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EUROPE

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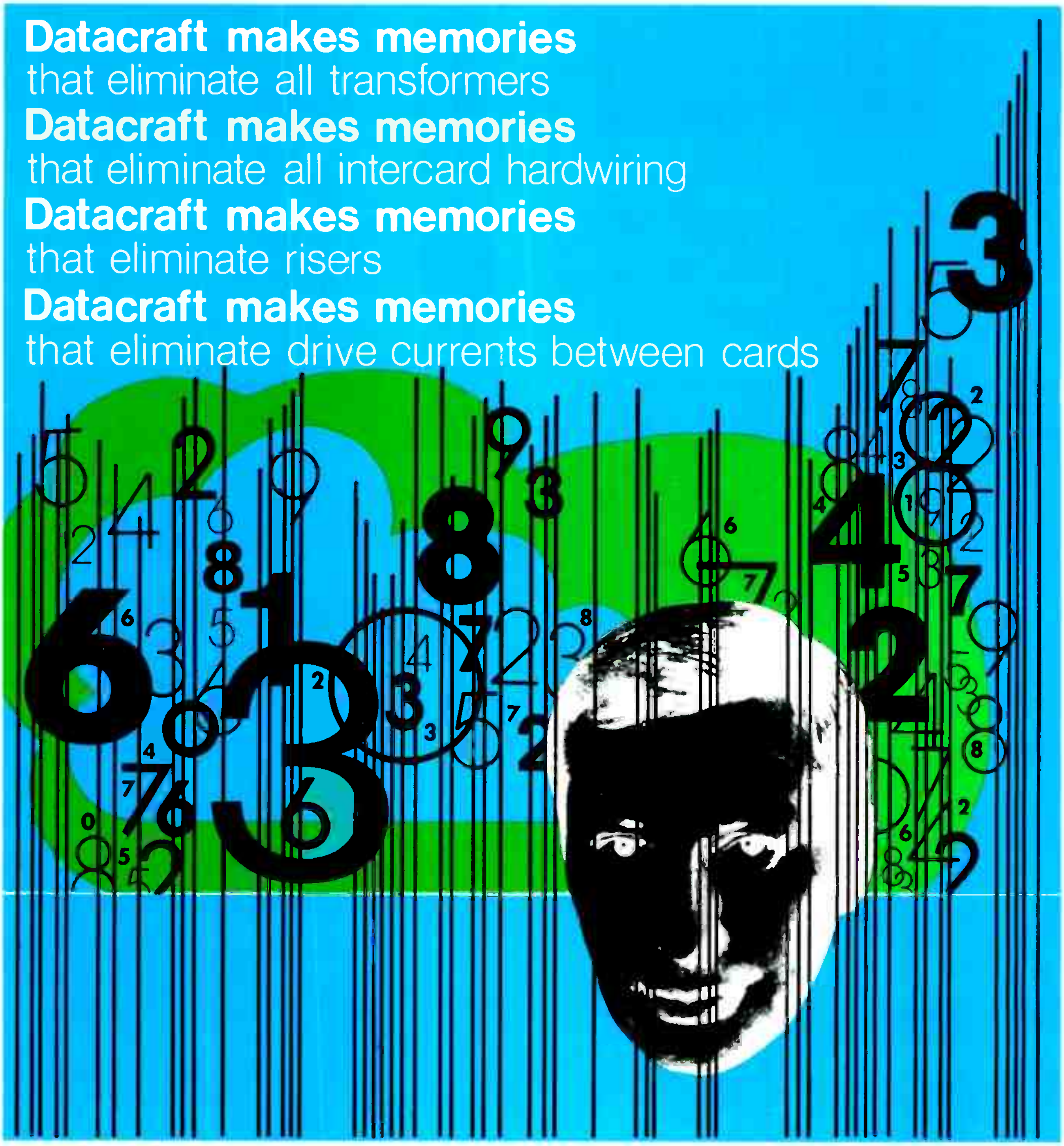

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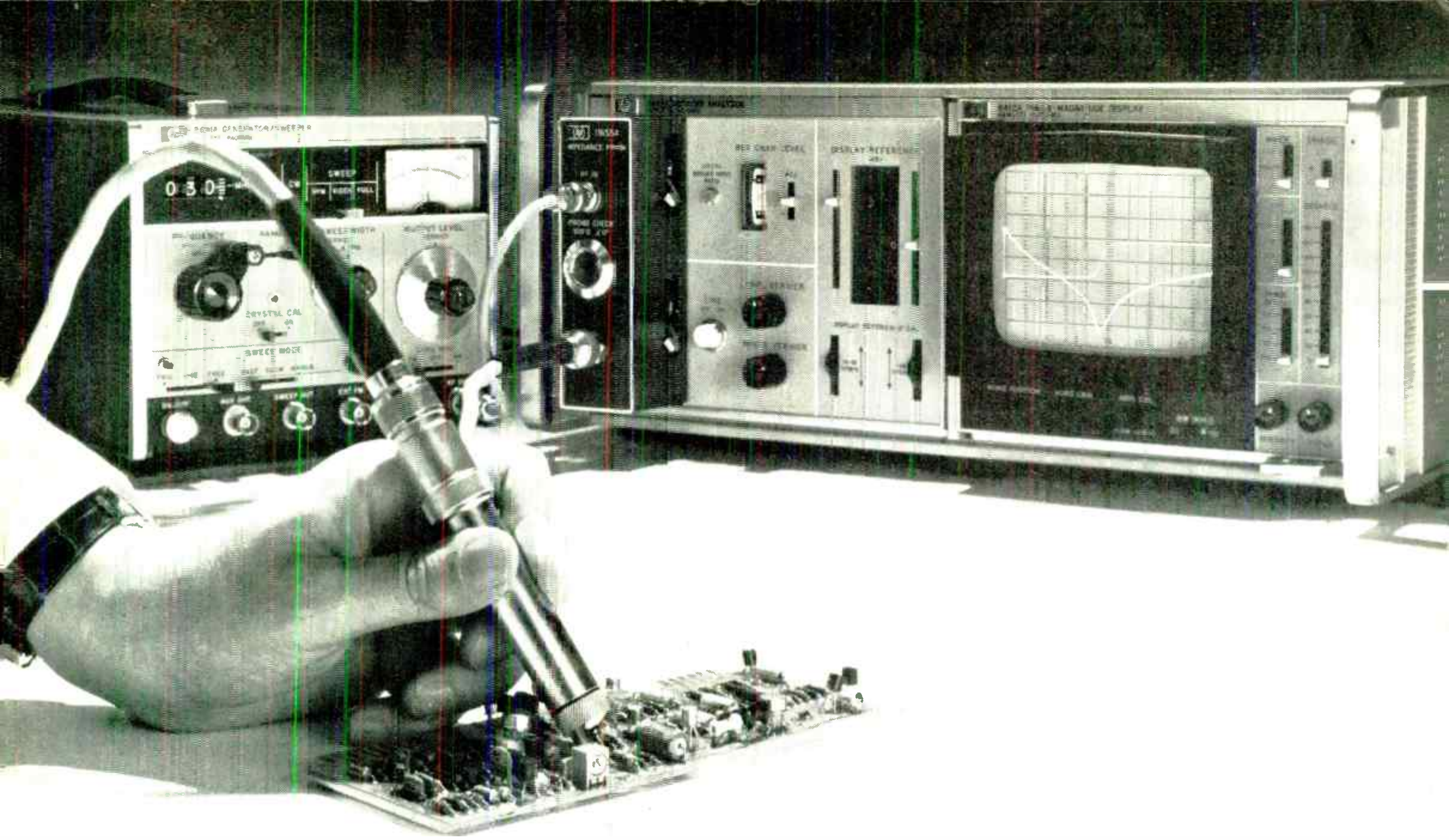

Introducing "touch & see" swept impedance measurement. Now the "do-everything" RF test system does even more.

Just add our new impedance probe to the HP 8407A Network Analyzer, and you can measure complex impedance of circuits, coax systems, discrete components. View impedance excursions over the wide range from 0.1Ω to 10KΩ as you sweep between 500 kHz and 110 MHz.

The HP 8407A Network Analyzer itself makes comprehensive swept RF measurements quickly, and with high accuracy. You see important characteristics like gain/loss, phase shift, voltage and current transfer functions, group delay, impedance, return loss and S-parameters. Dynamic range is greater than 100 dB, yet you can resolve 0.05 dB. It has 360° phase range with 0.2° resolution.

The 8407A Network Analyzer with the 8412A Phase-Magnitude Display costs $4525. The new impedance probe (Model 11655A) costs $750. Other accessory kits for circuit probing and for general measurements in coaxial systems are also available, priced from $325 to $500.

To learn more about how our "do-everything" network analyzer can help you in design and production test applications, call your field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

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NETWORK ANALYZERS

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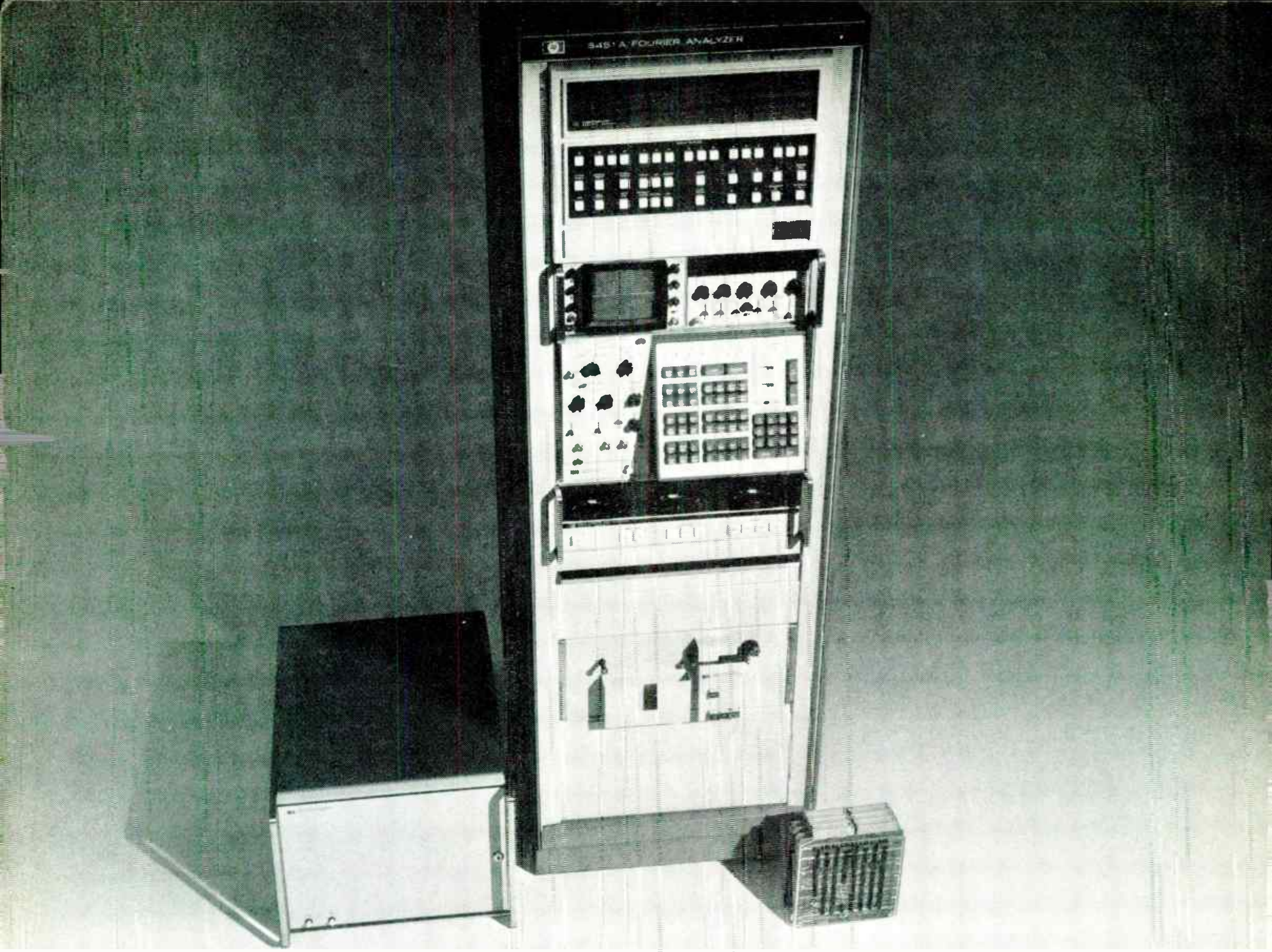

Introducing the 3-speed FFT Signal Analyzer.

So many different uses have been found for our signal analyzers that we've come up with three new models to cope with different needs.

We think our new system and Fast Fourier Transforms Processors represent a significant step forward in the analysis of mechanical and structural vibrations, environmental stress, sonar and other acoustical studies. They can even be used for preventive maintenance and "listening" for oil.

First gear: the new HP 5451A Fourier Analyzer. This complete, push-button system is faster than our earlier versions, taking only one second to perform a 1024-point transform. We've extended its dynamic range to 80 dB for both power and voltage spectrums. So you don't miss those buried weak signals any more. Complete, ready-to-use software is furnished with the system but special user-written software can be easily added. On-site installation and a comprehensive training program are included. Yet with all these advantages, the $35,000 price tag is much lower than any comparable system on the market.

Second gear: the new HP 5471A FFT Arithmetic Unit. Plug it right inside our Fourier Analyzer's computer and you get a 1024-point transform in 160 milliseconds with no change in operation. The new FFT AU can also be used simply as an additional arithmetic unit in any HP computer to perform fast Fourier transforms of up to 2048 points. And it will only set you back $4500.

Third gear: the new HP 5470A Fast Fourier Processor. Add it to any of our analyzers and it gives you a transform time of 15 milliseconds, letting you carry out continuous real-time power spectrum analysis up to 20 kHz. Multiple 5470's can be used for even greater increases in speed. It handles complex block arithmetic including multiplication, conjugate multiplication, addition, block scaling and HANNING, in addition to the Fourier transform.

