August 30, 1971

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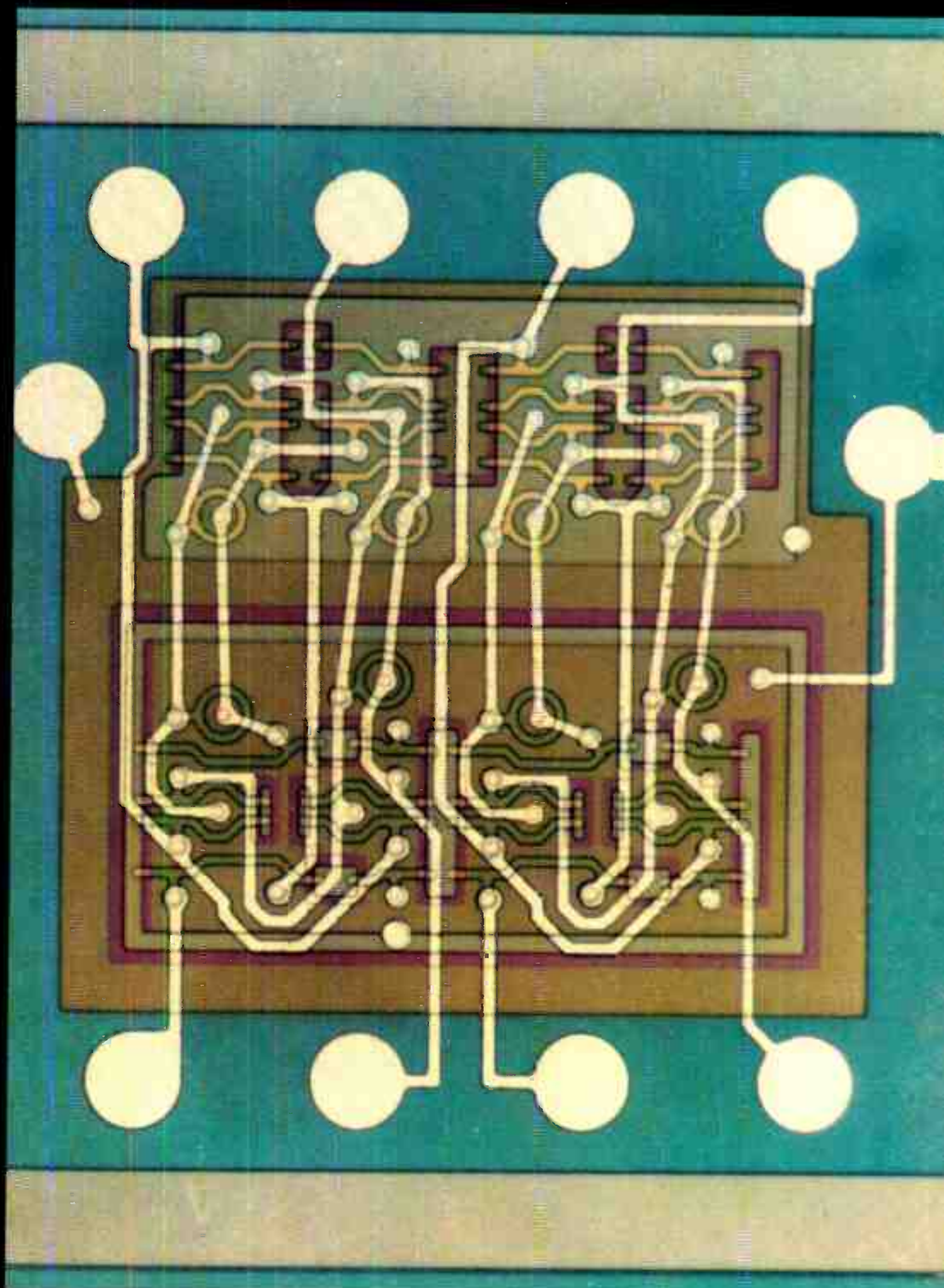
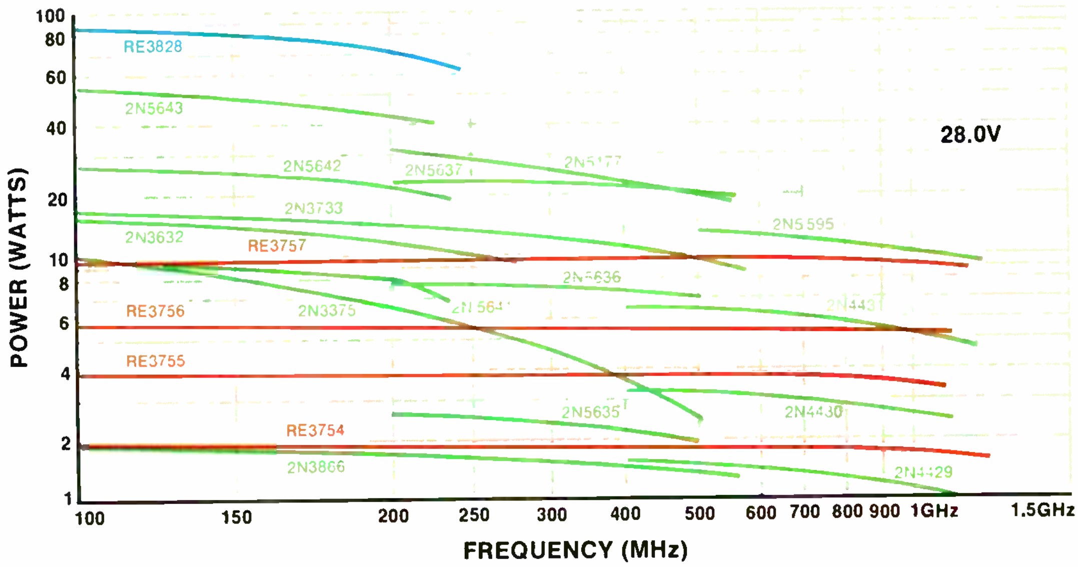
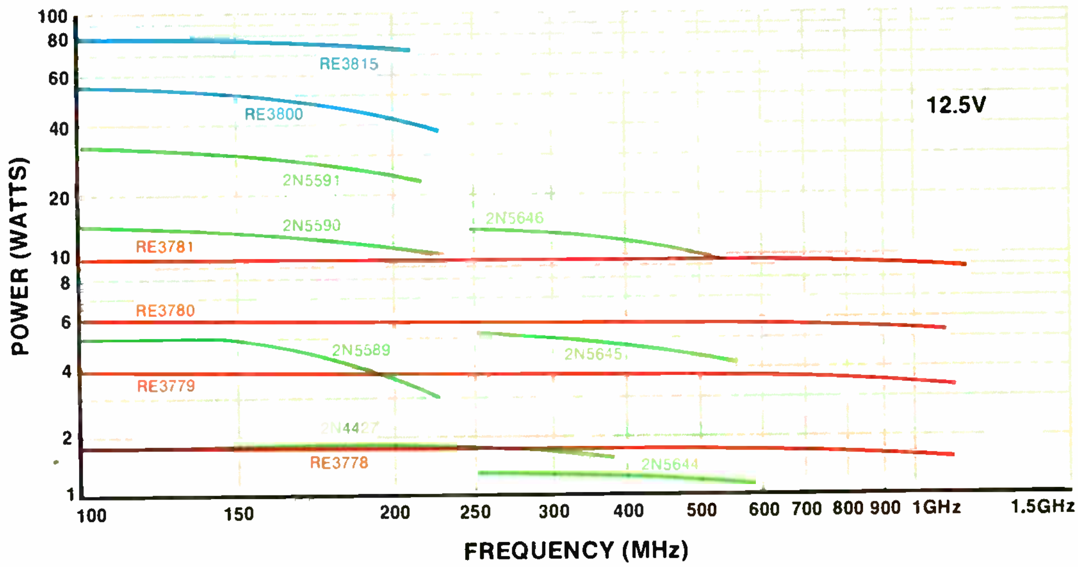
Electronics®

Silicon gate, C/MOS combine for faster micropower circuits



Build the chain of your choice:





with three new high-power, infinite-VSWR devices, eight of the broadest broadbands you can get, twenty-one standard 2N friends, and a couple of other helpers.

The 2 N's (green lines), you'll recognize: industry standards. We manufacture twenty-one of them. More than enough for most power chains, but not all. That's the reason for the red and blue lines.

The RE-3700-series (red lines), you may not have seen before. Now that you have, you still may not quite believe them. They're our proprietary broadbands. And they're for real. Plug any of them in and it will play, from 100 MHz to 1000 MHz.

The RE-3800's (blue lines) are our three newest, and most pleasant, surprises. They deliver lots of watts, with an honest-to-Hemholtz infinite VSWR —not just at dead short and wide open, but across the full range.

All of which adds up to a most convenient way to put together an RF power chain: with one phone call, one purchase order.

Try the phone call, or a letter, first. We'll send you data on more RF power devices than anyone else can give you.

Unisem Corporation, P.O. Box 11569, Philadelphia, Pennsylvania 19116. Telephone: (215) 355-5000.

Unisem

The Partner People

Circle 900 on reader service card

Plain

& Fancy.

Now you can go from 10 MHz to 12.4 GHz in either of two solid-state sweepers: the streamlined 8620B or the flexible 8620A.

The "plain" version will give you highly linear sweeps, stable CW and versatile modulation. Yet, including RF plug-ins, it costs 20 to 40 percent less than any similar combination on the market. The mainframe itself is a mere $975.

The fancy 8620A mainframe will only set you back $1450. And it proves once again that good things do come in small packages. Advanced engineering has packed exceptional resolution, great setability and remarkable latitude of control into an instrument about half the size of previous models. Besides having push-button controls, it can even serve as a completely programmable source for systems.

For both plain and fancy versions, nobody can equal our approach to RF coverage. From 10 MHz to 12.4 GHz, you use low-cost octave bandwidth plug-ins or combine RF sources for multiband operation. (For example, you can configure a multiband plug-in to take you from 0.1 to 6.5 GHz or from 5.9 to 12.4 GHz.)

But whatever approach you choose, you'll get impressive solid-state performance at attractive prices.

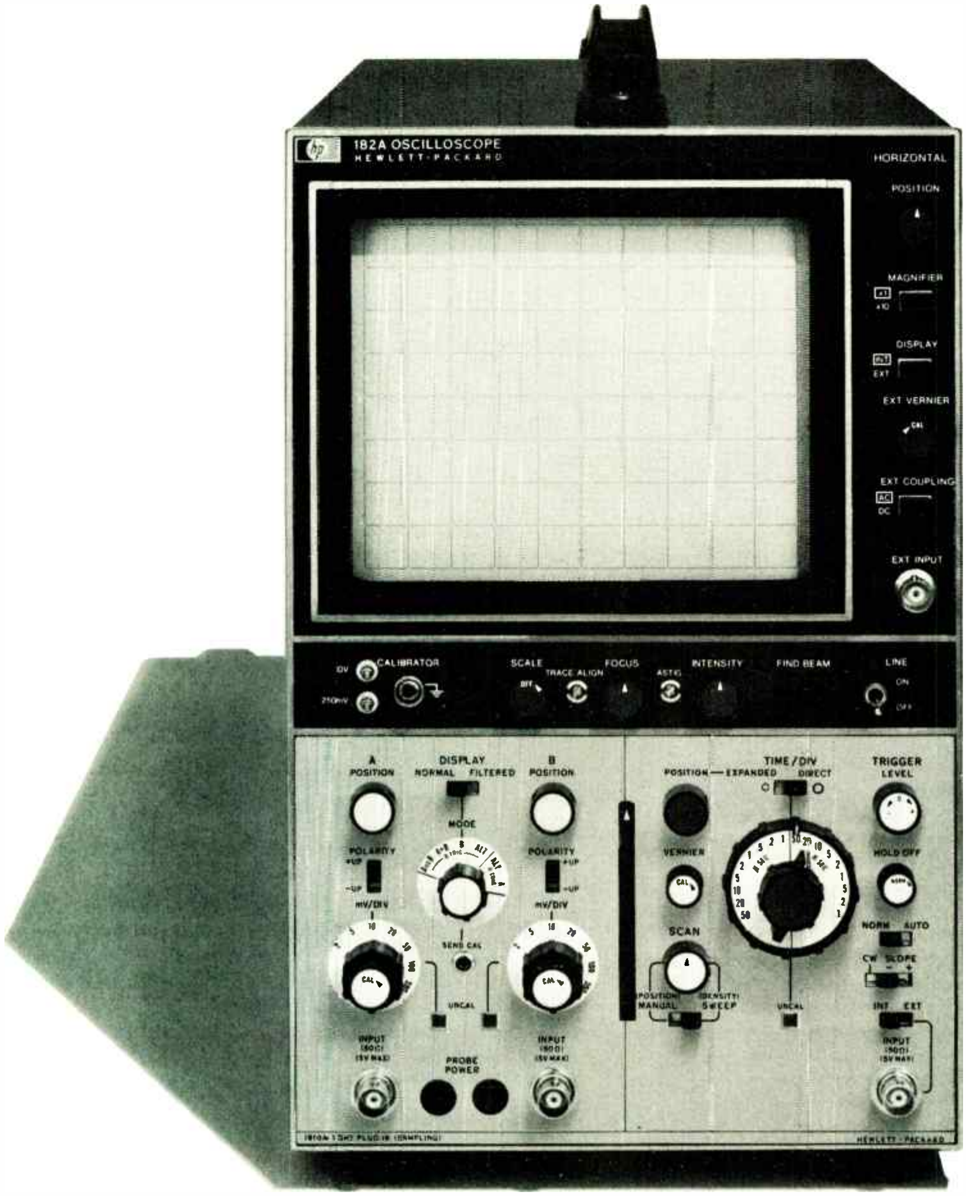
It's easy to select the best RF units and mainframe for your application; they're all described in our new sweeper brochure. Ask your local HP field engineer for a copy. Or write us for one at: Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

04114

HEWLETT hp PACKARD

SWEEP OSCILLATORS

Circle 1 on reader service card



Look again.
It's a 1GHz sampling scope!

If, at first glance, you didn't realize that the instrument shown above is a 1GHz sampling scope, it's understandable. HP's new 1810A sampling plug-in for the 180 Scope System is designed to have controls like those of a real-time scope.

The result is the **first truly easy-to-use sampling scope ever.** No longer do you have to pore over a manual or tinker for hours in order to "get the hang of it." If you can use a real-time scope, you can use the 1810A. Internal calibration adjustments are simplified, too—only 13, none of them interacting. And modular construction makes servicing literally a "snap."

Simplified doesn't mean unsophisticated, however. The 1810A gives you <350 ps risetime and 100 ps/div sweep time, with a choice of seven deflection factors ranging from 2 mV/div to 200 mV/div. Accuracy is ±3%. Reflection coefficient is <6% (measured with wide-band TDR), at 50Ω input resistance. And the 1810A's two channels can be operated to give you: channel A; channel B; alternate A and B; A + B; and A vs B.

However, the 1810A's **most exciting feature is its price tag,** $1650. Use this plug-in in any of the eleven HP 180 Series mainframes—including conventional, variable-persistence and storage, large-screen and militarized models.

For further information on the new 1810A 1GHz sampling plug-in, or on the 180 System in general, contact your local HP field engineer. Or write Hewlett-Packard, Palo Alto, California 94304. In Europe: 1217 Meyrin-Geneva, Switzerland.

Scopes are changing. Are you?

081/8

HEWLETT hp PACKARD

Electronics
The International Magazine of Electronics Technology
August 30, 1971

Volume No 44, Number 18

Publisher's letter

Developing realistic options—as many as possible for the least investment—is the hallmark of every good engineering manager. And that is precisely what Deputy Defense Secretary David Packard is trying to do with his Directive 5000.1, which calls for step-by-step prototyping of tangible military hardware to develop the real systems cost and performance estimates that have eluded his predecessors [see p. 65].

Our Washington bureau manager, Ray Connolly, looked at Packard's plan—and its potential impact on electronics manufacturers and their engineers—by drawing on conversations with the man whose massive 6-foot, 5-inch frame and role as the most powerful Pentagon deputy yet have Washington subordinates calling him "The Big Man." Connolly, who has covered Federal electronics programs from Washington for six years now, also draws on observations by John S. Foster, Jr., the Director of Defense Research and Engineering, whose office is charged with implementing 5000.1.

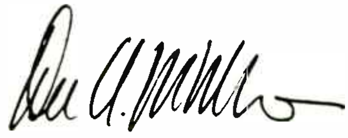
"Of course there is a lot of industry suspicion that Packard won't have any more success bringing the military back into the real world than Robert McNamara did," says Connolly. "But if the outcome of the 1972 elections lets him stay on the job, Packard will have more going for him than McNamara did. Packard's been bitten by the same 'power bug' that gets everyone in the Washington hierarchy sooner or later, but he knows the problems of technology better, seems to listen better, and certainly delegates more responsibility than McNamara did."

Reporters, he says, appreciate Packard "for a candor that's uncommon in Washington. So does the Congress. That could eventually get him in trouble, but the interesting thing is that it doesn't really bother him. The job doesn't have him up tight yet. He's much more of a hip-shooter than McNamara ever was, but it is based on the same intuition that got him a bankroll of $300 million. That's tough to argue against."

What Packard is telling military project officers and their contractors are the same things he used to tell his manager at Hewlett-Packard: He won't spend money for unproven 'quantum jumps' that come in pretty brochures on costly paper.

Connolly's zeal as a reporter keeps him in close touch with these top Pentagon officials. But one interview with Foster brought him nearer the two than he expected, because it evolved into an unofficial invitation to a Pentagon-related cocktail party, at which he was the only member of the press. Connolly says he caught Packard and Foster in conversation with giant-sized martinis in their hands. Sticking with equal parts of scotch and water, Connolly retained the conversational advantage: "It has a much slower response time," he says.

While some at the party were shifting from "loose, flexible bundles of discrete components into a rigid solid state," according to Connolly, Packard was one outstanding exception. "The man is as close to fail-safe as anything in the American or Soviet inventory."



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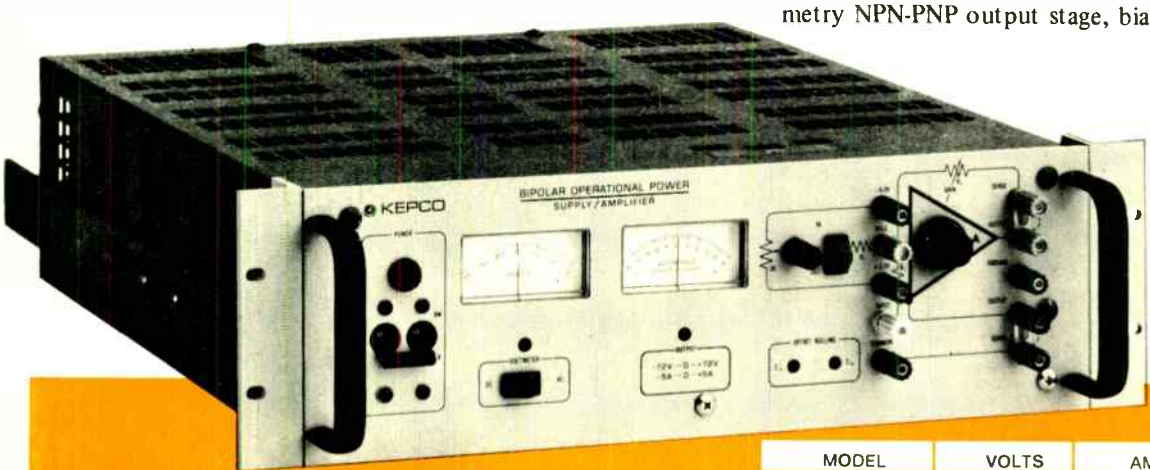

Model BOP 72-5M

MODEL	VOLTS	AMPS	PRICE
BOP 15–20M	+15 to -15	+20 to -20	$1,150.00
BOP 36–1.5M	+36 to -36	+1.5 to -1.5	562.00
BOP 36–5M	+36 to -36	+5 to -5	803.00
BOP 72–1.5M	+72 to -72	+1.5 to -1.5	1,204.00
BOP 72–5M	+72 to -72	+5 to -5	1,579.00

For unmetered Modular units: delete suffix "M" and deduct $60.00 from listed price.

These power supplies are true operational devices, whose output direction and magnitude are determined by your selection of signal, input, and feedback parameters. Dynamically, the *small signal* frequency response extends to 300 kHz and the *large signal* frequency response 20–30 kHz (the frequency at which the fully modulated, fully loaded output reaches 3% harmonic distortion). Of course, the BOP can be controlled to stabilize its output voltage (or current) at a selected d-c level with, typically, 0.02% load effect (regulation).

You can employ these unique instruments as voltage controllers, current controllers, servoamplifiers, magnet exciters, X-Y deflectors or even (if your ears can take it) superb Hi-Fi amplifiers.

There are five models that are available in either a laboratory format (Suffix M) with meters, panel controls, patch board, etc., or in a package form that can be used with remote monitoring and controls as part of your system or product.

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Readers comment

Patented

To the Editor: I was most interested to read of the new metalization system "developed" at Japan's Nippon Telegraph and Telephone Public Corp. [June 21, p. 134]. I feel it appropriate to refer to my patent, 3,409,809, dated Nov. 5, 1968, which covers the contact system of aluminum-nickel-gold as applied to semiconductors.

Donald S. Diehl
Teledyne Semiconductor
Hawthorne, Calif.

Pioneers

To the Editor: Smith-Kline Instruments' medical monitoring system for Gadsden, Ala.'s Baptist Memorial Hospital [July 5, p. 83] is not the first computerized setup to be delivered. Beehive Medical Electronics installed a computerized intensive care/coronary care monitoring facility, capable of checking up to eight beds, at Doctors' Hospital in San Leandro, Calif., in early April. Several other of our medical computer systems have been installed since, including a unit at the VA hospital in New York City. Our system uses a Data General Nova 1200 minicomputer with either 8k or 12k of core. Storage is by tape cassettes and data is displayed on a memory oscilloscope.

Ronald J. Hatch
Beehive Medical Electronics Inc.
Salt Lake City, Utah

No coup

To the Editor: In the Washington Newsletter on automatic number and location identification [July 19, p. 50], you state: "In a coup that may prove embarrassing for Bell, however, independent phone companies in Nebraska have submitted a $150,000 proposal to the Law Enforcement Assistance Administration for the installation, demonstration, and evaluation of 911/ALI for 80% of that state's population."

This is erroneous because the Northwestern Bell Telephone Co., which operates in Omaha, now has 911 with identification and ringback circuitry. Bell serves 51% of Nebraska's population, with Omaha alone accounting for about 27% of the total population. It would not be possible for the independents to serve 80% of the state with 911/ALI.

H.M. Scott
Northwestern Bell Telephone Co.
Sioux Falls, S.D.

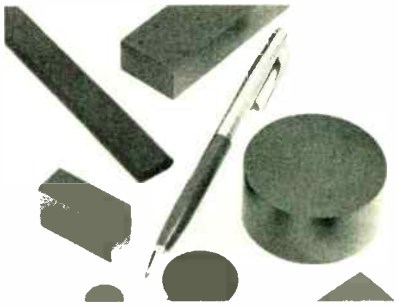
▪ *Brig. Gen. Donald G. Penterman, Deputy Adjutant General for the State of Nebraska, says that the independents' proposal differs from Northwestern Bell's system in that the former "would have a display capability, probably a video screen, and a computer link would make identification and location automatic—not operator-handled." He also notes that the independents provide Nebraska government phone service to 24 counties with 80% of the population.*

Wrong picture

To the Editor: Your story on Ampex lithium ferrites for microwave applications [Aug. 2, p. 92] used a picture that shows Ampex hot-pressed ferrites for magnetic recording heads, not the microwave units.

Joel E. Zneimer
Ampex Corp.
Sunnyvale, Calif.

▪ *These are the lithium ferrites for microwave applications.*



Acronyms anonymous

To the Editor: I enjoy reading *Electronics* but find myself struggling with the modern electronic alphabet soup. You could help by publishing a decoding list with brief definitions of abbreviations such as ROM, RAM, DIP, TTL, DTL, MOS, BCD, MSI, LSI, SCR, CCD, LED, etc.

Einar Strommen
Bethel, Conn.

▪ *Electronics' policy is to spell out the full identification in an article before using the abbreviation.*

40 years ago

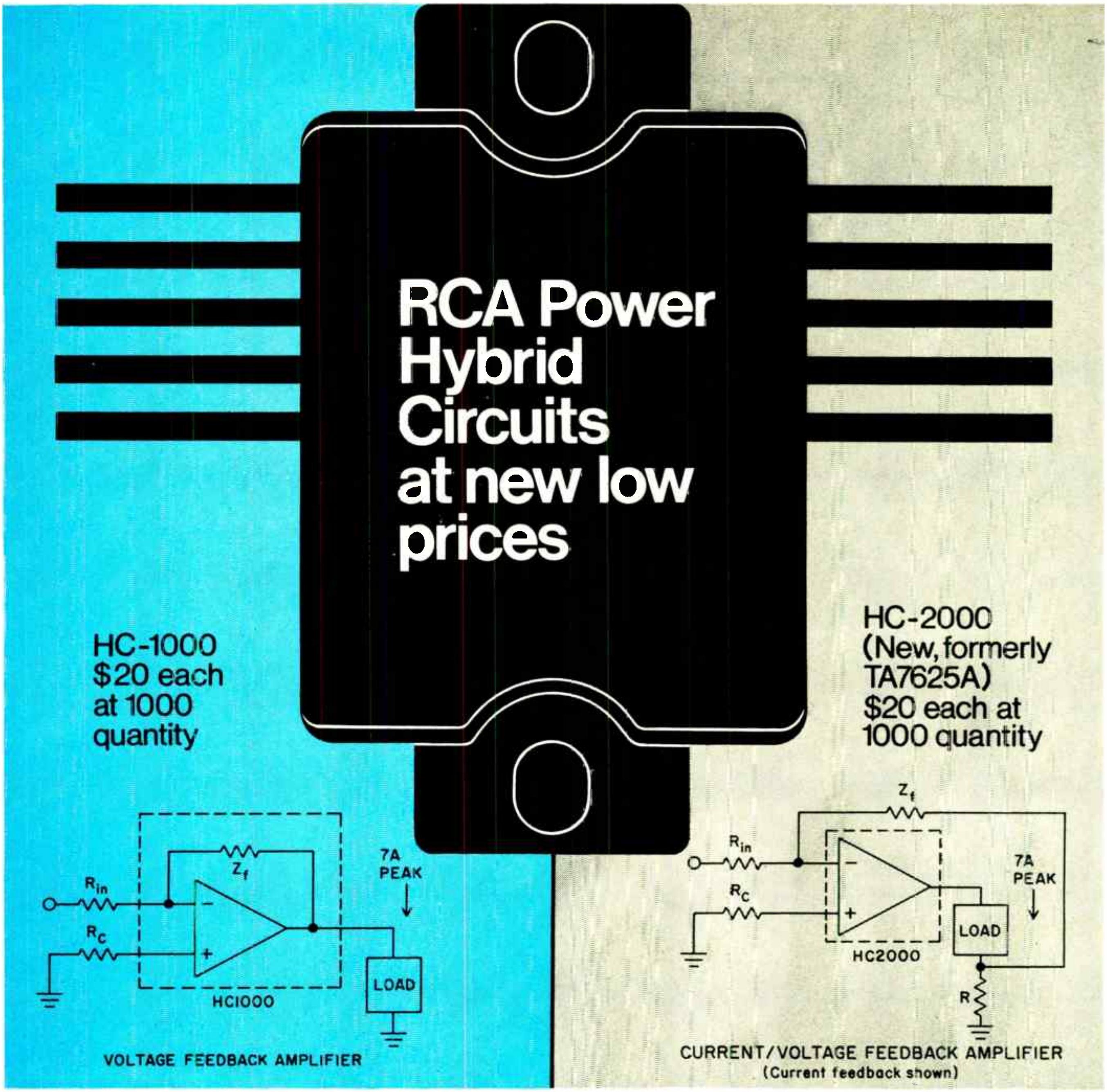
From the pages of Electronics, August 1931

Proposal by the Department of Justice of an "open patent pool" as the condition of withdrawing the government's suit against the Radio Corporation of America and its associated companies, has created wide discussion in radio circles. Whatever the degree of assent of the principal defendants to the proposal—from several independent quarters have come opinions that a patent pool of the kind proposed might turn out thoroughly unsatisfactory to the radio industry, and especially to the radio inventors.

The fear among the independent radio manufacturers is that an "open patent pool," administered under the supervision of the Federal Government, would have to admit as members all applicants for licenses, whatever their experience in radio.

For use on the new giant dirigible Akron, the Navy Department is having constructed the most powerful radio set that has ever been installed on an aircraft. There are to be three receiving sets: one for high frequency, one for intermediate frequency, and a direction finder. Provision is made for two trailing antennae of the reel type and for one fixed-wire antenna. The fixed-wire antenna will follow a longitudinal girder and will be secured between short struts extending out from the hull of the airship. This location eliminates the possibilities of the fixed-wire antenna being fouled during landing and handling operations. Two independent gas-engine-driven generators located in the generator room will be used for auxiliary purposes.

Spurred by recent encouraging pronouncements as to the progress of television, a veritable land rush for the television wavelengths is slowly gaining momentum. Not only the two great national networks, but more and more individual stations are climbing atop the television bandwagon. The result may soon be an overcrowding of the television wavelengths somewhat akin to that on the broadcasting channels.



Price plus performance — that's what RCA's HC-1000, linear power amplifier, and HC-2000, power Op Amp, deliver in a big way! Available now at an attractive low price, these power hybrid circuits will bring new economies to your designs for industrial and commercial systems. Both the HC-1000 and HC-2000 provide these design features:

- 7 A peak current
- Bandwidth: 30 kHz at 60 W
- Power output to 100 W
- Rugged plastic package

For fixed voltage feedback systems, such as audio, you can use the HC-1000 or the HC-2000. The added feature of external feedback modification on the HC-2000 provides for both current and voltage feedback — current feedback is an important advantage for servo applications.

Using these RCA units you can simplify your designs in such areas as:

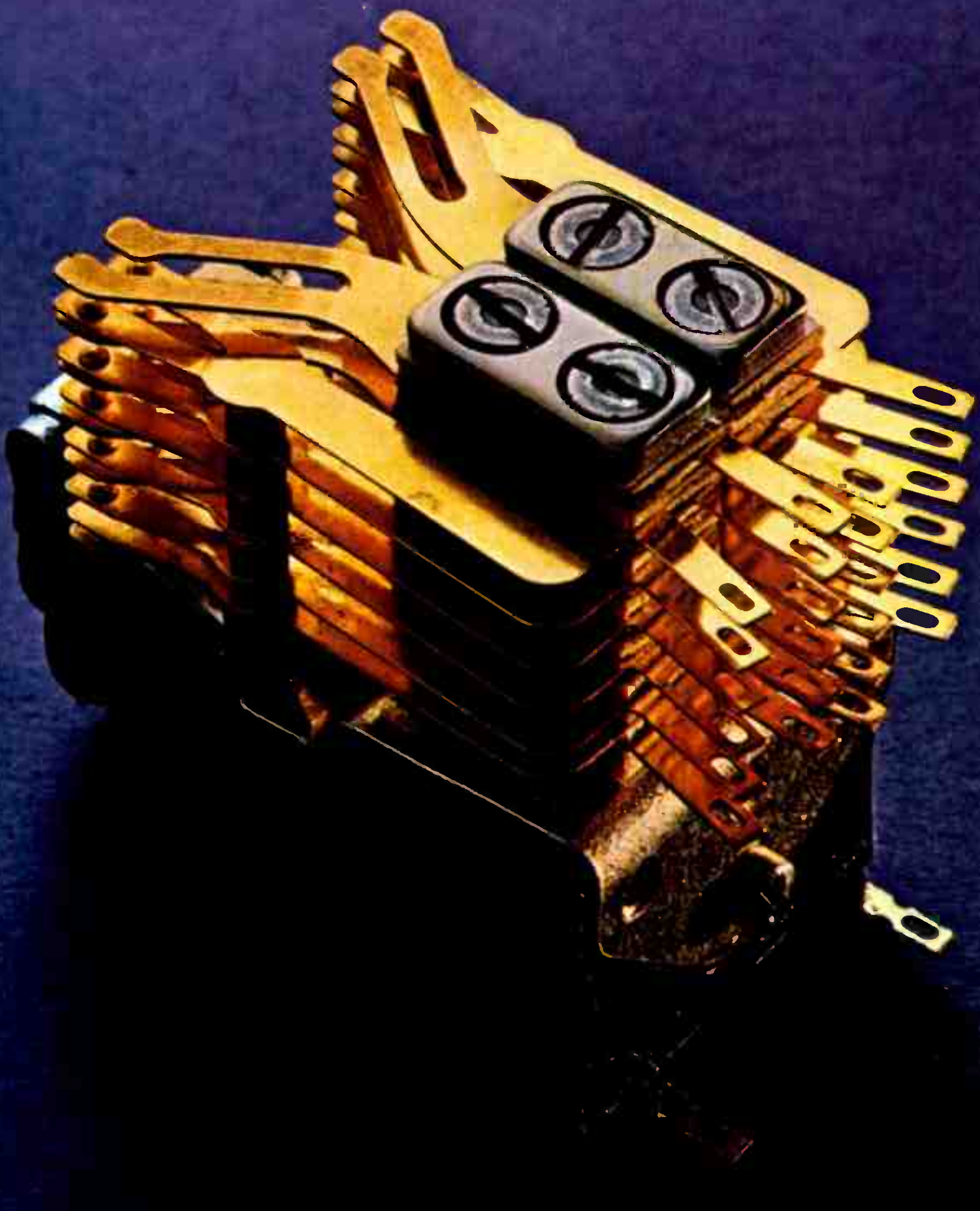
- Servos
- Tape drivers
- Stepper motors
- Linear motor controls
- Audio systems
- Magnetic deflection

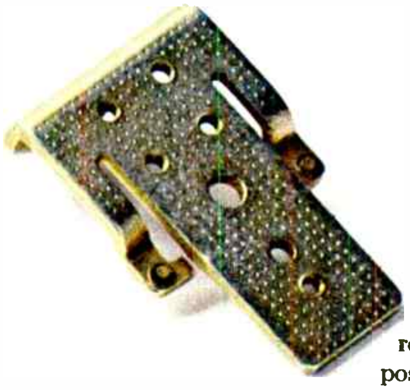
These are rugged units offering uncompromised reliability. Ask your local RCA Representative or your RCA Distributor about them. For application information on these devices and the RCA growing line of power hybrid circuits, write: RCA, Commercial Engineering, Section 70H30/UC4, Harrison, N.J. 07029. International: RCA, Sunbury-on-Thames, U.K., or P.O. Box 112, Hong Kong. RCA Limited, St. Anne de Bellevue, 810 Quebec, Canada.

RCA Solid State

Circle 9 on reader service card

Reliability is six things we do that nobody else does.





We're fanatics.

We build our relays stronger than we have to. That way, they last lots longer than they ever have to. Our Class E relay (shown on the opposite page) is a good example of our way of thinking.

The industry's strongest heelpiece.

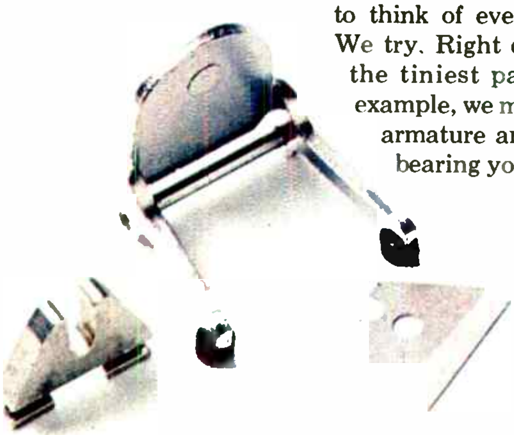
We make the strongest heelpiece in the industry. A gigantic machine bangs them out extra fat and extra flat.

Extra fat to carry a maximum of flux. To handle big loads. Extra flat so that once an AE relay is adjusted, it stays adjusted.

Since our backstop is part of the heelpiece, it's just as thick and flat. But, tough as it is, the slightest wear here would throw the entire contact assembly out of whack. So, to be safe, we weld two tiny, non-magnetic pads where the armature arms meet the backstop. You might say we created the no-stop backstop.

Three parts that'll wear like crazy.

When you build a relay like a small tank, you have to think of everything. We try. Right down to the tiniest part. For example, we make our armature arms and bearing yoke extra thick.



Thicker than years of testing and use say they have to be. Then, to make sure they don't cause wear problems, we insert a hardened shim between the hinge pin and the frame. The pin rides on the shim, instead of wearing into the heelpiece. (You can forget the bearing, it's permanently lubricated.)

Buffers with lots of muscle.

We make our buffers of a special tough phenolic material that lasts. And lasts. And lasts. All without wear or distortion. Another reason why our relays stay in whack.

To make sure our buffers stay in place, we weld the buffer cups to the armature arms. We weld, instead of using rivets, because our lab found that rivets have a habit of falling out.

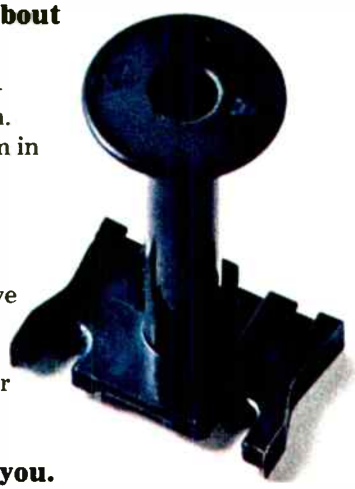
For the very same reason, we weld buffer cups to the contact springs. And also use the same special tough phenolic buffers.

No, we didn't forget the contact springs.

We have some strong feelings as to what makes a contact spring reliable. Our sentiment is that two contacts are better than one. So, we bifurcate all the springs, not just the make and break. This slotting and the addition of another contact to each spring means you get a completed circuit every time.

We make each set of contact points self-cleaning. The bad stuff doesn't have a chance to build up.

Now, what's different about our bobbin?



Our bobbin is one piece—molded of glass-filled nylon. This provides the maximum in insulation resistance.

Because our bobbin is nylon, we don't have to impregnate with varnish. Moisture and humidity have no effect on the stubborn nylon material. No effect means no malfunctions for you to worry about.

What all this means to you.

What this all adds up to is reliability. The kind of toughness no one else can give you. It means an AE relay works when it's supposed to, longer than it has to. Isn't this the kind of reliability you really need? GTE Automatic Electric, Industrial Sales Division, Northlake, Illinois 60164.

GTE AUTOMATIC ELECTRIC

Circle 11 on reader service card

Pushbuttons ad infinitum.

∞ An almost infinite variety of lighted and unlighted pushbuttons gives you the opportunity to custom design your panel without resorting to custom pushbuttons and indicators.

From the smallest (our miniature pushbuttons) to the largest (our heavy-duty oiltights) we'll meet your specs.

Select your switching action, mounting style, and shape. Choose from a wide variety of display screens and color filters. Pick from thousands of switching modules—all featuring the most reliable basic switches in the industry. And many meeting mil/specs.

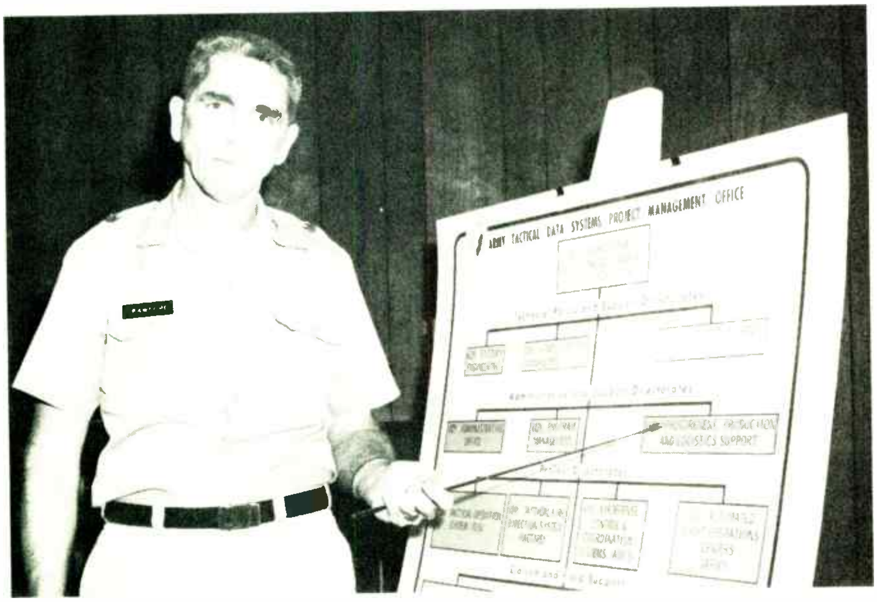
The selection is ours. The choice is yours. Ad infinitum.

For information, contact your MICRO SWITCH Branch Office or Authorized Distributor (Yellow Pages, "Switches, Electric"). Or write for our literature.

Circle 13 on reader service card

People

If you don't see a job you like, create one and then ask for it. That's just about how Col. Albert B. Crawford Jr., the head of the new Army Tactical Data System (Artads), did it [see p. 68]. A senior computer specialist, Crawford chaired the Department of the Army study group that recommended the concentration in a single project office of all the Army's tactical data processing technology developments. The study completed, the colonel then touted him-



Crawford: All it takes to get your star early is a striking technical background.

self as project manager.

