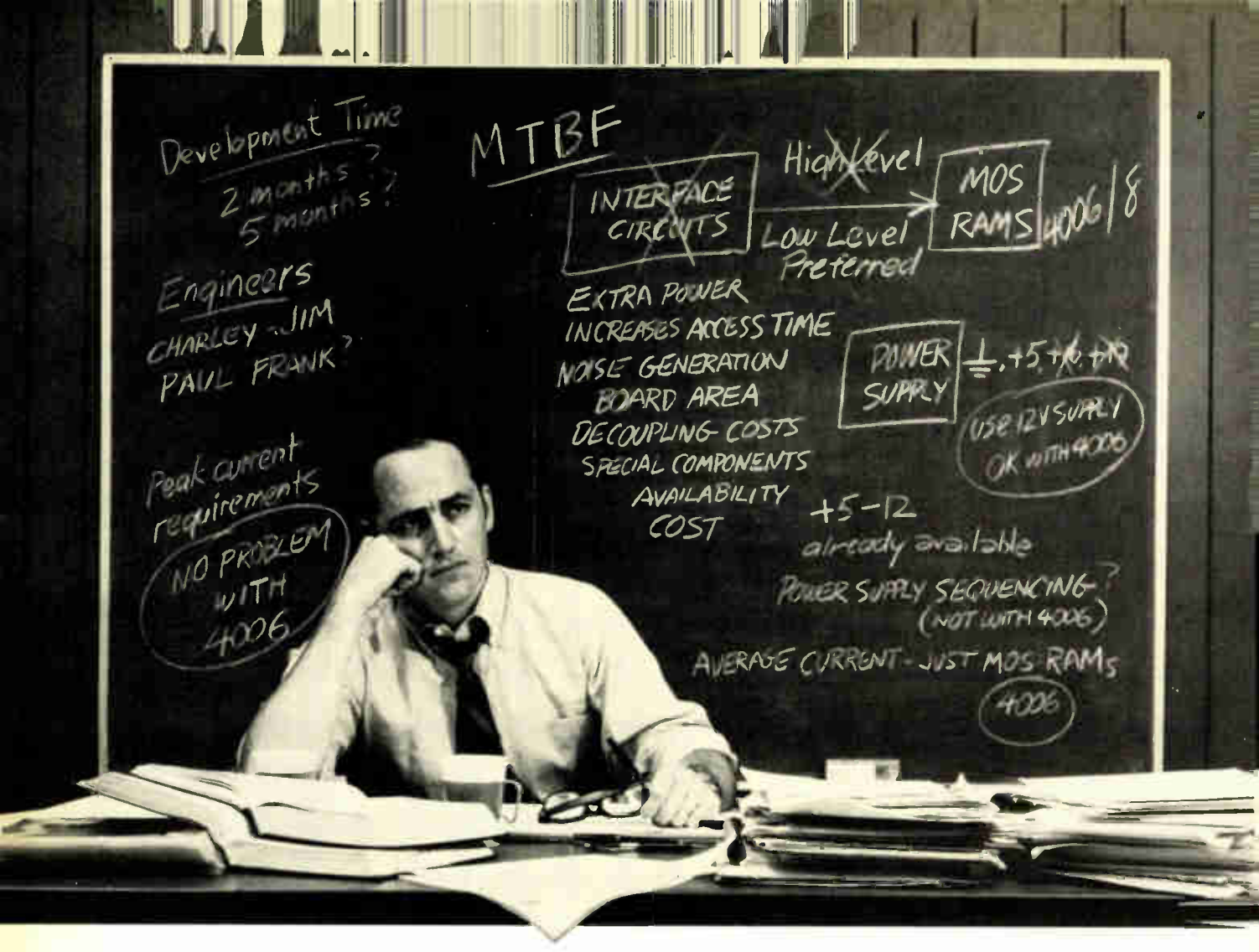

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CCDs spawn all-solid-state color TV camera

Bell Labs says demonstration model could be shrunk to size of a 35-mm still camera; three arrays replace tubes

The first all-solid-state color television camera, which could ultimately be shrunk to the size of a 35-mm still camera and hung from a strap around the neck, has been developed at Bell Laboratories.

To sense the primary red, blue, and green colors, the camera uses three arrays of the charge-coupled devices Bell announced last spring [*Electronics*, March 27, p. 29]. The more cumbersome vacuum-tube and electron-beam scanning systems of existing color cameras are eliminated. That's why Eugene I. Gordon, director of the Electro-Optical Device Laboratory, estimates that a fully engineered CCD color camera could be held in the hand.

Resolution. The present color camera measures 8 by 9 by 5 inches. The three CCD arrays, fabricated with tungsten metal electrodes deposited on silicon dioxide over a silicon substrate, each contains 128 by 106 elements. With this structure, resolution is half that required, for example, by Bell's Picturephone.

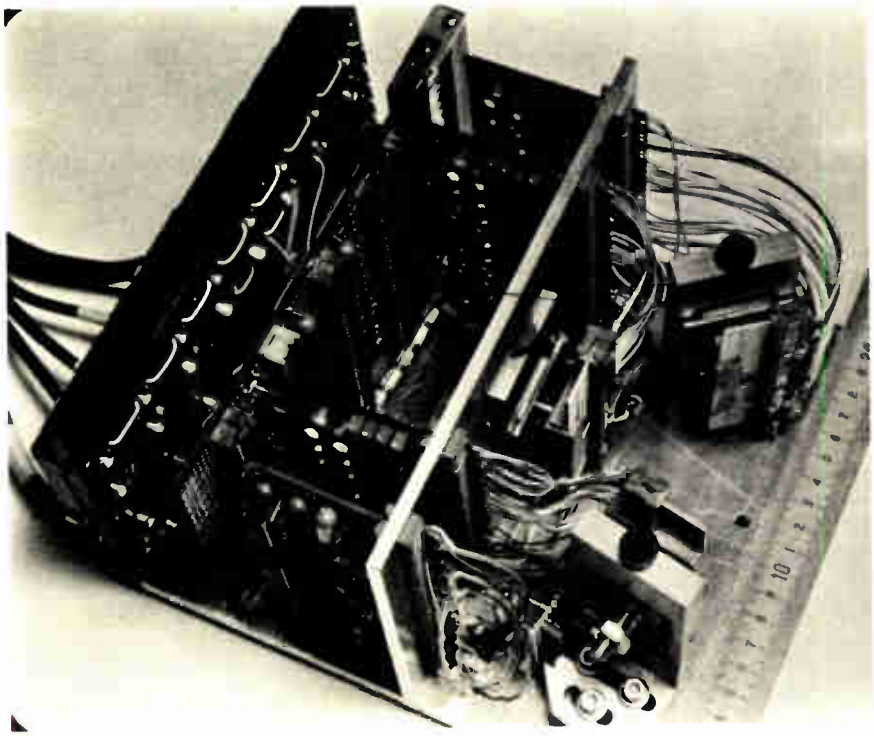
Because the camera is what Gordon takes pains to describe as a lab demonstration model, little effort has been spent on making it as small as possible. For instance, the beam-splitting optical device that produces the primary colors is a commercially available color-separation prism used in the ordinary three-tube, 1.25-inch Plumbicon camera. Actually, the prism is two or three times as large as needed for the 192-by-240-mil CCD chips.

In addition, points out Michael F. Tomsett of the solid state imaging Device group, the man who helped develop Bell's original CCD, as well as the new color camera, no great effort was made to miniaturize the circuitry. Discrete transistors are used for the drivers that interface with the CCDs, he says. And the logic, with a 1.45-megahertz clock frequency, is made up of standard transistor-transistor-logic packages. Once integrated on either custom or standard chips, the circuitry could be reduced to a mere handful of chips.

Another important feature of the CCD camera is that it's the first time interlaced line scans that make up a picture in conventional TV systems have been used with CCD solid state imaging. This is accomplished by interlacing the way the charge, stored under the metal electrodes of each picture element in the array, is integrated, or measured. Three 9-micrometer-wide tungsten electrodes, spaced 2 μm apart, make up each element, and the charge is produced in the silicon underneath by light emanating from the scene.

Fielding. The first of the interlaced fields is produced by integrating the charge under the first of the three electrodes, Gordon explains. Time to read out the charge in a

Color camera. Red, blue, and green are sensed by CCD arrays in Bell's 8-by-9-by-5-in. model solid state TV camera. With ICs and more engineering, unit could be half the size.



field is 1/60th of a second. The second field is produced by integrating under the second and third electrodes. As a result, the array produces twice the number of lines that would apparently be available from a given array size.

This doubling is needed because the elements in a CCD array are divided into two halves—an image section and a storage section; thus, each section contains an array of 64-by-106 elements. (A small part of the chip is also devoted to the readout circuitry.) During readout, charges in the image section are transferred to the storage section. But because of the interlacing, a 128-line rather than a 64-line picture is produced in the vertical direction. To achieve the 525-line scan of conventional TV, 263 elements would be needed in the imaging section, and 263 would be needed in the storage section.

As for the future, Gordon points out, "There are no commitments for color Picturephone service, nor for black-and-white Picturephone CCDs." However, work undoubtedly will continue on fabricating larger CCD arrays—ones suitable for Picturephone and even for commercial television. In either application, CCDs would have striking advantages over conventional vidicons, in addition to small size and low power consumption. And its fabrication and readout mechanism are far less complicated than those of other thin-film and silicon solid-state cameras being developed. □

Computers

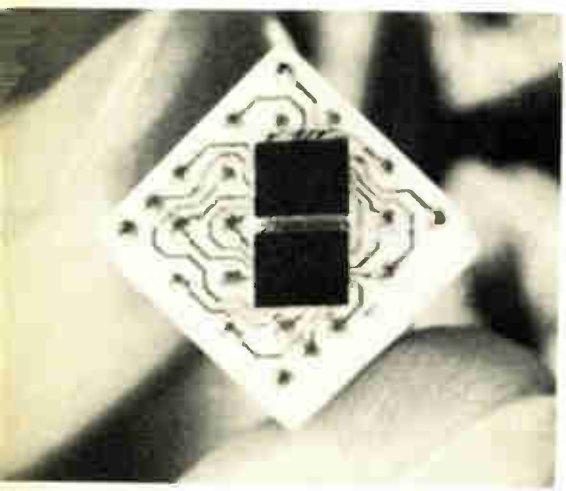
Two new 370s drawing wary looks from peripheral, semiconductor makers

IBM's long-expected announcement of its new System 370 models—the 158 and 168—has created the anticipated waves. Technological improvements in the two machines, as expected, constitute a threat to the future prosperity of independent peripheral equipment makers and also have semiconductor memory equipment manufacturers sitting up and taking notice. Both new machines have large virtual memories. But more significant are their MOS memories and the integrated file adapters for controlling the IBM 3330 disk storage units.

Though IBM has long been interested in MOS technology, this is the first time the company has used it in a computer memory. The memories are quite large—in the model 158, the MOS memory is available from 524,000 to 2 million bytes and has a 1.035-microsecond cycle time; the model 168 comes with 1 million to 4 million bytes that cycle at 800 nanoseconds. The memories come in 1,000-bit chips, with two chips (n-channel RAMs) on a ceramic substrate and two substrates in a package, similar to the packaging scheme IBM has been using since 1969. The performance of both machines is upgraded by cache memories that have specifications identical to those of the earlier models 155 and 165. Cycle times are 115 nanoseconds for the model 158 and 80 ns for the model 168. Both have capacities of 8,000 bytes, with 16,000 bytes available on the 168. The cache memory makes the main memory appear to be faster than it is, whereas the virtual memory (see panel on opposite page) makes the main memory look bigger than it is.

Metal gates. IBM has used conventional metal-gate structure in its circuits instead of the newer and more compact silicon gate. Circuit designers recognize the better tolerances and the inteconnection advantages offered by silicon gate, a spokesman says, but IBM says it's skills in photolithography are sufficiently advanced that the tolerance build-up was kept low enough, even with the metal gate, so the extra interconnection level isn't needed.

These factors, coupled with the metal gate's better cost performance figure at the present time, and its simpler structure with IBM's design,



Memory. IBM uses four-chip storage modules in MOS memories for 158 and 168.

The bounce of the legal ball

As IBM prepared to announce the System 370 models 158 and 168, it let out the word in advance in a dazzling display of corporate oneupmanship. IBM's official reason for deviating from its long-standing practice of not "preannouncing" products was to forestall rumor and speculation. But the real reason was to defend itself from a legal action brought by Telex Corp. As part of that action Telex asked for an injunction against such an announcement.

To defend itself, IBM would have to discuss in court its plans for announcement. So IBM asked for, and got, a "sequestration" of the court proceedings to keep the discussions off the public record until after the litigation was over. But the judge also barred IBM from making any announcements until after Telex had its day in court.

At this point, IBM gambled. Rather than postpone its planned announcement, it appealed the temporary injunction and won. But in appealing, it had to permit the earlier proceedings to become public; so it "preannounced."

tipped the balance against silicon-gate technology.

Because MOS memory, even with metal gates, is much more compact than a ferrite-core array, the new machines take up much less floor space than the models 155 and 165, their nearest neighbors in the 370 line. Space is available in the smaller frames to expand the memories to the maximum.

Older IBM units required additional frames to be connected to the basic machines for expanded memory, even within IBM's own announced specifications. Makers of add-on memories aimed to connect their own frames at lower costs in place of IBM's. With the maximum memory in the basic frame, the independents might expect to encounter a little more difficulty in selling their products; but a marketing spokesman at Advanced Memory Systems Inc., Sunnyvale, Calif., didn't seem to be worried about this prospect. And Mike Markkula, marketing manager at Intel Corp., hinted that Intel might supply memory cards to plug into IBM sockets, rather than providing an add-on memory in a separate frame.

Robert Lloyd, president of AMS, says the announcement makes him very happy "because it sort of legitimizes aluminum-gate MOS, not silicon gate." AMS builds a 1,000-bit memory chip with p-channel MOS, which he says is fast enough to compete with IBM's n-channel chip. Lloyd expects to be able to compete well in selling add-on memories for the new machines—in part because he expects the 500-ns 2-megabyte specification "will squeeze out core memory" from the add-on market.

Independent peripheral equipment makers are unhappy, but not particularly surprised, about IBM's incorporation of the control unit for the 3330 disk storage unit in the central processor, instead of in a stand-alone box. This changes the characteristics of the interface so that competitive machines that are plug-to-plug compatible with the 3330 can't be used with the new controllers. IBM did the same thing almost two years ago with an older and smaller disk storage unit, the 370/145, and made suppliers of plug-to-plug compatible equipment unhappy then too. □

Virtual memory a la IBM: what you see isn't exactly what you get

Virtual memory permits the programer to write his program as if he had direct access to a much larger memory than is actually installed in his computer. It relieves him of concern with storage management.

In the System 370, the maximum is over 16 million bytes, which is much larger than any main memory ever installed on any computer. This flexibility is achieved with the 24-bit address that every machine-language instruction in the 370 has.

This 24-bit address is part and parcel of the instruction format and was also present in the System 360, introduced in 1964. But in the absence of virtual storage, many of those bits in the address went unused. Even the more sophisticated attempts at beefing up performance and simplifying programing couldn't use all those bits.

The key to virtual memory is the ability to modify addresses dynamically. With virtual memory, "pages," or portions of a program, are sloshing back and forth between main memory and bulk memory (drum or disk) all the time. The operating system software has to keep track of what pages are in the main memory at any given time, to modify the address in every reference to those pages, and to fetch the desired page from bulk memory if necessary and relocate it in some available spot in the main memory.

Virtual memory will be available as additions to the models 135 and 145 without charge, and to purchased models 155 and 165 at charges of $200,000 and $400,000 respectively. It involves the address modification hardware, which is minor, and changes in the control program, which in the two smaller models is reloadable.

In the larger models a whole new read-only memory must be installed; besides, they have core memories instead of semiconductor memories, which alters the modification scheme somewhat. This accounts for the steep charge for the two larger models. Virtual memory is not offered as an option to be added to leased 155s or 165s; for those customers, merely trading in the old machines for the new is simpler.

Medical electronics

HEW examining treatment via TV

The Department of Health, Education, and Welfare is starting a series of seven pilot projects using a new health care team—television teamed with laser, microwave, or cable communications—that will let doctors treat patients at a distance with the help of on-the-spot paramedical personnel. Some of the equipment will permit transmission of hard-copy data like electrocardiograms.

Moreover, as the projects grow, they will provide the broadband data from which planners can design national health care communications networks, says Maxine L. Rockoff, logistics chief of the Health Care Technology division in HEW's Health Services and Mental Health Administration. Eventually, computers will be part of those networks, she adds. HEW's job, Ms. Rockoff cautions, is simply to determine the requirements for health care communications. Private groups will have to build them, but "anybody who needs to design a national network needs to know what the needs are," she says. Proliferating "wired city" concepts make it vital to define requirements.

One project using coaxial cable will connect a doctor's office in New York's Mount Sinai School of Medicine with a pediatric clinic in East Harlem, reports Edward Wall-

erstein, communications section coordinator with the school's department of community medicine. The two-way link will use two TV screens in each location, permitting a nurse to examine a baby under the doctor's directions before a fixed-focus black-and-white camera. Prototype equipment for hard-copy transmission is being installed now, Wallerstein says. "You have to start on a small scale and work up," he adds. "A year from now we hope to use color." More clinics are also planned.

Case study. At Case Western Reserve University's School of Medicine, a 1-milliwatt helium-neon laser will enable an anesthesiologist to supervise a nurse anesthetist, and will include color television, voice, and hard-copy transmission on the same beam. The nondigital system employs an fm subcarrier in a proprietary modulation format, says John W. Allen, who helped develop the system and is now chief engineer for electro-optics, Laser Communications Inc., Cleveland.

The advantages of a laser system for distances up to a few miles are that "you don't need a license to transmit" and "you can transmit any information," Allen says. Also, it's portable and much cheaper than using telephone lines or microwave lines. But it's line-of-sight.

A Picturephone network connecting four community mental health centers and a combination Picturephone and cable system for record transmission are two Chicago programs at Illinois' Medical Center complex and Bethany Brethren Hospital, respectively. Picturephones are cheap and available in Chicago, Ms. Rockoff comments. The other multi-discipline projects use television and/or cable or microwave systems for doctors to direct paramedical personnel in four clinics at Cambridge Hospital, near Harvard University, for a rural group practice in Waconia, Wis., and for speech therapy work at Dartmouth Medical School.

In breaking new ground, the projects raise some questions about patient examination. One is: do remote communications systems legally constitute adequate medical supervision? Ms. Rockoff says these problems will be studied as the projects go on. □

Phone system cuts EKG time, cost

The ultimate goal in remote interpretation of electrocardiograms is to permit the family doctor to obtain fast, accurate, and complete readings without having to consult a cardiologist or send the EKG to a laboratory. A new system, called Phone-a-gram, promises to cut costs and time required for reading electrocardiograms.

Phone-a-gram, a portable system, uses conventional phone lines to transmit an EKG in only 80 seconds to a computer equipped with a U.S. Public Health Service program. A complete diagnosis is possible in an additional three minutes, while similar equipment takes four minutes for transmission alone. Phone-a-gram leases for $24 a month.

Ten leads. Developed by Michael A. Robinton, a former MOS LSI tester designer, Phone-a-gram has 10 electrode leads attached to the patient. Twelve analog signals with values from 50 microvolts to 2 millivolts are derived; these are then multiplexed and sent as 13 blocks of data via a built-in acoustic coupler. The extra block is a 1-millivolt square wave that is used to calibrate the computer. At the other end, the 12 signals are demodulated and combined to form eight standard EKG traces.

Several safety features are built in. The patient is isolated from external electrical hazards because the box operates on self-contained batteries. Also, the high input impedence of the input operational amplifiers protects the patient from electric shock. The op amps, in a summing network, remove any offset voltage that might be present on the EKG signal. Robinton says that the offset can be as low as 30 millivolts or as high as 300 millivolts. The proper op amp is then selected by a multiplexing circuit, and that block of data is converted to an audio tone and transmitted over the phone lines to the computer, via the Phone-a-gram's built-in coupler.

Marketed and produced by the Fred J. Petersen Co., San Francisco, a small medical-equipment sales firm, the Phone-a-gram has 180 subscribers in seven western states. One user, Pittsburg, Calif., Community Hospital, does about 200 EKGs a month with the Phone-a-gram.

But there are still a few problems to be worked out. Says a hospital spokesman: "If we are to take all the computer's interpretations literally, we would very seldom get a normal person. There is a tendency to overread." □

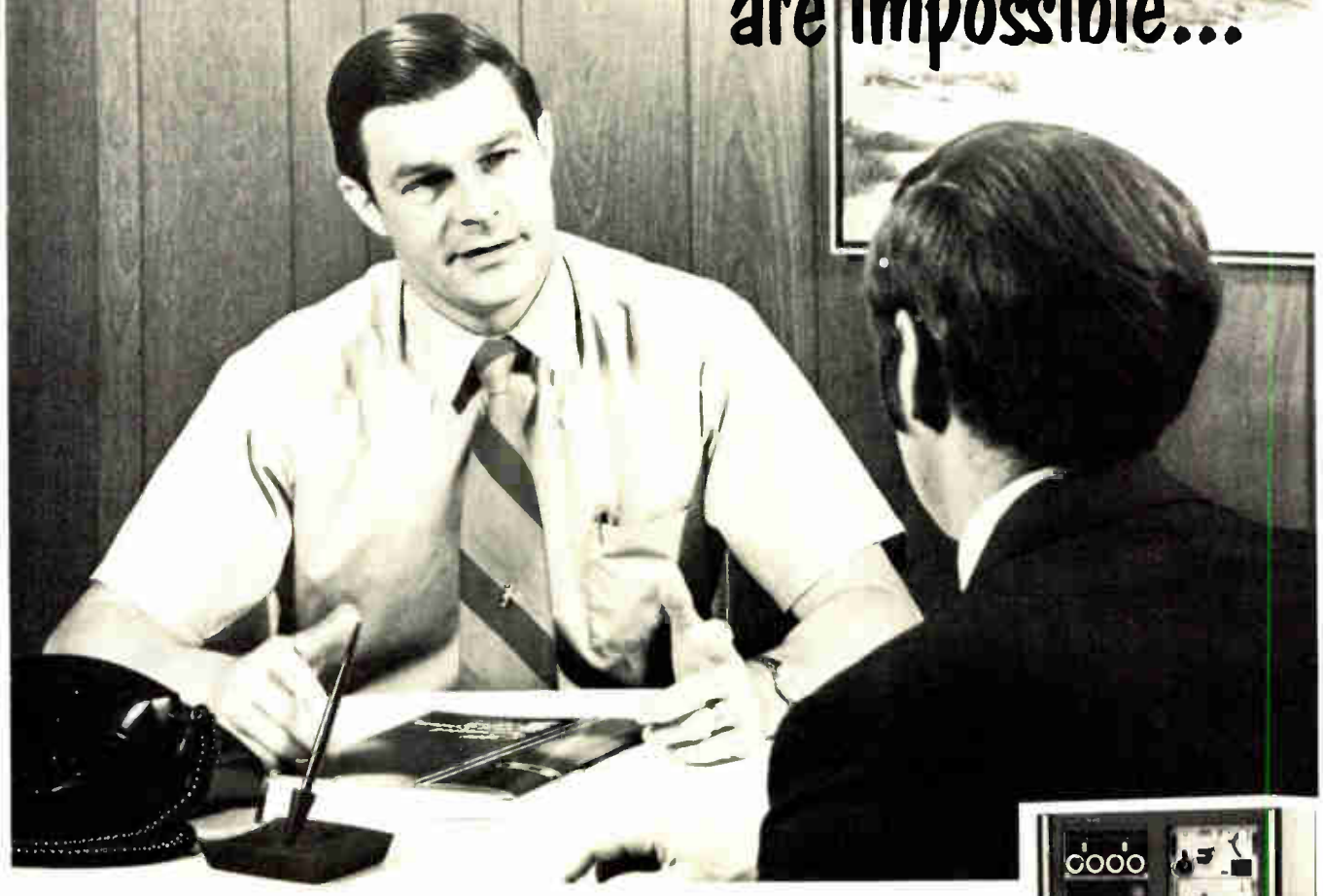
Remote. Phone-a-gram EKG reader promises lower cost, faster service from bedside.

Government electronics

LEAA pays for work on hardware

The major tasks of the Law Enforcement Assistance Administration to date have been to conduct paper studies and help state and local law enforcement agencies buy more equipment. Now, however, the

"...systems manufacturers have told me these speed / measurement capabilities are impossible..."



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Justice Department unit is turning its attention toward finding out what equipment is needed and helping industry develop it. Accordingly, LEAA has awarded two contracts totaling $2.85 million—to Mitre Corp. in Washington for evaluation, and to the Aerospace Corp. in El Segundo, Calif., for development of hardware.

List of needs. With the new awards comes a shopping list of hardware development, says George D. Shollenberger. He's a program manager in the equipment development group of LEAA's R&D arm, the National Institute for Law Enforcement and Criminal Justice. Among the electronic items to be investigated are: a relatively low-cost home burglar alarm system; a citizen's distress alarm that, though tiny, could broadcast a locational "help" to police; voice identification detectors; a better antenna for foot patrolmen's radios than their present stub antennas; concealed-weapons detectors; and sensors for spotting radio-isotope-tagged bombs and narcotics.

Developing automated drug analysis for crime laboratories is high on the list also: "If a corporation looked at the market, it might find that crime labs might be willing to pay $50,000 for one and that 10 systems could be sold across the country," Shollenberger says. However, "development costs might be 10 times that amount," he adds, and this is the reason why, although LEAA won't buy equipment, it will help by developing it and turning it over to private industry for production.

Inducement. An example in point is the lightweight personal radio for foot patrolmen that Martin Marietta and Sylvania will bring out of R&D shortly, Shollenberger says. Under contracts totaling $500,000, LEAA induced the two to compete to produce a new radio costing $650, half the usual cost, on a 10,000-unit production run, he says. After a two-month field trial, the two companies will produce it for sale, unfunded by the agency.

"I'd like to get the cost even lower," Shollenberger says. "In fact, I'd like to make them disposable, throw-away." This LEAA hopes to make possible in the next phase of the radios' development, by "making them on one chip."

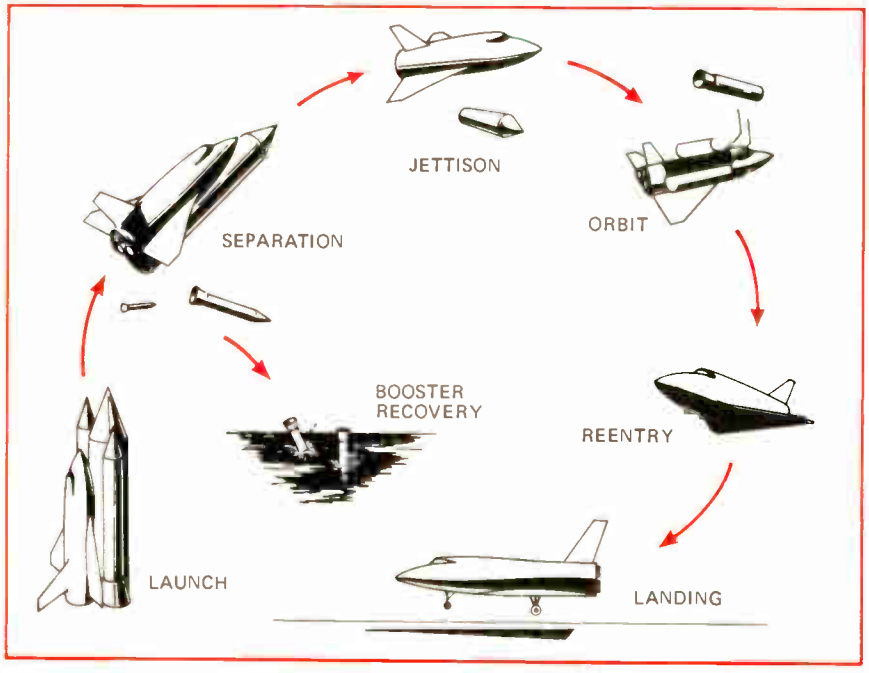
The agency's total fiscal 1972 program funding for evaluation, development, and standards was $4.25 million, with about $6 million asked for fiscal 1973. Even so, LEAA will investigate two blue-sky ideas, an evaluation of police helicopters and the electronic support equipment to see if their crime-fighting potential can be improved, and a remote automobile disabling system, Shollenberger says. Although he concedes that the latter idea may run into a lot of problems, it would, if successful, enable pursuing police to deactivate a fleeing car's ignition or fuel system electronically.

Down the road, Shollenberger foresees LEAA looking into an overhaul of police communications systems, that would integrate them into an urban communications system along with health, fire, and education components. Also, "there looks like there's some use for police in the 900-megahertz land-mobile band," he says. "It could handle video much easier than the vhf we have now." □

Costs determine shape of shuttle's $400 million worth of avionic gear

North American Rockwell must have been listening intently when NASA said it wanted low cost instead of blazing new technology for the space-shuttle orbiter program. In electronics alone, 60% of the hardware in NR's winning proposal is proven and available. And with avionics estimated to cost $400 million, such availability went a long way toward helping NR pull out the shuttle plum with its unexpectedly low bid of $2.6 billion. NR also assumes there will be few major changes during the life of the program.

Although the final price may change because of contract and specification changes, NASA's late-July award means that the Downey, Calif., company has most of the multibillion-dollar shuttle program



Even a 3.1% Function Generator return rate agitates Horace. IEC has trained him well.

It's an unwritten business rule that you don't discuss your problems with the outside world, but we're breaking tradition because we feel our F34 returns are worth talking about. This extremely low warranty repair record was established during the **first year** of production, even though industry statistics demonstrate that failure percentages are highest during the initial stage of product life. According to electronics manufacturers' trade association data, standard warranty returns can range from 10% for DVM's and oscilloscopes, to as much as 300% for some temperamental instruments. This is why we feel that our F34's current return rate of 3.1% is a real achievement.

Much of the credit for this reliable new function generator must go to IEC's Corporate Cal Lab, one of the few testing facilities with analysis standards one generation away from the National Bureau of Standards. The F-34 underwent the same kind of computerized error-analysis and evaluation testing that our Metrology staff developed for Polaris/Poseidon and other government programs.

With our stringent Quality Control system, we make sure that our test instruments measure up to performance standards, because we're vitally aware that downtime is a significant factor in test instrument selection. Over 300 generators were shipped before one was ever returned, and to date, 96.9% have never required warranty maintenance. But because our QC people, like Horace, worry about that 3.1%, we'll try to do even better.

If you would like a perfectionist like Horace on your team, specify the F-34. It generates reliable 0.03Hz - 3MHz waveforms, with Variable Width Pulse for pulse generator applications, and an outstanding combination of operating features for $495... In a hurry to match your requirements? Call John Norburg (collect) 714/772-2811.

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Circle 45 on reader service card

A "four-for-four" record for the Intelsat IV was achieved recently when the fourth of the giant communications satellites was successfully put in orbit over the Indian Ocean. It joins the Intelsat IVs already stationed over the Atlantic and Pacific to complete the global network. The newest satellite increases by five times the communications capacity among 17 nations in Africa, Asia, Australia, and Europe. It was built by Hughes and an international team of subcontractors for Comsat, manager for the 83-nation Intelsat Consortium.

A small hand-held surgical instrument that uses space-age thermal transfer techniques to bring cryogenic temperatures directly to a surgical area was introduced at the 71st Annual American Proctologic Society Conference in New York recently. Called the Kryostik™, it consists of a 12-inch probe and a ½-liter reservoir that can sustain the probe tip at temperatures lower than -190°C for over 30 minutes. It will be manufactured by Hughes and marketed worldwide by the Ritter Company, division of Sybron Corporation.

The U.S. Air Force's F-15 air superiority fighter, rolled out in St. Louis recently by McDonnell Douglas Corp., will have an attack radar system developed by Hughes which acts as an electronic extension of the pilot's eyes and mind. It automatically scans and acquires targets, makes complex computations, and displays on the cockpit windscreen the instant information he needs for successful air-to-air combat. The new radar makes the F-15 the only USAF fighter that can locate and track low-flying aircraft in the ground "clutter" that blinds conventional radars.

A new high-temperature strain gage for testing aircraft, missiles, and space vehicles in a simulated flight environment has been developed for the U.S. Air Force by Hughes. It can measure structural stresses imposed at temperatures up to 2000°F, producing capacitance instead of resistance changes as a measure of strain. Only ½-inch long, it can be welded or bonded to airframe surfaces. DoD and NASA have bought several hundred of the gages for use in such programs as the space shuttle.

Hughes has immediate openings for engineers in the following categories: field engineers, technical instructors, ground support equipment engineers, test equipment design engineers, technical writers, and configuration engineers. Must have at least a BSEE degree. All openings require U.S. citizenship. Please write: Mr. H. G. Staggs, Hughes Aircraft Company, Field Service & Support Division, P.O. Box 90515, Los Angeles, CA 90009. Hughes is an equal opportunity M/F employer.

Microwave filters for communications satellites and other spacecraft must be made of material with very low thermal expansion. So far, the only successful material has been invar, a very heavy alloy of iron and nickel. On some recent satellites, as much as 120 pounds of invar filters have been used. Now Hughes has developed prototype microwave filters made of graphite epoxy composite materials. They have performed better than their invar counterparts, weigh only 20 to 40 percent as much, are much easier to manufacture, and are expected to cost less.

[*Electronics*, July 31, p. 33]. This leaves NR very well set up, since that company also has the Minuteman-3 guidance and B-1 bomber programs. The new award calls for development and production of two orbiters for operation by 1978. The DC-9-size orbiters will be rocket-launched piggyback to tend orbital satellites and then be piloted back to earth and landed like gliders.

Three more. NR also is likely to get a follow-on $1 billion contract to refurbish the two orbiters and build three more for an operational shuttle system. The company says it plans to spread some of the development work among the orbiter losers: Grumman, which is hurting badly from the loss; Lockheed, and McDonnell-Douglas. Moreover, NR foresees business for about 10,000 contractors and subcontractors, big and small. Major NR subcontractors are IBM for data handling and Honeywell for flight control.

Extensive pursuit of off-the-shelf hardware has cut estimated cost of electronics, says Ronald V. Murad, NASA's shuttle avionics chief. Avionics cost was originally estimated at $600 million [*Electronics*, Jan. 17, p. 36]. But, "we're not installing black boxes without touching them," Murad says. "We'll redesign them to fit our environment." For inertial measurement units, for example, he says NASA is looking at three commercial units: the Carrousel-5 is by the AC Electronics division of General Motors, the LN-30 by Litton, and the KT-70 by the Kearfott division of the Singer Co.

In a sense, Murad comments, the situation is analogous to buying Boeing 747 avionics units and reconfiguring them to meet the shuttle's requirements. It's cheaper to buy production units, since the orbiter program of five vehicles will use about 20, and most of the items' cost is in the development, he comments.

Wide view. "We're going to take a look at the whole avionics world," Murad says, particularly the problem of redundancy. Since an orbiter will fly both as a spacecraft and as a plane, it will need two types of avionics equipment, each with interrelated functions of flight control, guidance and navigation, and performance monitoring. To meet the goal of triple redundancy, NASA is leaning toward a series of simpler systems using many black boxes instead of one large complex network.

Shuttle avionics will incorporate some innovation, though. Murad says NASA wants electronic fly-by-wire flight control, and "we'll take a good look at digital fly-by-wire." For the computers, the agency specifies floating-point units and may also want 100% margins with 32,768-bit or 65,536-bit units. Even large-scale integrated circuits will be considered if they're "tried and true," Murad says. All command and critical functions will be hard-wired, he says.

To simplify avionics development, "we're going to look at it functionally and hope to decouple problems," Murad says. One method would be first to develop the horizontal flight equipment for the 1976 flight trials and then develop the rest. An alternative would be to overlay the test-performance monitoring equipment on the regular shuttle avionics. □

Components

Shipments up 12.5% over 1971 period

Is no news good news? American components makers will be able to decide, now that the Commerce Department has disclosed that its latest quarterly report on U.S. components shipments—one showing a long-awaited upturn in the first quarter from the year before—will be the last.

The last report of the Bureau of Domestic Commerce says that factory shipments of U.S.-made components totaled $1.2 billion, a gain of 12.5% from a year earlier and 10.6% above the last three months of 1971. But from now on, an agency official said, the national statistical survey will be taken over by the Census Bureau and "converted

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from a quarterly to an annual basis." Bureau survey specialist John Clifford indicated that the quarterly reports were eliminated "for budgetary reasons."

Census Bureau annual statistical reports generally contain only about 20% of the detailed statistical breakouts of the Bureau of Domestic Commerce reports, which broke out the quarterly components data into about 190 product categories by application, power, and size. They also "run 18 to 24 months" behind the period they cover, adds Clifford.

Nondefense up. Strongest increases during the first quarter of this year were recorded in the nondefense sector of the components market. This showed a gain of 12% over the prior quarter and a 14% increase over the corresponding 1971 period. The defense share of the expanding market for components produced totally in the U.S. (as opposed to those assembled offshore from U.S. parts and imported duty-free) also rose 3.8% in the first quarter from the previous quarter and over 4% from 1971 first quarter.

Nevertheless, the defense share of the total market dropped to 16.8% as electronics applications expanded. According to Clifford, this decline has "been consistent at a few tenths of a percentage point each quarter" since 1960, when defense components accounted for about 25% of the total.

Under most product categories in the defense sector, components shipments were up over the last 1971 quarter. The only drops were registered in transistors and quartz crystals, each down 10%, and power and special-purpose tubes, off 6%. □

ESTIMATED COMPONENTS SHIPMENTS, FIRST QUARTER 1972
(IN MILLIONS OF DOLLARS)

	Defense	Change from prior quarter	Nondefense	Change from prior quarter	Total
Capacitors	$15,463	+14%	$ 94,030	+14%	$109,493
Connectors	31,804	+11	60,059	+12	91,863
Quartz crystals	1,108	−10	12,684	+ 4	13,792
Integrated circuits	40,784	+ 6	190,807	+ 9	231,591
Hybrid	8,300	+1.6	60,166	–	68,466
Monolithic, digital	22,628	–	100,660	–	123,288
DTL	8,607	–	7,324	–	15,930
TTL	9,605	–	32,118	–	41,724
CML (ECL)	1,857	–	30,925	–	32,782
MOS	1,399	–	24,083	–	25,482
Other	1,160	–	6,210	–	7,370
Monolithic, analog	5,044	–	23,815	–	28,859
Transformers & reactors	8,692	N.A.	102,862	+48	111,554
Relays (for electronics uses)	16,156	N.A.	56,070	+10	72,226
Power & special-purpose tubes	38,853	− 6	44,047	+ 8	82,900
Receiving tubes	3,171	N.A.	47,038	− 4	50,209
Resistors	15,644	–	84,903	+20	100,547
Semiconductor devices	30,555	–	163,406	+13	193,961
Diodes & rectifiers*	16,744	+12	83,514	–	100,258
Transistors	13,811	−10	79,892	–	93,703
Silicon	10,392	–	59,442	–	69,834
Germanium	843	–	11,172	–	12,015
Field effect	638	–	6,064	–	6,702

*Includes assemblies and special light sensitive and light-emitting semiconductors
Source: U.S. Dept. of Commerce

Commercial electronics

DOT plan forecasts STOL, rapid rail

When the Department of Transportation completed its Northeast Corridor transportation study [*Electronics*, Sept. 27, 1971, p. 25], it decided that the Boston-Washington axis needed better highway and high-speed rail travel, but could do without short-haul air routes served by short-takeoff-and-landing (STOL) aircraft. Now, in its new 1,000-page National Transportation Report, which looks into the nation's transportation needs over the next 20 years, the department sees a crying need for all three modes of travel and then some.

Unlike the Northeast, the DOT report says, "There are many intercity short-haul corridor-like regions in the country where improved rail and air technology" could be operated in "a more profitable and desirable manner than today's system." As an example, the study cites the Chicago area, where "a short-haul air transportation system using existing airports other than the large air-carrier airports could be economically viable for airlines."

To handle the growing congestion at large airports, DOT suggests increasing their capacity "through improved air-traffic control systems." Electronics would also play a part, for the study proposes a reduction in "total trip times by terminal and access-system improvements, such as the introduction of satellite downtown terminals linked by special transportation to the airport terminal," by systems like "people movers" and rapid rail.

Together. Besides providing a basis for DOT's planning and budgeting in the years to come, the report is significant because it shows DOT's movement toward considering integrated transportation systems, instead of merely highway or air. In analyzing the 63 urban areas expected by 1990, for example, the department sees many benefits in "major shifts in funds from highway to transit."

Electronics-laden new technology should be researched and developed to improve transportation where applicable, the report says. It divides new systems into three types: flexible-routing concepts, such as public automobiles and demand-responsive transit systems; fixed-guideway systems, such as people movers, moving sidewalks, personalized rapid transit, and fast-link transit

systems; and dual-mode vehicle and multipurpose pallet systems.

"The report provides a basis for future investment programs," declares Ira Dye, director of the office of system analysis and information. For the electronics industries, the report should provide a useful inventory of potential transportation markets. DOT surveyed every state government and many metropolitan planning and transportation agencies, as well as industry, to get its first overall look at needs.

The states told DOT that a whopping $670 billion would be required to meet their needs through 1990. Of this, highways would consume 85%. Public transit would need $63 billion, of which 70% would be rail-transit investments. Also, airports would need $27 billion. Even though the total would be a modest increase when compared to the Gross National Product, Dye concedes that the figure isn't likely to be met. However, the requests show the craving for new capital equipment in transportation systems.

Private industry projections to DOT also add to the pot. The railroads expect to spend $32.9 billion by 1980, the airlines $13.7 billion, and water carriers $1.5 billion. □

For the record

Ultrasonic flaw finder

Finding flaws in the bond between two ceramic layers joined by an adhesive such as Corning's Pyroceram has been made easier by a method of ultrasonic testing. Since the density and elastic properties of the bonding plastic closely resemble those of the ceramic, reflections of ultrasonic energy through the sandwich can reveal imperfections. In a method developed by Tektran, of Newark Ohio, ultrasonic impulses are sent through the substrate, reflected off a "mirror," and back through the substrate to the pick-up. Thus, the energy passes through twice. Defective bond areas are indicated by highly attenuated reflected waves.

TI names Cramer

After adding Cramer Electronics to Texas Instruments' distribution rolls in three western cities, TI distributor marketing manager O.F. "Orm" Henning is waiting for the industry—frozen in anticipation of the TI move involving distribution—to thaw.

"We've made the moves we felt would disrupt the markets the least," Henning explains. "And we expect to see very little reaction from the principals in the industry—Motorola, Fairchild, National. But from Signetics on down, I imagine they'll be shifting," he adds.

Jobs for engineers

The U.S. Labor Department says that it has identified as many as 55,000 professional jobs that could be filled through 1975 by engineers and scientists laid off by the defense and aerospace industries. Manpower Administrator Paul Fasser said a $750,000 skills-conversion study, carried out by the National Society of Professional Engineers with the IEEE and six other engineering societies, identified 14 major areas where engineers could work: food, health care, transportation, wood products, power resources, pollution control, security systems and criminal justice, ocean engineering and oceanography, banking and finance, solid-waste management, petroleum and chemicals, education technology, public service, and occupational safety.

Microwave routes

Three new special-service microwave common-carrier routes, to cost nearly $21 million, have been approved by the FCC. Nebraska Consolidated Communications Corp.'s application for a $12 million system linking Minneapolis to Houston and intermediate points was approved, while Western Tele-Communications Inc. was granted one route linking Seattle to San Francisco and another linking Los Angeles, San Diego, and El Paso, Texas, together with intermediate locations. Both will cost a total of $8.9 million, including multiplexing equipment.

Industrial electronics

GE, U.S. to develop automated ship gear

If anybody has an advantage in the potential market for automated ship control systems for the U.S. merchant fleet, it has to be General Electric Co., which is already important in ship control and propulsion systems. The company's Space division, Orlando, Fla., has agreed to develop with the U.S. Maritime Administration a prototype computer-directed system to control parts of a ship's machinery and propulsion equipment, as well as to link navigation and administrative functions via satellite to a shore-based computer.

Not only does GE want to develop the system, but it has agreed to pay $3.2 million toward the $7.8 million cost of the 42-month project. When developed, the prototype will be the forerunner of several operational systems. By the late 1970s, the Maritime Administration hopes to provide an extensive test by having 10 to 15 ships equipped with computers and three to four times that many with satellite navigation.

The development program is in two phases—18 months to design the system and develop the specifications and 24 months to install and test the equipment on board a Navy-chartered transport ship. If the program doesn't pan out along the way, either party can withdraw, and the other can continue, says Stanley D. Wheatley, chief of MA's office of advanced ship operations. He comments that GE, which also builds satellites, "is probably the only company in the world that could undertake the program."

The nuts and bolts remain to be worked out, but "we're going to look at the total ship system and determine what work computers can do

Moon TV available
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You probably noticed the greatly improved pictures transmitted from the surface of the moon during the Apollo XV and XVI missions. Previously it was difficult to handle detail in both deep shadow and bright sunlight. State-of-the-art camera tube technology from RCA overcomes this difficulty, while at the same time eliminating the possibility of catastrophic failure should the camera accidentally scan past the sun.

Responsible for these dramatic improvements is RCA's type 4804 16mm SIT (Silicon Intensifier Target) tube family. RCA's unique, no-compromise silicon - diode - array target structure enables simultaneous optimization of the SIT tube's resolution, lag and dark current. The extremely high sensitivity of the 4804 series is conveniently variable over a typical range of up to 1000 to 1 by means of a single, simple voltage adjustment.

Now you can afford to design this small size and remarkable performance into your camera. The popularity of the 4804 SIT series is rapidly increasing in space, defense, industrial instrumentation and day/night surveillance applications. RCA normally maintains off-the-shelf delivery capability of four grades of the basic 4804. You pay only for what you need: if your application demands a premium quality camera tube, specify 4804/PRE; if your blemish criteria are not ultra-stringent, order the 4804/PRO; when general surveillance is the name of the game, the RCA 4804/SUR represents an excellent buy; and finally, where price is an overriding consideration, the 4804/SCI is available to relaxed blemish and testing specifications. Potted versions, complete with high-voltage protective window, are recommended for safety and ease of use.

Check into the other low-light-level tubes in RCA's extensive camera tube line too. Isocons, 25mm and 40mm SIT tubes sizes, IV's and I^2V's also can be supplied, as well as Intensifier-Isocon and Intensifier-SIT coupled assemblies.

For more information, see your RCA Representative, or write, Mgr., Electro-Optics Marketing, RCA, New Holland Ave., Lancaster, Pa. 17604.

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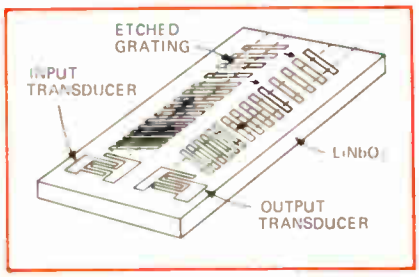
aboard ship and what can be done on shore," says Gene St. Germaine, senior project engineer for MA's advanced ship operations office.

Concurrently, MA also is pushing development of an operational maritime satellite by the mid-1970s to link the systems [*Electronics*, March 27, p.68]. The satellite may be one of the projected series of small application technology satellites under study by NASA or part of the doddering Aeronautical Services Satellite Program. □

Communications

Delay line draws radar makers' eye

A high-performance acoustic-filter delay line developed at MIT's Lincoln Laboratory, Bedford, Mass., is stimulating interest among builders of modern pulse-compression radar systems. It's drawing special attention from the Huntsville, Ala., office of the Army's Advanced Ballistic Missile Defense Agency.

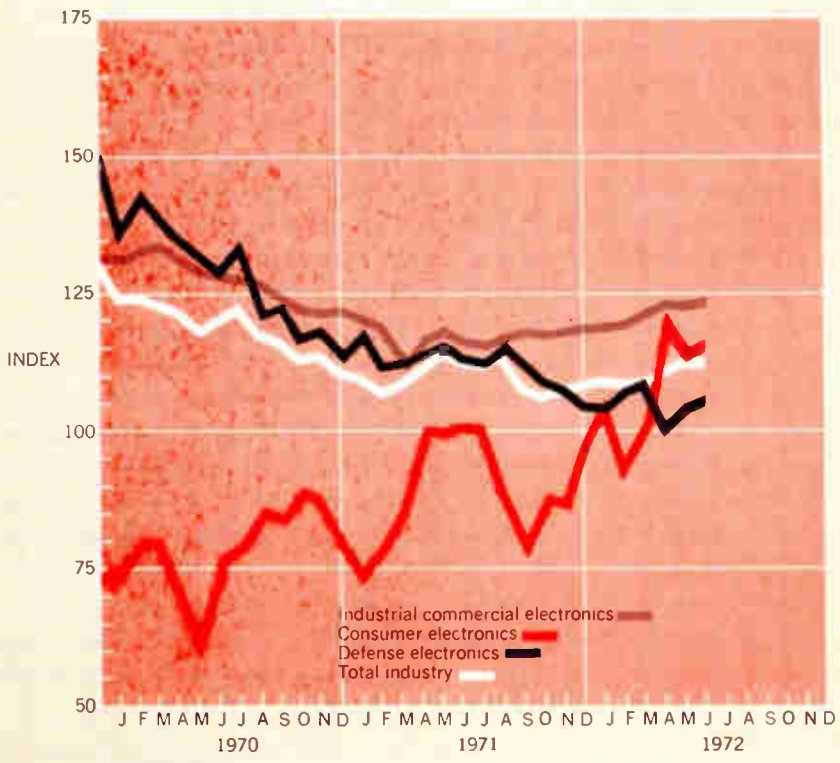


Grating grid. A dual grating with separated transducers allows radar signal delay lines to achieve performance several times better than previous single-grating techniques.

A chief measure of delay-line performance is its time-bandwidth product—the total time a signal is delayed in the line—multiplied by the signal's bandwidth. The laboratory has achieved a time-bandwidth product "in excess of 1,500 and with amplitude and phase ripple consistent with –35-decibel side lobes," says Robert Smith of ABMDA's Radar division. This is several times better than previously obtainable products. Lincoln Lab has also developed a unit with a pulse-compression ratio of 3,000, requiring several bridged Ts to compensate for 20° of phase ripple across a 75-megahertz band.

The technique used is a surface-wave adaptation of a dual etched-grating pattern developed at Andersen Laboratories Inc., Bloomfield, Conn. Andersen has been using a steel bulk-wave construction approach for several years to build these delay lines.

The Lincoln Lab version consists of an ion-beam etched grating on lithium niobate with interdigital transducers. It provides a dispersion of 60 microseconds in the frequency range from 150–350 MHz. □



Electronics Index of Activity

Aug. 14, 1972

The total industry index rose 0.9% in June to remain unchanged from its June 1971 level. While each sector of the index contributed to the increase, the consumer area chalked up the healthiest gain: 1.4% for the month and 13.2% over the year-ago figure. Industrial-commercial managed a 0.4% advance, leaving it 5.7% beyond the comparable 1971 total. Its year-to-year gain can be credited to increased spending for capital equipment.

Even defense electronics moved up in June. The increase was a modest 0.9%, leaving it 7.6% behind the June 1971 level.