The processor's self-contained memory allows parallel processing in the computer and the processor for faster analysis speeds. Options include transform sizes to 4096 points, and an 8K memory instead of the standard 4K. The cost: $25,000.

We'd like to show you all these new refinements. If you'd like to see them, call in your local HP representative. Or write for complete information to Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

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SIGNAL ANALYZERS

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Electronics

The International Magazine of Electronics Technology

December 20, 1971

Volume No. 44, Number 26

Publisher's letter

Washington Commentary—that's the title of the new department we've inaugurated this issue. It's aimed at giving you the perspective and behind-the-scenes details to better understand the way things are going in the capital—and how they affect what's going to happen in our industries.

Writing Washington Commentary is Ray Connolly, our Washington bureau manager. A veteran newspaperman, Ray has covered the nation's capital for six years, the last three of those years for *Electronics*. A cannier and more knowledgeable commentator would be hard to find.

The first commentary, on page 38, delves into the reasons and results of David Packard's resignation as deputy secretary of defense. Ray is just the man for that analysis, having interviewed Packard a number of times since his arrival in the Administration 35 months ago and having carefully reported his activities in the Pentagon.

The end of the year is traditionally the time for summing up. And it has become a tradition here at *Electronics* to bring you a triple-barrelled end-of-the-year summation of where the key electronics markets are headed. We've already covered Japan. This issue we feature Europe. The next is devoted to the U.S.

To produce this year's West Europe special report (see page 87), we sent a group of one dozen reporters and researchers into action in 11 countries. In addition to our own four overseas staffers, we had the help of eight reporters from McGraw-Hill World News, which maintains a worldwide stable of business journalists.

Arthur Erikson, our Paris-based Managing Editor, International, coordinated both the country-by-country survey and the writing of the report.

"Until you've been involved on a deep-research project like this," Erikson writes, "you can hardly believe how much work is invested in it. As a rough estimate, I'd say that at least 30 man-weeks went into the interviewing to gather the data for the charts and the text.

"And a good part of the toil was logged by our European Special Projects man, Oliver Ball, who scouted up inputs in 10 countries for the forecasts that go to make up the charts. We analyzed the mass of raw data to codify the inputs and developed some 3,200 consensus estimates to describe the West European market."

This is the seventh year we've done the job and the contributors are veteran reporters in their geographic areas, making the report, we feel, more authoritative than ever before.

The credits: *Electronics'* own field men John Gosch (West Germany) and Mike Payne (Great Britain); World Newsmen Mike Johnson (France), Andrew Heath (Italy), Robert Skole (Sweden), James Smith (Holland and Belgium), Dominic Curcio (Spain), Laura Pilarski (Switzerland), John Heaslip (Denmark), and Haakan Boerde (Norway).

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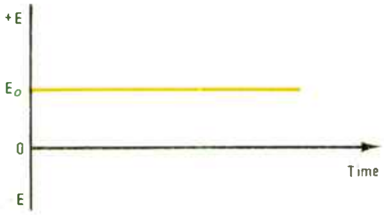
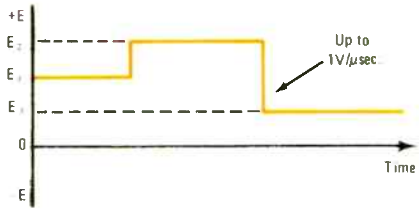
what's a BIPOLAR power supply?

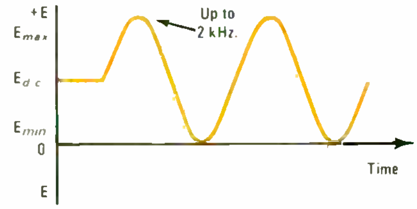
The world is full of power supplies that can do this:



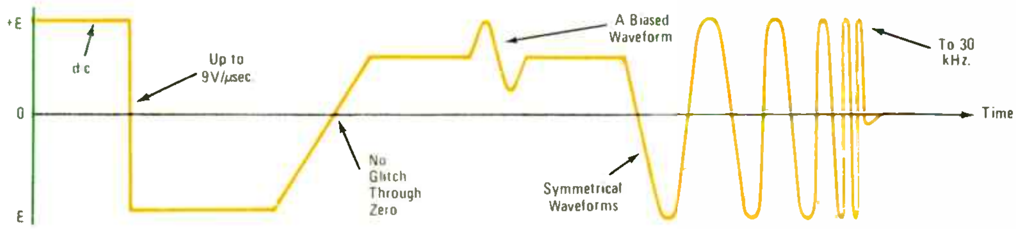
Even programmable ones that can do this:



Or this:



Only a BIPOLAR OPERATIONAL POWER supply (we call 'em BOP) will let you do things like this:



We make a bunch of different BOP's:

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The ±36V BOP's are illustrated in metered and modular styles.
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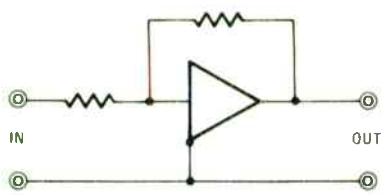
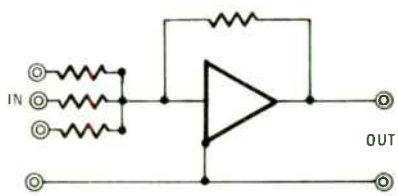
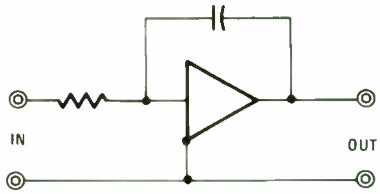
The "OPERATIONAL" part of the BOP means that you use 'em like giant OP-Amps:



SCALE OR AMPLIFY



SUM OR SUBTRACT



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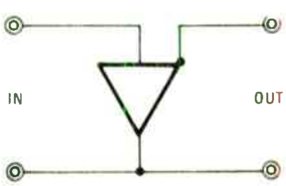
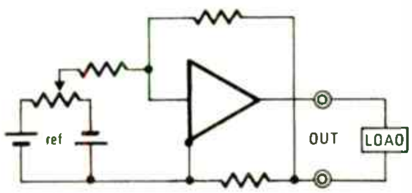
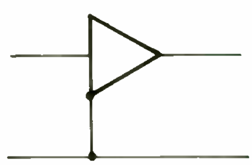


FOLLOW A VOLTAGE



CONTROL A CURRENT BI-DIRECTIONALLY



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Readers comment

Correct operation

To the Editor: In my Designer's Casebook, "Comparator logic limits switching regulator current" [Nov. 8, p. 79], there were a few errors. The inductor between D_1 and Q_1 should be 0.1 millihenry, not 0.1 microhenry. And the note "integrate pulse to get triangle" refers to the 0.1-microfarad capacitor in the lower righthand corner of the drawing. Finally, the switching points on the triangular wave should be opposite each other, one on the rising leg and the other on the falling.

Robert S. Olla
National Semiconductor Corp.
Santa Clara, Calif.

Figure of merit

To the editor: I was interested in your summary of R.W. Keyes' conclusions regarding the eventual limitations on computing speeds and performance imposed by heat dissipation [Oct. 11, p. 34]. Two years ago, at the International Electron Devices Meeting, I reported identical conclusions, but in terms not simply of ultimate speeds, but of a more interesting quantity—how much computing capability a dollar's worth of hardware will buy. I show that this figure of merit depends on the power-delay product of the switching device, which, for semiconductor devices, appears to bottom out at about a few picojoules per bit. Only by lowering this can performance be improved.

T. P. Brody
Westinghouse Electric Corp.
Pittsburgh, Pa.

Mistaken acronyms

To the Editor: Regarding the LEAA guidebook "Police Telecommunication" [Nov. 8, p. 51], the following may be helpful to your readers. The book is obtainable for $4.75 a copy from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. It was written by the IIT Research Institute, Chicago, Ill. We are a part of the Illinois Institute of Technology, and not International Telephone and Telegraph Corp.

B. Ebstein
IIT Research Institute
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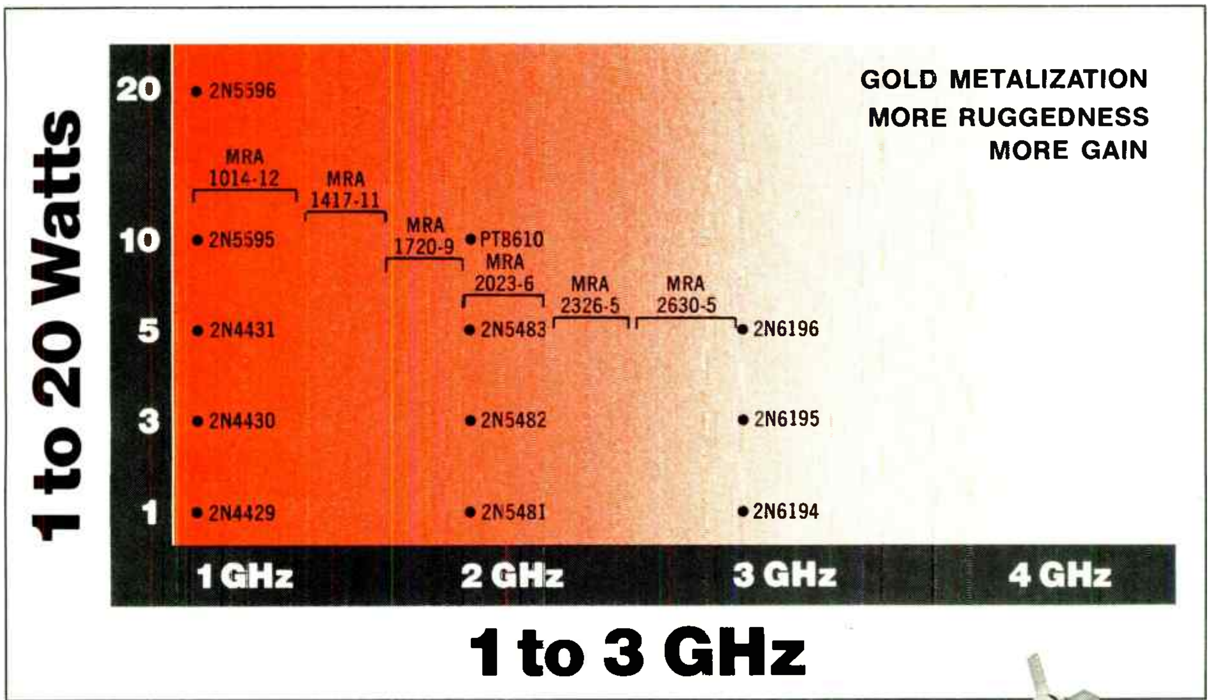

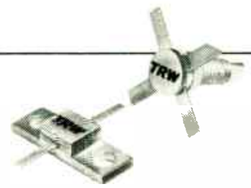

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40 years ago

From the pages of Electronics, December 1931

New tubes are being developed. New circuits are being invented and applied. New services are being put onto existing wire networks. New electrical principles are being applied for familiar uses. Ease of tuning is being improved. Sound recording has been radically altered on disks and film. New converters and inverters give new flexibility of appliances and circuits. The exquisite mechanics of the electron itself is being harnessed for everyday service. And even the citadel of the atom and its positive nucleus are being hammered and now bid fair to crack—with what undreamt electronic results!

The number of radio receivers in Europe seems to keep pace with the number in the United States. In 1929, the number in use in Europe was roughly 11,000,000, in the United States and Canada slightly less, in 1930 the numbers were about the same, and in 1931, the number of receivers in use in Europe was 13,000,000 roughly.

Radio has never taken seriously the threat that music might, someday, come into the home by means other than through "the air." Telephone wires are in telephone service only 18 minutes of the day; systems are ready by which programs of high-grade music could go over the same conductors. A system is ready for installation for transmitting several music channels over power wires.

Already announced is a phonograph record that will play for 15 minutes, or 30 minutes if turned over once. There need be no talk on them. Fidelity and volume range can be vastly better than the average radio set can interpret.

By a close decision of three to two, the Radio Commission has denied the application of the Columbia Broadcasting System to install a 250-watt booster station in Washington, D.C., to be synchronized to the clear channel of WABC, its New York key. The station was sought as an experiment on feasibility of common frequency operation.

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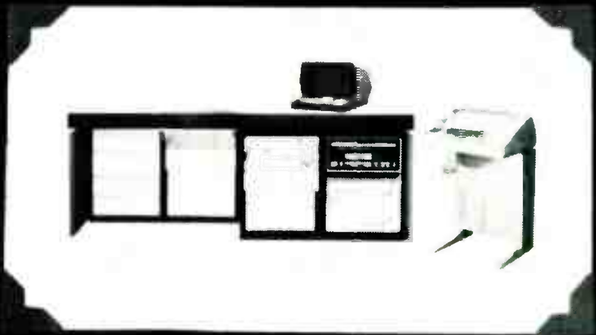

Full Capability Logic Circuit Analyzer
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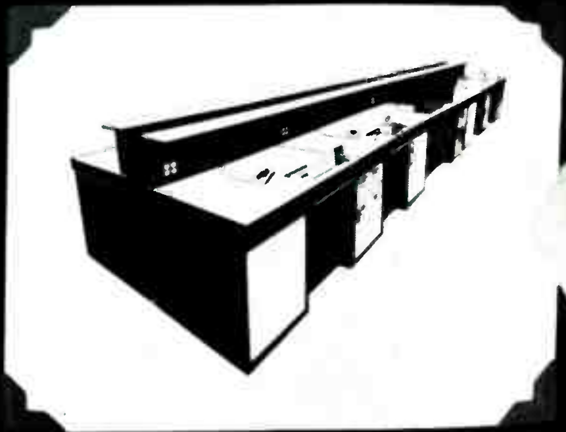

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. . . a faster, lower-cost way to perform analog tests, logic tests, and passive tests. Take your pick of any combination to measure (simultaneously, if you wish) analog, hybrid and digital pc boards; active and passive networks; hybrid IC's; active, passive and digital components. But, get only the capabilities you need now. Don't worry about adding more later; we've already made provision for expansion with modular hardware and software.