It would be hard to find a better-qualified man for the job in or out of the military. A 1950 West Point graduate, Crawford, 43, holds masters' degrees in both electrical and industrial engineering, with data processing majors, from Stanford University. As early as 1957, he was studying the feasibility of using computers in the field and was with the first large-scale computer—the Mobidic—when it was first used in Europe for supply applications.

Also under the colonel's belt are three years at Ft. Huachuca, Ariz., designing and developing communications systems with computer modeling; a year with the Fourth Armored division applying data processing techniques to command and control problems; and a stint preparing the contract definition for the artillery-directing Tacfire system, and aiding in procurement and source selection.

Crawford spent a year at the Army War College in Ft. Leavenworth, Kan., where in 1968 he wrote a thesis on how the Army ought better to organize itself to develop tactical data systems, that foreshadowed his present role. Posted to Vietnam, he commanded an engineering agency responsible for installing strategic communications systems and last October began work on the Department of the Army study that led to Artads. Its charter was signed on April 9 and by July 1 Crawford was moving into new quarters at the Electronics Command, Ft. Monmouth, N.J.

Crawford is a brigadier general-designate at an age some three or four years below the average for that rank. He believes his specialization in automatic data processing has helped his rise, and sees it as an indication of the high status the Army gives officers with striking technical backgrounds.

Applications engineers, especially in smaller companies, are becoming more and more important in their role of molding customer attitudes about products—in fact they're becoming indispensable. Take, for example, John Springer, newly named memory applications engineer at Advanced Micro Devices Inc., Sunnyvale, Calif. Springer had been in digital logic circuit applications for the past two years at Fairchild Semiconductor. Now, he'll work with logic and memory customers.

Springer emphasizes a fundamental difference between marketing memory and logic. "There isn't going to be the permanence with memory products that we've seen in the past with logic circuits. When a customer turned to a specific digital logic family," says Springer, "he generally has stuck with it; but the same is not true with semiconductor memories. Some companies are even designing with two types of memories—if one board gives them trouble, they can remove it and plug in a different type."

The reasoning, says Springer, is that the demand for semiconductor memories is high but the supply is limited. "Many people are designing in the 1103-type memory, even though they say it's difficult to use, just because it's available. There are some other memories—like the static 1,024-bit device—that are easier to use in a system but are not available. When they are, the customers will simply switch."

Springer's background is based in neither memories nor logic. He received his master's degree in analytical chemistry from Oregon State University in 1969 and then began designing analytical instruments using digital ICs. However, he became more interested in the ICs than the instruments.

Springer: Analytical chemistry of ICs.

Circle 15 on reader service card

Meetings

Conference on Displays, IEE; University of Loughborough, England, Sept. 7-10.

International Conference on Engineering in the Ocean Environment, IEEE; Town & Country Hotel, San Diego, Calif., Sept. 14-16.

Joint Power Generation Technical Conference, IEEE; Chase Park Plaza Hotel, St. Louis, Mo., Sept. 19-23.

International G-AP Symposium & USNC/URSI Meeting, IEEE; University of California, Los Angeles, Sept. 20-23.

Conference on Infrared Techniques, IEE; University of Reading, Reading, England, Sept. 21-23.

International Computer Technical Conference, IEEE; Boston, Mass., Sept. 22-24.

Fall Broadcast Technical Symposium, IEEE; the Washington Hilton Hotel, Washington, D.C., Sept. 23-25.

International Telemetry Conference, Instrument Society of America, Electronic Industries Association; Washington Hilton Hotel, Washington, D.C., Sept. 27-29.

International Electron Devices Meeting, IEEE; Washington Hilton Hotel, Washington, D.C., Oct. 11-13.

Electronic and Aerospace Systems Convention (EASCON), IEEE; Marriott Twin Bridges Motor Hotel, Washington, D.C., Oct. 6-8.

CALL FOR PAPERS

Spring Joint Computer Conference, IEEE, Atlantic City, N.J., May 16-18, 1972. Oct. 1 is the deadline for the submission of papers to Jack Schwartz, technical program chairman, Box A—Computer Science department, the Courant Institute, 251 Mercer Street, New York, N.Y. 10012.

Electronics Newsletter

August 30, 1971

ECL at crossroad: 9500 or 10,000?

Three major semiconductor companies are about to make a decision that will shape the direction of the emitter-coupled logic market. Signetics, National Semiconductor, and Raytheon Semiconductor are about to announce which ECL line they will second source: Fairchild's 9500 series or Motorola's 10,000 series. What they decide will determine which ECL family becomes the industry standard.

At Signetics, management has picked Motorola's ECL to second source. Insiders say the large computer mainframe houses feel that the 10,000 series suits their needs better than the 9500 series. In fact, two of the largest computer companies—Univac and Britain's International Computers Ltd.—already have committed themselves to the 10,000 series. Because of this, National Semiconductor, which has always gone after high-volume business, has indicated to some of its customers that it will most likely second source the 10,000 series.

Raytheon, to avoid what will become a real battle between Motorola, National, and Signetics for the 10,000 series business, will probably go with Fairchild's ECL line. Its reasoning reportedly is to pick up some of the business with peripheral manufacturers, who seem to favor Fairchild's ECL because it's very similar to TTL in many ways, and perhaps also to get any 9500 business that Fairchild can't handle.

Fairchild puts off Unibond; Signetics pushes automation

Fairchild Semiconductor has shelved plans to put its automated IC assembly line called Unibond [*Electronics*, Jan. 4, p. 21] into production. Sources close to the company say that the main reason is that the industry is in a condition of overcapacity now, and the last thing it needs is more. Unibond would help Fairchild cut assembly costs, but it has spent millions on production equipment in the past two years and isn't willing to make the investment in capital equipment that would be needed now to get Unibond out of the pilot line stage.

Signetics, on the other hand, is moving ahead with its own automated IC line, which is very similar to Fairchild's Unibond. IC chips are attached to small spider-like lead frames using a controlled collapse bump technique. Then the assembly is encapsulated in a small pill-shaped package for use in hybrid ICs. Or, it can be bonded to a dual in-line lead frame and the whole thing encapsulated in a dual in-line package.

Signetics is now producing from 25,000 to 50,000 devices per month and its automated line should be turning out 100,000 per month by early 1972.

The big advantage of the line, of course, is cost. While other companies were spending money in building up conventional production techniques Signetics put its funds into automation. The company says that it can assemble an IC in the U.S. for half what it costs in Korea. First products to come off the line will be the 7400 gates and some op amps—high volume products.

NR says Victor is an MOS/LSI buyer

North American Rockwell Microelectronics Co. has finally made it official: it's supplying MOS/LSI calculator chips to Victor Comptometer [*Electronics*, Feb. 1, p. 17]. Until now, NRMEC has been able to name only one customer for its circuits, Sharp, which really put the company into the MOS/LSI business. But the Sharp business is tailing off and NRMEC wanted to say it was more than a single contract house. **It also has chip-development contracts with 16 other companies.**

Victor has unveiled the first five machines in its 1800 series, priced from $395 to $595, each with six NRMEC chips. **This is just the first step in Victor business for NRMEC;** there will be more entries in the calculator family, other business machines, and possibly cash registers for which NRMEC will supply chips.

LA switches to SEL for fire system

Systems Engineering Laboratories has won a $700,000 contract to automate the command and control system of the Los Angeles fire department. The system, **said to be the largest and most sophisticated in the country,** uses a pair of redundant 810B digital computers to help dispatch and redistribute fire-fighting equipment at any one of 114 fire stations throughout the city [*Electronics*, Dec. 7, 1970, p. 113].

The computers do this by accessing a central data base, stored on an IBM 2314 disk file, containing information on the cross streets at each fire alarm box, the location of fire-fighting and other emergency equipment, and the routes to be taken through the city. Information is presented to the firemen on 30 CRT displays located at fire headquarters and on a large 8-by-10-foot display board.

The award is significant because **it is the first time Los Angeles has elected to buy data processing equipment from a company other than IBM.**

White House backs CATV demonstration

To hasten the development of new broadband communications services, the Nixon Administration, aided by a top CATV consulting firm, is laying plans to demonstrate two-way cable systems in several cities. The demonstration program could be announced as early as January, when the President gives his State of the Union and budget messages.

The White House Office of Telecommunications Policy is responsible for coordinating the program, and is asking Malarkey, Taylor and Associates, a Washington CATV consulting firm, to identify the experimental services that should be offered over the demonstration systems. M.F. Malarkey, the company's president, says he has a firm Nov. 1 deadline for the submission of the report, which is being funded under a $62,400 contract.

If the White House gives the program the expected go-ahead, **the Department of Housing and Urban Development or of Health, Education and Welfare will pay part of its cost, and CATV operators will be asked to fund the remainder.** The Government funds will probably come out of the fiscal 1973 budget, although a 1972 supplemental request is still possible.

Addendum

Digital Equipment Corp. is about to announce the first three of what could grow to a line of five or more large-scale computers, the DECsystem-10. The company already is benchmark testing the machines against the IBM 370/155, the CDC 6500, and, in the case of the largest one, against the 370/165 and CDC 6600. **The DEC is claiming "far superior" price-performance ratios for the machines priced at $400,000 to $1 million or $2 million.** They can handle up to 63 time-sharing users, or up to 16 remote batch-users.

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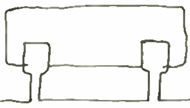

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Electronics firms ponder ground rules for new game plan

Import surcharge, floating dollar, and tax credits should help U.S. firms, but angry foreigners could retaliate

International business in the electronics industries, growing rapidly in complexity as well as in size, will never be the same. President Nixon's dramatic new economic policies, as temporary and as iffy as they might seem (Congress has to approve much of the package) have made it a new ballgame for companies that sell or manufacture overseas, or have foreign competition in domestic markets. And that covers a lot of companies.

Even after they had time to absorb the President's bag of complex economic moves, companies both here and abroad were unsure about the impact. On the surface, it looks good for U.S. electronics makers. The 10% surcharge on imports seems certain to improve domestic producer's competitive positions in such areas as consumer electronics.

And Nixon's decision to "float" the dollar, in effect devaluing it, will also add to the price of imported goods. Moreover, the floating dollar will make it easier for U.S. prices to compete in the international marketplace since the dollar will be worth anywhere from 10% less in Europe to 15% less in Japan.

The 10% tax credit for capital equipment proposed by the President should help the capital equipment markets—such as computers—though one economist says such spending "will not begin to rise significantly until late next year."

While U.S. companies may be merely confused about the new economic game plan, foreign companies are also angry and apprehensive. Most of them are worrying about losing a substantial share of their U.S. market by the double impact of a lower-valued dollar and the 10% surcharge.

But some companies, both here and overseas, fear equally strong reaction from other countries to the President's strong protective stance, throwing the entire trade picture out of kilter. What would happen, some companies ask, if other nations decide to retaliate by setting off a chain reaction of similar protective measures? A French aerospace representative in Washington goes further and forecasts economic retaliation within a short time by his country, affecting U.S. exports of such items as data processing equipment.

U.S. companies, selling products overseas that were built in this country or in overseas plants, are expecting the floating dollar to make them more competitive—particularly in Europe. Both Varian Associates and Texas Instruments, for example, expect to receive a boost. "We expect to enjoy the fruits of devaluation," says an official of TI in France. "We should be able to market our computer peripherals in France at a lower price," for example, he says.

One electronics sector that should profit is communication equipment. Companies in this field, which have not been seriously affected by imports yet and are not exporters, "seem to be the real beneficiaries of the President's action," says an official of the Electronic Industries Association.

Of America's principal trading partners, the nation most affected is Japan, which last year shipped 30% of its exports or $6 billion worth of goods. Japan's Ministry of Foreign Trade and Industry estimates that this will drop 20%. There's now growing pressure within Japanese industry to devalue the yen—one figure mentioned is about 8%.

Several Japanese companies say that the President's action will cause a significant drop in their U.S. export business. Sharp Corp. expects its U.S. sales, which amount to 20% of its total production, to fall about 30%. It expects desk calculators to drop 20% to 30%.

Component makers in Japan will probably fare even worse than the consumer product manufacturers. Not only will they lose domestic sales, but they will lose their tradi-

New stake? RCA color TV production aide could find work increasing as result of President Nixon's new economic game plan being considered by the Congress.

tional price advantage, indirect export sales. There is some fear outside this country, particularly in Europe, that the Japanese will turn to other export markets, such as Europe.

The West German electronics industry is deeply concerned, too, over the new U.S. policies. The combination of the floating Deutsch Mark and the 10% surcharge makes German goods sold in the U.S. nearly 20% more expensive than they were at the beginning of the year. And German firms say they feel the pinch. Last year, Germany sold about $80 million worth of electronics products to the U.S.

While about $27 million worth, or only 3%, of its sales go to the U.S., Siemens AG expects to feel it most in medical electronics with more than $3 million of this gear going to the U.S. Siemens also fears indirect effects such as reduced sales of components and control devices to the German car and machine tool industries.

There's no definitive answer yet on how the 10% surcharge would impact products in which U.S. parts are exported to low labor cost nations, assembled, and returned with a duty charged on the value added. Most industry officials believe, though, the 10% would be applied only to the value added.

For semiconductor makers, who ship chips abroad for assembly, this tax will be "insignificant compared with the unit's total price," says an ITT Semiconductor official. Instead of paying 7%, companies will pay 17% on the value added, which "amounts to an insignificant amount that will not be passed along," says National Semiconductor.

The Nixon move will hit harder another product area of offshore assembly. The surcharge, coupled with the dollar devaluation, could raise production costs anywhere from 15% to 20% for core memory products.

One major Western semiconductor maker doubts the administration's move will make overseas assembly less inviting because overseas plants are becoming regional marketing centers. Overseas facilities are now a necessity to serve the market in which they're located, the firm says.

"The biggest impact of the Nixon plan," an official of the firm says, "will be that fewer products assembled overseas will be brought back to the U.S."

Solid state

Fairchild develops 30-GHz GaAs FET

Development of a gallium arsenide field effect transistor that could operate at 10 gigahertz and beyond would do for the microwave bands what silicon FETs did for the vhf and uhf bands—provide them with high-gain, low-noise amplifiers. Designers of communications and radar systems now have to turn to $5,000 parametric amplifiers, but work at the R&D laboratory of Fairchild Camera & Instrument Corp., in Palo Alto, Calif., may soon give those designers a $100 transistor instead.

"We have developed a GaAs FET that exhibits a maximum oscillation frequency of 30 GHz," reports George Bechtel, manager of the microwave device development department at the lab, "and have measured power gains of 8 decibels at 8 GHz and 4 dB at 16 GHz, besides obtaining a noise figure of 3 dB at 4 GHz." The key is a thin epitaxial process developed by Fairchild. The device is fabricated on a thin (10^{17} atoms per cubic centimeter) sulfur-doped epitaxial film deposited on a semi-insulating GaAs substrate. The structure is made with conventional photomasking techniques, but instead of doping to make the low resistance contacts to the N-type material, a gold-germanium alloying technique is employed for the source and drain. The gate is a Schottky barrier structure.

In general, GaAs hasn't been used for transistors because it is hard to work with. For one thing, at the high temperatures normally associated with diffusion processes, the arsenic out-diffuses, and impurities are also hard to diffuse into the compound. But, says Bechtel, "FETs employ a low-temperature process, so the out-diffusing is no problem." On the problem of diffusing in contacts, he says, "we don't—this is where the alloying technique comes in to form the ohmic contacts." The FETs were developed under a contract with the Air Force Avionics Laboratory at Wright-Patterson Air Force Base in Dayton, Ohio.

Typical solid state amplifiers employing silicon bipolar transistors exhibit noise figures of 6 dB at a 4 GHz, compared to the 3 dB at 4 GHz for the GaAs FET, adds Bechtel. And 4 GHz is just about the limit for silicon.

In electronic countermeasure equipment, the GaAs FET's low noise figure and linear transfer characteristics make it very attractive. Further, Bechtel adds, it has a large dynamic range—parametric amplifiers are narrow band but the GaAs FET is a wide band device.

The development of the GaAs FET is at the stage where, says Bechtel "we have a manufacturing process with low but reasonable yields. This could produce a commercial product priced at around $100," he adds that "there is no reason why the GaAs FETs can't be as cost-competitive as silicon transistors as two-inch GaAs wafers become available—there are only three masking steps and there are no critical diffusions. What remains to be done is work on manufacturing methods and circuit development."

Optoelectronics

A-6E gets Norden's multimode radar

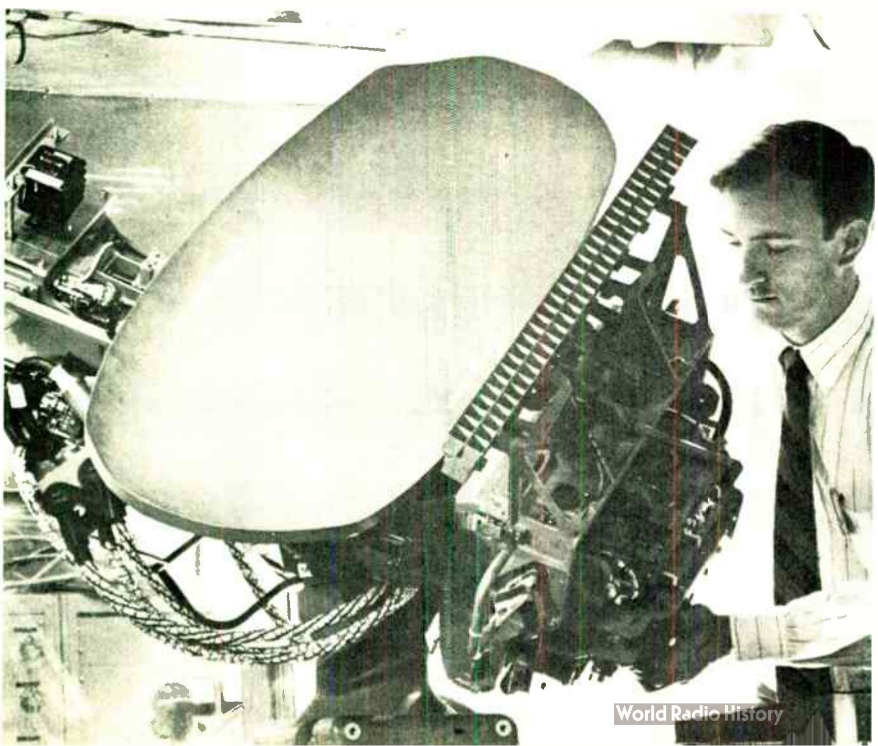
The first production model of a new multimode radar, designed to replace two radars aboard the Navy's A-6E all-weather attack aircraft, has been delivered to Grumman Aerospace Corp. by the Norden division of United Aircraft Corp. The new radar, the AN/APQ-148, replaces the AN/APQ-112 tracking radar that went into production about a dozen years ago.

Weighing less than 500 pounds, the 148 is about 200 lbs lighter than the two radars it replaces, and occupies considerably less space. It is made up of nine boxes, including a 36-inch-wide Ku-band antenna dish below which is mounted a phase-interferometer antenna. The interferometer provides the elevation-angle information needed to develop, via digital data processing and in conjunction with returns to the dish antenna, the track-while-scan and the terrain avoidance/terrain following displays. Returns from the dish also produce a ground map display. In addition, the radar has a beacon mode to aid in attacking targets on the ground.

Being all solid state, with the exception of the high-power magnetron and a ceramic thyratron in the magnetron's firing circuit, the radar yields an order of magnitude better mean time between failures compared with its two predecessors, says Norden's A-6E project manager Daniel R. Nuzzo. The radar also has built-in self-test capability, Nuzzo points out, with trouble spots pinpointed on both special indicators and the radar's own display.

So far, Norden has received an $18 million development contract—in August 1969—and two production contracts worth $6 million each.

Plug. Receiver electronics, above technician's left hand in prototype of Norden's multimode radar, can be unplugged. Conventional dish plus phase interferometer perform functions previously handled by two separate radars aboard the Navy's A-6E aircraft.



Avionics

MOS/LSI opens doors to small airborne computers

Now that MOS/LSI is a production reality, it's possible to build small, lightweight computers that consume very little power and are suitable for airborne or spacecraft applications, and two Southern California firms are moving quickly into this market. Already the Electronic Systems division of Garrett AiResearch Manufacturing Co., Torrance, Calif., is mass-producing a series it calls Adapt, the smallest of which weighs just 8 pounds, fills some 240 cubic inches, and consumes just 20 watts.

One of the Garrett units has won its wings in the air inlet control system of the Navy's Grumman F-14 fighter. Meanwhile, in Anaheim, Calif., the Autonetics division of North American Rockwell Corp. is quoting six-month delivery for its D216 computer. Both families are billed as general-purpose computers, but both are expected to be used principally in airborne and space programs.

The Autonetics D216 evolved from what is possibly the industry's first operational computer to use MOS/LSI arrays exclusively in its processor and control units. That was the D200, which was unveiled almost three years ago at the Fall Joint Computer Conference [*Electronics*, Dec. 9, 1968, p. 33], and which has logged almost 60 flights as a Loran navigation computer. But the architecture will also permit general-purpose usage, because the D216 central processor is being used as the computer in a company-built machine that tests similar subassemblies and systems.

Peter D. Georgantas, product development manager in the computer and avionics department of the Autonetics Avionics and Sensors division, says that in 58 flight tests of the D200 prototype, not one of the MOS devices failed. On the basis of reliability data extrapolated from the prototype's chips, as well as from other chips made by North American Rockwell Microelectronics Co. for electronic calculators, he believes that the D200 family should have a mean time between failure of 10,000 hours or more.

But he's also convinced the D216's small size and weight, plus low power consumption, will make it a contender for military systems use. "We're very near a contract with one customer, and it's been proposed for various other programs," Georgantas says of the D216. The unit, including 8,192 words of 16-bit plated-wire memory, weighs just 8.5 lb., is 250 cu in. in volume, and consumes just 30 w. It has an add time of 2.5 microseconds, a multiply time of 13.75 microseconds, and a divide time of 23.75 microseconds. The memory write and read cycles are 800 and 500 nanoseconds, respectively.

In comparison, a typical airborne computer in production at Autonetics, which fits into the IBM 4-Pi class, consumes 250 w, weighs 52 lb, and occupies close to a cubic foot. With 16,000 words of 24 bits in plated-wire memory, it adds in 7.2 microseconds, multiplies in 14.4 microseconds, and divides in 30.6 microseconds.

There are two other entries in the D200 family to date: the D224 and D232, which are 24- and 32-bit units as against the D216's basic 16-bit data word length. An even smaller unit in proprietary development is expected to be breadboarded by the end of next year. The beam-lead MOS/LSI chips it will use will be bonded face down to beryllium oxide substrates. Georgantas says devices have been made and tested for it that support these speed projections with a plated-wire memory of 8,192 words of 24 bits, plus a parity bit. It will have an add time of 1.5 microseconds, a multiply time of 6.4 microseconds, and divide time of 22.4 microseconds.

Instead of the packaged MOS devices of the D216, the advanced version will have unpackaged chips in the processor and control unit, and possibly in an MOS memory, which will allow further size reduction. But for now, the D216 is the newest unit being readied for production status. It consists of four circuit boards—the CPU (or arithmetic and control board), plated-wire memory stack, and a sense board and word board to interface with the stack.

Autonetics chose plated wire for the D200 memories because it's nonvolatile and electrically alterable. But MOS read-only and random-access memory units can be used where the application allows it. For example, in Loran navigation, data about Loran station positions can be stored in 4,096-word ROM chips. The RAM envisaged for use with the family is a 512-by-1-word unit. The MOS logic chips are four-phase units.

Companies

TRW move into SUHL could open new markets

When the Semiconductor division of Sylvania Electric Products bailed out of the IC business [*Electronics*, Oct. 12, 1970, p. 46], other semiconductor manufacturers, most of whom had been providing Sylvania's SUHL line of transistor-transistor logic as second sources, swooped in with loud claims that they were ready to save Sylvania customers who had designed SUHL into their systems. One company that didn't say a word, but got busy equipping itself to make SUHL 1, is TRW Semiconductors Inc., Lawndale, Calif.

TRW bought everything from engineering drawings and masks to diffusion furnaces, die bonders, and test equipment from Sylvania. "We were very careful to duplicate their process exactly, but with our own control systems," says W.D. "Dan" Rasdal, division manager. By control systems he means cost control, and Rasdal is convinced that TRW can produce SUHL 1 economically "for ourselves and for our customer." Although TRW officials won't acknowledge it, that customer is Automatic Electric Co., Northlake, Ill., which manufactures equipment for General Telephone and Electronics Corp. [*Electronics*, Aug. 16, p. 26].

And SUHL 1 could be only the beginning. Rasdal is quick to point out that the prime concern now is to produce for the first customer. "We don't want to foul up what we're doing to go after new business. This isn't any headlong plunge." But he adds that the company has established a basic IC capability that could easily be expanded to encompass MOS or bipolar LSI. "We've played 'what-if'," Rasdal says in mulling other IC or LSI business.

The first SUHL 1 evaluation units, including about 15 different circuit types initially, came off the TRW line earlier this month, marking the first time the firm had produced ICs since the mid-1960s, when it made its own TTL for missile systems.

"The program is right on schedule," Rasdal says, and it has been from the outset, early this year. TRW brought in a Sylvania engineer for about two months because "we wanted to make sure we were making what the customer wants," Rasdal says.

Though it might seem foolhardy to get into the fiercely competitive TTL business at this stage of the game, Rasdal says the reason is simple: "When Sylvania withdrew, we found a customer looking for a reliable source of supply. He wanted continuity, so we agreed to set up and produce. The price is such that we're sure we can make a profit."

TRW has supplied a broad range of semiconductor and other components to Automatic Electric in the past. Without naming the company, Rasdal says, "This customer is aware of what's going on in the market. He may get delivery now from other TTL manufacturers, but what will hapeen when business gets good again? The question is whether they'll want to supply SUHL 1. This customer will have SUHL 1 designed in for a long time and wants assurance there will be a source of supply even after business gets good again."

Air traffic control

Associative processor tests are on track at Knoxville

Tests of the first associative processor to be used in a real-life setting—tracking aircraft for the FAA at the Knoxville, Tenn., airport—are right on schedule, the agency reports [*Electronics*, Feb. 15, p. 91]. The timetable for the Goodyear Aerospace Corp. machine calls for more tests to be followed by a Sept. 15 demonstration of conflict prediction; the system is to be completely operational by Oct. 15.

Meanwhile, Honeywell's Aerospace division engineers are working on an MOS associative processor that would differ from the Goodyear unit in that it would have logic at each bit location. The Goodyear unit's logic serially processes the bits within each word. Honeywell hopes to have its first chips sometime next year.

As for the Knoxville tests, Herbert Wachsman, the FAA official in charge, says: "I'm really happy with the progress we've had so far." He notes that since the machine was accepted on June 30, the 256-word-by-256-bit processor has successfully tracked both airplanes entering the Knoxville control area and FAA aircraft, using both primary and secondary radar tracking. The machine was borrowed from the Air Force, which paid Goodyear for its development. Ultimately, the system will be used to keep tabs on aircraft at the saturated metropolitan airports, where growing traffic threatens to overwhelm the Univac computers used for tracking and display.

"We're presently in the final stages of debugging the tracking logic," Wachsman says. Once this chore is completed, FAA plans will be used to test the machine's ability to handle worst-case problems, such as how the system will recover when it loses track of an aircraft or when two planes' tracks cross. If the associative processor module passes these tests, "I'm sure it will go operational in Knoxville," he says.

Knoxville, of course, isn't like Chicago, where the nation's fiercest traffic-control problems are centered. But because the prototype Univac Advanced Radar Terminal 2 system, with excess computer capacity, was located at the Tennessee airport, FAA officials decided it was the best place to begin testing.

The associative processor also might be used for conflict prediction, a task that is already being tackled by the Univac team charged with interfacing the ARTS 2 system with the Goodyear machine.

Communications

S-band earth station would cost only $200

When engineers discuss communications satellite terminals, they're generally thinking about the big $2 million rigs. But a Stanford University group has put together an S-band earth station that will sell for $200 or less in 1,000 unit quantities, with dish antenna. The work was done at Stanford's Center for Radar Astronomy under a NASA contract to design a receiver that could acquire a signal directly from an orbiting satellite and convert it for viewing through a standard television set.

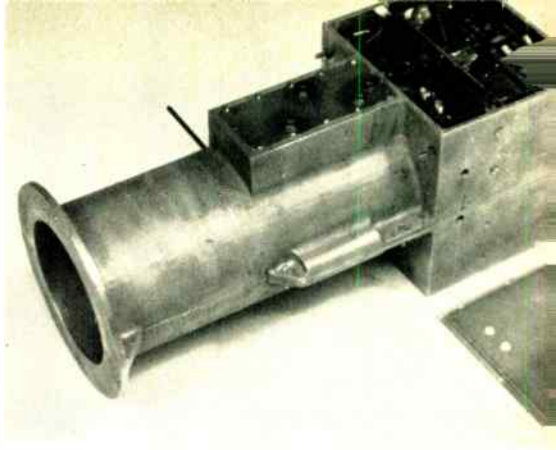
The system's initial application might be in an educational television experiment linked with Applications Technology Satellite F [*Electronics*, June 21, p. 40], if the Corporation for Public Broadcasting and the Department of Health, Education and Welfare can get NASA to place an S-band transponder aboard. At the World Administrative Radio Conference in Geneva this past June, the 2.5-to-2.69-gigahertz band was set aside for direct broadcast television, opening the road for the ATS-F experiment in May 1973.

Direct TV broadcast from satellites has long been eyed as a way to provide information to underdeveloped areas around the world. And so when the Stanford team, headed by James M. Janky, began designing the terminal, it had to employ components and manufacturing techniques that were readily available in those areas. Underdeveloped countries probably won't try out an unproved highly technical system, so the Rocky Mountain states are a likely test area.

The key to the low-cost design is a two-piece, die-cast housing that contains three functional areas: a circular cavity facing the antenna that forms the feed and provides a direct mounting for the mixer diode; a rectangular housing that holds a local-oscillator digital filter, and a box attached to the circular cavity that has a series of die-cast compartments for four printed circuit boards. The four boards used are a local oscillator, an i-f amplifier, a discriminator, and a limiter-remodulator.

Janky says that many of these circuits and components could have been integrated with ICs. However, these parts might increase cost and may not be available in many parts of the world. All the components used can be obtained in areas where there is some industry—like the manufacture of automobile parts and televisions.

The station operates with a center input frequency of 2.62 megahertz.



Low cost. Group at Stanford has built S-band earth station to sell for $200 in quantities of 1,000 units.

The antenna is a seven-foot-diameter metal dish with an efficiency of 55% and a gain of about 33 decibels. Output signal can be factory-set from 50 to 88 MHz (channels 2 to 5), and signal-to-noise ratio is about 42 dB, for a top-grade TV signal.

The mixer is a single-diode type employing a Schottky-barrier diode. The local oscillator produces a 250-MHz signal; it's then multiplied up to 2.5 GHz by a step-recovery diode multiplier. The 2.5-GHz signal then is fed to the interdigital filter. The i-f amplifier employs a dual-gate field effect transistor, because, says Janky, it provides substantial protection against cross-modulation and makes for a good, low-noise first stage.

The rest of the circuitry is straightforward. The discriminator, together with the detector, converts the wideband fm signal back into the baseband TV signal. The remodulator amplifies this baseband signal and then shifts it to a convenient, unused channel location. The power supply for the adapter is mounted near the television set and the dc is sent up the same twin lead used by the down signal.

Industrial electronics

Plated wire finds spot in productivity robot

Proponents of plated-wire memories have long contended that nonvolatility is their single biggest selling point in competition with cores and semiconductors. They cite machine-tool controllers as a good market niche on the industrial side [*Elec-*

tronics, Jan. 18, p. 101]. Bruce Kaufman, president of Memory Systems Inc., the Hawthorne, Calif., plated-wire maker, contends it has made "one of the first major scores for plated wire in an automatic tooling or machine tool application."

Memory Systems is delivering the first plated-wire, electrically alterable read-only memories that will be used to store data to drive a digitally controlled "productivity robot" built by Unimation Inc., Danbury, Conn. The contract is for "hundreds of thousands of dollars," Kaufman says, but he thinks it's only the beginning of plated wire's penetration of industrial applications closed to semiconductor and core memories because of their volatility. "We think it is the forerunner of bigger things to come," he says.

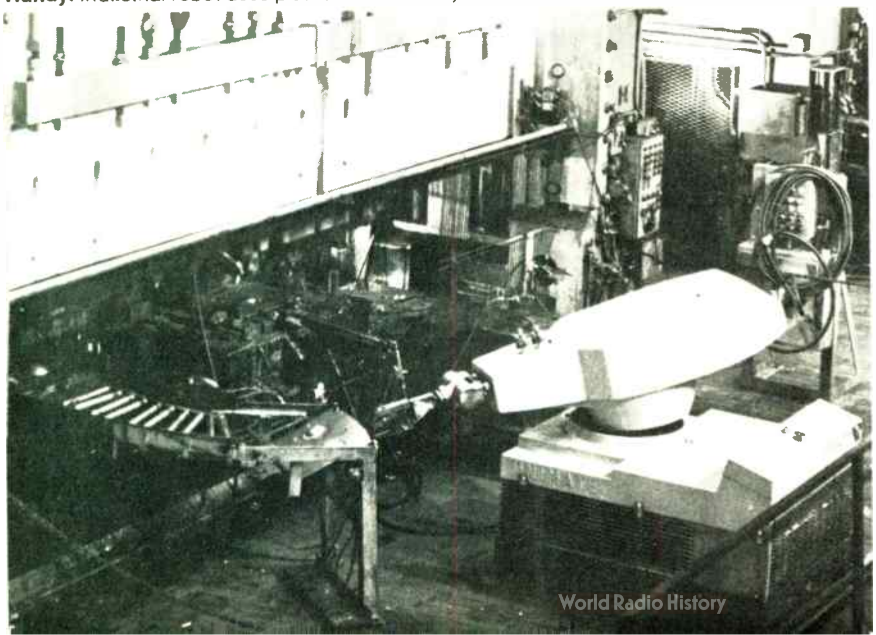
The memories are replacing a drum store that formerly held data for the robot's controller. The robot, dubbed Unimate, is a multipurpose, production-line machine used mainly in the automotive industry. It resembles a small gun turret, but it has a sliding arm where the gun would be, a wrist-like joint, and fingers that can be articulated under digital control. Commands for a given operation, such as welding, drilling, grinding, grasping, or twisting, are stored in the plated-wire memory.

Unimation isn't anxious to spell out the precise application, but officials say the robot's hand is articulated and has 6 degrees of freedom. Unimate is programed in X, Y, and Z coordinates to do complex, repetitive tasks on a production line at high speeds without error. "It's got to have absolute idiot-proof nonvolatility with fail-safe control," Kaufman says. Unimation engineers made the commitment to plated wire, he adds, because they can't afford to have a workpiece ruined by the memory's inability to retain all commands.

The company wanted to replace the drum memory because it was more expensive, larger, and not as reliable as other contenders. Unimation evaluated cores and semiconductors. It ruled out semiconductors because of their volatility, then found that the data in a core memory was wiped out in 30 seconds because of the robot's noisy environment. That's when memory systems got the nod to furnish its 16-bit, electrically alterable ROMs in word sizes varying from 1,000 to 16,000.

Unimate doesn't require software; it can be programed by a skilled workman who sets the arm and/or fingers in the desired position, then pushes a button to take the position from shaft-angle encoders and store it in the memory, first going through an analog-to-digital converter. The memory allows programs to be set up and altered on the shop floor, instead of being written into paper or tape. Further, the tape can't be easily altered, while the read-only memory, by definition, can.

Handy. Industrial robot uses plated-wire memory because it's nonvolatile, alterable.



Kaufman looks for such programable robots to be used in other environments hostile to humans.

Software

Program recognizes handwritten math

A program that will enable engineers and scientists to write mathematical problems in textbook form for direct input to a computer is under development at System Development Corp., Santa Monica, Calif. As it stands at present, the program is capable of solving many types of arithmetical problems, including matrix arithmetic.

The work is an outgrowth of SDC's character-recognition program, which has been in operation for about three years. As the user prints letters, numbers, or symbols on a tablet, the coordinates of the characters are recorded in a computer for processing.

SDC has used two tablets. One is the Bolt Beranek & Newman Grafacon 1010-A, the commercial version of the so-called Rand tablet, which has a wire grid system and a stylus that reads the bit serial signals peculiar to each line and transmits them to the computer. Currently, the company is using a Science Accessories Corp. Graf-Pen, which has a spark pen that generates a sound pulse 200 times a second. When the pen is pressed on the tablet, the sounds are picked up by X and Y strip microphones along two edges of the system's tablet and recorded by X-Y counters for input to the computer.

The computer program, or character recognizer, can identify at least 100 characters for a person. The dictionary of characters is built up from the writing of its user—the writing of two persons seldom will be so alike as to permit them to use the same dictionary.

Characters are compared to those in the stored dictionary stroke by stroke. As SDC's Morton Bernstein explains it, the dictionary, being made up of stroke abstractions, is

Bell & Howell & a Change in the Weather

"Well, they've done it again." "Who?" "The guys in the back. Look." "What is it?" "A digital barometer."
"So?"
"So. you realize that in this great electronic age, weather bureau types are still eyeballing a big glass tube of mercury to get barometric pressure?"
"Even at big airports?"
"Even at big airports."
"My that's comforting. And with ours?"
"Says here it's easy to use. That to get any kind of accuracy on standard mercury manometers, you've got to know column temperature, amount of gravitational correction relative to where you are, and you've got to keep cleaning the mercury and the column.
Ours you just plug in and read. Nothing to interpret or interpolate."
"Accurate?"
"0.025%. And it records any pressure change in about a second."
"What else?"
"It's portable. Only six by six by twelve inches."
"Is that a big deal?"
"How'd you like to haul about four feet of old glass tube around in the field upright all day?"
"I see what you mean."
"Boy, they really did a number. Because it's digital you can feed it directly into a computer for storage or computation. And it's compatible with remote data links. (Not only that, they've come out with a secondary pressure standard version that reads out in psi.)"
"Where would they use the things?"
"Oh, meteorology labs, private weather bureaus like TV and radio stations have, federal weather bureaus, marine installations, altimeter and airspeed calibrations. And it's rack mountable for OEM's."
"Anybody else got one like it?"
"Looks like we're all alone. And it's going to sell for around $3K to boot."
"Guess we better run an ad. Coupon?"
"Don't think we'll have room. Tell 'em to write for the 4-461 Digital Barometer and the 4-462 Digital Secondary Pressure Standard. Bell & Howell Instruments Division, 360 Sierra Madre Villa, Pasadena, California 91109."

INSTRUMENTS DIVISION

BELL & HOWELL

built like a tree. When information is processed, the dictionary is scanned until the best match is found for a stroke. If a character is made up of more than one stroke, the system examines other lists of strokes linked to the main list until it completes the character.

As a next step, SDC has now partly developed a program that will accept and process mathematical problems, written on the tablet in standard textbook form. SDC calls this program TAM, for the assistant mathematician.

The user gets an immediate feedback of his input solutions via a CRT display projected onto the rear of the tablet; a hard copy printout may also be obtained. Information may be altered or erased by scribbling over the unwanted characters. To erase everything on a tablet, the user simply touches the word "erase," displayed as a "virtual pushbutton" on the tablet. Other such pushbuttons are provided for other operations.

"The significance of this system is that it offers an engineer the potential of being able to communicate directly with a computer without having to become a programer or have someone else do the job for him," says Bernstein, who is assistant manager for advanced development. "He communicates directly with the machine in the same way that he communicates with a fellow engineer."

Medical electronics

Buffalo hospital to install Reach computer system

Though there's been a lot of discussion about how computers could make hospitals more efficient, few hospitals now use them except for bookkeeping. One system designed just for hospitals is National Data Communications' Reach (real-time electronic access communications for hospitals). Now installed in two hospitals, and with a contract just signed for installation in the 549-bed Millard Fillmore Hospital in Buffalo, N.Y., the Reach system came out on top [not IBM, as reported in *Electronics*, June 21, p. 32] in a survey for the Defense Department by Westinghouse Electric Corp.'s Health Systems department. The study reported that out of seven systems studied, only IBM's MISP and NDC's Reach were cost-justified at present and Reach most nearly meets the desired criteria.

The Reach system uses a custom CRT terminal made by Raytheon Co. Though it has a keyboard, most communication is through a set of pushbuttons. These are keyed to queries on the CRT in an interactive, multiple-choice manner, and trained keypunchers are not necessary.

Coded badges identify personnel qualified to have access to various levels of information. A physician, for example, has access to all records on his patients, whereas a billing department can display only financial data.

Reach uses two on-site, redundant Honeywell 516 computers. Depending on size, the system leases for $65,000 to $105,000 per month, and about the minimum economical size is one for a 200-bed hospital.

Memories

Memory bus improves CPU interactive file managing

When computers are used for interactive file management applications, disk memories typically chug away 30 milliseconds foer every millisecond worked by central processors. And because hardware and software must be kept compatible with earlier systems, there seems to be little that can be done to end this waste in conventional systems. But United Technology Laboratories Inc. has developed a much more efficient way of using computers, which permits replacing a 370/145 with two minicomputers. Applications are in interactive file management systems—for example, in savings and loan institutions or in electronic countermeasures (ECM).