Segment of Industry	June '72	May '72*	June '71
Consumer electronics	115.2	113.6	101.8
Defense electronics	105.1	104.2	113.7
Industrial-commercial electronics	123.4	122.9	116.7
Total industry	112.5	111.5	112.5

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.
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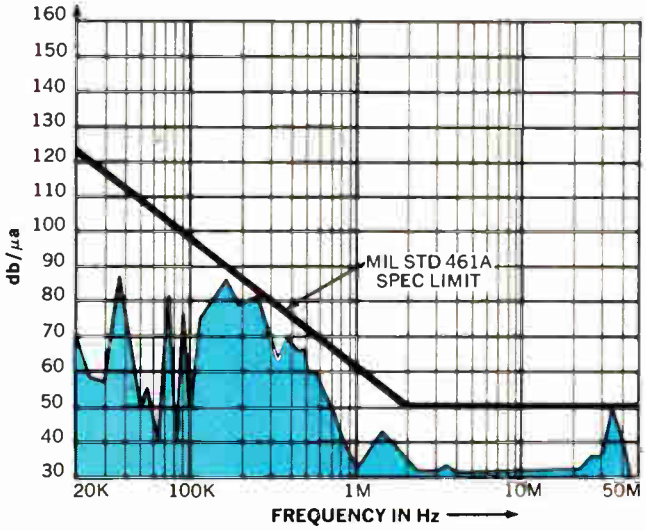
Package Size: Module III – 3-5/16" x 5-1/8" x 9-1/2" – Weight: 6.5 lbs.															
STM3.5-24	3.0	4.5	24	19.4	14.9	9.6	.05%	5 mv	50 mv	105-132	1.8	50-440	150±15%	1.5	$229
STM5-24	4.5	6.0	24	19.4	14.9	9.6	.05%	5 mv	50 mv	105-132	2.3	50-440	150±15%	1.5	229
STM9-12	6.0	10	12	9.7	7.5	4.8	.05%	3 mv	50 mv	105-132	2.1	50-440	150±15%	1.5	239
STM12-12	9.5	13.5	12	9.7	7.5	4.8	.05%	3 mv	50 mv	105-132	2.9	50-440	150±15%	1.5	249
STM15-10	13	17	10	8.1	6.2	4.0	.05%	3 mv	50 mv	105-132	2.7	50-440	150±15%	1.8	239
STM18-10	16	20	10	8.1	6.2	4.0	.05%	3 mv	50 mv	105-132	3.2	50-440	150±15%	1.8	249
STM24-8.5	19	25	8.5	6.8	5.3	3.4	.05%	3 mv	50 mv	105-132	3.3	50-440	150±15%	1.9	249
STM28-7	24	30	7.0	5.6	4.3	2.8	.05%	3 mv	50 mv	105-132	3.2	50-440	150±15%	1.9	249
STM36-4	29	43	4.0	3.2	2.5	1.6	.05%	3 mv	50 mv	105-132	4.0	50-440	150±15%	1.9	259
STM48-4	42	56	4.0	3.2	2.5	1.6	.05%	3 mv	50 mv	105-132	4.0	50-440	150±15%	1.9	269
Package Size: Module IV – 3-5/16" x 5-1/8" x 14" – Weight: 9.0 lbs.															
STM3.5-36	3.0	4.5	36	29.1	22.3	14.4	.05%	5 mv	50 mv	105-132	3.8	50-440	150±15%	2.2	319
STM5-36	4.5	6.0	36	29.1	22.3	14.4	.05%	5 mv	50 mv	105-132	4.2	50-440	150±15%	2.5	324
STM9-20	6.0	10	20	16.2	12.4	8.0	.05%	3 mv	50 mv	105-132	3.8	50-440	150±15%	2.2	299
STM12-20	9.5	13.5	20	16.2	12.4	8.0	.05%	3 mv	50 mv	105-132	4.8	50-440	150±15%	2.8	289
STM15-15	13	17	15	12.1	9.3	6.0	.05%	3 mv	50 mv	105-132	4.3	50-440	150±15%	2.6	289
STM18-15	16	20	15	12.1	9.3	6.0	.05%	3 mv	50 mv	105-132	5.0	50-440	150±15%	3.0	299
STM24-13	19	25	13	10.5	8.0	5.2	.05%	3 mv	50 mv	105-132	5.5	50-440	150±15%	3.2	309
STM28-11	24	30	11	8.9	6.8	4.4	.05%	3 mv	50 mv	105-132	5.5	50-440	150±15%	3.2	309
STM36-6	29	43	6.0	4.8	3.7	2.4	.05%	3 mv	50 mv	105-132	4.5	50-440	150±15%	2.6	329
STM48-6	42	56	6.0	4.8	3.7	2.4	.05%	3 mv	50 mv	105-132	5.5	50-440	150±15%	3.2	329

*Free – air rating – no external heatsink **Worst case. Typically less than 30 mv †U.S.A. list prices



DC Load Leads. Conducted Current Level in db above a Microamp/ MHz

Specification	Sorensen STM5-24	Brand "X"
Size	3 5/16 x 5 1/8 x 9 1/2	4 15/16 x 7 1/2 x 9 3/8
Volume	160 in³	344 in³
Price	$229	$235
Efficiency	58%	29%
Regulation (line & load combined)	0.05%	0.2%
Temperature Coefficient	0.01 %/°C	0.03%/°C
Overload Protection	Current limiting-adjustable electronic	
Overvoltage Protection	Built-in adjustable, all models	Optional @ $30 (except built-in, fixed, on 5-volt model only

Compare this point-by-point spec-check between Sorensen's STM5-24 and Brand "X."

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We've optimized the design of 3534 in five important areas. Important to those who would use it as a plug-in replacement for the 1103 in an existing system. Equally important to those who would design our device into new systems. Important to both because these innovations solve the major problems of the existing 1103.

No Precharge and Chip Enable overlap requirement. Result: Better and less critical timing margin on control of Chip Enable-Precharge overlap. Less drift problem. Less adjusting. Less maintenance. No critical window to stew about. Greater design margins (other 1103's have no margin, worst case).

Data Out referenced to the leading edge of the Chip Enable. Unlike other 1103's, which have as many as five critical times affecting access, ours has only two; the 3534 array access time is dependent on the timing of only one critical edge relative to Precharge and only one delay relative to Chip Enable. No timing margin problems to create system malfunctions, board rework, acceptance tests, downtime, and other virulent forms of field aggravation.

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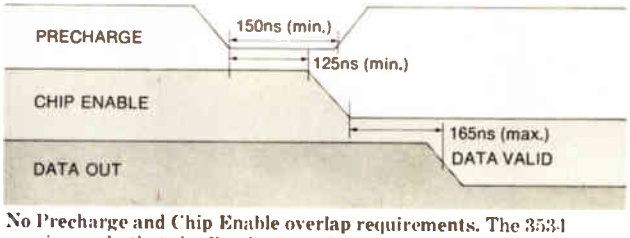
35343 DC (1103S146)	220ns	$9.60	$6.00
35344 DC (1103-1)	180ns	$12.80	$8.00
35345 DC (1103-1)	150ns	$18.40	$11.50

24-page applications guide free. Detailed, comprehensive applications guide (and composite data sheet on each of the 4 versions of 3534) are available on request.

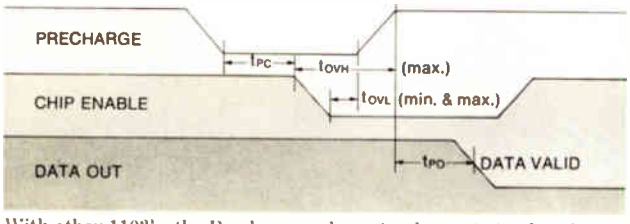
Fairchild 3534/1103 (300ns version)



No Precharge and Chip Enable overlap requirements. The 3534 requires only that the Precharge pulse stays low for a minimum of 150ns and that at least 125ns delay occur from the start of Precharge to the start of Chip Enable. The Data Out is valid 165ns after the Chip Enable goes low but is independent of Precharge.

There are no other restrictions on the Precharge pulse. It can go high immediately or it can stay low throughout the entire cycle. Or it can remain low for successive cycles.

Other Standard 1103's



With other 1103's, the Precharge pulse not only must stay low for a precise Precharge interval but its transition from low to high must occur within a time interval which has a *minimum* as well as a *maximum* limit. As a result, the designer must stay within very tight boundaries of these maximum and minimum values. All control circuitry must be extraordinarily precise, and system costs rise sharply.

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Tariff exemption sought for plastics used in packaging

The Treasury Department is threatening tariffs on the epoxy used to encapsulate component packages assembled abroad from U.S. parts, and elimination of that threat will be the goal of the Electronic Industries Association's talks with the department. EIA hopes to repeat its success before the U.S. Court of Customs and Patent Appeals. In a late-July landmark decision, that court drew on EIA's *amicus curiae* brief to uphold General Instrument Corp.'s position that U.S.-made gold wire used to interconnect U.S.-produced parts in a transistor can did not lose its "physical identity" and therefore **qualified for tariff exemption under item 807.00, which permits deduction of the value of U.S. parts assembled abroad provided there has been no "further fabrication."**

EIA Solid State Products division vice president James J. Conway, who says the decision could save components makers up to $5 million a year in duties, notes that the court rejected the Government position that cutting gold wire from spools constituted further fabrication. **EIA plans to argue that plastic used to encapsulate components does not undergo further fabrication either.**

Pollution monitoring awards promise . . .

Companies eager to get a foothold in the pollution monitoring market are anxiously awaiting two awards by the Environmental Protection Agency expected around the end of the year. **The Regional Air Pollution Study, an experimental network of electronic sensing stations to be set up in the St. Louis, Mo., area,** was bid on by "you can say almost everybody," says an EPA official. During the five-year program, the stations will continuously monitor a combination of air quality and meteorological data and feed the results into a central computer.

. . . a big edge to winners

In addition, requests for proposals are expected within two months for **an upgrading of EPA's Community Health Air Monitoring Program network from mechanical to electronic sensors.** Located in six urban areas, the network continuously monitors air pollution data which EPA can call up on cathode-ray-tube displays as part of a study to determine the effects of pollution on health.

EPA officials say that the **winners of the two $1 million contracts are likely to have a good lead on the market,** as the agency moves to expand its systems and as state and local governments get deeper into pollution monitoring.

Communications trade mission set for USSR, Poland

A dozen U.S. communications and industrial equipment makers have signed up for a Commerce Department trade mission to the Soviet Union and Poland. Scheduled to arrive in Moscow on Sept. 11 with a representative of EIA, which initiated the trade visit, are executives from Harris-Intertype's Gates Radio Co., General DataComm Industries, General Dynamics Corp., GE, GT&E, ITT, Magnavox, PathCom Inc., RCA, Scientific Atlanta, and Collins Radio.

The companies are makers of communications and industrial electronics, including hardware for over-the-air broadcasting, cable television, head-end transmission and a variety of modems. They will spend a week in Russia and a week in Poland.

Washington commentary

McGovern's 'plan' to reorient technology

With the selection of a vice-presidential nominee, George McGovern and the Democratic party appear to have moved back to square one. But appearances cannot be trusted, as the recent turmoil within that party over the Eagleton affair has vividly demonstrated. Indeed, just before the meeting of the Democratic National Committee in Washington to confirm the selection of Sargent Shriver for the second spot on the ticket, Sen. McGovern himself remarked that "I feel we're about where we were at the beginning of the New Hampshire primary. We've got to come from behind."

At this time, however, it is ludicrous to forecast just how the final ballot will go in November. As the crafty chairman of the House Ways and Means Committee, Wilbur Mills, has pointed out, incumbent Presidents must defeat themselves, and there are no signs yet that Richard Nixon is doing so.

The language barrier

The Mills dictum is particularly applicable to the upcoming contest, for the campaign of George McGovern appears cursed. And the single thread that ties together all its misfortunes is sloppy staff work. On defense and aerospace spending—the issue most likely to affect the viability of the electronics industries—examples of bad staff work abound.

One of these can be found in the misguided McGovern effort to amend the fiscal 1973 military procurement bill to reduce the Nixon budget by about $4 billion. At first, the McGovern headquarters said the amendment would hold "military expenditures" to $77.6 billion, the same as last year. Thus did Senator McGovern's staff confuse Pentagon expenditures with congressional appropriations, as Republicans were quick to point out. Where the White House requested a total of $85.7 billion in obligational authority, or appropriations, it has estimated that only $77.7 billion of that will be spent this fiscal year—a figure that hardly differs from the initial McGovern press release.

The earlier failure of an amendment by a conservative Texas Democrat, Sen. Lloyd Bentsen, that would have slowed funds for development of the new Trident missile submarine, made it evident that the broader and less specific McGovern effort was doomed from the start, but the poor staff work on the McGovern amendment insured its defeat. "It's unbelievable," one long-time committee man on the Democratic side of the House declared sadly. "These people around McGovern just don't do their homework. If you're going to talk about amending a bill, especially when it is a matter of controversy, the least you must do is get the language right."

Search for a plan

But for the community of aerospace and defense electronics engineers and managers long accustomed to the precise documentation and detailed options their customers demand, there is a larger flaw in the McGovern plan to reduce defense outlays by some 40% in three years. The flaw, of course, is that there appears to be no plan at all to turn industry's technological expertise to a reordered set of national priorities without generating a massive economic downturn.

Whether or not one agrees that priorities need to be reordered away from defense and space is beside the point. There are in fact many engineers, scientists, and economists who concur with the view that one of the major sources of the American electronics industries' present problems in world competition has been their heavy dependence on Federal funds for defense and space programs. And it appears that this group is becoming the most bitter about the inability of the McGovern staff to spell out an alternative. Grappling with the needs of humanity and the environment is praiseworthy indeed, but industry's past attempts make clear that it has yet to find the means of doing so. Says one despondent industry supporter of the Democratic nominee, "It is hard to know where to turn now. If there is a McGovern plan for industry after he cuts the defense budget, it must be like Nixon's plan in 1968 to end the Vietnam war—a secret."

What is astonishing, however, is how little all the criticism of McGovern, whether over the Eagleton affair or his lack of a plan for reorienting American technological resources away from defense and space programs, seems to trouble the candidate or his staff.

Of the latter, it must be said, there is not a single heavyweight knowledgeable in the field of defense and aerospace budgeting. And thus those who carry this burden are free to compound their ignorance with arrogance, secure in their belief that one engineer is much like another, able—along with his corporate employers—to quickly adapt his expertise from missiles and spacecraft to health, education, and pollution control just so long as the Federal funds are there. Regrettably, that concept is naive in the extreme.

—Ray Connolly

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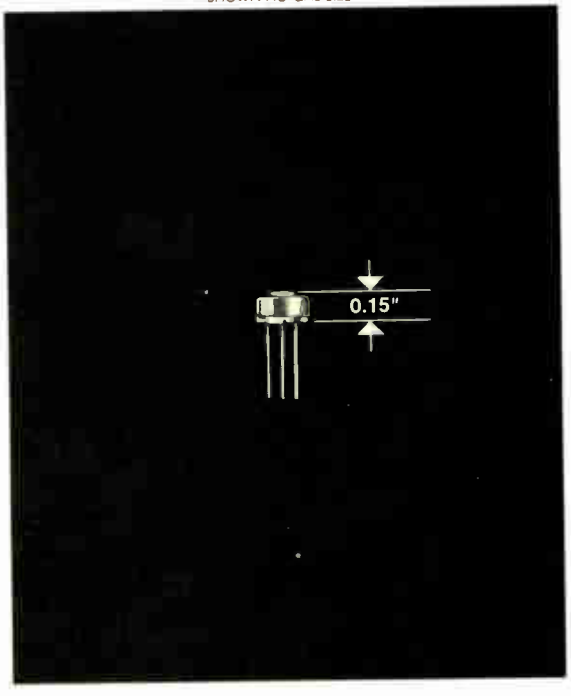

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Moving-map display for light planes cuts costs by using VOR/DME signals

Fliers agree that the moving-map navigation display is a great boon, expecially in bad weather and at night. However, it's an expensive item. It's used mostly in military aircraft, where it's driven from inertial systems through computers—and where cost is secondary to accuracy.

Now a Briton at the Royal Aircraft Establishment has built a map display that he says can be made for less than a tenth the cost of standard military display. It could probably be sold for between $1,000 and $2,000. Because it is driven from VOR/DME receivers already installed in most aircraft, there's nothing more to add that costs money. Thus, it could become standard in light commercial and private aircraft.

Inventor Ken Honick led the team that worked on the original RAE moving maps for military aircraft 10 years ago. He says trials of the new map in an RAE aircraft show that in flat countryside it works from 350 feet up at 40 miles from a beacon.

Beacons. Reception of beacon signals varies widely according to topography, so it's not possible to generalize about performance in relation to distance from a beacon. But the map will operate wherever beacon signals can be received, and VOR/DME beacons are pretty thick on the ground, particularly in the U.S. It will also operate from Tacan military signals.

Because of the map's commercial potential in light aircraft, a manufacturing license has been taken out by Elliott Brothers (London) Ltd., part of Marconi-Elliott Avionic Systems Ltd. Elliott is testing a display in its executive Aero Commander.

Honick's display uses two radio frequency outputs from co-located VOR and DME beacons to move a map transparency in two axes so that the point on the map below a cross on a covering lens indicates the aircraft's position. The map is on a circular transparency 2.25 inches in diameter, representing about 200 nautical miles radius from a co-located VOR/DME beacon.

To use the display, the pilot tunes into a beacon en route to where he's going, puts the transparency that's centered on that beacon into a slot, and switches on the light. Thereafter, he changes the transparency only as often as he changes beacons.

Drive. The mechanism is very simple. VOR and DME cockpit receivers have spare output sockets in addition to those that drive the normal instruments. Honick's display plugs into these sockets. The VOR signal from the ac synchro in the receiver is used to drive a dc servo that rotates the transparency via a rim drive according to the bearing that the aircraft is flying. The DME signal feeds a self-balancing bridge circuit, which produces an analog voltage that turns a screw drive to move the map backwards and forwards in linear motion according to distance from the beacon.

The optical system on the prototype displays a section approximately 50 miles across a 6-inch diameter screen. All in all, the unit fits in a box about 7 inches square by 6 in. deep. □

France

Sescosem integrates dc-motor control

The financially troubled French semiconductor firm Sescosem is going after the consumer market with a new integrated circuit designed for portable tape recorders and record players. It won't solve the company's money problems, but at least it indicates one market sector that Sescosem hopes to stay in.

The new linear IC, a high-performance speed regulator for battery-powered electric motors, comes amid increasingly gloomy talk about the company's survival prospects, ranging from rumors of total collapse to the more likely eventuality of a merger of sorts with the semiconductor operation of West Germany's AEG-Telefunken.

New circuit. Developed in large part for the consumer line of its parent firm Thomson-CSF, the IC also will be sold to competitors in Europe. It is being shown to consumer electronics firms in France and Germany. "Several hundred thousand" units are expected to be produced in 1973, says Sescosem marketing people. The first deliveries are scheduled for October.

Jean-Pierre Oehmichen, an engineer who worked on the project, says the circuit will replace the conventional card of discrete components that usually includes at least three diodes, two transistors, two condensers, six or seven resistors, and two coils. No other semiconductor maker has yet commercialized an IC to replace the standard speed regulator, but others are known to have IC versions under development.

Power consumption normally runs about 10 milliamperes in conventional regulators. The Sescosem version consumes only 6 mA. And where the standard regulators allow motor revolutions to vary up to 3%, the new IC keeps this fluctuation down to between 1% and 2%. The ESM227 can handle power supply ranging from 3 to 18 volts. And nominal motor current ranges from 10 to 160 mA. The IC has been tested successfully in temperatures ranging from −15° to +55°C. □

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Circle 64 on reader service card

International newsletter

Japanese TV imports: a court fight in West Germany . . .

There's a courtroom showdown between West Germany's AEG-Telefunken and Japan's Sony Corp. coming up over PAL TV patents. Sony is now selling Trinitron color TV sets specifically engineered for use in West Germany—that is, suitable for PAL reception. AEG-Telefunken, the developer of PAL, has instructed its legal experts to take the Japanese firm to court. **The Sony sets introduced this month are 13-inch versions. The selling price Sony is recommending is 1,598 marks—equivalent to just below $500.**

. . . and mounting concern in Britain

Britain's TV set makers are getting really worried about imports from Japan. **From nothing 18 months ago, sales climbed to an average of 7,500 per month in the first half of this year, or nearly 4% of total color sales by value.** Almost all sets were made by Hitachi and Sony. Although volume is not enough so far to have hurt sales of British-made sets, industry leaders believe that, unless forcibly discouraged, the Japanese will maintain this rate of increase, particularly if other makers jump on the bandwagon.

Because several British industries are threatened by Japanese imports, two months ago Britain's trade minister warned the Japanese to ease the pressure. Next month an official British delegation will visit Japan, **looking for evidence of Japanese goodwill. If they don't find it, the government will consider legal sanctions to limit imports.** But a voluntary limitation agreement is preferred by most Britons, so that attempts to open up the Japanese market to British products are not hurt.

Bipolar speedometer being readied by British company

First models of a car speedometer built around a custom bipolar IC will be working within a month at Britain's Smiths Industries Ltd. The IC is built to Smiths' design by Texas Instruments Ltd. and is an eight-pin dual-in-line pack that mounts with timing and filter capacitors on a thick-film substrate. For speed measurement, gearbox revolutions drive a monostable circuit that puts out pulses controlling a current switch. For total mileage indication, the input pulses are divided by 256 and used to drive a stepping motor through two of the pins. Bipolar rather than MOS technology is used because Smiths' engineers say bipolar makes it easier to obtain analog stability and the high output currents needed to drive the stepping motor. **The chip complements Smiths' existing IC revolution counter chip, and one of the aims is to mount both on a common substrate driving paired instruments.** Speedometer price is expected to be slightly higher than for a mechanical speedometer.

A six-digit calculator sells for $42.67 in Japan

Until recently, a buyer could get a larger discount on almost any calculator than the $42.67 list price in Japan of a new six-digit hand-held calculator announced by Casio Computer Co. The company says it plans to make 10,000 per month, with about half to be sold in Japan and about half to be exported, primarily to the U.S. **Six-digit calculators are not covered by recently imposed export restrictions.**

The calculator uses a single LSI chip, made by Hitachi Ltd., for all logic and the six individual 8-millimeter-diameter fluorescent display tubes. It will operate for 10 hours on four AA alkaline cells. While the

calculator can add and subtract up to six digits—with double-length display for multiplication and division—**no decimal point of any type is provided.** However, in division the ordinary six-digit display shows digits before the decimal point, while the shifted display shows digits after the decimal point.

Alpha Jet will boost German, French avionics market

Like the British-German-Italian Multi-Role Combat Aircraft (MRCA) project, the German-French Alpha Jet program promises to provide a boost to an otherwise sluggish avionics market. The Alpha Jet, now in its $50 million development and prototype phase at West Germany's Dornier AG and at France's Dassault/Breguet, **will come in two versions—as a light jet trainer for the French and as a close-air-support plane for the West German air force.** The German version, of which 200 are likely to be built, will therefore require more avionics gear—between 10% and 15% of the plane's total cost of $1.1 million—than the less expensive French version, of which also 200 may be produced.

Although the Alpha Jets' serial production is still some time off, **avionics producers in both countries are already forming bidding consortia** to improve their competitive positions. In West Germany, Standard Elektrik Lorenz AG (SEL) has signed agreements with several French avionics producers to offer jointly the equipment of each partner, and, in case of a contract award, to jointly produce the two aircraft versions. **Should any equipment be used in the German version only, SEL would build French-developed gear under license.**

MOS leads to a touch-plate TV selector

EMI-Hughes Microcomponents Ltd., joint subsidiary of Hughes Aircraft Co. and EMI Ltd., **is sampling TV set makers with a touch-plate channel selector using MOS technology.** A finger touch makes a high-impedance path between two contact plates, passing a current which effectively applies a voltage to a MOS transistor gate. Six pairs of plates control six channels, a new touch automatically canceling the current channel. The selector works in conjunction with a varicap tuner.

The company claims the high-impedance characteristics of a MOS transistor make it a natural for the function, so that the chip is potentially cheaper than existing biolar touch switches. Furthermore, it is easy to drive cheap, high-voltage neon channel-indicator lamps more directly than with integrated bipolar selectors. EMI-Hughes claims negotiations to supply a large TV set maker are at an advanced stage.

Philips to unveil two new Plumbicons at Geneva show

Look for Philips Gloeilampenfabrieken to introduce a couple of new Plumbicon camera tubes at the European electro-optics show at Geneva next month. **One will be a 30-millimeter-diameter tube, designated 36XQ and intended primarily for broadcast applications.** Beam-discharge lag is cut down by a light pipe, which illuminates the cathode side of the target plate to achieve a small, uniform, and controllable dark current. **The other tube is a fiber-optic version of the firm's 1-inch-diameter second-generation XQ1080 Plumbicon.** The tube, called 30XQ, also has a light pipe and an anti-comet-tail electron gun to reduce blooming of bright lights. Intended for high-quality low-light-level cameras, the 30XQ comes with an 18-mm-diameter image intensifier that is fiber-optically coupled to the target plate.

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Cinch Dura-Con Micro-Miniature Connectors are described in Bulletin PBC-174, available free on request from Cinch Connectors, an Operation of TRW Inc. Electronic Components, 1501 Morse Avenue, Elk Grove Village, Illinois 60007. CM-7203

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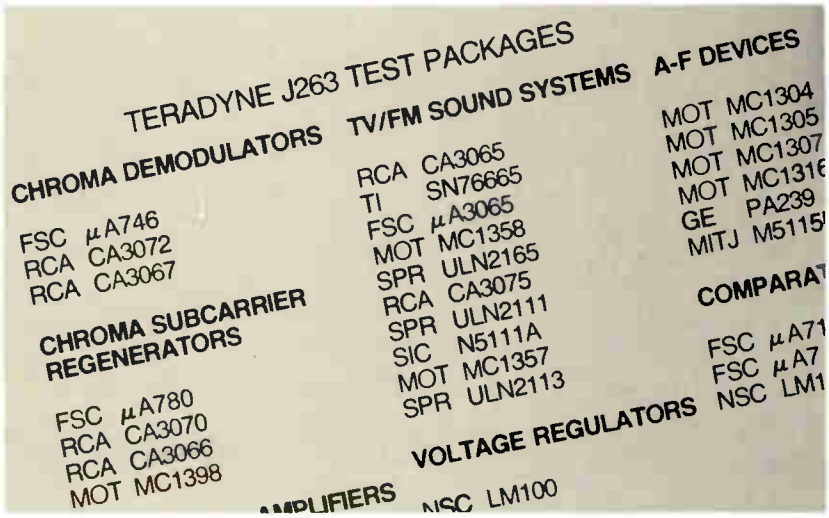

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TERADYNE

Poland switches to electronics

Current five-year plan doubles the previous budget for the industries; computer expenditures to increase six-fold, and consumer gear is boosted

by John Gosch, Frankfurt bureau

Priorities have changed drastically in Poland since grievances over rising prices led to street riots in 1970. The emphasis has shifted from agriculture and heavy industry to more sophisticated industry—and electronics is the star. Since 1970, prices of consumer electronics have stabilized and in some instances dropped.

Government planners have targeted production of all kinds of electronic equipment, including computers, for a 20% annual increase between 1971 and 1975. The $1 billion estimated for 1972 is predicted to reach $1.73 billion in 1975—more than double last year's production.

The task of reaching these goals falls mainly on two state-run combines, the Unitra Electronic Industry Union and the Mera Union.

Unitra, a 70-factory conglomerate employing 78,000 persons, concentrates on consumer electronics, industrial/commercial equipment, and components. Mera specializes in computers, peripheral devices, automation gear, and measuring instruments.

The electronics industries are scheduled to receive twice the investment under the current five-year plan that they did during the previous one. For computer activities alone, $136 million will be dished out between 1971 and 1975—six times the previous budget. In the consumer electronics sector, the Polish government plans to increase the output of consumer goods by 42% during the five years, in contrast to the 36% increase during the preceding half-decade.

Computers are spotlighted in Poland's electronics world. The country is probably second only to the Soviet Union in the number of computers used among the countries of Comecon, the East Europe trading bloc that includes Poland, East Germany, Czechoslovakia, Hungary, Rumania and Bulgaria. About half of the computers are of Western origin, but the country is cranking up its own production, with the first third-generation machine due off the assembly line this year—and production goals are ambitious.

Poland already has developed a few specialties of its own. Polish-designed marine radar equipment is being used on Western ships, as well as by East Bloc fleets. The Poles have also been highly successful with communications gear and computer components, especially magnetic tape heads, which have also been exported to the West.

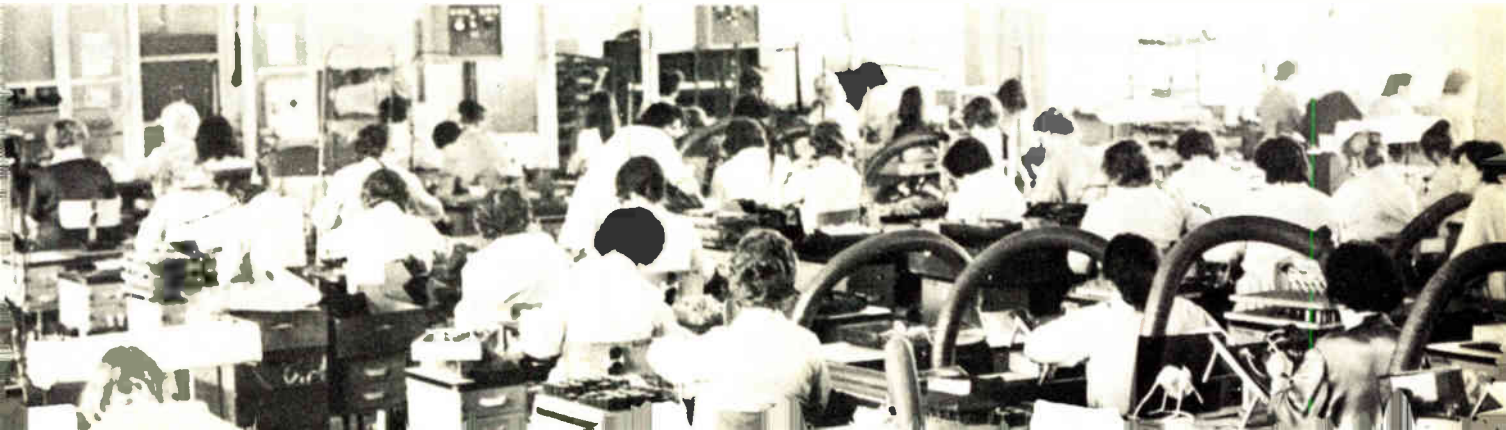
In the more sophisticated areas of electronics, Polish authorities are building on expertise furnished by Western countries. This reliance is in sharp contrast to the go-it-alone attitude of other Communist Bloc countries [*Electronics*, May 22, p. 81]. The Poles are employing technology agreements with the United Kingdom for computers, France for integrated circuits, West Germany for phonographs, and The Netherlands for TV tubes.

With the emphasis that the Warsaw government is giving Poland's light industry, Ryszard Kujalnik, head of Unitra's advanced design and development department, is confident that electronics industries will achieve their production goals, enabling them to approach the production posture of West Europe in recent years.

Export phase. Unitra's Kujalnik, an unassuming man of 47, says: "We are now in the second phase of our electronics efforts. The first, which ended only recently, was devoted to satisfying the basic needs of our country. The second phase will stress exports and across-the-border cooperation."

As for exports, Unitra is already beginning to chalk up big sales abroad. Of the combine's total pro-

Entertainment electronics. At the Fonica plant in Lodz (below), production of consumer electronics is increasing 18% annually.



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duction—around $650 million this year—nearly 20% will be sold on foreign markets, says technical director Jerzy Bilip.

The Mera combine employs 40,000 people in computer, automation, and measuring-equipment manufacturing. The company's production goal is to increase sales from 8.16 billion zloty this year to 12 billion zloty by 1975, that is, from $221.8 million to $315.2 million, a 42% rise over the next four years. For data processing alone, however, the increase will be much steeper—302%.

"By far the biggest benefactor from increased investments in electronics will be the components sector," says Kujalnik. No less than 80% of what Unitra will spend in its 1971–1975 expansion and modernization program is slated for components—two-thirds for active devices, primarily integrated circuits, and one-third for passive devices.

Unitra has produced a million integrated circuits thus far, claims Bilip. These are digital types, made by Russian fabrication techniques. These epiplanar ICs, called Logika 2, are for industrial applications and are roughly equivalent to the West's SN series. Of Polish origin are circuits based on thin-film, thick-film, and hybrid techniques.

Next year, France's Sescosem will supply Poland's devices and digital IC makers with technological assistance for production. Next year, too, should see the start of MOS device fabrication in Polish factories.

Linear ICs, supplied by another arm of Thomson-CSF, are now being used in commercial equipment such as TV monitoring gear, and they should turn up in Polish consumer electronics next year. The development of advanced components, such as liquid crystals, and gallium-arsenide devices, are carried out at four Unitra-associated institutes—the institutes for semiconductor materials, for technology, for application, and for semiconductor-production equipment.

A sector-by-sector assessment of Polish electronics clearly shows computers to be the leader. Both the level of technology achieved and the number of systems in use are impressive by Eastern standards. Officials of Mera, the data-processing and automation-equipment combine, report that 758 digital machines are now operating in Poland. Counting minicomputers, analog, and hybrid machines, the number is twice as high.

Of the digital systems now operating, about half are of foreign origin, with Western firms like the International Business Machines Corp., Honeywell Corp., and above all, Britain's International Computers Ltd., supplying a substantial number. And there's still a need for more digital systems from the West. "Imports of Western systems," says a Mera man, "will rise along with installations of our own computers."

Poland's continuing need for systems from abroad should not be construed to mean that the country hasn't developed a computer capability of its own. To be sure, much help has come in the past from Britain's ICL. In fact, Poland's Odra model 1304 computer is based on the ICL 1900 series.

The Poles are wasting no time in getting their new systems off the production lines in their 5,000-man Elwro computer plant in Wroclaw, Silesia. This year, Poland will introduce its first domestically designed third-generation computers—the Odra 1305, a general-purpose central processor, and the Odra 1325, a process-control system.

Of the Odra 1305, 25 systems will be built this year, and twice that number in 1973. The production target for the Odra 1325 is 30 systems in 1972; for 1973, the figure will be 100. The long-term production goal for Odra models 1304, 1305, and 1325 is for 500 to 600 machines during the 1971–1975 period. Above that, the Poles will produce the Soviet Union's third-generation Rjad R-30—five to six systems this year and from 15 to 20 in 1973.

The 1305 computer is a medium-size machine roughly equivalent to Britain's ICL 1904. The software includes the Plan, Cobol, Fortran, Algol, CSL, and Simon languages and a large library of programs for planning, production management, control, and scientific and engineering calculation.

Functionally, the Odra 1305 contains two processors plus consoles. A ferrite core memory common to both processors consists of up to four blocks of independently operating entities, each block having a capacity of either 32,768 or 65,536 words. The maximum capacity is

How Poland's electronics industries grew

Poland's coming of age in electronics has been a decades-long uphill struggle, Unitra's Ryszard Kujalnik recalls. Before World War II, there wasn't much industry, except for a few communications houses and several foreign-owned subsidiaries of such companies as Holland's Philips and Germany's AEG-Telefunken. After the war, which left Poland devastated, there was even less of a base for electronics activities.

Not until the late 1940s did a group of 110 people or so—Kujalnik, then a young engineer fresh out of college, was one—form the nucleus of Poland's electronics industries. First priority went to restarting the broadcasting networks and conventional communications lines. Only slowly could electronics people turn to more sophisticated gear. Now, some 20 years later, Poland boasts of an electronics sector employing about 120,000 people. And production facilities are expanding.

The new plants, such as the Meramat computer components plant on the outskirts of Warsaw, exude an air of freshness: the test equipment is up-to-date, the work areas are sparkling, and most of the technicians and engineers don't seem to be more than 30 years old.

Outside, workmen are adding yet another building to the complex, which has become too small to meet the production targets for the next few years. Meramat's expansion activities, repeated at plant after plant across the country, belie the notion that Poland is mainly a farming society. Zdizislow Lapinski, Meramat's general director, boasts that there'll be an eight-fold rise in output of line printers by 1975—to 1,600 units—and a doubling of magnetic tape head production by next year, to 60,000 devices. Spectacular spurts are targeted for other computer products too.

thus 256,000 words. The 1305 has a cycle time of 1 microsecond. Either Polish-made or ICL-designed peripheral equipment can be used with the machine.

The other machine, the Odra 1325, is intended for remote control of industrial processes and for scientific applications. It is a small-to-medium computer with multiprogramming capability. Technically, the 1325 checks in with a working store cycle time of 1 microsecond and a storage capacity of 8,192, 16,384, and 32,768 24-bit words. Elwro's K202, a minicomputer intended for industrial-control purposes is expected by Mera officials to find customers in Western countries.

Computer components. Western markets are also opening up for Polish-made computer components in a fairly big way, especially for the magnetic tape heads made at Meramat. Half of all foreign orders, reports Zdzislaw Lapinski, general manager of Meramat are from Western countries. So big are these orders that he says demand is outstripping his plant's capacity by three to four times. Not surprisingly, output of the tape heads—30,000 this year—will be doubled in 1973. Fully 80% are for exports both to East and West.

The success of Meramat's tape heads is based on the ferrite material used for their magnetic circuits. That material is made by a proprietary process that assures high material uniformity, hardness, and resistance to wear of the head faces. Except for saying that "the material is especially dense," Lapinski declines to reveal details of the process.

Lapinski is not tight-lipped on the unit's performance characteristics, though. Crosstalk, he says, is only 0.5%, which compares with 2% typical for Western-made heads using permalloy material. Compatible with IBM dual-gap heads and conforming to International Standards Organization standards, a typical Meramat unit such as the GPT-3z handles nine-track, ½-inch magnetic tape with a recording density of 800 bits per inch and a speed of 3 meters per second. The reading voltage is 15 millivolts peak-to-peak, and the writing and erase currents are 80 and 55 milliamperes, respectively.

The conglomerate also makes magnetic-tape handlers, as well as heads for drum memories and line printers. And "under preparation" at the 2,200-man firm is a cassette-type recorder for industrial and consumer applications.

Polish expertise. The Poles also have to their credit considerable expertise in communications. As frank as Kujalnik is in pointing out deficiencies in ICs, he exhibits as much pride in the strengths of commercial radio and radar equipment. In addition to the marine radar gear supplied to East European fleets, an automatic radio direction finder having an accuracy within 0.5° is in full production and also seems destined for export. The unit, ARC 1402, features simple operation, with the direction of the received emitter station automatically indicated by digits without the need to specify the beacon's sides.

For all their emphasis on computers and commercial equipment, the Poles aren't neglecting consumer electronics. At Unitra's Zelos factory at Piaseczno, a few miles outside the Polish capital, black-and-white TV-tube production is going on at a feverish pace. The 2,700-man plant is the country's only TV tube manufacturer.

Poland's black-and-white TV saturation level now stands at 140 sets per 1,000 people, and Zelos' general manager Ryszard Witkowski figures that the demand will keep up at least through 1978. After a two-year stable-production period ending in 1980 or so, his plant's black-and-white tube output should drop because of color-tube production. Black-and-white sets now sell for $150 to $285, depending on model.

Zelos supplies its wares primarily to the country's two set assembly plants—one in Warsaw, the other in Gdansk. Output is expected to climb to a million tubes next year from 850,000 this year. In 1975, 1.2 million tubes are scheduled to leave the factory. Between 18% and 22% of Zelos' production is exported to such Western countries as England, France, and West Germany, where monochrome tube production is being throttled because of increasing color tube production.

On record. The growing production of phonographs is typical of Poland's turn to consumer electronics.

Zelos' production program includes nine types of picture tubes with screen diagonals from 14 to 24 inches and with deflection angles from 70° to 114°. This year, production was started for rectangular tubes with screen diagonals of 12 to 16 inches for portable receivers. Much of Zelos' production equipment is Corning Glass-supplied. Philips, from whom a license was bought in 1959, supplies the TV tube production knowhow. Production, which started a year later, has now reached a total of 7.5 million units. Of these, 1.5 million have been sold abroad.

Other consumer products. Another deal involves production of phonographs under license by West Germany's AEG-Telefunken. Initially, these phonographs, produced at Fonica, a 3,000-man plant and a member of the Unitra group, were exported to West Germany to pay for the manufacturing knowhow the German firm supplied. With that expertise now acquired, Fonica is producing the equipment for Polish consumption.

Fonica's production of record players and chassis of both foreign and in-house design is about 600,000 units a year. One quarter of the plant's output, valued at $30 million for 1972, is exported. Lodz, about 75 miles southwest of Warsaw, expects annual production increases of between 16% and 18%. □

This report completes the *Electronics* survey of the East Bloc countries. A comprehensive analysis of the other countries in the Comecon group was published in the May 22 issue.

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	Depth — 2.50 Width — 7.87 Height — 4.00	*2K5, 15D	5V, 3.0A or 6V, 2.5A	12V, 1.5A or 15V, 1.3A	NA	
		*2K5, 24D	5V, 3.0A or 6V, 2.5A	18V, 1.0A or 20V, 1.0A or 24V, 1.0A	NA	
2L — DUAL OUTPUT		2L15D-2.8	+12V, 3.0A or +15V, 2.8A	−12V, 3.0A or −15V, 2.8A	NA	
		*2L5D-6.0	5V, 6.0A or 6V, 5.0A	5V, 6.0A or 6V, 5.0A	NA	**$65.00**
	Depth — 2.75 Width — 9.38 Height — 4.88	*2L5, 15D	5V, 6.0A or 6V, 5.0A	12V, 3.0A or 15V, 2.8A	NA	
		*2L5, 24D	5V, 6.0A or 6V, 5.0A	18V, 2.0A or 20V, 2.3A or 24V, 2.3A	NA	
2R — TRIPLE OUTPUT		2R-70T	+12V, 1.5A or +15V, 1.3A	−12V, 1.5A or −15V, 1.3A	5V, 6.0A or 6V, 5.0A	
		*2R-72T	5V, 3.0A or 6V, 2.5A	12V, 1.5A or 15V, 1.3A	5V, 6.0A or 6V, 5.0A	**$69.00**
	Depth — 2.87 Width — 11.00 Height — 4.88	*2R-74T	5V, 3.0A or 6V, 2.5A	18V, 1.0A or 20V, 1.0A or 24V, 1.0A	5V, 6.0A or 6V, 5.0A	
		*2R-76T	12V, 1.5A or 15V, 1.3A	18V, 1.0A or 20V, 1.0A or 24V, 1.0A	5V, 6.0A or 6V, 5.0A	
2S — TRIPLE OUTPUT	Depth 4.00 Width 15.00 Height 4.88	2S-140T	+12V, 3.0A or +15V, 2.8A	−12V, 3.0A or −15V, 2.8A	5V, 12A or 6V, 8.0A	
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		*2S-144T	5V, 6.0A or 6V, 5.0A	18V, 2.0A or 20V, 2.3A or 24V, 2.3A	5V, 12A or 6V, 8.0A	
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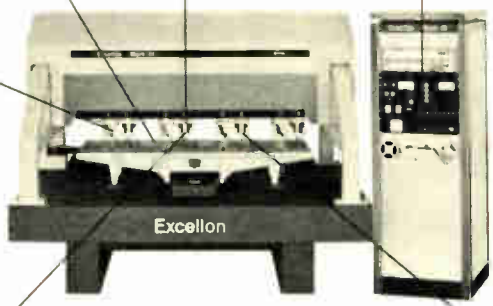

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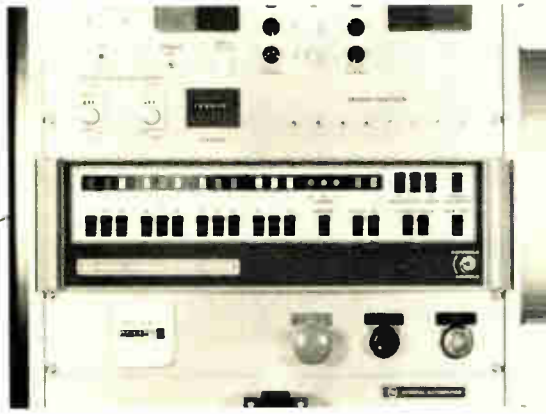

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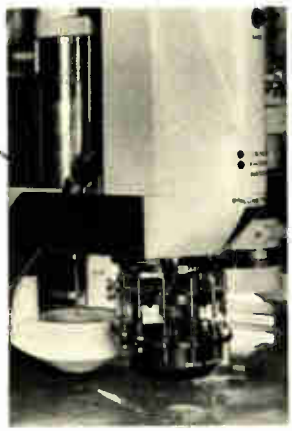

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Commercial electronics

Point-of-sale rings up $$

Store executives like the convenience and efficiency of point-of-sale equipment, but they grumble over lack of standardization by suppliers

by Gerald M. Walker, Consumer Editor

"Anyone who buys an electromechanical cash register now, instead of an electronic point-of-sale terminal, is investing in obsolescence." This is the view stated by one retail-store EDP manager and espoused by many others. The expected growth in this relatively new electronics industry segment has begun.

This year, the market for p-o-s is estimated at $74 million and that figure is expected to reach $390 million by 1976 (see *Electronics*, July 31, p. 22). Several large retailers already have passed through the trial-and-error period to all-out conversion of cash registers to point-of-sale terminals, particularly in new stores.

P-o-s users are generally satisfied because the hardware has performed as promised, and the software—data collection systems to track sales transactions—has provided more and better information than previously was possible with the best electromechanical machines. Although installation cost represents a heavy investment, this is expected to be amortized by providing greater control over inventory, increasing sales-force productivity, and improving credit verification and billing efficiencies.

Essentially, the p-o-s system involves registers that capture all pertinent data involved in a sales transaction by reading a coded tag and picking up keyboard input from the sales clerk. This input is either collected on magnetic tape and fed to a central data collection computer via telephone lines or partially processed in a stand-alone unit.

Although some 25 companies are competing for point-of-sale business, retailers agree that less than 10 manufacturers will become dominant suppliers—perhaps only five.

Despite their general satisfaction, retailers have specific complaints about the point-of-sale systems. The lack of equipment compatibility among contending manufacturers is the most persistent gripe. Lack of standards on hardware, coding, and procedures from one supplier to another has forced some stores to depend on a single source, once they decide to buy that company's equipment. There is little prospect that standards will be set soon, despite the efforts of the National Retail Merchants Association and the National Bureau of Standards to come up with guidelines.

Other recommendations include more flexible terminal keyboards with full alphanumerics and special-function keys, more extensive software and, because wiring is one of the largest expenses in conversion, wireless transmission from terminal to data collector.

Ideally. One discount-store executive says that he would like to be able to combine features from a handful of manufacturers: the programability of one, the training aids of another, the credit-check capability of a third, and the back-office system of a fourth. But, another newcomer to point-of-sale comments: "It's like buying a new car. Next year's model will always have something you want. We need the terminals now. However, we will continue to evaluate suppliers."

As important as hardware features are, it's software support, maintenance capability, and overall financial stability of the supplier that will determine success in the market. "The best-designed circuits may not get very far if the manufacturer is not prepared to back his equipment up with field servicemen," says Morton Weitz, vice president of management information of Korvettes, New York City.

Though Weitz's evaluation of manufacturers is intended to minimize risks, Korvettes has entered point-of-sale systems in a gutsy fashion by converting the most difficult stores first. Rather than singling out a relatively safe, quiet suburban store, Weitz has chosen to take the plunge in the high-pressure cookers of New York City. His reason: "If it works in New York City, it'll work anywhere. I'd much rather see the equipment perform under combat conditions than at Walden Pond."

Korvettes is evaluating three systems at three different New York City stores. At one store, there are 90 free-standing terminals made by the Singer Co., New York. At a smaller store, 45 terminals from Pitney-Bowes-Alpex are tied to a dedicated minicomputer. This month, a third Manhattan store will go online with 90 free-standing terminals from National Cash Register Co., Dayton, Ohio, serving a minicomputer data-collection setup that also handles a central credit verification plan for both a bank card and Korvettes' credit card. Eventually, the giant discount chain will need 2,500 terminals in 22 different locations on the East Coast.

Unlike Korvettes, Montgomery Ward & Co., Chicago, began its pilot runs outside a city. After starting a small program in 1970 at Lima, Ohio, Montgomery Ward added 14 trial terminals during August 1971 in a small-town store in Illinois. Today, however, the firm has about 1,000 terminals—all from NCR—in

30 stores. Even without adding new stores, Montgomery Ward will convert 10,000 to 15,000 standard cash registers to p-o-s terminals during the next seven to eight years.

At the May Co., in Los Angeles, William DeBoer, general credit manager, says that after a year and a half of developing the system, the store has what "we believe to be the fastest credit authorization in Southern California," thanks to the TRW System 4000. It takes three seconds to get a "yes" or "call central credit office" back to the selling floor after the clerk punches in the credit card number on the terminal keyboard and requests authorization. "This allows us to authorize all credit sales regardless of the amount, since a significant number of our losses were the result of charges made on low-dollar sales," says DeBoer.

One of the first p-o-s installations in the country is at Kaufmann's, a May Co. division in Pittsburgh, Pa. It has 700 Uni-Tote terminals made by American Totalisator Co., Towson, Md., in use in five stores— 80 to 85 in branch locations, and the rest in one downtown installation. In the two years the equipment has been in full use, hardware failures have been minimal. At first, Uni-Tote handled service, but as the number of terminals grew, Kaufmann's hired its own service crew.

One of the newest p-o-s installations is the 180-plus terminal system put on-line by Gimbel Bros. Inc. last February at its newest store in New York, Gimbels East. The store uses Uni-Tote terminals and data collectors, but provides its own credit verification system. The weak link, says Edward A. Strobin, director of management information services, is the telephone service between the store and the data collectors.

Strobin says that the installation at Gimbels East was simplified because of programing assistance from Gimbels in Pittsburgh, which had been using p-o-s equipment for more than a year before the New York store started planning. Strobin reports, "We did need to modify some of the reports used in the other store, but at least we didn't have to go from ground-zero."

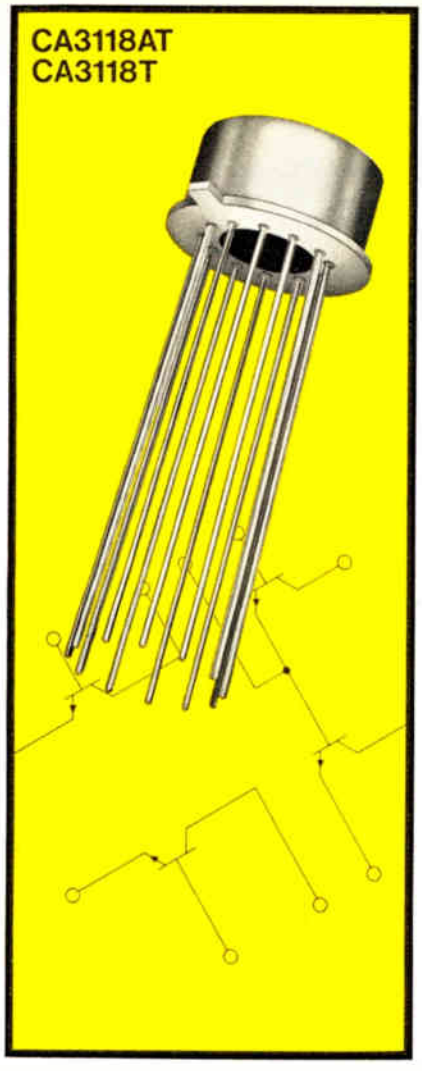
Full alphanumeric printing is one of the features that gets high praise from James Gray, director of management information systems for Bullock's Magnin Co., Los Angeles. Using terminals from American Regitel Corp., San Carlos, Calif., a clerk can fully describe merchandise on the sales check without handwriting. "We can pretty much dictate what we want, especially when the manufacturer is small," says Gray. As a consequence, the Regitel system is "pretty much customized to our specifications."