Here's the big difference between our system and others. The measurement units in GR Systems 2200 are modules especially designed for computer control. They are not automatic instruments adapted for computer control but unique modules that do their jobs faster than instruments. There's no time wasted translating commands, driving readouts, and the like. You get faster testing, increased throughput, and over-all cost savings in your test operations.

The "ultimate" system illustrated was designed and built for a giant electronics manufacturer who needed 10-station capability to handle a huge volume. Almost everybody's testing requirements, however, can be satisfied with a single-station system, selecting from the several modules already designed for the 10-station ultimate.

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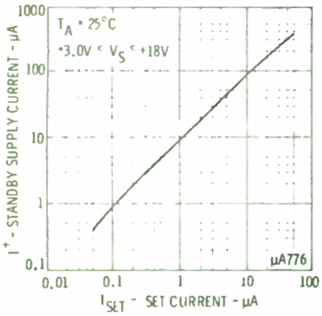
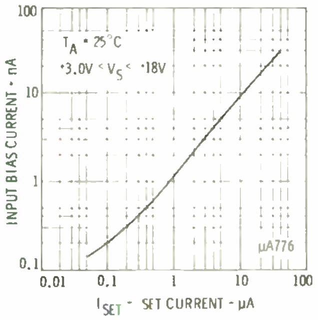
μA776 Typical Performance

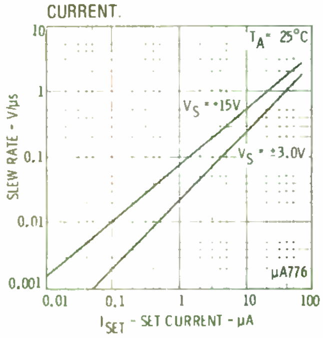
QUIESCENT SUPPLY CURRENT AS A FUNCTION OF SET CURRENT.



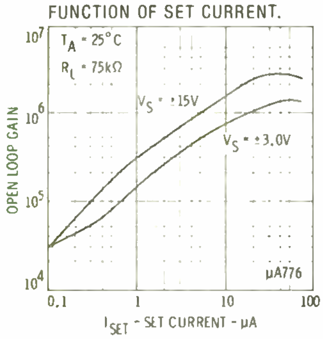
INPUT BIAS CURRENT AS A FUNCTION OF SET CURRENT.



SLEW RATE AS A FUNCTION OF SET CURRENT.



OPEN LOOP VOLTAGE GAIN AS A FUNCTION OF SET CURRENT.



The wide range of available characteristics makes it extremely versatile. And useful. It is adjustable for either standard or micropower application. It can be biased to have any of a number of fixed characteristics; or biased so that the characteristics of the amplifier can be varied in response to an input signal. And it can be turned on or off externally.

The μA776 offers superior operation at levels similar to standard general purpose op amps. In fact, when biased with a 15μA set current, it has approximately the same gain, slew rate and bandwidth as a μA741. But with an *order of magnitude improvement* in input bias current, input offset current, noise current and power dissipation.

Or you can operate it from a supply voltage of only ±1.2V. This means the device can be run off of two battery cells and with the proper set resistor the total power drain of the op amp will be lower than the battery leakage.

The broad versatility of the μA776 means it is ideal for micropower applications, battery powered systems, medical electronics, long-time integrators, high-accuracy sample and hold, frequency processors and active filters. For many uses, it becomes the only op amp you need specify on your standard parts list.

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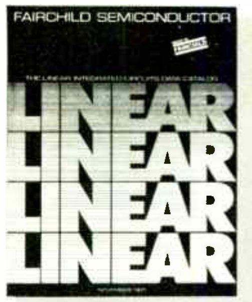

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People

Saxton wants EEs to hear traveling music

Although he calls himself "one of the new breed of NASA retreads," Lyle G. Saxton has a dedication to ground transportation systems that extends beyond merely earning his livelihood. His avocation is to interest aerospace-oriented EEs in broadening the engineering base of transportation.

"There's a real future for the electronics community in surface transportation systems," says Saxton, head of the Federal Highway Administration's Systems Development and Technology group, "the appreciation for the systems aspects—interaction of programs, and hardware design and fabrication cycles—make aerospace experience useful," he contends.

Saxton typifies the engineer he is trying to convert to traffic systems engineering—he previously worked as a systems manager at NASA's Goddard Space Flight Center on the Earth Resources Technology Satellite, and earlier, at RCA's Astro-Electronics division in camera design for meteorological satellites.

Challenge or frustration? The biggest difference between NASA and the ground transportation agencies is the 30,000 political subdivisions that the Federal highway, railroad, and mass transit agencies have to deal with. For example, "since the Federal Highway Administration doesn't own and operate its system like NASA does," Saxton explains, "implementation is a sales program to the states." Like the diverse markets that companies run up against when developing transportation electronics systems, the agencies' relationships with the states can be seen as either challenging or frustrating.

Saxton's biggest part-time effort in his campaign to convince aerospace EEs to make the jump to transportation was a stint as guest editor on the IEEE Transactions on Vehicular Technology, where he produced a special issue on highway electronic systems for February 1970. "And we're planning another special issue for February 1973," he says. "The first was a survey of the state of the art; the next will have sections on automatic vehicle monitoring [*Electronics*, Aug. 2, p. 77], dynamic traffic control, and highway communications [*Electronics*, Oct. 25, p. 101]."

Saxton: Of the new breed of NASA retreads.

Reinig expects 1975 to be a happy new year

Many medical electronics marketing men forecast a steady rise in the demand for patient monitoring systems. But William Reinig has a different idea. He expects business to level off, stay there a while, then jump in 1975. To prepare for that jump, the former Medtronic vice president has started his own company in Madison, Wis., called Med Data Inc.

Reinig is an EE who became interested in medical electronics while designing data-acquisition systems for electroencephalographic studies. His decision to start the new firm springs partly from a desire to get back to such design work.

In March, Med Data will introduce a series of electrocardiogram machines featuring computer analysis. But the company's eye is really on the middle of the decade when, as Reinig puts it, there will be a "renaissance in monitoring gear."

Meetings

Power Engineering Society Winter Meeting: IEEE, Statler Hilton Hotel,New York, Jan. 30-Feb. 4.

Integrated Optics Meeting: IEEE, OSA, Sands Hotel, Las Vegas, Nev., Feb. 7-9.

Aerospace & Electronics Systems Winter Convention (WINCON): IEEE, Biltmore, Los Angeles, Feb. 8-10.

International Solid State Circuits Conference: IEEE, Sheraton Hotel, University of Pennsylvania, Philadelphia, Feb. 16-18.

International Geoscience Electronics Symposium: IEEE, Marriott Twin Bridges Motor Hotel, Washington, D.C., April 9-14.

International Conference on Magnetics (INTERMAG): IEE, Kyoto International Conference Hall, Kyoto, Japan, April 19-21.

Southwestern IEEE Conference & Exhibition (SWIEEECO): IEEE, Baker Hotel & Dallas Mem. Aud., Dallas, Texas, April 19-21.

Off-Shore Technology Conference: IEEE, Astrohall, Houston, Texas, April 30-May 3.

Spring Joint Computer Conference: IEEE, Convention Center, Atlantic City, N.J., May 15-18.

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1972 International Symposium on Electromagnetic Compatibility: IEEE; Arlington Heights, Ill., Jul. 18-20. Submit all papers to J.J. Krstansky, Chairman, Program Committee, ITT Research Institute, 10 W. 35th St., Chicago, Ill. 60616, no later than Jan. 14.

1972 Annual Conference of the Association for Computing Machinery: IEEE, Boston, Mass., Aug. 14-16. May 20 is the deadline for submission of papers to Prof. John J. Donovan, ACM72 Technical Program Chairman, MIT Project MAC, 545 Technology Square, Cambridge, Mass. 02139.

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Electronics Newsletter

December 20, 1971

Bell developing fast 15-megabit bubble memory

Bell Laboratories' massive magnetic-bubble effort is paying off to the point where researchers are developing a 15-megabit mass memory that can access each of its 1,328-word blocks in 1.25 milliseconds. Each garnet chip contains 19,920 bits stored in 80 249-step shift registers, and each register is linked to I/O circuitry via a single 249-step register.

The importance of the development can be seen in a comparison with disk files. A moderate size disk file—10 million to 100 million bits—would occupy 2 feet on each side. In contrast, the bubble memory would require only 2 to 3 inches of space. For power, the bubble requires 10 watts but the disk needs 500 W. Access time for the bubble is an order of magnitude less, while its storage density is three orders of magnitude better. And the price probably would be one-tenth that of disk files per bit of storage.

Project Search test results called 'very good'

Initial tests of Project Search, the narrow-band transmission of fingerprints across the country via satellite [*Electronics*, June 7, p. 46], have proved the feasibility of the concept, says Paul Wormeli of Public Systems Inc., national program coordinator. He adds: "The tests are going well. Initial results are very good for both the Videofile system and the facsimile system, and overall system degradation is less than we had expected." The tests are aimed at determining if the relay is economical, if the image is adequate, and how much the fingerprint search can be speeded up.

In the test, a facsimile land link from Los Angeles to Sacramento simulated a local police department's transmission to state headquarters. Then, prints were sent from Sacramento to Tallahassee, Fla., via satellite using both Ampex's Videofile and fax to simulate state-to-Federal transmission. Videofile handles a video analog signal while the faxed signal can be either analog or digital.

NRMEC cuts price of SOS ROMs

Silicon-on-sapphire technology appears finally to be reaching long-awaited production and demand status. At least that's the word at North American Rockwell Microelectronics Co. which, after introducing a 40-by-128 diode ROM in development quantities [*Electronics*, Feb. 1, p. 24] and later as a production device, is cutting prices on the unit as much as 42%. The reason: NRMEC has increased production to meet brisk demand for the ROMs as microprogramed memories; the company says it has 10 major firms in its backlog. Applications range from character generation to speech synthesis for stored messages; the array also can be used as a microprogramed control store in ROMs where speed of at least 50 nanoseconds is needed.

The biggest price cut comes in quantities from 500 to 999, where the unit, designated 159-66NA, has been slashed from $45 each to $26. Price cuts in other quantities average about 30%. Approximately 3,200 bits are available for laser encoding on the array, which works out to a price per bit of 0.7 cent in the larger quantities.

National courting custom MOS business

In an effort to broaden its customer base, National Semiconductor Corp., is going after custom MOS business. While the company has built its reputation as a standard-products-only house, it actually has been work-

ing on some high-volume custom MOS programs.

As one source at National puts it, "We have a large market share in many segments of the business; so, to expand and become a bigger company, we have to look into some new areas, such as custom MOS. **Besides, the custom business will bring in more standard-product business** for us in market areas that we haven't served previously."

Heading the new operation is Roy Thiels, who was one of the founders of Unisem in Phoenix.

TTL clock offered in TO-5 can

Users of TTL now can get a low-frequency crystal clock oscillator in a TO-5 can. What's more, the manufacturer, the Statek Corp. of Orange, Calif., says that **price is competitive with that of the substantially larger digital oscillator modules** being sold for TTL applications.

The device, the SQXO-2 TTL logic clock, offers frequencies from 10 to 100 kilohertz, includes a thin-film hybrid substrate with resistors, plus three chip capacitors, three transistors, and the quartz crystal, and is compatible with 5-volt logic circuitry. **The logic clock will sell for as little as $11 in quantities of 5,000** for a device that operates over the −55°C to +125°C military temperature range. The price for quantities from one to nine over the same temperature range is $84, which Statek president Jergen Staudt says is competitive with that of larger oscillator modules.

The device also offers size and price reductions to quantity buys over the AT-cut crystals often used with divider circuitry to get from the crystal's 5-megahertz frequency to the lower frequency required for TTL systems. Statek produces the quartz crystals photolithographically [*Electronics*, Oct. 25, p. 26].

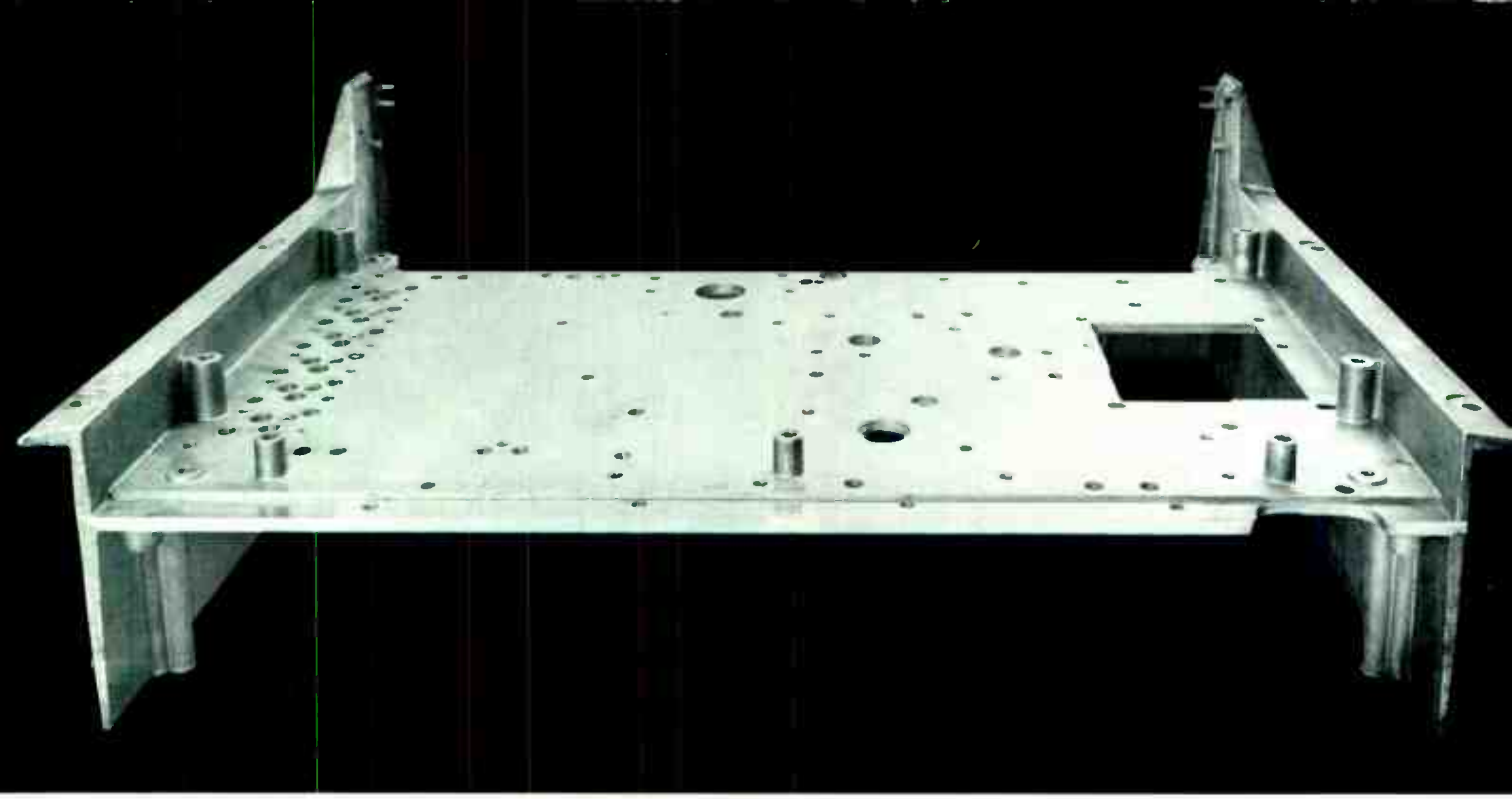
Signetics to sell D/MOS transistors

Signetics Corp. is getting into the transistor business. According to informed sources, the Santa Clara, Calif., IC house is looking for a marketing manager to handle "high-technology, high-frequency discrete devices." **This means that the firm plans to go ahead with its D/MOS double-diffused microwave transistor** [*Electronics*, Jan. 4, p. 24]. These devices are good low-noise, high-frequency amplifiers and are thus a natural for cable TV systems. Although the company won't comment, samples are expected to be available by midyear.