The Garland, Texas, company developed the technique for use in airborne ECM, where an incredible amount of data from receiving equipment must be processed and updated in a very short time. Here, a conventional computer would have to be impossibly large to overcome its inefficiency, so the company developed what David Chung, head of the computer group, calls a common memory-bus structure.

In this arrangement, the two central processors and two "channels" (which can be connected to disk memories, telephone lines, or input/output devices) are instead connected to four memory blocks through a special memory switching unit. These 500-nanosecond access memory blocks can be switched very quickly to the CPU's AND channels, so all elements may operate at once. In the conventional setup, the channel must feed the memory, which is then connected to the CPU, while in the new system, one mini is assigned a boss role to keep track of operations, but the other computer can take over if necessary.

Along with this, the company developed what it calls a T-box, a generalized I/O box that interfaces with any digital device as long as it is within the bandwidth of the mini. This includes almost all peripherals except disk and drums. The T-box is connected through the CPU rather than to the channel, and can handle up to 256 devices per CPU: printers, keyboards, tapes, modems, CRT terminals, for example. Speed of the T-box is up to 0.25 megabit per second total transfer.

A number of airborne ECM systems, using minicomputers developed by the company, are now in use by the military. A ground station for processing the data for the aircraft was recently completed, and a mini for use with a common memory-bus structure is also nearing completion. Chung also has definite plans for commercial applications. The company has acquired a service bureau that handles 13 savings and loan institutions, giving it a good feel for the problems of this type of institution. The bureau now uses IBM equipment.

For the record

Patient safety. Litton Industries has introduced an isolation panel to protect patients from electrical hazards in hospital operating rooms and intensive-care units. The wall-mounted transformer unit (called Isopanel and developed by Litton's Jefferson Electric division) includes an aluminum electrostatic shield. It isolates the patient from stray current and detects any that's emitted from the electrical equipment attached to the patient. Leakages above a predetermined limit are indicated by a red light and warning beeper. The unit's leakage is .005 milliamp or less.

Adding up. RCA will announce an extension to its current line of computers, the RCA 2, 3, 6, and 7, early in September, and further extensions next spring or summer.

Subwork. The Naval Air Systems Command is nearer introducing its network of moored surveillance systems for the detection and tracking of submarines, having awarded cost-plus-fixed-fee contracts for the project's concept formulation to three of the 10 bidders. The contractors for this study phase of the self-mooring, air-dropped sonobuoys will be: Sanders Associates' Ocean Systems division, $1.37 million; General Electric's Re-entry and Environmental Systems division, $1.09 million; and Litton Industries' Data Systems division, $841,000.

Production and deployment of the antisubmarine fleet is expected to begin in the mid-1970s.

People mover. Boeing has taken over the management of the Morgantown, W. Va., personal rapid transit system, now scheduled for October 1972 completion. The revenue-producing prototype, designed and subcontracted under Jet Propulsion Laboratory management, consists of 17-passenger, rubber-tired buses on dedicated guideways between two West Virginia University campuses and downtown. The DOT now plans to fund the $20 million experiment.

Washington Newsletter

August 30, 1971

Metal lasers will provide workable ABM radars . . .

High-energy metal vapor lasers with quantum efficiency potentials as high as 70%—powerful enough to penetrate the blackout period of high-altitude nuclear blasts—are believed close to successful development for use as ABM radars. The program is getting strong support from the Pentagon's Advanced Research Projects Agency, with the Air Force Special Weapons Center, Kirtland AFB, N.M., as the lead laboratory.

Kirtland is developing a flowing copper vapor laser which puts out 5,000 to 5,700 angstroms at very high energy. It penetrated a barium simulation of a "nuclear cloud" of free electrons and positive ions generated in atmospheric tests under ARPA's Project Secede [*Electronics,* Aug. 3, 1970, p. 51].

. . . once a small laser generator can be built

One problem still to be overcome is the development of a lightweight, compact and efficient copper vapor generator for the laser. Consequently, Kirtland is prepared to award a six-month study contract for such a generator, which must also be capable of being scaled up by four to five orders of magnitude in volume and mass flow rate, and of generating a vapor at densities greater than or equal to 10^{15} atoms/cc, while maintaining copper atoms at temperatures less than or equal to 1,600°C. Qualified respondents to the Kirtland request are scarce, sources say, but include MIT's Lincoln Laboratory, which has done much of the Air Force work in this area, Pratt & Whitney, and GE's Space Sciences Laboratory.

Lockheed in trouble over submarine detector for S-3A . . .

Specifications for submarine detection are not met by the electronics now in test for Lockheed Aircraft's developmental S-3A carrier-based ASW plane, and scheduled for retrofit in Lockheed's land-based P-3C Orion. The Pentagon's Directorate of Defense Research and Engineering, which is monitoring Lockheed's tests, is disturbed that it isn't getting enough out of S-3A's detection system to track submarine diesel engines. The system reportedly yields only 3 decibels of gain, and not the needed 10 dB.

Though officials won't specify the weak link in the detection chain, one source makes it clear that the problem lies in the contractor-furnished equipment, and is disturbed by a Lockheed attitude he says occurs too frequently in the aerospace industry. "They're so concerned with building and flying airplanes, they don't pay enough attention to the performance of the total system," he complains.

. . . as S-3A costs go up and up

Rising S-3A costs are also generating concern among DOD's economic monitors. Apparently, the increases on Lockheed's $397 million fixed-price incentive development contract for six planes are already above the $63 million projected in December, 1970, in the Navy's selected acquisition report. Lockheed would have to pay $23 million of the $63 million out of its 12% profit [*Electronics,* Jan. 8, p. 51].

Moreover, S-3A project manager, Capt. Fred H. Baughman, has told Congress that the unit cost for a buy of 199 planes is expected to run to $14.7 million, of which an estimated $4 million will go for avionics. Defense officials say they will not be surprised to see costs rise beyond that point should Lockheed avionics and airframe suppliers, like Sanders Associates and LTV Aerospace, push to renegotiate their contracts because of increased overhead resulting from declining sales volume.

FDA may ask for voluntary medical device standards . . .

Discouraged by the dimming prospects for medical device legislation before the 1972 elections, and by Nixon Administration bickering that has blocked the introduction of a Department of Health, Education, and Welfare device bill, the Food and Drug Administration apparently is turning back to industry to work out voluntary standards, say industry sources. The FDA is footing the bill for a national conference on medical device standards, which it has asked the Association for the Advancement of Medical Instrumentation to hold next May. The conference will help collate the efforts of the more than 50 organizations now engaged in medical device and instrumentation standards activities in the U.S., says AAMI president Cesar Caceres.

In addition, David Link, the FDA's special assistant for medical-clinical devices, is pressing the EIA for a follow-up conference aimed at the health care electronics industry. An EIA spokesman, who admits that EIA has the experts in the field and probably isn't working hard enough for voluntary standards, says, "Maybe."

. . . and malpractice body plans look at hospital electronics

The Government's newly created Commission on Medical Malpractice will be investigating malpractice claims arising from faulty medical electronics equipment in hospitals. William J. Walsh, commission research director, says, "Product liability of drugs and devices is within the scope of our mandate."

Charged by Department of Health, Education and Welfare Secretary Elliot L. Richardson with the job of identifying and evaluating "the causes and consequences of malpractice claims through an intensive program of research and analysis," the commission plans to hold public hearings, and will be creating advisory panels of experts.

Committee proposes satellite SOS system for 1975

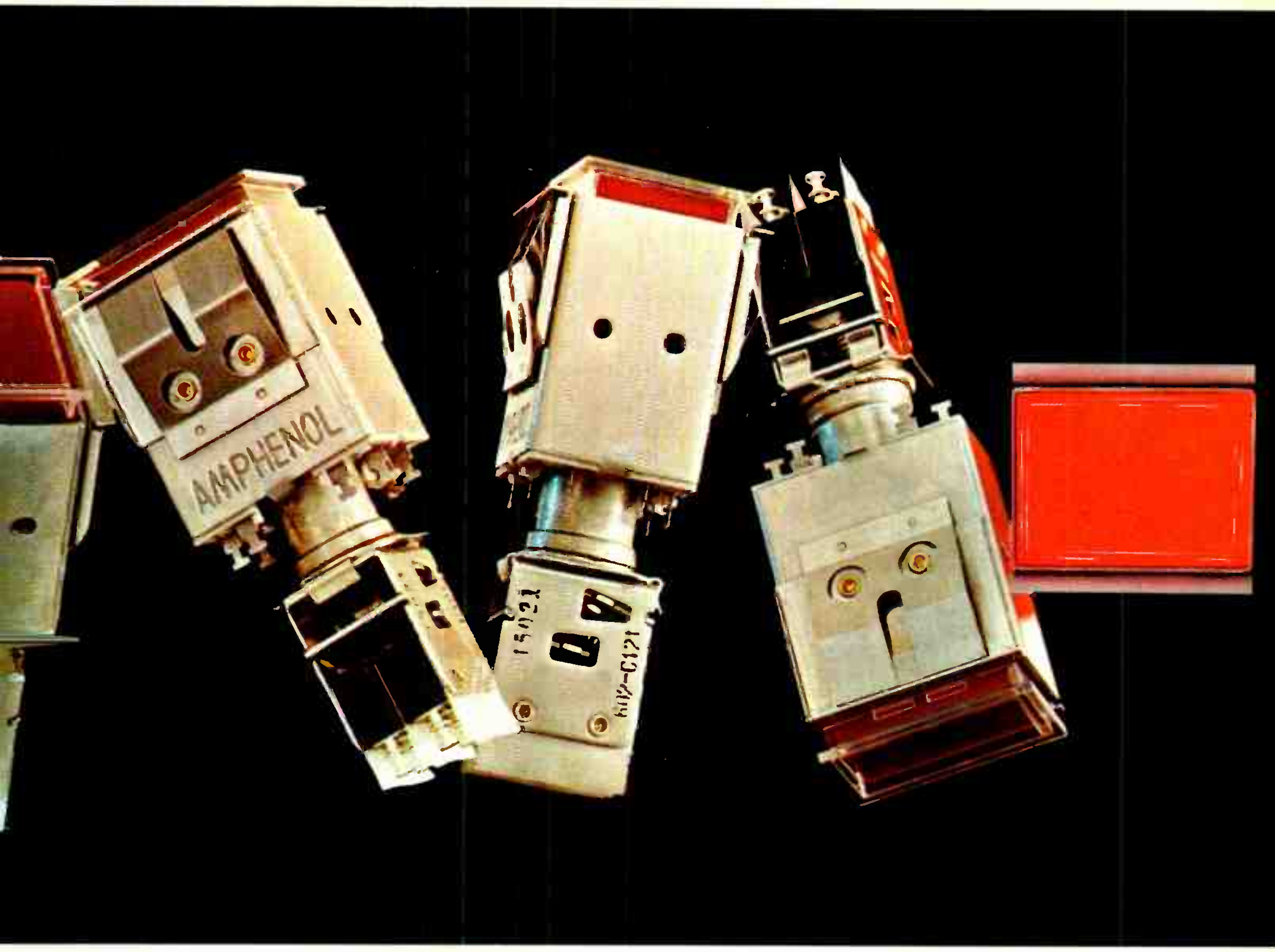
A special satellite system will be relaying distress signals and also locating survivors by 1975 if a joint Navy, Coast Guard and NASA search and rescue committee has its way. The ad hoc committee is recommending that ships and airplanes be equipped with small emergency beacons that would use 1 to 5 watts of rf power and transmit over the 157.3125- to 156.4124-megahertz uplink and 161.9125 to 162.0125-MHz downlink bands allocated for distress alerting at the World Administrative Radio Conference.

At committee meetings, NASA has suggested testing the concept by putting a transponder aboard Synchronous Meterological Satellite A, due to be launched in September of 1972. One system being considered would superimpose Omega or Loran signals on the uplink signals to convey location data.

Addenda

The Labor Department's Bureau of Labor Statistics projects that the demand for EEs will increase 49% by 1980, from an estimated 230,000 employed in 1968, while the demand for physicists will increase 63.9% from 45,000. . . . NASA has created a new Transport Experimental Programs Office for program direction of the planned quiet STOL aircraft.

Look at it from every angle.



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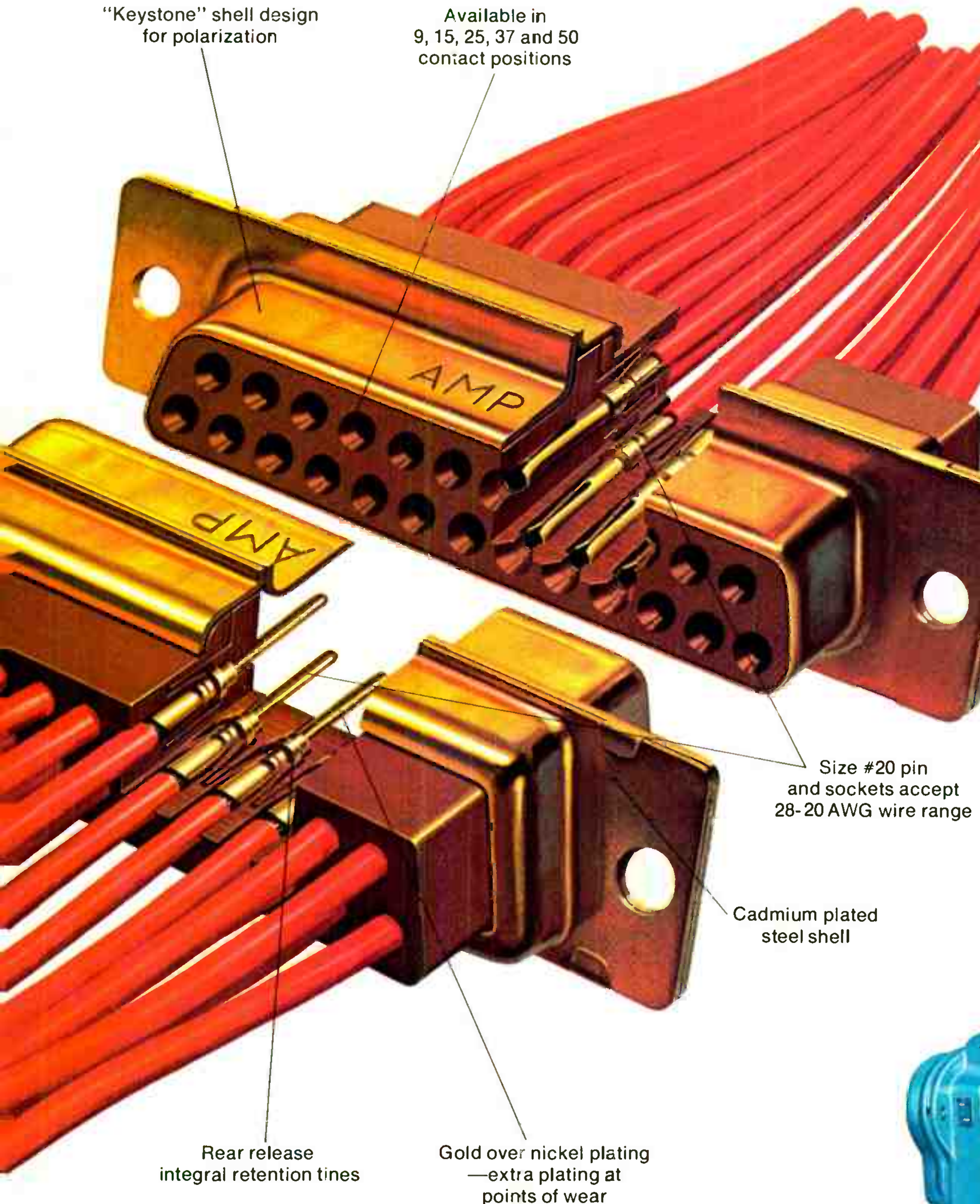

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Technical articles

C/MOS + silicon gate = micropower technology: p. 38 (cover)

Electronic watches, portable communications gear, and battery-powered calculators have one thing in common: they need very-low-power logic circuits. This micropower technology, say authors R.R. Burgess and R.G. Daniels, is the offspring of a marriage between the complementary MOS and polysilicon gate technologies. The resulting circuits dissipate 99% less power than standard MOS at low frequencies.

The cover: Shown in the photomicrograph is a silicon-gate C/MOS dual-toggle flip-flop. This type of micropower component will be used in one of the first electronic wristwatches.

It pays to have a cost-effective IC screening program: p. 44

How expensive is an IC failure? The answer depends on what kind of application it's used in and how far along the road to implementation it is. Once that's determined, assert authors John J. Lombardi and Fred Danner, a cost-effective test and screening operation can be set up that economically minimizes failures.

AGC goes digital for precise, programable control: p. 52

Designers of radars and radios alike need no introduction to the benefits of automatic gain control. But they'll be glad to know that digital techniques are available for AGC, says author Max. F. Farley. The digital circuits provide more precise level control than analog methods for complex loop characteristics, and lend themselves to computerized adjustment on production lines.

Design an electrometer and solve current-measurement problems: p. 58

Several commercial electrometers are available for measuring very low currents, but these general-purpose units aren't always useful in applications that have specific requirements. However, it's not difficult to design your own instrument, notes author Richard G. Weinberger; that way you'll get high sensitivity, fast response, or whatever combination of features you need.

And in the next issue. . .

A special report on where computer technology is heading in the '70s . . . the state of the art in rf power transistors.

C/MOS unites with silicon gate to yield micropower technology

Logic circuits that dissipate 99% less power than standard MOS at low frequencies are ideal for watches, portable communications systems, and battery-powered calculators, which all need low-voltage power supplies

by R. R. Burgess and R. G. Daniels, *Motorola Inc., Phoenix, Ariz.*

□ Micropower semiconductor technology combines two well-known integrated circuit techniques—complementary MOS and polysilicon gate—in an ideal compromise between switching speed and power dissipation. These Si-gate C/MOS logic circuits have nanowatt quiescent-power requirements, and can operate at supply voltages down to about 1 volt. This new family of circuits is by now moving onto the production line and has applications wherever low power is essential—in battery-pack mobile communication systems, portable calculators, or electronic wristwatches.

Gate electrodes of polycrystalline silicon have two advantages over conventional metal gates: lower threshold voltages and lower capacitance. Thresholds are lower because the work function of polycrystalline silicon can be made much closer to that of single-crystal silicon substrates than can the work function of conventional metalization. The capacitance is lower because the silicon gate also functions as a self-aligning mask for the source and drain diffusions, and therefore minimizes overlap capacitance.

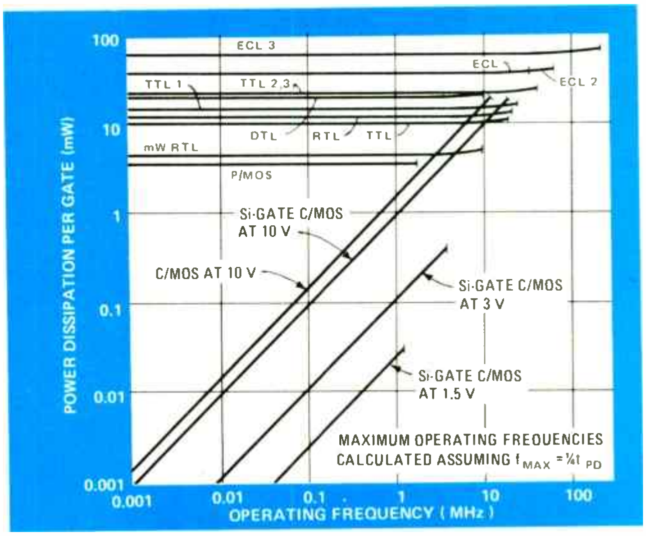
Utilizing silicon-gate MOS devices in complementary pairs (one p-channel and one n-channel device in series) ensures extremely low quiescent current—in the nanoampere region. Whenever one device is conducting, at least one complementary device is held off, and the net circuit quiescent current is determined only by the leakage current of the off devices.

Figure 1 compares the performance of a basic Si-gate C/MOS logic gate with that of other digital families presently available. With a 1.5-V supply, its power dissipation is over two orders of magnitude less than that of standard p-channel MOS, yet its maximum operating frequency is about the same.

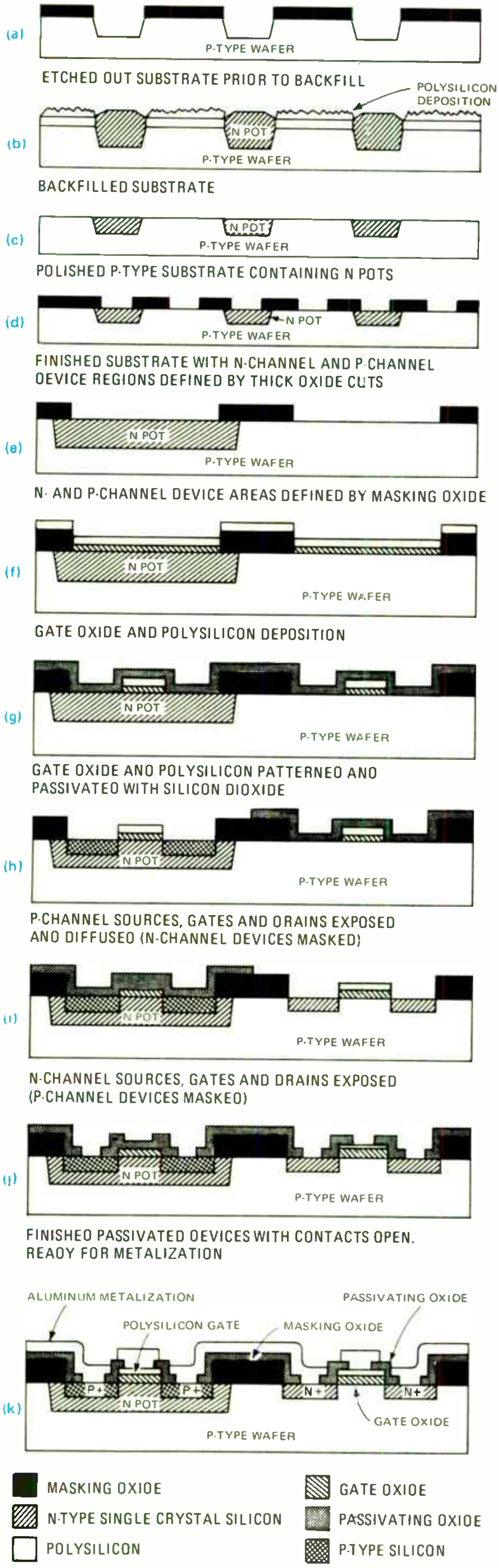
Of course, at higher drive voltages C/MOS circuits will attain higher frequencies, and with a 10-V power supply they will achieve speeds approaching those of TTL, DTL and RTL at equivalent power levels. The difference is that, while other digital families dissipate about the same power regardless of the switching frequency, the power dissipation of C/MOS circuits drops dramatically at the lower frequencies. Some of the logic elements in any digital system are idle much of the time or else are switching much more slowly than the maximum clock rate. Thus, the net power saving for a Si-gate C/MOS system can amount to over an order of magnitude.

Needed for the production of a low-threshold silicon-gate C/MOS integrated circuit is a substrate that contains both p- and n-type regions. The substrates are fabricated by first chemically etching away material and then epitaxially growing the opposite type. While many techniques other than epitaxy may be used to produce the complementary regions, it appears that at present, for large-volume low-cost production, the degree of control required can be easily achieved by epitaxy. For example, a 0.5-V threshold voltage requires a surface concentration of about 10^{15} atoms per cubic centimeter for the n substrate—a condition difficult to attain by conventional diffusion techniques with the desired degree of accuracy.

The fabrication process is displayed in Fig. 2. In (a), a p-type starting wafer has been chemically etched to produce regions or "pots" suitable for backfill. Using conventional epitaxial techniques, an n-type deposition is made in the pots (b). Polycrystalline silicon deposited on the masking oxide serves as a depth gauge for the subsequent polishing step. Typically 3–5 ohms/cm, p-type, 100-oriented starting material is used with 4–6 ohm/cm n-type backfill. In (c), the filled substrate has been shaped back and polished. The final step (d) in substrate preparation involves growing a relatively thick



1. Sound logic. Basic Si-gate C/MOS elements are star performers when compared to the other logic families available. With a 1.5-V supply, power dissipation is two orders of magnitude less than with P/MOS; maximum operating frequency is about the same.



2. Making it. Si-gate C/MOS devices are made by incorporating a polysilicon masking technique into the basic C/MOS process. The wafer is prepared in steps (a)–(d): n diffusions are made in pots that are chemically etched in p starting material, after which a thick oxide is grown to reduce interconnect capacitances. Device fabrication is shown in (e)–(k). Miller capacitance is almost eliminated.

oxide layer—in the 0.5- to 1-micron range—to reduce the capacitance of the bonding pads and metal interconnects. Areas of this thick oxide are etched away to expose the substrate and pots in the regions where the MOS devices will be fabricated.

The first step in the device fabrication sequence is shown in (e). It involves growing a high-quality gate oxide (about 1,000 angstroms thick) for both the n-channel and the p-channel devices. Then a layer of polycrystalline silicon is deposited over the entire wafer (f). The polysilicon and the gate oxide are patterned, and the wafer is covered with a passivating layer of silicon dioxide (g).

This layer of oxide is selectively removed over the n pot to allow diffusion of the source, gate, and drain regions of the p-channel devices (h). The wafer is again covered with an oxide layer, but this time what will be the n-channel devices are exposed to allow for an n-type source, gate and drain diffusion (i). Following this diffusion, the wafer is again passivated with an oxide layer. As a final step the contact areas are opened to allow interconnection with a suitable metalization (j).

The completed structure is shown in Fig. 2 (k). Notice that, since the polysilicon gates act as self-aligning masks for the source and drain diffusions, the usual MOS gate-to-drain and gate-to-source overlap (Miller) capacitances are virtually eliminated. (The lateral diffusion under the gates can generally be ignored.)

Designing with Si-gate C/MOS. From basic device physics, the threshold voltage of an MOS transistor is given by

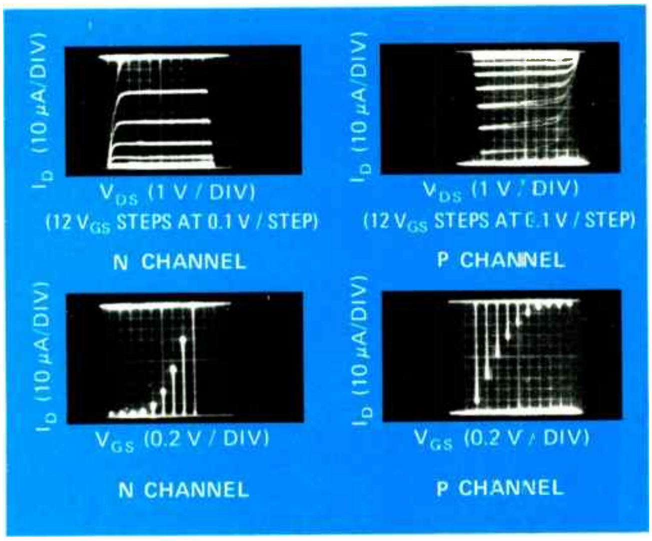
$$V_t = \phi_{ms} - \frac{Q_{ss}}{C_{ox}} \pm \left\{ 2|\phi_F| + \frac{1}{C_{ox}} \sqrt{4K\epsilon_o q N_B |\phi_F|} \right\}$$

where the plus in the plus-or-minus sign is used for an n-channel device, the minus is used for a p-channel device, and the terms are defined as follows:

N_B = the doping density of the substrate
Q_{ss} = the equivalent fixed oxide charge
ϕ^F = the Fermi function for the substrate
C_{ox} = the capacitance per unit area of the gate oxide
$\phi_{ms} = \phi_m - \phi_F$ = the work function potential difference between the gate electrode and the substrate
$K\epsilon_o$ = the dielectric constant of silicon
q = the electronic charge.

The parameters in this expression that require substantial process control, and which therefore determine the final threshold voltage, are the substrate doping level, N_B, and the oxide charge, Q_{ss}.

Typical transistor characteristics are shown in Fig. 3 for monolithic n-channel and p-channel Si-gate MOS devices. It can be seen from this figure that in fact, the device characteristics are complementary with threshold



3. Good character. From typical parameters for an n-channel and a p-channel silicon-gate MOSFET on the same chip, it's clear that characteristics complement threshold voltages of about 0.6 V. Transconductance g_m corresponds to Z/L of 10.

voltages of approximately 0.7 volt.

A reasonable approximation for the maximum frequency response of a given C/MOS circuit is

$$f_{max} = (V_{DD}-V_T)^2/V_{DD} \quad (2)$$

From Eq. (2) it seems that the best threshold voltage should be the lowest achievable threshold voltage, since this would yield the largest f_{max}. However, if the threshold voltage of a device is too low, then it may not be possible to turn it off in normal circuit operation. That is, at very low threshold voltages, the quiescent current will become appreciable.

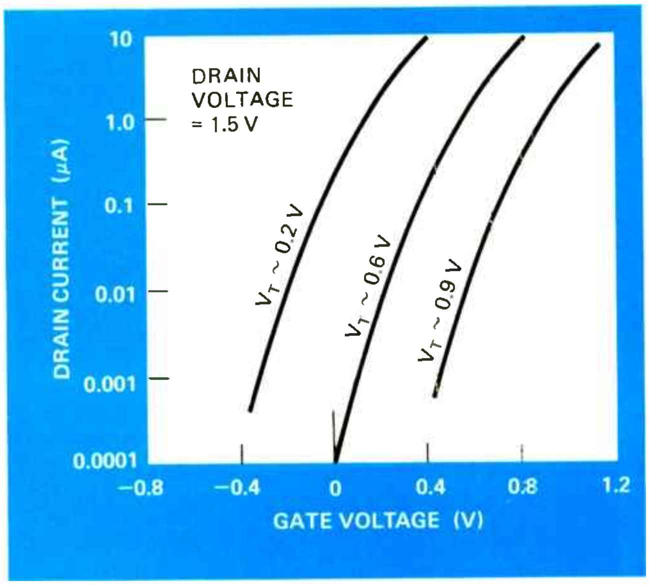
This is illustrated in Fig. 4, which plots the log of I_D as a function of V_{GS} for three devices identical in geometry but having different threshold voltages. (The threshold voltage V_T is arbitrarily defined here as the gate voltage required for 5-μA drain current.) For each 0.1-V decrease in threshold voltage the curves show that the drain current at zero gate voltage increases about one order of magnitude. This is not leakage current in the usual meaning of the term, but the normal channel current to be expected from a MOSFET with a very low threshold voltage. A tradeoff must therefore be made: the threshold voltage must be high enough for low quiescent current but low enough for good frequency response.

Another tradeoff involves the ratio of the device's gate width, Z, to channel length, L. It can be shown that the current capability of a Si-gate MOSFET at a given gate voltage is linearly proportional to the Z/L ratio. Also, the upper limit to the operating frequency of a C/MOS circuit is determined by the ability of the active devices to supply the current to charge the various node capacitances. Devices with higher Z/L ratios will yield higher operating frequencies. But on an IC chip these node capacitances are dominated by the device gate capacitances. (This is particularly true for Si-gate C/MOS circuits because the gate-to-drain and gate-to-source capacitances are negligible.) The problem is, the device gate capacitance is also geometrically dependent on Z and L. Therefore, for maximum speed, what is desired is high Z/L and low Z ÷ L, or

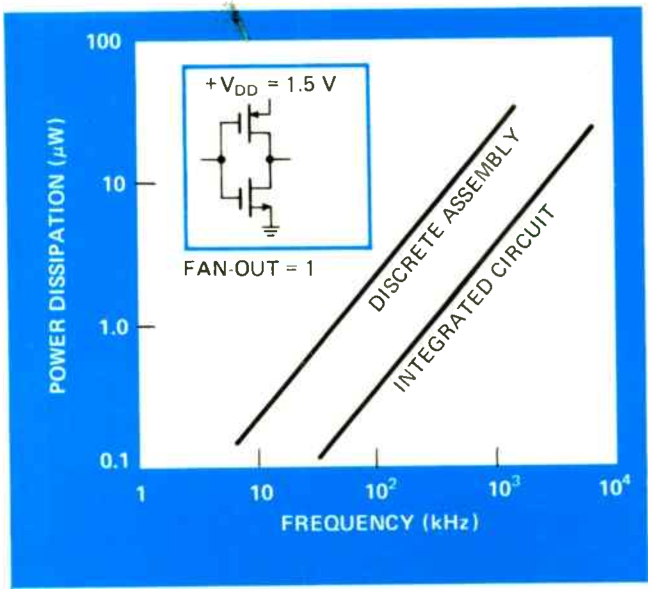
$$f_{max} \sim (Z/L)/Z \cdot L = 1/L^2$$

In short, a designer's ability to obtain maximum speed with Si-gate C/MOS circuits is limited by the threshold voltages, which must be low, and gate widths, which must be minimal.

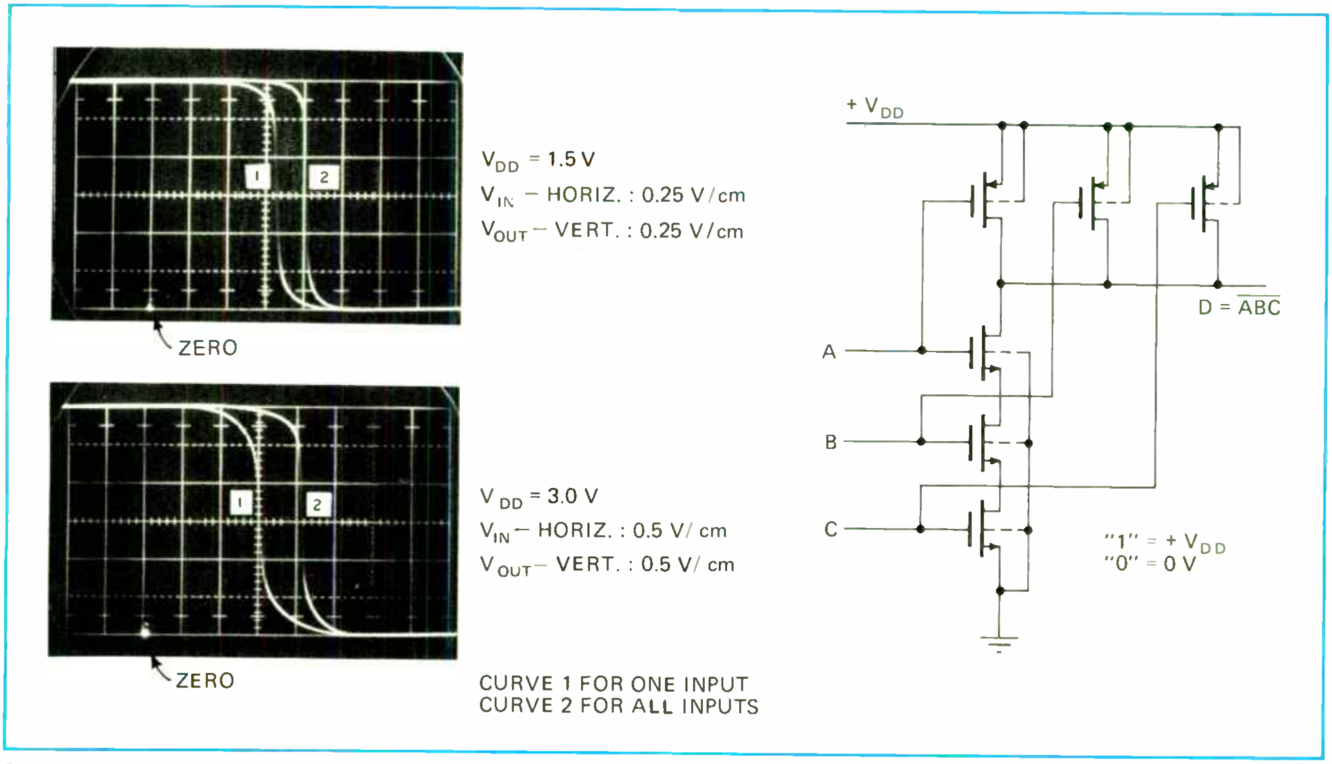
The dynamic power dissipation, on the other hand, is not appreciably affected by device threshold voltage, but at any given frequency is proportional both to the various node capacitances and to the square of the supply voltage. Again, gate capacitance of the devices must be minimized, which means both Z and L should be as



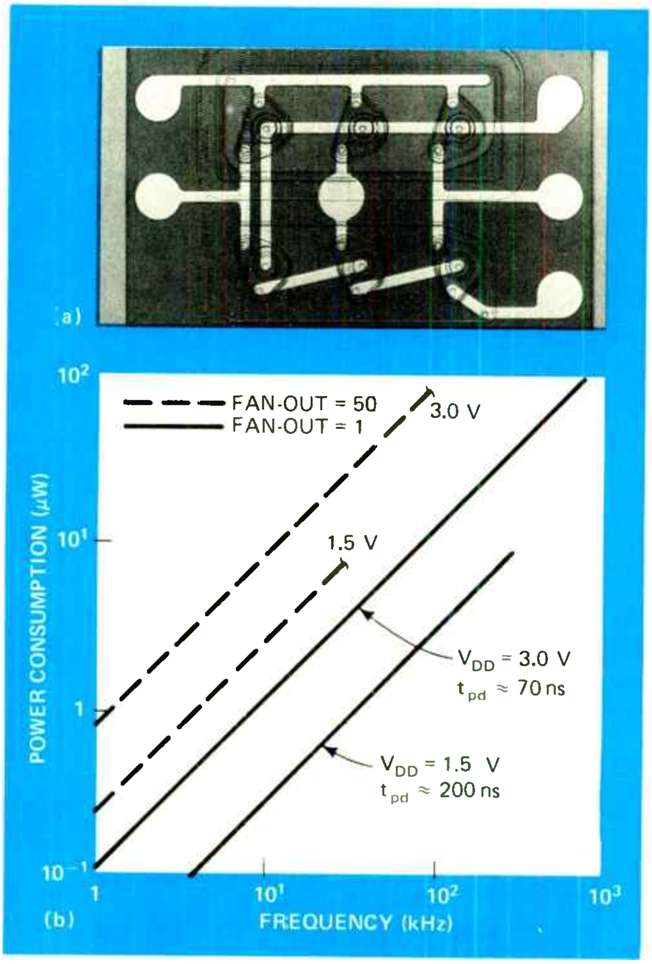
4. Compromise. Drain-current-versus-gate-voltage curves show that for each small (0.1-V) decrease in threshold voltage, the zero-gate-voltage drain current rises tenfold. Threshold must be high enough for low quiescent current, low enough for good frequency.



5. A discrete difference. The extra parasitic capacitance of the discrete inverter makes it dissipate considerably more power than an integrated inverter does. A schematic of an inverter, which is the basic building block of C/MOS logic circuits, is also shown.



6. NAND some. In order to build a Si-gate C/MOS NAND gate, the p-channel devices are connected in parallel while the n-channel devices are connected in series. Typical transfer curves show the high degree of noise immunity that is present in the circuit. Note that these are worst-case curves, and that all other input conditions yield transfer curves that fall within the area enclosed by the worst-case curves.



small as possible. The supply voltage should also be minimized to the extent allowed by the frequency response required.

Performance of basic circuits. The basic building block for C/MOS logic circuits is the inverter shown in Fig. 5. This circuit was fabricated with device parameters in the following range:

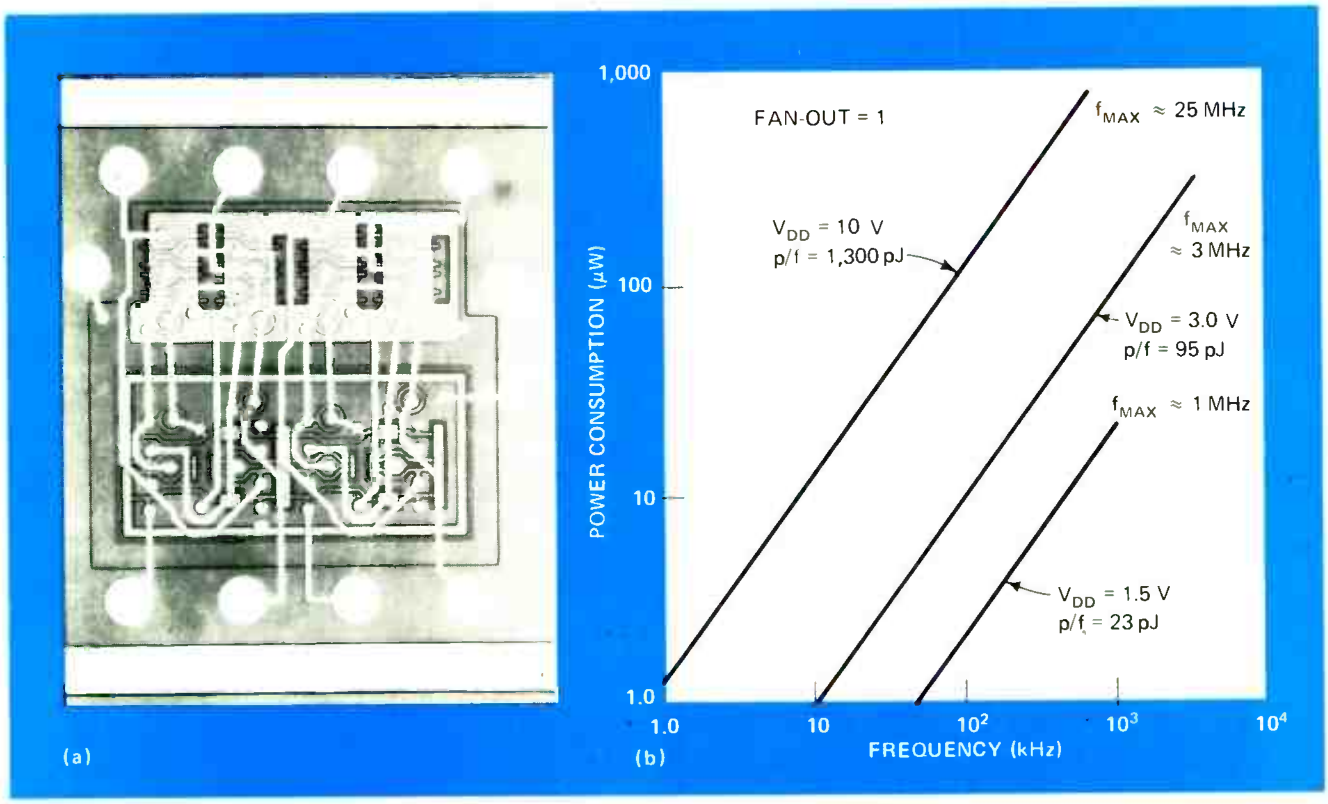
$$0.5 < V_T < 0.9V \text{ (both n and p)},$$
$$0.2 < L < 0.3 \text{ mil, and}$$
$$5 < Z/L < 12.$$

(These values are intended to give an appreciation of the circuit performances realized, and are not indicative of limitations of the technology.)