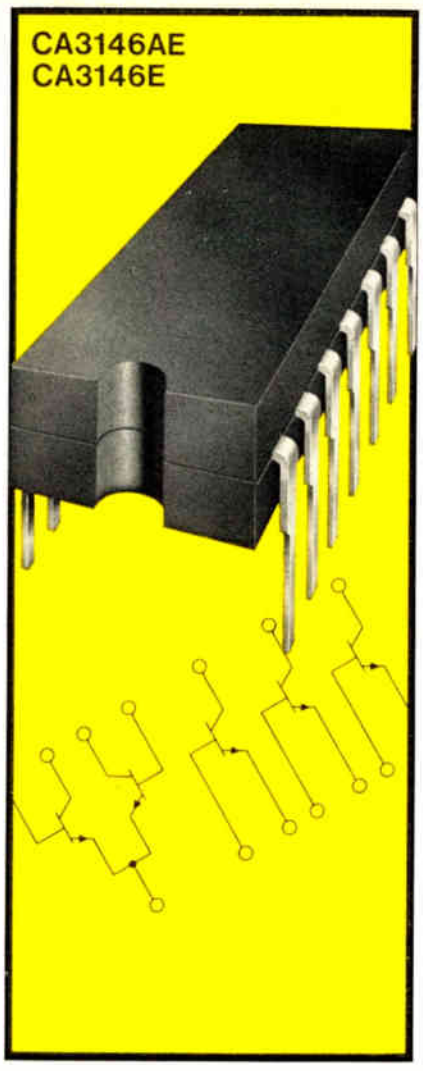
A similar step was taken by Bloomingdale Bros. of New York when it set up a trial system, tailored to specifications, in its Stamford, Conn., store near supplier Pitney-Bowes-Alpex. Now 90 terminals are on-line, and the next step is to add another 60 to 70 terminals in the New York City store. Eventually, 800 or more terminals will be needed.

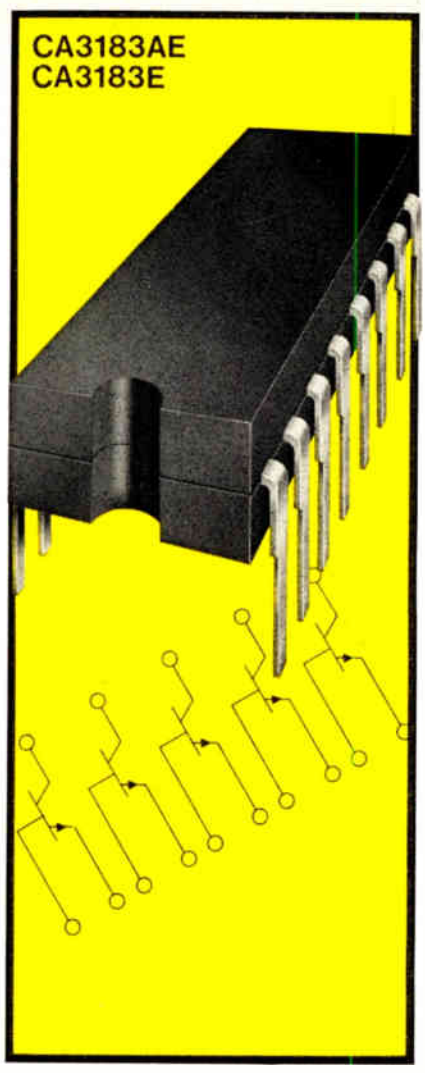
It pays. Although 50 terminals in 28 Hahn Shoe stores near Washington, D.C., were operating in 10 months after the initial concept, Arthur Boyle, Hahn data processing manager, says that the next 150 or so terminals planned by the firm can be installed in a year. After evaluating most of the manufacturers, Hahn chose Singer equipment, and he expects to realize a seven-year pay-back on the $700,000 investment.

Another Singer user in the Midwest has vowed to buy nothing but electronic registers from now on. The discount stores in this nationwide group saw the light, says the manager of systems planning, when one store generated 270 miles of punched paper tape during one day of Christmas shopping. That kind of load was putting too much strain on the data processing equipment in the back office accounting department and convinced the firm that electronic point-of-sale was the only way out of a massive bottleneck. □

Spicing sales. On line at Rink's, Hamilton, Ohio, is an array of SPICE (sales point information computing equipment) registers made and marketed by Pitney Bowes-Alpex.







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Commercial electronics

Technology scores Olympic firsts

At Munich, new electronics for measuring, computing, and displaying results will speed compilation of statistics and announcement of victors

by John Gosch, Frankfurt bureau manager

The summer Olympics in Munich will not only be a mammoth sports festival—it will also celebrate several technology firsts. Besides doing its traditional job of spreading the words and the pictures around the globe, electronic equipment will take on the evaluation and display of results, as well as assuming the basic functions of timekeeping and distance-measuring.

For the first time during an Olympic games, data-processing equipment will operate on-line, and many scoreboards will be computer-controlled. The systems will keep track of everything that happens in the 196 events of the 21 Olympic sports. Infrared beams will replace tape-measures, electronically controlled cameras will replace stopwatches, and microswitches will assure that competitors are timed with the smallest margin of error.

In previous Olympics, computers have been used as decentralized systems to tabulate decisions of the judges. This time, however, computers will accept electronically obtained data right at the contest areas and process it in real time.

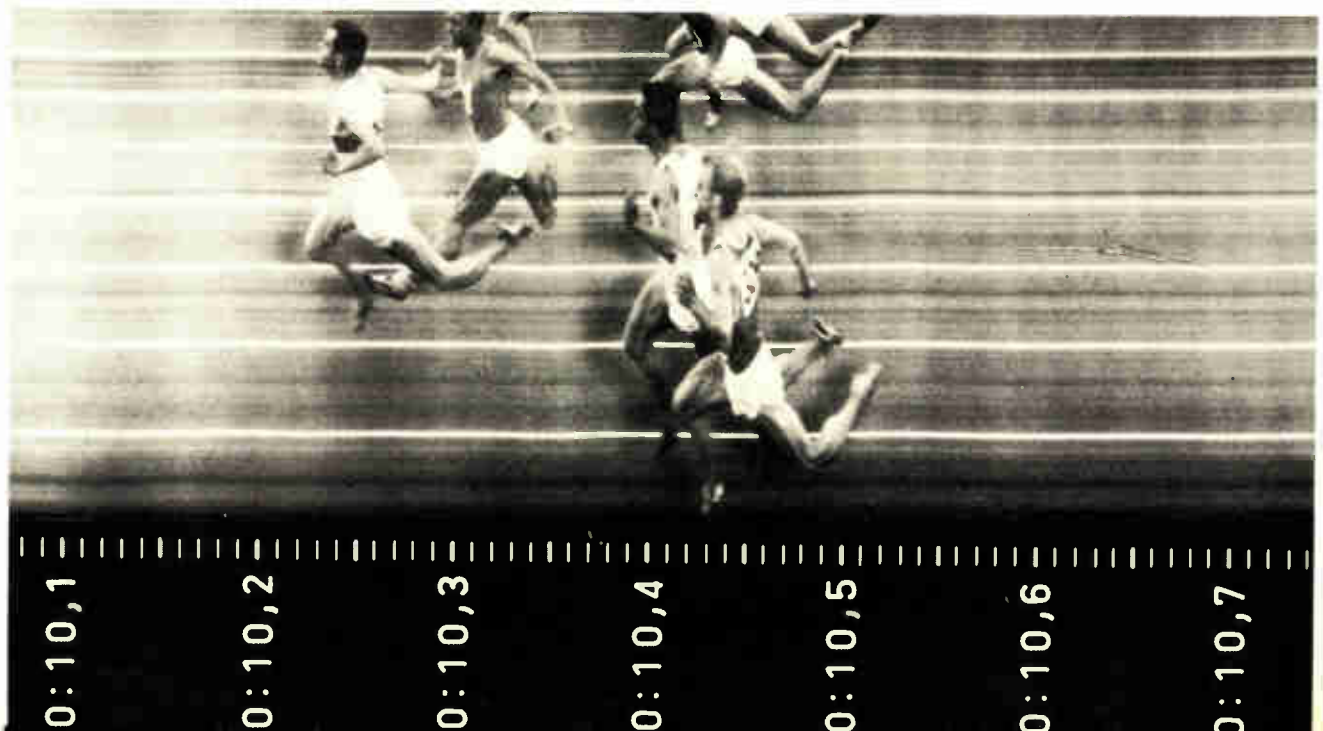
The Munich computers will also handle the results coming from Augsburg, site of the canoeing events 30 miles away, and from the North German city of Kiel, where the yachting competitions will be held. Further, results will be distributed to the scoreboards at Munich's Oberwiesenfeld Olympic grounds, as well as to display systems spotted around the city. Computers will also answer queries relating to any Olympic competition since 1896, the year of the first modern games.

Like the athletes, the electronic equipment at Munich's Oberwiesenfeld stadiums comes from many parts of the world. Not surprisingly, though, most is furnished by West Germany, and Munich-based Siemens AG, the biggest German electrical and electronics equipment producer, out-supplies all other firms. Helmut Becker, chairman of the Siemens committee responsible for the company's Olympics-related activities, reports that the firm has received nearly $22 million worth of primary contracts.

Siemens data-processing equipment constitutes the largest single electronics installation at the games. It has two configurations, the real-time competition-results system, built around three 4004/45 processor models, and the sports memory and retrieval system, which uses two such processors. One computer in each system is a standby.

Results. The basic job of the results system is to assure that journalists, spectators, radio listeners, and TV watchers get the latest scores. This system will also help produce a

Infallible decision. Photo-finish cameras, developed by Junghans GmbH, will replace stopwatches for the first time in Olympic competition.



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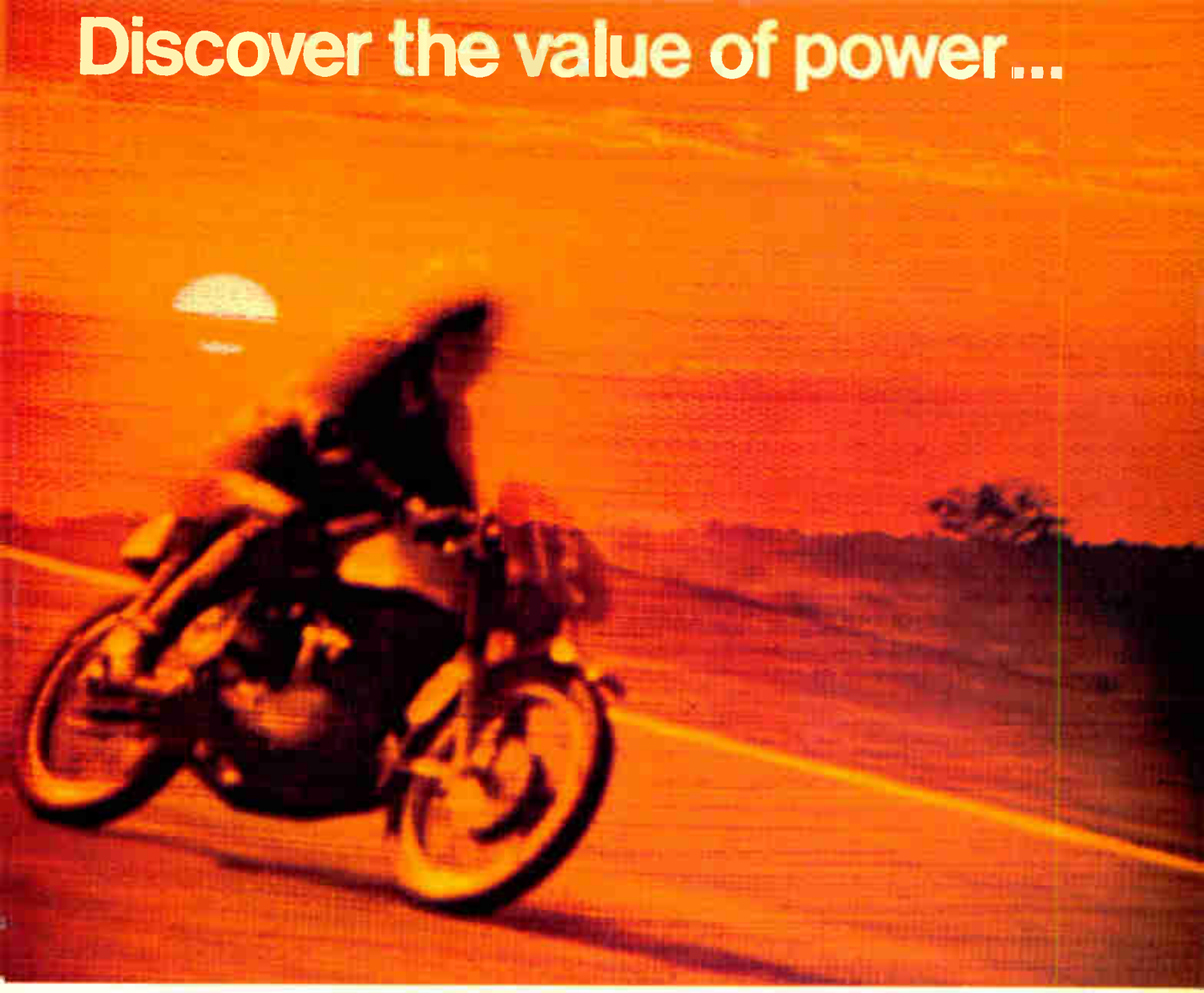

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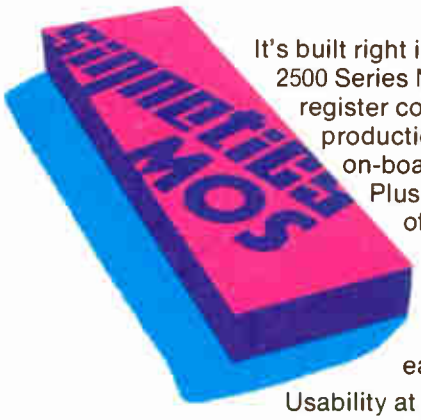

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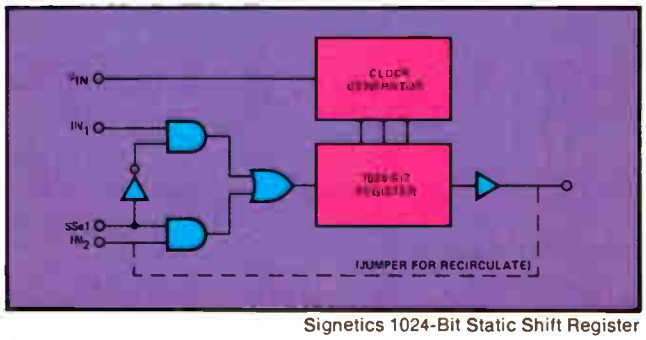

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several-hundred-page final report on the 1972 Olympic Games within hours after they are finished.

About 300 teleprinters are tied in with the results system and used as terminals at the competition areas in the three Olympic cities. Data communication is via 5,400 miles of dedicated telegraph circuits, having transmission speeds between 100 and 1,200 bits per second.

At the contest areas, the terminals accept the results from judges and referees and feed them to the computer system. However, in some events, data is entered automatically from sensors. In the swimming events, for example, inputs come from foot- and hand-actuated timing devices that are closed when a swimmer applies pressure to the touch-finish strips at either end of the pool.

One of the competition-results computers controls the two-way communications with numerous terminals, thus replacing scores of messengers. The second computer processes the results: when fed an athlete's number and performance, it determines his name and nationality for presentation on the scoreboards and other displays. The machine also computes the placings of competitors, notes who qualifies for the subsequent events, and works out team competition tables.

The other Siemens EDP installation, the two-computer sports memory and retrieval system, dubbed "Golym," stores hundreds of thousands of Olympics-related bits of information in eight data pools to which journalists and sports fans have access via 72 terminals. One pool contains all personal data such as name, date of birth, nationality, height, weight, and victories of some 15,000 athletes and sports officials. Other pools provide information in German, English, and French on rules for all Olympic events.

With the competitions to be held at more than 30 stadiums and courses in the three Olympic cities, there is a need for numerous scoreboards. There will be 56 boards, many of them computer-controlled, worth about $3.2 million.

The score. One major scoreboard supplier is Elektron GmbH, the German subsidiary of the Conrac Corp., New York City. The company is providing three large computer-controlled information displays worth $1.7 million. Two of them are for the main stadium in Munich. Each is about 23 feet high by 56 feet long, and consists of a matrix of 24,000 25-watt light bulbs. The third Conrac scoreboard is a mobile unit for use at places far from the main stadium.

Each lamp in the boards' matrix is computer-controlled so that characters, symbols, and drawings of varying sizes can be shown. The computer, a model CA216 from Computer Automation Corp., operates with a Siemens model 301 machine, which stores prepared programs, such as prior Olympic and world records.

Another major scoreboard supplier is England's Associated Instrument Marketing Ltd., which is providing a large four-sided board operated by a Unidata computer, as well as a smaller electronically controlled board for the equestrian events. The Swiss firm, Omega Louis Brandt and Frère S.A., is supplying two boards, one of which is computer-controlled, and the Hun-

Automating scores. The results computer is fed scores and posts data on scoreboards.

garian company, Elektro-Impex, is supplying a number of electronically controlled boards for the bicycle stadium and other places at the Olympic grounds.

Timing, one of the most important responsibilities at the games, will be handled by West Germany's Junghans GmbH and Switzerland's Compagnie des Montres Longines Francillon S.A.—Longines, for short. For the first time in Olympic athletics, hand-operated stopwatches are being replaced by photo-finish film cameras. In a short race, the cameras produce a 3.5-by-4.75-inch picture of the finish in 20 seconds. For a longer race, a 130-foot film of the finish is projected onto a screen 45 seconds after the race. The simultaneously reproduced time-scale shows results to within 3 milliseconds.

Should a runner be completely covered by another at the finish line, an overhead TV camera will show results. The camera produces 100 images a second, which are recorded on magnetic tape.

Electronic tape measure. Another Olympic innovation in Munich is replacement of the tape measure by a new optoelectronic method whereby distance results are obtained immediately after the throw of, say, the javelin, or the discus. The heart of the new distance-measuring equipment is the Reg Elta from the West German optical equipment maker Carl Zeiss of Oberkochen. A small computer connected to the instrument determines the distance thrown. The instrument prints out the result, and displays it on scoreboards. □

Sports history. Olympic data from Siemens' Golym computer is displayed on terminal.

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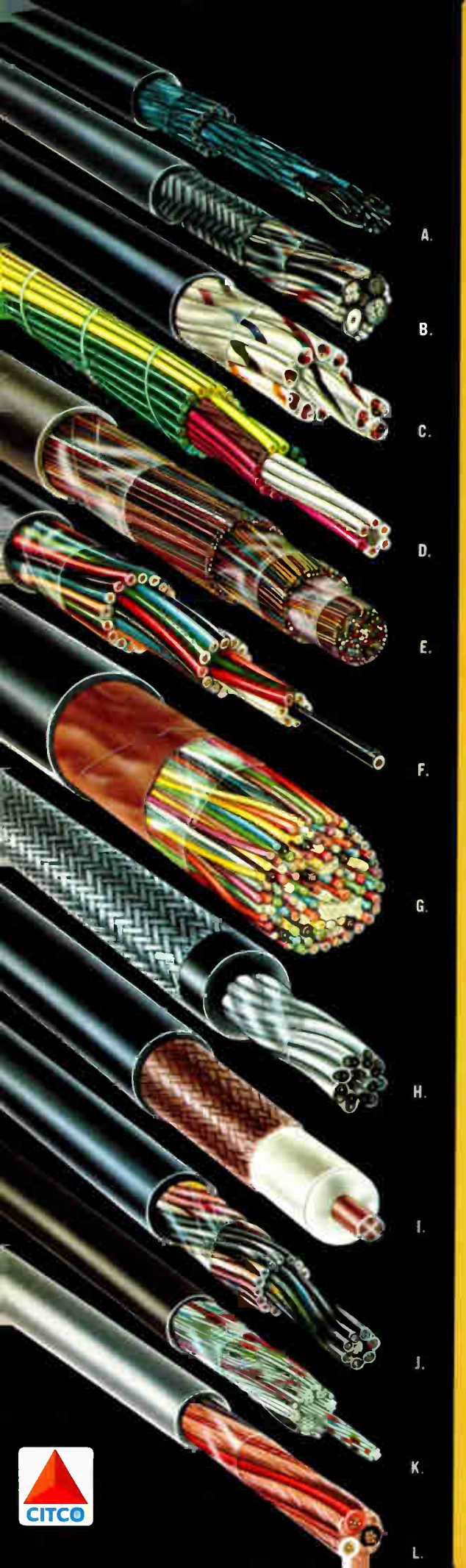

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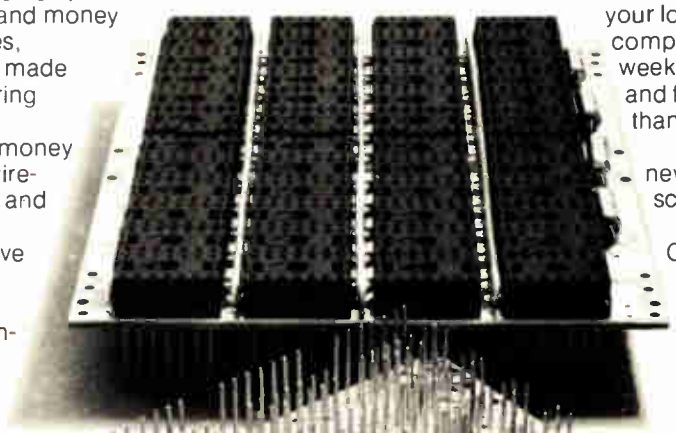

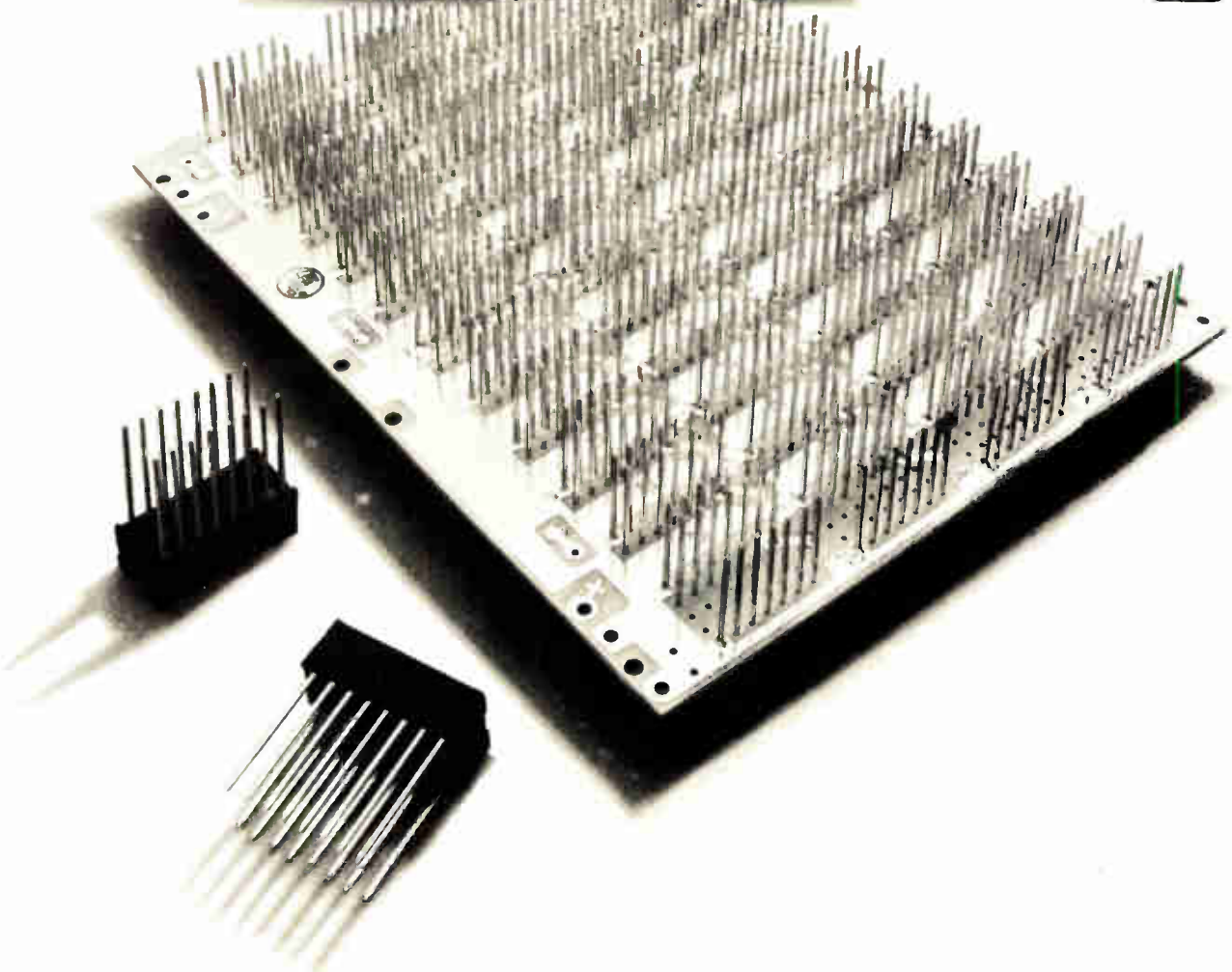

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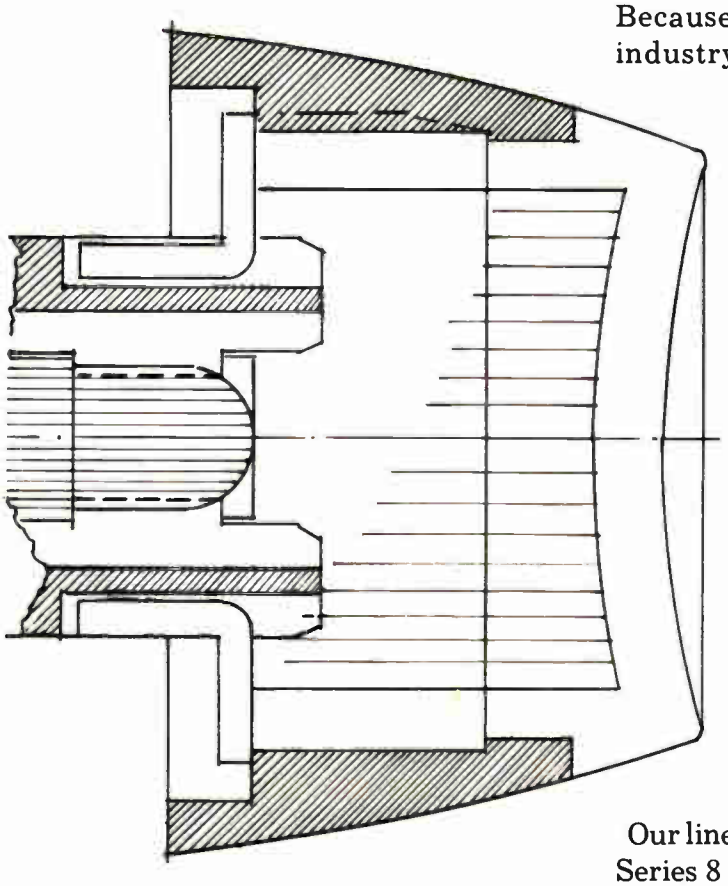

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Special report: Consumer gear benefits from IC design tradeoffs

Home-entertainment equipment designers, turning to in-house IC work, are balancing advantages—longer life, compactness, maintainability—against lower cost of discrete components; when volume picks up, prices may plummet

by Gerald M. Walker, *Consumer Editor*, and Laurence Altman, *Solid State Editor*

☐ Designers of consumer electronic equipment—particularly color television sets and audio equipment—are beginning to take advantage of the high performance, reliability, and compactness of linear integrated circuits. And IC manufacturers are still developing and improving circuits, but they are now beginning to focus on the technical challenges of audio ICs. All are emphasizing power monolithic audio amplifiers, as well as high-sensitivity, low-noise preamplifiers, phase-locked-loop stereo decoders, and Dolby noise-reduction circuits.

Equipment manufacturers have been convinced, further, that prices of linear ICs will drop, as they have for digital devices, with increased demand. Extensive price cutting on large orders has already begun. And some observers have expressed doubt that the supply of linear devices will meet the demand by 1973, with the probable result that more competitors will enter the market to try to fill the gap.

This two-part special report explores the imminent explosion of linear ICs—probably this year—into the $4 billion-a-year consumer electronics market. An earlier story, [*Electronics*, June 5, p. 83] traced the development of linear circuits.

The first part of the following article reveals the experiences and attitudes of consumer equipment manufacturers, and the second part summarizes the design activities of IC suppliers for that lucrative market.

Among the trends this investigation uncovered are:

- Major increase in IC design in television sets in the new model year.
- More functions per chip on the way for TV applications—combining two, maybe three, present-day devices into one.
- The number of ICs in a TV chassis to settle at a total of five or six, with all functions integrated except the high-voltage supply.
- Reliability the key selling point in the wake of consumerism and the increasing cost of repairs.
- Arrival of the throwaway module, as well as the retrofit board and ICs to upgrade previous-model TV sets.
- Growing insistence that IC manufacturers share in the costs and risks of longer warranties by sharing the costs of repairing product failures.

Part 1: Home-entertainment picture

Integrated circuits—virtually all linear—are moving into consumer electronic products in a big way. What began on a tentative scale two to three years ago has now mushroomed into significant IC utilization by television receiver manufacturers and, to a lesser extent, by audio equipment producers and camera makers.

The trend is also in full swing abroad. Ironically, home entertainment equipment producers in West Germany and Japan have been using integrated circuits in larger numbers than in the U.S., where the IC was invented. Companies in Great Britain and France, on the other hand, appear to be lagging behind the U.S. in numbers of ICs in use for consumer products.

The demand for ICs is expected to grow so large that there will likely be a capacity problem among IC suppliers, starting in 1973, says Ronald J. Strout, manager of components engineering for General Electric Co. The demand centers on specific devices, rather than a range, and there will be increasing demand—not only from television and audio manufacturers—but also from auto and appliance companies by 1973. Consequently, the semiconductor houses may not be ready to handle the peak orders, Strout cautions.

Though there is little argument that the long-awaited era of consumer ICs has arrived, equipment manufacturers are taking a cautious view toward expanding their application. The next move will require a step closer to the state-of-the-art, particularly toward linear high-power designs.

TV chassis with as many as six—and even 10—ICs are in production now. Audio equipment with three to four linear circuits will also reach the consumer this year. And hybrid packages—three and four to a unit in both TV and audio gear—are right alongside the monolithics

in this push. Adaptation of digital ICs for such conveniences as automatic shut-off, tuning, and frequency display is being explored by—among others—Fisher Radio, Long Island City, N.Y.

The invasion of ICs into consumer products became almost certain when the manufacturers successfully introduced and sold the public on solid-state electronics. "All solid state" is a feature that most consumers can understand and believe. From there, the route to integrating 30 to 50 discrete components into a single IC chip was a logical design step, but to date, promotion of integrated circuits to the buying public has been almost completely nonexistent.

For an industry that ordinarily introduces new designs mainly to save pennies or tickle the consumer's fancy, to make an unheralded conversion to ICs is remarkable. In a sense, the costs and risks of this effort mark the coming of age of engineering in the consumer sector after years of playing second fiddle to aerospace innovators.

System approach begins

Some of the designers responsible for bringing ICs into consumer land are, in fact, former aerospace and semiconductor industry engineers specifically recruited for their backgrounds. These engineers probably were influential in the shift to the system approach of design that ICs have initiated in the consumer sector. No longer is the typical tradeoff made in terms of saving a few pennies by changing, say, one resistor. The total cost of making the product—from design to consumer's home—is considered when converting to ICs, including the costs of repairs covered by warranties.

Companies have decided to pay the additional price to gain systems advantages. In addition, every user need only study the price trends for ICs in the last few years to know that accelerating sales will bring down prices and increase reliability from the present base, thanks to increased IC yields.

The majority of the design effort was accomplished with in-house talent, painfully self-taught in IC technology during the last five years. On the whole, direct applications assistance from the semiconductor houses was limited, with the possible exception of TV manufacturers that had semiconductor divisions within their companies.

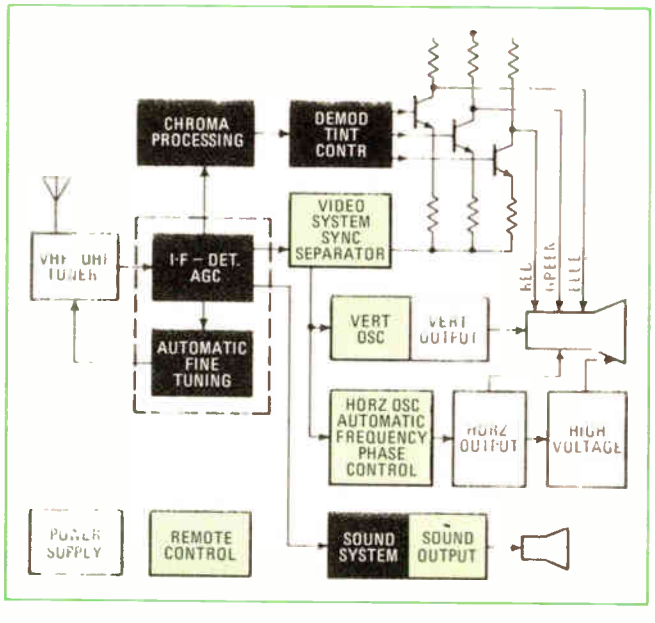
Related divisions help

However, of four leading television manufacturers interviewed in depth for this report—RCA Corp., General Electric Co., Zenith Radio Corp., and Motorola Inc.—RCA and Motorola profited from the interaction of their consumer-products and solid-state divisions.

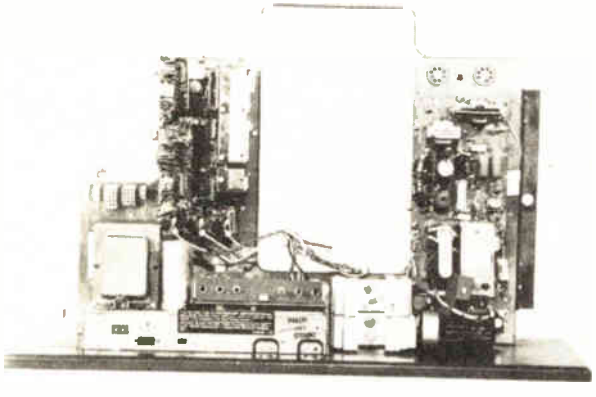
An early advocate of the solid-state chassis and conversion to integrated circuits, RCA Consumer Electronics division, Indianapolis, Ind., exploited a close relationship with the Solid State division to bring IC knowhow into the design effort. Despite the close ties, the consumer group has maintained the attitude that IC cost, rehability, and performance have to be equal to those of the discrete components they replace. Therefore, conversion has not been made simply to use RCA microelectronics.

In Motorola's case, the Semiconductor Products division is the leading supplier, but the Consumer division also purchases from RCA and Sprague. Having an association with the Semiconductor division helped Motorola cross the design hump to get optimum chip size and to lock up final parameters that assure required performance without creating extra costs in production. However, Consumer Products division engineers did the bulk of the design work, reports Richard Kraft, head of color TV development.

The conversion has picked up steam so rapidly in the last year, however, that ICs sometimes have leapfrogged discrete components in the steady replacement of vacuum tubes that started 10 years ago. Along with the introduction of integrated circuits, two long-discussed concepts have become realities: the throwaway module and the solid-state retrofit for upgrading older units. These two developments, partially related to ICs, are the



1. **ICs now and later.** The block diagram of the typical TV chassis shows functions performed by ICs now (solid areas) and those RCA plans for later (shaded areas). Current model line XL100 chassis has five ICs in all-solid-state configuration.



direct result of a parallel trend toward modular construction.

However, one audio equipment supplier dissents from the general switch to ICs. John Spanos, vice president of engineering for H.H. Scott, Maynard, Mass., contends that linear devices have not come far enough to be a major economic attraction for audio components. Scott's receiver line uses two to three bipolar devices, but Spanos insists that adding more ICs to the present units would be of marginal benefit.

Spanos, a former semiconductor industry engineer, adds, "We have to balance our natural enthusiasm for new technology against the business outlook. It costs anywhere from $7,000 to $30,000 just to develop a linear circuit, and that's still too expensive when overall system costs are considered. What sells a stereo unit is performance, not promotion. If the consumer cannot hear a difference, he won't pay a premium to get integrated circuits."

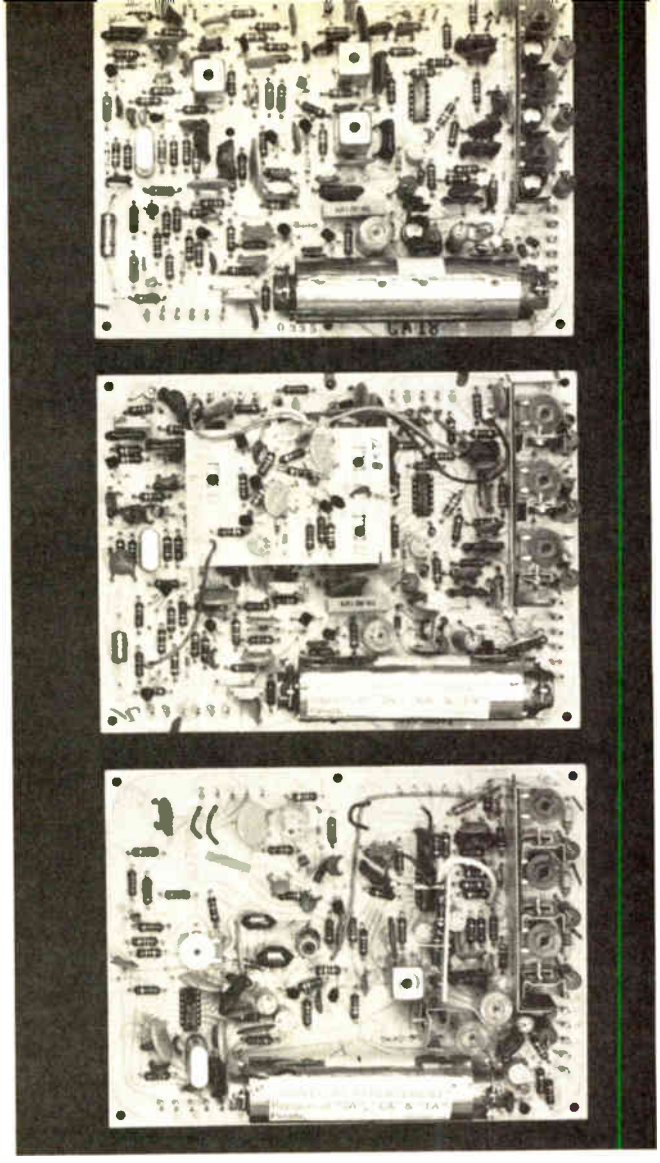
Performance and reliability improved

More direct benefits of applying integrated circuits to consumer products concern performance and reliability. The industry is in the throes of competition to extend warranties on parts and labor—a feature the consumer can appreciate even without Ralph Nader—and at the same time to add more and more complexity. This puts a premium on reliability that ICs promise to fulfill. Now, television set manufacturers have generally settled on one-year warranties on solid-state color receivers. Fully aware that if ICs survive shipping damage and the first two to three months of normal use, they will not ordinarily break down during the remainder of the warranty, set makers have an incentive to apply integrated circuits, even if the individual devices are now priced higher than the discrete components being replaced.

There are direct savings in production and inventory overhead, once the assembly-line conversion is complete. Another advantage on the design side is that ICs permit direct coupling in some functions, thus eliminating the need to use the ac coupling circuits required with discrete parts. For example, in the chroma processing circuit, the transistors for red, green, and blue undergo different thermal changes at any given time, requiring ac connections; but when the functions of the three transistors are integrated side by side on a chip, thermal changes are the same, thus permitting direct coupling.

Problems have arisen in applying ICs, however. The demands that entertainment equipment makes on linear designs are more stringent than those that are made on digital circuits. In addition, one chief engineer points out, "They [semiconductor suppliers] don't have the experience and control over the linears that they have in digital."

Industry officials are arguing over the relative merits of plastic versus ceramic packaging and what is optimum partitioning of chips. Another design consideration is whether to use proprietary or off-the-shelf devices. The proprietary design has the advantage of secrecy, but this route requires production of hefty quantities of devices to become economical, and not many individual consumer companies can bargain in the large numbers to which semiconductor suppliers are accustomed. The reverse is true for off-the-shelf circuits—the numbers game is right, but when everybody has a "me-too" chassis there isn't much room for innovation.



2. Generation gaps. Three model years of one of Motorola's modular boards illustrate retrofit panels from 1969 (top), 1970 (middle), and 1973 (bottom). Addition of color tuning circuitry in 1970 required "piggyback" board, but in 1973, addition of another IC eliminated that board by making enough room on the master board to handle the necessary circuits. The IC thus saved production costs.

Officials at Zenith Radio, the Chicago TV manufacturer, justify using proprietary designs in four out of five of their ICs by the volume of Zenith's requirements and the company's emphasis on high performance. Donald W. Ruby, engineering specialist who headed the Zenith microelectronics team, points out that Zenith's demand for proprietary devices was greater than one of its semiconductor supplier's sales of off-the-shelf units for the same consumer applications. "Performance is the only element that distinguishes our product from others, and we feel that we have that edge with these circuits. Besides, we don't like looking at our designs in someone else's cabinet," he explains.

RCA's Consumer division took both routes in the proprietary versus off-the-shelf tradeoff. Three of the

five devices—i-f detector/automatic gain control, automatic fine tuning, and sound system—are supplied by RCA Somerville and other semiconductor manufacturers. The color-processing circuits, however, were designed by the Consumer division engineering department, with developmental assistance from Somerville. These circuits, sole-source to RCA, are proprietary.

As for packaging, Gordon E. Kelly, manager of color television engineering at RCA, advocates the plastic-packaged silicon chip "for low-level, low-power applications, but for high-power, high-voltage applications, thick film is the way to go." All five of RCA's ICs are in plastic packages, but Kelly says that plastic can cause difficulty with hermetic sealing. But RCA is using plastic because ceramic is too costly.

RCA uses five ICs

There are five bipolar ICs in the RCA XL 100 chassis (Fig. 1). A single package performs i-f video detection, automatic gain control, and i-f gain in automatic fine tuning. Two color-processing ICs include automatic color gain control and chroma selectivity. The fourth IC is for demodulator and tint control, and the fifth is an i-f sound-input detector for 4.5 megahertz.

In addition to these silicon monolithic devices, the XL 100 uses three ceramic hybrid devices for video and chroma drivers, one for each of the three color channels. A sound output is also hybrid. Other functions now being evaluated for conversion to ICs are video systems synchronization separation, both vertical and horizontal oscillators, and a power device for sound output.

"It appears that the sound detector, now integrated, and the sound output could be put on one chip," says Kelly, "but we're nervous about the idea."

Divisions cooperate

The conversion to ICs was facilitated by a team of a dozen or so Consumer division advanced engineers who are stationed at RCA in Somerville. Lead time from design concept to breadboard to finished device was approximately two years. "The first thing we learned," says color engineer Eugene Lemke, "is never to confuse digital and linear. Linear devices for TV were far more difficult to deal with—the signal level is greater, there is no redundancy on the chip, capacitors can't be avoided, the limits are a lot tighter, and yield is much lower." Lemke points out that the industry is in the early stages of using linear ICs, and the applications still represent risks.

General Electric's Television division, Portsmouth, Va., has pushed ahead with two new all-solid-state chassis—one with five ICs and another with four. GE is also making a monochrome receiver with one IC for the i-f audio stage. The chassis for large-screen color sets has ICs in sockets for first and second video i-f, afc, chroma demonstration, and color processing. The fifth device, for audio i-f, is soldered onto a throwaway audio module (Fig. 3) designed to make in-home repairs faster and less costly.

GE has incorporated this same module in a black-and-white set. However, since the tolerances are wider in the lower-priced monochrome receivers than in the color sets, GE realizes considerable savings by salvaging the dropout ICs from its color lines for the black-and-white sets. The GE audio module includes a 4.5-MHz amplifier-limiter, 4.5-MHz fm detector, an electronic attenuator, and a push-pull audio output amplifier. The IC provides the amplifier limiter function. The rest of the throwaway module contains the typical array of capacitors, resistors, and a transformer, along with three discrete transistors for audio drive and output for 2 watts. An output transformer is not required, since the speaker is driven directly.

Don E. Garrett, manager of product design engineering for the TV division, predicts that the next generation of large-screen color sets will probably have eight to nine ICs; the small-screen sets will have about seven or eight. By 1974–1975, these numbers will shrink as more functions are combined on single chips, he adds. TV sets would wind up with medium-scale integration at this point. For instance, the two i-f functions, video detection, and chroma demonstration, now on three separate chips, could be combined on one.

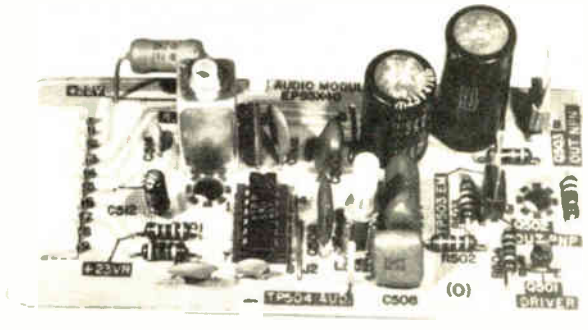
Zenith uses five ICs

Another TV manufacturer that has gone heavily into integrated circuits is Zenith Radio. The Zenith color TV chassis that began with one IC jumped to five in a six-month developmental period, although the planning and design for this move dates back to 1969. Three of the ICs are for color signal processing, one is for f-m sound limiting and detection, and one is for video signal processing.

Four of the five are proprietary designs being supplied by Texas Instruments, Sprague, RCA, Motorola, Fairchild, and Signetics. Zenith engineers have designed these devices through to the primary breadboard stage. In the case of signal processing, the company jumped from using nine vacuum tubes to an IC, although they used discretes for signal processing in a chassis that was never marketed.

As for future applications, Zenith's Ruby suggests, "We're living in a throwaway age. We can expect to see eight to 10 ICs for the complete TV receiver, all on one disposable board."

3. Throwaway. This audio module in General Electric chassis has one IC for the i-f function, plus other discrete components, including three transistors for output stage. The board can be discarded when repairs are required. The same audio IC appears in a b-w set.



Unlike GE and Zenith, Motorola's Consumer Products division, Chicago, converted to ICs gradually. Its first color all-solid-state, works-in-a-drawer chassis, introduced in the fall of 1967, achieved notable success. That model was the first with an IC—for 4.5-MHz audio processing. In the 1969–70 model year, a second IC was added for color demodulation. And last fall, Motorola phased in a third device for automatic gain control and video i-f amplifier functions.

One of the values of integration came in the last two stages. When Motorola introduced its automatic tuning feature, Insta-Matic, the circuit board had to be mounted piggyback over the basic video module. But the arrival of the third IC freed enough space to eliminate the piggyback board and thus integrate the Insta-Matic on the master circuit board.

The gradual evolution toward ICs has worked for Motorola, says color TV developer Kraft. And Motorola has designed a "universal-replacement" panel in order to retrofit modules of 1969–70–73 design into older sets.

"Reliability, function for function, has broken even from discretes to ICs," Kraft reports, "but the potential for improvement is on the side of ICs. There is an inherent capacity for substantially greater reliability as we get used to designing with ICs."

Fisher gets design help

Like Motorola, Fisher Radio carried the design ball to the semiconductor houses in developing its new line of hi-fi receivers. The company uses both monolithic and hybrid circuits. In the fm tuner section of the current line, one IC for i-f decoder function replaced 200 active components. (An IC also performs muting functions.)

Fisher has already entered the early stages of MSI by combining two or three ICs formerly used in the fm i-f strip into one. In the fm multiplex section, four tuned circuits were replaced by an IC using a single 9-cent potentiometer for adjustments. "This not only improved performance," comments Frank J. Krausser, Fisher's chief engineer, "but reduced production costs."

The two hybrids used for power amplifiers in the Fisher line are produced in Japan. An advantage of the thick-film hybrid over a monolithic circuit, says Krausser, is that these circuits are now available, whereas the monolithics to perform power functions are still under development.

Through a newly formed R&D department, Fisher is now turning its attention to digital IC applications for such convenience features as automatic shut-off at a preselected time, tuning, and frequency display combinations.

"Considering that the audio enthusiast pays more for quality equipment, it's remarkable that a stereo amplifier does not have a timing device to turn it on and off automatically," observes Joseph L. Behr, vice president for R&D. Fisher has included an integrated phase-locked loop in its newest tuner. And similar circuits will also be developed at the company.

New products benefit from ICs

But ICs have invaded more than TV and audio equipment. A unique set of circumstances has caused kit manufacturer Heath Co., Benton Harbor, Mich., to pull out all the stops in buying integrated circuits. Says Eugene C. Fiebick, vice-president of engineering, "ICs have made possible complex products that can be assembled at home. This is our main justification in designing with them." As Fiebick explains, a single device may replace 30 to 50 discrete components. This makes packing the kits for shipment not only simpler but much less susceptible to errors or omissions of key parts.

For example, Heath's $540 AJ-1510 digital fm stereo tuner kit contains no less than 55 ICs. The odds in favor of successful assembly of this tuner by a do-it-yourselfer using discrete components would approach zero, Fiebick explains.

The company's color TV set was the first home-assembly product to incorporate ICs. The bulk of the devices are off-the-shelf. ICs also appear in kits for model airplane control, phonograph amplifiers, and an electronic calculator, as well as some servo equipment.

The kit business poses some unique problems for IC designers. First, it is impossible to provide circuit diagrams for all the ICs—the manual would weigh more than the equipment—so Heath has had to provide block diagrams to guide users.

Another problem with ICs is soldering because closer pin spacing necessitates greater care than discretes. Consequently, Heath warns customers to use thin soldering-iron tips or else wrap No. 12 wire around iron tips. The connection pattern on a digital depth sounder is so complex that the company is planning to include a foil pattern that the hobbyist can lay over each printed-circuit board after he finishes soldering. If any solder appears outside the foil pattern, he knows there is a bridge that needs correction.

Another integrated circuit helped create a new product—Polaroid Corp.'s new electronically controlled camera. Though few technical details have become available since Erwin Land, Polaroid president, demonstrated the single-lens reflex folding camera last spring, it is known that Fairchild and TI are the subcontractors for the IC, which controls the 21 separate functions performed in the camera. The circuit, which contains the equivalent of 290 transistors and more than 200 resistors, controls exposure, start and stop of the unique film-drive motor, length of film exposure, and operation of the shutter, as well as the flash mechanism. When a five-flash array, made by General Electric, is inserted, the IC checks the resistance of each bulb until it reaches a good one and sets it off. This feature eliminates the chance of spoiling a shot with a faulty flash.

Overseas ICs romping

Manufacturers in West Germany and Japan are ahead of the United States in the application of ICs to home entertainment equipment. However, this technology has not advanced so fast in the United Kingdom and France.

In West Germany, Europe's biggest market for home entertainment equipment, consumer IC design and application is one of the industry's strong areas. German home-entertainment equipment makers began applying ICs to consumer products because the lack of a big space and military investment and absence of a strong domes-

tic computer industry have directed the country toward linear IC development.

For example, in the mid-1960s Grundig Werke AG applied monolithic circuits in a pocket tape recorder. Last year the company incorporated TTL digital ICs in TV receivers for electronic tuning. Grundig's latest color TV line includes a set containing 12 ICs that has a 26-inch screen and 110° deflection.