Addenda

Honeywell will modify its APN-194 short-pulse, leading-edge aircraft radar altimeter, now in production for the Navy's Grumman F-14 fighter, **to go on the Navy's Harpoon antiship missile** now in development at McDonnell Douglas. . . . Engineers at North American Rockwell Microelectronics Corp. have developed what they say is the **first MOS/LSI telephone-frequency tone generator.** It's not a standard product yet, but NRMEC has "a few evaluation circuits available," and is investigating "the best characteristics of voltage and frequency to meet industry requirements," a spokesman says. . . . IBM has received a 1.5% across-the-board price increase from the Price Commission [*Electronics*, Dec. 6, p. 26]. **It had requested increases ranging from 3% to 8%.** . . . Robert C. Wilson, new president of the Collins Radio Co., has reorganized the company into four groups. They are avionics (based in Cedar Rapids, Iowa), international operations and telecommunications and switching systems (both in Dallas), and special telecommunications (Newport Beach, Calif.).

Circle 19 on reader service card→



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It can go anywhere you do.
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It can make buying and maintaining a counter less expensive than ever before.

Meet the Hewlett-Packard 5300, the snap-together counter that's not much bigger than the palm of your hand. It has six digit accuracy, solid state display and autoranging. It'll make period, frequency, time interval and ratio measurements, operate on its optional snap-on battery pack and drive a printer. Rugged dust-proof aluminum case resists almost any bumps it might get in the field. Prices start at only $520 for one of the most amazing counters you've ever owned.

Start with the basic mainframe ($395). Then snap on any of the following modules (more on the way) to make just the counter you need, and avoid obsolescence, too:

10 MHz frequency module. Model 5301A, $125.

50 MHz all-purpose module includes period, time interval. Model 5302A, $250.

500 MHz module with both 50Ω and 1 MΩ inputs. Model 5303A, $750.

100 ns time interval module with: unique "time holdoff" feature, dc coupling, slope and trigger level controls, and period and frequency measurements to 10 MHz. All the functions you'd pay $1200 for in a universal counter. Model 5304A, $300.

Rechargeable battery pack module works with any of the other modules for cord-free operation. Model 5310A, $175.

The 5300 is one system you have to use to appreciate. If you've ever needed to accurately measure frequency or time interval, you owe it to yourself to call your nearby HP field engineer for further information. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 1217 Meyrin-Geneva, Switzerland.

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ELECTRONIC COUNTERS

Navy wants to put electronics gear outside new subs

Hull-mounted devices able to survive 90 days in water are technological challenge to electronics manufacturers

A Navy study of the submarine of the future—one in which most of the boat's electronics would be mounted between its pressure hull and outside shell—could sire a new breed of ultrareliable components.

However, the Office of Naval Research concept hasn't been met by universal enthusiasm. Even Raytheon Corp., which has just started the second phase of the study, "was reluctant to do it" when the Navy proposed the concept less than a year ago, according to the ONR project office. "But when they got going they became more and more interested"—to the extent of putting five people on the program and "company money in an amount equal to, or more than" the total of its one-year, phase two contract of $60,000. Though the money isn't much as defense contracts go, Navy advocates see a successful program producing a complete change in submarine design and warfare.

Mounting a submarine's electronics between the hull and the shell, or fairings, poses some obvious problems. Chief among them is the inability to service components while under way.

Don't exist. Thus, says the ONR, the whole concept of "hands-off hardware" could rise or fall on industry's ability to come up with ultrareliable components that do not now exist.

"We're looking for 90 days of failure-free performance from hull-mounted systems," says an ONR source, "a requirement that cannot now be met and one that will probably lead us to take a closer look at how manufacturers make things."

The overriding consideration is the issue of component reliability, however. "That single question of reliability is so serious as to say go or no-go" at that point in the future when the Navy decides whether or not the performance it needs can be achieved. Since word on the ONR's concept began to spread among industry's submarine specialists, "there has been an awful lot of interest and a lot of skepticism, too."

Negativism within the industry appears premised on the view that hull-mounted electronics would necessarily "require a whole new set of mil specs" for component performance, says ONR's man, "and manufacturers are fearful of the increased costs" these would produce. For this reason the ONR's approach toward this particular innovation is slow but steady.

Positives. On the plus side, the Navy can see multiple advantages. The saving within the pressure hull in terms of space and elimination of cooling systems for electronics is 2-for-1 on the basis that "for every cubic foot of hardware you put outside you gain two cubic feet" now required for spares and maintenance space.

At the moment, preliminary information leads the ONR to believe that virtually all a submarine's electronics could be hull-mounted in either pressure-hardened (gas-filled) or pressure-compensated (water-filled) containers. "The exceptions, of course, are those things you need to get your hands on and repair, like navigation, fire control, and weapons systems," the Navy explains.

Extending technology to permit hull mounting has Raytheon exploring such obvious areas as integrated circuits and semiconductors generally, as well as fiberoptics for communications and superconducting systems to extend lifetimes.

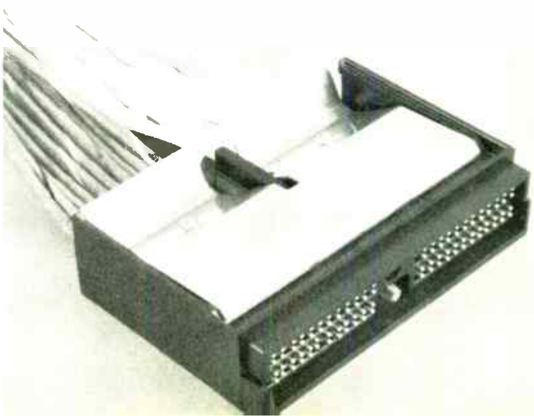
Modular subs. Raytheon's efforts, says the ONR, is "just one facet of a larger look at submarines of the future." Conceptually, these boats would consist of interchangeable modules with one containing all or most of a boat's electronics.

Components

Connector for peripherals ripples IBM pond

For years, IBM has had a neat little way to keep close track of competitive peripherals that were being plugged into 360 and 370 computer mainframes. To be compatible, other peripheral manufacturers needed a connector that mates with the one on the end of the cable from IBM's mainframe. And, as it turns

Checkmate. Amp's Amplimate 48-position connector is billed as competitor to IBM's Serpent for plug-to-plug peripheral market



out, IBM was the only source of the connector.

Now, Amp Inc., Harrisburg, Pa., and National Connector Inc., Minneapolis, are offering those manufacturers an alternative. Amp's Amplimate, a 48-position hermaphroditic connector. Although Amp's marketers are treading lightly in their promotion of the Amplimate lest they disturb their position as a supplier to IBM, they say their connector will do all that IBM's so-called Serpent connector does. National's is the 200318.

Amp pushes an additional advantage: peripheral makers can reduce their costs by assembling their own connectors using Amp's automatic termination machines, which handle the contact reels.

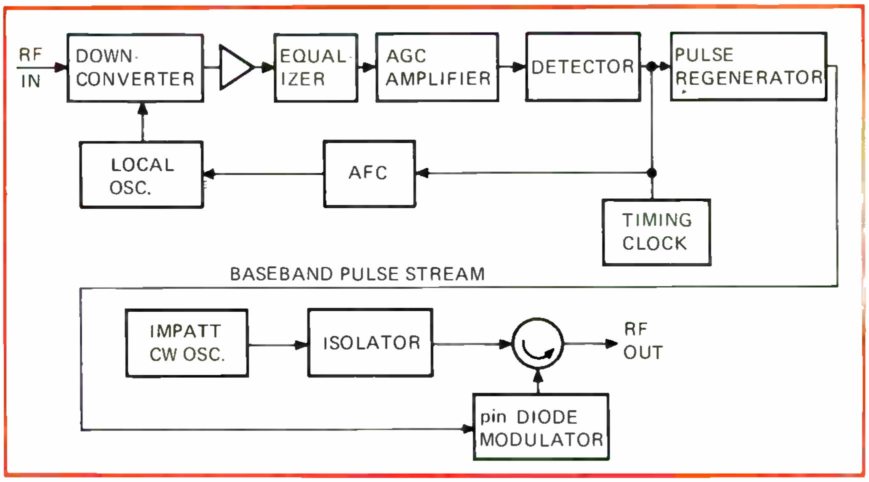
The contacts themselves are phosphor bronze, plated with gold over nickel and with heavier gold on the mating areas. Insulation support ears on the contacts eliminate the necessity for heat-shrink tubing to achieve strong terminations for coaxial cable. The housing is a heat-stabilized nylon block that's fire-resistant and self-extinguishing. Other features are a spring-loaded jackscrew for locking mated connectors, a strain relief cover clamp that isolates loaded contacts from stresses, and coding on the front and rear or side for cavity identification.

Communications

Millimeter-wave repeater prepares to leave lab

Millimeter-wave-guide communications have been brought a step closer to practical application by scientists at Bell Laboratories, who have operated a manufacturable repeater. They are part of the Bell team developing a buried waveguide system [*Electronics*, Feb. 2, 1970, p. 38].

"Until now, experimental repeater configurations have been pieced together, often spreading over several lab benches," says Per Brostrup-Jensen, who supervises the millimeter-wave circuit design group at Holmdel, N.J. "This one is packaged in an 18 x 18 x 4-inch box. Also, the components of the design could be manufactured on a production basis," he adds.



Baseband repeater. Pulse-modulated inputs are downconverted and detected for regeneration at baseband. The reconstructed data stream then phase modulates the rf output.

In a typical system, this channel repeater would be one of 120 used in a relay station operating from 40 to 110 gigahertz (the channel repeaters have a bandwidth of several hundred-megahertz and are spaced almost equally in the 40-to-110-GHz range).

Error rate. The error rate of a single link, from baseband at one repeater to baseband at an adjacent unit, has not been accurately determined. "We are encouraged by the results obtained so far," says Brostrup-Jensen, adding, "We feel confident that we can achieve an error rate less than 1 bit in 10^9 bits transmitted."

The repeater recently tested has an information bandwidth of over 400 MHz centered at 57.4 GHz. It is sensitive to inputs down to –50 decibels per minute and retransmits at a level up to 100 milliwatts, giving a gain of as much as 70 dB.

The repeater's receiving portion consists of a down-converter followed by i-f amplification and filtering in the band from 1,200 to 1,600 MHz. The i-f signal then is equalized and detected at baseband frequencies from dc to about 300 MHz. Timing is extracted from the average frequency from dc to about 300 MHz. Timing is extracted from the average frequency of the pulse stream to produce properly reconstructed pulses at baseband.

In the repeater's transmitter, a millimeter-wave signal from a cw Impatt oscillator passes through a circulator in which the side arm totally reflects the signal. The point of reflection is at a p-i-n diode which, in its conducting state, represents a short with a reflection coefficient of –1 and an open of +1 in its nonconducting state. By turning the diode on and off, the phase of the millimeter-wave carrier can thus be made to shift by 180° in response to the baseband pulses, yielding a two-level, phase-shift-keyed output.

Arinc to build its own microwave networks

Aeronautical Radio Inc., the airlines' communications service organization, plans to build two regional microwave networks. The move comes after Arinc complained about the doubling of its annual bill to $60 million since 1968 [*Electronics*, Sept. 13, p. 25]. Arinc runs the world's largest commercial private-line network, with lines leased primarily from AT&T.

The two regional nets, forerunners of a national network, will be based on a study made by Collins Radio Co. earlier this year [*Electronics*, April 12, p. 38]. Arinc says it will ask the FCC next April for permission to start building the links at an estimated cost of $8 million. They would be located in the Los Angeles area and between Chicago, Cleveland, and Detroit, and go into operation about a year after FCC approval.

The Los Angeles basin network would comprise 18 stations with 1,220 voice channel ends, including a Las Vegas extension. Twenty-three airline users would be served over the 376-mile system at 14 service locations. The Chicago segment, 23 stations and 1,520 voice channel ends, would extend over 474 miles and serve 44 airlines at 10 service points.

Competitive bids. Further site, engineering, and frequency studies have to be made for the two subnets, Arinc says. The subnets, financed by bonds, will be constructed on a competitive bid basis. There is speculation that Collins would be a major contender.