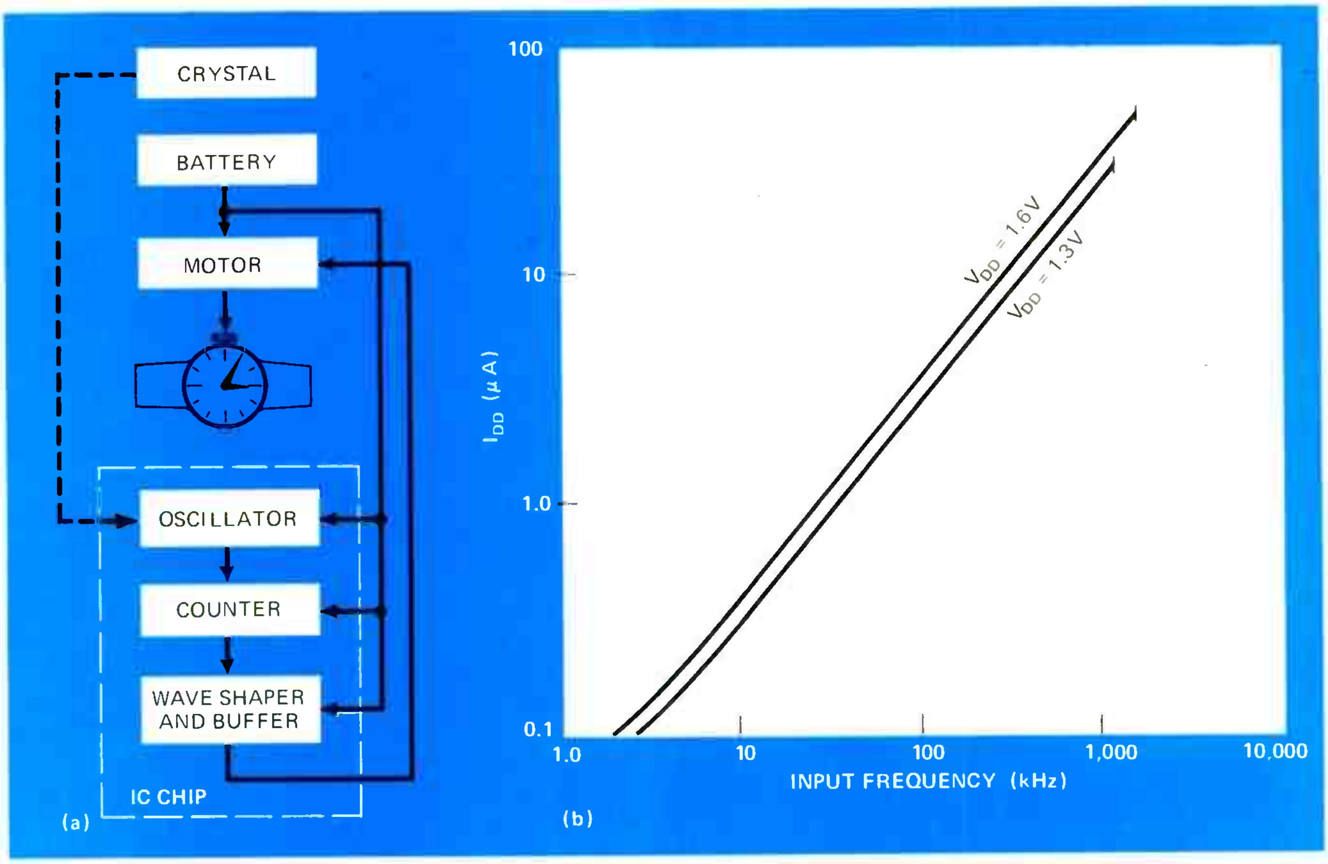
In general the dynamic power dissipation of a C/MOS inverter is proportional to the load capacitance, the operating frequency, and the square of the supply voltage. Therefore, for a given supply voltage and load capacitance, the power/frequency (P/f) ratio is constant.

Figure 5 also shows characteristic power dissipation vs frequency for the inverter. The upper curve is for a typical discrete assembly, the lower curve for an integrated inverter that has the same device geometries as the discrete assembly. The effect of additional parasitic capacitance is clearly evident here, for the discrete assembly has a P/f ratio nearly an order of magnitude

7. NAND some more. Photomicrograph of a Si-gate C/MOS NAND gate IC die reveals the p-channel devices located in the pot region at the top. Typical performance characteristics shown in the graphs are derived from 1.5-V and 3-V power supplies. For the supply voltage of 1.5 V, the quiescent power dissipation is only about 10nW, while propagation delay time is approximately 200 ns.



8. No flop. Area of the Si-gate C/MOS dual toggle flip-flop is only 35 by 35 mils square, even though it contains 40 devices. An added advantage of adopting polysilicon gates is that cross-unders can be made to save space. Performance of flip-flop is charted in the graphs: with a 1.5-V supply, maximum toggle frequency is about 1 MHz, and power dissipation is only 2 nW. Even at 10 V, frequency is a good 25 MHz.



9. Watch time is now. The immediate application for micropower technology is in electronic wristwatches. The heart of the system is the counter (or frequency divider) which divides the oscillator frequency down to about 1 Hz. The performance curve for a typical Si-gate C/MOS counter shows that with a 32-kHz input frequency the current drain is only about 1 microamp at a 1.3-V to 1.6-V power supply.

higher. The integrated inverter, at 1.5 V, with a fan-out of 1, has a P/f ratio of only 3.3 pJ(nW/kHz.

Figure 6 shows the circuit diagram and typical transfer curves for a Si-gate C/MOS NAND-gate. The p-channel devices are connected in parallel, while the n-channel devices are connected in series. (A NOR-gate would have the p-channel devices in series and the n-channel devices in parallel.) Notice the high degree of noise immunity present in this circuit. The curves shown are for worst-case conditions; all other input conditions yield transfer curves within the area enclosed by these two curves.

The photograph of a closed-geometry Si-gate C/MOS NAND gate IC die, labelled Fig. 7(a), shows the p-channel devices located in the pot region at the top. It should be emphasized that this was a developmental chip, and in no way representative of packing densities which can be achieved with this technology. Nevertheless, typical performance characteristics, summarized in Fig. 7(b), are proof of the potential of this technology. When the gates were driven with a 1.5-V supply, the propagation delay time was only about 200 ns and the quiescent power dissipation a dramatically low 10 nW.

A die photograph of a Si-gate C/MOS dual toggle flip-flop that utilizes open geometry (diffusion-guarded) devices is presented in Fig. 8(a). A unique advantage of Si-gate C/MOS circuits can be seen in this photograph: the polysilicon gates may be used for cross-under connections. This can be very helpful during chip layout since it in fact provides a simple, two-layer metalization system.

Typical performance for this flip-flop is shown in Fig. 8(b). With a 1.5-V supply and a fan-out of 1, the maximum toggle frequency is about 1 MHz, the quiescent power dissipation is about 2 nW, and the P/f ratio is only 23 pJ. What's more, with a 10-V power supply, the maximum toggle frequency is a respectable 25 MHz.

Some applications. One immediate application for Si-gate C/MOS technology is in quartz-crystal-controlled electronic wristwatches. This application requires operation from a single 1.3- or 1.6-V battery, with minimum current drain.

The system block diagram is shown in Fig. 9(a). The crux of the system is the counter or frequency divider, which divides the oscillator frequency (8-131 kHz) down to a frequency of about 1 hertz, depending upon the particular motor and gearing arrangement.

The counter consists of a cascade of Si-gate C/MOS binary flip-flops. Due to the constant P/f response of the flip-flops, the first (highest-frequency) flip-flop draws half the total dynamic current of the counter; the first 10 flip-flops draw 99.99% of the total current. This means that, except for quiescent current, the counter performance is nearly independent of the number of flip-flop stages.

Figure 9(b) shows the typical performance of a Si-gate C/MOS counter for electronic wristwatches. With 32-kHz (2^{15}-kHz) input frequency, the current drain is only about 1.0 ampere at a 1.3- to 1.6-V supply.

Figure 10 is a photograph of an electronic wristwatch chip die. This chip contains 16 flip-flops, dual output buffers and waveshaping circuitry, input oscillator, and two passive components for the oscillator (a 20-pF MOS capacitor and a 50-megohm polysilicon resistor).

The die size is only 82 × 94 mils; total active device count is 312. This chip, a battery, a quartz crystal, a motor and a frequency trimming capacitor comprise the complete electronic system for a wristwatch. With a 32-kHz crystal and a 1.3-V mercury battery, the total current drain for this chip (excluding motor current) is typically less than 4 μA.

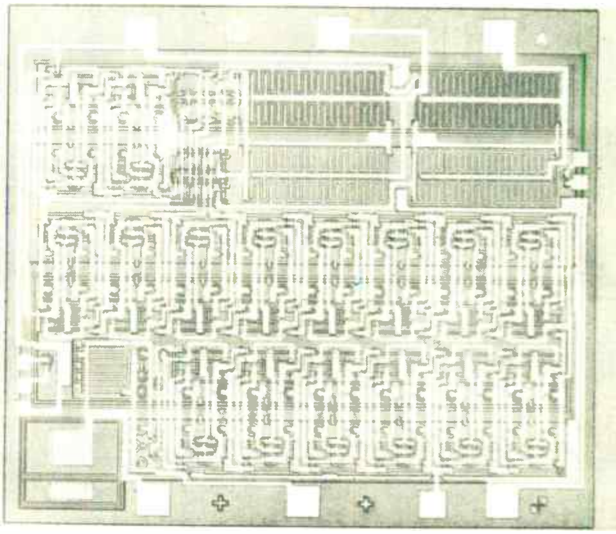
This technology will be equally applicable to the next generation of solid state clocks that have no moving parts. A prototype clock was built with an analog LED display consisting of two concentric circles. The outer circle contains 60 elements, and indicates the second and the minute. The inner circle contains 12 elements and indicates the hour. By using a multiplexing scheme with a 64-Hz strobe rate, three LEDs appear to be on at any given instant, when in fact each of the three LEDs is operating at a low duty cycle to conserve power.

Besides wristwatches and clocks, silicon-gate C/MOS ICs seem likely contenders for all types of portable digital systems. Those systems demand minimum power dissipation and/or operation from low-voltage power supplies in the 1-V to 3-V range. Small, portable calculators with battery-powered, nonvolatile IC memories would, for example, fall in this category.

In the field of aerospace digital electronics, power supply requirements are critical. Si-gate C/MOS micropower circuits would yield longer system life from a given power source. A great advantage may be realized in applications in space vehicle equipment that spend a large portion of time in a stand-by mode. A C/MOS system requires almost no power in this quiescent state.

In the bioelectronics field, the lower supply voltages permitted by Si-gate C/MOS will, of course, be safer for the patient. In addition, in the case of implanted digital measuring and telemetry systems, battery replacement requires an operation, making battery life of paramount importance. In fact, human fuel cells may soon be capable of powering low-energy systems without the need for any replaceble batteries whatsoever. □

10. Timely chip. Die photomicrograph shows the 16 flip-flops, dual output buffers, wave-shaping circuitry, and input oscillators that go to make up a typical silicon gate C/MOS watch circuit.



Setting up a cost-effective screening program for ICs

With a firm grip on the costs of both test procedures and replacement of ICs in various stages, the engineer is ready to implement a screening program that economically minimizes risks of failures

by Fred Danner and John J. Lombardi, *Grumman Aerospace Corp., Bethpage, N.Y.*

☐ What makes one electronic system run error-free for hundreds of hours while another system, designed in the same way and using integrated circuits from the same supplier, breaks down every half hour? One major reason for the difference lies in how well the integrated circuits were screened before they were put into operation. To plan such a screening program requires not only a knowledge of device metallurgy and failure mechanisms, but an awareness of the cost of each test in the program.

For screening programs can be costly. Since only the largest facilities will be able to afford their own IC screening equipment, most engineers will have to rely either on the tests performed by the semiconductor manufacturer or on an outside, independent testing service. In either case, the costs of such services must be balanced against the degree of screening actually necessary.

But how much ought to be spent on screening? That depends on the cost of replacing defective ICs. Figure 1 shows the typical cost for four different types of equipment (consumer, industrial, military, and space) at each of four stages of the life cycle (receiving room, mounted on a board, boards assembled into system, and field use). These curves are based on actual experience at Grumman and on estimated costs for consumer and industrial systems, and can be used as a guide to determine what a company can afford to spend on screening each IC.

The curves show that initial replacement costs are low, particularly for consumer equipment, in which the subassemblies contain so few components that troubleshooting is not difficult. Once the equipment leaves the factory, however, these costs increase because entire subassemblies are usually replaced, rather than just the failed part. And the more complex the equipment, the faster the costs grow.

For industrial equipment, for example, field-repair charges usually start at about $20 an hour for a service technician, plus expenses—transportation, meals and lodging. Field maintenance costs for military equipment are also high because troubleshooting equipment is usually not carried along with the gear in the field. Instead, spare subassemblies are carried, entire subassemblies are replaced, and faulty modules are shipped back to a central repair facility. The inventory of spares naturally adds to the replacement cost. As for replacement costs of any spacecraft equipment in orbit, they are essentially equal to the cost of the entire mission if the mission aborts as a result of the module failure.

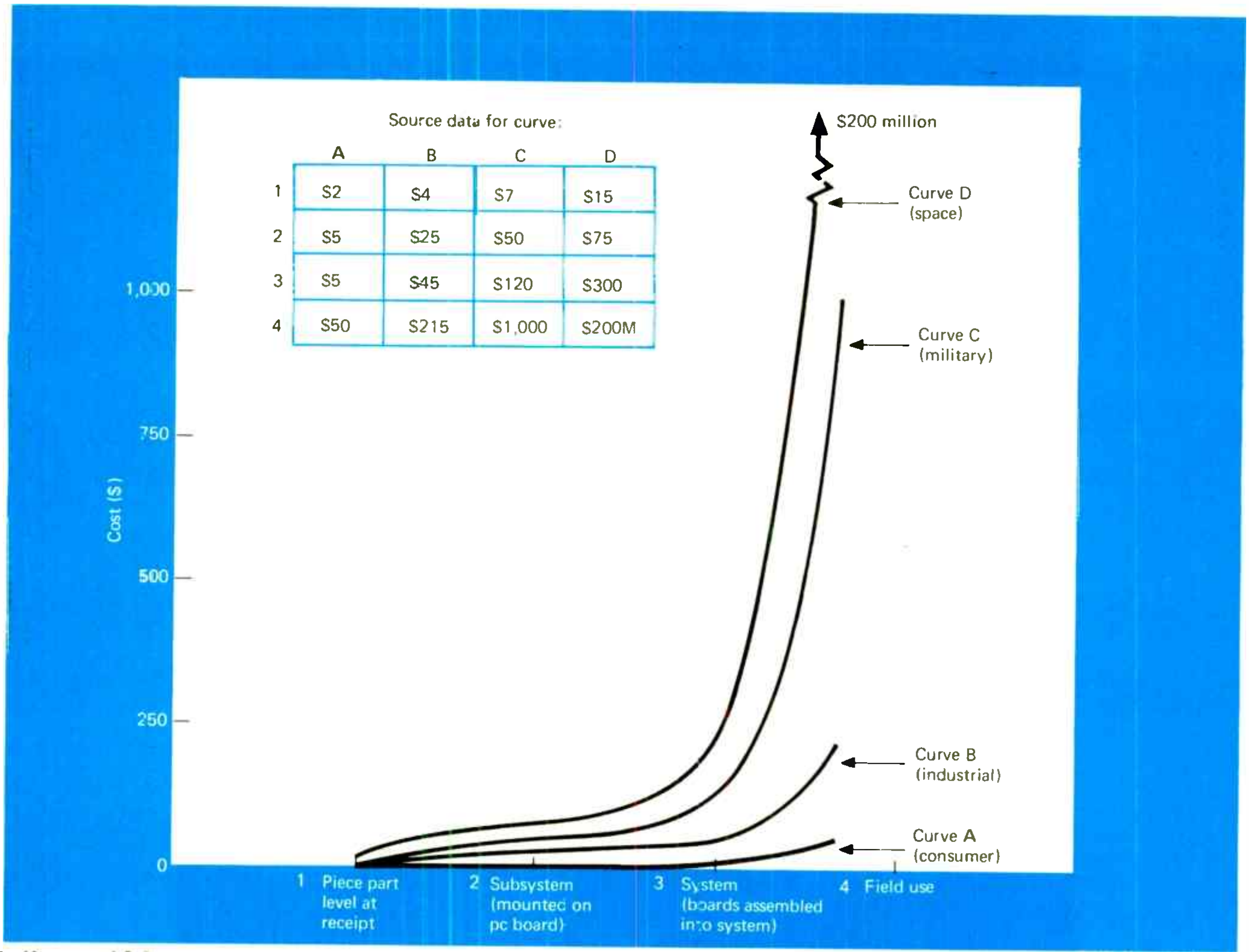
As an example of the use of the curves, suppose that on the average 5% of each 1,000-lot of ICs, or 50 out of 1,000, are defective when they reach the equipment manufacturer's plant. If only a rudimentary, go/no-go screening is applied in the receiving room, perhaps 20 of the defective ICs might be caught. Subsequent tests during production might catch another 15 defective devices at the subsystem level, and perhaps 10 more might be detected at the system level. But the remaining five would be installed and shipped, only to be discovered once the equipment went into field use.

If this were military equipment, the cost of replacing the ICs at the receiving stage would be $7×20, or $140, at the subsystem stage $50×15 or $750, at system stage $120×10 or $1,200, and in the field $1,000×5, or $5,000. In sum, the defective ICs would cost $7,090 to replace. This $7,000 or so is what could be spent on an effective screening program of the incoming 1,000 ICs—that is, about $7 could be spent on each. From a practical standpoint, however, about $4 to $5 per IC is a better estimate, since that allows for unexpected repairs.

After an engineer has estimated how much can be spent on screening, his next step is to set up the sequence of tests that will satisfy both reliability needs and the dollar allocation. It's important to recognize that the tests follow a logical sequence and are not unrelated. Some of the defects exposed by one test will also be exposed by others, and tests performed early in the sequence can be used to stress devices in preparation for later tests that will identify the defective units. Table 1 lists such tests and the defects each reveals.[1]

The test that obviously should be done first is to inspect the device before it is sealed in its package. Most semiconductor manufacturers already do this, but for critical applications, as in space missions, the user might specify special requirements based on such factors as particle size and clearance between metalization paths. However, the wise program manager will compare the costs quoted by the semiconductor manufacturer to perform and document these special tests with the cost of sending his own engineer to the semiconductor plant to perform the checks. Often, the second alternative is cheaper.

After the devices are sealed, thermal stresses are ap-



	A	B	C	D
1	$2	$4	$7	$15
2	$5	$25	$50	$75
3	$5	$45	$120	$300
4	$50	$215	$1,000	$200M

1. How much? Cost of replacing defective circuits at various stages of equipment life is lowest for consumer gear, rises moderately in industrial environment, jumps steeply for military applications in field use, and is prohibitive for space equipment. These costs can be used to estimate amount to be allotted for screening ICs, since catching potential failures early will pay off in replacement cost later.

plied to allow checking of thermal expansion coefficients, then mechanical stresses to induce weak parts to fail. Such failures are detectable with X-ray or hermeticity tests.

Next, electrical tests detect parameter degradations caused by the previous stresses and also act as a reference for burn-in, in which the devices are held at a high temperature (125°C is common) for an extended period (usually 168 hours). Burn-in, which is required under Mil Std 883, will stress the marginal devices, and then a final electrical test will detect such potential failures as drift or out-of-specification parameters.

Approximate costs for each test, based on experience and data provided by IC manufacturers, are listed in Table 2. There are two reasons for the wide variation in minimum and maximum costs of particular tests—some independent testing services charge less than others for particular tests, but make up the difference on others, and some tests can be performed with varying degrees of thoroughness, depending on the type of special equipment used.

Thermal tests, for example, may take the form of automatic cycling in a temperature chamber, an expensive approach, since the cost of the chamber must be amortized by the tester, or may simply involve immersion of the devices in liquid baths at the required temperatures. The cheapest thermal-shock technique for uncovering thermal mismatches is also normally adequate in most applications, and simply requires the device under test to be immersed first in an ice-water bath and then in boiling water. If a lower temperature is necessary (say, to stress a package whose manufacturer is known to have problems with thermal stresses), a slightly more expensive test would substitute dry ice in alcohol (−70°C) for the ice water.

Mechanical integrity is verified with centrifuge tests, usually made with a 20,000-g, vertical-axis force. This much force is usually enough to lift weak wire bonds off the bonding pads on an IC or package, and to separate a poorly mounted die from its header.

Hermetic tests are aimed at screening out leakers—devices with faulty package seals. The most common failure mechanism in such devices is the entry of air containing water vapor into the package, where the moisture condenses and corrodes the aluminum interconnections on the device. Either gross-leak (up to 1×10^{-5} cubic centimeter per second) or fine-leak (up to 1×10^{-8} cc/s) tests can be performed, with a significant premium being charged for the fine-leak tests because they require more expensive equipment. As much as 25

Table 1: Failure mechanisms detectable by screening tests

Screening tests / Failure mechanisms	Substrate mounting defects	Bulk silicon defects	Substrate surface defects	Bonding & wire defects	Particulate contamination and extraneous material	Seal defects	Package defects	External lead defects	Thermal mismatch	Electrical stability
Internal visual examination	X		X	X	X		X			
External visual examination						X	X	X		
Stabilization bake		X	X	X						X
Thermal cycling	X		X	X		X	X		X	
Thermal shock	X		X	X		X	X		X	
Centrifuge	X			X	X		X			
Shock	X			X	X		X			
Vibration	X			X	X		X			
X-ray	X			X	X	X	X			
Burn-in		X	X	X						X
Leak tests						X				

cents extra per device might be charged for a 10^{-8} cc/s test compared with a 10^{-7} cc/s test.

Burn-in, one of the most effective of the screening procedures, also is one of the most expensive, since it can tie up capital equipment for weeks at a time. However, it has cut equipment failure rates by as much as 10 to 100 times, according to Joseph Brauer, chief of the solid state applications section of the Air Force's Rome Air Development center.[2]

The costs shown for burn-in in Table 2 are for devices with standard, steady-state power applied as in Mil Std 883 (using forward bias for the collector supply) for 168 hours. Adding reverse bias to as many junctions as possible could cost another 75 cents to $1 per device, and applying a signal to the devices could up those figures by another $1 to $1.50. As much as $1 per device can be charged for measuring and supplying a list of device parameters before and after burn-in, which is customarily done if the user is concerned with drifts. And lengthening the test time from 168 to 300 hours (a common NASA requirement) will almost double the costs.

The dynamics of the screening program—using test results to cure ailments in the IC production process—often pay off as much as the screening procedures, since some of the expensive screens, such as X-ray testing, may be reduced or even eliminated if the production difficulties are resolved. For example, on one project, Grumman initially required the subcontractor to perform 100% X-ray testing at about $1 per IC. The X-ray procedure initially screened out IC packages containing loose conducting particles. When the information was fed back to the IC producer, he instituted special cleaning and inspection procedures, and it soon became possible to use X-rays only for sample testing and eventually to eliminate them altogether without loss in reliability. However, such feedback action has to be taken immediately, while devices are being produced.

In general, test costs are a function of the quantity of devices to be screened and the types of tests to be performed. Semiconductor manufacturers usually base their estimates on lots of 100 or more of the same devices. Independent test labs require a minimum quantity, usually 75 to 100, and will charge for this number even if fewer devices are tested.

However, it's sometimes possible to buy devices that have already been tested. Several major distributors stock large inventories of commercial and military-qualified ICs that have been subjected to various screening tests by the semiconductor manufacturer. Using such devices may cut weeks off system delivery times.

In one military program at Grumman, for instance, high-reliability specifications called for full screening on small numbers of different device types. Semiconductor manufacturers quoted hundreds of dollars for such tests because of the setup costs. However, a local distributor was found to have on his shelves devices that the manu-

Table 2: Screening costs

Tests	Conditions	Typical costs per IC
Internal visual inspection before sealing	Per workmanship specs	15-30¢
External visual and mechanical inspection after sealing	Per workmanship specs	10-25¢
Stabilization bake	48 hours @ +150°C	20-40¢
Temperature cycling	10 cycles, −55°C to +125°C	30-50¢
Thermal shock	15 cycles, 0°C to +100°C	20-40¢
Centrifuge	20,000 g, vertical axis, 1 min.	30-75¢
Mechanical shock	5 pulses, 1,500 g, vertical axis	60¢-$1.00
Vibration fatigue	30 g at 60 Hz, 32 hours	60¢-$1.00
Vibration, variable frequency	30 g, 1 to 2,000 to 10 Hz, 4 min.	60¢-$1.00
X-ray	Negatives supplied, one view	30-50¢
Burn-in	168 hours at +125°C	$1.00-$2.50
Gross leak test	1×10^{-5} std cc/s	15-30¢
Fine leak test	1×10^{-7} std cc/s	15-40¢
	1×10^{-8} cc/s	25-50¢
Electrical tests	Room temperature, go/no-go (digital ICs)	25-50¢
	Room temperature, go/no-go (linear ICs and MSI)	25-75¢
	Recorded data	15-30¢

facturer had already processed through the standard military tests (thermal cycling, centrifuge, fine- and gross-leak testing, electrical tests, etc.). These devices met the specification at no extra cost, except that they had to be sent to an outside test lab for burn-in, at a charge of $3 to $4 each.

The relationship between screening and reliability is shown in Table 3, plus the documentation required for each level of mean time between failures. The first level simply calls for a functional check without any particular stress on reliability, and will give at least 50,000 hours MTBF. Level 2 improves MTBF to 200,000 hours by subjecting each part to such procedures as thermal cycling, centrifuge, and leak tests.

Level 3 represents what most semiconductor manufacturers would like to call high reliability. It adds burn-in to the tests of the two lower levels, and testing samples would probably yield the million-hour MTBF. Some device manufacturers might claim a 10-million-hour MTBF for this level, but the results of more than 20 programs at Grumman disprove it. To reach 10 million hours, the tests must be performed not on a sampling basis, but on the specific lots of devices to be used in the system. □

References

1. J. Lombardi, L. McDonough, H. Padden, "High Reliability Screening of Semiconductor and Integrated Circuit Devices," NASA CR-721, April 1967.
2. "Putting the stress on IC reliability," *Electronics*, May 27, 1968, p. 149.

Table 3: Screening tests for different levels of reliability

Reliability level	1	2	3	4	5
Expected MTBF*	50 × 10 hours	200 × 10 hours	1 × 10 hours	10 × 10 hours	25 × 10 hours
Typical cost per device	No charge	$1.50 to $3	$3 to $5	$5 to $10	$10 to $100
Sequence of typical test and screening plan	Electrical, functional.	Electrical, functional, plus defined end-of-line pre-screen such as thermal cycling, centrifuge, and leak tests.	Burn-in with tests of 1 and 2, plus MIL-STD-883 sub-group B tests on a sample basis. Alternate: buy hi-rel military units from authorized distributor, and burn-in	Tests of 1 and 2, plus specific internal visual, X-ray, burn-in, 100% electrical, plus MIL-STD-883 sub-group B with data on specific lot, plus qualification tests with specific-lot data, plus lot rejection provisions.	Tests of 4, plus complete process-line control, including certified operators, lot control lot rejection provisions, plus special life and environmental tests, plus destructive tests performed on a sampling basis, plus nondestructive bond tests.
Type of documentation	None	Certificate of compliance	Lot summary report	Specific-lot test data, failure reports with corrective action, factory records available for review	Specific-lot test data, traceability, variables data, failure reports with corrective action, complete history on individual part

*For severe environments, MTBFs must be scaled down.

Designer's casebook

Variable pulse generator consists of four inverters

by Michael L. Harvey
Air Force Cambridge Research Labs, Bedford, Mass.

All that's needed to realize an inexpensive adjustable pulse generator is two-thirds of a hex inverter IC package and a few external components. Besides output frequency, the on and off times of the circuit can be varied. Frequencies as high as 500 kilohertz can be obtained with diode-transistor logic, or up to 10 megahertz with transistor-transistor logic.

When power is applied, capacitor C_1 charges and the output is low. The potential at point A increases until point B goes low, point C high, and point D low. The output now becomes high and C_1 discharges.

The voltage at point A drops until point B becomes high, point C low, and point D high. The cycle is then complete as C_1 charges while the output is low. All charge and discharge paths are inside the Fairchild type 936 DTL hex inverter. (A Fairchild 9016 TTL inverter may be used instead.)

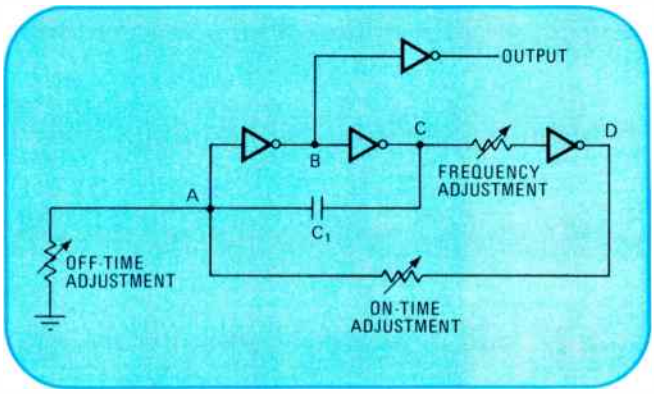
The resistor from point A to ground controls the generator's off (charge) time. Increasing the resistance decreases off time, while on time remains relatively constant. Resistance can range from 1.2 kilohms to infinity.

Similarly, the resistor between point A and point D performs as an on (discharge) control. Increasing the resistance increases on time; off time stays more or less constant. Maximum recommended resistance is approximately 2 kilohms; the minimum is a short.

Another resistor can be included, as shown in the diagram, for frequency adjustment. However, its effectiveness is limited to around a 2:1 range variation. The resistance can vary from a short to about 2 kilohms.

Capacitor C_1 can range from 0.001 to 500 microfarads. All component values are limited by minimum driving requirements for the integrated circuit.

Inverter generator. Output of pulse generator is low when C_1 is charging. Voltage at point A rises until point B becomes low and output high. C_1 then discharges until inverters change state again.



Low-frequency oscillator uses subharmonic sync

by Donald F. DeKold
Santa Fe Junior College, Gainesville, Fla.

A single-IC oscillator, which provides both sine-wave and square-wave outputs, can be synchronized with a submultiple (lower harmonic) of its output frequency. The circuit operates over a range of 1 to 500 kilohertz. Its applications include frequency multiplication, low-frequency filtering, and generation of low harmonics.

The oscillator requires a pulse or square-wave signal, whose frequency is f_o, from a low-impedance source. Capacitor C_1 and resistor R_1 differentiate the input into positive- and negative-going spikes. Diode D_1 couples only the negative spike to the inverting input (point A) of the comparator.

This forces the inverting input to be negative with respect to the non-inverting input. The comparator then switches, and point B becomes positive, creating a step voltage that is coupled by R_2 into the tank circuit formed by inductor L_1 and capacitor C_2.

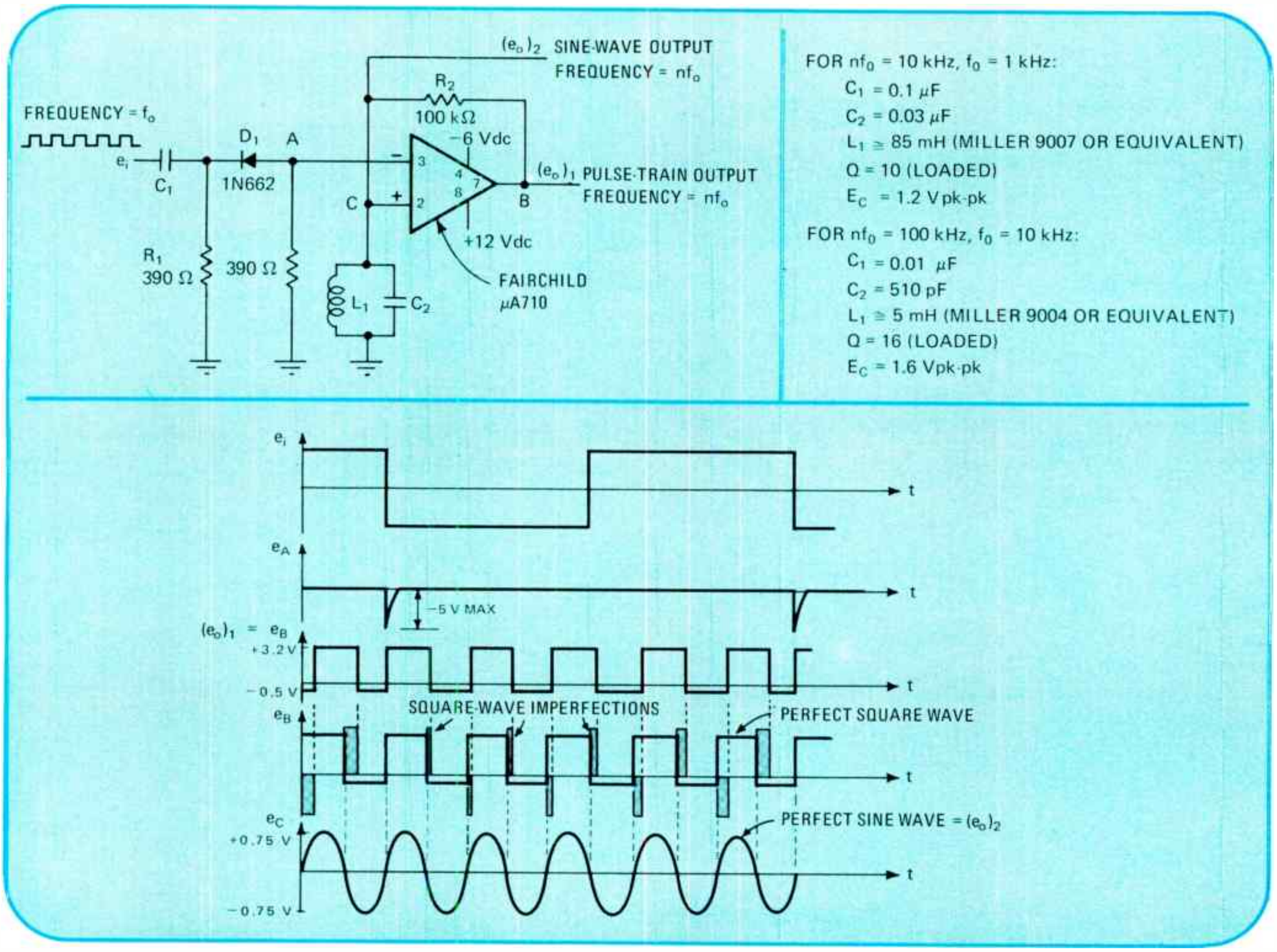
Every time the voltage across the tank crosses zero, the comparator switches. If the tank is excited by a positive step voltage, the initial voltage excursion of the ringing response across the tank will be positive. Similarly, if a negative-going step is applied, the excursion across the tank is negative.

Feeding back the output of the comparator to its input causes the positive and negative step voltages at point B continually to excite the tank. These steps form a square wave that is in phase with the ringing sinusoidal waveform at point C.

For stable synchronization, the oscillator frequency should be slightly less than nf_o, the desired output frequency. Each trailing edge of the input square wave becomes a synchronization pulse after differentiation.

The comparator output is forced to switch to its high value with the arrival of each new synchronization pulse prior to its free-run transition. It is then filtered by the LC circuit to yield a sine-wave output, which is taken from point C.

For the timing diagram shown, the pulse train at point B may be regarded as the superposition of a perfect square wave at frequency $5f_o$, in addition to a number of narrow pulses occurring at repetition rates of f_o.



Signal locking. Oscillator keeps output signal in step with a subharmonic input. Differentiated trailing edge of input signal provides the synchronization pulse. Synchronized pulse train output from comparator is filtered by tank circuit to give synchronized sine-wave output. Comparator output is superposition of perfect square wave and narrow pulses that contain input harmonics.

The width of these narrow pulses depends on how much slower the comparator output is than the desired nf_o output. Since the narrow pulses are square-wave imperfections, they contain frequency components that are multiples of f_o.

A Fourier series analysis reveals that the amplitude of these components becomes smaller as their width decreases, or as oscillator frequency approaches nf_o. Since a square wave of frequency nf_o essentially is being filtered, even a moderate-Q tank circuit will result in practically perfect sine waves.

There are a few practical considerations that limit the oscillator's operating range. For output frequencies below 1 kHz, inductors may not be available with a high enough Q for good sine-wave outputs. Above 500 kHz, square-wave rise and fall times frequently increase to an objectionable degree.

For best performance, synchronization frequency ratios should range from 1 to 10. Although ratios as high as 40 can be obtained, the oscillator may lose its synchronization lock due to signal instabilities. Moreover, the synchronization pulse, which varies from −3 to −5 volts, should decay to zero in less than one-sixth the period of the output signal.

Feedback zeros dc level of diode gating circuit

by Roland J. Turner
RCA Corp., Moorestown, N.J.

Whenever a tracking filter is changed from its low-Q state to its high-Q memory state, gating transients and dc offsets during the gating interval may introduce errors to the stored information. A closed-loop balanced-diode-bridge gating circuit minimizes these errors by employing a degenerative feedback loop that automatically forces the dc level at the gate output to zero.

An open-loop circuit can also be used to perform the signal gating, but it requires an expensive integrated circuit quad diode and is not self-compensating. The success of this approach depends on maintaining each diode voltage drop within 5 millivolts, matching the diode leakage currents over temperature, and keeping diode capacitance low as well as matched.

With degenerative feedback, less expensive diodes can be used, and the gate dc output is self-correcting despite temperature variations. Cost for the entire gating circuit is less than $5, instead of the $25 or so for a circuit using the expensive matched diodes.

The block diagram shows a quad diode bridge embedded in a complementary control flip-flop. When a gating command (control pulse) is applied, the flip-flop becomes regenerative, changing the state of the gate. A degenerative control loop assures that the correction applied to half of the flip-flop forces the gate dc output to zero. A low-pass filter in the amplifier feedback path controls the speed at which the degenerative loop corrects for output dc offset errors. A detailed schematic illustrates the improved gating circuit.

To stabilize dc signal level during the gate's off period, a differential operational amplifier compares the dc level at the output of the gate to ground reference. If the gate dc output is not zero, degenerative feedback to the base of Q_1 forces the dc signal level output of the diode bridge to zero. Transistor Q_1, which is the npn half of the complementary control flip-flop, actually cancels the dc signal that initiated the error.