Linear ICs are in the video i-f amplifier, video amplifier, color signal processing, horizontal deflection circuitry for phase comparison, sound i-f amplifier, and audio output amplifier, and in the tuner for voltage stabilization. The only likely function left for integration, the company says, is to replace with a single IC the seven transistors used for tuner voltage selection and seven more for range switching.

The German manufacturer has already discussed this possibility with a U.S. firm. Grundig says that integration in hi-fi equipment will not proceed as rapidly as in TV because of the critical requirements in distortion, group delay, and crosstalk.

Grundig has followed much the same reasoning as American companies in justifying use of integrated circuits—reliability and cost. One difference, however, is that Grundig contends that the space-saving factor of ICs alone makes possible the modular concept of equipment design. U.S. engineers argue that it's possible to have modular design without ICs, and that it's possible to have ICs without modules.

Other equipment makers using ICs generally go along with Grundig, but not to the same extent. Deutsche Philips GmbH, a subsidiary of Philips in The Netherlands, says it is using two ICs in black-and-white TV receivers and several in color sets for various functions: sound i-f amplification demodulation, PAL [French TV system] switching, and other color-signal processing jobs. In one portable radio, an IC handles functions in all stages except those in the uhf input stages and in the power output amplifier.

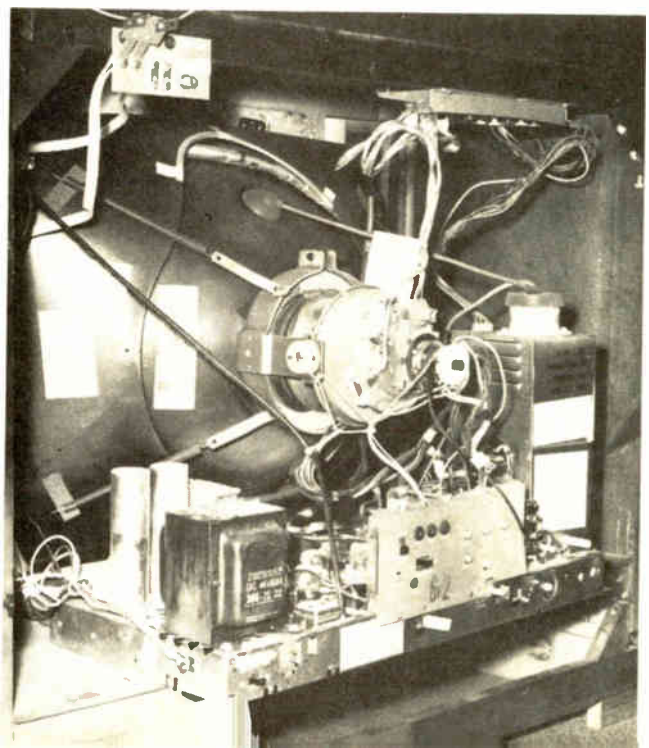
Japanese consumer goods manufacturers have also converted heavily to ICs, with television manufacturers accounting for an estimated half of all consumer ICs sold. This percentage could grow as device prices decline, wages increase, and the economic factor bends in favor of more ICs. This rapid growth in television may not be duplicated in stereo equipment, radios, or tape recorders because of the wider variety of requirements and power supply voltages that would be involved.

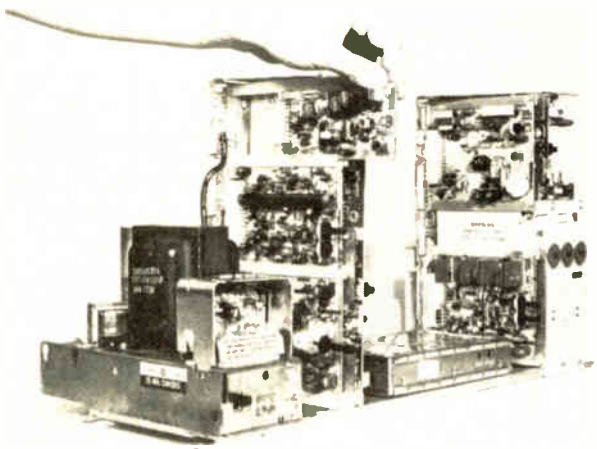
Tax incentive that wasn't

A nondesign factor that has artificially encouraged more ICs in TV chassis was a belief that receivers would win a waiver on the Japanese excise tax, based on the number of integrated circuits they contained. Instead, the Japanese government increased the tax on solid-state color receivers from the previous 10% to 15% (for sets with picture tubes up to 20-in. outside dimension), regardless of the number of ICs or transistors used. As a result, many companies are redesigning their ICs to reduce the numbers required and achieve a better cost balance.

Matsushita Electric Industrial Co. now uses nine integrated circuits in many of its color receivers. These are for sound i-f and demodulator, local oscillator, automatic fine tuning, sync separation, jungle circuit, hybrid-vertical and horizontal oscillator (including horizontal automatic fine-tuning), video preamplifier, (including driver, automatic resolution control, chroma amplifier), chroma continuous-wave oscillator, and chroma demodulator. More expensive models also have an MOS LSI that generates a 31.5-kHz signal from which frequency-counter circuits derive horizontal and vertical oscillator frequencies.

Hitachi Ltd. is also a heavy user of ICs, with 10 in its large-screen sets and either one or two in inexpensive small-screen units for sound i-f, as well as automatic fine tuning in sets with this option. Among the functions in the large-screen models are ICs for color sync, including oscillator automatic phase and frequency control, color dc control, and video amplifier-through-driver, automatic resolution control, automatic brightness control, and contrast and brightness dc control. The rest of the ICs are much the same as other producers are using.





4. Old and new. The hybrid GE chassis at the left had tubes and discrete components. The leap to all solid state in the new modular chassis (right) included ICs, which helps to ease home repair.

Hitachi's enthusiasm for the benefits of ICs matches the company's commitment in numbers. Improvements cited by a company source include increased sensitivity, decreased noise, less cross-modulation with strong signals, higher bandwidth for better resolution, and better age speed than sets with discrete components.

Separate age circuits for tuner and i-f stages eliminate age adjustments, and use of a low-level demodulator eliminates interference from detector harmonics. Also, the bandpass amplifier maintains constant saturation, despite changes in signal level; the ordinary bandpass amplifier has an ac circuit that maintains a constant signal, which saturation tends to change. Finally, because most chips have built-in regulator circuits, they are almost completely unaffected by power-supply variations.

While both Matsushita and Hitachi acquire ICs from within their companies, Sharp Corp. has to purchase them from outside sources. Sharp is using five ICs in a 10-in. set without automatic fine tuning, and six in a 14-in. set with automatic fine tuning.

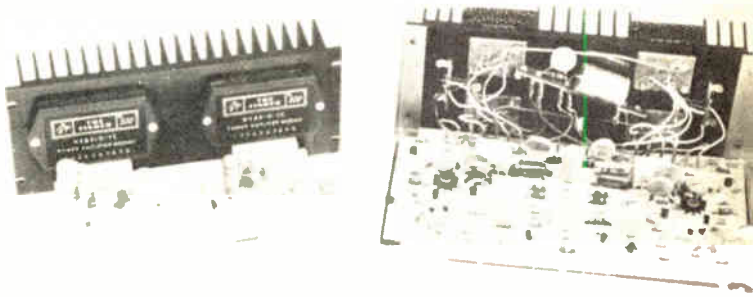
Sharp's second generation

The company is now starting production of chassis for large-screen TV with five ICs. This line is a redesign of last year's chassis that had 17 ICs, nine of which were monolithic and six hybrid. In response to the unexpected excise tax increase, Sharp has removed all the hybrid circuits and some of the monolithic ones, retaining only the sound i-f, video i-f, chroma subcarrier regenerator, and chroma demodulator. Despite this cutback, Sharp is contemplating design of another chassis that will have seven or eight monolithic ICs. The company has also added a MOS LSI circuit for remote tuning that displays the channel number on the screen for 1.5 seconds after tuning to the frequency.

Another Japanese television set maker that had planned to consolidate ICs because of the tax break that never materialized is the General Corp. Its 23-in. chassis has six monolithic and four hybrid ICs. The automatic resolution control of the video-stage IC varies the frequency passband of the amplifier for optimum performance in both color and black-and-white sets. The automatic beam limit controls an average beam current and thus prevents overload of the horizontal output transistor. General had originally planned to use more hybrid and fewer monolithic circuits, but the present lineup with monolithic circuits costs less. For the horizontal output stage, the company is also using two SCRs made under license from RCA by Tokyo Sanyo Electric Co. Field claims, says General, have dropped to less than one-fifth of those for receivers that employ transistor output stages.

UK makers are cautious

Manufacturers in Great Britain have been more cautious than either the Japanese or Americans in adapting ICs. At British Radio Corp., the biggest TV producer, for example, ICs are used for sync detection, color modulation, and the usual sound i-f. Chief development engineer Tony Henk points out that the firm uses only standard circuits in the belief that they offer the best cost advantage in converting to ICs. He is particularly enthusiastic about the color demodulator supplied by Motorola because it permits direct coupling, whereas discrete circuits have to be ac-coupled to accommodate differing thermal effects.



5. Stereo hybrids. Fisher Radio uses two hybrid ICs made in Japan for power functions. At right is the same assembly before the introduction of the hybrid circuits into the design.

The attitude toward ICs at Rank-Bush-Murphy Ltd., another major TV set maker, is slightly different from BRC's. R-B-M uses two chips that between them carry out nearly all the color decoding functions. These chips are designed by R-B-M engineers and made by Plessey Ltd. In the late 1960s, when R-B-M decided to use ICs, there were no standard chips available. Better performance, primarily greater stability and reliability, was the stimulus, rather than savings. Cyril Ward, development projects manager at R-B-M's Plymouth plant, says that the company may continue to design its own chips for future sets, though with so many standards available now, it's less likely than before.

R-B-M now uses an off-the-shelf sound intercarrier IC in all sets, while in its monochrome sets it uses the Motorola sync detector and the TI sync-line oscillator jungle.

Audio IC creates new radio

Eddystone Radio Ltd. has begun marketing a high quality a-m/fm stereo receiver that would not be available on the consumer market without ICs. Eddystone, subsidiary of Britain's GEC, is mainly a maker of professional communications equipment and has used professional techniques and top quality components to make a portable receiver designed to perform under arduous conditions.

There are four integrated circuits, one each in the a-m i-f, the fm i-f, the fm stereo decoder and the output circuit. The first three devices are standard RCA products, and the latter is a Mullard product.

Richard Carroll, managing director, says ICs are used because the alternative discrete component receiver would be so complex and expensive that it would not be practicable. Carroll adds that Eddystone has used the same ICs for some time in professional communications equipment, so there were no developmental bugs to work out in the consumer product that followed.

Part 2: TV and audio ICs

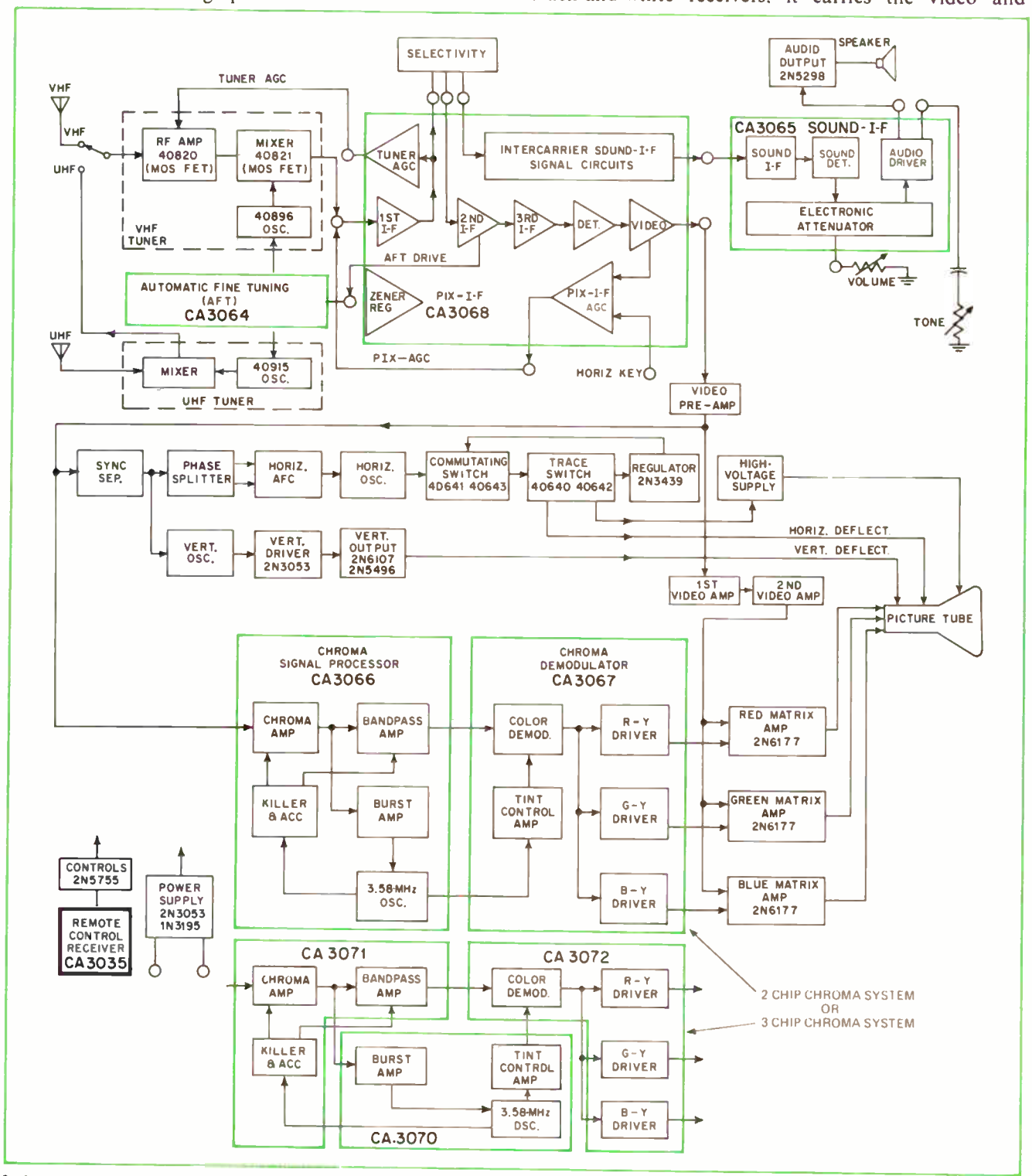
The rush of TV manufacturers to incorporate the new IC designs into their sets is well underway. In fact, all the small-signal functions in the TV set can now be satisfied with ICs—automatic fine tuning, video and sound i-f, video signal processing (called a jungle circuit be-

cause it contains a hodgepodge of diverse elements), and the chroma system (signal detector and demodulator).

Only the front-end receiver and the high-power deflection circuits at present still require discrete components, to supply the former's sensitivity and low distortion and the latter's high power.

Because different TV manufacturers partition sets differently, IC manufacturers have built different circuit versions for every functional-block area. For example, the partitioning method shown in Fig. 6 could be used in a top-of-the-line color set. Key to this partitioning approach is the use of a single chip, designated the CA3068, which supplies the entire video i-f function block.

Developed by RCA and applicable to both color and black-and-white receivers, it carries the video and



6. Layout. Partitioning scheme for color TV set has six ICs performing all small-signal functions. Recently developed is a single-chip sound channel, and under development is a one-chip chroma section (two- and three-chip chroma sections are shown).

sound channels from the front-end mixer stages all the way to the sound and video detector and amplifier stages. In the process, it performs video i-f amplification, video linear detection, video output amplification, automatic gain control from a keyed supply, age delay for tuning, sound carrier detection, sound carrier amplification, and buffeted automatic frequency tuned output. All this is available in a standard 20-lead quad in-line plastic package, with wrap-around shield to minimize interlead capacitances.

Figure 7 gives a functional block diagram of the 3068. One of its innovations is an isolated zener reference diode providing a convenient means for controlling the regulated voltage supply. Also key to the design is its wide bandwidth capability (10 to 70 MHz) and high over-all gain (87 decibels)—specifications that make this chip equally suitable for many a-m i-f applications.

The chroma section of the TV set offers another opportunity for IC implementation, and in fact color TV receiver design indicates a rapidly changing trend toward ICs to supply this function. As shown in Fig. 6, two schemes are generally used: a two-chip and a three-chip partitioning scheme.

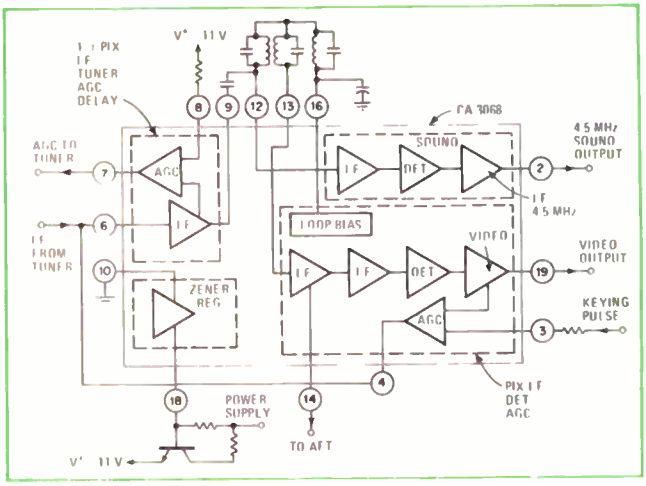
A recently developed circuit, the RCA CA3067, demodulator, is intended specifically for the two-chip chroma system. Its design guidelines took into account the set manufacturers' growing preference for a red-green-blue (RGB) receiver system instead of a color-difference (CD) system.

The chip, which is supplied in a quad in-line 16-lead plastic package, provides the following color demodulator circuit functions: amplification, balanced chroma demodulation (where chroma means sidebands of the modulated chrominance subcarrier), dc-operated tint (phase) control, and zener-diode voltage regulation. A phase-shift circuit is included for tint control, a limiting amplifier eliminates the need for amplitude modulation of the reference subcarrier, and a preamplifier circuit boosts the subcarrier signal before it's injected into the balanced demodulator. Most important, because rf filters are provided on the chip to remove the high-frequency products of demodulation, external filtering is unnecessary.

In addition, the output amplifier for each of the color-difference signals contains a feedback emitter-follower arrangement to keep the output impedance low during both the positive and the negative peak signal swings of the output stage. This arrangement assures sufficient drive capability for the high-voltage output transformers of present color systems, yet doesn't produce degradation of bandwidth characteristics, even when signal amplitudes are at peak values. The circuit can drive either an RGB or a CD circuit, making it very adaptable indeed for TV applications.

The basic connections of the 3067 for an RGB system are shown in Fig. 8. The chip's output amplifiers are directly coupled to the RGB output amplifier circuits. Regardless of dc bias considerations, it is always necessary to control the output drive level to obtain proper gray-scale tracking. This control is accomplished by adjusting the relative gains of the RGB amplifier, varying either the emitter or the collector resistors.

Another recently developed color-processing circuit,



7. Blockbuster. This video i-f function block (RCA's CA3068) is typical of the degree of integration being provided at low cost for consumer applications. Though it was designed for TV, its wide bandwidth and high gain are suitable for a-m i-f applications.

Motorola's MC1398P, was designed to replace the six to 10 discrete transistors now used in some TV sets to provide that function. The 14-lead package comprises a chroma i-f amplifier with automatic chroma control, a color-killer circuit, and an injection lock reference system. This last system generates the required chroma subcarrier reference signal by pulling a crystal oscillator into phase with the reference color burst. The IC also has an internal feedback oscillator that locks into phase only at a threshold level of 200 microvolts or more, thus providing greater noise immunity than was generally available in this type of circuit.

Another feature of the 1398P is the use of dc control circuitry for hue and chroma amplitude adjustments. This obviates the need to generate high-level ac signal levels, which require lossy shielded cables from the front panel to the circuit board. As a result, the manufacturer is given greater freedom in circuit mounting, a particularly useful asset for remote control sets.

Not all roses

However pleased the IC manufacturers are in general with their new relationship with the TV set makers, one aspect of it gives them pain: the growing demand that they, the IC manufacturers, participate in new set warranties. It's no secret that, as a sales leverage, the set makers want to use the increased reliability that ICs offer to extend their warranties—now typically one year (parts and labor) but as high as two years for some top-o'-the-line sets.

The problem from an IC manufacturer's point of view is not unwillingness to absorb the cost of a defective part, but that he is being asked to share in the labor costs of replacing the part as well. That could mean a significant portion of a $20 to $30 parts-and-labor charge.

Right now the situation is at a standoff—the set makers pressuring the IC vendors, and the IC vendors resisting the pressure. But as set makers use more ICs, the orders will go up into the millions of dollars, and resistance will be harder to maintain.

In the 1398P, a Schmitt trigger provides hysteresis action which squelches the chroma output during monochrome or weak color broadcasts—a color killer provision normally not found in many chroma processing circuits. Providing 40 dB of chroma gain with an agc range of 23 dB, the 1398 can be mated to any one of the typical chroma demodulators now available, such as the MC1326, to complete the entire chroma system.

The jungle

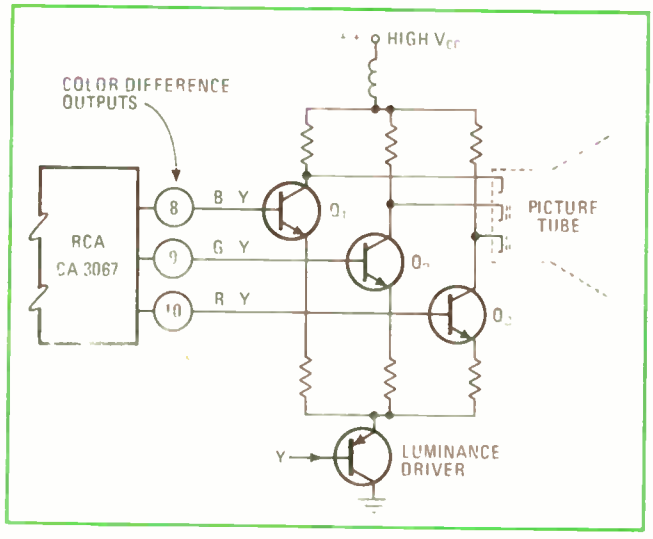
Many TV manufacturers found that, after they had integrated many of the standard circuit functions, a block of miscellaneous circuits was left over. This gap is now being filled by jungle circuits—single-chip function blocks that include any of the small-signal functions not already integrated. For example, one popular jungle circuit, Motorola's MC1345P, provides sync separation, noise inversion and age keying, amplifying, and delay. In some sets it replaces at least four transistors and the passive components associated with them.

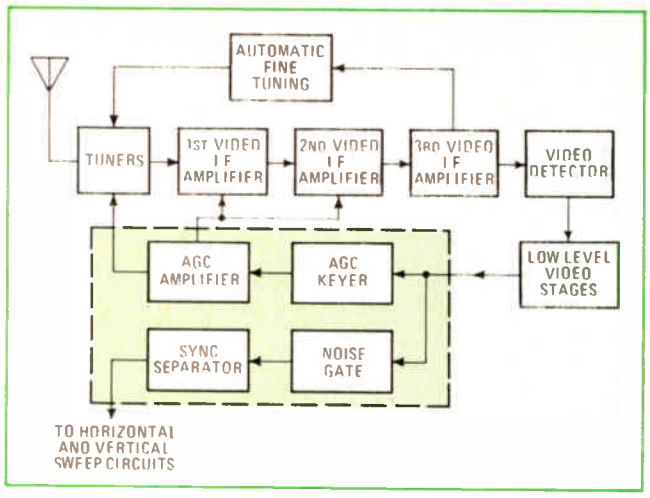
The chip provides a 10-volt range of either positive-or negative-going age voltage and a 16-V peak-to-peak sync output for horizontal and vertical sweep circuits, as shown in Fig. 9. The noise inversion circuit prevents noise pulse from being misinterpreted as a sync pulse. The noise threshold may be externally adjusted with an appropriate resistor value, while the maximum blanking interval for very long noise pulses is determined by an external capacitor. Thus jungle circuits become an integral part of the video i-f function described above.

One-chip sound channel

Perhaps the function that has benefited most from integrated-circuit techniques is the TV sound channel. The last few months have seen the introduction of chips capable of providing an entire sound channel, from the small-signal sound detector coils to the terminals of the speaker. Both Sprague and National now offer complete

8. Making colors. In a typical chroma section, the outputs of the color demodulator chip (RCA's CA3067) are coupled directly to the RGB output amplifier circuits





9. Remainders. Miscellaneous small-signal functions not integrated elsewhere are put on a single chip called the jungle—and everyone's making it. Motorola's jungle circuit (MC1345P), for example, provides sync separation, noise inversion, agc keying, and delay.

sound-channel chips, with the other semiconductor manufacturers not far behind.

A block diagram of the Sprague circuit, a 2-watt sound channel called the ULX2211, is shown in Fig. 10a. The basic sound system is composed of five blocks: the limiting amplifier, fm detector, gain control, audio pre-amplifier, and output amplifier. The limiting amplifier and the detector characteristics determine the sensitivity of the system, and are adequate to detect audio signal levels of all existing TV set designs. Note, too, that the device provides 2 to 3 W of output power, sufficient to drive any of the speakers currently in use in today's sets.

Key to the integration of the output amplifier was Sprague's use of ion implantation for the high-resistivity structures (up to 50 kilohms) needed to build output transistors. It is Sprague's contention that the normal diffusion methods are inadequate for creation of high-power monolithic devices in minimal chip areas. The use of implants, however, does allow fabrication of these high-resistance elements in smaller spaces. Moreover, they have tighter tolerances (typically well within ±10%) than normal diffused resistors (±30%). And as only one extra masking step is needed for implanted resistors, processing costs are only slightly raised.

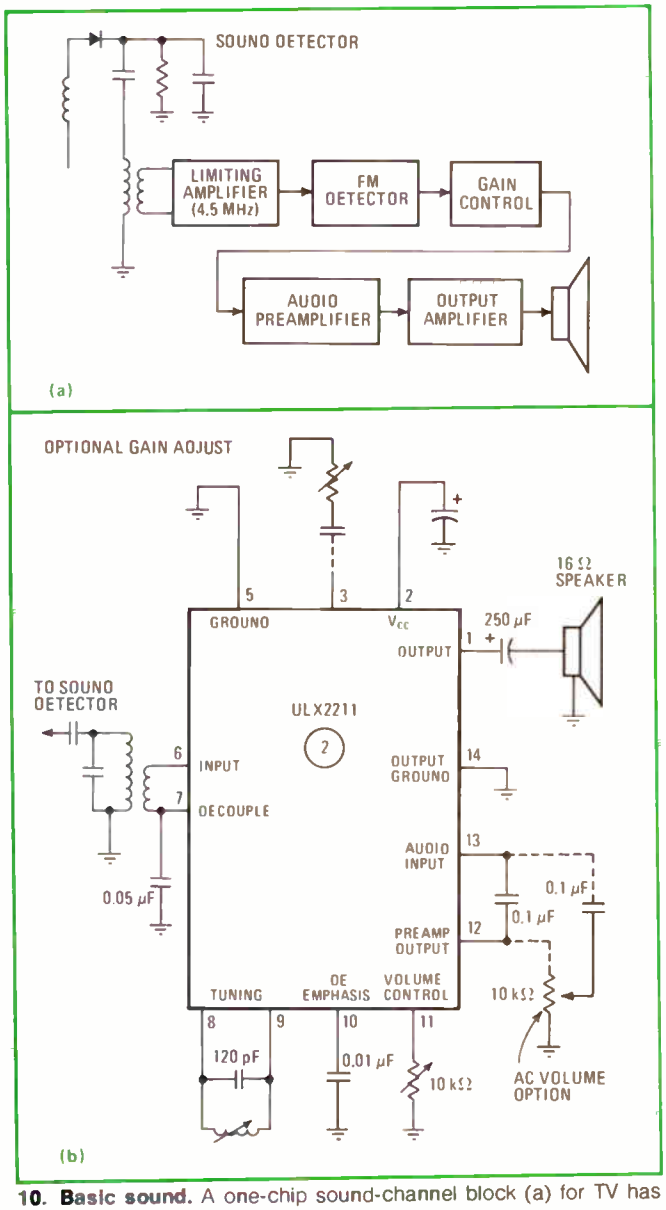
Figure 10b shows the 2211 used as a complete sound section of a TV receiver. This schematic shows that a minimum of external components is required for basic operation. What are needed are a tuned circuit, a volume control potentiometer, an ac volume control option, and an optional gain adjustment. The tuned network could simply consist of an external LC network, say, 120 picofarads and 12 microhenries, to provide the correct resonant frequency.

Since it may be necessary in some applications to decouple the dc control to eliminate buzz pickup from the vertical sweep, an ac volume control is provided as an option. Finally, the output is coupled through a electrolytic capacitor of approximately 200-μF to a 16-ohm speaker load. A small RC network is usually required to damp out the inductive action of the speaker coil.

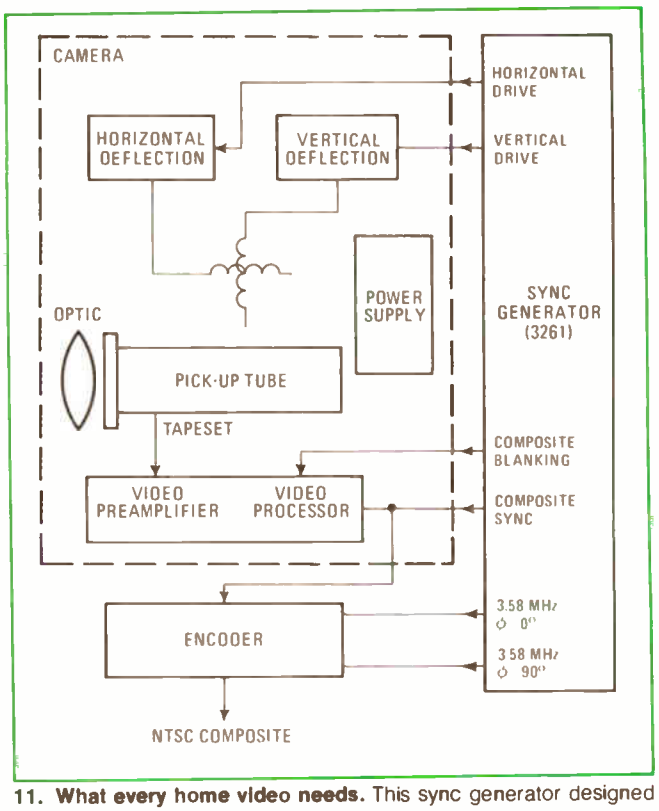
In addition to encompassing the complete sound sys-

tem for a TV receiver, the 2211 with a little help—a tuner, two ceramic filters and a few external components—can also be used as a "one-chip" fm receiver. Such a receiver would provide a sensitivity of about 10 to 20 microvolts. Automatic frequency control can be provided by properly filtering the detector output (pin 10) and using it to control the tuning diode.

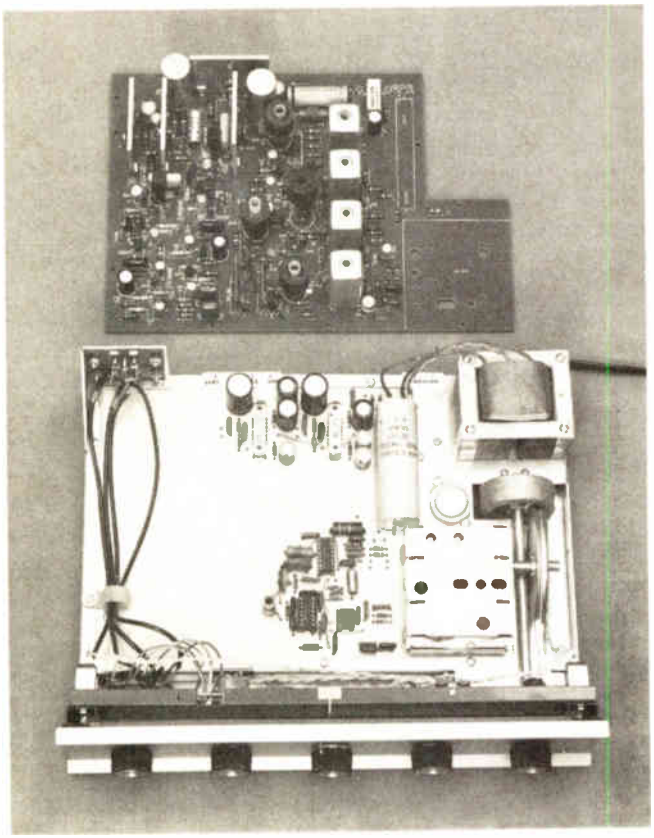
National's single-chip TV sound system, catalogued as LM1805, also combines good low-threshold performance and a-m rejection characteristics over more than three decades of input levels, with an output capability of 2 to 4 W. Like the Sprague circuit, the 1805 offers dc volume control, and has a 20-microvolt sensitivity and a-m rejection of 50 dB typically. Significantly, it requires only one tuning element, making set alignment at the factory very easy. The major difference between the National and Sprague circuits is that the former employs a differential-peak-detector, the latter a quadrature detec-



10. Basic sound. A one-chip sound-channel block (a) for TV has limiting amplifier, gain control, audio pre-amp, and output stage capable of 2 to 5 watts. The schematic (b) shows minimal external circuitry. Called the ULX2211, it's made by Sprague.



11. What every home video needs. This sync generator designed for low-cost portable and home video color sets, is Fairchild's μA3261. It provides complete horizontal and vertical sync functions: color subcarriers, horizontal drive, color burst flag, and blanking.



12. Wide open spaces. Using a PLL decoder in a stereo set eliminates tuning coils and therefore cuts back even more on board space. The Heath chassis (bottom) has a Fairchild PLL decoder, while the one above has the conventional tuning circuits.

tor. Quadrature detectors generally require higher-level signals than differential peak detectors.

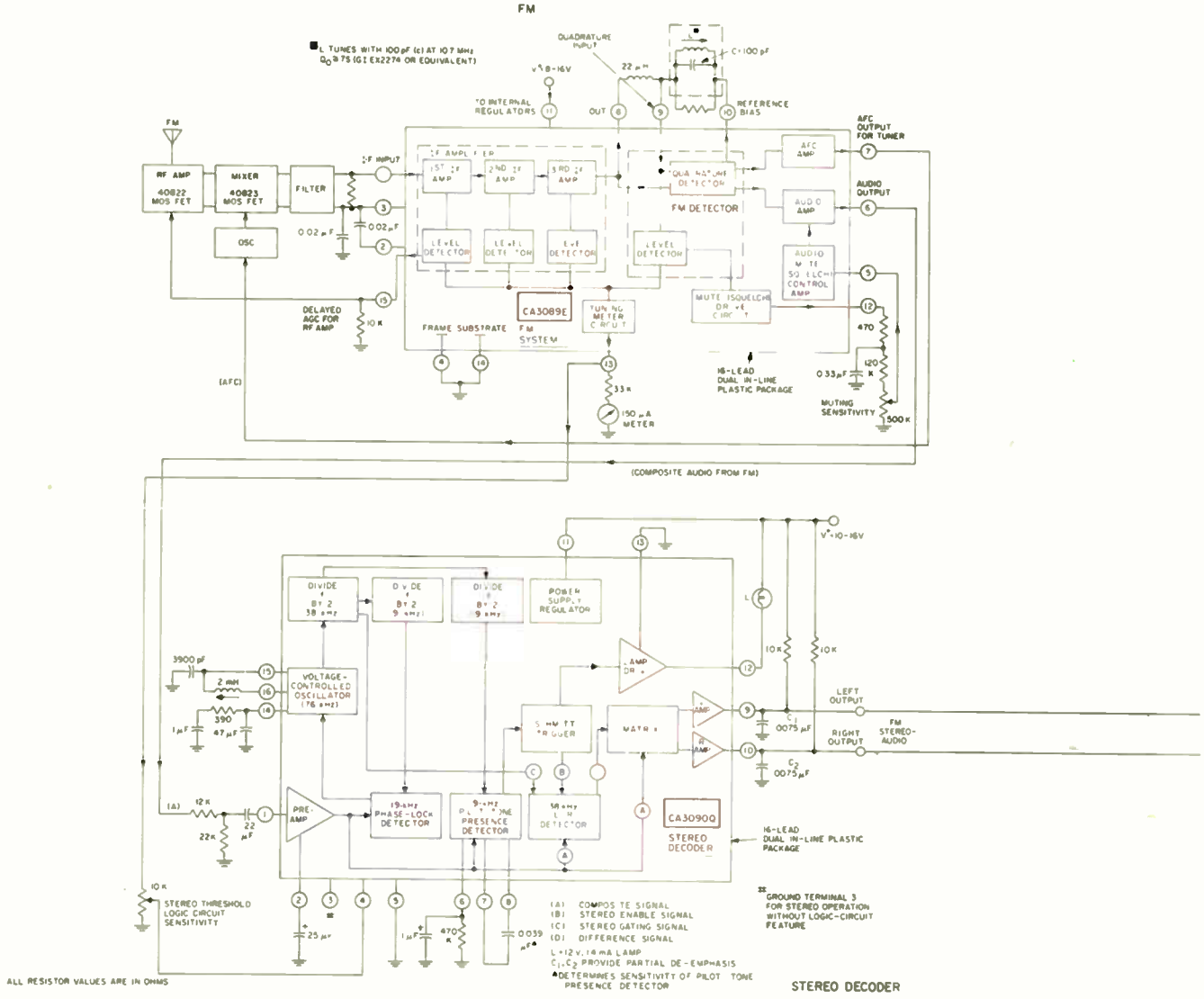
Conscious of the growing demand for small portable color TV sets, particularly those used with home video systems, Fairchild has designed a low-cost color TV sync generator on a single chip. Designated the μA3261, it provides a complete horizontal and vertical sync function (see Fig. 11). The circuit operates off a two-phase 14.31818-MHz clock, and supplies the 0° and 90° color subcarriers, the horizontal drive signal, the color burst flag, a composite sync signal, composite blanking, vertical drive timing, and odd and even frame indications.

If TV represents the greatest dollar value in consumer ICs, audio represents the greatest amount of new circuit activity. Indeed, at the recent consumer show held in Chicago, by far the greatest number of new products introduced was in the audio area.

Audio: starting to be heard

Because many of the top-of-the-line audio equipment manufacturers want to use a monolithic input stages in much of their equipment, both to improve reliability and to lower costs, IC manufacturers have become increasingly eager to produce suitable low-noise amplifiers. Until now, however, these amplifiers, although providing sufficient gain, introduced unwanted noise, forcing customers to stay with discrete-transistor circuits. Two new monolithic circuits from National, the LM381 and LM382, seem to have turned the trick, offering high gain along with low noise. Both operate from a single voltage of anywhere from 9 to 40 V dc, while an internal supply decoupler regulator provides 120-dB power supply rejection.

Because of this rejection, the LM381 is ideal for use with equipment that must work from low-level inputs, such as those from magnetic tape heads and phonograph cartridges. It has a total equivalent noise input of only 0.5 μV/rms, which is not only better than anything else available in integrated form, but equals or surpasses the noise figure of the best discrete circuits found



13. Decoding stereos. The block diagram of the RCA stereo decoder is shown at lower left in schematic of radio set. In addition to its decoding function, the CA3090 provides automatic stereo switching and lamp indicator signals. The schematic shown is for the circuit being used in RCA radios presently in production, because it offers high tuning reliability in a small space.

in top-of-the-line stereo equipment. Gain of the 381 is 112 dB. The small-signal bandwidth is 15 MHz, and power bandwidth is 75 kHz. Other features include a total harmonic distortion of typically 0.1% at 75 dB gain point, and channel separation of typically 60 dB.

The LM382 dual preamp is similar to the 381 except for a slightly higher noise—0.8 μV/rms. Technically, the major difference between the two is that a resistor matrix on the 382 chip allows the user to select a variety of closed-loop gain options and frequency response characteristics for either tape or record compensation.

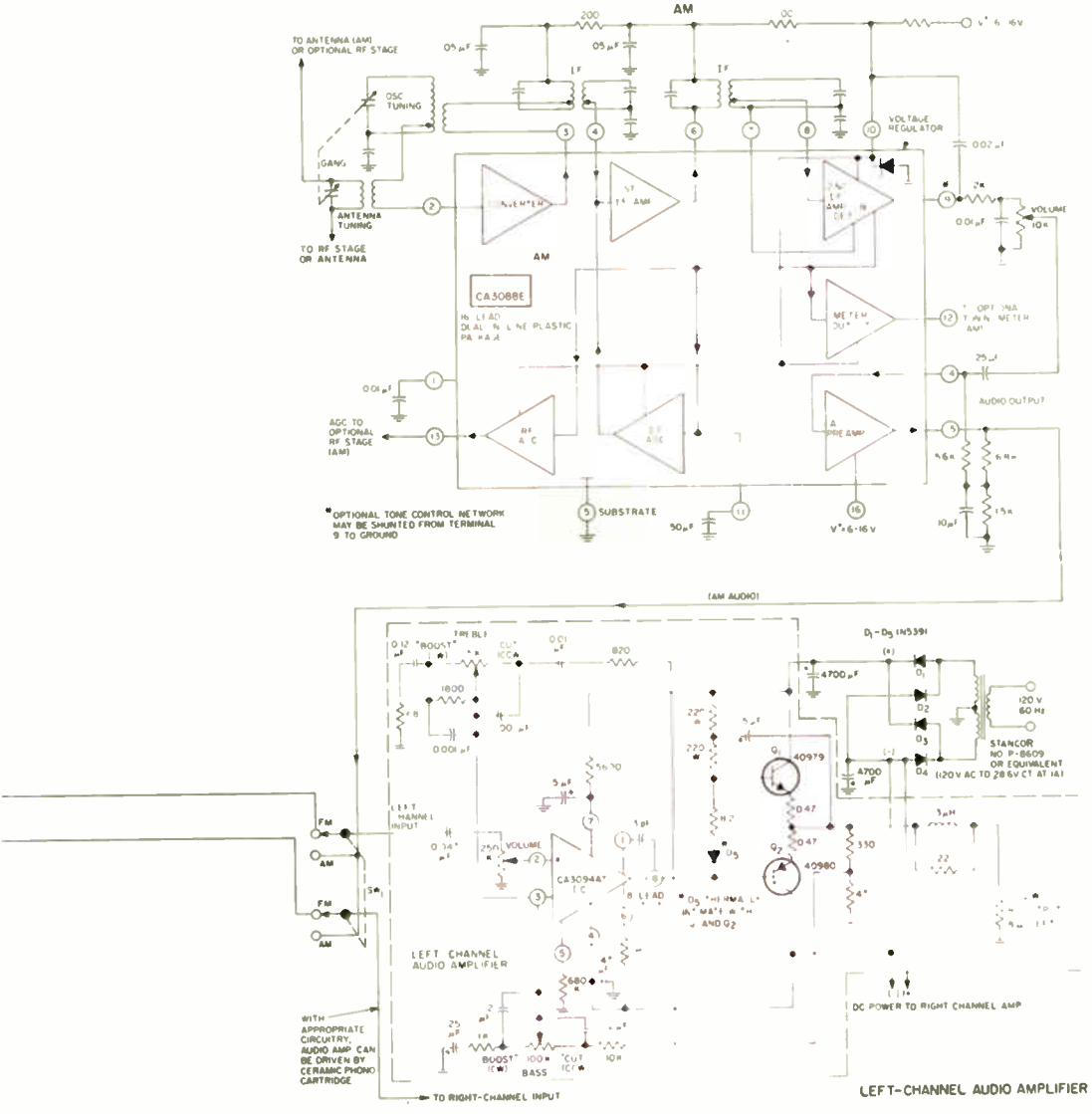
Phase-locked loops in stereo

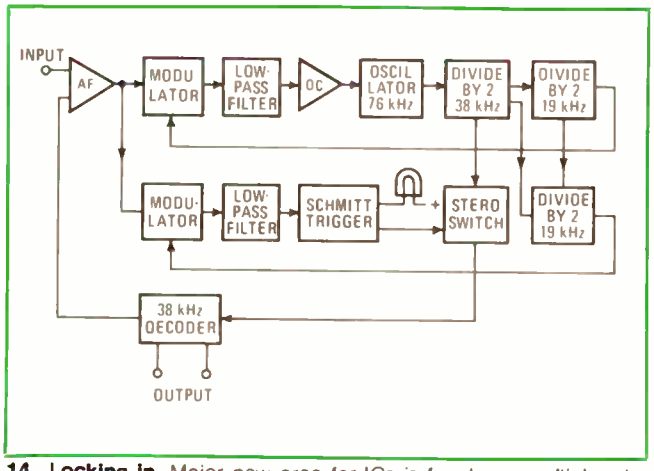
Phased-locked-loop (PLL) systems have been used for many years in other forms of consumer entertainment equipment, for example, in black-and-white TV receivers for horizontal sweep sychronization and in color TV receivers for regeneration of the chroma subcarrier. Only recently, however, has the PLL concept been successfully applied to fm stereo multiplex signal decoding. New PLL decoders have now appeared from many IC manufacturers, including Fairchild, Motorola, RCA, Sprague, and National.

These PLL decoder ICs offer the high performance demanded by high-fidelity stereo component equipment at a cost that most builders of fm stereo receivers can manage. Moreover, with such monolithic decoders, no tuning coils are required, and the total parts count for the decoder function is reduced by almost an order of magnitude.

In any fm stereo multiplex decoder, it's necessary to reconstruct the 38-kHz subcarrier present in the encoding equipment. Earlier decoders either doubled the 19-kHz pilot tone or used it to lock the 38-kHz oscillator. The problem was that both techniques require at least one, but more commonly two, selective 19-kHz signals to extract the pilot from the composite signal. In addition, a 38-kHz-tuned circuit is needed either to separate the 38-kHz subcarrier from the pilot in the doubler system or to establish the oscillator frequency for the injection lock system. Critical phasing is required for good separation, making the alignment of these tuned circuits critical and not easily obtained in large-volume circuits. Temperature and aging affect the drift characteristics of coils, further degrading long-term performance.

A PLL decoder announced recently, Fairchild's μA758 is one chip that eliminates this problem by doing away with the need for coils. Its PLL method of regenerating the 38-kHz subcarrier produces a signal with a phase accuracy limited only by the loop gain of the system and





14. Locking in. Major new area for ICs is fm stereo multiplex decoder that uses a phase-locked-loop circuit. Block diagram of Motorola's 1310 shows the principal parts of the circuit: the PLL sub-carrier regenerator and the stereo demodulator.

by the stability of the free-running oscillator frequency. Because the phase-locked-loop aspect of the 758 automatically provides for this phase accuracy, both the subcarrier and its phase can be easily controlled. In addition, the 758 system operates over the extreme temperature range encountered in the automobile radio environment, adding another potential application.

Figure 12 is a photograph showing two chassis manufactured by Heath Co.—the bottom one has the Fairchild 758 stereo decoder, the other has conventional tuning. Note the significant reduction in chassis space offered by PLL stereo decoding.

Motorola's PLL stereo decoder, type MC1310, also eliminates coils by employing the PLL principle to lock onto the 19-kHz pilot signal provided by the stereo broadcaster, creating a signal which is in phase with the pilot signal and of exactly double the frequency. Again, this 38-kHz subcarrier is then used to demodulate the stereo information.

A block diagram of the 1310 (Fig. 14) shows its two principal components, a phase-locked-loop subcarrier regenerator and a multiplier-type stereo demodulator. A stereo/mono switching circuit is provided to disable the decoder during monaural broadcasts or weak stereo broadcasts. This switch also controls a lamp driver that employs 6 dB of hysteresis to avoid flickering of the stereo indicator lamp caused by variations in signal level. As an example of the specs available in these circuits, the system gives stereo separation of 40 dB at 1 kHz, with total harmonic distortion typically 0.3% for a 560-mV level of composite input.

RCA's stereo multiplex decoder, which the company introduced about a year ago, operates with only one low-inductance tuning coil, and therefore needs one adjustment for complete tuning. The device, designated CA3090Q, can operate from a wide range of power supplies (10 to 16 V) and provides automatic stereo switching and stereo indicator lamp energization.

Figure 13 shows a block diagram of the decoder (lower left) as it would appear in a complete a-m/fm stereo multiplex audio system; these chips are presently being designed into medium- and top-line RCA radios.

In operation, the input signal from the detector is amplified by a low-distortion preamplifier and then simultaneously applied to both the 19-kHz and 39-kHz synchronous detectors. A 76-kHz signal, generated by a local voltage controlled oscillator (VCO), is divided down to a 38-kHz signal and to two 19-kHz signals in phase quadrature. The 19-kHz pilot tone supplied by the fm detector is then compared to the locally generated 19-kHz signal in a synchronous detector. The detector output controls the VCO output so as to phase-lock the stereo decoder with the pilot tone.

A second synchronous detector compares the locally generated 19-kHz signal with the 19-kHz pilot, and if the pilot tone level exceeds an externally adjustable threshold voltage, a Schmitt trigger circuit is energized. The signal from the trigger lights the stereo indicator, enables the 38-kHz synchronous detector, and automatically switches the circuit from monaural to stereo operation.

As shown in the schematic of the audio system, the output of the 38-kHz detector and the composite signal from the preamplifier are applied to a matrixing circuit from which emerge the resultant left and right channel audio signals. These signals are then applied to their respective left and right post amplifiers for amplification to a level sufficient to drive most audio amplifiers.

Integrating power: new audio game

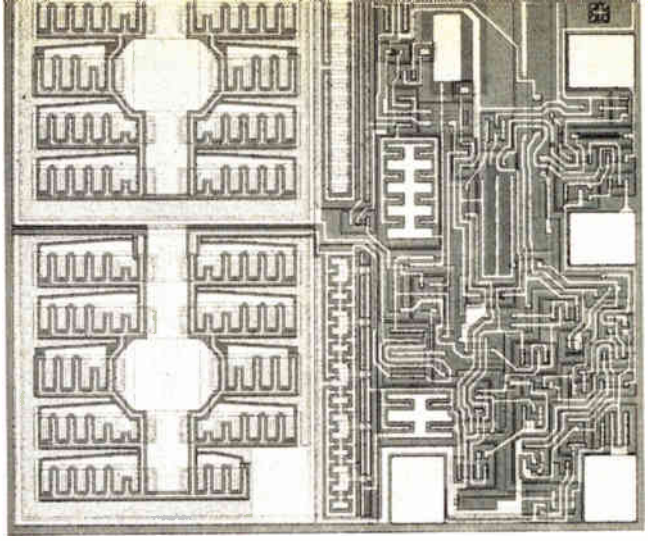
Another barrier lately overcome by the IC manufacturers is the integration of power, at any rate in the under-5-watt region. Most manufacturers now have monolithic power amplifiers ranging from 2- to 5-W outputs, and are working on 10-W capability. These devices are suitable for radio and TV receiver applications, as well as industrial audio applications requiring high-power and low distortion.

Fairchild's μA706 audio power amplifier (see p. 157 for more details) is an example of the high-output capability of these new circuits. It is suitable for applications in audio systems operating on 14-V nominal supplies. At this voltage the 706 can deliver 5.5 W continuously to a 4-ohm load. A unique feature of the device is its self-biasing capability and at any supply voltage from 6 to 16 V, making the amplifier very desirable for automotive and portable audio applications.

To attain a power of 5 W, not only must the drive circuit limitation be overcome with bootstrapping techniques, but voltage swing limitation due to the saturation resistance of the power transistors must also be overcome. Fairchild therefore uses a special diffused collector sinker, formed by a highly doped well that creates a low-resistance path for the collector current.