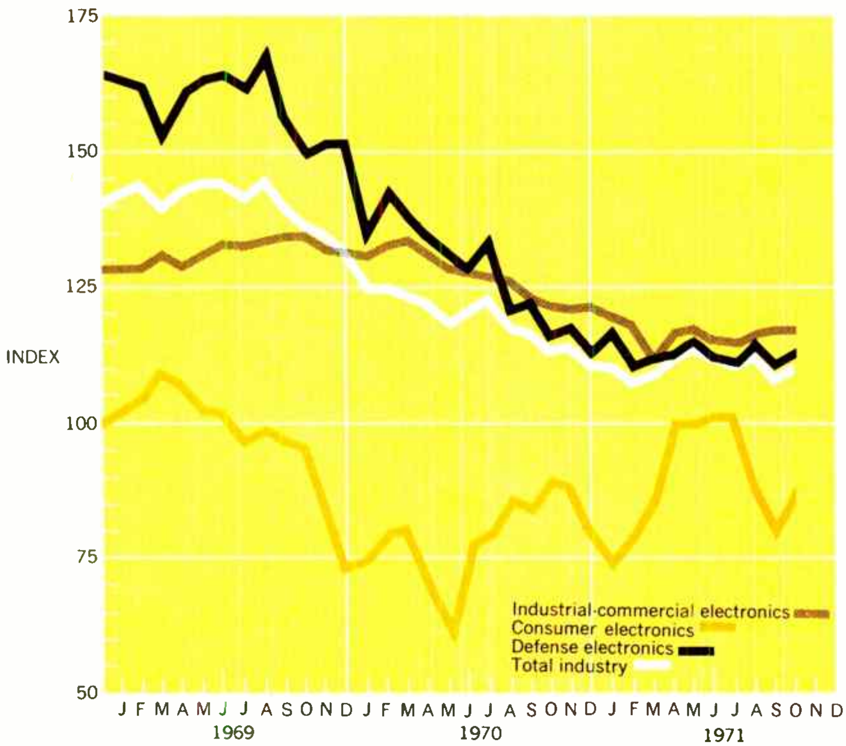
When Arinc talked about building its own network before, the speculation was that it was talking to keep its charges from AT&T down or to force the telephone company into a competitive situation with other proposed systems. Industry sources now believe that Arinc is serious, but point out that large problems remain for a nationwide network, such as finding the necessary $267 million, site selection, obtaining rights of way for coaxial cables where microwave interference from other networks precludes new stations in congested areas, and getting complete engineering studies.

IBM proposes common data bus for shuttle

It isn't often that a system used in oil field management winds up in an aerospace program, much less the proposed manned space shuttle. But IBM's Federal Systems division is proposing just that to NASA; using a common data bus—in this case, an electronic "party line"—to carry and route traffic among the many avionics subsystems in the shuttle and space station.

Frequency modulation techniques will allow many of the units to use the data bus almost simultaneously at the low data rate requirement of 1 megabit per second. The result is that the spaghetti wiring common to many airborne electronics interconnections is eliminated. This should save space and weight—50,000 feet of wiring or more than a ton, IBM says—and increase reliability and ease of maintenance.

Can handle 32. Combination input/output units called standard terminals are spaced along the length of the bus, a pair of twisted shielded cables connected by line couplers of single toroid cores. The terminals, each of which can handle



Electronics Index of Activity

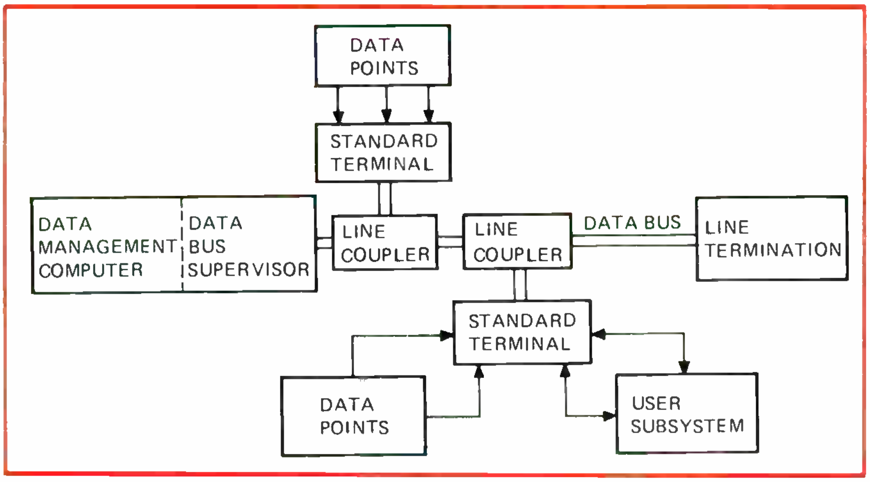
Dec. 20, 1971

October's production index was up 1.6% over the previous month's, though it was still 3.2% below its year-ago level. No category of the index fell, though industrial-commercial showed no change from September's revised 118.4.

Consumer climbed a healthy 6.8%, leaving it down 1.7% from a year ago. Defense showed a 1.3% gain, 3.6% lower than its October 1970 total.

Segment of Industry	Oct. '71	Sept. '71*	Oct. '70
Consumer electronics	87.5	81.9	89.9
Defense electronics	114.0	112.5	118.2
Industrial-commercial electronics	118.4	118.4	123.4
Total industry	110.9	109.1	114.6

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



Space bus. IBM Federal Systems division has proposed this data bus to NASA for space shuttle. IBM says it will save more than 50,000 feet of wiring or more than a ton on shuttle.

signals from 32 separate avionics sensors, allow the sensors to transmit data within the whole avionics system. Driving the bus is a data bus supervisor directed by a data management computer which serves as line driver, formatter, and receiver.

Follows trend. As a standard data communications trunkline, the bus will enable modifications of systems design and configurations without major redesign of cabling or electronics, according to IBM. Any terminal can be moved almost anywhere providing it's within plug-in reach of the bus. Thus, the concept takes advantage of two aerospace trends: the move toward on-board digital systems and the swing away from individual subsystems to totally integrated systems. Both trends reflect the increased data load complex aerospace systems now carry.

The data bus also will "reduce the requirement of onboard power supply," says staff engineer Richard R. Manasek of the division's Huntsville, Ala., electronic systems center. "Instead of 100 terminals using the system at full power, there's essentially only one up at any given instant." He estimates a 99-to-1 reduction in needed power on the shuttle in that instance. Most of the time, only about 20% of the system's data traffic capability will be used, leaving plenty of spare capacity to handle peak loading.

Manasek says the design enables the system to accept normalized analog, discrete, and digital signals: to handle particular input/output signals when directed; and to provide a universally acceptable interface for the avionics subsystems. Use of four computer/supervisor units, five twisted-pair cables, and extra terminals provides enough redundancy to preclude system failure, Manasek says. For example, the terminals are interconnected so that each can use any given cable pair. One cable is a command line and another a response line, giving three redundant cables.

Five tasks. Directed by the computer, the supervisor provides all signal conditioning, controls, and buffering required for computer interface with the data bus. The supervisor has five major functional elements: transmitter, receiver, timing and control logic, buffers, and word and address counters. A voltage mode transformer handles the interface with any given terminal.

The pulse-code modulation technique used is a baseband and biphase L (also known as Manchester 2 code). It allows the system to extract the necessary timing signals from the data itself in both the command and response lines. This way IBM gets around using a separate clock line as in synchronous systems, Manasek explains, or individual clock oscillators used in asynchronous systems. Error control can be handled by self-testing within the computer and supervisor unit, Manasek says.

IBM is designing the system for North American Rockwell, prime contractor for the space shuttle, and for McDonnell Douglas, prime contractor for the space station due to start orbiting in the early 1980s.

Computers

Computers take DC-10 'around the world'

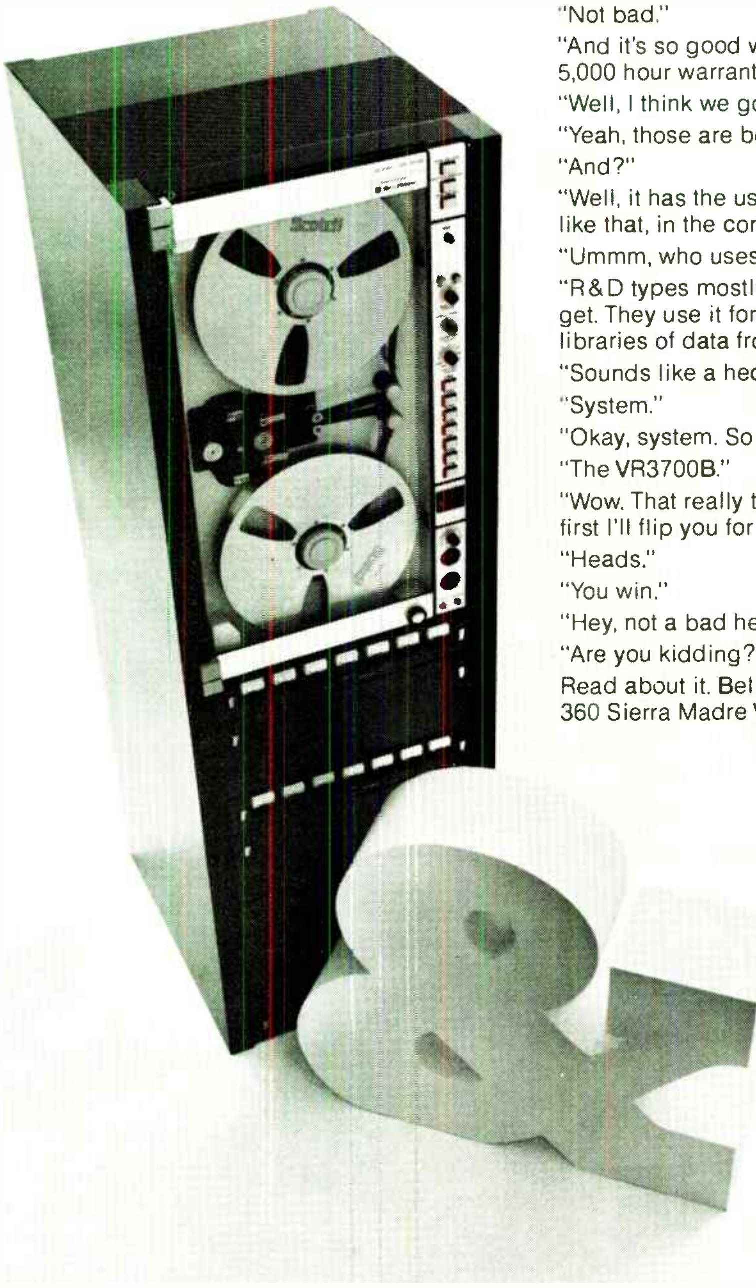
McDonnell Douglas DC-10 trijets, by means of a computer-controlled test system, are undergoing some of the most exhaustive ground testing ordeals ever imposed on a commercial aircraft. The system is taking a DC-10 through accelerated fatigue and structural testing equivalent to six plane lives, about 120,000 hours of simulated flight conditions. This is roughly equivalent to 2,600 trips around the world under the severest conditions imaginable. The system is similar to one that will be used for the Anglo-French supersonic Concorde [*Electronics*, Electronics International, March 1].

The work is being performed in a new 257,000-square-foot engineering development center in Long Beach, Calif. The complex test is under central control of a Systems 810B/RTX computer manufactured by Systems Engineering Laboratories, Fort Lauderdale, Fla.

Also included in the computer network installed at the Douglas Aircraft division facility are an additional 810B computer, five 810A computers on mobile carts around the test aircraft, 1 million words of fixed head disk memory, and peripherals.

Sliced plane. For the tests, the DC-10 is separated into nose, center, and aft sections. The computer controls 150 hydraulic jacks (the Concorde system uses 100) that flex and stress various parts of the aircraft as in flight maneuvers such as towing, turning, taxiing, takeoff, climbing, cruising, descent, and landing. It also simulates ground time in all types of aerodynamic conditions, such as gusts, updrafts, and downdrafts, as well as smooth air. An average test "flight" lasts

Bell & Howell & Heads You Win



"Wow! We've done it! A super headed recorder/reproducer like nothing nobody's ever seen!"

This from one of our brighter back room boys as he charged into our office.

"Take a look guys. 2MHz performance at 60 ips. Realize what that means? Perfect recording with half the tape. And at about $200 a reel, that's a cash register full of saved bucks."

"Not bad."

"And it's so good we've given the record head a whompin' 5,000 hour warranty."

"Well, I think we got something to work with. Anything else?"

"Yeah, those are both industry firsts from Bell & Howell."

"And?"

"Well, it has the usual 14 channels. 15/16 to 240 ips and stuff like that, in the conventional format."

"Ummm, who uses the thing?"

"R&D types mostly. It's about as sophisticated as you can get. They use it for aircraft tests. Cars. To pull down whole libraries of data from field recorders. That sort of thing."

"Sounds like a heckuva machine."

"System."

"Okay, system. So what do you call the super headed system?"

"The VR3700B."

"Wow. That really tells it like it is. Okay, we'll do an ad. But first I'll flip you for coffee. Call it."

"Heads."

"You win."

"Hey, not a bad headline for the..."

"Are you kidding? Beat it. Sheez, can you imagine."

Read about it. Bell & Howell, CEC/Instruments Division, 360 Sierra Madre Villa, Pasadena, California 91109.

CEC/INSTRUMENTS DIVISION

BELL & HOWELL

Circle 25 on reader service card

about 3.5 minutes, and is approximately an hour of actual flight.

To begin a simulated test flight, a computer operator initiates a program on the 810B/RTX that in turn requests a specific flight profile from the disk system. Once the test is under way, the central computer communicates flight parameters to the load control computer, which in turn communicates with a data acquisition and servo control system 500 feet away in the remote control station. There, the load control system activates servo amplifiers that drive the jacks stationed around the DC-10.

Positioned around the three sections of the craft are five carts, each containing an 810A and associated data-acquisition equipment. The 810A machines are linked to the 810B by serial communications links and monitor the testing while reporting status to the RTX system every millisecond or upon demand. Overrides built into the system automatically stop the test when a checked parameter is not within predefined tolerances.