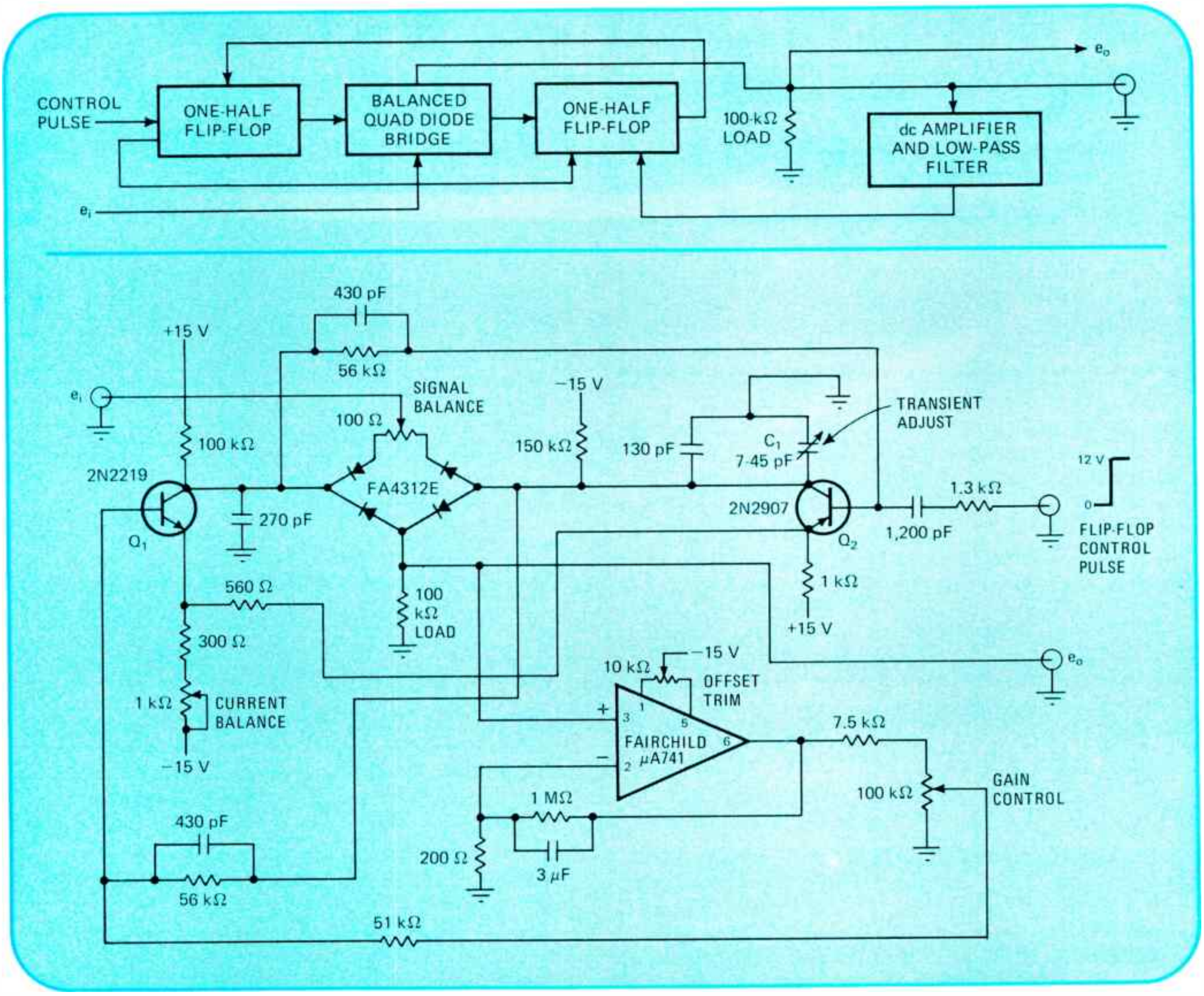
Capacitor C_1 is adjustable to control the shape of the off-going voltage waveforms at the collectors of Q_1 and Q_2. This minimizes transient signal leakage into the gate's 100-kilohm output load. An actual measurement for transients across the load when the gate is turning off will yield a 10-microsecond pulse with a peak amplitude of 5 mV. If the gate is turning on, the transient is also a 10-μs pulse but with a 50-mV peak amplitude. When gating at high-impedance levels, the more critical transient is the off-going one.

The emitter loop of Q_1 contains a current balance potentiometer that corrects for any difference between the initial drive currents of Q_1 and Q_2. The signal balance adjustment in the diode bridge compensates for any bridge signal imbalance that may occur because the diodes are not precisely matched.

Instead of discrete transistors Q_1 and Q_2, the complementary flip-flop can be realized with an integrated circuit—Motorola's type MD6003.

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.

Low-transient gate. Differential amplifier monitors output of diode bridge, which is flanked by complementary control flip-flop. The dc output signal, if other than zero, is automatically forced to zero by the degenerative feedback of Q_1. Transients across 100-kilohm load are minimized during the off-going state of the gate. Feedback assures stable operation over a wide temperature range.



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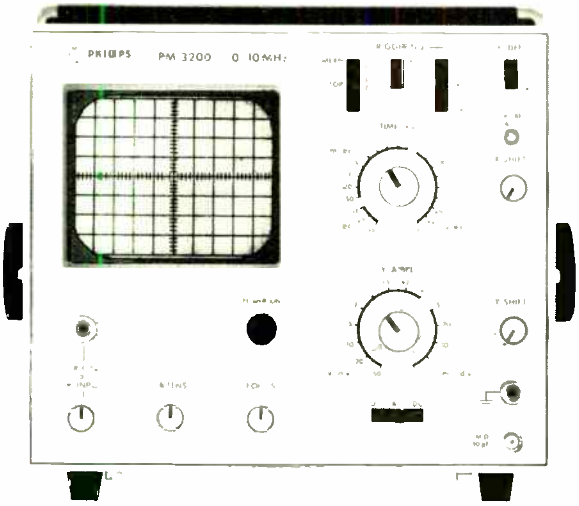

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Digital approach provides precise, programable AGC

Automatic gain control accuracy is much easier to achieve with digital than with analog methods; the programability also makes it relatively simple to satisfy complex loop gain specifications

by Max F. Farley, *Avco Corp., Avco Electronics div., Cincinnati, Ohio*

☐ Automatic gain control has many uses—it keeps the output of the simple home radio at a pleasant listening level even when the transmitted signal level changes, and it prevents sophisticated radar receivers from being saturated by high signals. But though analog AGC is excellent at meeting demands for maintaining a relatively constant signal level, it cannot provide precise level control for complex AGC loop characteristics.

Digital AGC (DAGC), while not a panacea, can cope with this kind of problem better than its analog counterpart. It operates in exactly the same way, except that the signal processing and gain control is digital. Although it requires more circuitry, digital LSI circuits are rapidly becoming a reality—and making DAGC easier and also less expensive than before.

The inherent accuracy of DAGC makes it usable in many places where analog AGC is impractical. For example, a signal strength measuring system could interface with a computer, a DAGC setting corresponding to a digital word. Or a broadband rf voltmeter could use the same technique, with the DAGC word used to drive a digital display.

Similarly, in industrial control and testing, new applications for DAGC appear likely because precise level adjustments can be obtained. This makes the approach suitable for computerized rf level setting in production line testing of, for instance, filters.

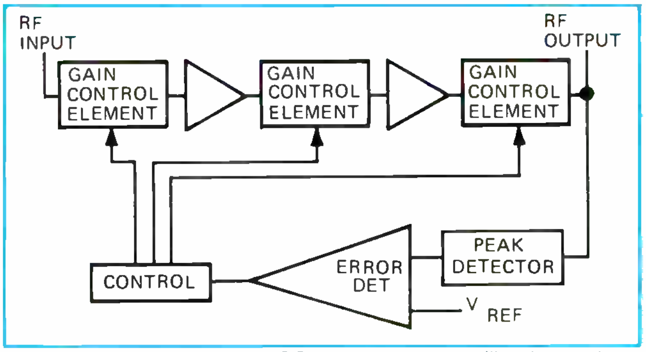
In more general terms, the reproducibility of gain control elements in the digital approach is particularly applicable in any area where two rf paths have to be matched. It makes an ideal solution to the direction-finding receiver problem where AGC curves from channel to channel must track together. In such applications, a single control circuit can be made to control the gain of as many channels as necessary.

A class of problems where DAGC offers unique solutions is that of the tricky AGC loop gain specification, such as a nonlinear input versus output curve. Consider the following specifications for a gain-controlled amplifier: output must not vary more than 1 decibel for the first 60 dB plus or minus 0.5 dB of AGC; between 60 and 100 dB the output must follow the input within 1 dB; and above 100 dB the output must not vary more than 2 dB. Meeting these specifications with conventional AGC would present a considerable problem, but such design specifications can be readily achieved with DAGC because of its programability and accuracy. Moreover, the optimum response characteristics for an AGC loop might require different attack (delay in the time to turn on) and decay (delay in the time to turn off) times at various signal levels. And digital AGC circuits can be readily designed to adjust attack and decay speeds to the magnitude of the input level change.

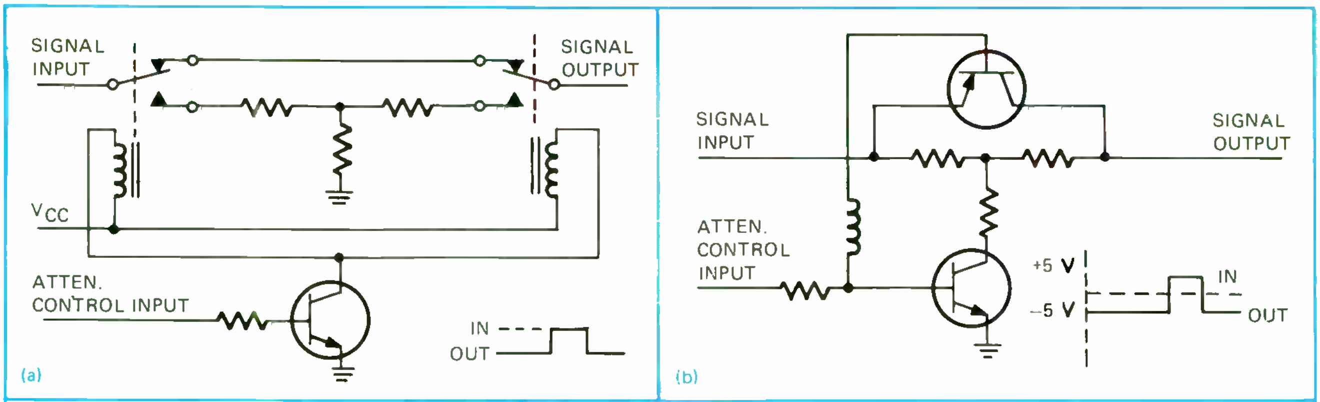
The basic elements of the DAGC circuit (see Fig. 1) are the same as in the standard AGC scheme, except that apart from the amplifiers the units are all digital.

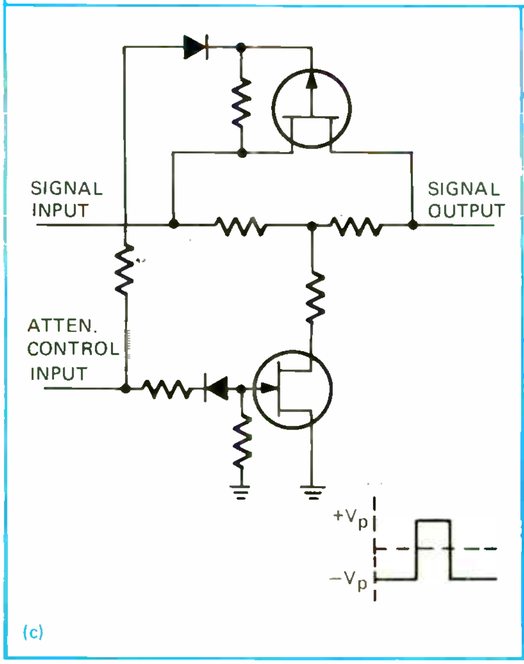
Similarly, a DAGC system operates like an analog system: as long as the input level is constant, the DAGC is static. But if the detected signal at the output increases due to a rise in input level, the error detector senses the change, and initiates an "increase attenuation" command to the digital logic. After accounting for any attack time constant, the digital circuitry adds steps of attenuation in the system until the output level is within the preset acceptable region—the so-called "dead zone" or deadband. Then the system stops and waits for a new command.

Two basic design considerations for DAGC systems are the size of the attenuation steps and the duration of required attack and decay time constants. The step size must obviously be less than the tolerable variation in the gain-controlled output. But there is no single answer to the question of how to specify attack and decay time constants. It depends on the kind of signal received (for example, a-m or single sideband) and the applications (whether measurement or tracking). For example, it is not sufficient to specify an attack time of 50 milliseconds without relating it to the amount of attenuation needed within the time interval.



1. Basic AGC. The digital AGC approach is very like the analog—only the signal processing and gain control are done digitally.





TRADE OFFS

	Frequency range	Power consumption	Phase and gain accuracy	Isolation of control signal	Ease of interfacing with TTL
Relays	Wide	High	Excellent	Excellent	Direct connection
Bipolar transistors	Low	Medium	Fair	Poor	Needs level shifter
FETs	Medium	Low	Good	Good	Needs level shifter

2. User's choice. The various tradeoffs between relays (a), bipolar transistors (b), and FETs (c) are detailed in the table.

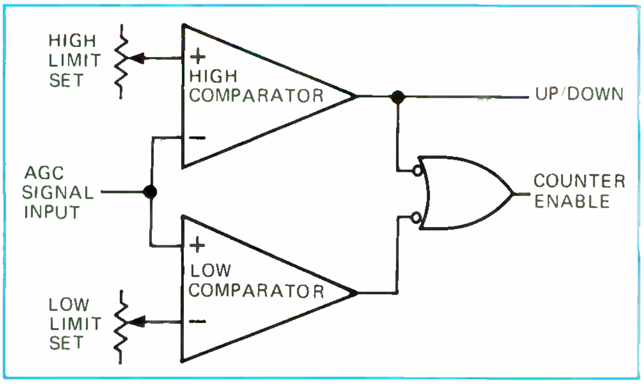
With conventional AGC, time constants are normally specified with respect to 63% of the total gain control range, where the standard curve of exponential control voltage versus time response applies. But with digital AGC, it is just as convenient to specify the 100% gain control range point, since in the simplest systems the time response is linear. Moreover, it is also practicable with DAGC to establish one response time for the first portion of the curve and another for the remainder; for example, it is possible to wait 49 ms until starting and correct the error in 1 ms to obtain the specified 50 ms.

Perhaps the most critical components in any AGC system are the attenuators. These will vary, depending on impedance, step size, etc., but in most cases they will be of the unbalanced type, since then a common ground can be used and this greatly reduces the amount of hardware required.

Frequently, attenuation-step increments below 10 dB can most readily be programed in a BCD fashion: if the smallest step size is 1 dB, then a minimum of four attenuators (1, 2, 4, and 8 dB) may be combined to provide 0- to 9-dB attenuation in BCD form. Above 10 dB, however, this approach would require large attenuation sections of 10, 20, 40 and 80 dB, which, although feasible, are impractical in view of the demands of sequencing, package attenuation, and the switch on and off parameters, and which are especially difficult to build when phase shift is of concern. It's therefore preferable to use a decimal code and a number of separate 10-dB attenuators above the initial 10-dB level. In this way, nine 10-dB sections could be used to provide 10, 20, 30, . . . 90 dB, with the 1-, 2-, 4-, and 8-dB pads providing 1-dB interpolation within each 10-dB step.

Switching the attenuator section into or out of the circuit can be done in three ways—with relays, bipolar transistors or FETs (see Fig. 2). Using bipolar transistors or FETs as switches offers the advantages of low power, small size, and the increased reliability characteristic of solid state switching. But in many cases, relays provide the only practical solution to switching high-frequency signals, for in that region the built-in on-off resistances and capacitances of solid state devices can create phase distortion.

Bipolar devices have other drawbacks. In the circuitry shown in Fig. 2(a), the on and off resistance of the transistors contributes a significant error into the system in the cases of zero attenuation or maximum loss. Transistor capacitances, however, are generally not of major concern unless low phase shift is a design goal: for example, two matched 600-ohm circuits built with bipolar



3. Setting limits. The comparator circuit's function is to establish the deadband range, which is determined by the highest and lowest acceptable levels that can be tolerated at the rf output. These voltage thresholds are built into the high and low comparators.

transistors produce about 0.5° of differential phase shift at 455 kHz.

Another disadvantage is that bipolar transistors can be turned on and off only by reversing the polarity of the control line. This is especially awkward if TTL logic is to be used in the control circuit, since most TTL outputs range between 0 and +5 volts and a somewhat complex interface circuit is required to turn this into the +5- to -5-V attenuator control signal. One last shortcoming of the bipolar approach is the inherent dc shift of, and control pulse coupling to, the rf path, which can cause serious loop instabilities unless a circuit is added to blank the rf signal during the rise and fall of attenuation.

For switching attenuator sections at low frequencies, a better technique is to use FETs. The FET circuit of Fig. 2(c) is similar to the bipolar, but its on-to-off resistance ratio practically eliminates problems due to the resistive component, and its extremely high gate impedance minimizes the need for a blanking circuit since the control path consumes much less power than is the case with bipolars. The superior gate-to-channel isolation further reduces any feedthrough problems. The on case is still not ideal, but the only real degradation in performance is in the out state of the attenuator. However, any insertion loss caused by the on resistance of the FET can be cancelled by including that resistance in the design value of the attenuator. If this is done, a dual polarity control signal is required, but it is at such a low current that the interface power consumption and circuit complexity are not unreasonable.

Sometimes a hybrid form combining the best features of two basic attenuator types is desirable. For example, using a bipolar transistor in the ground leg of the attenuator instead of a FET would provide better phase and gain accuracy. The reason: the saturation resistance of the bipolar is much less than the FET drain-to-source resistance, and also much easier to control.

The DAGC amplifier and detector must be discussed together, since it may be necessary to amplify the rf output before detection. If this is done, care must be taken in the design of the amplifier, since any gain variation at this point will show up as a variation in the rf output level. For this reason, the total gain variation of the AGC amplifier and detector due to supply voltage, temperature, and component tolerance must be subtracted from the rf output variation specification to determine the permissible width of the deadband.

In most cases, the signals to be handled by the DAGC system are not continuous-wave. With a-m or ssb operation, the time constant of the detector circuit must be carefully selected to prevent the AGC loop from following the modulation. This can usually be accomplished with a fast-attack, slow-decay detection scheme, which enables the system to adjust rapidly to the initial modulation peaks and then remain nearly constant between syllables. In the case of ssb reception, the fast-attack, slow-delay approach produces a very marked improvement in long-term audio signal-to-noise ratio and especially in intelligibility.

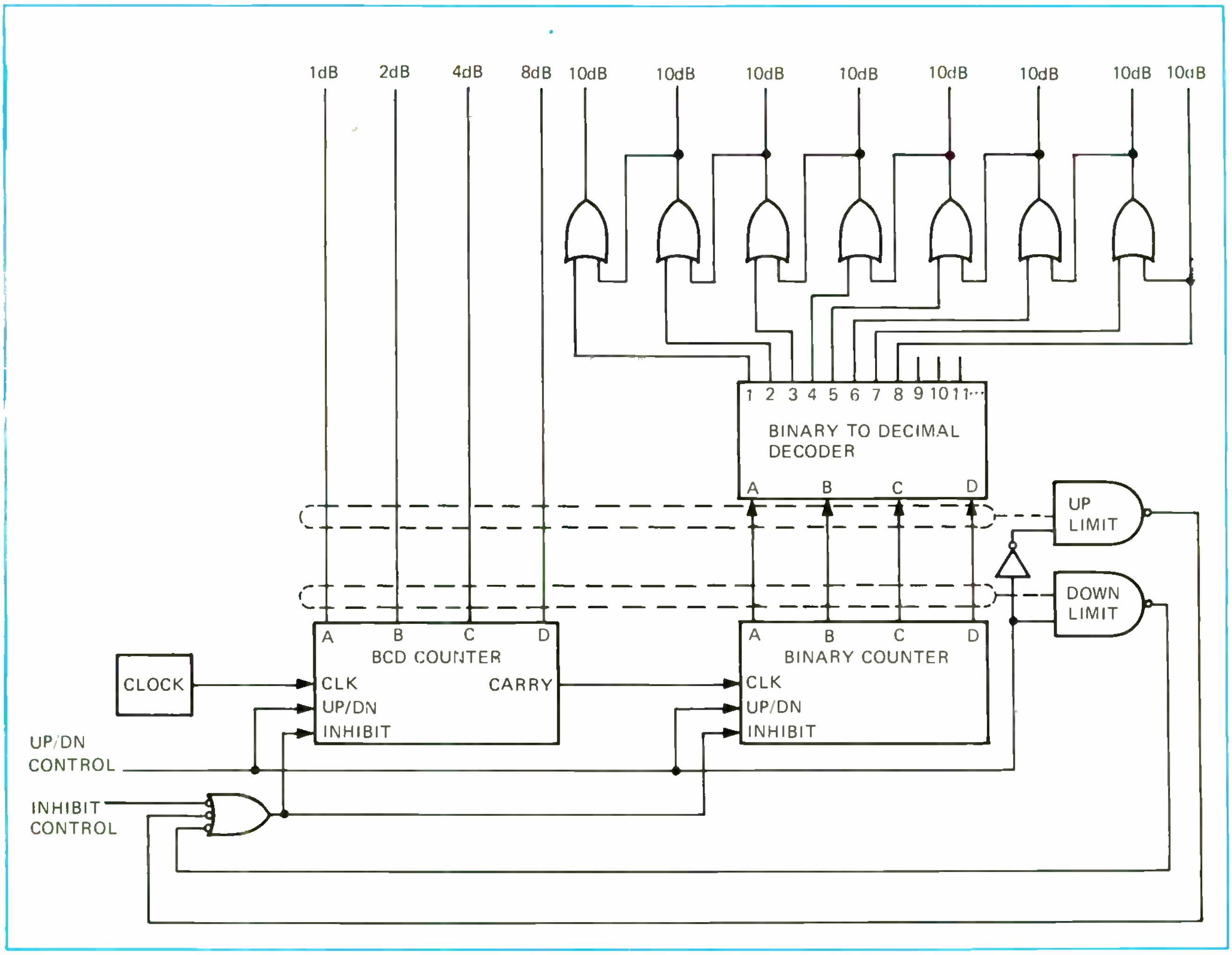
It's very necessary to assure that the digital system does not operate faster than the detector, since otherwise an unstable loop would result. Consider, for instance, what would happen when a large signal was applied. As soon as the system sensed an error, it would begin to run at high speed, inserting attenuation. The input to the detector would pass rapidly through the acceptable limit, but the detector would be following so slowly that it would be unable to generate the stop command. The detector would eventually, of course, notice an error, and the system would overshoot in the opposite direction. This is one area where there are some rather painful similarities between digital and conventional AGC.

The dc level from the detector, which in the analog system directly controls the gain, must now be converted into a digital signal. To command the digital circuitry completely, two signals are necessary—to start the counter, and to indicate the direction of the count (up or down).

Next, to establish the deadband of the system, two thresholds must be defined. One is the lower edge of the deadband, corresponding to the lower and acceptable level of gain-controlled rf output, while the second determines the upper limit of the deadband. Though there are many ways of generating the corresponding digital signals by means of discrete components, IC comparators seem to be the ideal solution to the linear-to-digital interface. Besides being small and highly reliable, they make threshold adjustment easy, as Fig. 3 shows, and also produce TTL-compatible outputs. Further, they are available in chip form if a hybrid circuit DAGC is required.

Since the DAGC counter will likely be NAND logic, as opposed to discrete diode logic, the comparator subsystem should belong to the same family. The circuit should be designed so that the outputs of both comparators are high if the DAGC signal input is within the deadband. In this case, both inputs to the NOR gate are high, so that its output is low and inhibits the DAGC counter. When input to the comparator exceeds the high limit, the output of the high comparator goes low, causing the NOR gate output to go high and enable the counter. The low comparator functions similarly when the input signal goes below the low limit.

The generation of an up-down signal is now a simple matter of tapping onto either of the IC comparator outputs. The choice is made by considering the direction of



4. Putting it together. The clock input to the BCD counter depends on how fast the attenuator sections respond. The combination of 10-decibel sections with binary attenuator sections requires a binary-to-decimal decoder and OR gates to sum the decimal sections.

count of the up-down counters to be used.

The final major component of a DAGC system is the control circuit—the interface between the comparators and the attenuators. It consists of an up-down counter, its associated logic, and the system clock. Typically, the up-down counter covers at least two decades. Decoding is simplified if the counting code is consistent with the weighting of the attenuators. For example, an attenuation range of 159 dB in 1-dB increments requires two up-down counters, a BCD unit to control increments of 0 to 9 dB (1,2,4, and 8 dB), and a binary unit for the 10-, 20-, 30-, . . . 150-dB sections. This circuitry is easy to implement since complete up-down counters are available in MSI from a number of manufacturers.

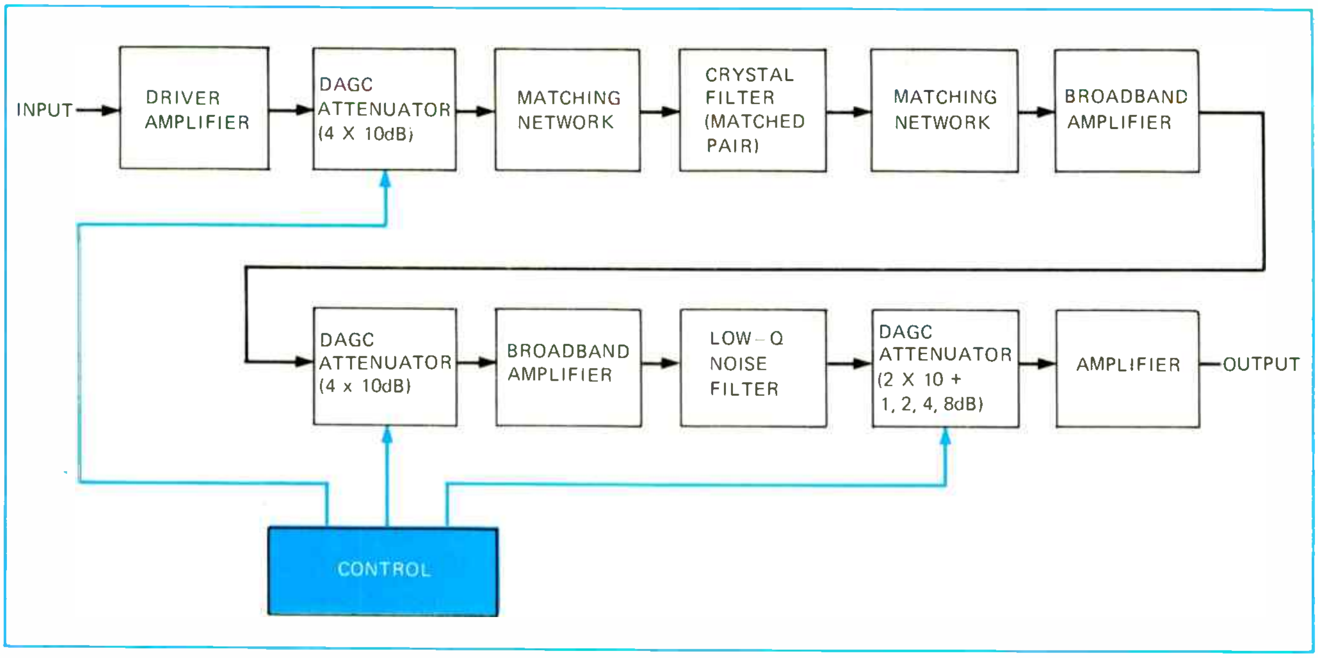
Once the counting code has been selected, limit gating circuitry is added to keep the counters within the range of the attenuator system. This operation is greatly simplified by the judicious choice of up-down counters. Most new IC versions of such counters provide an output at 0-dB attenuation when counting down and an output at 9-dB attenuation when counting up. Usually this carry-output feature solves the lower-limit decoding problem, but a gate is still required to recognize the upper limit. These limits, however, must be switched in and out by the sense of the up-down line, to permit the system to restart in the opposite direction should either limit be reached.

Another complexity of the control circuitry that is not immediately apparent is the need for carry-over gating in the multiple 10-dB sections, together with OR gates to allow the summing of these sections. Incidentally, a custom-programed ROM would be ideal for this job, and would also eliminate the need for a binary-to-decimal decoder.

As for the system clock, a simple multivibrator will suffice when the system requires a single clock speed. In fact, two cross-coupled NAND gates make an ideal clock since they not only produce a TTL-compatible output but also provide extra inputs which may be used to inhibit the clock.

The clock speed depends on the speed at which the attenuator sections must respond (or how many decibels of attenuation are required per second). Obviously this becomes a much more complex problem if the clock rate is a variable. In such cases, each attenuator section must be treated as a separate design.

Sequencing of the attenuator sections is one of the last decisions necessary in the design of a DAGC system. Once the counter and associated circuitry have been designed, the counter outputs can be connected to the at-



5. Typical setup. The crystal filter determines selectivity curve; the low-Q noise filter limits noise bandwidth and preserves phase matching.

tenuators in any order, so long as the correspondence of the digital weighting is retained.

The many fine points of an actual system design cannot be appreciated without considering a specific example. For such an analysis, assume the application is for a direction-finding system using a pair of phase-matched 445 kHz i-f amplifiers requiring a differential gain error of ± 0.5 dB and a differential phase shift of + 0.5° over an entire gain control range.

Figure 5 shows one channel of the matched pair. Since all of the amplifiers in the system are untuned, their phase shift contributions can be neglected at this frequency. Selectivity is provided by crystal filters, which are both phase- and gain-matched. To improve the system noise figure, two low-Q bandpass filters are inserted in the path. These units provide sufficient bandpass narrowing to limit the wideband noise with minimal differential phase shift. Adding varactor tuning to the final noise filter provides a means of adjusting the phase shift of the channel, and enables the addition of automatic phase correction, if desired at a later date.

With small signals (10 dB or less above noise) the attenuation should be placed toward the end of the amplifier chain. If added in front of the input amplifier, it would increase the noise figure, and make the whole system less sensitive. With very large signals, the attenuation should be added early so none of the amplifier stages saturates. Doing it this way assures the best possible performance.

Since the gain distribution and selectivity requirements of a typical i-f amplifier strip can vary over such large ranges, no hard and fast rules of DAGC sequencing can be written. Experience shows, however, that once gain is distributed in a design, it is wise to make a chart of signal path voltages versus input level. The columns of the chart should indicate the input and output voltages of each amplifier and attenuator, and the rows should begin with a signal level at the DAGC threshold and increase in incremental steps of, say 10 dB, up to the maximum required input signal. This chart may then be modified with various DAGC sequencing schemes based on the dynamic range limitations of the various amplifiers and on the composite noise figure. Usually, after a few trials, trends will appear which lead to an optimum sequence.

Another factor to be taken into consideration in a DAGC design is the effect of digital switching signals on the input of the peak detector. This control signal feedthrough, when amplified by the i-f amplifiers, can cause the entire control loop to be unstable. After this coupling has been minimized it is often necessary actually to blank the input to the detector during these digital pulses. In the two-channel system used as an example above, it was sufficient to blank only the detector input since the spikes in the output were vary narrow and only present during changes in signal level.

Although the problem of perturbation is usually encountered in broadband systems in which phase shift is important, it should be considered in the design of any DAGC system. Any perturbation on the line may charge the coupling capacitors and cause the amplifiers to saturate. When this happens, the detector assumes that the resulting output, due to the unwanted, amplified perturbations is a large input signal, and keeps correcting.

Normally, the perturbations are caused by the clock pulses leaking through and being amplified along the signal path. Perhaps the simplest solution is to slow the clock rate until the system is able to settle down between pulses. However, if a higher clock rate is necessary, one solution might be to use transformer coupling between i-f stages. Basically, this removes the most disturbing (low-frequency) components in the unwanted signal. In addition, the transformer approach shapes the bandpass and limits system noise.

When this system was actually built, measurements justified the choice of the digital approach. The system exceeded the 0.5°-phase and 0.5-dB-gain specifications over the entire AGC range. □

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Solve low-current measuring woes by designing your own electrometer

General-purpose instruments don't always economically meet the performance needs of specific jobs, but with your own design, you can get high sensitivity, fast response, or whatever you require

by Richard G. Weinberger, *Weinberger-Roberts, East Northport, N.Y.*

☐ Measuring small dc and low-frequency currents can be a big problem. In helium leak detectors, mass spectrometers, photomultipliers, and gauges for ultrahigh vacuums, currents as low as 10^{-15} ampere are common. Moreover, measurement often is coupled with special requirements, and while general-purpose commercial electrometers are available, they can be uneconomical for specific applications. In such cases, the engineer can readily design an instrument tailored to his own needs.

Electrometer design starts with the simplest configuration, a shunted voltmeter, shown on the left of Fig. 1. However, this straightforward method is usually restricted to measuring currents in the milliampere region and above. Handling lower-level currents would require a high-megohm shunt resistance to develop an adequate voltage drop, and stray capacitance across the shunt and the input capacitance of the amplifier would severely prolong response time.

In order to meet the high-accuracy requirement, the input impedance of the amplifier must be at least 100 times the shunt resistance, which is hard to accomplish. Despite these drawbacks, the shunt method still is commonly used in commercial electrometers where response speed is not a consideration; it's referred to as the "normal" or "slow" mode on multimode instruments.

A preferable approach to gauging picoampere-and-below currents is the feedback connection, shown in the center of Fig. 1. Input impedance is approximately the feedback resistance, R_f, divided by the open-loop gain, A_v. Therefore, even for high values of R_f, input impedance is relatively low. Also, response is much faster than in the shunted voltmeter. When the usual assumptions of high gain and negligible input current are made for the amplifier, it can be shown that:

$$e = (I_{in}R_f)/\beta$$

where β is the feedback factor. Note that e_o may be made arbitrarily large, up to the limit of the amplifier, simply by adjusting resistors R_1 and R_2.

The feedback approach can speed up response time by a factor of more than 100. In the shunted voltmeter, the time to reach 63% of the final response to a step input is:

$$\tau_1 = R_{in}(C_{in}+C_s)$$

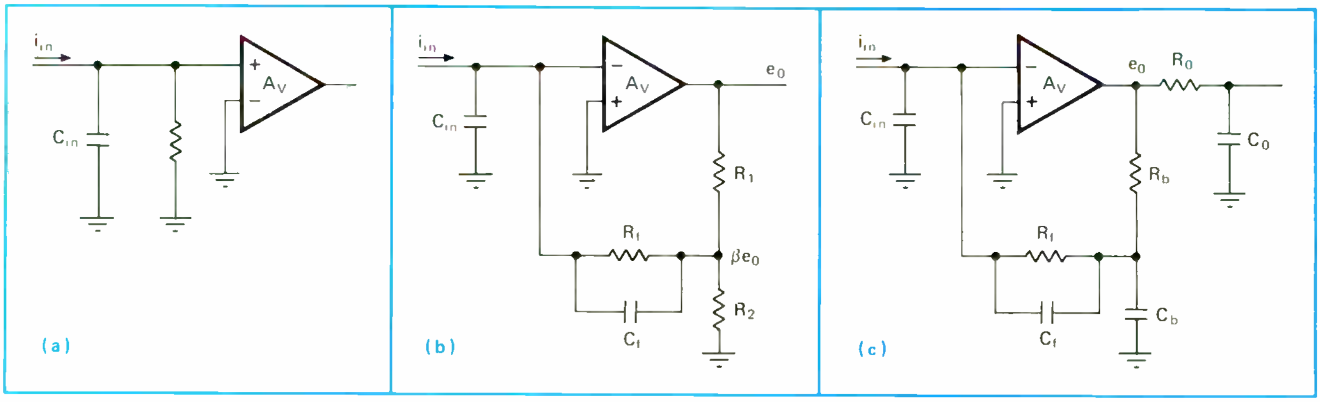
where R_{in} and C_{in} are the input resistance and capacitance and C_s is the stray circuit capacitance. In the feedback mode, the time constant τ_2 is much less. Assuming A_v is much greater than one, τ_2 is:

$$\tau_2 \approx R_f[(C_{in}/A_v)+C_f]$$

where C_f is the capacitance across the feedback resistor and is the same order of magnitude as C_s.

Minimum shunt capacitance of any resistor value in the high-megohm region is about 0.3 picofarad regardless of the exact resistance value. Thus for an R_f of 10^{12} ohms, the minimum time constant would be on the order of 0.3 second. If fast response time isn't needed, C_f may be increased by shunting R_f with a capacitor.

On the other hand, it's possible to further cut the time



1. Approaches. To measure very low currents, simple circuit (a) would require impractically large shunt resistance. Replacing resistance with feedback loop (b) solves that problem. Output voltage e_o can be made arbitrarily large simply by adjusting R_f, and response time is approximately two orders of magnitude lower. Adding frequency-compensating circuitry (c) to feedback loop permits even faster response.

constant by a factor of 10 to 20 with the circuit on the right of Fig. 1. There, R_f and C_f become part of an allpass feedback network that also includes R_b and C_b.

For this circuit, β is $(1+pC_bR_b)^{-1}$ where p is a complex operator. Output voltage is found from the e_o equation given for the basic feedback circuit, except that this new value of β is used and (R_f+p/C_f) is substituted for R_f to yield a response characteristic that can be critically, under- or over-damped. For the critically damped case⅔($R_bC_b = R_fO_f$), the time constant, τ_3, is

$$\tau_3 = R_f\left[\frac{C_{in} + C_f}{A_v}\right]$$

Unfortunately, this speed-intensifying method has limited value when applied to production-line electrometers because of the difficulty in mounting components to achieve identical stray capacitances. In addition, some of the shunt capacitance of R_f is distributed along the body of the resistor element, whereas in the derivation of τ_3 it's assumed that C_f is a lumped parameter in parallel with R_f. Therefore, when building the high-speed circuits, it's necessary to limit the speed-up achieved by placing a small resistor in series with C_b.

The high-speed circuit shown in Fig. 1 has a rolloff filter at its output. Electrometers usually handle low-frequency signals—typically less than 100 hertz—but their noise bandwidth can be much wider, particularly when using the high-speed circuit; a rolloff filter is necessary to optimize signal-to-noise ratio. But commercial electrometers often omit this output filter, depending instead on fairly slow meter response time to remove high-frequency noise. Thus the signal-to-noise ratio of a commercial unit often can be improved simply by the addition of such a cutoff filter at the instrument's recorder output.

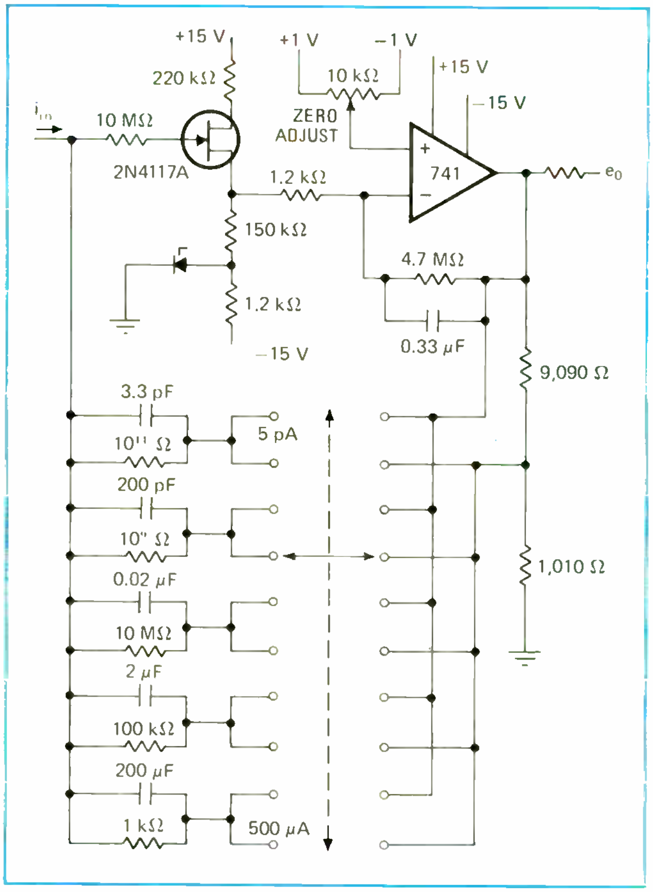
As in other types of low-signal-level measuring circuitry, an electrometer's sensitivity is best defined in terms of how much of the interfering signals appear at the output. Types of noise found in electrometers are:

- Input device noise, including shot effect and low-frequency noise.
- Thermal effects.
- Quantum and radioactive effects.
- Cable noise and other microphonic effects.
- Johnson noise.

The most sensitive electrometers commonly used a carrier-modulation technique (such as vibrating reed or voltage-variable capacitor) to convert input signals to a higher frequency, reducing 1/f noise in the input amplifier circuit. However, such approaches aren't necessary any longer thanks to the minimal 1/f noise in isolated-gate FETs and some newer vacuum tubes.

However, other noise sources still have to be dealt with. Input noise can arise because of the temperature-sensitive leakage current that flows across the header and between elements of the input transistors or tubes. With nitride-isolated IGFETs, leakage is almost entirely restricted to the header surface; it can be thermally insulated to prevent temperature gradients.

In most electronic instruments the major thermal effects are due to dc drift caused by changes in ambient temperature. Electrometers also are prone to thermal



2. Broad coverage. Versatile electrometer measures low-frequency currents over full-scale ranges from 5 pA to 500 µA. Ten-position range selection switch changes the impedance of feedback loop.

noise from transient cooling of components. The inevitable local convection turbulance inside an instrument causes this transient cooling, resulting in temperature differences between components that normally compensate for each other's thermal sensitivities. The low-frequency noise generated is well within the bandwidth of most electrometers. One way around the problem is to place compensating components very close to each other, thereby reducing both the transient time of the convection cooling and the temperature difference between parts.

Radioactive effects are particularly troublesome for electrometers used in pulse-monitoring applications. Energetic subatomic particles ionize the air in the vicinity of the input, causing random noise pulses at the electrometer's output. These particles may originate from ambient cosmic rays or from minute radioactive inclusions in electrometer components.

The noise pulses produce outputs similar in shape to the electrometer's impulse response. Amplitudes are several times that of the steady-state noise—on the order of 70,000 to 300,000 input electronic charges. These pulses typically occur 30 times an hour.