High-power amplifiers require heat sinks, and to meet this demand most manufacturers use a modified plastic dual in-line package with a copper heat sink. In addition, the user has the option of soldering a copper bracket to the top of the device, to serve as a mechanical support as well as an additional path to a heat sink.

The power amplifier line introduced by National at the beginning of the year includes a 2-W audio ampli-



15. **Power to the people.** New ICs capable of 2- to 5-watt audio outputs make low-cost power circuits available for radios, including auto designs. For instance, this chip from National, the LM383, can deliver 5 watts into a 4-ohm load at 14-volt supply.

fier, the LM380. The company is also about to bring out a 2-W-per-channel dual power amplifier (LM377), a dual 4-W-per-channel (LM378) and a single-channel 5-W amp (LM383). In addition, National is planning very soon to produce a single 10-W device, which will be the highest-power-output integrated amplifier commercially available.

The dual 2-W and 4-W stereo amplifiers are designed for stereo phonographs, tape players and recorders and a-m and fm receivers. The LM377 delivers 2 watts per channel into 8-ohm speaker, while the LM378 will deliver 4 watts per channel into a 16-ohm load. Both devices contain an internal bias regulator to bias each amplifier and yield 80-dB supply rejection. This high power-supply rejection spec makes these amplifiers strong contenders for the quality audio market.

For higher power applications, National's 5-watt amplifier chip, the LM383 (Fig. 15), is similar to Fairchild's μA706. The device delivers 5 W rms into a 4-ohm load at 14-V supply.

Like National, Sprague Electric has several new audio ICs in the works: a 2-W audio amplifier (ULX2277), designed primarily for TV; a dual 4-W-per-channel device (ULN2276); and two 5-W single-channel units (ULX2205) and (ULX2285). The 2277 (Fig. 16) delivers a full 2 watts continuous power per channel, and can be operated over a very large voltage supply range—9 to 30 V. Available in 8-lead plastic packages with two heat sink tabs, it is designed for use in stereo phonographs, a-m/fm and stereo receivers, auto radios, tape players and recorders, intercoms and motion picture projectors.

Texas Instruments has recently got into the audio power game by adding two amplifier ICs to their consumer line—a 1-W and a 4-W chip. Like the other IC makers, TI is aiming these circuits at the entertainment market, but other applications such as servo drivers and communication systems could use them also.

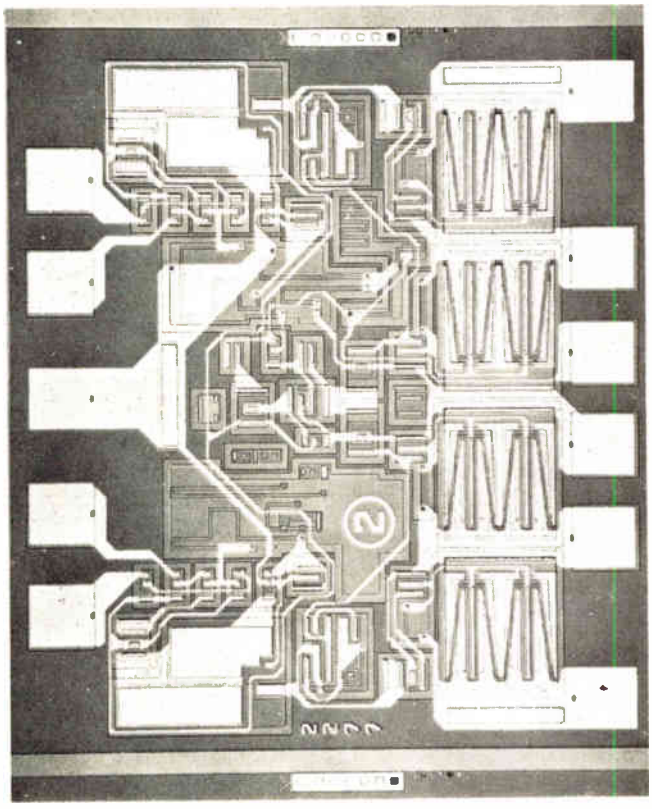
Both the 1-W (SN76011) and 4-W (SN76024) circuit are suitable for low-cost systems. They deliver their power into an 8-ohm load with maximum harmonic distortion of less than 5%. With a high peak output current of approximately 1 ampere, they can be used with low load impedances, such as those found in automobile speakers. Their ability to operate over a supply voltage range of 4 to 13 V further encourages this application.

Along with its TV IC activity, Signetics is presently concentrating its efforts in audio on an IC version of the Dolby "B-type" circuit. This is a noise-reduction circuit for sound equipment that is used, for example, to reduce tape hiss in quality audio transmission. Signetics has been licensed by Ray Dolby, inventor of the circuit, to develop an integrated version. Discrete versions of the system are presently being used by Decca/London, Columbia, RCA, EMI, Philips, and others.

The Dolby IC from Signetics, which will come in a 16 pin package, will reduce a manufacturer's assembly costs. For example, the only other parts each channel of a basic tape deck will require, in addition to the Dolby IC and associated components, are an equalized playback preamplifier capable of meeting the Dolby input spec of 30 mW, an equalized record amplifier, and a bias and erase amplifier. No output amplifier will be necessary.

Another push in the audio area is to the integration of the i-f portion of fm receivers. Signetics, for example, is soon to announce a phase-locked-loop audio chip that performs the entire i-f limiter and f-m demodulator function. Catalogued the 563, this chip will come after the front-end input preamplifier, and deliver demodulated fm to the output stages. Significantly, no external adjustment will be necessary other than setting the VCO in the PLL circuit. □

16. **Double dealing.** Dual-channel audio power amplifiers are now available in IC form in the 2- to 4 W range. This Sprague device, the ULX2277, which can operate over a wide supply range (9–30 V), provides 2 W per channel, and is suitable for auto applications.



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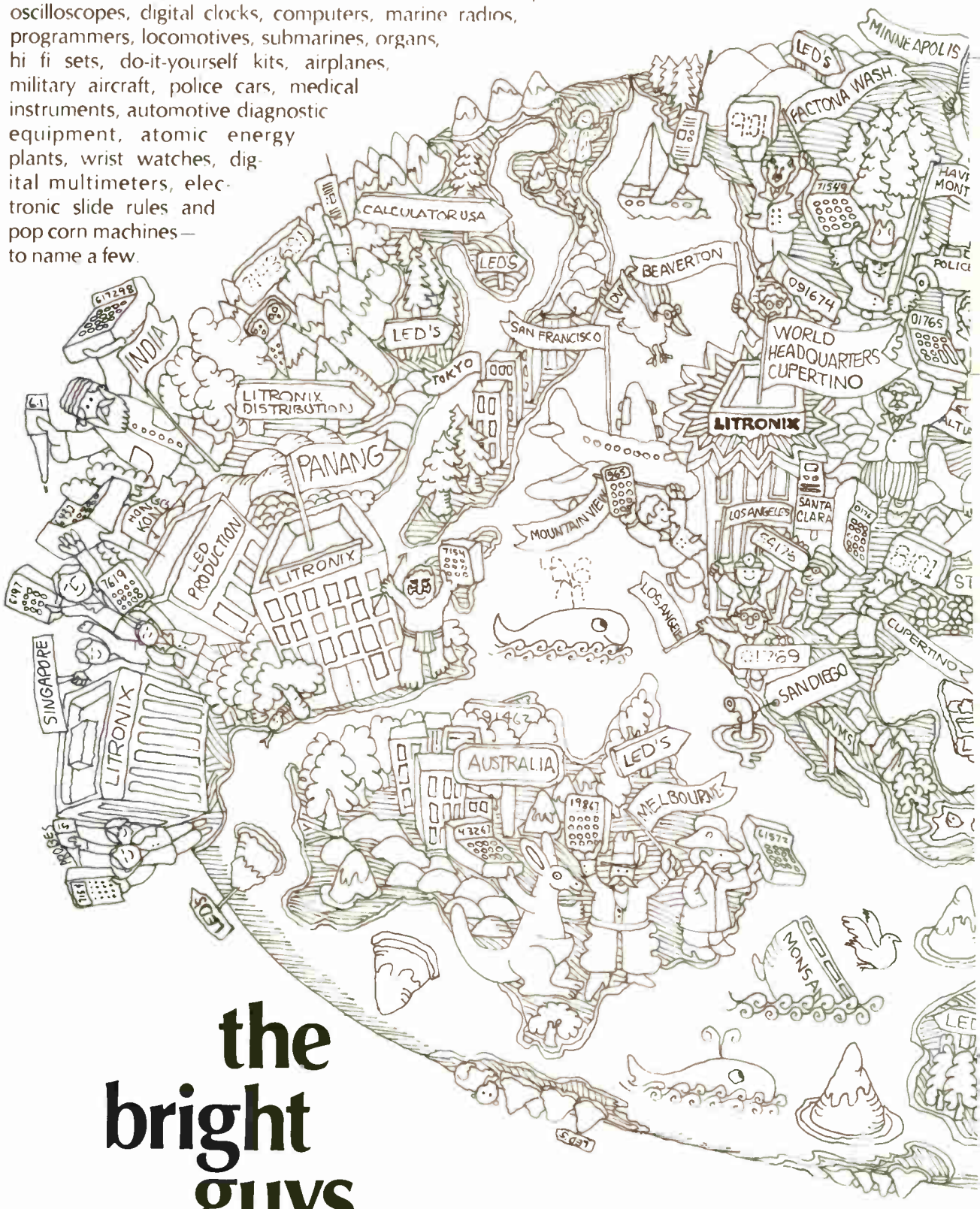

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Designer's casebook

Logic driving gates double as d-a converter switches

by Amos Wilnai
Monolithic Memories Inc., Sunnyvale, Calif.

The design of a weighted-resistor digital-to-analog converter can be simplified by using the gate that supplies the digital input data as a switch. This approach permits a high-resolution converter to be built with standard open-collector logic. With 1% resistors, five-bit resolution is possible; tightening the tolerance to 0.1% can provide seven-bit resolution on selected units.

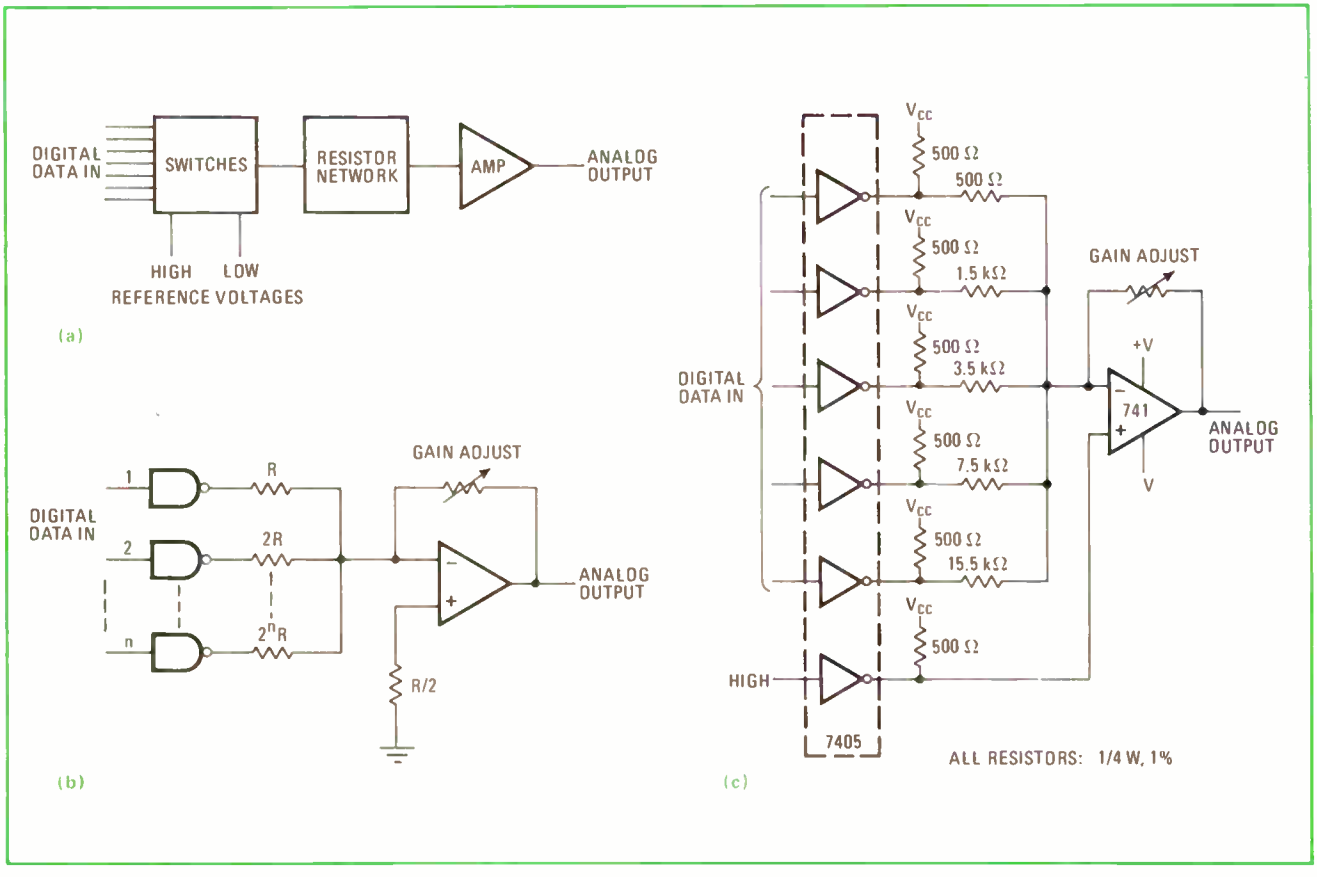
A d-a converter (a) usually contains input switches, a resistor network, and an operational amplifier that provides gain and a low-impedance analog voltage output. The digital input data is generally supplied at standard logic levels—for example, at transistor-transistor-logic levels or diode-transistor-logic levels. Logic gates driving the converter can therefore be used as its input switches (b).

Individually packaged gates, however, limit output word length to about two to three bits because of the marked gate-to-gate variation in logic low and logic high output levels. A TTL high, for instance, is guaranteed to be between 2.4 and 5 volts, while a low lies between 0 and 0.4 V. Output resistance also varies considerably from unit to unit. Excellent voltage-level tracking can, however, be obtained by using gates that share a common substrate if they are operated under the same load conditions. A five-bit converter (c) can be built with an open collector hex inverter performing the input switching function.

When the outputs of the open-collector gates are low, each gate has a load impedance of 500 ohms, and the collector-emitter saturation voltages of the gate output transistors are within millivolts of each other. When the outputs are high, each output transistor is off and the resistor network is referenced to supply voltage V_{cc}.

Longer output word lengths can be realized in the same way by utilizing two hex inverter packages. There may be some variation between packages in the low gate output voltage level, but this can be minimized by selecting the two packages from the same lot (by using the date code on the package). □

Let gates do the switching. Basic digital-to-analog converter (a) requires input switching network to interface digital input data. Using individual logic gates (b) to drive and switch converter limits resolution. However, up to five-bit word lengths can be obtained with open-collector hex inverter (c) as driving and switching network. Because inverters have common substrate, voltage-level tracking is good.



TTL gates speed up pulse-height analysis

by Joseph Laughter
University of Tennessee Medical Units, Memphis, Tenn

Being used mainly for analyzing nuclear energy, determining white-noise amplitude, or counting blood cells, pulse-height analyzers require high-speed performance. They are complicated to design with discrete transistors. But with transistor-transistor logic and integrated comparators, fast operation can be realized at a fraction of the usual cost.

Positive dc voltage E_L is the lower limit for a pulse passing from input to output, and positive dc voltage E_U is its upper limit. At the instant the input pulse rises above E_L, lower-level comparator A_1 switches to zero, triggering monostable multivibrator OS_1. The output of OS_1 returns to zero after about 300 nanoseconds and triggers monostable OS_2, sending a 60-ns pulse to the anti-conic gate. The anti-conic gate inverts the pulse and triggers the output pulse shaper (monostable OS_3).

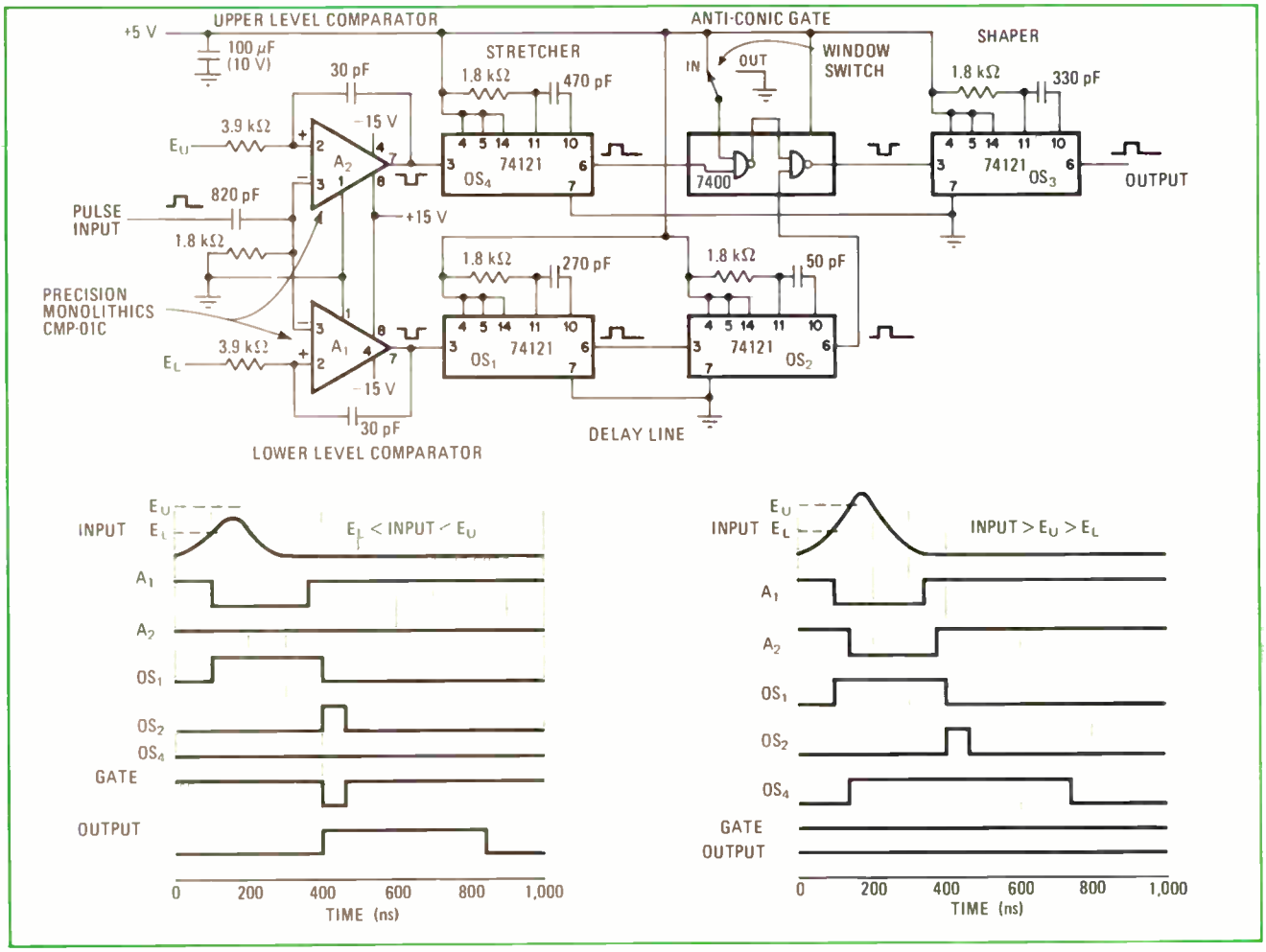
When input pulse height is greater than E_U, comparator A_1 is fired first, and then upper-level comparator A_2 is fired. Once A_2 switches on, the pulse stretcher (monostable OS_4) produces a positive pulse that turns off the anti-conic gate for 600 ns. Therefore, when the pulse from monostable OS_2 appears several nanoseconds later, it is blocked by the anti-conic gate and there is no output. Throwing the window switch to its "out" position disables the anti-conic gate, allowing a pulse to reach the output each time the input pulse exceeds the lower-level limit voltage.

This pulse-height analyzer can accept positive pulses having a maximum rise time of 250 ns and a maximum repetition rate of 500,000 pulses per second. The repetition rate can be increased by using lower-value timing capacitors for delay line OS_1, output pulse shaper OS_3, and pulse stretcher OS_4. However, input rise time requirements become more stringent.

The type CMP-01C comparators can be replaced by the more popular type 710 comparators if the supply voltage is changed from ±15 volts to +12 and −6 v. Although the type 710 is considerably cheaper, it does not perform as well in critical applications.

Timing curves show output wave forms for several important points in the circuit. □

Examining pulse height. Comparators A_1 and A_2 set lower (E_L) and upper (E_U) voltage limits. When pulse height exceeds E_L, one-shots OS_1 and OS_2 slow down pulse from A_1 and transmit it to anti-conic gate, which fires output pulse shaper OS_3. When input exceeds E_U, A_1 and A_2 switch, causing pulse stretcher OS_4 to turn off gate so that pulse from OS_2 cannot reach output. Window switch at "out" disables gate.



Analog voltage sensor controls LED threshold

by Thomas Mazur
Motorola Semiconductor Products, Phoenix, Ariz.

Most light-emitting diodes are found in alphanumeric displays and optically isolated circuits where they are usually controlled, either directly or indirectly, by digital logic systems. Analog LED control circuits can also be useful, provided that distinct light/dark LED transitions can be obtained. The scanning circuit in the diagram employs silicon unilateral switches, which function like four-layer diodes but have a gate control to produce sharp LED transitions for voltage-level sensing applications.

There are N circuit sections, depending on the number of voltage levels to be sensed. Each section consists of a LED, a silicon unilateral switch, a zener diode, a bipolar transistor, and two biasing resistors. The unilateral switch begins to conduct when its terminal voltage reaches a critical level, nominally 8 volts. Once the switch is turned on, its terminal voltage decreases to approximately 1 V.

While switch voltage is increasing, the LED and the transistor's base-emitter junction become forward-biased. LED current, which is limited by the emitter resistor, rises until the unilateral switch conducts. Since the transistor junction and the LED require around 2 V to be forward-biased, the LED shuts off when the switch voltage drops to 1 V.

Whether the switches are on or off, the voltage across the transistors continues to increase with rising input voltage. Because the transistors are separated by zener diodes, each succeeding section operates only after input voltage V_i increases by zener voltage V_Z. Therefore, accurate LED turn-on levels (V_D) can be set and, with the switches providing an abrupt turnoff, incremental control of each LED can be achieved.

Assuming that all the zeners have identical voltage ratings:

$(V_i)_{MIN} = V_{Z1} + V_{EB1} + V_{D1}$

$(V_i)_{MAX} = NV_Z + V_S$

where V_{EB} is transistor emitter-base junction voltage, and V_S is the critical voltage level of the preceding unilateral switch.

The LEDs may be operated sequentially or in an overlapping fashion by varying the type of zener used in each section. For a sequential mode:

V_S is less than or equal to $V_Z + V_{EB} + V_D$

For an overlapping mode:

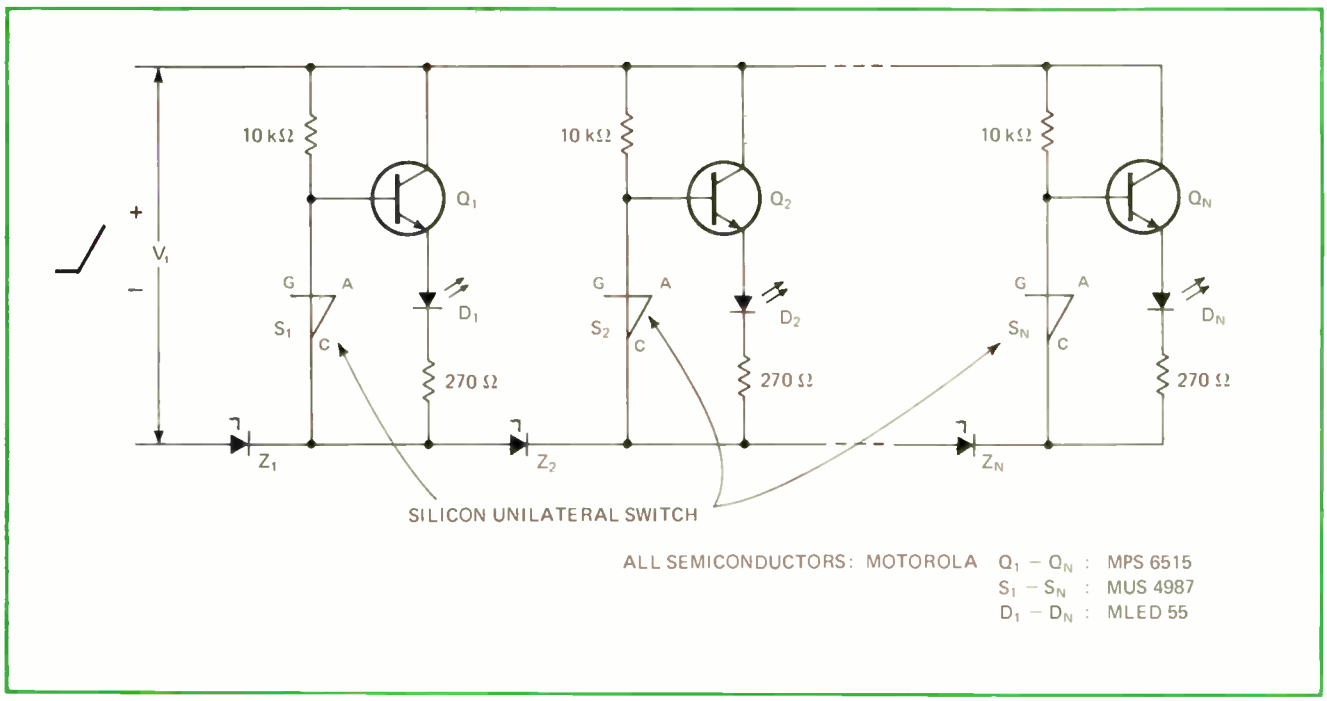
V_S is greater than or equal to $V_Z + V_{EB} + V_D$

In addition, the level of V_S may be reduced by connecting a zener diode between a switch's gate and cathode terminals.

The scanning circuit may be modified to provide highly discernible visual indication by replacing the emitter resistors by constant-current sources. This supplies the LEDs with uniform current pulses, allowing each one to produce a constant light output. Another modification permits the circuit to serve as a data transfer mechanism—phototransistors can be inserted between the LEDs and the emitter resistors so that the LEDs can be optically modulated. □

Designer's casebook is a regular feature in Electronics. We invite readers to submit original and unpublished circuit ideas and solutions to design problems. Explain briefly but thoroughly the circuit's operating principle and purpose. We'll pay $50 for each item published.

LED scanning circuit. Silicon unilateral switches S_1 through S_N require 8 volts to trigger, but only 1 V to stay on. Rising input voltage forward-biases transistor Q_1 and light-emitting diode D_1. LED emits light until switch S_1 conducts; it goes dark abruptly when switch voltage drops to 1 V. Zener diodes Z_1 through Z_N establish voltage levels that are sensed by each section of scanning circuit.



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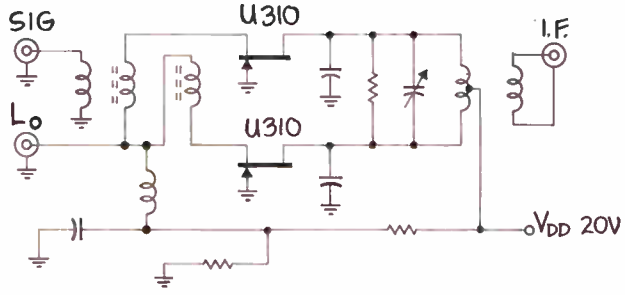

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50-250 MHz Mixer Performance Comparison

Characteristic	JFET	Schottky	Bipolar
Intermodulation Intercept Point	+32 dBm	+28 dBm	+12 dBm†
Dynamic Range	100 dB	100 dB	80 dB†
Desensitization Level (the level for an unwanted signal when the desired signal first experiences compression)	+8.5 dBm	+3 dBm	+1 dBm†
Conversion Gain	+3 dB*	−6 dB	+18 dB
Single-sideband Noise Figure	6.5 dB	6.5 dB	6.0 dB

† Estimated * Conservative minimum

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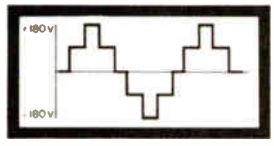

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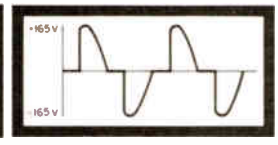

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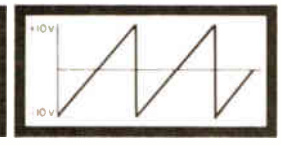

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Improved fault-finding with automatic functional testers

Automatic test equipment is gaining popularity from high labor costs; for complex logic boards, it will yield better fault diagnosis if logic designs are made more testable and if test programs are made more sophisticated

by Michael J. Riezenman, *Instrumentation Editor*

☐ Rapidly, but without the usual fanfare, a major area of electronics technology is coming of age. Automatic testing, which has long been used by big semiconductor houses for testing very large quantities of complex products, is becoming increasingly attractive to an ever growing number of users. In fact, 15% to 20% of all instruments sold today are going into automatic testing systems, according to Robert A. Grimm of Hewlett-Packard Co.'s. Automatic Measurement division.

Economics, as usual, is the key

The reasons for the great and growing interest in automatic testing are the increased complexity of modern electronics products, plus the increased cost of skilled labor. This combination is enough to make automatic test equipment (ATE) economically attractive, despite the often staggering initial cost of such systems.

And staggering is often the word. A "small" automatic tester for, say, the functional testing of digital IC boards is often a $25,000 investment. A fancy multi-station installation, capable of checking both digital and analog equipment, may easily cost ten times that amount. Neither of these figures is for equipment that includes automatic parts handling. Add that, and the sky's the limit.

Because of the high cost of ATE, the purchase of an automated system is not something to be taken lightly. Typically, the decision is made at the level of a vice president or comptroller an interesting challenge for an instrument sales representative.

Why is ATE so expensive? A simple answer is switching and "software." However, Richard W. Van Saun, chief engineer at John Fluke Manufacturing Co. in Seattle, prefers to say that about a third of the cost of a good automatic test system is hardware, the other two thirds is "other things."

Switching, in this context, refers to both the fixture that holds the unit under test (UUT)—typically a printed-circuit board or small subassembly—and the array of switches that feeds stimuli and responses between tester and UUT. Since a tester will almost invariably be called upon to handle a variety of UUTs, the switching matrix must be able to route signals from the tester, and connect measurement gear in the tester, to any terminal on the UUT. The solution to this switching problem is almost always an array of high-quality—and high-cost reed relays.

"Software" is tougher to define. Besides the actual programing, the term is used to refer to all of the careful planning and customer-manufacturer interfacing needed to put a working system into operation. (The automatic testing business, at least for the larger systems, is very much a customized one-of-a-kind type of operation.)

The cost of the actual system operating software is high because it is axiomatic that a product is no sooner designed than an engineering change order is written about it. Therefore, the tester that was purchased to test this new product must be capable of being easily programed and reprogramed to handle all of the changes that are, and are not, expected.

Making it work

The operative word in the preceding sentence is "easily." Test programs that can be changed only after much sweat and toil do not carry a high initial price. But a truly universal user-oriented language requires a package of very sophisticated software to back it up. According to Ernest H. Ehling, vice chairman of the board at Instrumentation Engineering in Franklin Lakes, N. J., the operating software in his company's ATE is every bit as complex as the operating system and compiler in a modern full-scale digital computer. Such a software package takes several man-years to put together and represents a healthy fraction of the value and cost of an automatic test system.

One of the most important applications of ATE today is in the testing of digital logic boards. While some so-called parametric testers are used in this area, most of the work is done by functional ATE. (Parametric testers measure actual electrical parameters such as voltage, current, resistance, frequency, rise and fall times, etc. Functional testers merely verfiy the logic operation of a circuit.) A good functional tester, however, incorporates a great deal of diagnostic capability in its software, so it can do a lot more than merely decide if a board is good or bad.

To get the maximum value from a functional tester, it's a good idea to make easy testability one of the prime design criteria of a logic board. The contributed article by Fredric Boswell, which follows, tells how to do this. It is followed by a discussion by Randall Cork and Christopher Salzmann of some of the latest techniques in automatic diagnosis. ☐

Designing testability into complex logic boards

by Fredric R. Boswell*
Digital General Corp., Cleveland, Ohio

As a cost-effective way of testing complex digital assemblies and subsystems, functional testing with modern automatic equipment is well established. Its efficiency, however, could be much enhanced if the logic design engineer included testability among his design criteria. As yet, no formal, systematic tools exist for synthesizing testable logic designs, but the following eight empirical guidelines have proven themselves highly successful in practice.

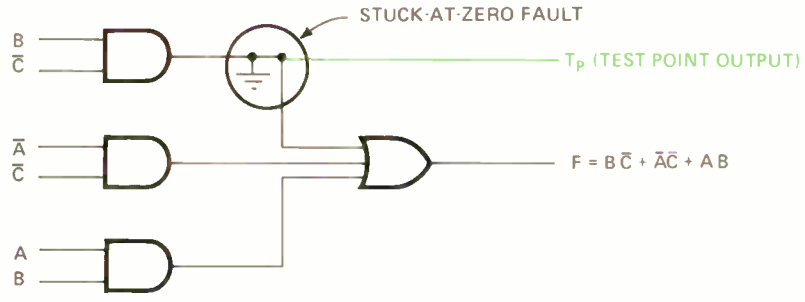
What a functional test does is to verify the logic operation of a circuit in terms of its binary-valued input and output signals, thus eliminating the need for direct, precision measurement of voltage, current and time at the terminals of the board under test. The faults detected by this process are shorts, opens, and "stuck faults." (A stuck fault is one that causes a logic element to behave as though one of its input or output terminals were permanently fixed at a logic 1 or 0 level.) Unfortunately, these faults are not always easily detectable from observation of the circuit's input and output terminals. Sometimes, in fact, a fault is impossible to detect in this way. The solution here is to give the tester more information. Hence the first guideline:

1. Give the tester access to internal circuit-board nodes. This is usually done either by using spare edge-connector pins or by providing a separate connector on the card specifically for test purposes. Since it is seldom feasible to bring out every node, the designer must choose test points that maximize the diagnostic information yielded by a test.

Figure 1 illustrates how it should be done. From the truth table, it is clear that no set of inputs to the circuit propagates the stuck-at-zero fault, which is shown in the figure, to the output terminal. This fault is therefore undetectable by the tester. However, incorporating a test point as shown in color allows input combinations 010 and 110 to detect the fault at the test point terminal.

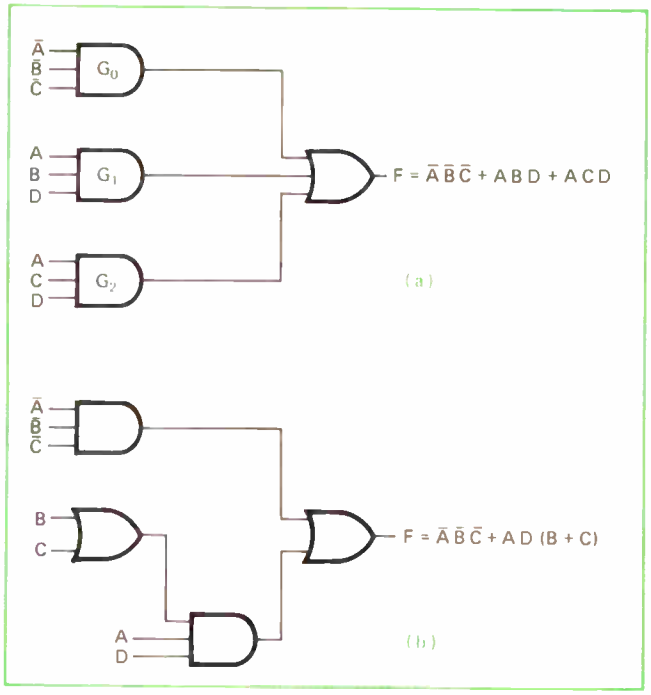
2. As a general rule, avoid logically redundant circuits. In the circuit in Fig. 1, the fault shown is undetectable because the circuit design is logically redundant. A connection in a circuit is said to be redundant if no change in the output function of the circuit occurs when this connection is cut. But if the uppermost AND gate in Fig. 1 is removed, the circuit will perform exactly the same

*Fredric Boswell is now practicing as an independent consultant in Cleveland, Ohio



TEST NO.	INPUT PATTERN A	B	C	CORRECT CIRCUIT OUTPUT	FAULTED CIRCUIT OUTPUT	CORRECT TEST POINT OUTPUT	FAULTED TEST POINT OUTPUT
0	0	0	0	1	1	0	0
1	0	0	1	0	0	0	0
2	0	1	0	1	1	1	0
3	0	1	1	1	1	0	0
4	1	0	0	0	0	0	0
5	1	0	1	0	0	0	0
6	1	1	0	1	1	1	0
7	1	1	1	1	1	0	0

1. Taking a peek. No set of inputs can detect the illustrated stuck fault merely by examining output F. However, if test point T_p is added to make an internal node visible at the output, the fault can be spotted quite easily.



2. Diagnostic resolution. Both of these circuits realize the same logic function. But circuit (a) gives the same output when the B input is stuck at 1 on gate G_1 and when C is stuck at 1 on gate G_2. Circuit (b) can isolate these faults to a single gate.

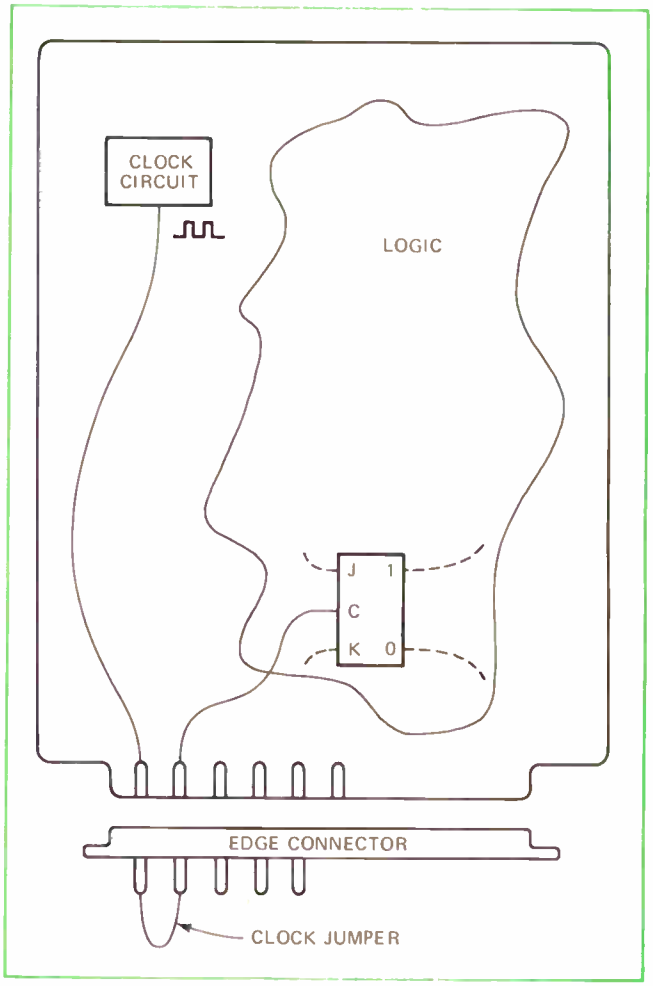
logic function, and it will eliminate the undetectable fault. By designing circuits without redundancy, the logic designer can eliminate many such faults. Note, however, that redundancy is not always a thing to be avoided—it has its uses in reducing circuit complexity, and in eliminating certain types of logic race problems (see last paragraph under guideline 7).

Where does it hurt?

3. Make faults as easy to locate as possible. Some uncertainty in the location of a fault is inherent in all circuits. For example, a stuck-at-zero fault at an input to an AND gate is indistinguishable from a stuck-at-zero fault at the output. The accuracy with which a fault can be located is called diagnostic resolution.

The design of a circuit can be a significant limiting factor in obtaining maximum diagnostic resolution. Figure 2a shows one possible realization of the function $F = \overline{ABC} + ABD + ACD$. The faults B stuck-at-one on gate G_1 and C stuck-at-one on G_2 can be detected only by the input combination ABCD = 1001. No input combination can distinguish between these two faults. However, if the function F is realized as shown in Fig. 2b, B and C are inputs to the same gate, and either fault is now locatable to one gate instead of two. Unfortunately, no systematic procedure for factoring logic functions to obtain maximum diagnostic resolution is presently known.

4. Use synchronous (clocked) circuitry whenever possible. Every tester, regardless of its internal organization, has a latency period between the time new test inputs are applied to the logic board and the time outputs are sampled. In this interval, the outputs may change without being detected. Consequently, if the latency period is long in relation to the operating speed of the circuit under test, the tester may not be adequate for circuit designs employing one-shots or asynchronous sequential circuits.



3. Beat the clock. Connecting the internal clock through a jumper at the edge connector allows the tester to break the connection and supply its own clock signal for testing purposes. The tests can use a slower clock rate that is consistent with the test setup time.

5. But do take precautions to isolate the clock from the logic. The problem is that the time that a tester requires to set up board inputs, scan the outputs, and compare them with the correct output values is usually long compared with the circuit operating time. Hence, a board with a fast internal clock may sequence through many states in one tester cycle, making it impossible for the tester to verify that the various states are reached in the proper sequence.

This difficulty can usually be overcome in the design phase in two ways. Either the logic can be partitioned so that the logic and clocks are isolated on separate boards, or the connection between the clock output and logic inputs can be made through a jumper at the edge connector (Fig. 3). This second method permits the tester itself to supply the clock signals at a rate consistent with the test setup time.

Start at the beginning

6. Make it possible to initialize sequential circuits—circuits with memory—prior to testing. Since the outputs of such a circuit are a function of the internal memory

states, the circuit must be driven to some known initial state before testing can begin. The most satisfactory solution to this problem is to incorporate in the logic design a master reset input that, when activated, drives the circuit to a known state.

A simple example of this problem is illustrated in Fig. 4. Here a D memory element is connected as a toggle. When power is first applied, the circuit latches in one of two possible states. A clock pulse complements this state. No preset input sequence exists that will drive the circuit to an unambiguous state. But if modified to include a reset input (shown dotted in Fig. 4), the circuit is easily initialized by a single pulse.

Of course, the circuit could also be initialized by monitoring the output terminal and applying clock pulses until the desired state is reached. This procedure implies a conditional decision-making capability within the tester. While a few testers provide a conditional-initialization capability for simple circuits such as this one, for some circuit designs, the initialization sequence may be so lengthy as to be impractical, or simply may not exist.

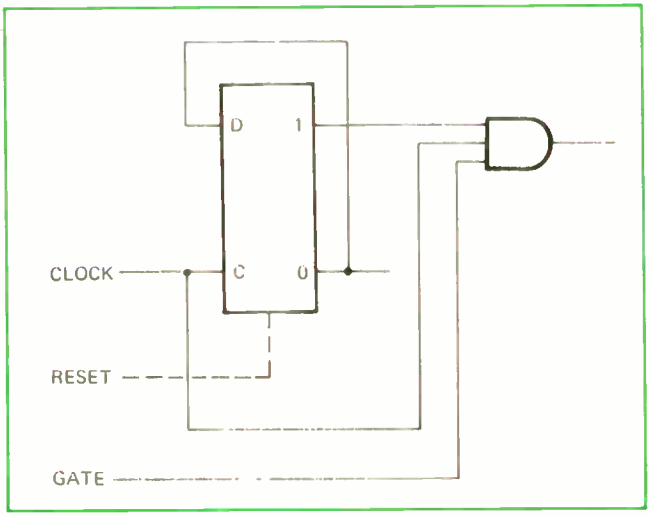
Dealing with the race problem

7. Take into account the operational characteristics of the tester to be used for a particular board. While all function-checking testers apply input patterns and monitor output patterns for the correct responses, the methods by which these inputs and outputs are applied and sensed vary widely. A parallel-organized tester applies input patterns to the board under test so that all input bits which change from one test to the next change simultaneously. A quasi-parallel organization implies that all input bits which change within a fixed n-bit group change simultaneously. (This organization arises quite naturally from using minicomputers with short, fixed word lengths as the test system controller.) A serial organization implies that only a single input bit to the board under test changes at any given instant of time. Figure 5 illustrates how a given set of input test patterns would be seen by the board under test for each of these three different tester organizations.

When it comes to monitoring output patterns, there are two basic approaches: the tester can compare the output of the board under test with that of a known good board, or it can compare it against a stored program of predicted outputs. The latter approach, as shall be seen, has the advantage of being able to eliminate some race problems by real-time modification of the test sequence.

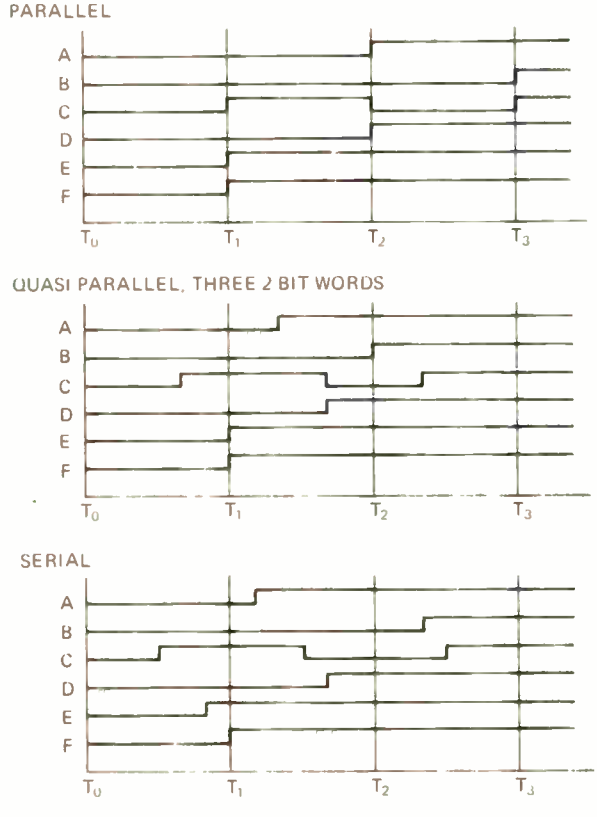
A race condition is said to exist when the operation of a circuit depends upon which of two or more variables, which theoretically change state simultaneously, actually does change first. If the various possibilities all eventually result in the same stable state, the race is noncritical. However, if the final stable state does depend upon which variable wins the race, the circuit's performance is indeterminate, and the race is critical.

A critical circuit race arises if the circuit in Fig. 6a is tested on a parallel-organized tester. If, for example, both A and B inputs change from 0 to 1 simultaneously,

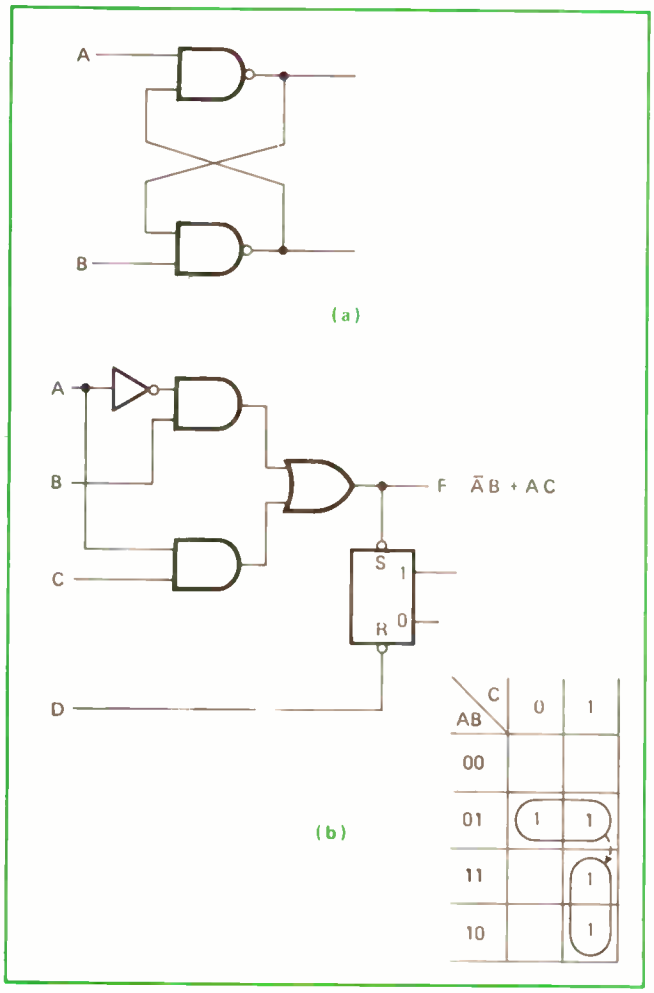


4. Reset. Sequential circuits pose a special testing problem because they have memory. Somehow, they must be driven to a known initial state before they can be tested. Adding a reset line is the easiest way to do this, if the connector space is available.

TEST NO.	INPUT PATTERN A	B	C	D	E	F
0	0	0	0	0	0	0
1	0	0	1	0	1	1
2	1	0	0	1	1	1
3	1	1	1	1	1	1



5. Patterns. All testers are not the same. These widely different input patterns show how three different testers—parallel, quasi-parallel, and serial—might realize the presumably unambiguous test sequence that is specified in the truth table.



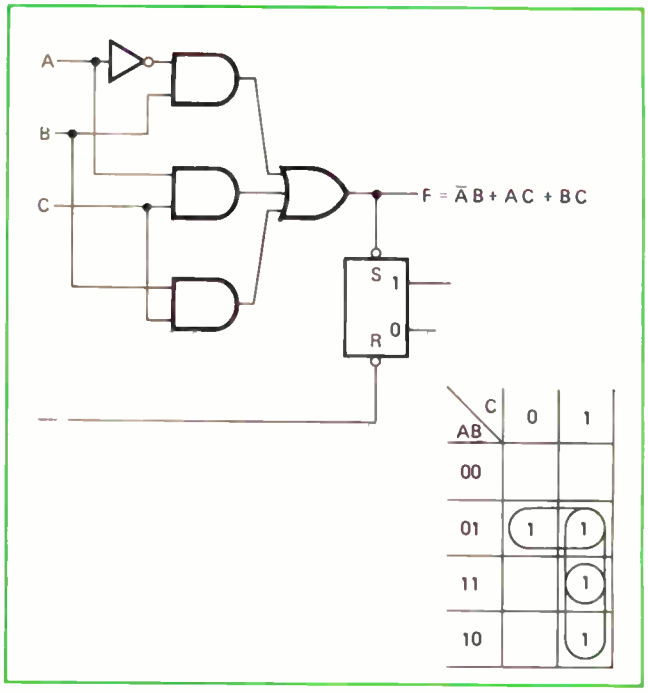
6. Two race problems. If both inputs to circuit (a) change from zero to one at the same time, the output is indeterminate. A programable tester is needed to assure that such a simultaneous change does not occur. In circuit (b), however, even restricting input patterns to single-bit changes won't help (see Fig. 7).

the resulting state of the latch is indeterminate. If the tester is programable, it may be possible to modify the test sequence to avoid the simultaneous input bit change. But if the tester employs random test patterns, this corrective measure would probably not be possible.