No people. The carts containing the 810A computers are closed-loop systems. Communication with each cart is restricted to the 810B/RTX system and there is no need for personnel on the test floor to interact with the units. The mobile computers can simultaneously conduct three nonrelated tests each. Reading data at a rate of 20 kilohertz, the five test stands can conduct 100,000 measurements each second.

McDonnell Douglas describes the system as the most sophisticated and most comprehensive ground testing program ever devised for a commercial jetliner. It also marks the first time aircraft test engineers have entrusted the computer with such a magnitude of responsibility. Douglas officials say that the system saved several million dollars over former testing systems in manhours and equipment.

Space electronics

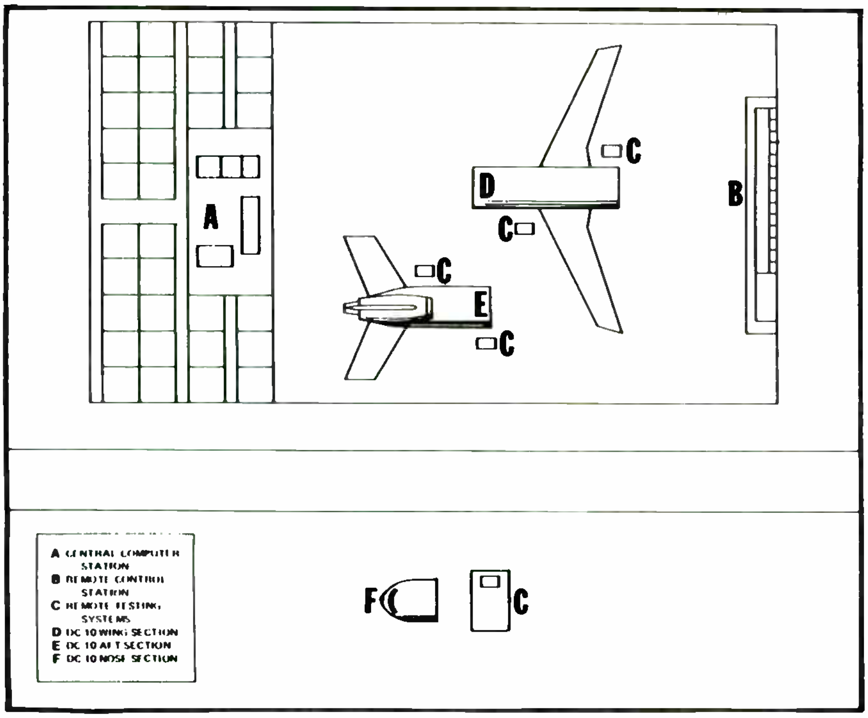
Shuttle control system getting simpler approach

As NASA has made numerous budget-induced reduction in plans for the space shuttle [*Electronics*, Dec. 6, p. 42], the vehicle's electronic control system also has undergone changes to reduce its complexity, scope, and—of course—cost. As it became apparent that most Congressmen and the Administration were not as heavily committed to the shuttle as NASA would like, the space agency backed off from initial proposals for completely new systems. In an attempt to make the program appear more reasonable, the agency decided to use as much available and proven hardware and techniques as possible.

Integrated. The shuttle will differ from any vehicle yet developed in that it will be both an air and space craft and must have the capability to perform in both environments. Although aircraft and spacecraft guidance and control systems are well developed and proven, no vehicle ever has had to combine the two. NASA, initially hoping to develop an integrated system to control the shuttle in both modes, awarded contracts with this in mind.

An additional complication was that—unlike Apollo's single control system and manual backup—NASA wanted the shuttle to have highly redundant systems. A quadruply redundant system based on a data bus was chosen because it would permit two partial failures without system failure.

Systems using four central processing units, as well as four input/output bus control units, were



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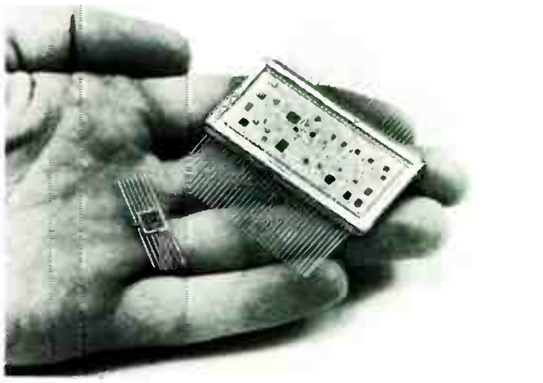


Circle 30 on reader service card

plied Physics Laboratory in Baltimore, which is cooperating with Interior's Geological Survey on the project.

Interestingly, says MacDonald, one of the advantages of the doppler system is that it will accurately fix reference points from which good maps can be made so that explorers can find those points to make even better maps.

People

David L. Sarnoff of RCA, industry pioneer, dies at 80

Gen. David L. Sarnoff, one of the giants of the electronics industry, died on Dec. 12 at his New York townhouse. A radio pioneer whose entrepreneurial genius built RCA, Sarnoff's rise was the classic story of the immigrant who started at the bottom—he was a \$5.50-a-week office boy—to become chairman of the huge communications company.

It's generally agreed that without Sarnoff's driving force the television and radio industries would have arrived much later. He was responsible for RCA's initial investment of \$50 million in television; before that, he had molded the National Broadcasting Co. into the model for today's broadcast networks.

Sarnoff was a minor officer in the Radio Corp. of America, then owned by General Electric and Westinghouse, when, in 1915, he wrote a memo to management that is a landmark of the communications business. It read in part: "I have in mind a plan that would make radio a household utility in the same sense as a piano or phonograph. The idea is to bring music into the home by wireless."

Years later, he took another giant step when, answering objections to RCA's acquisition of Victor Talking Machine on the grounds that the phonograph and radio were natural enemies, he said, "We'll combine radio and the phonograph."

But perhaps his crowning achievement was persuading the FCC in 1953 to change its mind and base standards for color television on the RCA compatible system after the agency had first ruled in favor of a CBS noncompatible system.

For the record

Competitor. The latest challenge to Bell's Picturephone comes from Sweden. Called the LME (see picture below), it is the progeny of L M Ericsson, which says it offers better resolution than the Picturephone: 650 lines at 25-hertz frame frequency versus 525 at 30 Hz. Ericsson will start making the LME "in

small quantities" in about 18 months. As for hookup to Bell's phone lines, Ericsson is offering a converter.

The LME uses a vidicon camera and optical scanning. However, the company says that in the near future a silicon target unit, with a bandwidth of 6 or 7 MHz, will be offered as an option.

Morton dies. Jack L. Morton, 58, who was in charge of Bell Labs' development of the transistor, was killed Dec. 11 in Neshanic Station, N.J. At his death, Morton was vice president of electronics technology at the labs.

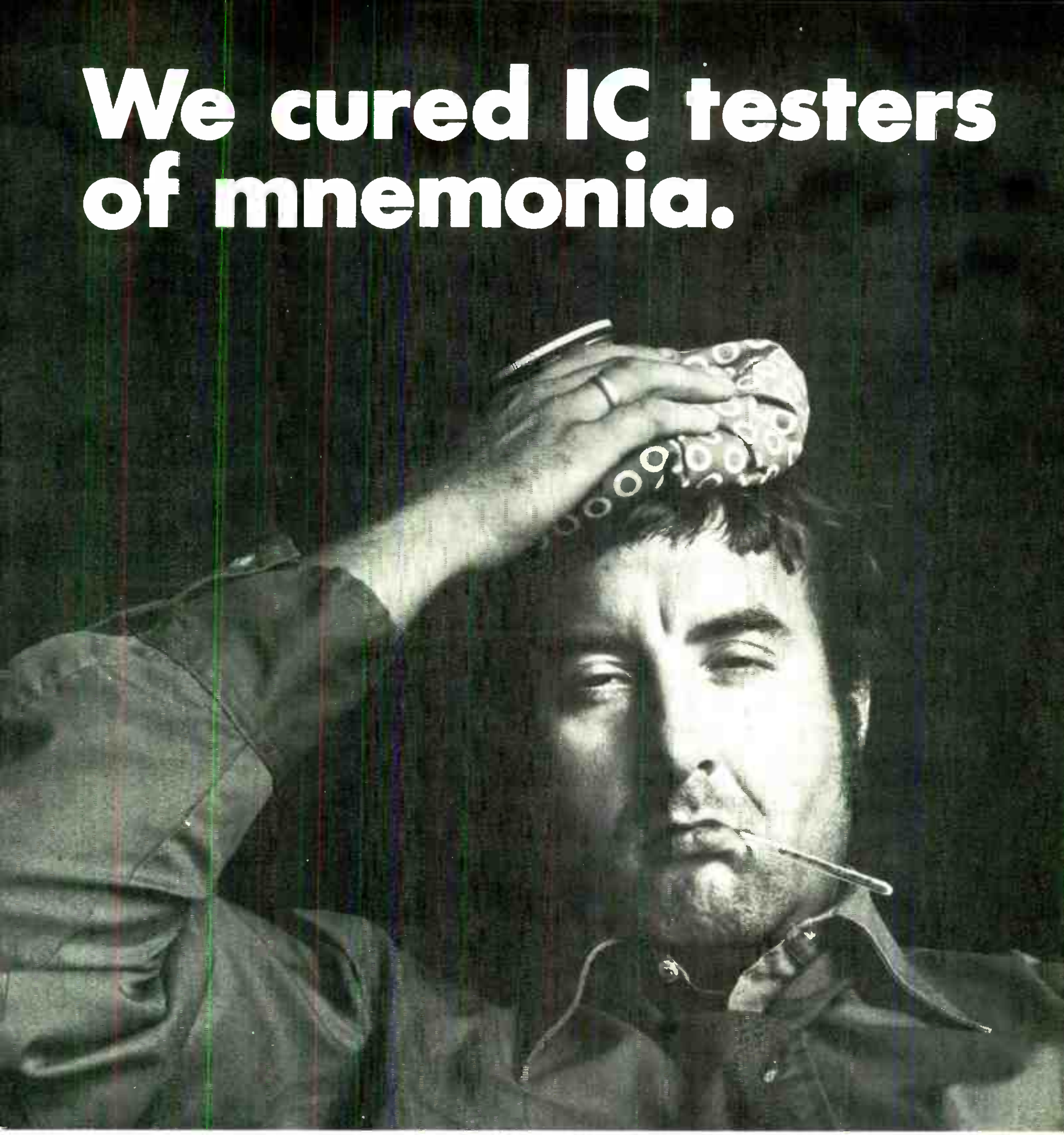
Morton, whose body was found in his burning auto, was responsible for many semiconductor developments. After the invention of the transistor, he led the group that made it economically and technically feasible for manufacture. He suggested the first widely used equivalent circuit for the transistor, as well as methods for finding other equivalent circuits.

Among major developments to which he contributed were the 416 close-spaced triode and the traveling-wave tube.

Destroyer. Hughes Aircraft Co.'s Ground Systems group, Fullerton, Calif., has picked off a big plum in the subcontracts being awarded by the Data Systems division of Litton Industries Inc., Van Nuys, Calif., for the Navy's Spruance-class destroyers.

The Hughes group has won a $30.1 million contract to provide digital displays for 30 of the destroyers.

Precious process. Many package makers have been reluctant to invest in expensive equipment to eliminate the gold-plating bottleneck of LSI package fabrication. But now they have an alternative: a gold-plating solution from Engelhard Minerals and Chemicals Corp. of Newark, N.J. With Engelhard's EHS acid-gold solution higher currents can be used, and time in the tank is cut to four minutes from 10 or 15 minutes.



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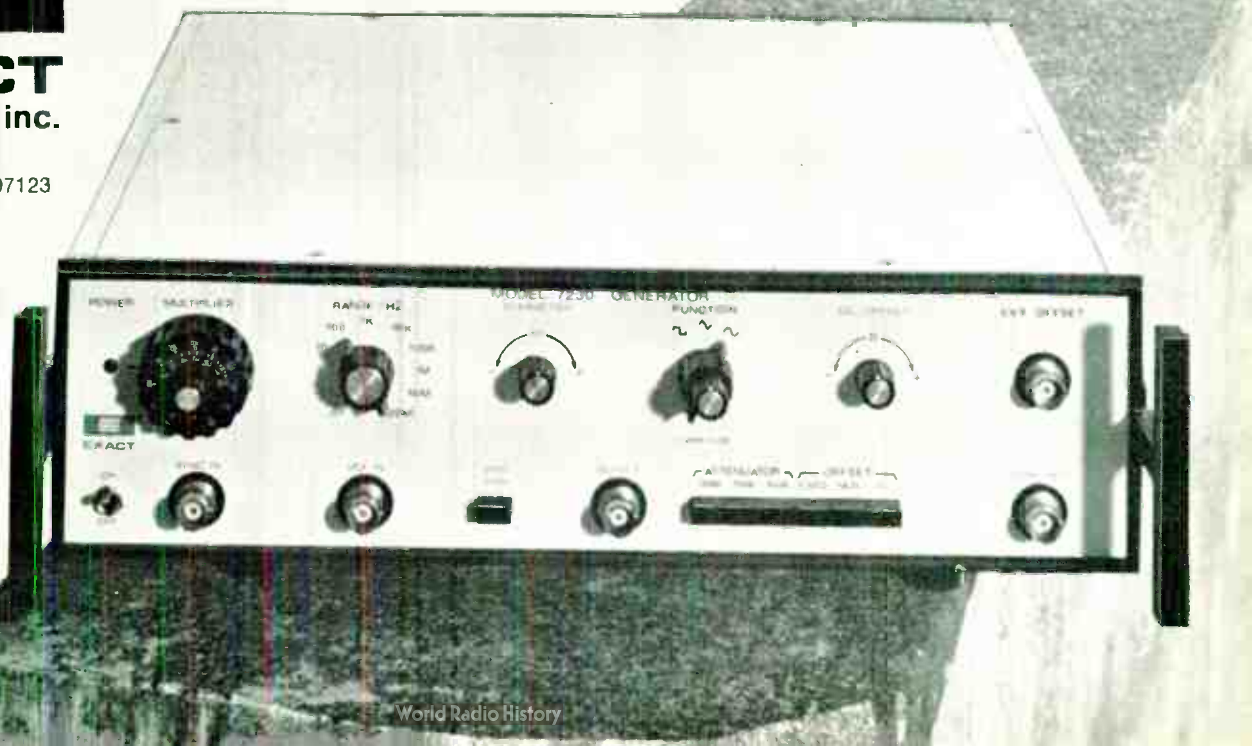