Since an electrometer looks for relatively few electronic charges per time constant, any statically and capacitively generated charges can easily mask input signals. These static charges can be caused by rubbing motion almost anywhere in the input circuit—between the shield and dielectric of a flexed coaxial cable, for ex-

Know your Johnson noise

Johnson noise is thermally induced noise produced in all resistors and semiconductors. Since it limits an electrometer's sensitivity, it's very helpful to be able to express Johnson noise of an electrometer's output in terms of measurable parameters. Johnson noise power, N, can be expressed by the statistically derived relation:

$$N = 4kT\delta f F^2$$

where δf is the bandwidth; k is Boltzmann's constant; T is the temperature in Kelvin; and F is a dimensionless noise factor, characteristic of a particular resistor.

Since R_f is by far the largest resistance in the electrometer circuit, the expression $I^2_N R_f$ closely approximates N, where I_N is the rms noise current measured over a bandwidth δf. Combining this with the above equation yields an expression for rms noise current:

$$I_N = 2.2\left(\frac{2kT}{\pi\,\tau_c\,R_f}\right)^{1/2}$$

where τ_c is the electrometer time constant, equal to $1/(2\pi\delta f)$, and, based on recent measurements, F for a high-megohm resistor is taken to be 2.2

Although correct, this equation isn't particularly useful because no standard instruments can measure rms values of low-level signals that fall within electrometer bandwidths. It's more valuable to define the peak-to-peak noise current, I_{pk-pk}. Since it has been demonstrated subjectively that for typical electrometer circuits I_{pk-pk} is approximately five times I_N:

$$I_{pk-pk} = 3\times10^{-11}(T/\tau_c R_f)^{1/2}$$

To this point, it has been assumed than an ideal low-pass filter is at the electrometer's output. However, for the more realistic case of a single RC section filter (6 decibels per octave rolloff), this equation must be modified.

Since noise bandwidth exceeds signal bandwidth, it turns out that I_{pk-pk}', the pk-pk noise current for the case of a single RC segment, equals $(\pi/2)$. I_{pk-pk}. Therefore at room temperature (T = 300 K), the pk-pk noise output of an electrometer with a 6-dB/octave rolloff filter is

$$I'_{pk-pk} = \frac{6.6\times10^{-10}}{(R_f\,\tau_c)^{1/2}}$$

As more filter sections are added, the noise current value increases to some value between I_{pk-pk} and I_{pk-pk}'.

ample, or between the floating pin and dielectric of a coaxial connector. In a noise-limited electrometer, where the noise is the same order of magnitude as the expected signals, a connector type that does not require a floating pin should be used.

Aside from shielding the input leads, elimination of statically and capacitively generated noise requires that all input elements be made as rigid as possible so that natural vibration periods are high enough in frequency to fall well outside the electrometer's passband. Some cables, such as the lead to a floating connector, cannot be made rigid. In these cases, the cable is empirically designed to assure that changes in lead-to-ground capacitance caused by flexing of the lead are minimized.

3. Wide range. Typical application for electrometer of Fig. 2 is measuring output of vacuum gauge, such as the glass Groszkowski gauge shown below. Such components have wide output ranges. For this particular gauge, output can go from 0.1 pA to 0.1 μA.

After all other noise sources are reduced by careful design, there is still the Johnson, or thermal, noise to contend with. This noise is due to thermal agitation of charged particles present in all conducting and semiconducting materials. And since there's no way to eliminate it, Johnson noise determines the electrometer's sensitivity (see "Know Your Johnson Noise," above). The maximum sensitivity can be expressed in terms of an equivalent current by a semi-empirical formula:

$$I_s = \frac{6.6\times10^{-10}}{(R_f\,\tau_c)^{1/2}}$$

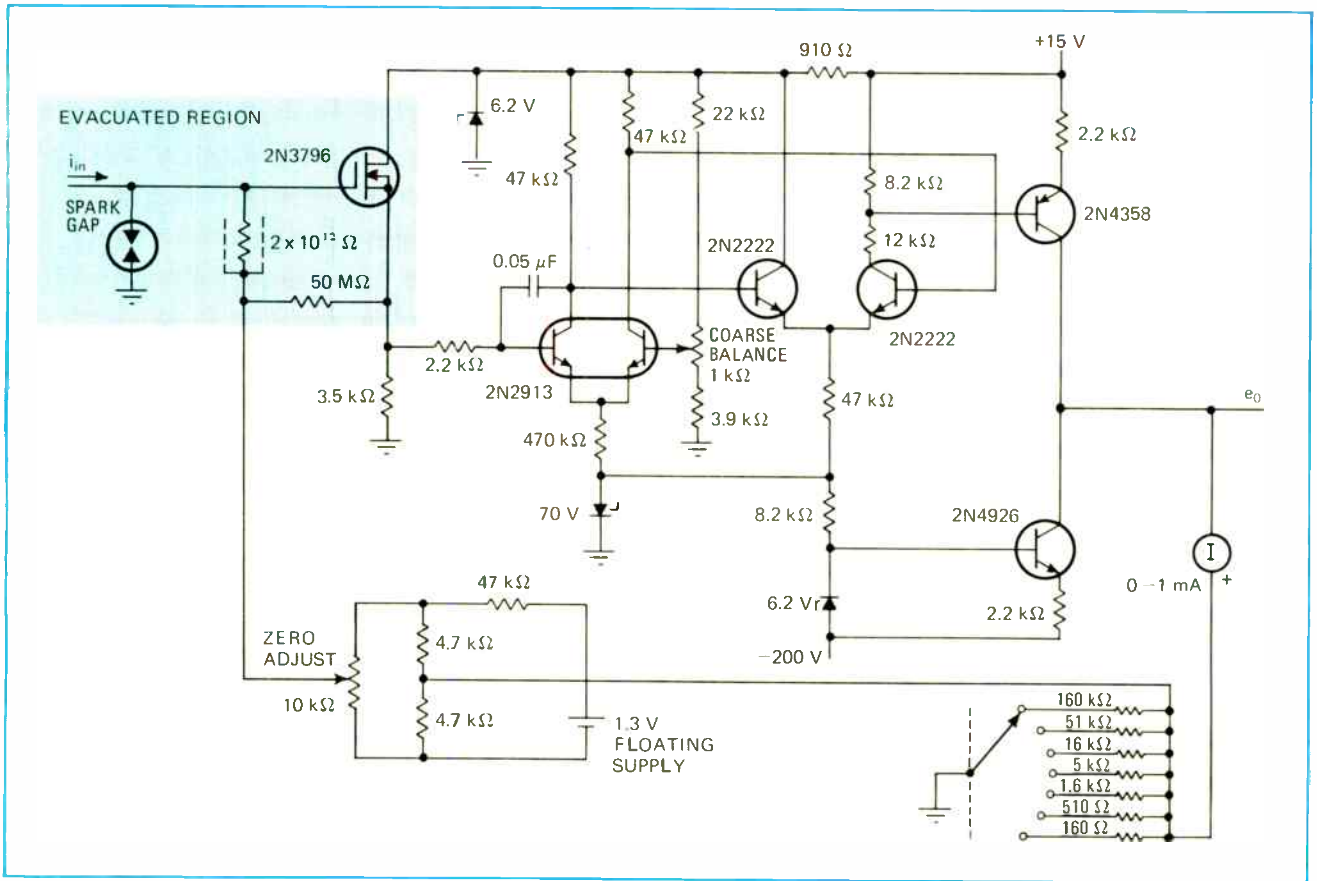
where R_f is in ohms, I_s is the dc input current in amperes that shifts the e_o by an amount equal to the peak-to-peak noise, and where the output has a simple RC filter whose time constant τ_c, is given by RC.

After all noise sources have been dealt with, actual electrometer design can proceed. Based on their specifications, electrometers can be classified into three categories: non-noise-limited, high sensitivity, and high speed. In the non-noise-limited example, the requirement calls for covering eight decades in 10 ranges from 5pA full-scale to 500 microamperes, with scale linearity of 1% and a time constant of 0.2 s in all scales.

To check whether an electrometer circuit is non-noise limited, the equations for e_o and I_s are combined with I_s set equal to I_{in} in the equation for e_o. The result is:

$$\beta e_o = \frac{4.4\times10^{-19}}{I_s\,\tau_c}$$

It's assumed that the non-noise-limited case prevails if I_s never exceeds 1% of the full-scale reading on the most-sensitive scale. Therefore, I_s must always be less than 0.05 pA. Substituting this value for I_s and 0.2 s for τ_c into the above equation results in a βe_o equal to 44 microvolts. Since β will be approximately 1, e_o must be greater than 44 μV for the electrometer to be non-noise limited. Put another way, when the electrometer is set to



4. Sensitive. Electrometer has maximum peak-to-peak noise level of 5×10^{-16} A. To achieve this sensitivity input must be in vacuum chamber. Otherwise ambient cosmic rays produce noise pulses. In many applications, particularly where measurement itself is made in vacuum, it's not inconvenient to isolate input in this way. Spark gap protects IGFET from input currents that may flow when power isn't applied.

the most sensitive range—5 pA full scale—1% of the full scale value of e_o must be greater than 44 –V. For this particular instrument, the f.ll-scale e_o for all ranges is chosen to be 5 volts; this value easily satisfies the non-noise-limited condition and is large enough to make thermal drift of the input stage insignificant.

The complete electrometer is shown in Fig. 2. A 2N4117A junction FET is chosen for the input. Besides having a low leakage, it has a low pinch-off voltage which makes possible a low temperature coefficient by precise biasing. Any junction FET has a zero gate-to-source temperature coefficient when gate-to-source voltage is 0.63 V less than its pinch-off voltage. However, pinch-off voltage is usually specified as a range of values: the higher the average value of pinch-off is, the wider the range. Therefore, if a transistor has a low pinch-off voltage (i.e., one with a narrow range of pinch-off values), it's much simpler to approximate the zero-temperature-coefficient condition.

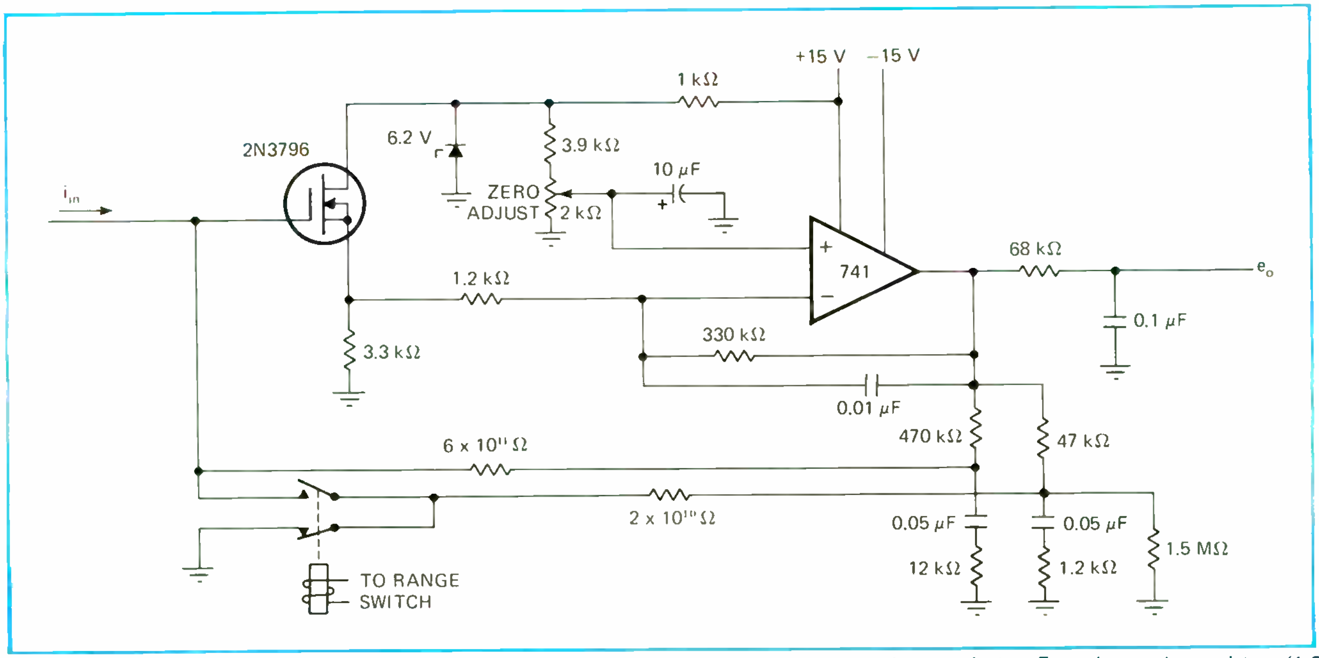
Circuit response is controlled by the capacitors shunting the feedback resistors. The smallest capacitance value is somewhat larger than the calculated value to compensate for the inevitable stray capacitance in the switch rotors and between the network and ground. To minimize the number of high-megohm resistors required, each feedback resistor is used for two ranges.

A high-sensitivity electrometer for an ion collector in a mass filter provides another example. The specifications require a noise level below 5×10^{-16} A peak-to-peak, a maximum input current of 9×10^{-11} A (in seven ranges covering 3½ decades), and a time constant of 1.5 s. With such a low noise-level requirement, the electrometer input should be inside the vacuum chamber along with the collector. Besides minimizing lead lengths, this protects the electrometer from radiation-induced noise.

Solving the I_s equation for R_f shows that R_f must be greater than 1.2×10^{12} ohms; a standard value of 2×10^{12} ohms is chosen. To keep the voltage swing of the output within the range of commercial transistors, β is set close to 1. Then the output ranges from 1 mV at the noise level to 180 V at the maximum input current.

The complete circuit is shown in Fig. 4. The remote location of the input makes it inconvenient to change scales by switching feedback resistors, so an amplifier capable of the full 180-V swing must be used. The input stage uses a single-ended IGFET with no built-in zener diode between gate and source; protected types aren't suitable because their gate leakage currents exceed the measured current. A depletion-mode device operated at a low gate-to-source voltage will minimize voltage gradients across the header. Standard IFGET construction provides excellent guarding of the gate lead from header leakage if a low gate-to-source bias is used.

Transistors throughout the circuit must have matched temperature coefficients to provide optimum drift behavior. FETs for the amplifier stage can be obtained from the manufacturer with a guaranteed temperature



5. Quick reading. Frequency-compensated feedback loop gives this electrometer response times as fast as 7 ms. Low-value resistors (1.2 and 12 kilohms) in series with the 0.05-μF capacitors give circuit predictable high-frequency cutoff, thereby preventing any instability in the electrometer. Top reed relay switches ranges. When it's open, higher resistance is in feedback loop, giving electrometer 20-ms response time and 1-pA range. When it's closed, lower resistance shunts the higher one, dropping response time to 7 ms, and changing range to 300 pA. Second relay insures 20-ms response time. When top relay is open, bottom one closes, grounding stray capacitance of open relay.

coefficient of at most 50μV/°C.

The amplifier stage also must be carefully designed for tight thermal coupling between components in order to minimize thermal differential transients. Thus, the second stage is a dual-transistor integrated circuit; its emitter-current source is a temperature-compensated zener diode and a temperature-stable resistor.

The input stage, along with the ion collector, is mounted in a remote vacuum chamber. A spark gap (or other protective device) guards the IGFET's gate from the gate-to-source voltages which could occur if input current caused by ions striking the collector were applied with the power supply off. In addition, a 50-megohm resistor is placed inside the vacuum region between the feedback resistor and the FET's source. This resistor works to prevent accumulation of static charge that could damage the IGFET when power is removed.

Response speed is limited by the stray capacitance across the 2 × 10^{12}-ohm feedback resistor. This capacitance depends on the proximity of the resistor to other components in the circuit. However, response will be somewhat faster than the desired 1.5 s unless the circuit is slowed either by using an RC input filter or by adding a painted or clipped electrode to the outside of the guard, connected to the resistor's ground end. The clipped unit increases the resistor's stray capacitance.

The last example involves the design of a high-speed electrometer. The instrument is to have two ranges: 1 pA and 300 pA full scale. For the 1-pA range, noise level is not to exceed 6 × 10^{-15} A and the response time is to be 20 ms. Precise zeroing is achieved by placing a floating voltage in series with the feedback resistor.

For the more sensitive range, when the value for I_s and τ_c are substituted into the equation for I_s, the minimum value for R_f is found to be 6 x 10^{11} ohms. But even with this R_f, the loop's time constant is an order of magnitude too high. The reason is very clear: a guarded high-megohm resistor has a stray capacitance of at least 0.3 pF, making loop response time at least 200 ms.

The solution is to use the high-speed approach shown on the right of Fig. 1. The complete electrometer for this example is shown in Fig. 5. In constructing this circuit, care must be taken to mount all resistors on a ground plane to make circuit capacitances reproducible.

Since β is approximately 1, the electrometer's full-scale output on the more sensitive range is 0.6 V—$(I_{in}R_f)$—well within the output capabilities of an operational amplifier. To produce this same maximum e_o for the less sensitive range, the value of the feedback resistance is calculated to be 2 x 10^{10} ohms—$(\beta e_o)/I_n$.

Since the value of the feedback resistance for the higher sensitivity range is an order of magnitude greater than that required for the other range, switching can be accomplished simply by putting the two feedback resistors in parallel and having a single switch in series with the 2 × 10^{10}-ohm resistor. There is a small error due to paralleling the two resistors when the electrometer is in its less-sensitive range, but it can be compensated for by resistors in the β network

To provide the necessary isolation from ground, the switching is achieved with a reed relay. However, this type of switch introduces a problem. When the relay is closed, and the electrometer is in its less-sensitive range, the instrument performs well. However, when the relay is open, the capacitance between its contacts (approximately 1 pF is in parallel with the 6 × 10^{12}-ohm resistor, thereby increasing the circuit's response time.

This drawback can be alleviated by another relay—one that closes when the first one opens—between ground and the 2 × 10^{10}-ohm resistance. □

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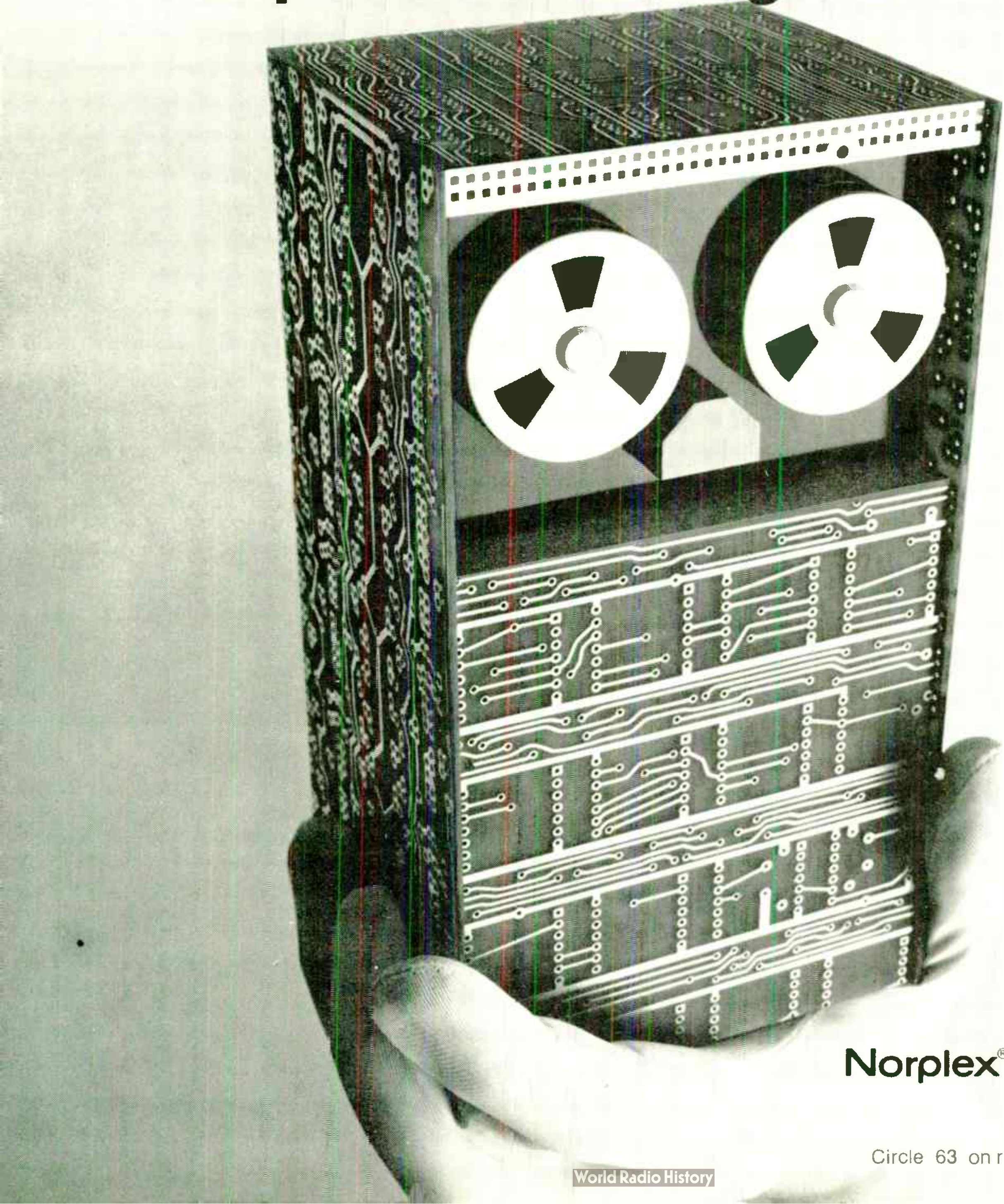

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I_p	(mA)	130	259	305	354
rV_1	(mV)	11	31.4	36	39
wV_z	(mV)	1.2	6.8	6.0	6.2
t_p	(ns)	230	142	136	123
t_s	(ns)	490	290	270	230

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Probing the news

Analysis of technology and business developments

Packard's game plan shakes up procurement

DOD deputy feels competitive hardware prototyping will curb waste; industry applauds, but is skeptical

by Ray Connolly, Washington Bureau manager

While President Nixon was making economic history with his program of wage and price controls to keep down costs in and out of Government and bolster the economy, deputy Defense Secretary David Packard was already nearly a month along in his own major new effort to control Pentagon system acquisitions waste and costs. With his procurement policy directive, 5000.1, Packard aims to eliminate the "bad management" that characterized programs such as the Lockheed C-5A supertransport as well as the unreliable paper studies of his predecessors. Instead there will be competitive hardware prototyping programs at several levels.

First outlined publicly in mid-August before a two-day symposium of the National Security Industrial Association, the Packard plan was handed down within the Pentagon in mid-July [*Electronics*, Aug. 2, p. 35]. Packard expects it to achieve more than just better performance and lower system costs. He is confident he can cut through the Pentagon's paper jungle "by holding requests for proposals to six or seven pages" and limiting bidder's responses "to 200 pages maximum," against the 600 to 700 that now glut program project offices. He acknowledges that one of his biggest jobs will be "getting the word to the troops"—what one NSIA panelist calls "that distant legionnaire," the project officer.

Though there's no lack of enthusiasm on Packard's part, some defense industry spokesmen are adopting a "show-me" attitude. Industry's caveats are expressed most clearly by Irving K. Kessler, RCA Corp.'s vice president for Government and commercial systems. Although he "heartily applauds" the intent and rationale of 5000.1, he recalls that under prior procurement panaceas, "we all experienced the thrill of 'weighted guidelines' and 'total package procurement,' which was neither total nor properly packaged."

From industry. With those failures in mind, Kessler is urging the industry association to form a standing committee to work with DOD on successful implementation of 5000.1, even though its present fiscal boundaries embrace "only one third of all contracts" for major systems. Potential problems not addressed by 5000.1, he contends, include the prospect of varying standards within each military service for such things as contract documentation and price inflation factors. Moreover, he says, uncontrolled operational autonomy at the program manager level can defeat 5000.1 unless DOD "insists upon and polices uniform interpretation," and implements a training program for project office personnel at all levels.

Packard believes he has already acted to solve the problem of getting those "distant legionnaires" to march in step with the August opening of the Defense Systems Management School at Ft. Belvoir, Va. [*Electronics*, May 10, p. 58]. After five months of close-order management drill there, graduates will move into major systems projects, where they will remain until a program is either completed or cancelled.

Though Packard is creating more individual responsibility at the project level, he is not opposed to the committee system at the top, as in the Defense System Acquisition Review Council, which blesses the user's Development Concept Paper. This paper determines a system need, examines issues and alternatives, and then proposes a system choice by spelling out objectives, plans, performance parameters, risk areas, and acquisition strategy. The council reviews will come at major decision thresholds. Prototyping can come at both the experimental and advanced-development level, Packard points out. "We want to keep programs in advanced development longer until we are sure we know what we are doing" and have demonstrable hardware choices.

First steps. The deputy defense secretary confirms that he will proceed during this fiscal year with "a modest program of experimental prototypes," beginning with a new lightweight fighter plane (FX) and drawing on industry teams. But he quickly adds that the concept is equally applicable for "electronic countermeasures equipment, radios, hydrofoils, and many other areas" of subsystems as well. However, he cautions, experimental prototypes must not be confused with preproduction versions; the former will "precede, not be a part of, engineering development," he adds.

What Packard wants, of course, are options—as many as he can get—to avoid being locked in with an overrun-plagued contractor building an essential system that, for national security reasons, can't be canceled. John S. Foster Jr., deputy Director of Defense Research and Engineering and the man responsible for the development paper and the systems school, puts it this way: "Right now, we have so few programs that each one is individually and directly related to our near-term security. That is the reason we don't—or can't—cancel some programs with which we are not entirely happy." Packard's ideal of small-scale, experimental prototyping blends nicely with Foster's "new initiatives" program, which aims to dramatically upgrade present systems via expensive improvements [*Electronics*, Jan. 4, p. 33]. Some 30 of these are included in the fiscal 1972 DOD R&D budget, "with more expected to be developed for 1973," says Foster.

Though defense electronics marketing managers view with pleasure these new opportunities, however small at the start, they also recognize that Congressional constraints on future defense spending are going to exact a toll somewhere else in the system. Foster agrees. "We are absolutely serious about stopping some programs," he declares.

The Pentagon research and engineering chief also is prepared to wield the Packard price bludgeon with skill. "We are absolutely serious about trading off performance, cost, and reliability as we move through weapons acquisition," he declares. Its emphasis leads one to believe that the item least subject to future negotiation will be cost, including its application to system operation and maintenance. This, Foster says, "is more a function of basic design than any other factor." Industry's independent R&D programs would be better oriented, he jibes, "toward acquiring demonstrable hardware instead of publishing brochures."

Foster concurs with the criticism that industrial technologists tend to get hoist with their own petard by developing sophisticated, sometimes exotic components and then searching for a military user. "That's exactly right," says Foster, urging potential contractors to do a better job identifying defense needs before plunging ahead with technology.

There is substantial evidence on the other side of the coin that the Pentagon's management problems don't all fall within the realm of contractor performance. Yet moves under way to correct these woes seem certain to affect industry, notably manufacturers of test instrumentation and special tools, and suppliers of technical data. Barry J. Shillito, assistant Secretary of Defense for installations and logistics, says DOD has "over $4 billion worth of excess and surplus inventory" and attributes some of it to buying test equipment, tools, and spares before they were needed.

More attention to weapons system standardization in design and development stages could eliminate some of these buys altogether, he suggests.

Paring. Pentagon sources say Shillito is getting heavy pressure from Packard to cut logistics costs, estimated at "about $20 billion each year for support of $104 billion worth of systems and equipment."

Shillito—who recalls he was once styled as "the man from the mushroom factory—where everything is kept in the dark and well fertilized"—is regarded by some contractors as famous for platitudinous generalizations of his departments' needs and economies that never evolve. Yet those who listen to Packard suspect that that image will have to change. They also believe DOD Comptroller Robert C. Moot—who prefers to talk of contract "cost growth" rather than "cost overrun"—is getting support from Packard in the effort to track down and eliminate price escalations.

Realistic. In his most recent analysis of 48 systems contracts worth $110 billion, Moot says "erroneous early estimates" by contractors and DOD accounted for 29% of cost escalation, the largest single share. This, plus another 10% in a catch-all "other" category, should be industry's principal management concern. Packard's serious concern with bad cost estimates and contract buy-ins is reflected in his 5000.1 notation that cost or incentive contracts "may be penalized during evaluation to the degree that proposed cost is unrealistically low."

Packard's concept of getting better performance and lower costs through prototyping "will probably become a buzzword for a while," concedes Foster. But, he cautions, "We will not allow that to drive policy," which is pushing for "a new way to develop new weapon systems." To industry's criticism that prototyping sounds like "fly-before-you-know-what-you-want," Foster has a sharp response: "It's fly-so-we'll-know-what-we're-getting. Cost, performance, and scheduling will be different, and that's the name of the game." □

'Show me'

Through DOD Directive 5000.1, titled "Acquisition of Major Defense Systems," deputy Secretary of Defense David Packard is putting forth his biggest effort thus far to bring costs and performance of weapons and their electronics into line. The goal eluded Packard's predecessors, troubled by war and its accompanying inflation, and the inability to identify mismanagement early in a program because of the sheer size of the Defense Establishment. Thus, significant segments within industry and the Congress, though they wish Packard well, are going to have to be shown.

With his directive, the Deputy Defense Secretary expects to show them by requiring:

- Designation of a single individual responsible for conceptual effort on major new programs.
- Establishment of unit production cost as a system design parameter.
- Consideration of logistics support cost as a principal design parameter.
- Prohibition against production options that are contractually priced in the development contract.

Definition of a "major new program" includes those with estimated RDT&E cost of more than $50 million or production costs of more than $200 million. Implementation is called for by Oct. 18.

Memories

MOS firms eye 1-transistor cells

Advocates of fast, dense memory design say it has the edge for upcoming 4,096-bit RAMs; 3-transistor stalwarts doubt its performance capabilities

by Alfred Rosenblatt, New York bureau manager

With the push to develop denser MOS memories on smaller chips, new designs using a single transistor in each memory cell may challenge the conventional three-transistor cell design that dominates the small, but rapidly growing, random access memory market. Going to this new design is justified, say its fans, by the smaller cell size and higher speed, but there are just as many who feel that the single-transistor cell memory won't be able to meet cost, performance, and systems requirements of mainframe applications.

Several companies are interested in the new single-transistor cell RAM. First to announce one was General Instrument Corp., Hicksville, N.Y., this month [*Electronics*, March 23, p. 17; Aug. 2, p. 69], and others are hard at work on this design approach. The race to get MOS RAMs designed and into production is sparked by the promise of a $200 million-plus market that will exist for such devices by 1974-75.

Sizes. One factor likely to influence the way most of the market will go as far as cell design is concerned is what size chip will dominate and become the volume leader. While many believe it will be the 4,096-bit monolithic RAM, others lean to the 2,048-bit chip, noting that Honeywell Information Systems already is working with vendors to come up with a 2,048-bit MOS RAM for its new computers.

Single-transistor-cell advocates cite the trend to larger memories as a major point in their favor. There's substantial agreement on both sides that a 4,096-bit RAM will utilize chip real estate much more efficiently than a 2,048-bit configuration. Thus the one-transistor fans feel their smaller cells will give them an even bigger edge with larger memories. Among them, Barry Cash, marketing vice president for Mostek Inc., Carrollton, Tex., terms the one-transistor design "the key to the 4-k, 1/10-cent-per-bit memory." And enthusiasm is strong at Fairchild Semiconductor division, Mountain View, Calif., which admits to considering one-transistor cell designs for RAMs of "4k and over," although none has been built yet. Texas Instruments Inc., Dallas, is another firm believed hard at work perfecting a single-transistor design, probably for its 4-k RAM which it expects to introduce later this year.

Cons. However, the doubters are equally vocal in their reservations about the single-transistor configuration. For example, both Intel Inc., Mountain View, Calif., and its neighbor, American Micro-systems Inc., Santa Clara, feel that some three-transistor designs yield cells at least the same size or even smaller than the one-transistor scheme. And, comments Glen Dumas, AMI's vice president for research, output signals, and hence noise margins, are higher for the three-transistor design.

Other sources at semiconductor memory firms say that cost will be a factor until large production runs are made.

In a multitransistor memory, data is stored as a charge on a capacitor—usually a thin film oxide associated with each MOS transistor. To reduce the number of transistors, a capacitor must have a high enough value so that it has sufficient charge to produce an output pulse large enough to be conveniently sensed over and above the cell's parasitic capacitance. General Instrument has been able to achieve such values in a single capacitor. Less total charge can be stored, though, than with the three-transistor-cell, and the output voltage is commensurately lower. GI compensates by an improved sense amplifier design that's incorporated into the memory chip.

The resulting memory cell is smaller than the present three-transistor design, so that the 2,048-bit memory occupies about the same area as Intel's available 1,024-bit model 1103, points out Leo Cohen, manager of new product development for GI

Cohen also claims his standard unit's speed—250-nanosecond access time (the 1103's is 300 nanoseconds)—was accomplished "without straining our technology. We wanted to prove feasibility using known production techniques and a conservative approach," he asserts. "We can make the cell smaller if we try and we're sure we can get its access time down to less than 200 nanoseconds."

Keeping up. Although three-cell designs hit this speed in 2,048-bit configurations, Cohen points out that they will be hard-pressed to attain such performance in larger sizes because they will have longer resistive interconnects and higher capacitive loading.

Mostek's Cash believes the single-cell design will be of critical importance in larger memory sizes, even if a company has to change its manufacturing process to build it. "This part will be running at such a volume that it can support a new process," he concludes. □

Military electronics

Army moves to unify tactical EDP

Newly formed Artads office brings under its roof all of the Army's tactical computer-based systems; the goal: to achieve interoperability and commonality

by Alfred Rosenblatt, New York bureau manager

A single umbrella will cover the development of all tactical computer-based electronic systems for the U.S. Army—and the new organization may spend some $500 million over the systems' life cycles. Called Artads (Army Tactical Data Systems), the project brings together at the Army's Electronics Command, Ft. Monmouth, N.J., just about every data processing system function performed by the Army. Only exceptions are communications and administrative systems.

Primary goal for the new project office is to achieve "interoperability as well as commonality" among the Army's tactical systems, asserts Col. Albert B. Crawford Jr., Artads director [see p. 14]. With interoperability, one system not only can receive data from another, but "it also can understand and use the data," he explains.

Artads is a forerunner of more interoperability requirements to come, says Crawford. The Joint Chiefs of Staff, he points out, are pushing for multi-service systems. One such project waiting in the wings is Ground and Amphibious Military Operations, designed to provide interoperability among all ground command and control systems.

Programs. Two of the programs being placed in Crawford's new project office are from the Automatic Data System for the Army in the Field (Adsaf) project. Adsaf, conceived in 1965 to automate artillery fire commands, intelligence, operations, and logistics systems, includes Tactical Fire Direction System (Tacfire) for artillery, Tactical Operations System (TOS) for intelligence-gathering and presentation, and the logistics-oriented Combat Service Support System (CS3) for logistics. CS3 will not be set up in Artads unless the Army decides the logistics system can be thought of in tactical terms.

As Artads "project directorates," Tacfire now is going into prototype testing at Fort Hood, Texas, while TOS is still having its basic systems concepts pinned down. Adsaf had been managed by the Army Computer Systems Command before Artads took over.

The other two ongoing programs at Artads are Air Defense Control and Coordination Systems (ADCCS), and Air Traffic Management Automated Centers (Atmac). So far only one program has been assigned to ADCCS, while no programs have been identified under Atmac because it is still in concept formulation.

Project goals. Under the ADCCS project is the AN/TSQ-73 missile fire control system, brought over from the Army Missile Command. Litton Systems Inc. developed the Q-73 for the Nike-Hercules and Hawk systems and is trying to see if it can be modified to handle the SAM-D missile requirements as well.

The Atmac project, deriving in part from a 1967 study by Hughes Aircraft Co. of a Semi-Automatic Flight Operations Center, seeks to develop digital data links for controlling Army aircraft in battle. Present control setups rely on voice links and, when the planes are high enough, on radar.

Crawford points out that digital data links must be developed for air-to-ground and ground-to-air transmission and possibly for air-to-air communications as well.

The Pentagon has talked about interoperability since 1965, but it's only been in the last two or three years that top level directives provided high-ranking support, Crawford says.

But it's a hard concept to implement. As late as last fall, a top level Army study—which Crawford directed—showed that development of the Integrated Battle Field Control System was not achieving interoperability goals. It concluded that the projects, in the Colonel's words, needed "a better focus." Setting up Artads will not delay projects already underway. Such systems would be modified in the field with software and buffering to insure interoperability, Crawford points out.

In fiscal 1972, Crawford will have some $20 million in research, development, test, and engineering funds to expedite Artads development, including seed money for advanced projects, "in technologies I see lagging," he notes. Displays and mass memories are two areas that could use further development, he adds.

Growth plans. Crawford expects his Artads installation at Ft. Monmouth to grow to 199 people—including 144 civilians—by March. About 60 will be relocated from the Computer Systems Command, and an equal number of new people will be hired, primarily to develop software and, in the process, beef up what Crawford terms a "short skill" area within the Army's technical capabilities. In addition, a 30-man systems engineering group will investigate interoperability tradeoffs. Crawford also will seek outside engineering services in "interoperability design and test planning," and expects a contract to be awarded by Jan. 1. □

International

Consumer renaissance flowers in Europe

Sparked by soaring color TV sales, European market shifts into a welcome high gear

All of a sudden, it's a movable feast for most of West Europe's consumer electronics makers. Hordes of well-heeled West Germans are scrambling around the stands these days at the mammoth Berlin international radio-TV show. In Zurich, meanwhile, the always-affluent Swiss are doing their set shopping at a similar, but smaller, affair. Before the Berlin Funkausstellung ends Sept. 5, the Italians will have their nine-day fall entertainment-electronics showcase open for business at the Milan fairgrounds. And before the blare of the hi-fi is silenced there, the loudspeakers and color TV sets will have been switched on at still another show in Amsterdam.

The action doesn't figure to end with this late summer rash of public shows. After a generally lean first half, business snapped back in July, and it now looks as if the feast will go on in retailers' showrooms—Italy excepted—at least through the end of the year. Consumer hardware, in fact, is one of the rare bright spots on the currently lackluster European electronics scene.

Mainly, the glow is coming from color television. "This year is the real breakthrough year for color TV in Sweden", says Aake Johansson, sales manager of Luxor Industri AB, an independent company and one of the two remaining sizable consumer electronics producers in the country. The other, of course, is the Swedish subsidiary of Philips Gloeilampenfabrieken, the ranking producer of consumer hardware in Western Europe.

Back at Philips headquarters at Eindhoven, market seers also see a Europe-wide breakthrough in color TV: there's a chance, they say, that factory sales of color sets for 1971 will soar 45% and possibly push past the $1 billion mark in West Europe for the first time. With color coming on so strong, sales of black-and-white sets figure to sag off at about 10% this year. All the same they'll account for nearly $1 billion. In the audio sector, cassette tape recorders and hi-fi equipment are setting a sprightly pace, which contrasts with "a certain weariness," as the men at Eindhoven characterize it, in the traditional radio market.

Looking East. The phrase changes to "a certain wariness" when it comes to the incursions—present and future—of Japanese producers, who had been trying to offset their dropping U.S. sales with new business in Europe even before the U.S. decision to add a 10% surcharge to all imports. Now they are expected to step up their drive. "Watch for the Japanese to kick off a massive attack on European consumer electronics markets during the Berlin radio and TV show," says a spokesman for a large West German consumer electronics manufacturer. Until the surcharge, however, European producers hadn't been unduly alarmed. Says James A. Goodson, vice president and general manager of the consumer products group at ITT-Europe, "American set makers badly underestimated the Japanese strategy in the U.S. market and geared up for an onslaught of cheap Japanese products. The Japanese were successful because they came in with high quality and low prices. We're not about to make the same mistake in Europe."

Wariness is also the word when it comes to putting new technology into TV sets. West German set makers have largely moved to 110° color tubes and so has Philips in Holland and Sweden; elsewhere the 90° tube prevails. In the next year or two, though, wide-angle tubes will be widespread and there's a battle royal shaping up between Philips, with its thick-neck tube and the thin-neck contingent headed by RCA.

With their wares selling strongly, color set makers are not rushing to shift to higher-cost and all-solid state designs just to get added sales. Goodson figures that only 20% to 30% of the color sets sold in Europe next year will be all solid state.

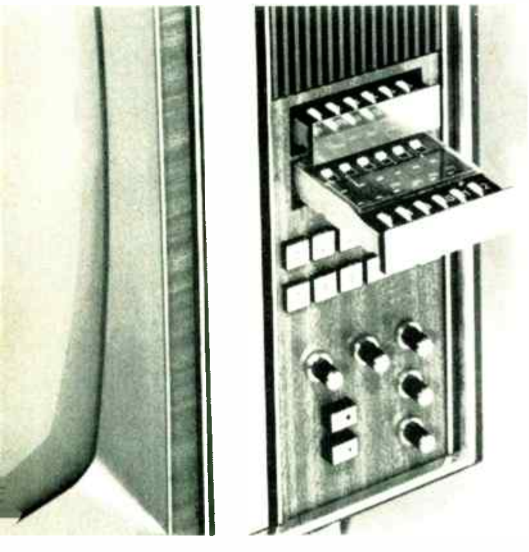
As for integrated circuits, they're being used widely, but there are still few per set. The mainstays, according to Denes Ilkovics, ITT-Europe's head of consumer products engineering, are i-f sound strips, audio drivers, color decoders, and PAL switches. Electronic tuning prevails in new sets and there's often an IC voltage regulator in the circuit. British Radio Corp., a division of Thorn Electrical Industries, has a pioneering set with an IC synchronous detector, which semiconductor houses think may be as prevalent as the widely used i-f intercarrier package.