Even restricting input patterns to single bit changes may not avoid the critical race problem on some testers. For example, consider the circuit of Fig. 6b. Here a single input-bit change (in bit A) causes a circuit race which may set the flip-flop erroneously.

While this may not create any difficulties in the normal operation of the circuit, it can cause particularly acute problems with a tester of the type that compares the outputs of the board under test with those of a standard reference board. In this case, the comparison tester may reject boards that are effectively fault-free. With a programable tester, which compares actual board outputs against program-predicted outputs, this difficulty can be overcome by conditionally modifying the test sequence on the basis of the state of the flip-flop after changing input A.

The circuit of Fig. 6b could be changed to eliminate the race condition as shown in Fig. 7. By incorporating a redundant term in the network output function, the



7. A solution. Adding redundancy solves the race problem shown in Fig. 6b. This, of course, raises problems of its own, but they can be solved by adding extra test points as in Fig. 1.

race which occurs when input A changes is made noncritical. With the introduction of redundancy, however, the problem of undetectable faults returns, and the circuitry must be made more complex to solve it.

Standardize when possible

8. Take test economics into consideration when developing a new logic design. Factors such as package design and the physical partitioning of logic functions between boards can significantly affect test equipment and labor costs.

For instance, most testers use some type of mechanical adapter to interface the board under test to the tester—and adopting a standard card edge connector and power supply pin assignment on the edge connector minimizes the number of adapters required. With adapters usually priced in the $100 to $200 range, and with adapter wiring times typically four to five hours for a moderately complex board, this savings can be substantial.

Again, most testers available commercially have voltage levels intended primarly for testing transistor-transistor logic, and many manufacturers also provide logic level translation circuitry which permits testing other logic forms. Some of these logic level translators are capable of accommodating mixed logic types on the same board, but if so, they generally account for a substantial percentage of the tester cost. Minimizing the number of different logic types which appear at the edge connector can therefore reduce test equipment expenditures significantly. In fact, for low- and medium-volume production boards, the designer may wish to convert all input and output signals to TTL levels before routing them off the board. □

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Devising patterns to test complex logic circuits

by Randall C. Cork and Christopher H. Salzmann,
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The total parts count of digital logic boards has been steadily increasing, and the boards have become progressively more complex. Now the only practical procedure for detecting and isolating IC failures is to apply diagnostic patterns to the board inputs and monitor the outputs. What is not so clear is the best way to do this.

Although much has been published concerning computer generation of diagnostic patterns, little of the literature has seemed concerned about actual restrictions imposed by modern logic design. Most of the published results are valid only for the diagnosis of combinational (gates-only) circuits; those that may be applied to sequential (flip-flop) circuits have inconvenient restrictions.

Stating the problem

The problem can be concisely expressed in the following manner:

> Given a sequential synchronous or asynchronous logic board, S, as an arbitrary interconnection of combinational or sequential logic blocks, and given any one failure, F, in S, the problem is to devise a test consisting of a sequence of input patterns T(1) through T(p), to be applied to the primary inputs PI of S. The response, consisting in general of a corresponding sequence S(1) through S(p), of output patterns on the primary outputs PO of S, differs, depending on whether or not the failure F has occurred (Fig. 1).[1]

Since the problem is rather abstract, it is helpful to solve a simple practical example before discussing the solution to the complete problem. The example also serves to introduce the definitions of several terms.

The objective is to design an input test pattern that will check to see if the output of gate J in Fig. 2 is stuck low (at a logic 0). The solution is so to constrain the inputs to J that its output is forced to be a 1, and then to observe outputs N and O to find out whether or not the output of J actually does become a 1. All circuit outputs are initially given the unknown (U) assignment.

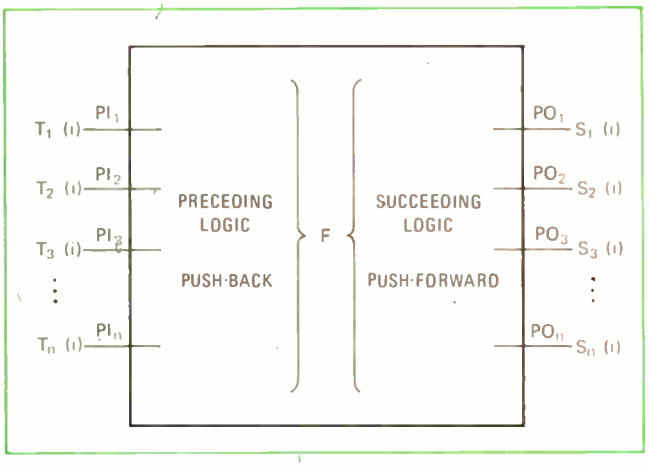
The drives (circuit predecessors) of gate J are gates G and H. To force the J output to 1, either the G or H output must be 0. If G is 0, H may be either 0 or 1—that is, the output of H is a don't care (X). The output assignments 0 and X for G and H, respectively, represent a test assignment on J. The test assignment is minimally restrictive in that it contains as many don't cares as possible. The output of G must be assured by placing a 1 on both B and C, since these are the only assignments that will result in a 0 output on G. The assignments on B and C represent a forcing assignment for a 0 on G. Forcing assignments are pushed back from a test assignment to a board input.

Ascertaining that the output of J will be forced high is not enough to accomplish the test; the output of J must be visible from at least one of the two board outputs, N or O. The process of making this output visible, called sensitization, is achieved by a push-forward phase.

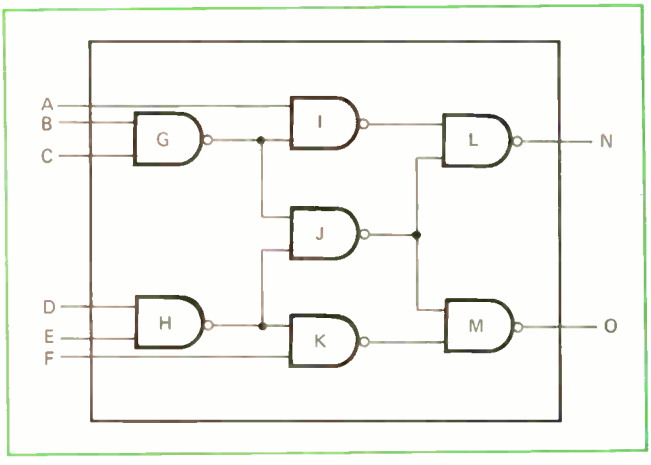
This phase begins with a decision as to which load of J, either L or M, will have the output of J sensitized through it. If M is selected, a 1 on the other input of M will cause the output of J to be visible at board-output O. However, to make sure there exists a 1 at the output of K, the push-back phase must be implemented, which results in a 0 at input F. The input vector ABCDEF is U11XX0, where the U is effectively the same as an X, and the fault is visible at board-output O.

Treating the general case

The elements needed to solve the complete problem have been implemented by a special computer program that incorporates three significant improvements over others that have been designed to select test inputs for failure detection: a fault-ordering scheme to improve fault detection; an extended circuit-assignment set, including assignments for rising and falling edges, "don't care" and "unknown" assignments; and a special loop-analysis scheme that attempts to prevent cycling while achieving the desired circuit assignments.



1. Find the failure. Given fault F, buried somewhere in the middle of a digital-logic board, the problem is to find a sequence of input patterns that will make F visible at the board's output terminals.



2. Is gate J stuck low? To find out, let B = C = 1 and F = 0. Then, if J is indeed stuck low, output 0 will be high. For this test A, D, and E can each be either 0 or 1; it doesn't matter.

The basic strategy followed by the program can be described in four steps:

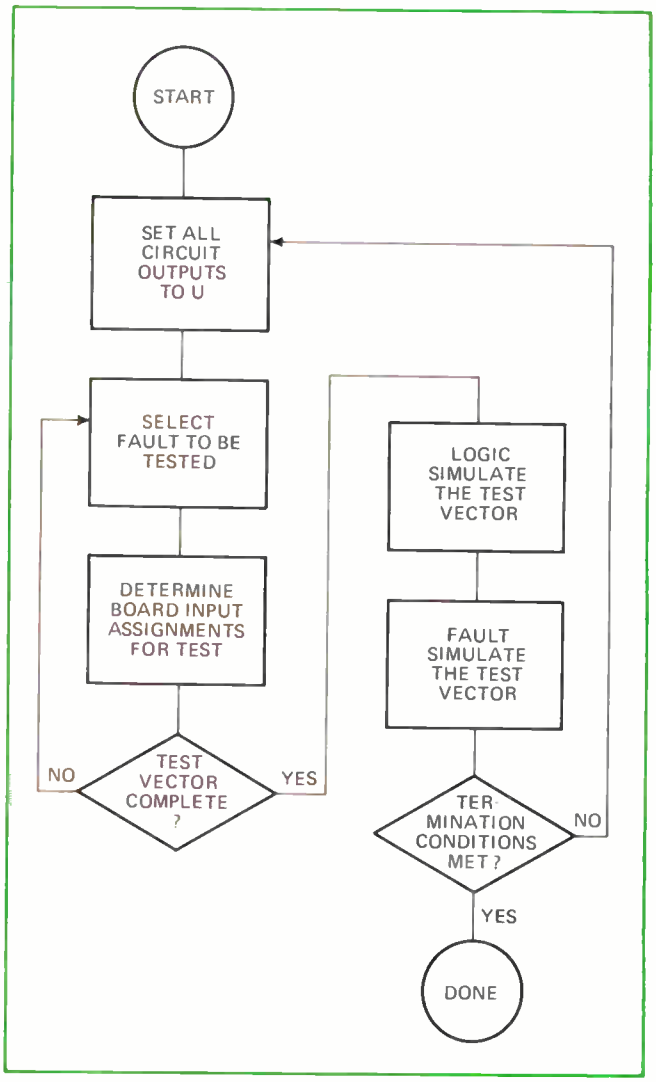
- Select a failure, F, from the logic board, S, utilizing the configurational design characteristics of S.
- Transform the diagnosis of failure F in S into the diagnosis of a corresponding failure F_p, in a circuit model, C_p, constructed from S.
- Compute a test, T, for F_p in C_p.
- Simulate T in S to verify that T is indeed a test for F in S, in view of possible races, hazards, and inadequacies of the model.

The fault-mode selection for testing is ascertained by the way in which the logic blocks are put together. For this reason, the program includes user-input fault-mode ordering options so that the user may inspect the logic and then decide which option would work best.

C_p, the dynamic analytical circuit model constructed from S, is called the state matrix. The circuit model is analytical in that it attempts an analysis of the response of S to specific circuit assignments, and it is dynamic in that those circuit assignments are applied as the circuit is under construction.

The test T for F_p in C_p is formulated by utilizing the state matrix to trace paths back to inputs and sensitize (make visible at an output) faults forward to outputs.

Finally, the computer simulates T in S for models of both a good board in which no faults occur and a series of bad boards, each of which has a single different fault. Thus, all faults detected by T are determined, allowing the fault-selection algorithm to ignore those fault candidates already inadvertently tested. The preceding basic strategy description is summarized in the gross-flow chart of Fig. 3.



3. The Grand Plan. After using an advanced fault-ordering scheme to select the fault being tested and an array of advanced push-mode algorithms to determine the board input assignments, the test program simulates the test vector for both good and bad boards.

The fault-ordering scheme

One problem encountered in a test-vector generation algorithm is how to decide which failure should be tested next. Previous solutions have been based on stepping through the total set of failures either by random selection or by means of a prime number. While either of these methods is adequate for combinational logic and for some simple sequential networks, they are not adequate for an arbitrary sequential circuit.

When a board is in a particular state, the state necessary for the detection of a given failure mode may not be a valid next state. Furthermore, random selection does not take into account parallelism in the logic and therefore tends to lead the recursive test-generation process away from the minimum test set. But if random selection is not acceptable, how are faults to be selected?

A major part of the fault-selection process is the method by which the failure modes are ordered. In the new program, faults are selected through level ordering, circuit-type ordering, ordering by number of drives or loads, or any combination of these.

The level-ordering options cause the fault-selection algorithm to tend to select the same failure modes on parallel networks and, thereby, cause the over-all testing algorithm to generate fewer vectors to test a highly parallel network. For this type of network, random selection may cause the test-generation process to diverge, generating an endless set of vectors.

The advantages of circuit-type fault-selection ordering are more subtle. In fact, depending on the ordering of the circuit types under test, the option may be disadvantageous. This option is intended for highly sequential networks, where a certain operation sequence moves the board through a restricted set of states. The needed ordering causes the test generator to assign highest priority to testing bistable circuits first, and then, while keeping the network frozen in a state, generate tests for combinational elements of the network. This ordering scheme causes the test-generation process to generate fewer vectors to test a highly sequential network. Misuse of the option may cause the opposite.

Fault-selection ordering by the number of drives into a circuit can be similar to circuit-type fault selection ordering. Drive fault-selection, primarily for combinational networks, causes the test-generation process to follow the classical find-rate curve (Fig. 4). Since many failures are detected early in the test, the find-rate drops sharply towards the end. Fault-selection ordering by number of loads generates the same results. It should also be used primarily for combinational networks.

There is one other option—the user may specify that a

particular fault mode on all circuits has top priority for detection. This option may be of use in combination with other fault-selection options; but by itself, it is essentially a random selection process and, therefore, of little meaning for a general sequential network.

The fault-selection process

In the beginning, the fault-selection program puts all the undetected failure modes in one ordered fault-list file. The network is placed in a completely or partially unknown state, depending on whether or not manual inputs have been inserted and whether or not test assignments have already been made. The next step is to enter the sensitizability identifier. This algorithm identifies all circuits that may be made sensitive to the terminal chosen by the user or control mechanism.

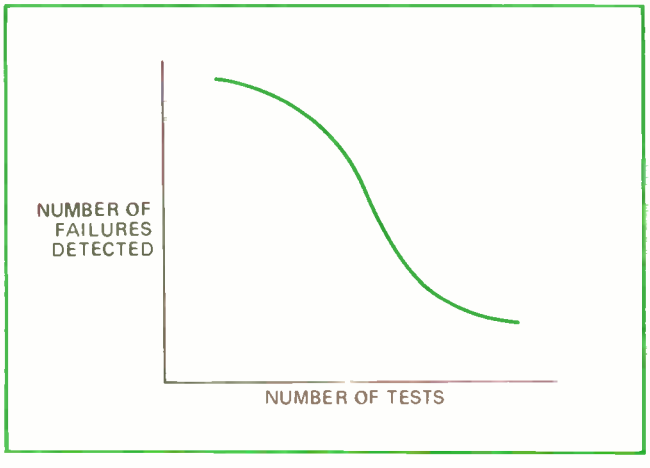
By stepping down the fault-list containing the ordered fault modes, an analysis determines whether or not the circuit containing the failure is sensitizable. If it is, the failure is handed off to the push-mode algorithms (push-back and push-forward) to have the test generated; if it is not, the next failure mode is selected.

If there remain sensitizable circuits after one pass through the ordered-failure bin, a search determines if there are any failures for which the test-generation algorithm had previously generated a test, but for which for some reason the fault had not been detected during fault simulation. If such a failure mode exists, it is determined whether the failure is on a sensitizable circuit. If it is, the failure is handed off for test generation.

On completion of the second bin search, all unassigned inputs are assigned their previous states, and the newly generated test vector is sent by the control mechanism to the logic and fault simulators.

The test-generation control mechanism may also set the "trapped-faults flag," which will give top priority in sensitizing trapped faults to outputs. Trapped faults are faults in which bistables have interfered with visibility. These faults must be trapped by bistables that are sensitizable to an appropriate terminal (bistable or board output).

The same routine that handles fault selection also controls the automatic initialization of the network. Under automatic initialization, the fault-list file orders criteria for initializing bistables to known states.



4. Diminishing returns. Fault-selection ordering by number of drives (or number of loads) results in this classic find-rate curve.

In the push-mode algorithms, most test-generation routines build in assumptions as to what may constitute the network under test. Typical restrictions of first-generation algorithms are that no bistable may toggle more than once during a particular test, and no bistable may be used to shape the clock input for another bistable. This sort of restriction is inordinately severe for the types of networks now used. Since the advent of MSI and LSI technology, networks seldom satisfy such assumptions.

The thoroughly modern push-mode algorithm

It is, therefore, necessary to modify design constraints imposed by the earliest test-generation algorithms and substitute innovations to be incorporated in the push-mode algorithms for circuit analysis.

The first modification is an extension to the assignment set (logic 0 and logic 1) to include X, the don't care; U, the unknown; E, the falling edge; and $\bar{E}$, the rising edge. The edge assignments are necessary because certain bistables are triggered by an edge rather than a level on the clock input; also, the edge assignments may be used to remove contradictions in pushing an assignment backward through reconverging paths of odd polarity.

Incorporation of D and $\bar{D}$ (the sensitive level 1 and level 0, respectively) is necessary to ensure the proper operation of the push-forward process, specifically, that portion of the process in which the results of a testing assignment are made visible at an appropriate sensitization terminal (a bistable or network output). The existence of D and $\bar{D}$ guarantees that a sensitive path will not be destroyed in a later attempt to push any assignment back onto a previously sensitized line.

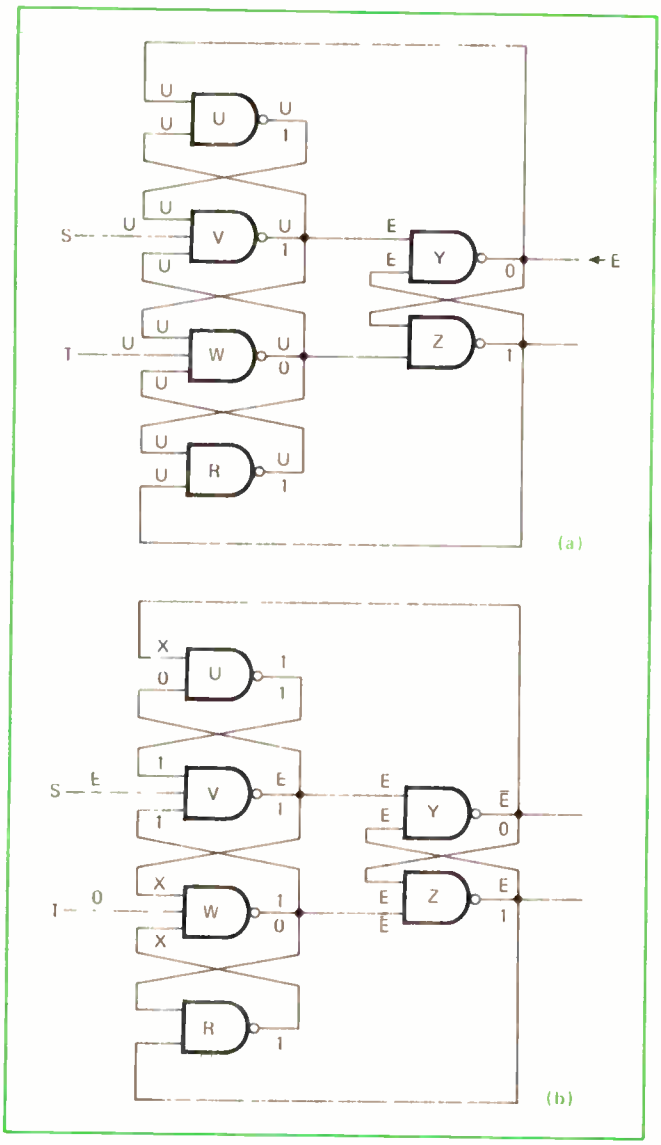
A further innovation is a compatibility matrix to determine if a desired assignment contradicts an assignment already in place. A matrix allows the criteria for a contradiction to be exactly defined, and, if desirable, redefined by the user because what constitutes a contradiction is not hard-wired in the program.

The last and, perhaps, most important innovation is loop analysis, which has been built into the push-mode algorithms. All loops in the network are identified at the time the network image is constructed. The compatibility matrix circuit assignments are divided into three priority classes for loop analysis. These classes are basically an ordering by degree of time-independence, beginning with the most independent. The priority classes are:

1. X
2. 0, 1, $\bar{D}$, D
3. $\bar{E}$, E

These three priority classes are used to make the best fault-detection assignments possible to push back and forward through a circuit which is part of a logic loop. The major goal for the push-mode algorithms in loop analysis is to avoid causing the loop to cycle. The first loop analysis, therefore, attempts to place a class 1 don't-care assignment on the loop line(s), and the possible non-loop assignments are then taken in order from classes 1, 2, and, finally, 3.

If such circuit-input assignments are possible, then the desired output is achieved without cycling. The na-



5. Edge push-back. To push back the $\bar{E}$ on the output of gate Y (a) requires an input vector, ST = $\bar{E}$0 (b). Note that the previous-state output of each gate is specified below its output line, while the succeeding-state output is shown above.

ture of cycling is almost always based on a functional assignment contradiction on a loop line; however, if a don't-care assignment can be applied to a loop line, no contradiction can exist. The exception is when all circuit-input lines are loop lines.

In this case, all input assignments must be taken from the class 3 edge assignments because, despite their low priority, their timing exactness is necessary to simplify the loop analysis of the preceding or succeeding loop circuits. Eventually, of course, a loop circuit will have the non-loop lines necessary to impede cycling.

Before illustrating how edge assignments are pushed, as well as how loops are analyzed, it seems appropriate to give a short description of the algorithm for pushing back rising and falling edges:

- The circuit assignment to be pushed back through the block in question is assumed to be the quiescent logic level of the edge -that is, in logic 1 is pushed back for an $\bar{E}$, and a logic 0 is pushed back for an E.
- A set of inputs for the block is selected so that a change in the logic level of at least one of the inputs will result in a change in the output level—that is, at least one of the inputs is sensitized to the output.
- An input logic level that is sensitive to the output is selected for the edge assignment. If the logic level is 0, an E is assigned; if it's 1, an $\bar{E}$ is assigned.
- The push-back of an edge through a circuit requires that the previous state of the circuit be the pretransitory state of the edge. For example, an E can be pushed back only through those circuits with a logic 1 previous state.

An example involving edge push-back and loop analysis is illustrated in Fig. 5a. The previous-state output of each gate is specified under its output line. In pushing back an $\bar{E}$ (rising edge) through gate Y, it is first noted that the previous state output of Y is a logic 0, the pretransitory state of an $\bar{E}$. This indicates that the edge push-back through the loop is possible.

The next step is to push back a logic 1 (quiescent level of an $\bar{E}$) through Y. This leads to two possible input vectors: 0X or X0. (Note: the vector components from left to right correspond to the gate inputs of Fig. 5 from top to bottom.) Loop analysis indicates that the X assignment should be placed on the loop line; however, in this case, both lines are loop lines. The two possible input vectors are, therefore, transformed into $E\bar{E}$, EE, and $\bar{E}E$. Since the previous states of both V and Z are logic 1s, the best of the three possible input assignments is EE, and these are the input assignments applied to Y.

The next push-back sequence involves the pushing back of the E assignment through V. Since V has a non-loop input, loop analysis indicates a X1X, input vector for a logic 0 output. This, in turn, transforms into a $1\bar{E}1$ input vector for an E output.

The same sequence of events is repeated for gate W, resulting in a X0X input assignment (Fig. 5b), since both V and R belong to elements forming a loop with W.

Although input assignments now exist for both the S and T inputs, the push-back process must still be accomplished for the other E input to Y. The push-back through Z results in the circuit input assignment vector $\bar{E}\bar{E}$, which is compatible with the $\bar{E}1$ vector already on the two input lines to gate Z. The push-back algorithm terminates at this point with the input assignment vector ST = $\bar{E}$0 to obtain the desired $\bar{E}$ output from Y. □

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Digital ICs set temperature compensation for oscillators

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The availability of digital integrated circuits, along with a trend toward monolithic analog-to-digital and digital-to-analog circuits, demands that an engineer take a fresh look at his field to ascertain if digital techniques could do the job better then his present analog methods. In temperature-compensated crystal oscillators (TCXOs) where low power and compact circuitry are musts, digital methods can simplify the adjustments needed and remove many constraints imposed by purely analog methods of compensation.

Such a digital system therefore must be integrated to save space, while power consumption can be reduced by low-power IC technology such as low-power MOS or even complementary MOS. Another way is to use a low duty cycle; since the temperature response of the crystal is rather slow, conversion rates of one per second or less are quite acceptable.

The analog temperature-compensated crystal oscillator circuit (Fig. 1) contains a varactor as part of its load capacitance. With a fixed bias voltage, the oscillator frequency will vary with temperature. This frequency-versus-temperature curve can be used to determine the varactor bias voltage, as a function of temperature, needed to compensate for temperature changes. A network of resistors and thermistors can be used to generate the temperature-dependent bias voltage. The closeness with which the voltage can be approximated will determine the oscillator's over-all frequency stability.

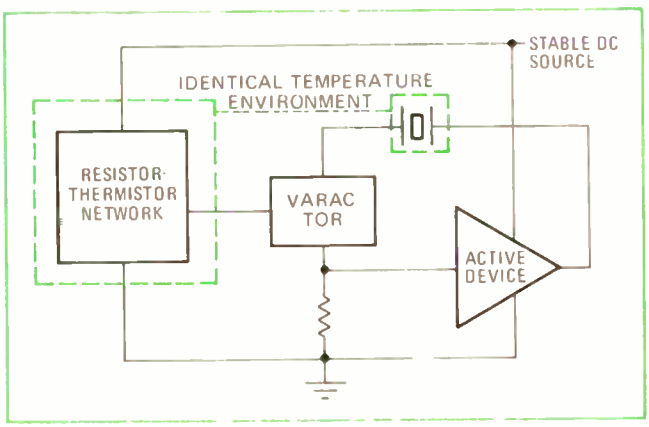
There are several problems inherent in this analog compensation scheme. The number of elements and accuracy of the resistor-thermistor network depend on the parameters of the crystal curve to be compensated (such as the curve's steepness) and the level of accuracy required. Corrections may also have to be made to the network a number of times to trim it into final form. However, if the slope of the crystal frequency-versus-temperature curve is steep, and the supply voltage is limited, sufficient voltage change may be impossible to get from the resistor-thermistor network over some temperature intervals.

A digital temperature-compensation system will overcome some of these problems. In its simplest form (Fig. 2), the oscillator circuit also contains a varactor, but bias voltage is generated digitally. A simple temperature sensor (one thermistor-resistor voltage divider) generates the input voltage for an a-d converter. The converter output addresses a ROM, which stores the compensation data, and the ROM is in turn connected to a d-a converter. The required bias-voltage-versus-temperature curve is matched by the curve generated by the digital system. Thus, by adjusting the contents of the ROM, it's possible to accommodate most constraints on the analog system. A programable ROM that will have contents that can be determined after a temperature run of a complete system can be used to eliminate the need for any trimming and adjusting.

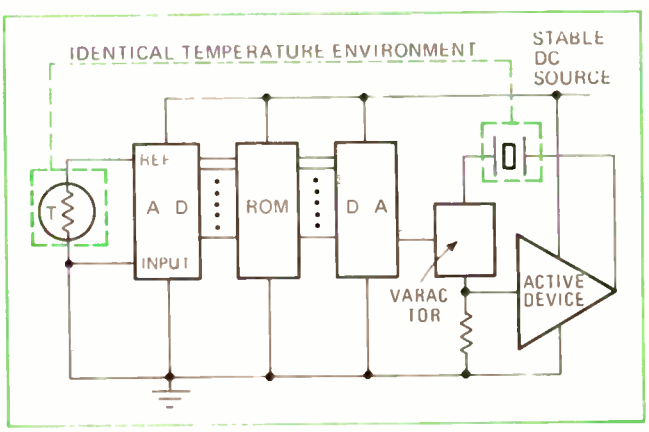
How well the ROM compensates depends on its capacity. If N is the number of output bits of the a-d converter (and thus the number of words in the ROM) and M the number of input bits to the d-a (M is thus the word size of the ROM), then the number of bits needed in the ROM can be expressed as $M \times 2^N$; thus N should be minimized before M.

For TCXOs of limited accuracy (about 1 part per million over the specified temperature range) the circuit used for the direct method (Fig. 2) is probably most cost-effective. However, there are ways of reducing the number of ROM bits from the $M \times 2^N$ needed for this "brute-force" approach. Figure 3 shows one alternative.

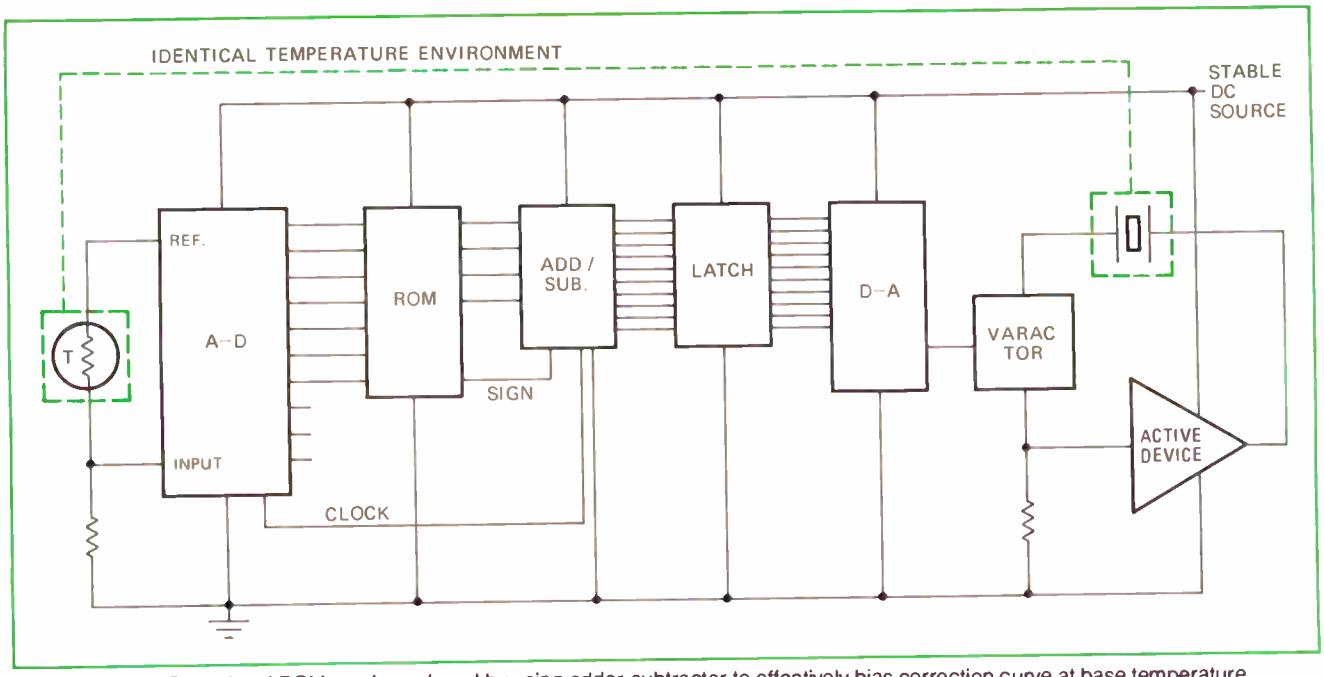
Assume a system with a resolution requiring N = 10 and M = 12, so that the direct method would require 12,288 bits in the ROM. Let the a-d converter consist of a clock generator, a 10-stage binary counter (not an up/



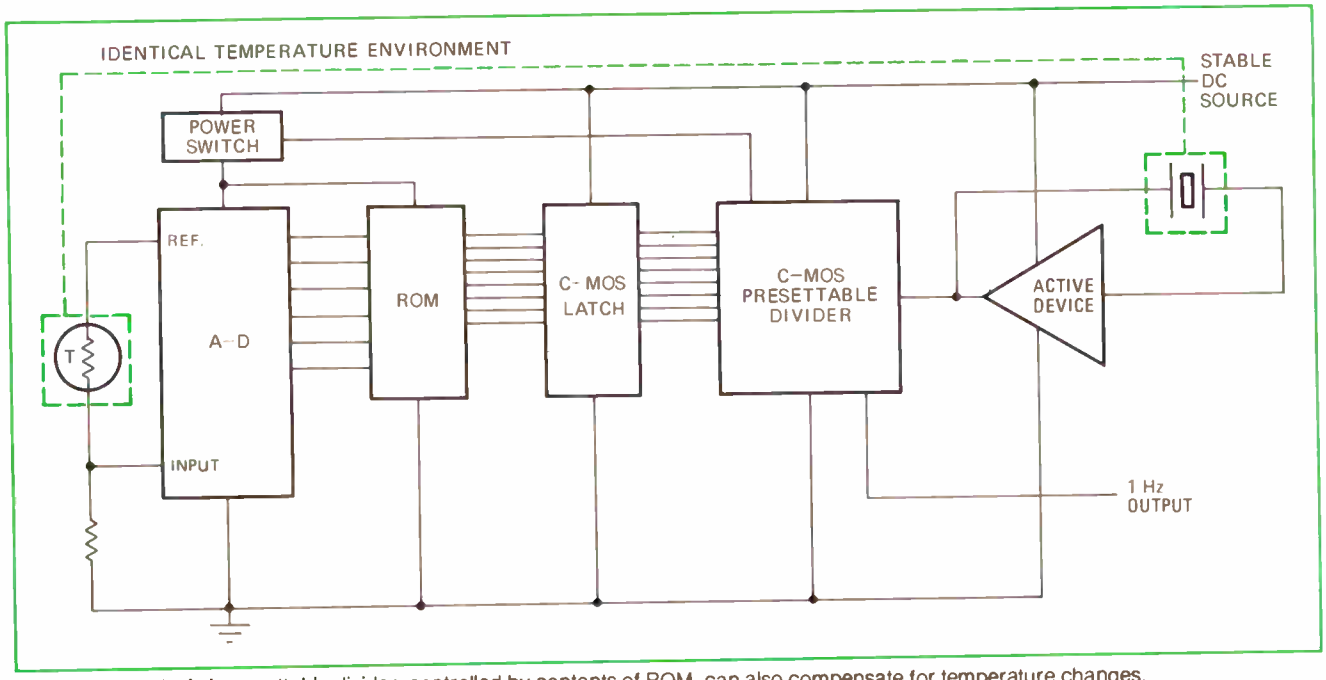
1. Analog way. Temperature compensation for crystal oscillator is obtained by providing temperature-variable voltage to varactor.



2. Digital way. Read-only memory stores correction-curve characteristics; a-d converter addresses ROM, which drives d-a converter.



3. Small ROM. Capacity of ROM can be reduced by using adder-subtracter to effectively bias correction curve at base temperature.



4. Divider control. A presettable divider, controlled by contents of ROM, can also compensate for temperature changes.

down counter) with current sources, and a resistor ladder network to generate an internal voltage. This voltage is applied to a comparator that stops the count when the internal voltage equals the applied analog voltage. The counter's 10-bit output then represents in digital form the analog input voltage.

The seven most significant bits of the counter are fed to a 128-word ROM with five output bits, one of which is used as a sign bit. The a-d converter's three least significant bits are left unconnected. The ROM output lines feed into an add/subtract circuit which adds or subtracts the ROM output to or from a 12-bit accumulator. The accumulator is reset to a value corresponding to the output voltage desired at the bottom of the temperature range. When the conversion starts, every clock pulse applied to the counter in the a-d converter simultaneously causes the ROM output from the previous conversion to be added to (or subtracted from) the contents of the accumulator. Since the three least significant bits are not connected, the contents of each ROM address will therefore be added eight times before a new number appears on the ROM output lines. In this way, the total curve is divided up into 128 linear segments, and each segment is broken down into 8 steps.

This is not a very fast system, but quartz crystals normally respond fairly slowly to changes in ambient temperature. One conversion per second or less is adequate. With such a system, the worst-case frequency error obviously becomes somewhat greater, but more than offsetting that, the number of ROM bits has been reduced

nearly 20-fold—from a high of 12,288 to 640.

A digital temperature-compensation system, as it might be used in a watch or clock, is shown in Fig. 4. The a-d converter and the ROM are used in a low-duty-cycle mode. The output of the ROM is stored in a C-MOS latch that is permanently on. The d-a converter and the varactor have been eliminated by using the digital information to modify the operation of the divider, which divides the crystal frequency down to 1 hertz. This output drives either a stepping motor for a conventional time display or a counter/decoder-driver circuit for a digital display system. The divider also provides the signal that turns on the low duty cycle components.

There are many more ways of applying these ideas to an actual system (several patents have been applied for). Its application is not limited to quartz crystal oscillators but extends to all types of temperature-dependent systems. Moreover, the basic circuits can be easily modified to obtain an ultra-linear voltage-controlled crystal oscillator (VCXO) or any other functional dependence of frequency on voltage that the system designer may want. □

Charting power losses for hybrid-combined amplifiers

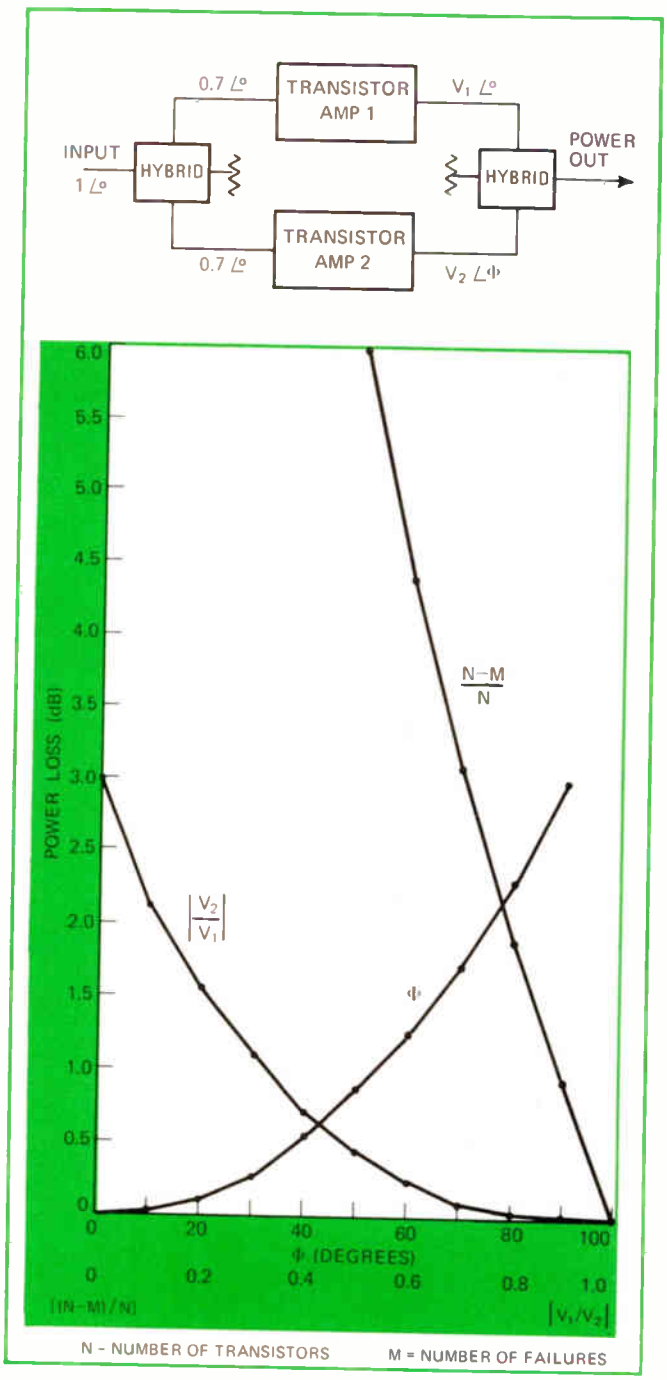
by Ronald M. Sonkin
Electronic Navigation Industries Inc., Rochester, N.Y.

If a hybrid junction is used to combine the output power of several transistor amplifiers that are in phase and of equal magnitude, then it's easy to figure the total output power—simply multiply one amplifier's power by the total number. However, in the real world, outputs are seldom exactly equal in phase or magnitude. For such cases, the designer has to know how much gain and phase mismatch between amplifiers he can tolerate and still deliver the required output power. The accompanying curves show this latitude.

Hybrid junctions represent a class of four-port networks that have the properties of being matched, isolated, lossless, and reciprocal. In the basic hybrid connection for a two-transistor amplifier, a hybrid at the input splits the power for each transistor, and another hybrid at the output combines the transistor outputs.

The curves show the resultant loss in power at the output as a function of differences in phase and magnitude. The curves are derived from the scattering matrix of a magic-T hybrid junction. For example, if the ratio of the absolute values of the output voltages of the amplifiers is 0.8, the output power would drop by 0.05 decibel from the ideal level (where the two magnitudes and phases are equal). And, if the phases differ by, say, 30°, then an additional decrease of 0.3 dB would occur (the two effects are cumulative). For this example, output power thus would be 0.35 dB less than ideal.

Also shown is a curve that helps estimate the effects of a failure of one or more output transistors. For example, in the simple two-transistor case, if one transistor fails, the output power drops by 6 dB below the ideal level, since (N–M)/N is 0.5 (N is the total number of transistors that have their outputs combined, and M is the number of failed transistors). In this case, the output from the one transistor still operating is split by the hybrid—half to the output and half to the terminating resistor required on the hybrid's fourth arm. □



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L. Young et al., "Advances in Microwaves," Academic Press, Vol. 1, 1967

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Engineer's newsletter

New 1103 RAMs can be enabled almost at leisure

If you've been using 1103-type random-access memory chips, chances are you've had to design around some critical timing problems—the chip has to be enabled during a narrow window in the pre-charge cycle. That's no longer the case, however. **Now coming on the market are 1103s that don't have an overlap between chip enable and pre-charge,** and consequently timing circuitry and clock supplies are simplified. Early models will cost about $5 each in 1,000 quantities, but there's little doubt that prices will soon drop to present 1103 levels.

Double slide rule helps with ion implant control

If you are setting up ion-implantation production facilities for semiconductor devices, here's an item that could be a boon, according to the developers, Accelerators Inc., Austin, Texas. It's a copyrighted double **slide rule that will allow direct reading of the ion dosage required to yield a desired concentration and the total charge in coulombs required** to obtain that particular dose. The rule works for boron, phosphorus, arsenic, and aluminum implants, and contains charts of equivalent mass ratios to ascertain stopping power of common masks such as silicon oxide, silicon nitride, and aluminum oxide. Price isn't firm yet, but the company expects it to be around $25. You can write to them at P.O. Box 3293—zip is 78704.

5-W audio amps go monolithic

Engineers requiring moderately high-power audio amplifiers can now satisfy their needs with low-cost monolithic amplifiers instead of hybrid circuits or discrete components. This substitution saves money, not only on the amplifier, but also on the wiring and package-count costs. **Amplifiers supplying 1 to 5 watts can be obtained from a half-dozen IC makers,** and up to 10 watts will soon be available.

Computer centers keep your designs secret

Do you get a little nervous when you have to reveal your proprietary design plans to IC makers in order to develop a custom-designed chip? If so, you might look into the **computer-aided design centers that are being established by many IC manufacturers** in cities across the country. The manufacturers store their design rules in computers, and you input your parameters from remote terminals in your own plant and get back design schematics.

Addenda

Fast turnaround on custom designs appears to be the name of the game today. **Allen-Bradley is setting up and training distributors at eight locations to assemble and test A-B's modular potentiometers,** 5.8 inch-square, hot-molded composition types that can be assembled with a variety of switch, shaft, and drive options. Delivery time on the Mod Pots, they say, will be cut from weeks to days. . . . "Photon Couplers," an application note out of General Electric's Semiconductor Products department in Syracuse, looks worth having, no matter what your design specialty. **The couplers, combinations of light sources and photodetectors, have many uses—for anything from logic circuits to triggering SCRs.** For a copy, write to GE SPD at Electronics Park, Building 7, Mail Drop 49, Syracuse, 13201. Ask for note No. 200.62.

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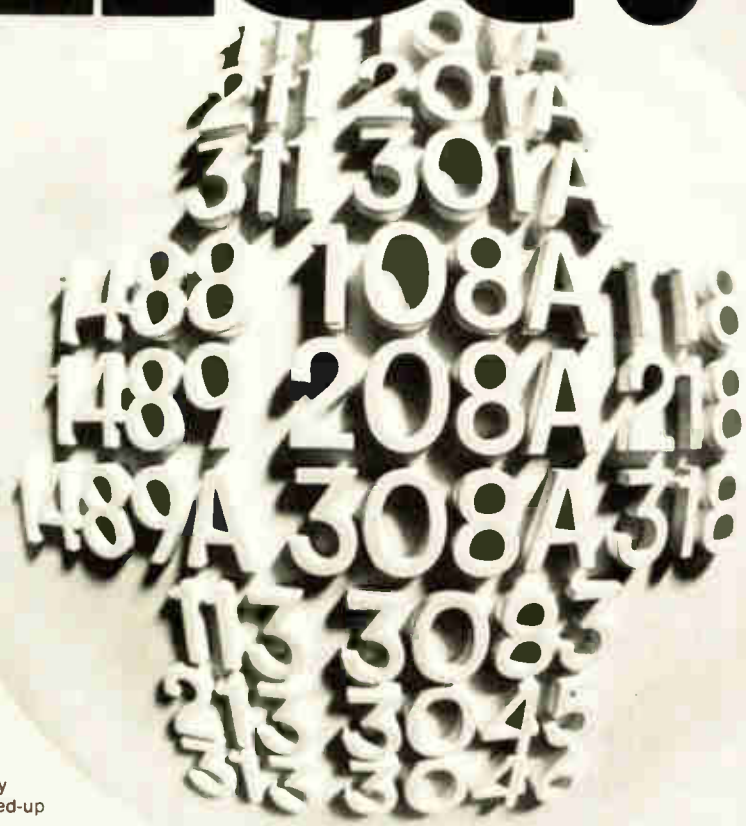
That's the word for selected linears from Microsystems International



Quiet means virtual elimination of popcorn noise and 1/f noise—typically less than 1 db increase at 10Hz over the 1KHz value.

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Multifunction tester polices data links

User-oriented device monitors multiplexers, modems, and lines; terminals can be emulated to check out an installation in advance

by Harry R. Karp, Special Issues Editor, and Paul Franson, Los Angeles bureau manager

Data communications, heralded as a growth market for the 1970s, labors under standards and conventions established 30 or 40 years ago, while using the advanced electronics developments of recent years. Thus, even a medium-size network operates with different data speeds, code formats, communications links, and terminals.

Testing such diverse systems often takes a variety of instruments—some specific to a particular test and others capable of several tests. Recognizing the need for a tester that can provide user-oriented system tests, yet handle a variety of technical configurations, Computer Transmission Corp. has developed an all-purpose tester which, the company says, is the most versatile unit of its kind available in a small package and at a low price.

Called Checktran, the tester evaluates the functional operation of multiplexers, modems, and the communications links. It is, the company says, the only unit that can check both internally and externally clocked modems. With a diagnostic procedure, the user can isolate faulty equipment anywhere in a widely dispersed system by employing one Checktran at the computer center. The flexibility of Checktran allows it to be used in links ranging from the lowest-speed terminals to direct computer-to-computer transmission—even up to 2 megabits per second for internally clocked configurations.

Another novel feature of Checktran is its use as a versatile terminal emulator. Thumbwheel switches permit selection of any asynchronous code at speeds up to 1,800 bits/s. Thus, for example, Checktran can prove out an installation even before a terminal has been shipped to a station site.

The basic Checktran 350 includes several test features: delay measurements between request to send and clear to send, scope synch points, both mark and space display of transmit and receive data and clocking signals, testing of asynchronous devices in a true start-stop mode, and a versatile data-rate selection technique that provides practically every standard and nonstandard rate from 45 to 4,800 bits per second, asynchronous, and up to 2 megabits, synchronous.

The test set provides a full complement of test patterns, with force-error capability in each. In the asynchronous mode, it offers three patterns: mark hold, break (all spaces), and alternate mark-space with its complement. In the synchronous mode, it provides four patterns: all marks, all spaces, alternate mark-space, and 2,047-bit pseudo-random. Automatic or manual receiver synchronization may be selected for the 2,047-bit patterns. The manual mode allows isolation of error to clock or data.

The Checktran 350 is designed to accept most standard and special interfaces on plug-in modules. The modular approach permits the user to purchase only the interfaces he needs today and add others without buying a completely new instrument.

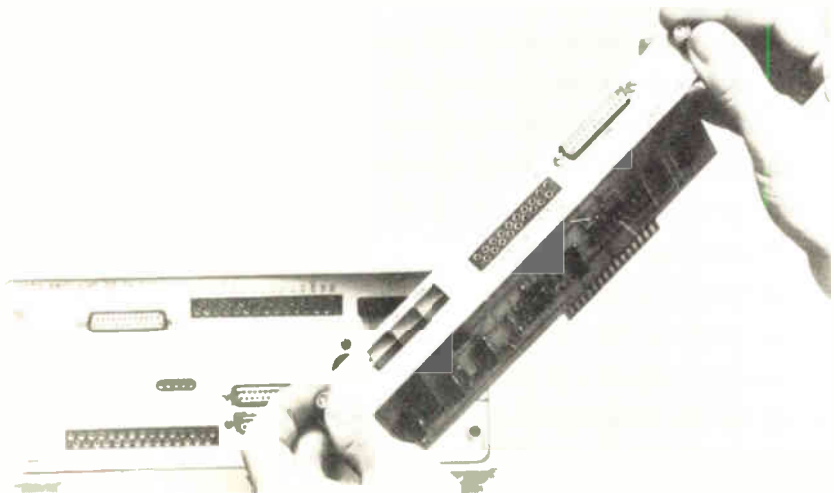
Plug-in modules are available for six standard interfaces. These handle both synchronous and asynchronous signals and special military systems; they permit Checktran to emulate terminals, to test system equipment, and—in a transparent mode—to check out the lines.

The front panel includes a three-decade error display with an overflow indicator, and data-status and control-status indicators; all are light-emitting diodes. Pushbuttons are provided for power, delay/error count, reset, control signal selection, pattern selection, manual/automatic synch, and force error.

The price of the basic Checktran is $1,450. Standard interface modules are priced at $250 and $350. Prices for six-foot test cables range from $50 to $170. Delivery time is 60 days.

Computer Transmission Corp., 1508 Cotner Ave., Los Angeles, Calif. 90025 [338]

Quick change. Plug-in interface modules permit Checktran to test modems, multiplexers, transmission facilities, and other components of a data communications system.



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RAYTHEON

Circle 132 on reader service card

Data handling

Mini executes 92 instructions

Machine aimed at end user is built with small circuit cards for easy repairs

When minicomputers first appeared on the market almost 10 years ago, they were characterized by very short word lengths of eight to 12 bits. Because such short words could contain only limited amounts of information, rather large memories were necessary to hold programs and data bases of reasonable size. Such large memories paid off because with core arrays, the more bits, the less cost per bit. But, because of the short word length, clever addressing schemes were necessary to compensate for the fact that a single word could not hold all the necessary information about an instruction and an address.

Later, as the cost of integrated circuits decreased, they could be employed with greater abandon in driving and sensing ferrite core arrays, and longer word lengths became economical—16 bits is almost standard for today's minicomputers.

Today, ICs cost less than ever, and the word length continues to creep upward. A case in point is the new EPI 218 computer, from Electronic Processors Inc., a subsidiary of Samsonite Corp., Englewood, Colo. It has an 18-bit word length and a repertoire of 92 instructions. While the word length is the same as that of its predecessor, the two-year-old EPI 118, it has 54 more instructions. These, plus the availability of six addressable internal registers (as against two in the 118) permit the programer to employ any of several addressing techniques.

Other features of the 218 are three index registers, an extension for the accumulator to permit double-length words to be processed, instructions for processing half-words and individual octal digits (three bits), and indirect addressing.