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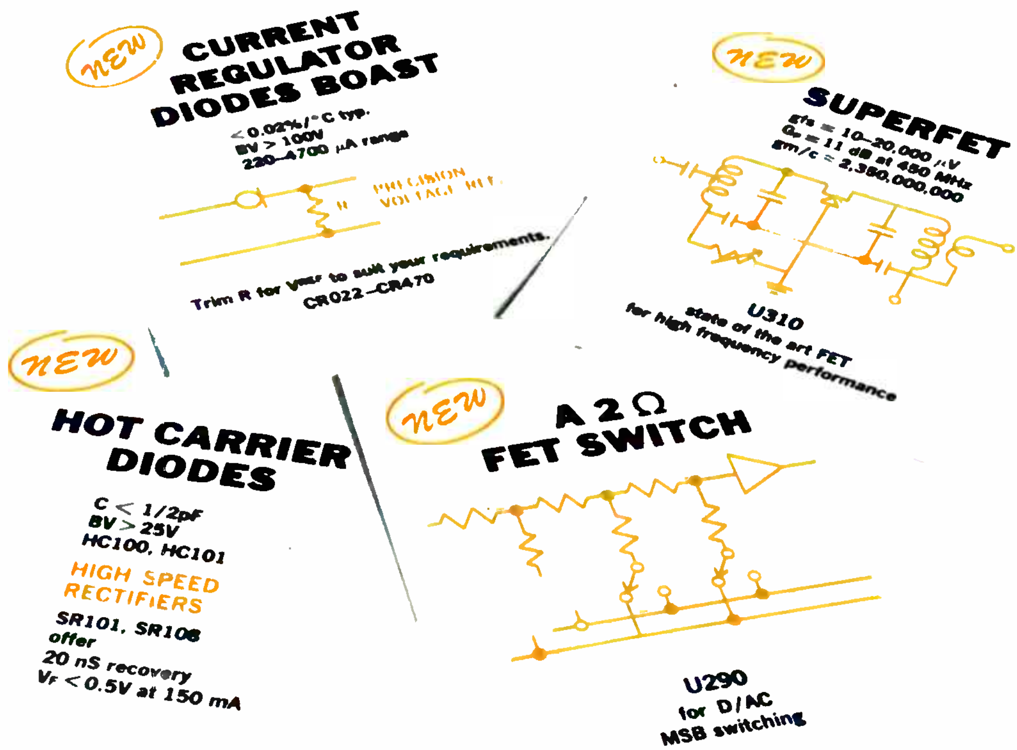

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Washington Newsletter

December 20, 1971

Study suggests microwaves disable AF personnel

Air Force jobs around microwave radiation sources produced the most disability discharges due to eye pathology and blood diseases in 1970, the Bureau of Radiological Health has found. When asked about the unpublished epidemiological study, project head Dr. Loren Mills said **there appeared to be more eye problems among workers repairing navigational, communication and directional radars, or exposed to the commercial microwave ovens used for cooking.** But Mills cautions that no firm conclusions can be drawn before three or four additional years of disability records have been compared with the current study.

Senate angry with FAA deal over Aerosat

In its attempt to get into the aeronautical services satellite business, the Federal Aviation Administration is running into heavy Senate opposition. The upper chamber is annoyed by the agency's rather arbitrary handling of the proposed agreement with the European Space Research Organization. **Until the matter is resolved, Commerce Committee Chairman Warren G. Magnuson (D., Wash.) has asked the Appropriations Committees not to fund the satellite project, and also has asked the White House not to sign the agreement.** The FAA will be called before the Commerce Committee early next year to answer for its actions.

The FAA is certain to have a difficult time, if powerful Sen. Howard W. Cannon (D., Nev.), who will chair the hearings, is any measure. **Cannon doesn't buy the FAA's argument that the agreement won't bind the U.S. to full operation.** He also questions putting the agency into business when "you have commercial facilities available such as Comsat." That company reportedly stirred up the Hill.

NASA tries again to sell its technology

The National Aeronautics and Space Administration is having another go at recovering its lost momentum by launching an Office of Applications. It will explore a wide range of earth-oriented programs, from navigational satellites to waste disposal technology, for clients from other Government agencies and industry.

The sales shop could run into some trouble, however, because it will have no research capability of its own and will have to negotiate its work with other NASA groups. According to its head, Charles M. Mathews, the office is considering taking over the Office of Technology Utilization, itself created to transfer applications of space technology to earthly problems. Among the projects Mathews has on tap is a study for a **navigational satellite program to establish the precise position of all ships on a global basis, with requested FY 1973 funding of $1 million.**

Addenda

Watch for the Senate's quick approval in January of the creation of a second deputy defense secretary post, an action stymied in committee by Sen. Stuart Symington (D., Mo.) the day before David Packard quit. . . . With two Pentagon deputy slots to be filled—most likely from within because of the short time before the election—Defense Secretary Melvin Laird is considering these candidates: DDR&E chief John S. Foster, Jr., Air Force Secretary Robert Seamans, top SALT negotiator and former Air Force Secretary Harold Brown, and, on the administrative side, Pentagon comptroller Robert Moot.

Washington Commentary

The Pentagon loses Packard . . .

When David Packard resigned as Deputy Secretary of Defense on December 13, he received lavish and deserved praise from nearly every quarter for his 35 months on the job. Secretary Melvin Laird called his effort "the best thing that has happened to the Department of Defense since it was established." Though that broad judgment must stand the test of time, Laird's estimate that **Packard's combination of "honesty, realism and straight talk" was a major factor in his success** is unquestioned. **But it was that combination, rare in the Capitol, that occasionally got Packard into trouble.** His initial opposition to a federally guaranteed loan to Lockheed Aircraft Corp. is the best example.

That lost battle was but one of many frustrations for a man who is neither professional politician nor bureaucrat and unaccustomed to losing. Officially, Packard's reasons for resigning were "strictly personal," ostensibly tied to his sacrifice of an estimated $1 million a year in income. **But sources close to the man stress his increasing concern with the political constraints that hampered his taking a harder line with the services and contractors who dragged their feet.** He was, for example, furious with the Navy and Grumman Aerospace when cost overruns on the F-14 fleet defense fighter came to light only because of a totally unrelated event—the crash of the first plane because a hydraulic system failed. "He would have loved to have canceled the F-14, but he couldn't," says one source. "There was nothing in the pipeline."

. . . will the nation lose sight of his goals as well?

The ultimate frustration for David Packard was that DOD too often found itself with no available options when a major program encountered technical or economic problems. He moved to counter that with a series of directives that reflected his own success as an engineer and a manager. In addition to demanding better definition of weapon systems needs, better planning and better procurement, **he instituted a program for competitive prototyping that would permit evaluation of hardware,** rather than paper proposals [*Electronics*, Aug. 30, p. 65]. But just as that program was about to take off, Congress shot it down by cutting out funds for 10 of the 12 programs on the grounds that all but two of the Air Force efforts were merely sour wine in new bottles [*Electronics*, Nov. 22, p. 46].

Subsequent events suggest that Packard, too, like Congress, believed his prototyping plan was being exploited by the military as a means of funding old concepts previously rejected. And he remains disturbed by "the growing anti-defense attitude in this country" and the program overruns and mismanagement that contribute to it. One of his last public statements laid the issue out: **"I want to emphasize that better management . . . is a responsibility above the parochial interests of the military services and above the selfish interests of industry."**

Unfortunately, the mere expression of an ideal rarely makes history, and **many of Packard's advocates are afraid his fresh ideas and their effective implementation—prototyping included—will die on his departure.** Bureaucrats in Government and in industry, in uniform or not, may feel a thorn has been removed from their side; taxpayers who wonder if the best national defense is necessarily also the most expensive believe they have lost a champion. For some electronics manufacturers, Packard's inclination to take useful technologies where he found them—overseas, if necessary—was upsetting. Others were pleased with his programs to consolidate similar military requirements such as communications into single systems like the Tri-Tac switch. Some of these efforts will surely now fade.

—Ray Connolly

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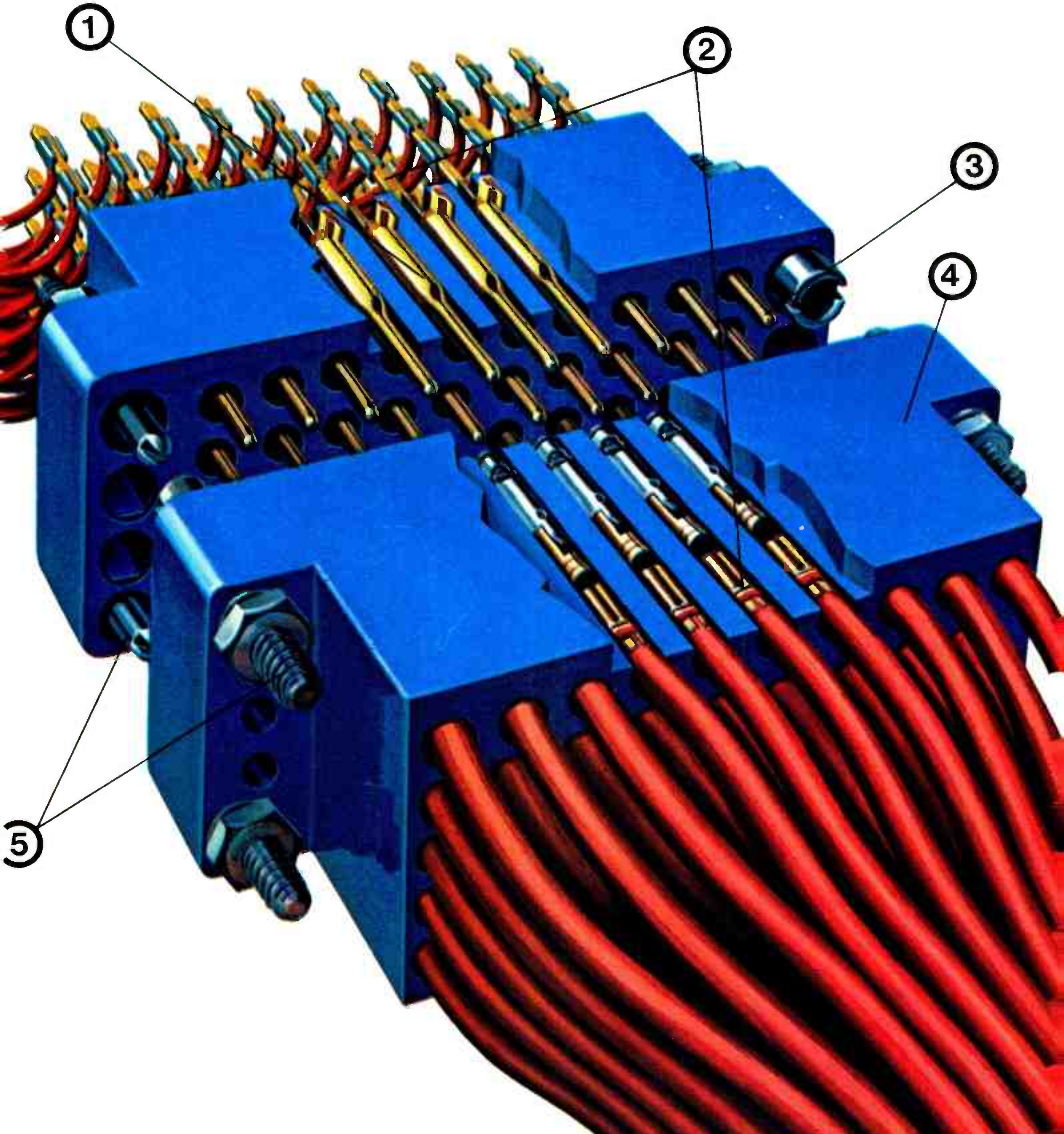

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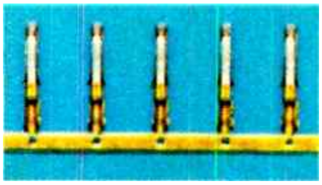

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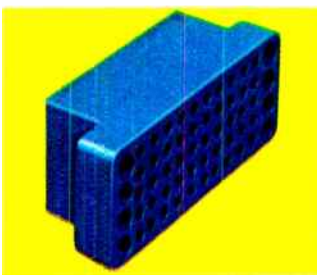

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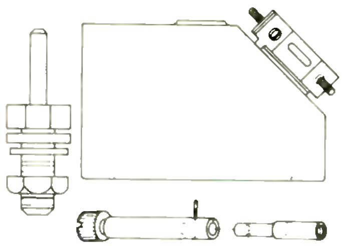

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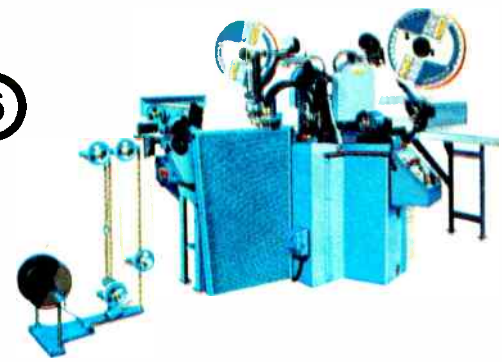