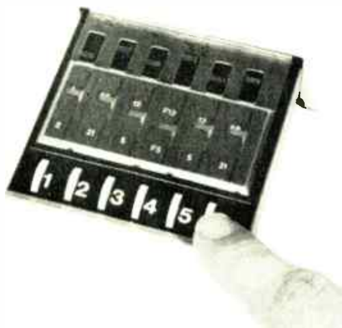
Follow the leader. West German set makers, who have going for them the kingpin economy in West Europe, are once again wallowing in good times after a sluggish first half. One fillip for color TV sales is the upcoming 1972 Olympic Games, which will bring added hours of color programing. All told, the West German color TV market should run at least 800,000 sets this year; some even predict 900,000.

In Great Britain color set sales have shot up since the government lowered the purchase tax and lifted the credit restrictions on consumer goods in July. Exuberant set makers now expect they'll sell 800,000 sets this year, nearly twice last year's 467,000. There's also a boom in mass-produced hi-fi sets and in tape recorders, where the Japanese are starting to chalk up significant sales. Other sectors are static.

Laggards. The other countries are far behind the Germans and the British in color set sales but nonetheless have strong consumer markets, Italy excepted. Paul-Roger Sallebert, director general of France's Fédération Nationale des Industries Electroniques, expects 1971 will be "satisfactory" for consumer electronics, meaning that sales so far have matched FNIE's expectations. For color TV the expectation is 320,000 sets this year, a leap from last year's 208,000 units. Better programing by the state-run radio-TV network is the key, Sallebert feels, to hitting the long-range growth target—900,000 sets a year when the current five-year economic plan ends in 1975.

Spurts in color TV sales are in the offing this year, too, in Scandinavia and Switzerland, so strong consumer electronics are certain there. The proof that color TV carries the consumer market comes from Italy—no color, drab market.





Electronic. In Philips tuner potentiometers (in drawer) are used to preselect stations.

Italian set makers have been bemoaning the government's indecision on color TV ever since their market went into the doldrums three years ago. Although the industry figured that at the very least the choice of color system—PAL or Secam—would be made when the last five-year plan ended in 1970, nothing has happened. The state-run network RAI, has been transmitting with PAL experimentally, and PAL sets are made in Italy for export. Nonetheless, France is putting such strong pro-Secam pressure on the Italian government that it still is wavering between the two. The decision won't come until 1972, according to the minister of post and telecommunications.

Wide ends. Along with the top ranking in set sales, the Germans are collectively also in the vanguard when it comes to wide-angle color tubes and electronics tuning. Most major producers have sets with a thick-neck 110° tube and all are keeping close watch on the thin-neck tube that RCA is championing.

Philips, though, has high hopes of keeping setmakers in its thick-necked camp. This month, the Dutch company announced that it had wiped out one of the major drawbacks of thick-necked tubes—the need for a costly convergence correction circuit. To do so, it developed saddle-shaped deflection yokes that introduce astigmatism along the main picture axis as in Philips' 90° tubes.

Wide-angle color tubes will appear on the French market next spring but are at least another two years off in Britain. A Thorn Engineering executive says the company intends to see how the thin-neck tube fares before its set-making subsidiaries decide which way to go. However, Thorn is RCA's partner in Britain in a joint color-tube plant. ITT-Europe's Ilkovics says, "We consider thin-neck technically better and less expensive." However, ITT's tube division in Esslingen is covering itself doubly with plans to produce both tubes.

Electronic tuning is very strong in Germany. Last spring, for example, the ITT subsidiary, Standard Elektrik Lorez, (SEL), introduced its "feather touch" tuner. Rather than pushbutton switches to select pretuned channels, it has a solid state switching circuit that's actuated by the resistance change occuring when a viewer touches a channel-selection plate. SEL has stereo tuners with "feather touch" at the Berlin show.

Even more sophisticated is Grundig's new electronic tuner. Touch its selection plates and you feed a coded signal into a control circuit built up of transistor-transistor logic packages. There are seven preselected channels available with this tuner, the first, Grundig maintains, to utilize TTL.

A color TV set maker who doesn't have an IC of one sort or another in one of his offerings is an outsider, except in France. The package most often found is an I-F sound intercarrier amplifier with an fm demodulator on the chip. Color demodulators, PAL switches, audio drivers, tuner-voltage regulators, and a delay circuit for Secam sets are often used, too.

In its set, BRC is using Motorola's MC1330P, made in Phoenix, by an Englishman, Gerald Lunn. Tony Henk, chief development engineer at BRC's Bradford plant, says the chip eases the problem of sound getting into the video.

Competition. Motorola won't have the IC synchronous detector market to itself for long. Plessey and Mullard, a Philips affiliate, are well along with even more elaborate low-level detectors. Plessey has samples of its 24-pin SL437B package out to set makers. The circuit includes the i-f amplifier stages before the low-level detector, so a 50-microvolt input direct from the tuner gives 6 volts peak-to-peak output.

The Mullard chip is still in development; it has 12 pins and takes yet another line. Like the Motorola chip it needs peak-to-peak output. And like the Plessey chip there are agc generators for tuner and an afc buffer. But unlike the others it has a noise inverter to protect the video, sync and agc signals from interference, and it has complete afc generation. Sound processing, though, is on a separate chip. □

Reporting for this story was done by *Electronics* staffers Michael Payne in London and Charles Cohen in Tokyo. Additional inputs came from McGraw-Hill World News correspondents Robert Ingersoll and Tyler Marshall in Bonn, James Smith and Michael Kolbenschlag in Brussels, Andrew Heath in Milan, Michael Johnson in Paris, Robert Skole in Stockholm, and Laura Pilarski in Zurich. It was written by Arthur Erikson, Managing Editor, International.

Circle 71 on reader service card→

Data acquisition system tries for middle-road jobs

by James Brinton, Boston bureau manager

Price is cut by tailoring accuracy and resolution to mid-scale tasks; $3,000 unit from Digitem uses LEDs

Taking data isn't just a pencil-and-clipboard job anymore. With the drive or increased accuracy and output accelerating, data acquisition is becoming a growth electronics market. The latest entry is the Digitem division of Microwave Systems Inc., East Syracuse, N.Y. Its first major product is a data acquisition system tagged DAS-1.

The DAS-1 is targeted for the middle spectrum of applications; its five ranges of from 10 millivolts to 10 volts allows it to handle fairly low-level signals—like those from thermocouples—as well as signals from amplifier-equipment solid state transducers, such as strain gages. But little attempt has been made to reach either for kilovolts or nanovolts in the dc system because Digitem's managers feel the average customer wouldn't want to pay for it.

Accuracy and resolution specifications reflect the same attitude. Both about 0.1% worst case, they represent a tradeoff between cost and complexity of the DAS-1's instrumentation amplifier inputs and analog-to-digital conversion system, as well as that extra decade or two of resolution or accuracy. Richard G. Wiley, director of the division, feels the average user doesn't usually require them, particularly since they could increase price by 50%.

The result is a data-acquisition system capable of monitoring inputs from 10 channels (up to 100 with an expansion chassis) for about $3,000. This, says Digitem, is 30%-50% less than the going price for competing instruments. Even so, the DAS-1 has enough convenience features to offset any thought that it's stripped.

The most notable convenience is a 3½-digit light-emitting diode display. The LEDs can be used either to read out incoming voltage levels on selected channels, or the time—the DAS-1 includes as standard equipment a real-time synchronous clock.

There's also a printer output. Like the LED display, it has a floating-decimal presentation, but instead of moving the decimal point as in the numerical display, the printer shuttles numbers from side to side about a fixed decimal position. Printout occurs at about two lines per second, showing data in an eight-column format that includes voltage level, sign, and channel number. Time is printed out immediately below.

Although any channel can be selected manually using thumbwheel switches on the front panel, electronic scanning isn't random. Though the DAS-1 can be made to scan from, say channel 35 to 43, and then stop, it always scans from the lowest-numbered channels upward. (Random access was another frill dropped to keep price in the $3,000 ballpark.)

There are five operating modes: automatic scanning at rates from one all-channel scan per hour to 30 channels per second; one-shot scan between selected channels; continual monitoring of individual channels picked by the thumbwheel control switches; externally triggered reading of the input at a single channel or of a single scan of all channels; and manual channel advance.

All inputs to the DAS-1 are three-wire (floating without regard to ground if necessary), feeding instrumentation-type amplifiers with 100 megohms input impedance on all ranges. The three wires are switched and isolated, allowing a 200-V common-mode voltage, relatively high for a unit with a 10-V maximum measurement range. This should

Middle ground. Digitem's DAS-1 will sell for $3,000 and is aimed at middle range of applications. It has five ranges of from 10 millivolts to 10 volts, 0.1% accuracy and resolution.

make the DAS-1 suitable for floating, guarded measurements in electrically noisy industrial environments. Common-mode rejection, at 120 decibels for dc, 100 dB at power lines frequencies, also is high.

Amplification is controlled from a back-panel board. The user sets amplifications of 1,000, 100, 10, or 1 by putting a shorting plug into the appropriate jack; there's one set of such jacks for each channel. A fifth jack disables the channel, allowing the DAS-1 to skip over it as it scans.

From the amplifier, the signals are fed to an integrating a-d converter. The 12-bit device is heavily isolated from its electrical environment by optical isolators at its output. Since it's one of the most important subassemblies in the unit, Digitem engineers tried to minimize capacitance between ground and signal paths this way, and appear to have succeeded: a residual capacitance of about 3 picofarads is claimed.

Some of the convertor's serial output goes to the format and data conversion circuits (transistor-transistor-logic) that fed the LED display; some is directed to formating logic for a Teletype output; some feeds a serial-to-parallel convertor that emits eight-bit ASCII characters for high-speed printout devices, like drum printers or the low-speed, built-in printer. There also is provision for IBM-compatible tape output, either nine- or seven-level.

Expansion beyond 10 channels is a matter of buying an add-on chassis. It is the same size as the original DAS-1 version—7 × 20 × 17 inches—and includes slots for up to nine additional 10-channel input boards, and also an enlarged plug board gain-control set that supplants the mainframe. As in the mainframe, a reed relay matrix handles switching between channels.

The DAS-1 is to be introduced in mid-September and already it has been ordered by several universities, a drug maker, and at least one industrial user. By mid-September, delivery should run from stock to about 30 days.

Digitem, a division of Microwave Systems Inc., 1 Adler Drive, East Syracuse, N.Y. 13057 [338]

Components

FET has 140-dB input range

Wide-junction device for receiver front ends can dissipate 2 watts cw

In designing communications receivers that must handle strong signals without clipping, engineers look for a front end with the broadest possible input-power dynamic range. That's one of the applications in mind for a field effect transistor developed by Crystalonics and designated the CP640. It has a dynamic range of 140 decibels, against the usual 110 dB for FETs and 90 dB for bipolar transistors.

"It's almost as if we paralleled 20 small-signal FETs," says Joel Cohen, Crystalonics' director of engineering. The FET's lengthy interdigital pattern allows greater currents, higher transductance, more junction capacitance, and lower noise. And the junction is quite long by semiconductor standards; Cohen estimates that there is at least an inch of one-tenth-mil-wide geometry folded up in the CP640's interdigital structure.

Transconductance is about 75,000 at 50 milliamperes input; this compares with about 7,500 for the average small-signal FET with a 5-mA input. Thus, not only is the new device handling more current at a given voltage than its competition, but it's also handling it more cleanly.

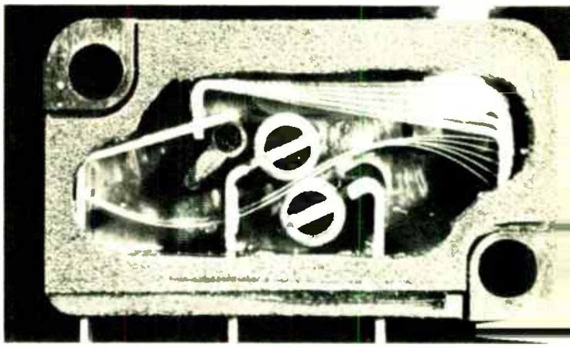
Input impedance is only 50 ohms, very low for a FET. The CP640 thus is a closer match for 50- and 70-ohm coax lead-ins than is the usual kilohm-impedance FET. "For a given input power and signal-to-noise ratio," says Cohen, "a small-signal FET like the 2N4416 could need about 20 times the voltage input of the CP640.

"But, the CP640 can handle about 10 times the maximum input signal of the 2N4416 before clipping. This, in turn, has enabled us to achieve pretty good intermodulation distortion figures," he points out. Using 3- and 5-megahertz mixed signals, third-order harmonics are 80 decibels below signal level at 250 millivolts input, 75 dB down at 300 mV; even at a rarely encountered 1 volt, it is down 44 dB.

Specified for the high-frequency band, the unit—housed in a special rf package—is usable through 400 MHz. And though it handles small signals in receiver front end and amplifier applications better than small-signal FETs, it is catalogued as a power FET by Crystalonics and can dissipate 2 watts cw at a 25 C case temperature.

Delivery is from stock, with single units priced at $15. The price falls to $9 in quantities of 500 to 999.

Crystalonics, a Teledyne Co., 147 Sherman St., Cambridge, Mass. 02140 [341]



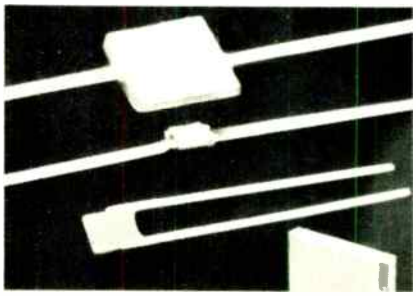
Component briefs

Sinusoidal oscillator. Model S-310 is epoxy-encapsulated, and designed to create a stable sine wave signal source. Frequency range is 100 Hz to 1 MHz, and tuning range is ±5%.

Operating temperature is from −20 C to +80 C, and only one power supply is required. Price is $145 in small quantities. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343 [344]

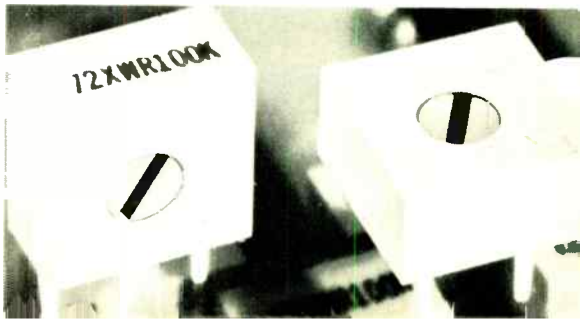
Miniature switch. Snap-acting unit, 1SV rolling wave series, features S-shaped beryllium copper spring and barrel-shaped, multi-point stationary gold contacts. The device operates at 25 grams maximum force and is designed for low voltage circuits. Reduced contact disturbance allows interface with solid state logic with little or no buffering. Return force is equal to half the operating force. Micro Switch Div., Honeywell Inc., 11 W. Spring St., Freeport, Ill. 61032 [349]

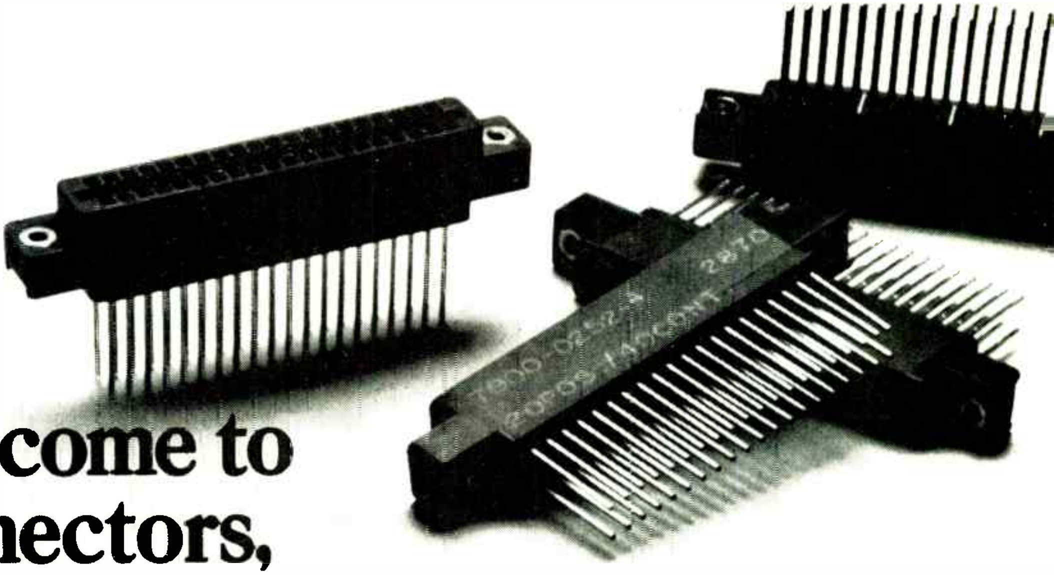
Ceramic capacitors. Units for high-power rf applications measure 0.546 in. square by 0.172 in. thick. They are designed for frequencies up through microwave and have a rat-



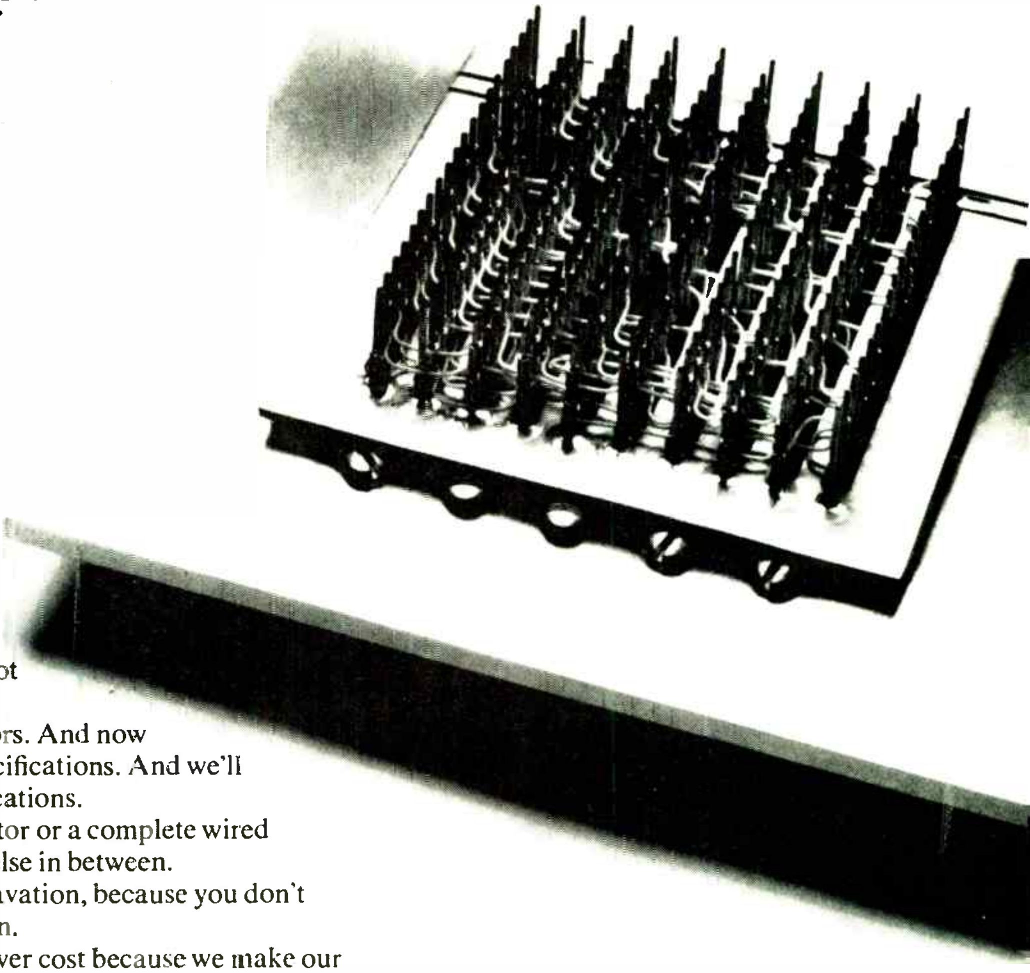
ing of 8 amperes at +25°C. Capacitance values available range from 10 to 3,000 picofarads. Glass encapsulation prevents corona loss at high rf voltages, and leads of the series, designated the UFP, are flat fine-silver ribbons to carry high current. JFD Electronics Corp., Components Div., 15th Ave. at 62nd St., Brooklyn, N.Y. 11219 [345]

Cermet trimmer. Potentiometers, series 72, offer a life expectancy of more than 5 years under full-rated power and continuous duty. The ⅜-in.-square, single-turn units are compatible with wave-soldering and board-washing techniques. Price: 70 cents for 1 to 9, 49 cents for 1,000. Beckman Instruments, 2500 Harbor Blvd., Fullerton, Calif. [343]





When you come to us for connectors, you could have your whole job wrapped up.



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And we can probably do it at lower cost because we make our own plastic bodies, form our own contacts, and assemble our own connectors. We even draw our own wire for wrapping.

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GTE SYLVANIA

New products

Instruments

Multimeters come in low

Prices are $650 and $1,295 for 4½- and 5½-digit instruments

Digital multimeters are among those rare species of products whose prices are dropping. Practically every instrument house has been introducing new lines that are successively less expensive.

The latest low-priced instruments come from Systron-Donner Corp. Its new 4½-digit multimeter, the 7004, sells for $650, while the 5½-digit 7005 goes for $1,295.

The 7004 operates from 115/230 V ac, 48 to 440 Hz lines power, from a $95 optional battery pack, or from an external dc source.

The instrument has five ranges of dc and ac volts, ±10 nanoamperes to 1.5 amperes, and five ranges of resistance resolving 0.1 ohm to 13 megohms. Accuracy is ±0.01% reading ±0.01% full scale for the top four dc voltage ranges; input impedance is greater than 1,000 megohms for the first three ranges. Overload is rated at ±1,100 volts for any dc voltage range, 500 V rms for any ac voltage range, ±300 V dc or peak ac for any resistance range, and 100% over selected dc or ac current ranges. Dual-slope integration, plus a built-in filter, combine to reduce internally generated noise feedback to the source being measured. Front-end noise kickback specification is less than 1 millivolt into a 1-megohm source.

The display includes four full digits plus a fifth digit for 30% overrange, polarity indicator, automatic decimal point, and nonblinking readout storage. An optical BCD output is available for data logging.

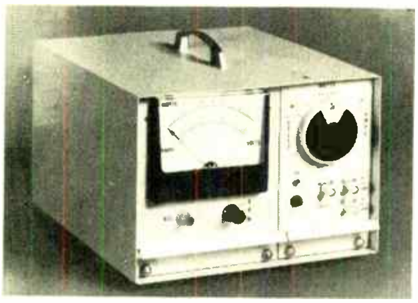
The basic unit provides four measuring ranges of dc volts, allowing measurements from ±10 microvolts to ±1,100 volts. Available as plug-in options are autoranging for four ranges of ac voltage with 10-microvolt resolution up to a maximum of 750 volts rms; five ranges of resistance resolving 10 milliohms up to 10 megohms; in dc current ranges allowing measurement from ±10 nA to 1 A; and DTL/TTL compatible BCD output and ±100 mV dc range featuring ± 1 mV resolution.

Modular packaging of the 7005 allows expansion or servicing by simple insertion of plug-in accessory cards. Expansion may be performed by the customer any time he wants by simple card installation at prevailing data sheet prices—even to the extent of the optional BCD output card and prewired connection. A convenient internal calibration cover is supplied with clearly labeled adjustments, all accessible from the top. Price with all options is about $2,200

Systron-Donner Corp., 888 Galindo Street, Concord, Calif. 94520 [351]

Instrument briefs

Wattmeter. Model M1/SC1 measures true rms voltage, current, and electrical power. It operates over the range of 5 to 100 kHz, has a recorder output available. Voltage ranges are 200 V rms to 2,000 V rms full scale, current ranges from 0.1 to 10 A rms, resulting in power ranges of 20 W to



20 kW full scale. Price is $495. Wave Energy Systems Inc., Newtown Commons, Newtown, Pa. 18940 [355]

Voltmeter. Peak-reading meter records voltage peaks of short duration. It senses and displays highest positive or negative peak value of any ac or dc voltage from 0.1 V to 1,000 V full scale. Responding to peaks as brief as 1 μs, it holds reading until unit is reset manually or

automatically. Designated the Peaklok, the instrument provides analog dc output of +5V full scale for automatic control or logging. Pioneer/Instrumentation, 4800 E. 131st St., Cleveland, Ohio 44105 [358]

Varactor capacitance ratiometer. Model 172A is intended for fast production-line testing of varactors for capacitance at preset bias levels. The programable instrument can also be used as a standard capacitance meter for other measure-

ments, and three-terminal and differential tests can be made within the ratio ranges of 0-2 or 0-20. Capacitance value is from 0.01 pF to 2,000 pF with an accuracy of 0.25% of reading ±0.05% fs ±1 digit. Price is $2,700. Boonton Electronics Corp., Rte. 287 at Smith Rd., Parsippany, N.J. 07054 [357]

Circuit tester. Battery-powered unit uses a test voltage of less than 0.1 V that may be used for all semiconductor junctions. Short circuit current is less than 1 mA. The portable unit has a variable threshold control so that the trigger point can be adjusted between 0 and 40 ohms. Price is $49.50. C-O Manufacturing Co. Inc., Box 125, Brockton, Mass. 02403 [353]

Data handling

Mini line speed doubled

Interdata cuts price 40%; second model to have MOS/LSI main memory

The first low-priced microprogramable minicomputer was introduced by Interdata Inc. in 1970. It sold in the $12,000 range and featured a memory access time of 600 nanoseconds. Next month, the New Jersey company will market the first of a new series of minicomputers that will continue the basic architecture of previous models; but the first of the new series, the Model 70, will have an access time of 300 nanoseconds. Moreover, prices will be cut by 40%: the 70 will sell for a unit price of $6,800, and for $5,440 in quantities of 20.

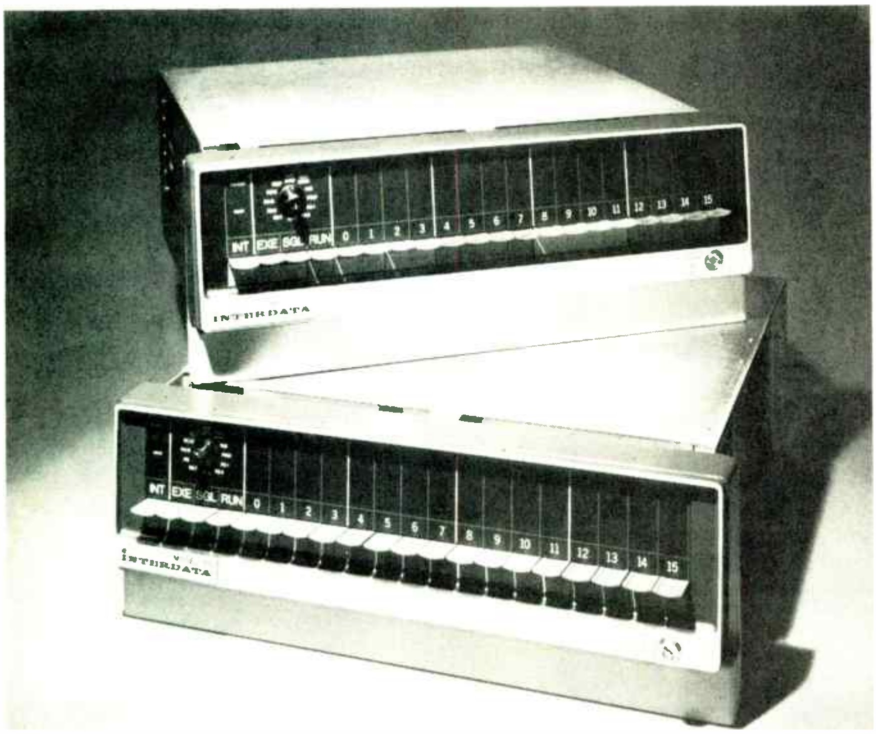
The directly addressable core memory of the Model 70, with 8,192 bytes, is expandable to 65,536 bytes and has a 1-microsecond cycle time. The LSI bipolar read-only memory is used in a machine instruction cycle time of 250 nanoseconds. There are 16 general registers, each with 16-bit capacity. The basic model 70 has a set of 113 instructions, including high-speed multiply/divide and 32-bit floating point. A double-buffered Teletype wiper interface is built in, along with a direct memory access port for up to four channels.

"The price-to-performance coefficients of the 70 are aimed at the OEM marketplace, and also at data communications and industrial control," says Ronald Paterson, vice president of marketing.

For industrial jobs, the 70 has mechanical stiffeners on every printed circuit board, two piece contact-to-contact mating of pc boards to back panels, and external cable connections that use two-piece connectors with captive screw-down clamps.

The Model 70 is available immediately. In the second quarter of 1972, Interdata will be selling the Model 80, which will feature advanced Schottky TTL logic and an MOS/LSI mainframe memory. Company officials say the 80 will be the fastest small computer being sold.

Interdata Inc., 2 Crescent Pl., Oceanport, N.J., 07757 [361]



Analog modem. Model PH-4000A is designed to fill requirements of redundant pictorial data transmission in slow-scan TV and other equipment. Frequency response extends beyond 2,000 Hz. The linear-phase

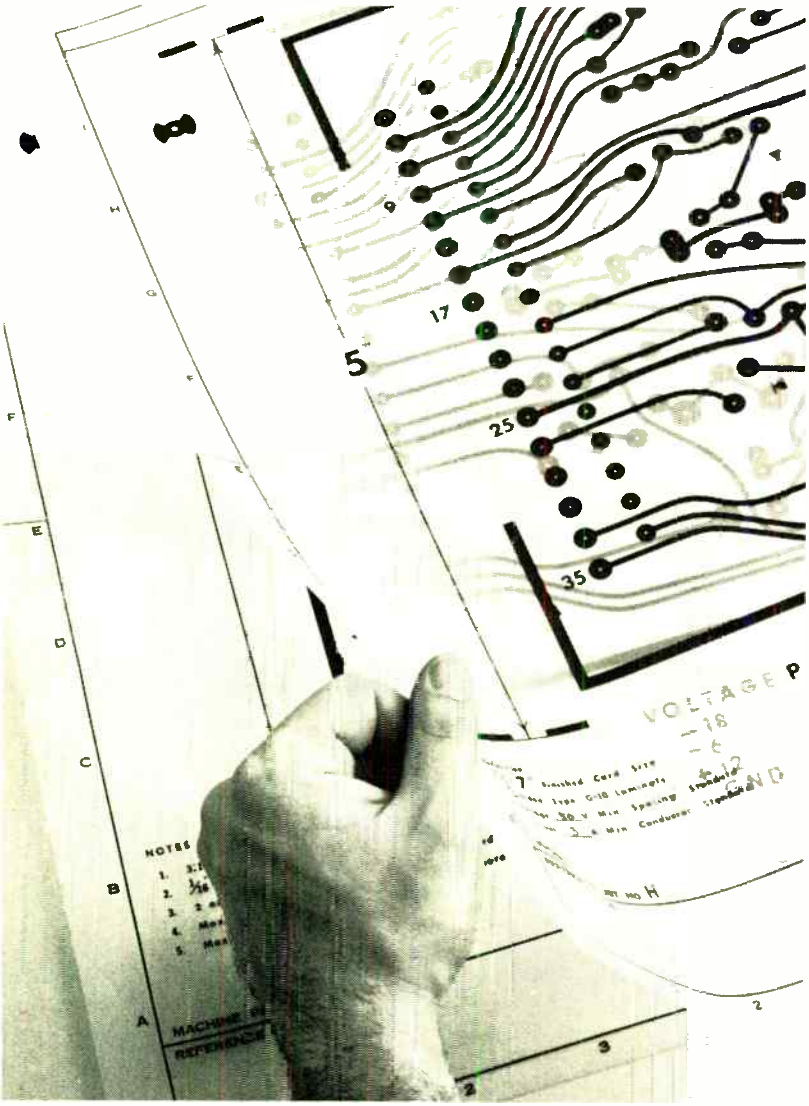
device is available in simplex or half/full duplex operating modes. Price ranges from $500 to $750 for the half/full duplex, cards/only model. Phonocopy Inc., 120 Long Ridge Rd., Stamford, Conn. 06904 [363]

Punched tape readers. High-speed photoelectric units permit continuous adjustment of slew speed from 300 to 625 characters per second and/or operation from an ac input over the range of 50 to 400 Hz. Model 5101 operates at 0 to 150 characters/s in asynchronous mode, and the 5401 at 0 to 300 characters/s. The controller mounts inside the reader and is priced at $150. The readers start at $650. Chalco Engineering Corp., 15126 S. Broadway, Gardena, Calif. 90247 [364]

Keyboard. Citation 600 series optical code generator uses light beams and key-operated shutters to generate ASCII code characters. The system eliminates contact bounce and mechanical breakdown since it does not use mechanical switches. The light has an operating life of 10,000 hours and is replaceable from the rear of the case. TEC Inc., 9800 N. Oracle Rd., Tucson, Ariz. 85704 [366]

Data coupler. Model 617 time-sharing-formatted system enables user to automate many data collecting tasks. Unit interfaces with Teletypes and converts the output

Short circuits.



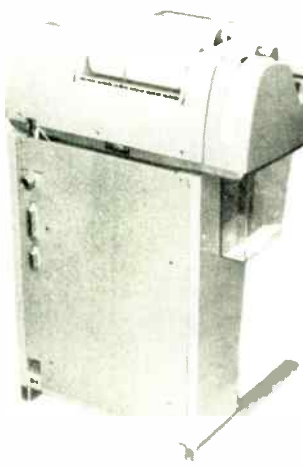
Now you can bypass slowdowns in printed circuit design.

Do your design problems include tape slippage and lack of dimensional stability on master layouts, numerous design changes, and other annoyances that hamper efficient printed circuit design?

If so, we believe that reproducing your taped master on KODAGRAPH ESTAR Base Film is the answer. For more information, contact your Kodak Technical Sales Representative, or write: Eastman Kodak Company, Business Systems Markets Division, Department DP803, Rochester, New York 14650.

DRAWING REPRODUCTION SYSTEMS BY KODAK

Kodak



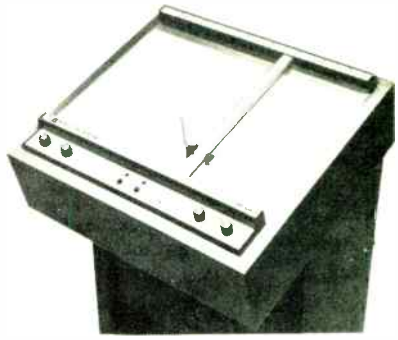
of digital measuring devices into compatible data that can be fed directly into the time-sharing program. It generates hard copy and punched paper tape from the digital output of DVMs, digital panel meters, counters, frequency meters, digital thermometers, and digital pH meters. Datac Inc., 1773 S. Taylor Rd., Cleveland, Ohio 44118 [365]

Readout system. Self-decoding visual device designated Major-64 is for computer peripheral and digital display fields. It accepts directly any four-, five-, or six-line binary code signals, and selects and projects any one of 64 images on an integral screen. Images are on a single piece of film. Quantity price is less than $100. Major Data Corp., 1796 Monrovia Ave., Costa Mesa, Calif. 92627 [386]

Modem. The model 5220 is comprised of a printed-circuit-card OEM modem in a desk or wall mountable package. The originate or answer-only system has its own power supply, and indicating lights for power

and carrier detect when supplied. Unit is compatible with Bell 101, 103, and 113 series. Price is $180 without carrier detect; with this capability the model 5220 will cost $195. RFL Industries Inc., Boonton, N.J. 07005 [367]

Time-share plotters. Models TSP-300 and TSP-310 offer 30 characters per second transmission, and drive an 11 by 17 in. X-Y recorder at 450 to 600 pen movements per minute, plotting an 18 in. line in less than 1 second. Units can be used with most



ASCII-coded terminals, and the model 310 can be switched to 10 characters/s. Price for both versions is $3,700. Time Share Peripherals Corp., Miry Brook Rd., Danbury, Conn. 06810 [369]

Data storage system. The model IVC-1000 stores more than 80 billion bits per reel of 1-inch magnetic tape, and uses the high packaging density characteristics of the helical scan recording technique to offer a den-

sity of over one million bits per square inch of tape. It records data at rates of eight megabits per second. The price of the IVC-1000 is $50,000 with quantity discounts available. International Video Corp., 675 Almanor Ave., Sunnyvale, Calif. 94086 [370]

Packaging and Production

Testers cover wide range

Two modular systems can be tailored to maker or user for checkout of ICs, arrays

"As much or as little as needed"—that was the rallying cry used by Macrodata Co. as it unveiled a modular family of semiconductor testers at Wescon. Parts of the family will be sold individually, and

they can be put together to form two systems, the MD-183 and the MD-150. Both systems can test either logic or memory devices, bipolar or MOS, ranging in complexity from the lowest order of integration to LSI.

The MD-150, the more sophisticated of the two, consists of three new modules that will also be sold on a stand-alone basis—a programable power supply, a clock generator, and an automatic parameter tester—plus the MD-100 memory tester [*Electronics,* April 12, p. 197].

The programable power supply offers voltage swings of 30 volts, and a 300-milliampere current-delivery capability, with slew rates of 5 V per millisecond for the supply voltages. The clock generator provides up to six clock phases, a repetition rate of 5 megahertz, and resolution in 10-nanosecond increments.

The automatic parameter tester performs dc parametric checks of bipolar and MOS devices. When coupled to the functional 5-MHz data rate capability of the built-in MD-100, it makes the system a complete dc parametric and functional tester selling for about $59,000 for a 24-channel unit. A 32-channel version will sell for about $68,000.

The MD-183 represents Macrodata's first attempt to crack the dc parametric testing market for ICs and LSI arrays, long dominated by Teradyne Inc. It uses the programable power supply, automatic parameter tester modules, tape cassette, and minicomputer, but omits the clock generator and functional memory tester. Intended for both semiconductor manufacturers and users, a 24-channel system costs about $33,000.

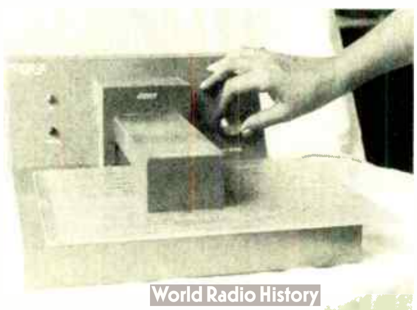
The big difference between the two systems is that the MD-183, without the clock generator and MD-100 unit, is a slow functional tester that specializes in accuracy measurements rather than speed, while the MD-150 does functional testing at device speeds.

Macrodata Co., 20440 Corisco St., Chatsworth, Calif. 91311 [391]

Optical technique spots plating voids in pc boards

When too many cold solder joints, or blowholes, appear in finished printed circuit boards, one of the first trouble spots to look for is voids in the plated through-holes. With a void in the plating, volatile chemicals in the laminate can be driven off by soldering heat.

Not every plated through-hole on every board can be checked, but if a test is fast enough, sufficient samples can be taken before committing a board to the soldering operation. That's the purpose of a new void detector, aimed at both pc makers and users, now being offered by Catoptrics Inc.



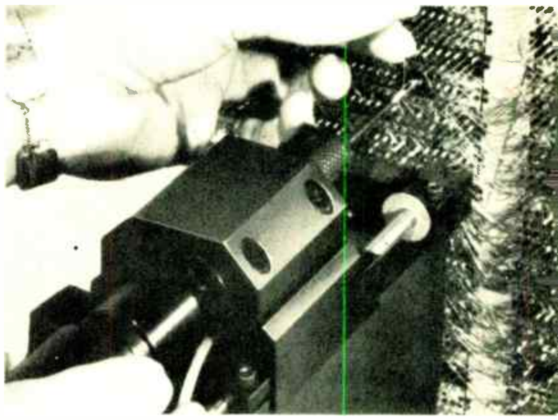
The instrument, called the Void/Tect, uses an electro-optical method to pinpoint voids as small as 5 mils in diameter without touching hole plating or leaving any marks. Total test time is about three seconds per hole. The operator simply aligns the through-hole to be checked, pulls the sensing head down, and watches for a go/no-go signal. Sensitivity level is set up with a predrilled template as a standard and an adjustment on the instrument.

Price of the Void/Tect, including one template on a 3/16-in. G10 board is $1,195. Templates for other board materials or laminate thicknesses are $25 each.