Whereas the 118 was designed for marketing only to manufacturers of other equipment in which the computer would be a subassembly, the 218, with these additional instructions and other features, is aimed at the end user. But, like the 118, it emphasizes rugged design and easy repairability—it's built with small printed-circuit cards of which only five different kinds are used in the entire processor-plus-memory complex. This simplifies the spare-parts problem; the company contrasts this with the trend in some minicomputers to use large cards, 15 or 20 inches square, with only one of a kind per machine.

Electronic Processors Inc., 5050 S. Federal Blvd., Englewood, Colo., 80110 [361]

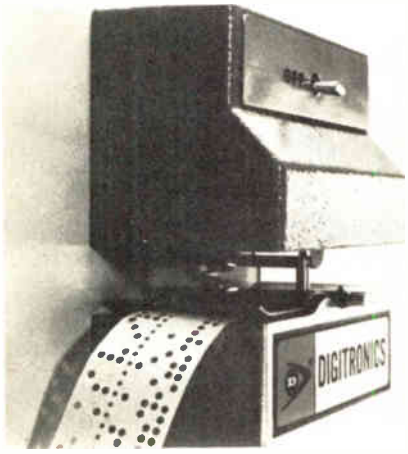
Add-on memory can expand storage to 2 million bytes

An expansion memory system for IBM System/370 model 155 computers can replace or expand the main memories up to a maximum of 2,048,000 bytes. The memory system, designated 370/STOR, is expandable from a minimum of 256,000 bytes to its maximum in modules that match exactly the expansion characteristics of IBM main memories. In addition, the 370/STOR can operate interchangeably on all seven models of the 370/155 with no additional cost to the user. The 370/STOR uses identical planar cards, each of which will store 32,000 bytes of data. Tiny 18-mil core arrays permit a high packing density. In addition, the cards are plug-insertable into small, 12-inch slots in the 370/STOR cabinet.

Cambridge Memories Inc., 285 Newtonville Ave., Newton, Mass. 02160 [362]

Paper-tape reader operates to 150 characters a second

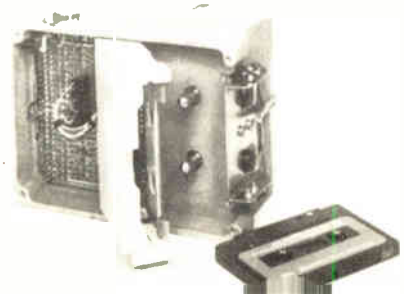
Operation in bidirectional read modes, at asynchronous speeds up to 150 characters per second, is offered by the model 2015 asynchronous paper-tape reader. The unit reads all commercially available tape, opaque or translucent, 5- to 8-level. Only one moving part assures long life. An optional tape handler is available.



Digitronics Corp., Route 9, Southboro, Mass. 01772 [364]

Tape cassette drive is servo-controlled

The model 4200 digital cassette drive is intended primarily for OEM applications. The transport has a servo-controlled reel drive that uses only two moving parts and provides constant tape velocity without capstan, pinch rollers or solenoids. A torque feedback tension servo maintains precise tape tension during starts and stops. Recording speed is



New products

37.5 inches per second, and options include speeds from 10 to 75 in./s. Rewind and search speeds are 120 in./s, and start and stop times are 5 milliseconds at 75 in./s. Also offered are single-gap read/write or dual-gap read-after-write heads. Price ranges from $1,000 to $1,600, depending on options.

Peripheral Dynamics Corp., 1809 National Ave., Anaheim, Calif. 92801 [363]

Disk drive links with any CPU

A single-density disk drive, when used with the Peripherals General model 844 universal controller, can then be used to interface with any computer. The model 741 is available in either single- or dual-spindle cabinets, and both the universal controller and disk drive may be packaged in one cabinet. The model

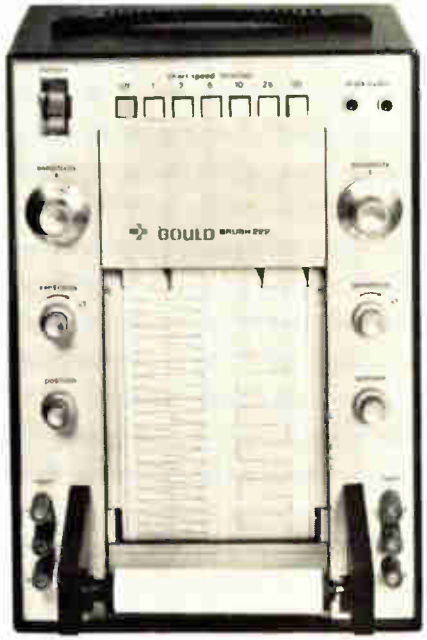
741 linear motor actuator increases access speed, and a maintenance panel provides built-in diagnostics. Price for the controller is $30,000 and for the disk drive, $9,500. Lease price for both units ranges from $1,609 to $3,524 per month, depending on configuration.

Peripherals General Inc., Cherry Hill Industrial Park, Cherry Hill, N.J. [365]

Hand-held calculators have multiple storage registers

Four models in a line called Micro Computers combine the power and versatility of desktop computers with the size and cost of hand-held

Why we think the Brush 222 is your best choice in a 2-channel battery-run portable recorder.



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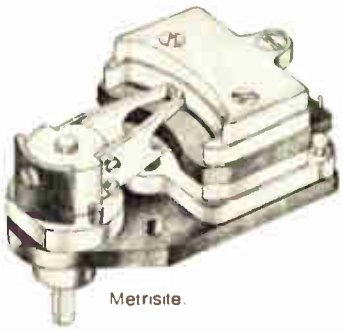
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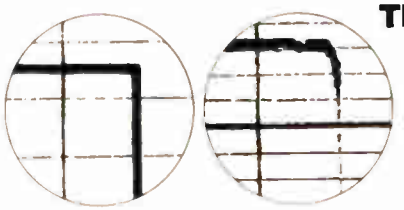
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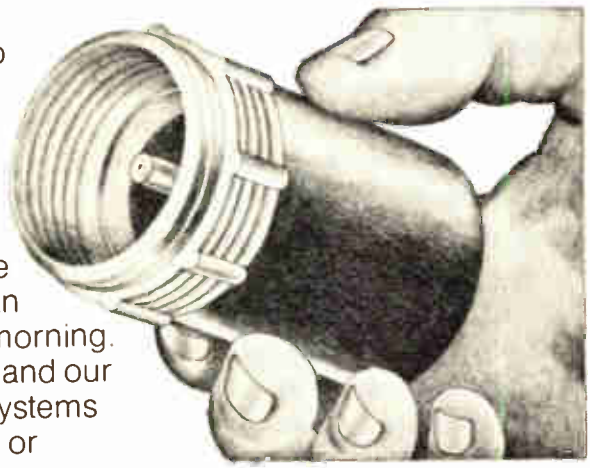
A year's supply of ink.

BRUSH INSTRUMENTS

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Circle 135 on reader service card

New products

calculators. The machines are the nonprogramable model 320 Scientist and 340 Statistician, and the programable models 322 and 342. The units offer a wide range of key functions, multiple storage registers,

calculation with 13-digit accuracy, and a display of 10 digits with sign and two-digit exponent. Prices begin at $595 for the Scientist and $795 for the Statistician.

Computer Design Corp., 12401 West Olympic Blvd., Los Angeles, Calif. 90064 [367]

Grid digitizer incorporates 4,000-word minicomputer

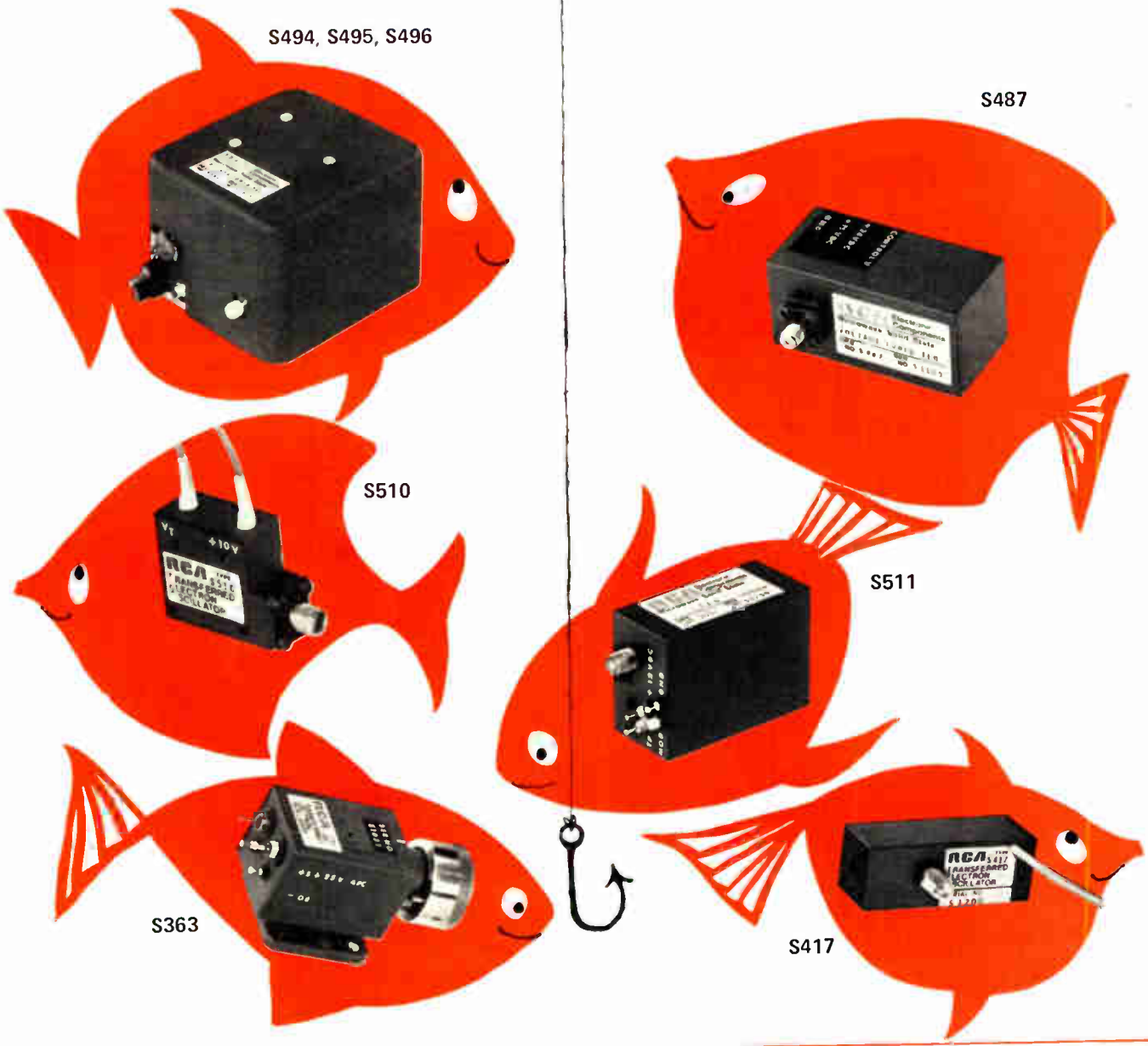
Free-cursor operation is included in the Comp-U-Grid digitizing system, which can also perform a variety of control and processing functions. This versatility is possible because the unit incorporates a 4,000-word minicomputer with teletypewriters or other optional output devices. The unit uses a 20-by-20 inch (or up to 42-by-60-inch) electronic-grid digitizing work surface, and its free-cursor operation is unencumbered by mechanical linkages. Accuracy is to within ±0.010 inch, and resolution is to 0.010 inch.

Computer Equipment Corp., 14616 Southlawn Lane, Rockville, Md., 20850 [368]

Reader/spooler operates at 800 characters/second

Designed to hold as much as 1,200 feet of tape, the TRS9300B reader/spooler operates in a stan-

Fishing for GHz oscillators? Try RCA's line for depth!



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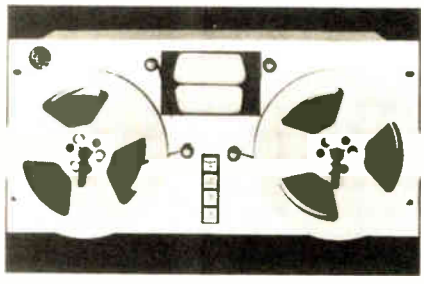
RCA Microwave Devices

RCA Family Type	Family Freq. Coverage (GHz)	Device Tuning Range	Typ. PO	Comments
S494	2.0 – 4.0	Elect. 2 GHz	10 mW cw	Electronically tunable ± 40 MHz linearity
S495	4.0 – 8.5	Elect. Any 3 GHz	10 mW cw	Electronically tunable ± 50 MHz linearity
S496	7.5 – 12.0	Elect. Any 4 GHz	10 mW cw	Electronically tunable ± 60 MHz linearity
S487	8.0 – 12.0	Elect. 500 MHz	30 mW cw	ΔF ± 10 MHz −45C to +85C
S510	8.0 – 12.0	Elect. 500 MHz	30 mW cw	Low AM/FM noise
S511	8.0 – 12.0	Mech. 400 MHz FM 30 MHz	60 mW cw	ΔF ± 50 MHz −54C to +100C
S363	14.0 – 16.0	Mech. 500 MHz Elect. 80 MHz	5 mW cw	ΔF ± 15 MHz −40C to +95C Hermetically sealed
S413	4.0 – 8.0	Mech. 500 MHz	10–120 mW cw	ΔF ± 6 MHz −40C to +70C
S427	8.0 – 12.0			
S417	4.0 – 8.0	Mech. 500 MHz	1 – 7 W Peak	ΔF ± 10 MHz −20C to +70C
S431	8.0 – 12.0			

New products

dard search-rewind mode at 800 characters per second. The 7½-inch punched tape unit, which can stop on character bidirectionally at 300 characters per second, can be operated manually or by remote control. The unit reads standard 5-, 6-, 7-, and 8-level tapes without adjust-

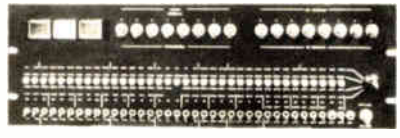


ment, even with tape opacity as low as 40%. The reader/spooler is compatible with DTL, RTL, and TTL circuits.

Electronic Engineering Co. of California, 1441 East Chestnut Ave., Santa Ana, Calif. [369]

Disk controller links IBM drives to DEC computers

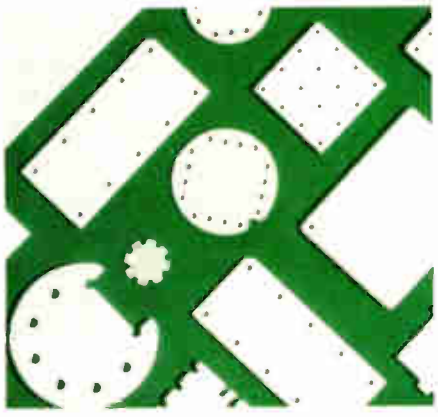
The model DC-18 disk controller is designed to interface IBM 2311- and 2314-compatible disk drives to DEC PDP computers. Up to eight drives can be controlled. Commands are interpreted by the controller and translated into a form compatible with the storage unit. The controller then provides 16 computer words of buffering and signal timing for the



core/disk transmission. The DC-18 monitors the status of the drives and the data transfers, presenting this information to the processing system. Features include simultaneous seek operations, verification of track location, and programing with only eight commands. Price starts at $15,000.

Telefile Computer Products Inc., 17785 Sky Park Circle, Irvine, Calif. 92664 [370]

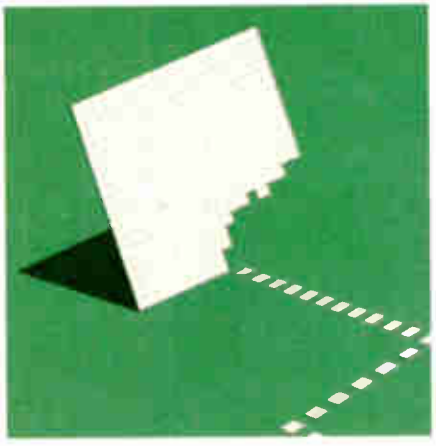
AlSiMag® BRAND COMPONENTS FOR HYBRIDS



SUBSTRATES

Many advanced ceramic substrate materials for thick film, thin film and microwave applications are available to suit your exacting requirements. Many sizes are stocked for immediate delivery. Custom prototypes can be quickly manufactured. High volume production fulfills your needs. New Bulletin 712 on request or phone 803/682-3215.

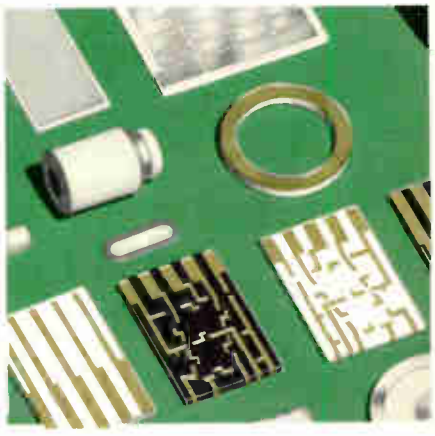
Circle 212 on reader service card



SNAP-STRATES

Originated by American Lava, these monolithic parts can be snapped into individual substrates after circuit work is completed. Tooled Snap-Strates permit odd shapes, holes, slots, etc. Laser Snap-Strates permit very small or thin parts of great accuracy.
Phone 803/682-3215.

Circle 213 on reader service card



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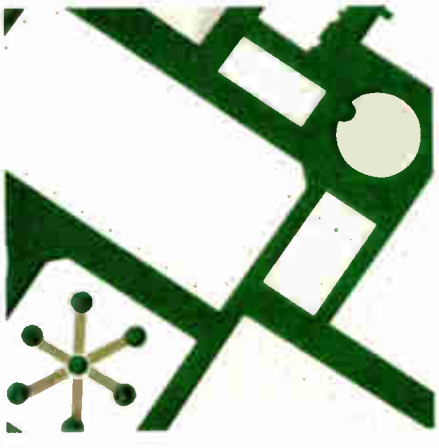
Circle 214 on reader service card



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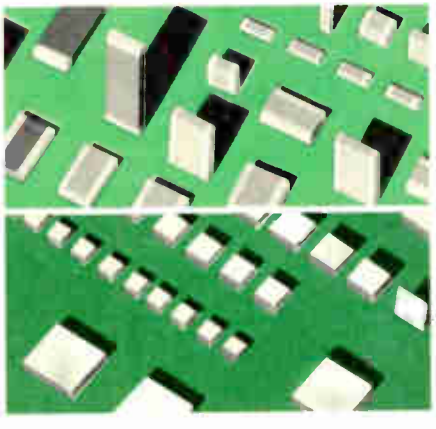
Circle 215 on reader service card



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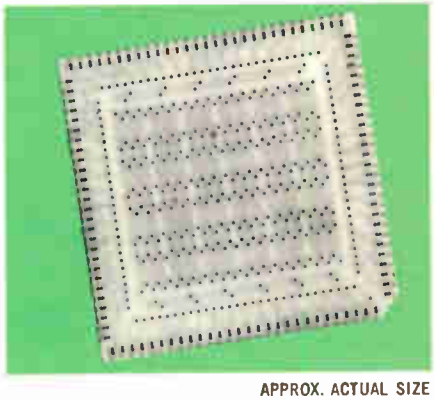
Circle 216 on reader service card



APPROX. ACTUAL SIZE

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Circle 217 on reader service card

American Lava Corporation

PHONE 615/265-3411 • CHATTANOOGA, TENN. 37405, U. S. A.

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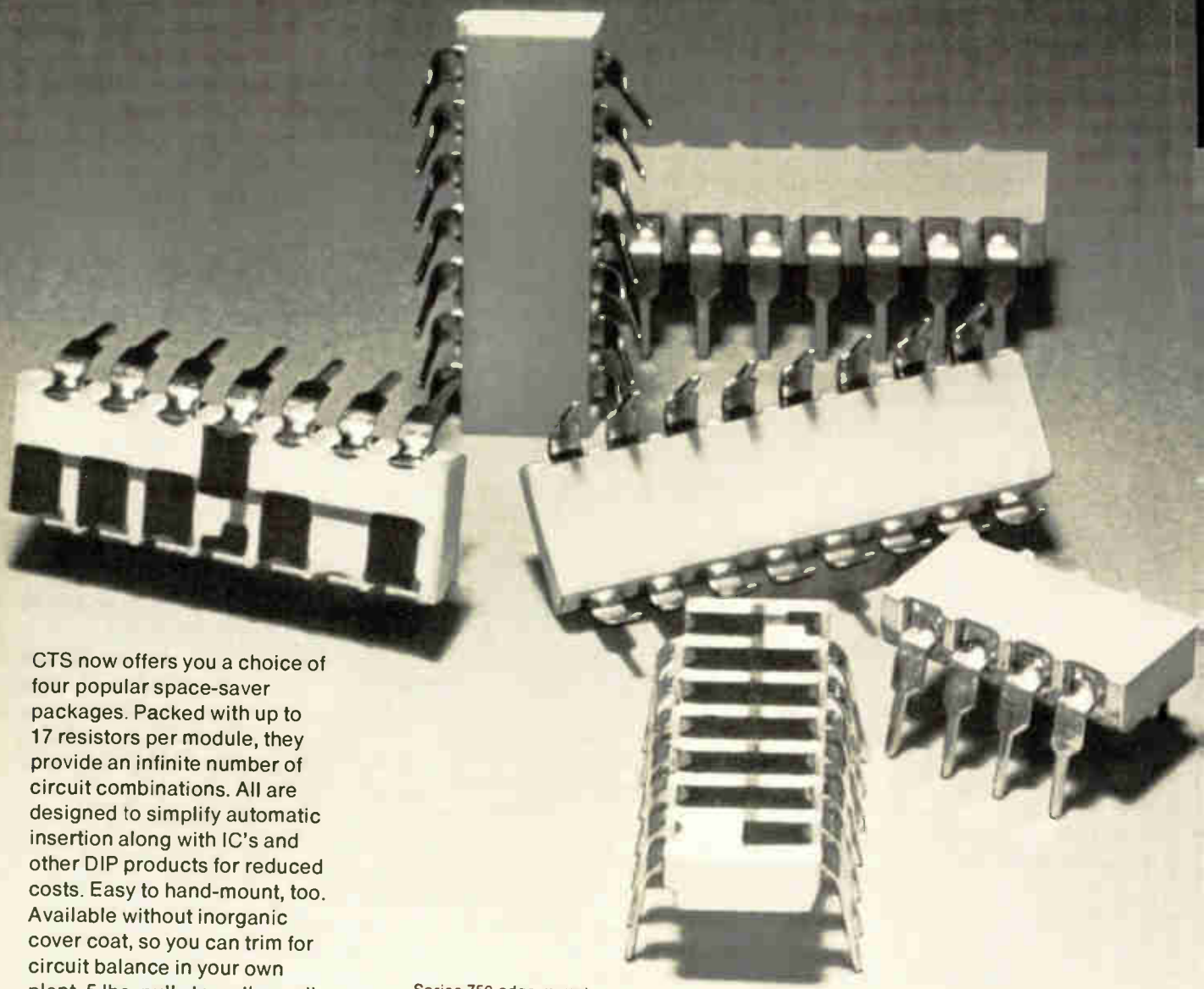

CTS now offers you a choice of four popular space-saver packages. Packed with up to 17 resistors per module, they provide an infinite number of circuit combinations. All are designed to simplify automatic insertion along with IC's and other DIP products for reduced costs. Easy to hand-mount, too. Available without inorganic cover coat, so you can trim for circuit balance in your own plant. 5 lbs. pull strength on all leads; .100" lead spacing; rated up to 2 watts on 18 lead style. Choose from standard circuit available for immediate delivery (see data sheet 3760 . . . or custom design to specifications).

CTS of Berne, Inc., Berne, Indiana 46711. (219) 589-3111.

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A world leader in cermet and variable resistor technology

Circle 140 on reader service card

Microwave

FETs give linear gain

Discrete transistors for vhf and uhf also offer low cross-modulation

The first semiconductor devices to employ Signetics Corp.'s D-MOST (double-diffused metal-oxide-semiconductor technology) are two discrete field-effect transistors that are aimed at such vhf and uhf applications as television receivers.

Although noise figures of the new devices are a little higher than those for bipolar transistors with which they will compete, "cross-modulation performance can be significantly better with the FETs," says George Urbani, marketing manager at Signetics.

The model SD200 is a single-gain transistor that combines high gain with low cross-modulation, low noise, and low feedback capacitance. The typical noise figure at 1 gigahertz is 5.0 dB, and feedback capacitance is 0.13 picofarad. Input impedance for the SD200 is typically 10^{14} ohms. Other specifications include forward transconductance of typically 15,000 microhms and an input capacitance of about 2.0 pF. Typical drain-to-source voltage is +30 volts, and gain is 10 dB at 1 GHz.

The SD300 is a dual-gate version. Special diodes are diffused into the transistor and connected electrically between the two gates and the source. These diodes bypass any voltage transients that lie outside the range of -0.3 V to +25 V, protecting the gates against damage in normal handling and operational situations.

Characteristics of the SD300 make it useful for a wide variety of applications in rf amplifiers. This FET is capable of linear mixing and reverse agc. Its two gates make possible much lower feedback capacitance, wider dynamic range, and much lower cross-modulation than can be achieved with bipolar and single-gate FETs.

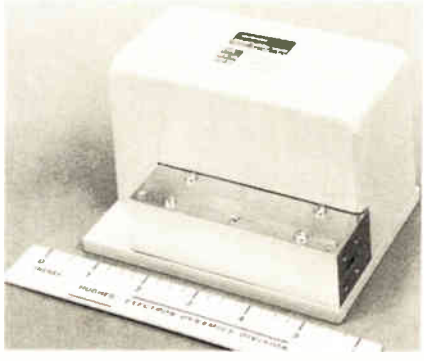
Feedback capacitance is typically 0.02 pF, and the typical noise figure at 1 GHz is 8 dB. The transistor also benefits from an unusually high input resistance and high forward transconductance (G_{FS} typically equals 10,000 micromhos). Input capacitance is low (2.0 pF typically), and gain is high (13 dB typically at 1 GHz) up to S band.

Both units are hermetically sealed in a standard 4-lead TO-46 package. They are guaranteed for normal operation over an ambient temperature range of -65°C to +125°C. The SD200 is priced at $5 each and the SD300 at $9 when they are ordered in quantities of 250 to 999. Orders must be placed directly through the factory.

Signetics Corp., 811 E. Arques Ave., Sunnyvale, Calif., 94086 [401]

Impatt diode amplifier operates from 33 to 40 GHz

A silicon Impatt diode amplifier operates in the Ka band between 33 and 40 gigahertz. The unit is designed as an alternative to high-power generator multipliers or traveling-wave tube amplifiers. The amplifier consists of two circular-

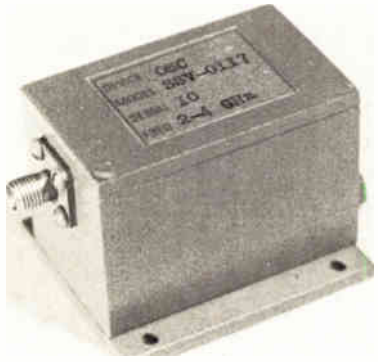


coupled reflection amplifier stages. Mixing the two stages can result in a variety of specifications. For example, a unit with a bandwidth of 2.5 GHz can have 10 dB gain and 200 milliwatts of output power, or 16 dB of gain can be obtained with 1-GHz bandwidth and 100-milliwatt output power. The amplifier has current regulators and limiters that protect the diodes from transients. Size is 4 by 3 by 5 inches, and weight is 4 pounds. Price of the model 46613H is $4,950.

Hughes Electron Dynamics Division, 3100 West Lomita Blvd., Torrance, Calif. 90509 [403]

Voltage-tuned oscillators cover 100 MHz–12 GHz range

Any octave bandwidth between 100 megahertz and 12 gigahertz can be provided by the SSDV-0100 series of voltage-tuned transistor oscillators. Among the higher-frequency units in the series are the model



SSDV-0103 (4-8 GHz at 5 mW output) and SSDV-0105 (8-12 GHz at 1 mW output). Harmonic rejection is -20 dB referenced to the carrier to 8 GHz, and -15 dB to 12 GHz. Tuning rate is 10 MHz. The oscillators measure 1 by 1.25 by 1.5 inches and weigh 2.5 ounces. Unit price for the 0103 is $2,144; for the 0105, $2,348.

Solid State Technology Inc., 1190 Norman Ave., Santa Clara, Calif. 95050 [404]

Preamplifier built for S-band telemetry

At least 23 dB gain over the bandwidth from 2,200 to 2,300 MHz (1-dB bandwidth) is provided by the model SMA-2250-NS3 transistor

preamplifier. The device is for the 2.250-GHz telemetry band and offers a maximum noise figure of 4.5 dB. Output power, with 1-dB compression, is +10 dB minimum. Other specifications include an input-output impedance of 50 ohms, VSWR of 1.5:1 maximum, and operation in the range from 0° to 60°C. Price is $695.

Spectrum Microwave Corp., 328 Maple Ave., Horsham, Penn. 19044 [405]

Monopulse antenna is for use in radar systems

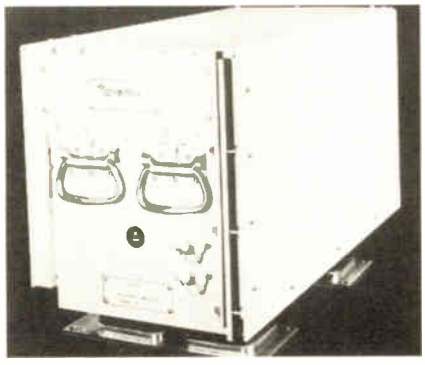
A four-port millimeter monopulse antenna for use at 70 gigahertz is designed for pulsed radar systems. Signal frequency is from 69.0 to 71.0 gigahertz, and gain is 47 decibels. Sum pattern beamwidth is 0.7°, and difference pattern null depth is 30

dB minimum. Other features are a side lobe of 19 dB nominal below the main lobe, and a voltage standing wave ratio (maximum any port) of 1.35:1.

Control Data Corp., Boston Microwave Products Division, 400 Border St., East Boston, Mass. [406]

Amplifiers are ruggedized for severe environments

Specially packaged microwave amplifiers are designed for operation in severe environments. Typical of the line is the model SSD-54112, which provides 100 watts of continuous-wave power from 2 to 4 gigahertz. The unit is modularly constructed and is designed to meet military specifications. Small-signal gain is 50 decibels, gain at rated power is 45 dB, and gain variation is ±1.5 dB across the bandwidth. In addition,

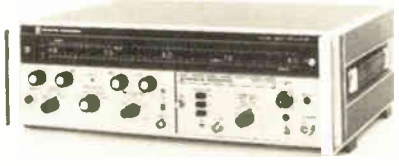


prime power input is 115/220V, 400 hertz, 1 phase with a maximum consumption of 2 kVA. Similar models are available up to 18 GHz, with output powers as high as 400 watts cw, depending on frequency.

Sperry Electronic Tube Division, Dept. 9002, Waldo Rd., Gainsville, Fla. 32601 [407]

Sweeper provides at least 10 mW up to 18 GHz

The model 430A solid-state sweeper is offered with a series of seven fundamental oscillator plug-in units to achieve a sweepable frequency range of 0.01 to 18 GHz. Internally leveled rf output power of the units is at least 20 mW from 0.01 to 2 GHz (40 mW from 1 to 2 GHz), 15 mW from 2 to 4 GHz and, with the high-power option, at least 10 mW across



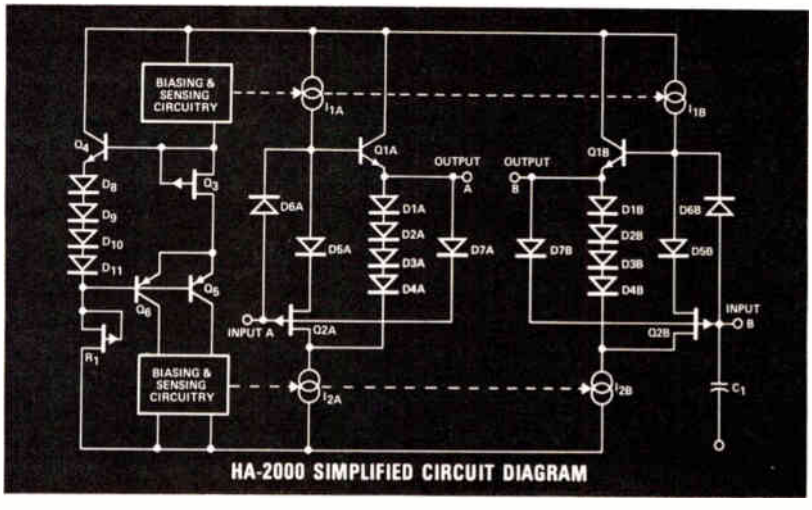
the 4 to 18 GHz range. Output power variation with internal leveling is +0.5 dB to 8 GHz. The unit features many modes of operation including automatic sweeping, 0 to 100% symmetrical sweeping, stable cw, a-m, and fm. One plug-in covers 0.01 to 2 GHz, and has a calibrated 20 mW minimum output, allowing precise power levels from +13 to

Unique:

Our new F.E.T. input preamp offers more design features and application possibilities than any alternative device.

The HA-2000 is universal. A monolithic unity gain differential amplifier stage with junction F.E.T. inputs and bipolar transistor outputs, it can be combined with any op amp, comparator, and most linear circuit functions without compromising the features of these devices.

As a result, the HA-2000 offers almost limitless possibilities for low-input current, high source impedance applications such as buffers for op amps and comparators. In addition, because of its compatibility with so many other components, the device permits the user great flexibility in systems design at optimum prices. Find out about our new "universal" F.E.T. preamp. See your Harris distributor or representative.



HA-2000 SIMPLIFIED CIRCUIT DIAGRAM

Features:

Converts any op amp or comparator to F.E.T. input

Input bias current 1 pA

Input resistance 10^{12} **Ohms**

Slew rate **100 Volts/μSec.**

Bandwidth **flat to 10 MHz and −10db at 100 MHz**

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	Input offset voltage	100-999 units
HA-2000 −55°C to +125°C	12mV	$ 6.50
HA-2000A −55°C to +125°C	5mV	$10.95
HA-2005 0°C to +75°C	25mV	$ 4.35
HA-2005A 0°C to +75°C	5mV	$ 5.95

For information on other new F.E.T. Op Amps incorporating the HA-2000, see the adjacent column.

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New products

–90 dBm. Price is $1,450, and plug-ins start at $1,600.
Weinschel Engineering, Gaithersburg, Md. [409]

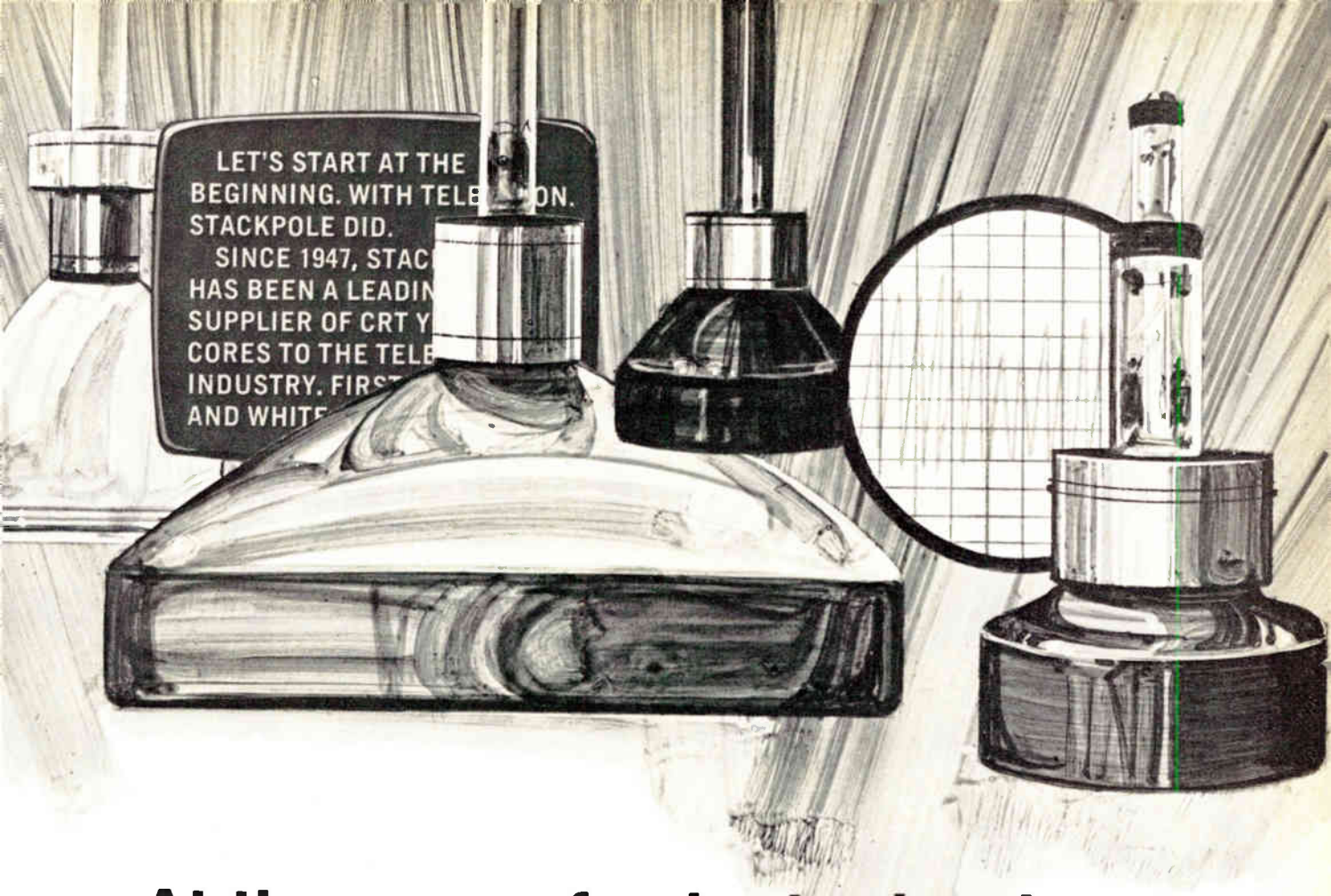
Mixer/detector diodes have high burnout resistance

Two series of thermal-compression-bonded low-barrier-height Schottky mixer/detector diodes are designated the MA-40100 and MA-40200 lines. The low barrier height results in a diode whose noise figure is optimum at a smaller local-oscillator level. The noise figure of the MA-40100 is less than 6.0 dB at 9.375 GHz with a local-oscillator drive of 0.5 mW. The MA-40200 series has a typical sensitivity of –58 dBm in X band. Burnout occurs in both diodes in excess of 2.0 watts peak for rf pulses up to 10 nanoseconds long, and in excess of 100 mW for cw rf power. Prices range from $15 to $27.50 each for 1 to 9 units.
Microwave Associates, Burlington, Mass. 01803 [408]

TWT can operate in pulse or cw mode

Operation in either a pulse or continuous-wave mode is offered by the type 2119 traveling-wave tube. Applications are in electronic countermeasures systems. The unit operates in the 1.7- to 4.0-gigahertz range,

and provides a minimum of 1-kilowatt peak pulse output at 5% duty factor, or 100 watts of cw power. The 2119 works at a fixed beam voltage, with its mode changes achieved through modification of the gating-electrode voltage. Price is under $4,000.
ITT Electron Tube Division, Box 100, Easton, Pa. 18042 [410]



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Let's start at the beginning. With television. Stackpole did.

Since 1947, Stackpole has been a leading supplier of CRT yoke cores to the television industry. First, black and white. Now color. This makes us the oldest ferrite yoke core manufacturer in the U.S.

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Stackpole also offers machining facilities for grinding to close tolerances.

TYPICAL CERAMAG® MATERIALS FOR INFORMATION DISPLAY YOKES

	7B	11	12	24
Initial Permeability	450	125	35	2500
Saturation Flux Density	2600	2550	2400	4500
Residual Flux Density	1650	1420	750	1700
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Curie Temperature	160	385	450	205

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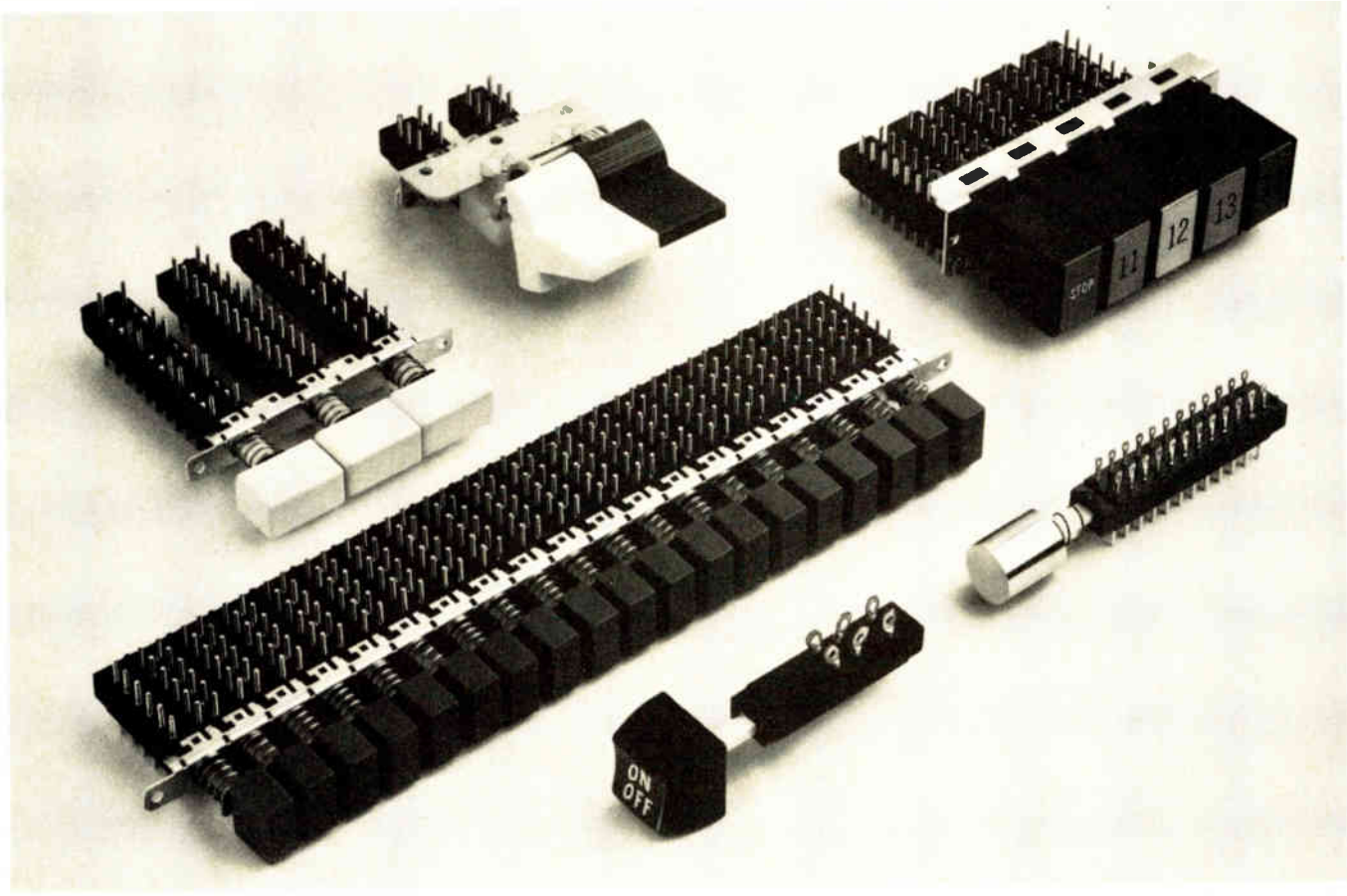
ELECTRONIC COMPONENTS DIVISION

Circle 145 on reader service card

Centralab Push Button Switches... in line with your design requirements

Write Centralab for Bulletin No. ELC-2



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Versatile Centralab push button switches* give you more reasons to change from the ones you're using now. Our push button switch conforms to a variety of specifications for consumer products, instrumentation, and industrial applications.

Reasons? Consider these: Centralab is the only manufacturer to offer diallyl phthalate—for highest possible insulation resistance—as well as phenolic or glass alkyd. Our phenolic modules provide greater than 65 db isolation in the voice frequency range. Our modules are available with sealed terminals to avoid flux penetration and we can provide gold contacts and terminals for dry circuit applications.

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Or ask for lighted push button switches that offer all the same features plus interchangeable lenses and filters in a variety of colors to provide maximum utility and appeal.

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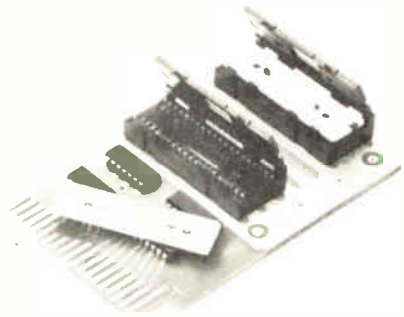
Package clamps into socket

Leadless technique reduces MOS/LSI costs, permits high circuit density



The two-headed monster of MOS-LSI packaging—costs of the package itself and the problem of removing 40-lead circuits when they're soldered into a pc board—is being attacked on a new front. In a combined approach, American Lava, Chattanooga, Tenn., has produced a leadless ceramic package that fits into a socket specifically designed for it by Amphenol Industrial division, Chicago. The package-socket pair will sell for less than present LSI packages with lead frames, according to the two companies involved.

The lowest-cost version of the American Lava package is a simple ceramic substrate on which are screened a refractory-metal conductive pattern and an aluminum dielectric layer. Pads along the edge, bonding fingers, and die-attach pad in the center are plated with 60 microinches of gold. A cup-shaped lid is required to cover the chip area. The die-attach pad lies in the same plane as the bonding fingers, so that downhill bonding is required. Some semiconductor makers have preferred the pad to be on a lower plane than the bonding fingers, allowing uphill bonding and avoiding the possibility of bonding wires shorting to the edges of the chip. However, this isn't the first single-plane package. The edge-mount package has been in use for several years, and many semiconductor manufacturers have by now gained experience with downhill bonding.

Other versions of the package do have three-level construction to allow uphill bonding, while a third variety has three-level construction with the contact pads on the bottom of the package. Present packages are available with 40 leads, but other configurations are under development.

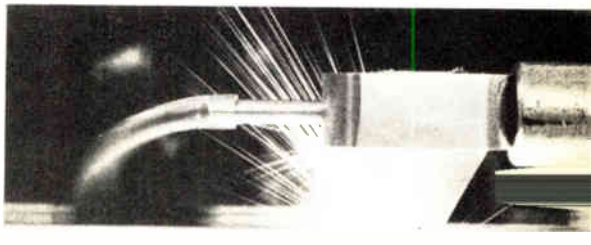
The Amphenol socket has a snap-down lid that presses the pads on the ceramic package against the contacts in the socket. The lid swings up without extending over the edges of the socket outline, so that the same package density is possible on the circuit board as with lead-frame ceramic packages. Designated the 851 series, the planar plug-in connectors are made of glass-filled nylon. Contacts are beryllium copper alloy, plated with 20 microinches of gold at their tips. Minimum normal contact force is 50 grams. Individual contacts can be replaced (test technicians have a proclivity for putting test probes into contacts and over-stressing them). Since no insertion force is required, the contacts are not subject to abrasion from the ceramic if the package is misaligned.

American Lava Corp., Chattanooga, Tenn. 37405 [391]

Amphenol Industrial Division, 1830 South 54th Ave., Chicago, Ill. 60650 [392]

Laser scribes 25-mil alumina at 4 in./s

Two carbon dioxide laser systems offer precise scribe lines for close-tolerance parts, and accuracies to within a few mils. The kerf has zero width, and scribe lines may cross with no adverse effects. The model 320 ceramic-scribing laser can scribe 25-mil thick alumina at up to four inches per second, and faster on



Tron Rectifier Fuses

Available in sizes from ½ to 1000 amps for voltages up to 1500, TRON Rectifier Fuses are ideal for protecting variable speed drives, inverters, battery chargers, plating power supplies, power controls, and any other application where fast opening and great current limitation are required.

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Circle 148 on reader service card

thinner materials. The model 310 scribes 10-mil alumina at up to one inch per second, with slower rates on thicker materials. Each unit has a control input for external switching in less than 0.001 second. Price of the 310 is less than $5,000, and the 320 sells for less than $10,000.

Apollo Lasers Inc., 6365 Arizona Circle, Los Angeles, Calif. 90045 [396]

Soldering machine has variable stroke adjustment

Difficult or odd-shaped pieces, such as open switch terminals, potentiometers, or printed-circuit terminals that cannot be wave-soldered, can be positioned with the Third Hand automated soldering iron. The model TH-1 can be fully automated for production runs in conjunction with single or X-Y axis positioning systems or be used as a self-feeding soldering iron for short-run or repair jobs. The TH-1 has a variable stroke adjustment up to 1.2 inches (30 mm), and soldering time is variable from 3 to 10 seconds. Solder-feed strokes are from 0 to 0.8 inch (0 to 20 mm), and the temperature-controlled solder heats from 260° to 430°C. Delivery is from stock.

Hollis Engineering Inc., Box 1189, Charron Ave., Nashua, N.H. 03060 [393]

Wave-soldering system handles 15-inch-wide boards

The Ultrapak 15 is a wave-soldering system that handles boards up to 15 inches wide. The unit includes foam-fluxing, preheating, soldering, and cleaning stations. The soldering station features an interchangeable nozzle capable of forming three different wave configurations and the option of soldering with or without oil. The preheating station offers dual controls to permit independent temperature regulation of the central and peripheral heating elements, so that rapid heat dissipation encountered around the periphery

New products

of the heating station can be compensated for, and a constant heat level can be maintained throughout the width and length of the panel. Price is $6,000.

Electrovert Inc., 86 Hartford Ave., Mount Vernon, N.Y. 10553 [394]

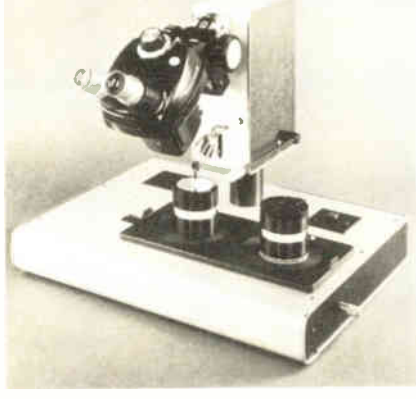
Generator is designed for ultrasonic wire bonding

The model 363 ultrasonic generator, designed for production wire bonding, features two channels and power output to 10 watts. The time and power controls are 10-turn potentiometers, which provide high resolution. Several options are available to adapt the unit to most wire bonders. The model 363 is also designed to operate as part of the company's bond-recording and analysis system. Price is $675.

Orthodyne Electronics, 817 West 17th St., Costa Mesa, Calif. 92627 [395]

Chip handler speeds accurate placement

The 4200 Pick and Place system is said to increase speed two- to four-fold over manual chip placement techniques, while eliminating material losses. The unit is designed primarily for manufacturers that screen epoxy on substrates to facilitate chip bonding, and it can also be used wherever small devices must be picked up and accurately positioned. One version of the unit has a heated work chuck and bonding tool, for manufacturers using



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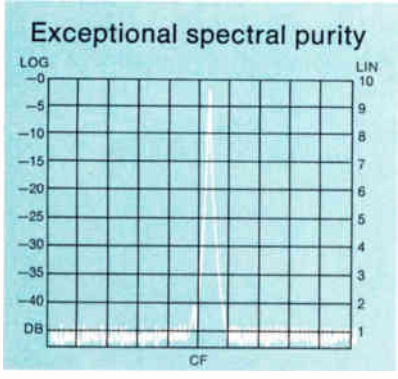

Judging from its stability alone, 1 ppm/24 hours, you might mistake the Singer 6201 Signal Generator for an expensive synthesizer. The 6201 gives you synthesizer stability and spectral purity, with no worry about spurious signals or phase noise. You get continuously tunable DAFL (Digital Automatic Frequency Lock) coverage from 61kHz to 1024 MHz. And the output frequency reads directly on a six-digit LED frequency counter with 0.0005% accuracy.