Catoptrics Inc., 159 Robby Lane, New Hyde Park, N.Y. 11040 [392]

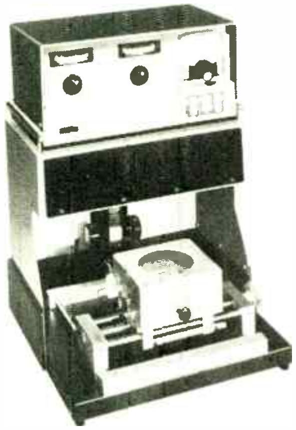
Production briefs

Wire-wrapping tool. Stationary sleeve, sideload device is for use on the company's vertical table P/2/P wiring systems. The tool is mounted horizontally on precision bearing shafts to move in and out over an



adjustable travel of up to 5.5 in. It does not have to be hand-held, and can slide forward onto the terminal pin with little pressure. A spring-loaded mechanism returns the tool to its retracted position after the wrap cycle. Synergistic Products Inc., 1902 McGraw Ave., Santa Ana, Calif. 92705 [396]

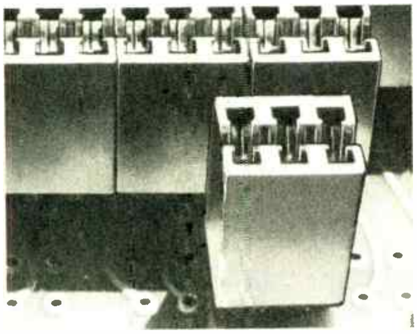
Flat pack sealer. Infrapak model 904 operates in an inert atmosphere using infrared energy and solder preforms. The device seals metalized ceramic lids and covers made



of other materials having low heat-transfer characteristics. Operation is semiautomatic. The maximum size flat pack usable is 1 by 1 in. Electromechanical Div., Electrovert Inc., 86 Hartford Ave., Mt. Vernon, N.Y. [397]

Power screwdriver, SL series, suited to electronic component assembly, features automatic vacuum pickup and adjustable torque control from 0 to 5 in. per lb. Device picks up and drives screws, with or without heads, from #000 to #4. The bench-mounted unit also picks up nuts and washers. Foredom Electric Co., Div. of Blackstone Industries Inc., Bethel, Conn. 06801 [393]

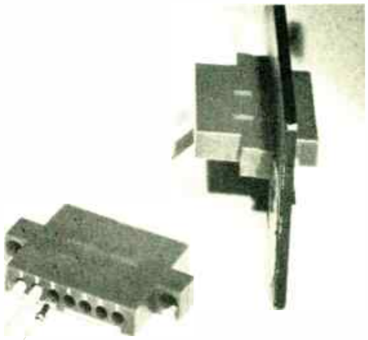
Connector modules. Card-edge devices provide a means to update connection systems without having to redesign existing pc cards that have 0.156-in. center contact traces.



Series 6318 units come in modules of four and six contacts which can be ganged together to custom-design contacts without soldering. Connection is vibration immune, gas tight. Elco Corp., Willow Grove, Pa. 19090 [398]

Edgeboard connector. Model EB7 has bifurcated bellows contacts and is designed for use on 1/16 in. circuit boards. The 0.156-in. unit adapts to variations in thickness from 0.050 to 0.071 in., and is available with single or double readout with from six to 22 contact positions. Slot depth for single readout is 0.300 in.; and for double, 0.260 in. The device is rated at 5 amperes, and leading edge of contact is recessed. Dale Electronics Inc., P.O. Box 180, Yankton, So. Dak. [394]

Terminal connectors. Internally bussed units in either feedthrough or feedback types are designed to accept insertable/removable pin contacts, crimp terminated to 16, 18,



or 20 AWG wire. The dielectric housings incorporate registration bosses and recesses to allow multiple stacking. Combinations of internal bussing are available to suit specific requirements. Appleton Electronics Div., Appleton Electric Co., 1701-1759 Wellington Ave., Chicago, Ill. [395]

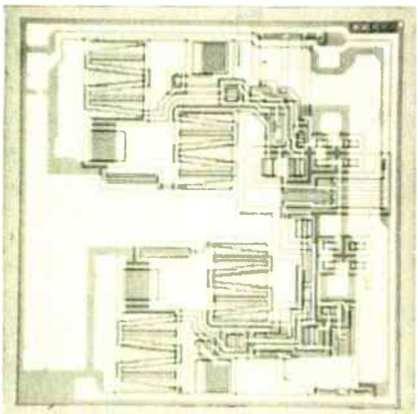
Hermetic package lids. New line called Unilids for final sealing of microelectronic packages are self-locating, and withstand pressures up to 100 lb/in.^{2} without oil canning. They are available in gold or nickel plate, and are supplied flat and remain flat, insuring higher part yields, because stresses are not induced into the lid during manufacturing. All methods of final sealing, including parallel seam welding and brazing, are possible. The units match any square, circular, or rectangular package without tooling charge. Solid State Equipment Corp., 15321 Rayen St., Sepulveda, Calif. 91343 [399]

Semiconductors

Chip drives 1103-type RAM

Monolithic TTL-to-MOS converter eliminates need for extra decoding circuitry

Although several monolithic TTL-to-MOS voltage-level shifters are available [*Electronics*, July 5, p. 70], none of those on the market can directly drive the widely used Intel 1103 1-



kilobit MOS RAM and the 1103 types made by others.

Texas Instruments Inc. is filling this gap with its SN75361 which, in addition to converting TTL signals to MOS levels, supplies the decoding functions not on the 1103 chip.

William D. Whittekin, manager of interface circuit design at TI, says the SN75361 is a dual NAND driver with TTL input and an output rated up to 20 volts. It can drive up to 30 chip-enable or precharge inputs, or 100 address inputs, as well as data lines that require much less current.

Whittekin says that TI developed the circuit because "a lot of our customers are looking at 1103s—and they all have drive problems." TI is one of the sources for 1103-type memories.

The SN75361 will switch high to low in 18 nanoseconds at 25°C with a capacitive load of 100 picofarads, and low to high in 25 nanoseconds, measured from 50% input to 90% output. Under 700-pF loading, high-to-low switching occurs in 42 nanoseconds and low-to-high in 45 nanoseconds.

The part requires a 5-V supply, plus another at 5 to 20 V. With a 16-V supply, and with both halves driving 100 pF with a 50% duty cycle, it dissipates 400 milliwatts at 1 megahertz, and 680 mW at 2 MHz.

Though specifically designed for 1103 driving, the SN75361 can also be used as a lamp driver, level translator, clock driver, bus driver, and line driver. For example, at a 5-V output, the part can drive 100 feet of twisted pair at 20 MHz.

The device is designed for the commercial, (0°C to 70°C) temperature range, and is housed in an eight-pin plastic dual in-line package. It is priced at under $3 in 100-piece quantities. TI also makes a similar part with a 12-V instead of a 20-V rating. It's called the SNF75360 and is also priced below $3 in 100 lots. Availability for both is six weeks.

Texas Instruments Inc., P.O. Box 5012, Dallas, Texas 75222 [411]

Decoder for industrial jobs has high noise immunity

Designers of systems that operate in an environment of high electrical noise usually have to clamp an indicator-tube driver with zener diodes to prevent false triggering. This precaution is not necessary with a decoder/driver developed by Teledyne Semiconductor.

The model 382 has a typical noise immunity of more than 4 volts, and guaranteed output is 70 V. It decodes BCD 1-2-4-8 code and drives cold-cathode indicator tubes requiring a cathode current of 7 milliamperes or less. It operates from 12- or 15-V power supplies and accepts inputs from all 300 series high-noise-immunity logic circuits. Because of the 4-V noise margin, the 382 can be used in a system with a 1-V power supply ripple, Teledyne points out.

The 382 is available in commercial and military temperature ranges. The commercial type, in a silicone dual in-line package, is priced at $6 each in quantities of 100. Delivery is from stock.

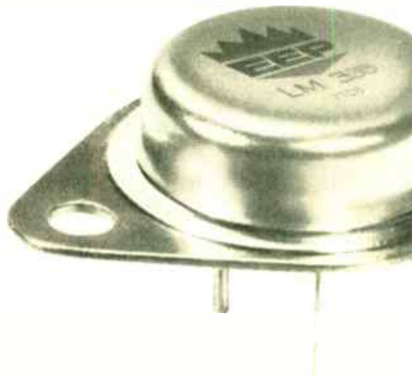
Teledyne Semiconductor, 1300 Terra Bella Ave., Mountain View, Calif. 94040 [412]

Semiconductor briefs

Instrumentation amplifiers. FET-input instrumentation modules, series 3621, are graded on input voltage drift into three units. Model 3621J has a maximum drift of $\pm 50 \mu V/^{\circ}C$, the 3621K, ± 15 $\mu V/^{\circ}C$; and the 3621L, ± 5 $\mu V/^{\circ}C$. Impedance is 10^{11}

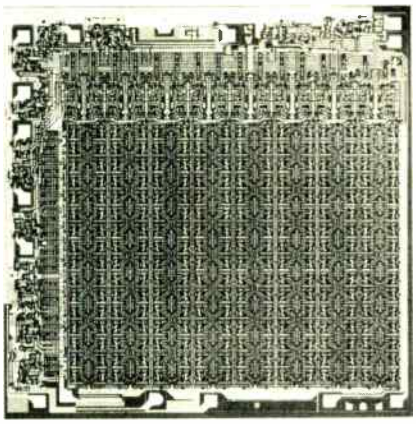
ohms, and input bias current is 10 pA maximum. Gain may be set to any value from 1 to 2,000 by the use of one external resistor. Price of the J is $39; the K, $45; and the L, $59. Burr-Brown Research Corp., International Airport Industrial Park, Tucson, Ariz. 85706 [413]

Power regulator. The model EEP LM335 linear IC unit for 5-volt applications delivers output at 600 mA with line and load regulation of less than 1%. Overload and short circuit protection are provided, and ripple rejection is typically 62 dB. Regulated output is 600 mA minimum, 850 mA typical, and operating range is 0 to 70°C. Unit is packaged in TO-3 metal can. Price is $3.60 in



100-lots. European Electronics Products Corp., 10150 W. Jefferson Blvd., Culver City, Calif. 90230 [418]

Memory. Fast 256-bit RAM offers three-level output and is organized 256 words by one bit. Called Am2700, it offers chip-select speeds typically of 12 ns, read-access time of 60 ns, full on-chip decoding,



power dissipation of 0.5 milliwatt per bit, and ability to be driven by TTL/MSI logic. It is available in a 16-pin hermetic package. Price in 100-lots is $27. Advanced Micro Devices Inc., 901 Thompson Place, Sunnyvalle, Calif. 94086 [416]

High-voltage diodes. FR series of transfer-molded silicon units are available in peak inverse voltage ratings from 1,000 to 40,000 volts. The multi-junction devices use 2 to 30 bonded wafers to cover wide voltage and current variations. Sarkes Tarzian Inc., Semiconductor Div., 415 N. College Ave., Bloomington, Ind. 47401 [419]

Thermistors. G series voltage-current, matched-pair devices operate in self-heat mode. Models G112, G126, and G128 have resistance values of 8,000, 2,000, and 1,000 ohms, respectively, at 25°C. The units are designed so that each bead is mounted on a hermetically sealed stem; standard housings are available. Applications include gas chromatography, fluid flow, thermal conductivity instrumentation, and medical instrumentation. Fenwal Electronics Inc., 63 Fountain St., Framingham, Mass. 01701 [415]

International Newsletter

August 30, 1971

Ferranti trials leading to big bipolar RAM with CDI process . . .

Engineers at Britain's Ferranti Ltd. say that trials of a 64-bit bipolar random access memory chip built with Bell Laboratories' collector diffusion isolation process [*Electronics*, International Newsletter, March 29] indicate that 1,024 bits plus decoding and interfacing can be packed on a single TTL-compatible chip. If so, it would represent a new high in bit capacity for a fast bipolar RAM. The company is using CDI to get a head start in what it sees as a very substantial emerging market for large, high-speed RAMs in computers.

The trial chip uses a variety of experimental circuit layouts. The memory bit is a single transistor with a low-current resistor in the base. The transistor acts as a bidirectional switch, charging and discharging its own collector-substrate capacitance, which constitutes the memory. A high ratio of collector-substrate capacitance to collector-base capacitance is necessary; 10 to 1 is optimal. The dynamic-mode trial chip, including a three-to-eight-line decoder and eight sense amplifiers, achieved a 75-nanosecond access time with 300-microwatt access dissipation and 5-μW standby dissipation in supply modulation use. The Ferranti men say access time can certainly be cut to 50 ns, and the power dissipation specifications at least maintained and possibly even reduced when and if the bipolar CDI chips are manufactured in still-larger configurations.

. . . as Japanese firms continue to push plated wire

Meanwhile, a number of Japanese manufacturers are continuing to develop plated wire memories and are announcing new products despite the trend to semiconductor stores. Pioneering Toko Inc. has just come forward with a 65-kilobyte plated wire memory module for medium and large computers, and Tohoku Metal Industries Ltd., a leading core memory manufacturer, has announced an 8-kilobyte plated wire module of its own.

Toko's memory is aimed at computers designed to compete with IBM's 370 series. The destructive-readout store has a full cycle time of 450 nanoseconds and access time of 220 ns. Price estimate is 2 cents a bit by the end of March, falling to less than 1.5 cents two years later. Tohoku's nondestructive-readout memory is built around the basic module announced earlier this year by the Nippon Telegraph and Telephone Public Corp. [*Electronics*, Electronics International, May 10]. Full cycle time is 500 ns and read-only cycle time is 300 ns, expected to fall to 350 ns and 200 ns, respectively, within a year. Initial price will be about 5 cents per bit; by 1973, the company expects to be offering memories of this type for less than 2.5 cents per bit.

Sony will drop plans for building plant in France

The French government apparently has discouraged Sony from establishing a manufacturing plant in France [*Electronics*, International Newsletter, July 5]. Finance ministry officials have told Sony representatives there will be "no concessions" on quotas restricting importation of components that would be necessary for building Sony television sets or tape recorders in France. Japanese sources in Paris say the tough French attitude, and now the monetary crisis, have forced their manufacturing plans "onto the back burner." Sony still has no factories in Europe; its products are marketed in France by Tranchant Electronique.

International Newsletter

Russian-German electronics deal is in the offing

The recent visit of a delegation of West German industrialists to Moscow has touched off strong speculation that new cooperation and licensing deals—including some for electronics—soon may be made with the Soviet Union. German electronics companies considered likely to enter such deals are AEG-Telefunken and Grundig GmbH; their top officials participated in the Moscow talks.

The Russians are reported to have shown strong interest in setting up, with Grundig's help, production facilities for audio and video recording equipment. Another subject of interest to the Russians is cooperation in producing components, communications gear, and control equipment—areas in which AEG-Telefunken is strong.

Japanese facsimile service may include real time capability

The international facsimile service proposed by Japan's Kokusai Denshin Denwa Co. [*Electronics,* International Newsletter, June 21] may also include a printed message capability encompassing facsimile, Teletype, or real time reproduction of a handwritten message or drawing. The company says it can transmit both a phone call and a printed message signal in a single voice-grade telephone channel. KDD is working on a new approach with telephone conversation and the written message going to the same destination. It could be designed so that the phone conversation is restricted to a half-channel bandwidth at the receiving end. Then high frequencies would be synthesized and reinserted when the written-message signal is also being sent. At other times, the phone call would occupy the entire channel. The narrow-bandwidth facsimile and Teletype signals can be transmitted in less than half of a telephone channel.

One source at KDD feels the real time drawing capability is a natural for use with Nippon Electric's Telemail system, in which a pen at the output end writes messages or drawings done with a stylus held by a user at the input end. This would be a valuable tool for engineers and salesmen, he feels, making the combined systems a "poor man's Picturephone" using only a single telephone channel.

Import tax may spur foreign firms to build TV sets in U.S.

With the new U.S. 10% import surtax expected to hurt foreign consumer electronics firms, look for overseas companies to emulate a deal in effect between Japan's Mitsubishi Electric Corp. and America's Wells-Gardner Electronics Corp. In a switch of the usual trans-Pacific arrangement, Wells-Gardner has been designing and building 25-inch color TV consoles to be sold in the U.S. under Mitsubishi's label; it's claimed to be the only pact of its kind between U.S. and Japanese TV companies. The original idea was for Mitsubishi to save huge charges incurred in shipping such heavy items to the U.S., but with the 10% surcharge in effect, Mitsubishi has an additional leg up on its competition because its U.S.-made sets are virtually unaffected.

Addenda

The latest Japanese companies to enter the electronic calculating scale business are Sharp Corp. and Omron Tateisi. Their products are underselling the others on the market and are forcing prices down . . . Among the early casualties of the 10% U.S. surcharge on imports are 3,500 Japanese middle- and high-school students who would have been hired by Hitachi Ltd. Hitachi now has cancelled this plan, and also has cut back on its hiring of college graduates.

Japanese test video phones as data terminals

System under investigation by NTT links time-shared computer with keyboard and facsimile printout at phone

A video telephone serves as a computer terminal, with all of the control and memory circuits located at the telephone exchange, in a system developed at the Electrical Communication Laboratory of the Nippon Telegraph and Telephone Public Corp. In addition to the standard TV telephone, the terminal equipment consists only of a keyboard for input of data and a facsimile receiver to make hard copies of the information displayed on the picture tube.

With control and memory equipment at a central location, many users can share them. Even with added cost of switching equipment, there should be a saving in installation cost.

Choice. The keyboard in the experimental terminal has four groups of keys. A group of 12 at the right side resembles the ordinary push-button-phone dial. Next is a group of 25 keys for symbols. The largest group, with 50 keys, is for roman alphabet characters or the Japanese katakana syllabary. At the other side is a group of 25 function keys. Keys select tones in three groups of five, five, and four frequencies each, giving 100 unique combinations.

At the central station, the equipment connected to one terminal includes a keyboard receiver, two different types of video response units, a switch controller and switch for selecting the output from one of the video response unit, and a facsimile response unit. There is also a central controller, a minicomputer, which has a drum memory for storage of Chinese kanji characters and a modem for connection to a time-shared computer.

One video response unit is the equivalent of the memory and pattern generator usually included in data display consoles. It has a pattern generator for alphanumerics, including the roman alphabet and katakana, and a small MOS memory to store codes of the alphanumeric character at each of 512 positions—in 16 rows of 32 characters each. The other video response equipment is used to display information, including Chinese kanji characters or graphics, originating in the data file of the time-shared computer or otherwise generated under program control from the computer.

The facsimile response unit converts the video signal into a slow-speed facsimile signal with a bandwidth equivalent to a single telephone channel. The signal is modulated onto a carrier that has a frequency slightly higher than the cutoff frequency of the video signal and is transmitted to the terminal on the same cable used to transmit the display video signal.

Flicker. The greatest shortcoming of the experimental system is the 1-megahertz bandwidth of the TV telephone. The individual dots making up the characters appear on only one of the two interlaced fields. Thus dots are displayed only 30 times per second and tend to flicker if brightness is reasonably high. This problem will be solved, though, if a 4-MHz bandwidth is selected for video telephones. By a slight change of synchronization it would be possible to change from a 512-line system, having 30 frames and 60 interlaced fields, to a 263-line system having no interlacing for displays. This would give almost the same vertical resolution as the present 1-MHz system and completely eliminate flicker.

International

Color TV—the Japanese knock on West Europe's door

The Common Market has been evolving in Western Europe since the Treaty of Rome went into effect in 1958. But despite the great strides made toward economic integration since that time, Western Europe is a crazy quilt for color TV producers. There are two color systems—PAL and Secam—and there are several sets of broadcast standards to boot. Even the cabinets have to be different, because what delights the eyes of Italians sometimes makes West Germans shudder.

West European producers, obviously, have long since learned to cope with the complex market pattern. And they're fairly well convinced that their feel for the way the Continental markets are stitched together will be a competitive weapon strong enough to contain the incursions of Japanese producers in European consumer electronics markets. [For a report on how they're faring, see p. 69.] And for color TV, there's an added line of defense—AEG-Telefunken's strong hold on PAL patents.

The Japanese, though, have begun to pierce this line. Both Sony Corp. and General Corp. have moved into the British province of PAL-land with sets that skirt Telefunken's patents.

General uses a subcarrier oscillator offset by one-half the horizontal frequency to get the necessary 180° phase shift alternate lines of the red-minus-luminance signal [*Electronics* International, Mar. 1]. Sony gets around the AEG-Telefunken patents by converting the PAL signal to an NTSC signal and then demodulating.

In normal PAL sets, the demodulator uses a reference signal that is switched in to demodulate the reversing-phase red-minus-luminence signal. Sony does away with the reference phase by means of a switch that is keyed to the flyback pulse. This switch selects a chrominance signal from every other line, either even or odd. The switch also rejects the signal from the line not selected—the choice is random and depends only on whether the switch locks first on an even or odd line. Chroma information for unselected lines comes delayed from the preceding line. Hence there's no phase alternation between successive lines.

Balance. This mode of handling the PAL signal obviously cuts the vertical chrominance resolution in two. But since the vertical resolution as broadcast is generally higher than the horizontal resolution, the end result is more or less balanced resolution and an acceptable image. The system at first glance seems oversimplified, but in essence it works much like the NTSC system used in the U.S. and Japan.

Along with the change in demodulation, Sony has turned to a different method of color synchronization to get around PAL patents. In the German system, the phase of the chroma subcarrier bursts alternates between +45° and -45°. Sony inverts the phase of alternate lines so that the burst phases are +45° and +135°. These two bursts are alternately impressed on the automatic phase control loop of the reference crystal oscillator. Its crystal has a high Q and thus can't follow instantaneous changes in phase. It settles down at the average of the two bursts—or 90°.

Sweden

Microwaves heat up Stockholm conference

If the 700 delegates to the Second European Microwave Conference, held last week in Stockholm, learned anything, they found out that there's a promising future for microwave technology in industrial applications. The conference's Swedish hosts showed what can be done—with little money, lots of ideas, and good salesmanship.

Of the eight papers at the conference on industrial applications, three were submitted by Swedes connected with the Microwave Institute Foundation of Stockholm—a unique organization in the electronics world. "The institute is market directed," says Bertil Agdur, who was able to convince the Swedish ministry of industry in 1968 that funding of a microwave foundation could bring results that would be profitable for Swedish industry and exports. Agdur is professor of microwave technology at the Royal Stockholm Institute of Technology, which first started a microwave department in 1960, with a four-man staff. Today, the foundation works on an annual budget of about $1 million, has a staff of 60, and gets about 75% of its funds from the government and the rest from industry or Swedish defense funds.

Wet. Agdur says his "selling job" to the ministry was made a little easier because his department had developed a device that was on its way to becoming a commercial success, and a company already had been set up to manufacture and market it. The device is a microwave moisture-measuring unit for use in the paper industry, and the company is Skandinaviska Processinstrument AB, owned 30% by an investment company linked to the giant Wallenberg banking-industrial empire, 30% by the large Swedish consumer cooperative federation, and the rest by private interests. Agdur was chairman of Skandinaviska Processinstrument until last month, when he became head of the Swedish board for technical development. As head of this state-supported board, which annually funds about $25 million in development projects, Agdur can be expected to apply the same pragmatic approach toward research and development that he successfully used at the Microwave Institute Foundation.

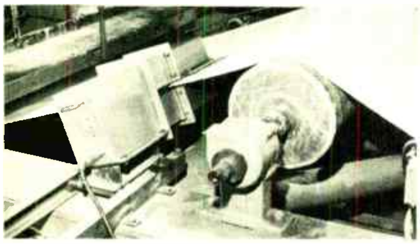
Versatile. "We regard ourselves as much more than just an institute," Agdur says. "We know the needs of industry and we can work on projects to fill these needs. Our boys get out of the lab and right onto the shop floor. We don't really regard ourselves as microwave specialists, but as a group that has knowhow in various fields."

Agdur emphasizes that one condition he set before accepting the top job at the technical development board was being able to continue his association with the foundation—as a board member and a consultant.

Skandinaviska Processinstrument's moisture meter has been marketed in Europe, Japan, and the U.S. for about two years and is the firm's major product. It uses a portable instrument that measures a dielectric constant, by means of microwave resonators, to gauge moisture in a web of paper during the manufacturing process. The meter can give an accurate picture of the critical moisture content.

The company's latest product is a microwave heating unit for drying paper in the final processing stage. Since the microwaves heat the water in the paper and not the cellulose fibers, the heating and subsequent drying can be controlled more accurately than by conventional warm-air-heated cylinders.

Now the institute has worked with industry in coming up with several other devices which were described in papers delivered at the conference. One device described by Christer Bergling and Bengt He-



At work. Conference covered uses of microwaves, such as in moisture sensing.

noch, measures the diameter of wire as it is drawn on wire-making machines. Up to now diameters have been checked by taking samples and measuring—either by weight or with a micrometer. There can be wide variations between samples: wire-making machines can turn out wire at 60 miles an hour or more. The institute's device, developed in cooperation with Sieverts Kabelverk AB, subsidiary of the telecommunication firm, L.M. Ericsson, functions by passing the wire through a cavity resonator. The device measures wire with diameter down to 10 microns with an accuracy of ±0.001. Readout is either digital or on graph paper. By using two resonators—one before the wire is coated with insulation and one after—measurements can be made on thickness of insulation.

Another paper describes using a microwave cavity for detecting small length changes in metals. So far this technique has been used in metallurgical laboratories and in seismography. The operating principle is that changing the resonant cavity changes the frequency. Used in a seismometer, the technique can provide more sensitive readings of earth movements and longer seismic waves than are obtained by conventional velocity meters.

Great Britain

Fixed path vs adaptive routing in data networks

Most Britons connected with computers believe that by 1980 the country will have a national data network, though nobody knows what form it will take. That decision rests with the government, through the post office, which will run it. However, there is no shortage of people prepared to offer advice. The latest proposal to be publicized comes from Sussex University, where half a dozen researchers have done computer simulation studies of a possible nationwide computer network. Team leader Trevor Beeforth outlined the ideas at the IFIP Computer Systems Congress in Yugoslavia last week.

Beeforth believes that data network users will be very much concerned with the way the system works. He thinks a system that seeks out a route along which all the packets of data in a message can pass—and guarantees to hold it until the message has finished—will have greater customer appeal than the adaptive routing method. In adaptive routing, the individual data packets find their own path through the network and may travel by different routes, so that they have to be reassembled by a computer in the correct order on arrival. In Britain, the National Physical Laboratory has proposed an adaptive network, and claims in its favor that eliminating the fixed route does away with the need to re-establish it if a link should fail in mid-call.

For real. Assuming 25-node exchanges in the network (a common assumption for England, Scotland, and Wales), the Sussex men have simulated the operation of a dedicated connection system. The nodes are interconnected to represent something approaching a real situation: more than one route is possible between any two nodes, and there are some bottlenecks.

To set up a connection, a route search message of about 70 or 80 bits is sent through the system to the terminus to seek out a route. In principle, the search message tries the most direct route first, then the least indirect route, and so on; but in practice the principle is varied to spread the loads.

The search packet has to find vacant capacity on each of the transmission links between the exchanges, but Beeforth doesn't think that exchange capacity will be a problem. Once a duplex route is found, this capacity is reserved for the user until he has run his message, and received his answer.

The simulation shows that, assuming likely bit rates of 2 megabits, the average number of links used per call when the system is 50% loaded is 2.5, or an average of 3.5 exchanges per call, though some calls were using as many as 11 links. If all calls had gone by the most direct route, the link figure would have dropped to 2.3, indicating that at that loading roundabout routing is not extensive. At only 10% loading, the average number of links used is 3.4, showing that at light loadings more calls requiring many links are successfully connected. At 90% loading the link average figure is only 1.5 links and the longest connection is three links, showing that no long-distance calls are getting through. In fact, the probability of a call's getting through remains at over 98% until the system is loaded to somewhere between 30% and 40%, when it begins to drop sharply. Beeforth deduces that the operational optimum may be somewhere in the 38% to 50% loading range.

Pilot. A search packet establishes a route by first interrogating each exchange it meets for a listing of the exchanges that could serve as the next step to the destination. Then it asks for the present loading on each of those links. Hence the route is established in stages from each exchange. Beeforth says that the university's Modular One computer, which has a 750-nanosecond cycle time, carries out the routing search and subsequent reply processes in about 220 microseconds. Thus the complete multistage route search is likely to take from a few milliseconds up to some tens of milliseconds, allowing for queueing delays, using a small computer.

Beeforth does not think route searching will occupy a worrisome percentage of system capacity unless the vast majority of messages are very short. However he concedes that this might turn out to be the pattern of data traffic. He points out that once the search packet has established the route, the following message data packets need only a few bits of address data each. With 512 bits per packet and an average of 10 packets per message, the ratio of message data to housekeeping is about 65%.

To prevent search packets from going around indefinitely in a heavily loaded system and gradually bringing it to a stop, the Sussex team proposes that the subscriber give each message a priority rating, paying more for high priority. He would tack a number to the search packet. For every deviation from the most direct route that has to be made, one unit or more is knocked off the rating number. When it reaches zero, the search is killed. Hence high priorities with high numbers get more chances.

Beeforth claims that his system would need nothing special in the way of computer exchange equipment. It would need a big read/write store, controlled by multiple small central processors, with minicomputers acting as input/output units.

France

How to take "pictures" inside the human body

A woman doctor in the French provinces has inspired a group of French researchers to develop a compact "camera" to examine organs of the human body. The first few months of tests indicate the new device might provide a serious challenge to the monopoly on gamma-ray cameras long sustained by Nuclear of Chicago's exclusive patent rights.

The French "multidetector" was designed for Dr. Therese Planiol of the Hospital Bretonneau in Tours, 140 miles southwest of Paris, by a team of electronics specialists at the government-backed Laboratoires d'Electronique et de Technologie de l'Information in Grenoble.

Planiol says the LETI prototype has given "very encouraging" results compared with her experience on the hospital's two gamma cameras. The multidetector can visualize an organ on an oscilloscope within a minute and a half, producing a more sharply defined image than the classic scintillation camera or linear scanner. It also can treat the data for storage in a computer memory.

The LETI developers claim the multidetector's main advantages are its low cost (around $10,000, or about one-fourth the gamma camera price), its compactness, its quick readout, and the fact that it subjects the patient to one-tenth as much radiation as currently used methods of examination.

Sales. The Paris-based Compagnie Générale de Radiologie (CGR) is studying the commercial prospects of the multidetector and says there is a "strong possibility" it will be marketed. CGR last winter took over the Medical Electronics division of Westinghouse and maintains a worldwide sales effort.

The greatest success registered so far has been with the examination of thyroid glands at Planiol's regional hospital. The thyroid was chosen for the first tests because it is a small organ close to the surface of the body.

Dozens of patients in Tours have been injected with small doses of radioactive iodine I_{125}, then examined 24 hours later by the LETI multidetector. The device uses a proportional gas counter tube filled with xenon-methane gas mixture under 5 atmospheres of pressure to visualize the radioactivity emitted from the organ.

The use of the proportional gas counter tube was an outgrowth of another LETI project, this one in cooperation with German scientists working at the Institut Laüe-Langevin in Grenoble. It was there that the original multidetector was conceived to replace conventional diffractometers in the study of neutron diffraction. The Franco-German "pure science" multidetector was designed for quick plotting of X and Y coordinates of neutron trajectories.

When Planiol learned of the original multidetector, she saw the possibility of an application in the growing field of nuclear medicine. She approached LETI, and the design was worked out jointly about a year ago by her and a staff of engineers headed by Dr. Robert Allemand, chief of the lab's nuclear electronics division. The thyroid ensemble is now considered workable, and heart and lung adaptations are in the development stages. The heart test will necessitate injection of cesium$_{131}$. Patents have been taken out on all three adaptations.

The visualization is accomplished by using a collimator to direct the flow of rays from the irradiated organ into the gas counter. Inside the counter tube is a screen of interlaced cathode strips with vertical and horizontal crossings in alignment with each of the 1,024 channels of the collimator. The cathode device serves to plot the X and Y coordinates of the electrons as they strike the screen.

But to amplify the signal from the electrons—which measures only 27 kilo-electron-volts in the thyroid tester—Allemand's team introduces electric current along an anode screen sandwiched between the cathode planes. As the rays hit the gas and are transformed into electrons, they move onto the cathode-anode screen and create a cascade amplifier effect. The X and Y coordinates can be interpreted from the cathode strips and can be visualized dynamically on the oscilloscope screen or produced in digital form for storage.

Aglow. LETI officials have shown visitors the strikingly sharp oscilloscope images produced in thyroid tests. All parts of the gland that contain the iodine give off a healthy green glow. Unirradiated parts are blank, giving the doctor clues to the gland's deficiencies.

Andre Benoit, a director of CGR, is involved in deciding whether to go ahead and market the multidetector. "We see this as a promising tool in examining organs that are transparent or close to the skin's surface," Benoit says. "It will not perform all the functions of a gamma camera, but it does a better job than the standard camera in many areas."

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1.5			2N3866		
2.0				BLX65	
2.5			2N3553	BLX66	
3.0		2N3924		BLX67	BLX92
4.0		BFS22A	BFS23A		
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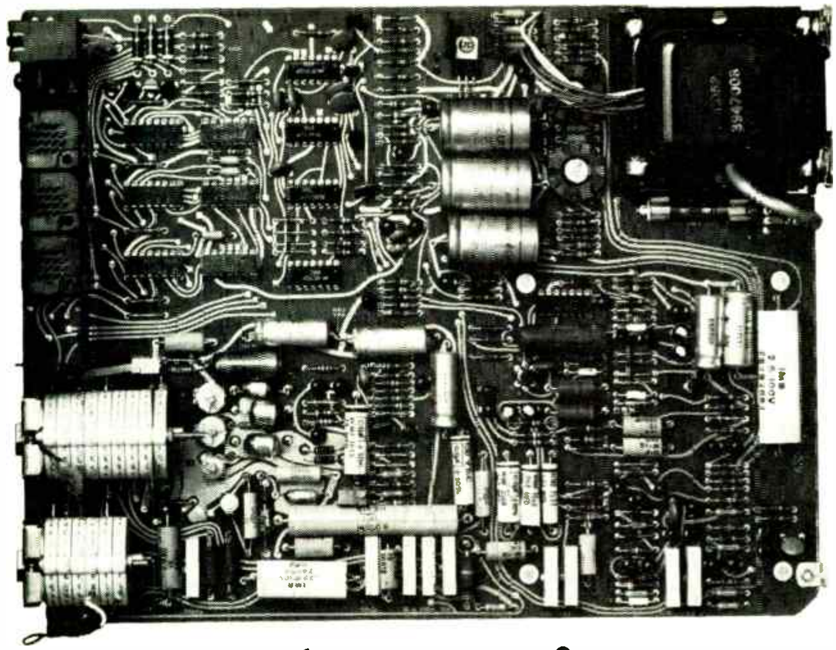

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Office 17 Kontor-Center AB, Hagagarten 29
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European Special Project Manager: Oliver Ball
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Tokyo: Masaru Wakeshima McGraw-Hill
Publications Overseas Corporation
Kasumigaseki Building 2-5, 3-chome
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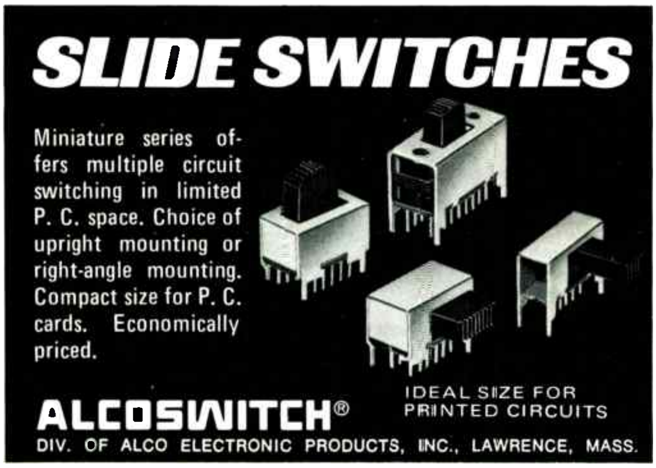

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9	30	51	72	93	114	135	156	177	198	219	240	261	282	303	324	345	366	387	408	429	450	471	492	968
10	31	52	73	94	115	136	157	178	199	220	241	262	283	304	325	346	367	388	409	430	451	472	900	969
11	32	53	74	95	116	137	158	179	200	221	242	263	284	305	326	347	368	389	410	431	452	473	901	970
12	33	54	75	96	117	138	159	180	201	222	243	264	285	306	327	348	369	390	411	432	453	474	902	971
13	34	55	76	97	118	139	160	181	202	223	244	265	286	307	328	349	370	391	412	433	454	475	951	972
14	35	56	77	98	119	140	161	182	203	224	245	266	287	308	329	350	371	392	413	434	455	476	952	973
15	36	57	78	99	120	141	162	183	204	225	246	267	288	309	330	351	372	393	414	435	456	477	953	974
16	37	58	79	100	121	142	163	184	205	226	247	268	289	310	331	352	373	394	415	436	457	478	954	975
17	38	59	80	101	122	143	164	185	206	227	248	269	290	311	332	353	374	395	416	437	458	479	955	976
18	39	60	81	102	123	144	165	186	207	228	249	270	291	312	333	354	375	396	417	438	459	480	956	977
19	40	61	82	103	124	145	166	187	208	229	250	271	292	313	334	355	376	397	418	439	460	481	957	978
20	41	62	83	104	125	146	167	188	209	230	251	272	293	314	335	356	377	398	419	440	461	482	958	979
21	42	63	84	105	126	147	168	189	210	231	252	273	294	315	336	357	378	399	420	441	462	483	959	980

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9	30	51	72	93	114	135	156	177	198	219	240	261	282	303	324	345	366	387	408	429	450	471	492	968
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12	33	54	75	96	117	138	159	180	201	222	243	264	285	306	327	348	369	390	411	432	453	474	902	971
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14	35	56	77	98	119	140	161	182	203	224	245	266	287	308	329	350	371	392	413	434	455	476	952	973
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16	37	58	79	100	121	142	163	184	205	226	247	268	289	310	331	352	373	394	415	436	457	478	954	975
17	38	59	80	101	122	143	164	185	206	227	248	269	290	311	332	353	374	395	416	437	458	479	955	976
18	39	60	81	102	123	144	165	186	207	228	249	270	291	312	333	354	375	396	417	438	459	480	956	977
19	40	61	82	103	124	145	166	187	208	229	250	271	292	313	334	355	376	397	418	439	460	481	957	978
20	41	62	83	104	125	146	167	188	209	230	251	272	293	314	335	356	377	398	419	440	461	482	958	979
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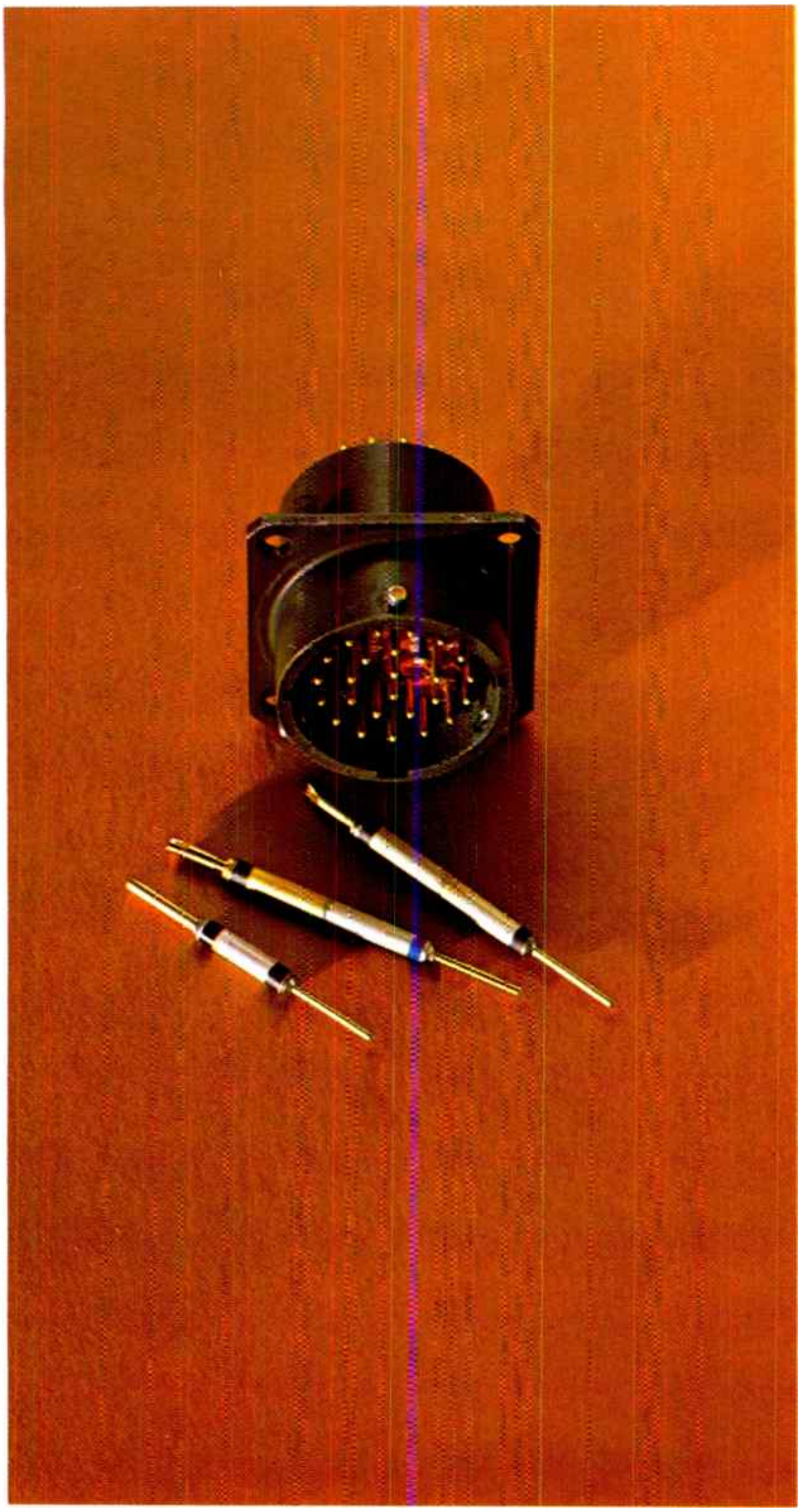

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