The 6201 has simultaneous modulation capabilities in AM, FM and pulse with negligible interaction. Output power is variable from an exceptionally high +20 dBm to −146 dBm. Negligible warm-up drift. No "settling time" after band switching. And the frequency readout indicator doubles as a counter for modulation frequencies and rep rates.

Get all the facts on the Great Imposter and its great price/performance advantages. Write today.

High performance Signal Generator Model 6201

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INSTRUMENTATION

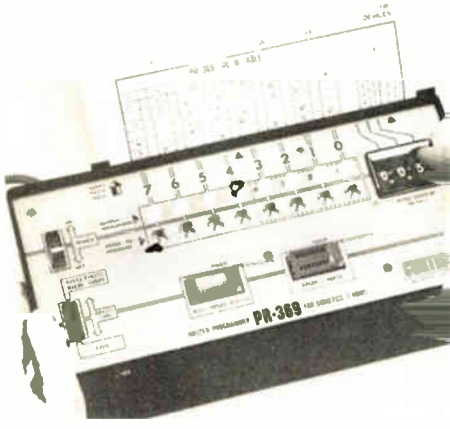
The Singer Company, Palo Alto Operation • 3176 Porter Drive, Palo Alto, Calif. 94304 • Telephone (415) 493-3231

New products

epoxy preforms for chip bonding. Price is $1,350.
Nordex Inc., 50 Newton Rd., Danbury, Conn. [397]

Master programer handles Signetics fusible ROMs

Manual programing of all Signetics fusible read-only memories is accomplished by a master programer called the PR-369. The unit programs five different devices having both 32-by-8 and 256-by-4 organizations. An automatic internal programing sequence is initiated by a



single pushbutton per output. Lamp indicators continuously display output states for addressed words. Addressing is accomplished by a three-digit octal thumbwheel switch. Zero-insertion-force DIP sockets provide in excess of 10,000 insertions. Price is $399.50.
Curtis Electro Devices, Box 4090, Mountain View, Calif. 94040 [399]

Sputtering system offers high coating uniformity

For large-batch thin-film coating, an automatic coaxial sputtering system has a load capacity several times larger than that of planar diode systems. It features a film uniformity to within ±2% over a 450-square-inch area and extremely low substrate temperatures for good adhesion. After loading, the operator starts the process with a single pushbutton

EA1500 N-CHANNEL Si GATE TAKES ON BIPOLAR.

electronic arrays, inc.

501 ELLIS STREET
MOUNTAIN VIEW, CALIFORNIA 94040
(415) 964-4321 TWX: 910-379-6985

There's a lot of noise these days about RAMs and new super, bipolar processes. Well, we'd like to challenge all those bipolar claims. In fact, you can too. All one needs to do is pick up the data sheets and compare.

You may have heard or read that MOS is slower than bipolar. The fact is that the EA1500 N-channel silicon gate 1K RAM has an access time of 85nsec—worst case, including voltage variation, over the 0° to 70°C temperature range. Our "fair" competition also specs their 1K bipolar RAM at 85nsec—but at a nominal voltage and a junction temperature of 25°C!

OK, let's just assume it's a standoff in speed. In power dissipation, the EA1500 with a maximum, worst case, guaranteed .220mW/bit wins right out. The 93415 draws .684mW/bit at 75°C case temperature. That would take a whole bunch of air conditioning if you're going to use more than one.

Then, of course, there's price. The EA1500 sells for about one-third less than the 93415. That's 2.4¢/bit vs. 6.8¢ per bit in 100 up quantities. Just add up your bits and add up your savings. Finally, when you come to EA, you can get it. Because we don't tout it until we got it.

THE GREAT RAM CHALLENGE: N-CHANNEL VS. BIPOLAR.

New products

switch; the machine cycles from vacuum pumpdown to argon backfill and plasma ignition and through

finely controlled coating. Uniformity to within ±5% is available over an area of 680 square inches.

Varian Associates, Vacuum Division, 611 Hansen Way, Palo Alto, Calif. 94303 [398]

IC tester does functional and parametric checkouts

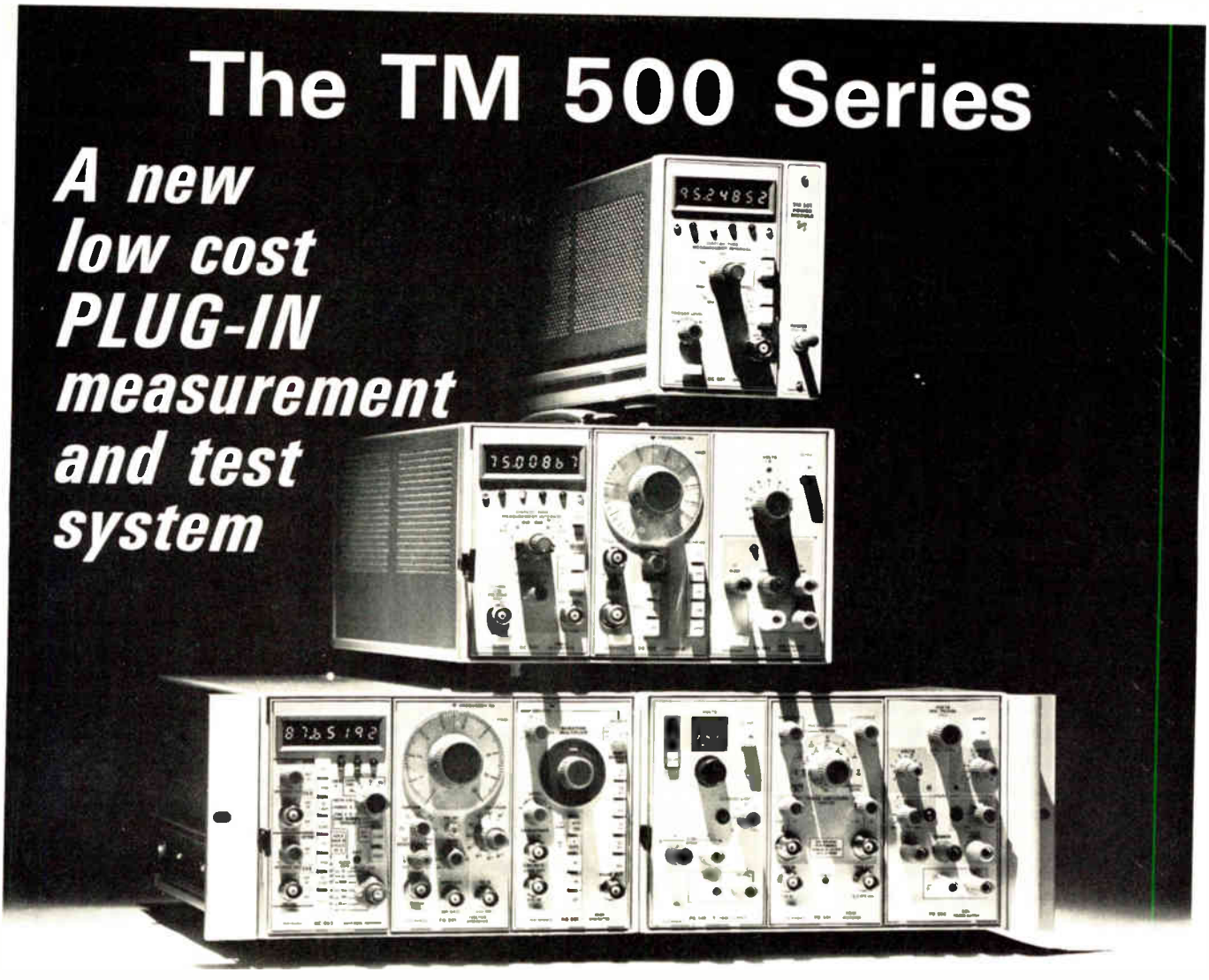
Both functional and parametric tests for digital and linear circuits are offered by the model 716A general-purpose integrated-circuit tester. The unit is designed for use in device characterization applications and in moderate-volume incoming inspection. The tester includes four adjustable constant-voltage sup-

plies, an adjustable constant-current supply, a square-wave pulse generator with adjustable amplitude and offset, a high-voltage supply, a swept-voltage supply, four voltage comparators, a DPM, and a cross-point matrix that can handle devices with up to 36 leads. Price is $2,990.

Computest Corp., 3 Computer Dr., Cherry Hill, N.J. 08002 [400]

The TM 500 Series

A new low cost PLUG-IN measurement and test system



space-saving modules you can mix and interface

Here's an example of what you can do: Combine a ramp generator, function generator, and universal counter in the 3-hole mainframe. Using the intra-compartment interface you can use the ramp generator to sweep the function generator, and monitor the output with the counter. Complete cost of this system is only $1345.

Need these plug-in functions?

- ***550-MHz digital counter***
- ***100-MHz digital counter***
- ***100-MHz universal counter***
- ***Digital multimeter***
- ***1-MHz function generator***
- ***10-μs ramp generator***
- ***50-MHz pulse generator***
- ***1-MHz RC Oscillator***
- ***20-V single- or dual-tracking power supplies***

Need a compact 3-function system for your bench?
The TM 503 power module accepts any 3 plug-ins, i.e., digital multimeter, function generator, ramp generator, yet only occupies 6 by 8.7 by 15.3 inches on your bench.

Need a rack installation?
Mount one or two TM 503s in a rack, and get 3 or 6 functions in only 5¼ inches of rack height. Compatible large-screen monitors available.

Need mobility?
The TM 501 accepts any single plug-in module for maximum carrying ease. The 203-3 Scope-Mobile® powers any 3 plug-ins, stores up to 4 more, and supports a scope or other instrument on its tilting platform.

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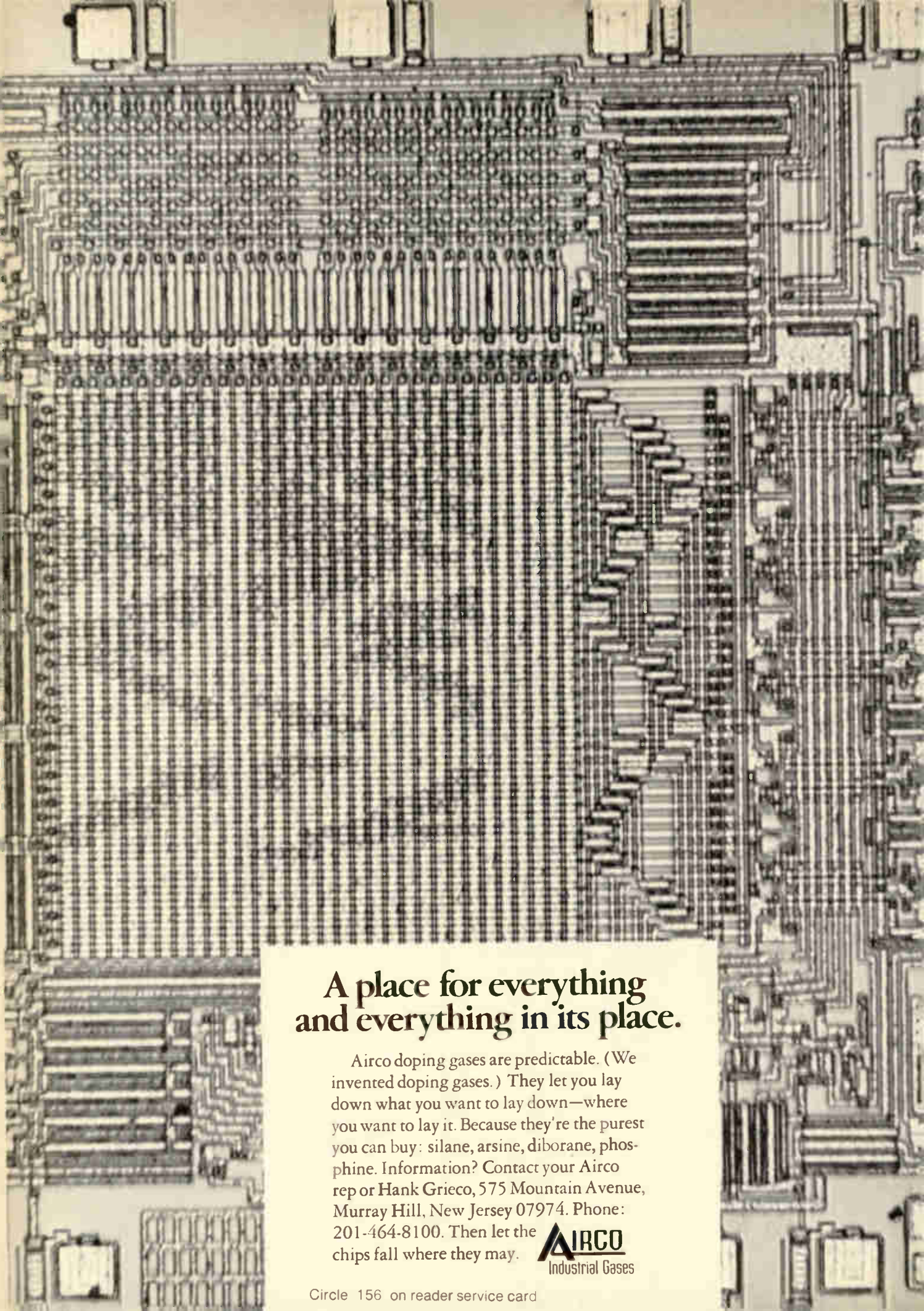
Circle 155 on reader service card



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Circle 156 on reader service card

Semiconductors

IC audio amp puts out 5 W

Harmonic distortion in unit for auto radios is as low as 0.3% at 50-mW level

One of the major thrusts in the development of ICs for consumer equipment is the integration of power circuits in the 2–5-watt range. In its μA706, Fairchild Semiconductor Corp. offers one of the highest power ratings available in IC audio amplifiers; when operated from a 12-volt supply, it delivers 5 watts into a 4-ohm load. The μA706 was developed for the automotive radio and tape-player market, and is particularly suited for high-noise environments such as occur in tractors and large convertibles.

The circuit operates over the full automotive battery range of 6 to 16 V. And, says John W. Chu, senior engineer for consumer microcircuits at Fairchild, "It incorporates special features such as self-centering bias, direct coupling to the input, low quiescent current, high input impedance and low distortion, which make it ideal for quality automotive applications." The quiescent current in the output transistors is typically 15 mA with zero power out; full output power is typically 5.5 W with a 14-V supply (battery fully charged) and with a 4-ohm speaker. At this level, the voltage gain is typically 46 dB, and the total harmonic distortion is 10%. Total harmonic distortion with 50 mW out is 0.3%; at 2 W, it's 0.5%; and at 4.5 W, the distortion is 3%.

The 706 consists of two sections, the preamplifier and the power amplifier. Basically, the preamplifier is a single-stage. common-emitter amplifier with an input buffer transistor, a gain transistor, a current source, and the associated bias circuitry. The input buffer is a high-current-gain pnp transistor that provides 3 megohms input resistance and a level shift that allows the input signal to be referenced to ground. The gain transistor is a high-gain common-emitter amplifier with a high-impedance collector load provided by the current source.

The preamplifier output is coupled directly to the power amplifier, which consists of a gain transistor, two buffer transistors, two output transistors, and the biasing circuits. The output stage is a quasi-complementary push-pull amplifier operating in the class AB mode, meaning that the output transistors are biased to achieve a conduction angle greater than 180°. This results in a low-distortion design. Also, a negative feedback is applied from the output of the power amplifier to the emitter of the preamplifier's gain transistor to further reduce distortion and improve linearity.

The μA706 sells for $2.80 in quantities of 100, and samples can be delivered from stock. Full production of the audio amplifier will begin by November.

Fairchild Semiconductor Corp., 313 Fairchild Dr., Mountain View, Calif. 94040 [411]

Dual comparator gives 25 mA per channel off 5-V supply

"When we came out with the LM 111 comparator," says Robert Dobkin, director of advanced linear circuit development at National Semiconductor Corp., "we found out that many people don't need a high-speed comparator, especially for real-time applications such as in a-to-d converters. What designers want, in systems where more than

New products

one is going to be used, is a dual comparator and one that can work off 5 volts."

National responded with the LM 119. It has a gain of 25,000, a bias current of 500 nanoamperes maximum, and a typical response time of only 100 nanoseconds to a 100-millivolt step input—faster than the LM 111. The LM 119 can supply up to 25 mA at the output, which is sufficient to drive relays. But best of all, says Dobkin, "the LM 119 is a dual comparator (each unit is capable of 25 mA output) and it can operate from a single +5-volt power supply; or if desired, −5 V and ground or ±5 V, or even ±15 V." And while the LM 119 was designed primarily for applications requiring operation from digital logic supplies, it also works well at voltages up to ±15 V. The response time is the same no matter what the power supply voltage is.

Dobkin points out that most other comparators employ zener diodes in the level-shifting network. "Monolithically-made zener diodes have a 6.5-volt breakdown, so they can't be used in 5-volt systems. We use a resistor/capacitor level-shift circuit, and this works well off 5 volts," he adds. And the uncommitted collector output stage of the LM 119 makes it compatible with RTL, DTL, and TTL systems. Minimum fan-out is four for each part of the dual circuit.

In a TO-5 can, the LM 119, designed to operate over the −55 to +125°C range, is priced at $13.95 in quantities of 100. The commercial version—for operation over the range from 0 to +70°C—is priced at $3.95 in the TO-5 can and $4.95 in a ceramic dual in-line package. Delivery is from stock.

National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, Calif. 95051 [412]

Laser diodes put out 4 to 15 watts peak

Gallium-arsenide laser diodes, designated the LD60 series, are housed in TO-18 coaxial stud packages. The

The industry was looking for a breakthrough in LSI design systems...

then along came Macrodata!

"Once upon a time IC chips were small and simple and no one needed an automated design system. Then suddenly thousands of transistors were being designed on a single LSI chip. Now, everyone discovered that the design and production of these complex circuits couldn't be accomplished by the old techniques without countless iterations due to errors. Still, no one could agree on what should be done about it.

"Some said: 'let's develop a computer system that will do all the design for us.' Others said: 'only the designer is creative and completely automatic systems would not provide an efficient working design.'

"Then along came Macrodata with the 'FEDIS' MD-170 LSI Design System, backed up by the unique 'CADIS' software packages. Here at last was the first truly original system designed to best utilize the creativity of the designer and the power of the computer. It was the first LSI design system available for outright purchase that offered transient analysis, logic equation simulation, logic equation generation, cross-talk analysis, and nodal analysis with design rule checks.

"Here was a system that could buy you calendar time, reduce your LSI design costs, eliminate subtle errors, and increase yield because you could be sure that your final artwork would be produced exactly as you designed it. The system houses were quick to see the advantage of such a turn-key, in-house capability.

"Here was the breakthrough. No one else offered so much. Now, you could control your own designs and assure yourself of a multiple sourcing capability. Here was a system totally compatible with all methods of artwork generation—both photo optical and rubylith. Here, at last, was the only system with the analysis packages necessary to produce error-free artwork."

But so much for Chapter Four of the Macrodata Story; you can read the rest of it in the new "FEDIS/CADIS" brochure. For your copy, just use the reader service card, or call us directly.

Chapter Four. The Macrodata Story.

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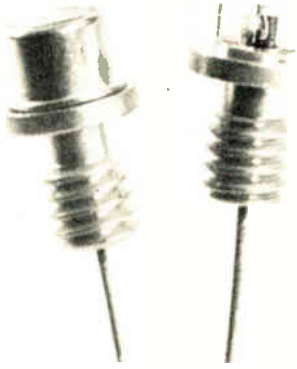
New products

package locates the optical sources on the stud's center rotational axis, which allows for simple laser alignment to optics. The units emit from 4 to 15 watts minimum peak power, and operate at 27°C up to duty

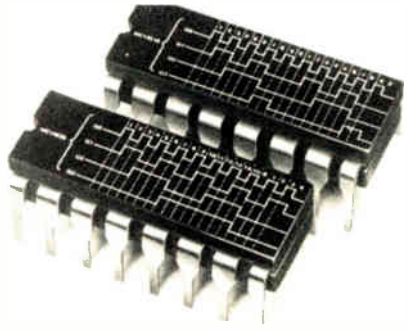


cycles of 0.1% when biased in the forward direction with up to 200-nanosecond pulses. The diodes are available in a hermetic package or a nonhermetic, high-thermal-conductivity copper package. Volume price ranges from $8 to $27.60.

Laser Diode Laboratories Inc., 205 Forrest St., Metuchen, N.J. 08840 [413]

C-MOS up-counters offer high-speed operation

The models designated MC14518 and MC14520 are C-MOS logic up-counters for counting applications at rates of up to 6 megahertz. An in-



ternal synchronous counting design reduces propagation delay where many counting stages are required. Both units consist of two identical independent four-stage counters. The MC14518 provides a dual BCD up-counting function, and the MC14520 offers a dual binary up-counting capability. Price ranges

See previous 3 pages

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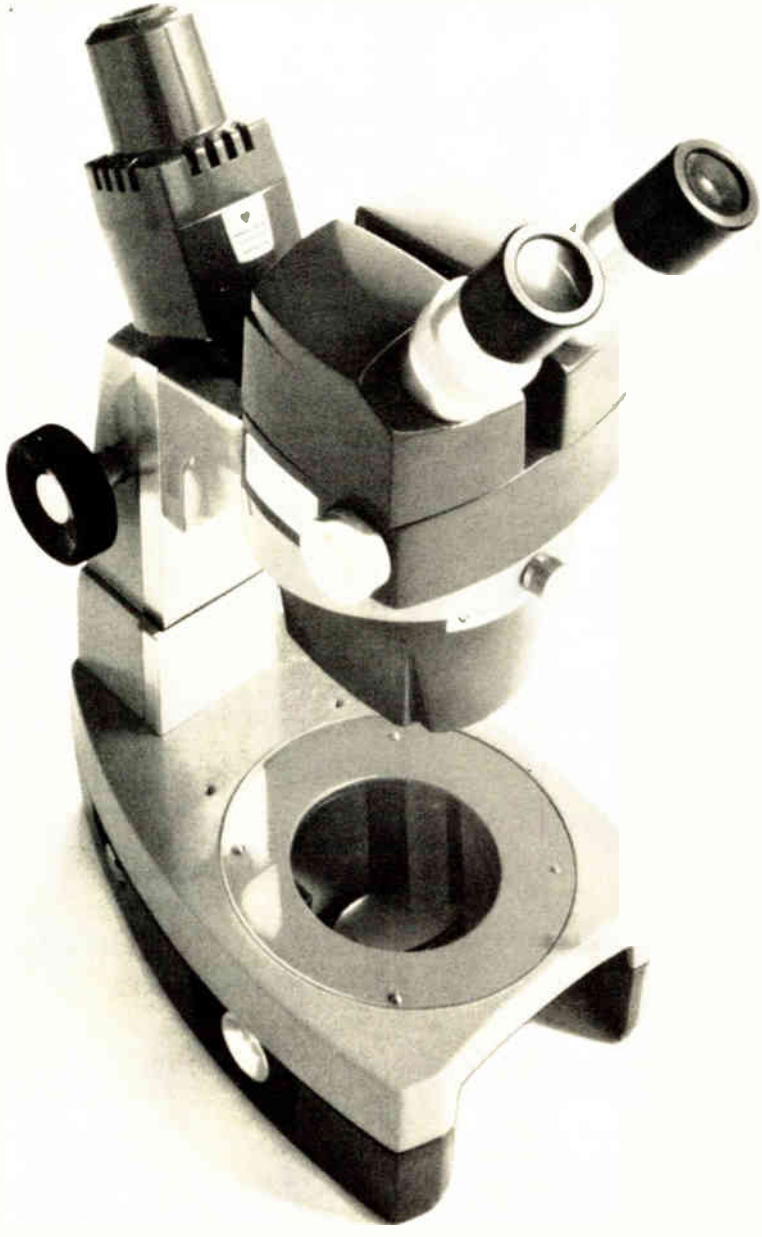


New products

from $7 to $19.35, depending on quantity and type.

Motorola Inc., Semiconductor Products Division, P.O. Box 20924, Phoenix, Ariz. 85036 [417]

First-in, first-out memory is organized 4 by 64 bits

A low-cost solution to problems associated with interface of digital systems that have different data rates is offered in the model 3341 asynchronous first-in, first-out memory. The unit is organized 4 bits wide by 64 bits long, and once data is entered, it propagates to the farthest downstream unfilled location, with no clocking required. When data is moved from the outputs by a shift-out signal, other data in the memory moves down automatically to fill the empty locations. The result is independent operation of input and output. Price in quantities of 100 to 999 is $22 for the 1-MHz version and $15.60 for the 0.6-MHz type.

Fairchild Camera and Instrument Corp., Semiconductor Components Group, 464 Ellis St., Mountain View, Calif. 94040 [415]

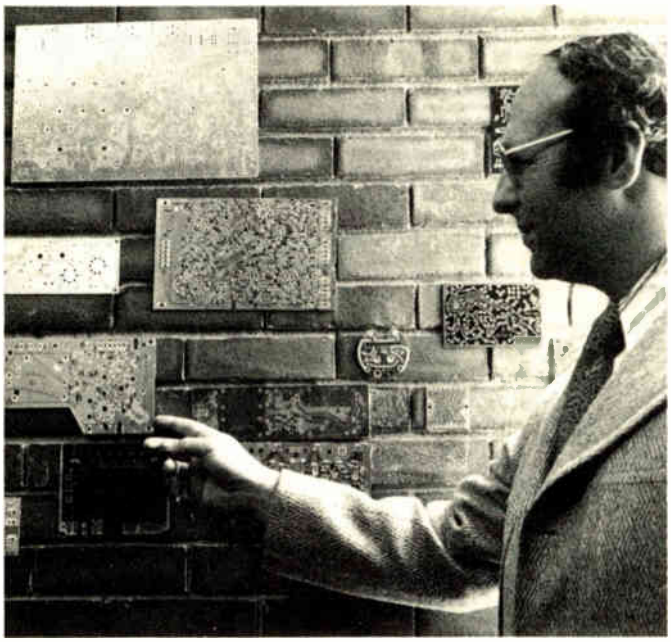
Power hybrids designed to drive inductive loads

A power hybrid device consisting of two Darlington amplifiers in a 14-lead dual in-line hermetic package is designated the TA8590. Each amplifier can deliver 5 amperes with a current gain of 500, or 3 amperes with a current gain of 600. The units are for driving inductive loads, and use hometaxial power transistor chips with good second-breakdown capability. The amplifiers also include integral diodes for load-current commutation. Applications include hammer drivers, solenoid

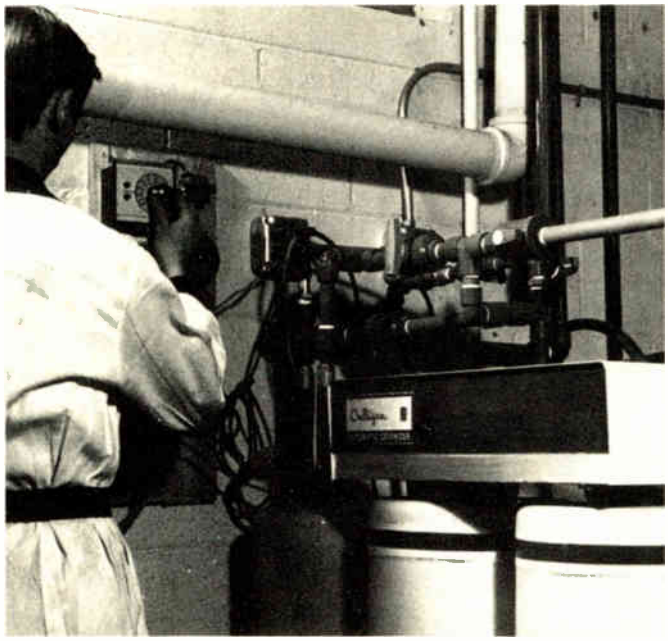
Culligan JOB REPORT

ELECTRONICS
NO. 137

How Deionized Water Aids Quality Control In Making Printed Circuit Boards



Some of the many printed circuit boards made by Poncher Industries, Inc., Cary, Illinois—shown by President Charles Poncher. Very high quality water is a production "must."



To provide water for plating solutions and ultra-clean rinsing of circuit boards—the treatment system includes a Culligan deionizer, activated carbon filter and deionizer exchange tank.

☐ Rejects stay low and quality stays high at Poncher Industries, Inc., Illinois manufacturer of sophisticated printed circuit boards for commercial and consumer applications. A key supplier to such blue chip electronics makers as Zenith, Motorola, Stewart-Warner, Seeburg, Oak Electro-Netics and others, Poncher stresses perfection in every step of manufacture.

"Our job is to make sure the printed circuit board is as reliable as we can make it," says Mr. Poncher. "This, of course, includes using the cleanest water possible in plating solutions and in rinsing tanks. The only answer to the contamination problem is deionized water."

The deionizer chosen was Culligan's Model DA.

The high-quality deionized water provided is used for rinsing at critical points in the cleaning, sensitization and electroplating processes. General Manager Andy Walsh emphasizes—

"I knew from long experience with printed circuit manufacturing that deionized water is vital, so we ordered the deionizer right from the start. It has proved to be a wise decision."

For detailed information and additional case histories, write to Will Sanders for our 4-page Job Report No. 137—or call your local Culligan Man for a consultation. ☐

Culligan USA, One Culligan Parkway, Northbrook, Illinois 60062.

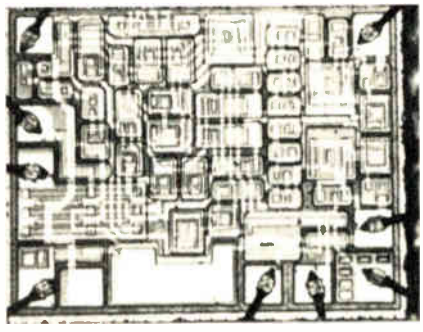
CUSTOMER:	Poncher Industries, Inc., Cary, Illinois
PROBLEM:	Need for high quality water for plating and rinsing circuit boards
SOLUTION:	Deionized water
EQUIPMENT:	Culligan Model DA Deionizer, Activated Carbon Filter, Deionizer Exchange Service

New products

drivers and stepper-motor drivers. Price is $4.25 in 1,000-lots.
RCA Solid State Division, Box 3200, Somerville, N.J. 08876 [416]

FET linear IC line includes preamplifier, two op amps

A new line of field-effect-transistor linear integrated circuits consists of three devices: the HA-2000 FET input preamplifier, the HA-2050 high-slew-rate FET-input operational amplifier, and the HA-2060 wideband FET-input op amp. Each is available in commercial and military versions. The 2000 is a high-impedance input buffer for op amps or comparators, and offers a bias current of 1 pA. The 2050 has a slew rate of 120/μs and a bandwidth of 20 MHz. Input is 1 pA. The 2060 features a gain-bandwidth product of 100 MHz and input impedance of 10^{12} ohms. Bias current is 1 pA. Prices range from $4.35 to $24 in quantities of 100.



Harris Semiconductor, P.O. Box 883, Melbourne, Fla. 32901 [418]

Power driver-control circuit is versatile building block

Off-the-shelf solutions to interface circuit needs are provided by a thick-film control circuit and power driver designated the LMD-1. By adding two external resistors to the hybrid unit, a Schmitt trigger capable of handling 50-volt, 10-ampere loads can be made. If a programable pulser is needed with a rate from 1,000 pulses per second to less than one every 10 minutes, only one capacitor and one resistor need

New products

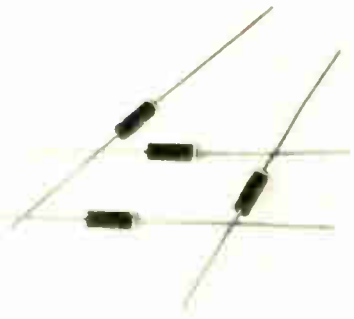
be added to the LMD-1. Controllers and time delay circuits can also be made with it. The LMD-1 is priced at $22 each in 100-lots.
Ledex Inc., 123 Webster St., Dayton, Ohio 45401 [419]

Low-power counters operate at 23 megahertz

New low-power MSI devices include the model Am93L60 decade and Am93L66 hexidecimal counters. The 4-bit up/down synchronous-counter pair offers separate up and down clocks, asynchronous parallel loading, and typical operating speed of 23 megahertz with a power dissipation of 85 milliwatts. The circuits are hermetically sealed, and are configured to the specifications of Military Standard 883. Price ranges from $6 to $23 in 100-lots, depending on temperature range and packaging.
Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, Calif. 94086 [414]

Ion-implanted rectifiers offer fast recovery

A series of 1-ampere hermetically sealed ion-implanted rectifiers features a forward voltage drop of less



than ½ volt and a reverse recovery time of 9 nanoseconds maximum. Forward recovery is 1 nanosecond maximum. The series is designated HSR-OA and is available in five separate types. They are housed in DO29 packages. Prices start at 75 cents in quantities of 1,000.
Solid State Devices Inc., 12741 Los Nietos Rd., Santa Fe Springs, Calif. 90670 [420]

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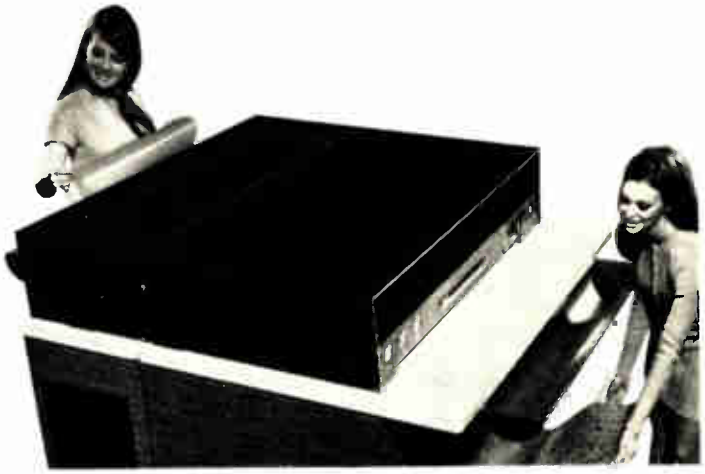

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New products/materials

A solvent-soluble temporary solder resist is designed for printed-circuit-board assembly. It prevents solder from adhering to selected portions of the boards during flow-soldering operations. The material, called Soder-Mask type CHL-1, may be applied with a brush or by dipping. It dries in five to 10 minutes at room temperature to form a hard coating that withstands the scratching and nicking encountered during automatic component insertion. It is heat-resistant to all flow-solder environments, and dissolves in the hot or cold chlorinated solvents that remove flux residue.
Solder Removal Co., 1077 E. Edna Pl., Covina, Calif. 91724 [476]

Stycast 2741 is an epoxy casting resin and sealing compound with adjustable capabilities. The flexibility and hardness of the cured resin can be tailored to meet the needs of the application. Hardness is adjustable from 30 to 80, Shore D, depending on the proportion of catalyst 15. The material is used for electronic embedding and in sealing ceramics, plastics and metals. It will not crack at temperatures as low as −55°C. It can be cured at room temperature or in a short time in elevated temperatures. Pot life is at least two hours. Price is $1.50 per pound in 12-pound lots.
Emerson & Cuming Inc., Canton, Mass. 02021 [477]

A line of palladium silver pastes includes six materials, each with distinctive adhesion, conductivity, and solderability characteristics for applications in the manufacture of hybrid devices. Resistance ranges from 0.010 to 0.060 ohm per square.
Plessey Inc., Materials Division, Melville, N.Y. [478]

A thermally conductive adhesive can increase the efficiency of high-wattage semiconductors by providing a low heat resistance bond to heat sinks. The material is designated Castall 341 and is a two-part adhesive that can be used where glue lines of 0.001 inch or less are required. It will maintain a strong bond over a broad temperature

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New products/materials

range. It is resistant to water, a variety of chemicals, and other harsh environments. Available in quart or gallon quantities, it is priced at about $15 a gallon.
Castall Inc., East Weymouth, Mass. 02189 [479]

Ceramacast 510 is a high-alumina castable ceramic material suitable for use at temperatures to 3,200 F. After mixing with water, the material is poured into plastic molds and hardens into a dense ceramic structure. After heat treatment, the resultant ceramic casting will withstand high temperatures. The material has zero shrinkage upon casting and firing at 1,500 F. Applications are in rf heating-coil potting and low-cost brazing fixtures. Price for an engineering sample lot of one quart is $25. In larger quantities, the price drops to $20 per gallon.
Aremco Products Inc., P.O. Box 145, Briarcliff Manor, N.Y. 10510 [480]

Soldering flux in paste form is designed for tinning or soldering of insulated wire and cable. AMCO 4363 eliminates corrosion due to wicking of fluxes within the wire and cable. Its residue is non-corrosive, and any amount of 4363 that travels up under the insulation will serve as a protective shield on copper wire. The fumes produced by the flux are nonirritating because the material is blended without heavy-metal chlorides.
Force Chemicals Division, American Solder & Flux Co., Paoli, Pa. 19301 [371]

A flexible copper-clad, glass-epoxy printed-circuit material is designed for continuous, large-volume production. Nelflex-1 withstands repeated solder temperatures of 500°F and has a high degree of dimensional stability (0.0005 in./in.) after etching, which eliminates subsequent drill registration problems. Moisture absorption percentage is 0.5%, and low Z-axis characteristics make it effective for multilayer packages. The material can be drilled or punched for plated-through holes.
New England Laminates Co., 25 Crescent St., Glenbrook, Conn. 06906 [372]

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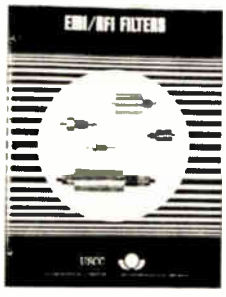

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Circle 171 on reader service card

Do we need a Chinese Wall around America?

Not so long ago, most of us got a good look at the Great Wall of China, in living color.

It is quite a sight.

Built where it is.

But some people would like to build a "Great Wall" around America. And that would be a different sight entirely.

The specifications for the wall are contained in the Burke-Hartke Bill, now before Congress. The key provisions of this bill would:

- Establish permanent quotas on foreign imports into the U.S., at about 60% of current levels.
- Regulate, and severely restrict, the export of U.S. capital and technology.
- Impose a form of double taxation on the foreign earnings of U.S. companies.

The Great Wall of China was built to keep out invaders. The Burke-Hartke Wall goes the Chinese one better. It has *two* sides. One to keep out, and one to keep in. One to shut out foreign competition, and one to shut in *American* competition—in the form of American products, or of American initiative and enterprise.

The clear prospect is that the Burke-Hartke Wall would do far more shutting in than shutting out, at the catastrophic expense of most of U.S. business and industry, most of U.S. labor, and all American consumers and taxpayers.

The even grimmer prospect is that this hostile and defiant act—the United States against the world—would trigger an international trade war. Which would be an economic, political and moral disaster for all concerned.

Why take such an obviously extreme, desperate and dangerous step?

Because, say the supporters of Burke-Hartke, our case is desperate. Foreign competition and the export of U.S. capital and technology have created a "national crisis." We face the "destruction of major industries" and the "loss of one million American jobs."

It is time to set some things straight.

For 77 years, from 1893 through 1970, the U.S. exported more than it imported. The net result was a constant, cumulative increase in U.S. jobs and wages.

In 1971, for the first time in this century, we imported more than we exported—by $2.9-billion. The net result, at least in theory, was to displace $2.9-billion worth of domestic goods with foreign imports—and to reduce total U.S. output and employment accordingly.

Total U.S. output in goods in 1971 was well over $600-billion. The possible loss in output attributable to the $2.9-billion trading gap was, consequently, 0.5% of the total—and the presumable loss in employment about the same. That is, less than one-half of one percent.

These are the exact dimensions of the "crisis" as it relates to trade.

The facts about the "outflow of U.S. capital and technology" are equally plain.

In 1971, the capital outflow—the additional investment made by U.S. companies in foreign operations—amounted to $4.5-billion. But the capital inflow—the return on previous investment—reached $7.3-billion. Leaving a positive balance of $2.8-billion.

Similarly, the previous export of U.S. technology produced a cash inflow, in the form of royalties and fees, that amounted to $2.0-billion in 1971.

The idea that the outflow of U.S. capital and technology costs U.S. jobs is quite simply a delusion.

The foreign subsidiaries of U.S. multinational companies are essentially local businesses. 92% of what they produce is sold abroad—and, in most cases, can *only* be made and sold abroad. It *cannot* be made in the U.S., shipped abroad and sold competitively against domestic products.

Thus, to put it bluntly, the "lost" jobs never existed, and cannot exist. Except in the imagination of those willing to ignore reality to make a case.

The plain truth of the matter is that the "crisis" that has produced the Burke-Hartke Bill is not national, and has nothing to do with exports—of goods, or of capital and technology.

This Bill is the result of the very particular and special problems of certain industries and companies that find themselves unable, for a variety of reasons, to compete effectively against foreign imports.

With all due regard for the reality and seriousness of these problems—and for the industries, companies and people concerned—the Burke-Hartke Bill is *not* the answer.

To protect their interests, it is proposed that we ignore all other interests, all other considerations, and all possible consequences. To (perhaps) save their jobs, it is proposed that we gamble the jobs of another, larger group of Americans.

The trouble is, it won't work—for anybody. It is a bad idea, and a worse gamble.

The Burke-Hartke idea, in brief, is to deliberately demolish the entire delicately balanced structure of international trade and commerce, kick aside the pieces, and declare "a whole new ball game."

The gamble, on which everything rides, is that we can play the game by *our own rules*—with the outcome fixed in advance, in our favor.

The Burke-Hartke rules arbitrarily and unilaterally cut U.S. imports almost in half—from $47-billion in 1971, to a fixed annual rate of about $28-billion.

This presents the other nations of the world with an ultimatum—and two equally bleak alternatives.

They can accept an $18-billion annual loss in sales *to* the U.S., while continuing to buy at the rate of $40-50-billion *from* the U.S.—thus accepting a *permanent* trading gap on the order of $20-billion a year.

Or they can cut their purchases of U.S. goods, build their own walls, and let the trade war take its ruinous course.

A hard choice. But can there be any doubt as to the answer? And the results?

Walls, in the general experience of mankind, are rooted in fear, built on delusion, and doomed to futility.

The Burke-Hartke Wall is no exception.

It is a product of fear, based on the delusion that the answer to competition is to refuse to compete.

It is a symbol of panic and despair—crying, "Stop the world, we want to get off."

But the world won't stop, we can't get off, and we don't need a wall, but a way.

A way, quite simply, to make this country what it can and should be. Strong, productive, and confidently competitive in a competitive world.

This is the way—the *only* way—to really save our jobs.

And our self-respect.

We at McGraw-Hill believe in the interdependence of American society. We believe that, particularly among the major groups—business, professions, labor and government—there is too little recognition of our mutual dependence, and of our respective contributions. And we believe that it is the responsibility of the media to improve this recognition.

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

Permission is freely granted to individuals and organizations to reprint or republish these messages.

John R Emery

John R. Emery, President
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New literature

Uhf transistors. RCA Solid State Division, Route 202, Somerville, N.J. 08876. Performance characteristics and circuit details of the 2N6104 and 2N6105 uhf power transistors for broadband uhf power amplifiers are described in a 10-page application note. Circle 421 on reader service card.

Magnetic diodes. A four-page applications bulletin on magnetic diodes is available from European Electronic Products Corp., 10180 West Jefferson Blvd., Culver City, Calif. 90230 [422]

Telephone transformer. Microtran Co., 145 East Mineola Ave., Valley Stream, New York 11582, has available an applications bulletin on telephone coupling transformers. The six-page bulletin provides definition of terms, bibliographies, and test methods. [423]

Optical scanner. The series G optical scanner is described in a catalog available from General Scanning Inc., 80 Coolidge Hill Rd., Watertown, Mass. 02172 [424]

Microwave devices. Transco Products Inc., 4241 Glencoe Ave., Venice, Calif. 90291. A brochure is available with specifications on 18 microwave devices, including filters, hybrids, couplers, multiplexers, and power dividers. [425]

Limit switches. Namco Controls, 170 East 131st St., Cleveland, Ohio 44108, has published a data sheet on a highly sensitive limit switch, series EA150, for rotary and oscillating applications. The two-page sheet includes design and performance features, specifications, and ordering instructions. [426]

Digital instruments. "Your Guide to Digital Instrumentation" is the name of an eight-page survey of products available from SE Laboratories Ltd., North Feltham Trading Estate, Feltham, Middlesex, England [427]

Light sources. Oriel Corp. of America, 1 Market St., Stamford, Conn. 06902. An 11-page catalog describes a series of xenon and mercury arc lamp sources rated at from 75 to 1,000 watts. Included are lamp power supplies and lamp housings. [428]

Data coupler. Elgin Electronics Inc., Walnut St., Waterford, Pa. 16441, is offering a two-page illustrated specification sheet on its EDC-1001B automatic data coupler, which connects the user's automatic data equipment to a switched telecommunications network for data and voice communications. [429]

Rf current probes. A 42-page booklet has been published by Singer Instrumentation, Los Angeles Operation, 3211 South La Cienega Blvd., Los Angeles 90016, presenting a discussion of current-probe characteristics and details on 14 models. [430]

Relays. A 12-page catalog containing information on solid-state ac relays is available from Hamlin Inc., Lake Mills, Wis. 53551. Bulletin A-00011B describes three-phase motor starters included in the company's line. [431]

Junction FETs. Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif. 94040. A 160-page manual is being offered on junction field-effect transistors and includes tabular data and specifications, application notes, selection guides, and glossary. [432]

Thermistors. Fenwal Electronics, 63 Fountain St., Framingham, Mass. 01701, is offering an applications sheet on thermistors. Bulletin AG-1A is designed to assist the engineer and reduce the time necessary to select the proper thermistor for applications that most often present the designer with problems, such as time delay and transistor compensation. [433]

MOS modem. A six-page brochure, describing an MOS modem featuring 4,800 bits per second full-duplex operation, is available from American Data Systems, Canoga Park, California. [434]

New books

IEEE Standard Dictionary of Electrical and Electronics Terms, Approved by the Standards Committee of the Institute of Electrical and Electronics Engineers, Inc., Wiley-Interscience, 716 pp., $19.95

What's wrong with this book is symptomatic of what's wrong with the IEEE. It's slow-moving, academically oriented, behind the times, and too wrapped up in committees to respond to the needs of its members. The cutoff date for the terms defined in this 1972 publication was January 31, 1968, and since then the book has become out of date.

Even so, it's still hard to understand why terms like "laser," "metal oxide semiconductor," and its common abbreviation, "MOS"—all of which were in use in 1968—are not included. "Electromagnetic braking" is defined, but "electromagnetic" is not. And while "random access" is in, "random-access memory" is not; nor is "read-only memory." "Bipolar" is defined in terms of power supplies, with no hint of the existence of bipolar semiconductor devices. "Silicon," "silicon gate," "charge-coupled device," and "emitter-coupled logic" are all omitted.

"Electro-optical" is defined in terms of "double refraction," but "double refraction" appears nowhere. "Hertz" is included, but the prefixes "kilo-," "mega-" and "giga-" are omitted along with most compounds that include them. Also among the missing terms are "Gunn diode," "Impatt diode," "bubble," "domain," and many others.

Even the definition for the term "electrical" is confusing, because it is given in terms of "electricity"—and electricity is not defined.

Perhaps the coverage is simply too broad. The jacket blurb emphasizes electronics—"13,000 words from every area of electrical and electronics engineering." The claims of "electrical" coverage are valid (with definitions relating to electric power transmission, electric railways, elevators, and the like), but the "electronics" part of the book's title falls far short of the needs of today's electronics engineer.

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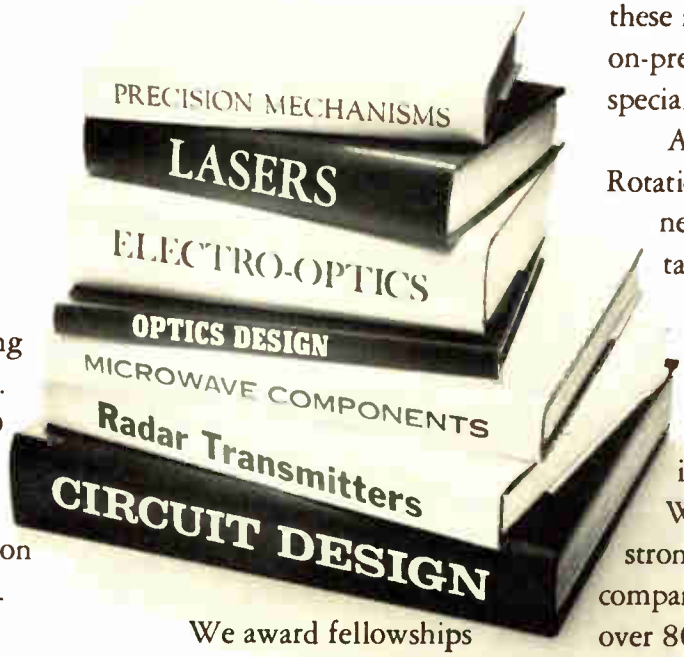

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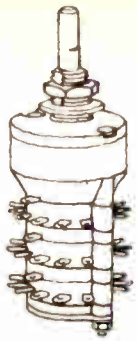

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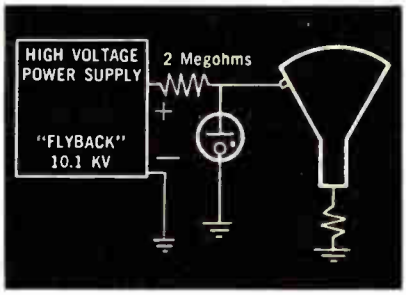

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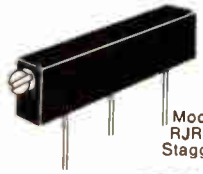
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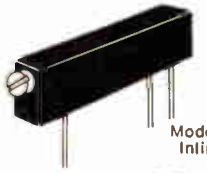
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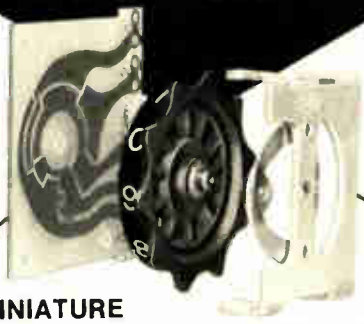

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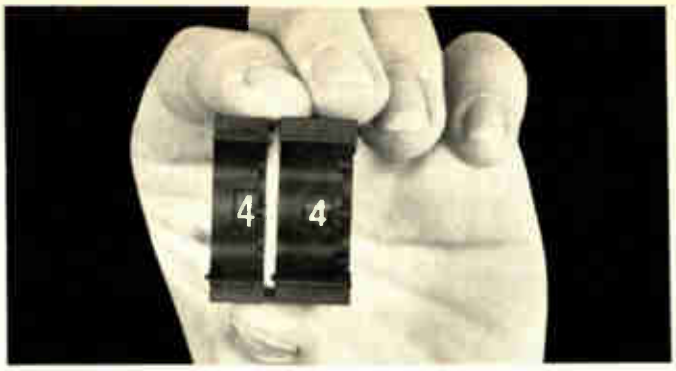

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