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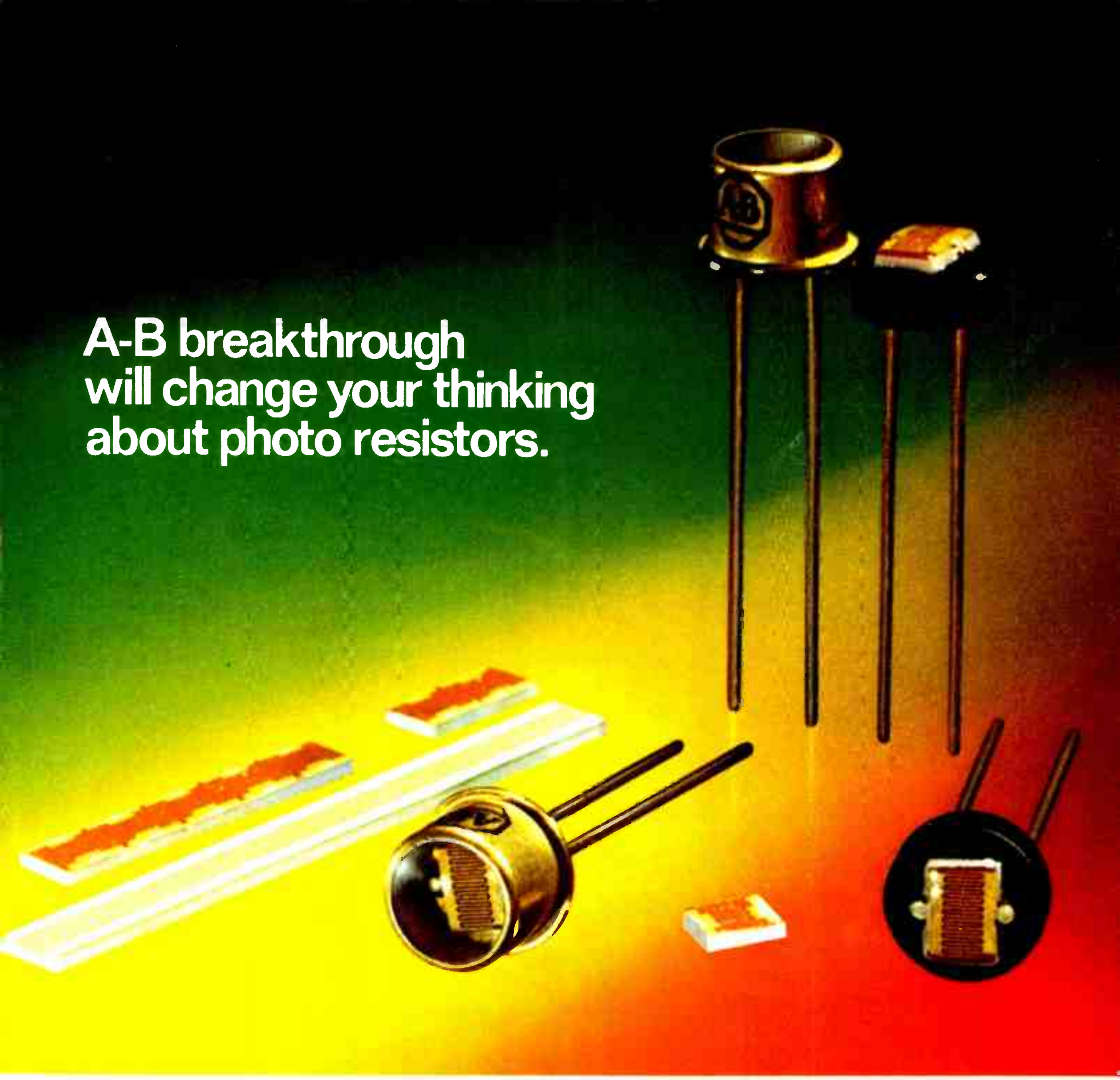

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Technical articles

Planox prods MOS back into the density derby: p. 44

Though oxide isolation technologies are being used widely by bipolar IC designers to increase density, they originally were intended for MOS devices, says author Franco Morandi. The Planox technique is going back to its MOS roots: when combined with self-aligning silicon gate technology, Planox through an extra processing step yields significant density—and hence cost—advantages over comparable bipolar circuits.

C/MOS and PCM team up for reliable, low-dissipation data acquisition: p. 49

Communications engineers need high-quality remote data acquisition systems, but what they don't need are data errors and circuitry that drains battery power supplies. The right team for the job, says author Alex Young, is pulse code modulation and complementary MOS: the former gives reliable data handling while the latter combines high immunity to the noise often encountered in field environments with very low power dissipation.

How to get along with pulsed laser diodes: p. 59

There's no doubt that the new large-optical-cavity structures developed for injection laser diodes have scored impressive gains in efficiency and power capacity. However, says author Ron Carroll, they do require high-quality current pulses to realize these benefits, and he tells how to obtain and handle them for optimal laser operation.

Special report: European markets at the crossroads: p. 87 (cover)

Infected with inflation, monetary woes, and rapacious competition in essential world markets, the health of Europe's economy is ailing, according to *Electronics*' staff report. These diseases have taken their toll in the electronics community, and while electronics continue to do better than the European economy as a whole, the days of 25%-or-better annual gains may be over. For 1972, *Electronics*' survey predicts only a 10% gain for European equipment markets, with computers and color TV racing ahead, and components and semiconductors falling behind.

And in the next issue . . .

How U.S. electronics markets shape up for 1972 . . . radar takes to the road . . . new self-aligned gate technique for MOS transistors.

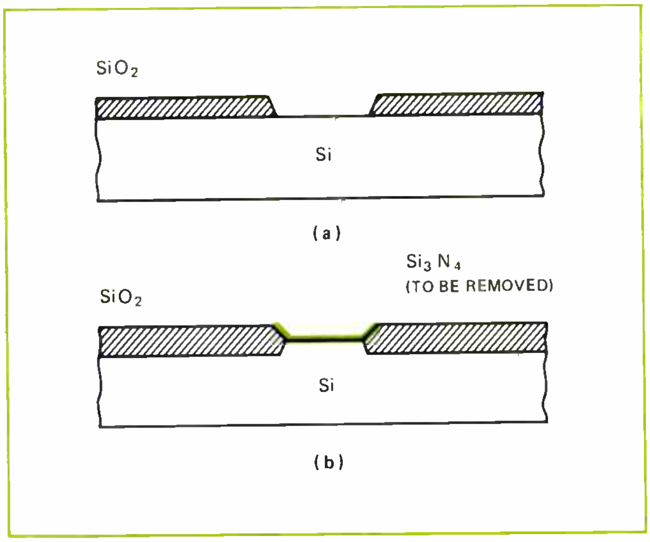
Planox process smoothes path to greater MOS density

By leveling the oxide surface of MOS chips, an Italian process improves their mechanical reliability; automatic partial self-alignment boosts performance also, and full self-alignment is possible with polysilicon

by Franco Morandi, *Società Generale Semiconduttori SpA SGS, Milan, Italy*

☐ Contrary to popular belief, the new oxide isolation methods that increase the packing density of bipolar integrated circuits are not the sole province of bipolar technology. In fact, the original Planox process was invented for discrete and IC MOS devices, and only later adapted to bipolar circuits. Moreover, when it's combined with the low-voltage, self-aligning silicon gate process, Planox offers the MOS circuit user a clear advantage in density and with it a significant cost gain over comparable bipolar components.

It is important to point out that the Planox process is not a sudden, dramatic advance in IC technology, but part of a continuing effort by semiconductor manufacturers to improve their devices. Specifically, the aim here was to reduce the threshold of each MOS transistor so that circuit speed could be increased and logic levels boosted to bipolar levels.



1. The difference. In the conventional MOS process (a), a layer of silicon dioxide is first grown over the surface of the wafer and then removed from selected gate areas by photoresist maskings and etching. In the Planox process (b), a layer of silicon nitride is first deposited on the wafer, then etched away according to the desired circuit pattern. The remaining Si_3N_4 layer acts as a mask for further gate diffusions. Thus the Planox process offers partial self-alignment.

For openers

Where the method differs from the planar technique of IC fabrication is in its way of creating openings in the oxide layer covering the surface of the semiconductor material.

In the conventional planar process, a film of silicon oxide is grown or deposited over the whole surface of a silicon wafer. This oxide is then etched away, with hydrogen fluoride, from selected areas that are defined by photoresist maskings.

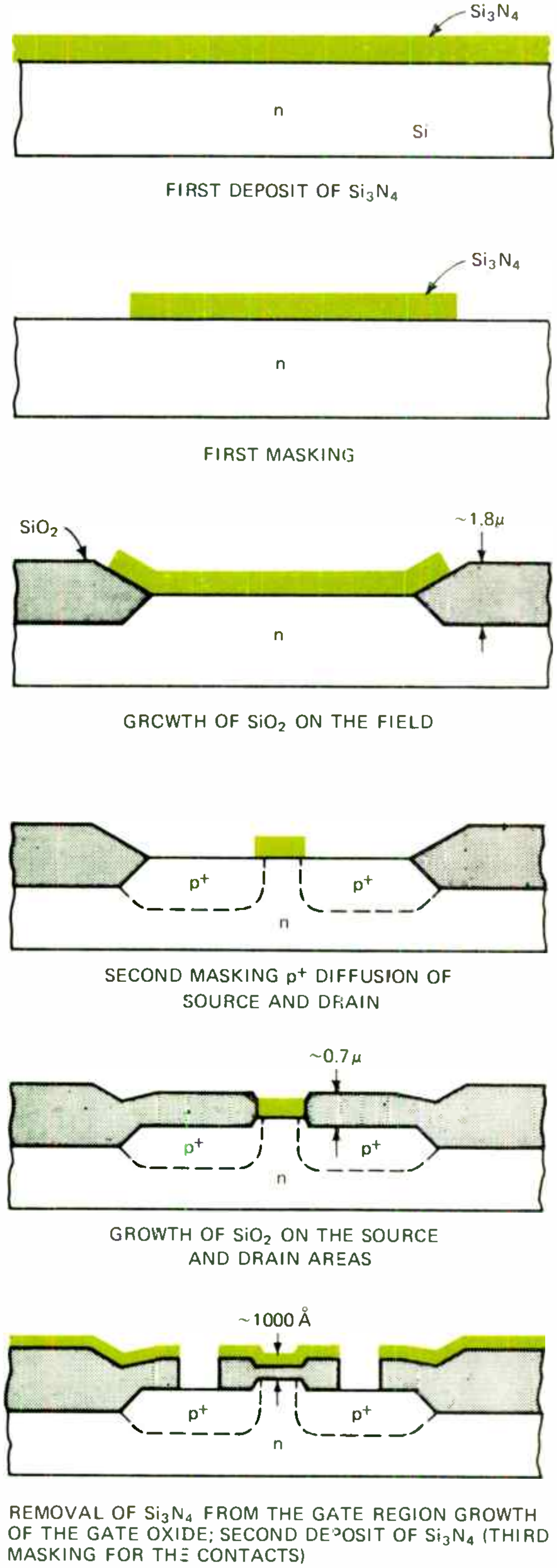
In the Planox process, however, first, a layer of silicon nitride is deposited on the wafer, and etched to the desired circuit configuration. Next the wafer is put into a furnace in an oxidizing environment. Since the nitride layer prevents any thermal oxidation of the silicon underneath it, oxidation occurs only on the etched, unprotected areas. Finally, the silicon nitride is removed completely with phosphoric acid, which has practically no effect on either the silicon beneath the nitride or the silicon oxide.

Figure 1 contrasts the configurations of the openings in the oxide obtained by the two different methods. Figure 2 portrays the sequence of operations constituting the MOS Planox process. Not shown are the usual, final operations of aluminum evaporations, metal mask, and alloy.

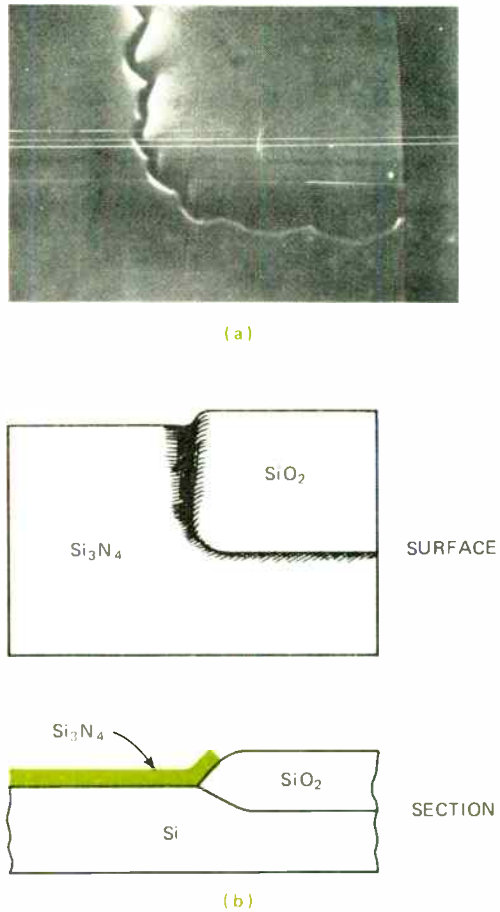
One point should be made clear concerning this fabrication process. During the formation of the oxide on the field region, the silicon nitride is slightly lifted at the edges of the protected region. The effect is visible in the greatly enlarged photograph in Fig. 3(a), and is shown schematically in Fig. 3(b), where it can be seen that the oxidation spreads under the rigid silicon nitride. Happily, it produces a controlled narrowing of the first mask vis-à-vis the dimensions of the working plate, and can be used to obtain very narrow p+ regions or load transistors.

A degree of self-alignment is an important benefit. Since the gate regions are defined by the superposition of the first and second mask patterns, the source and drain diffusions are self-aligned with respect to the gate dielectric. But perfect self-alignment of the gate structure, such as can be achieved with the silicon gate technique, is not obtainable, because the metal electrode is not used as a mask but is produced subsequently by evaporation and etching of aluminum film. This means that the mask tolerances used with conventional processing must be maintained.

However, even with metal gates the Planox method greatly reduces parasitic capacitances between the gate



2. The process. In the Planox process, the substrate is first covered with silicon nitride, and then the areas selected for the active region are etched away with phosphoric acid. The process ends with the usual operations of aluminum evaporation and metal mask and alloy.



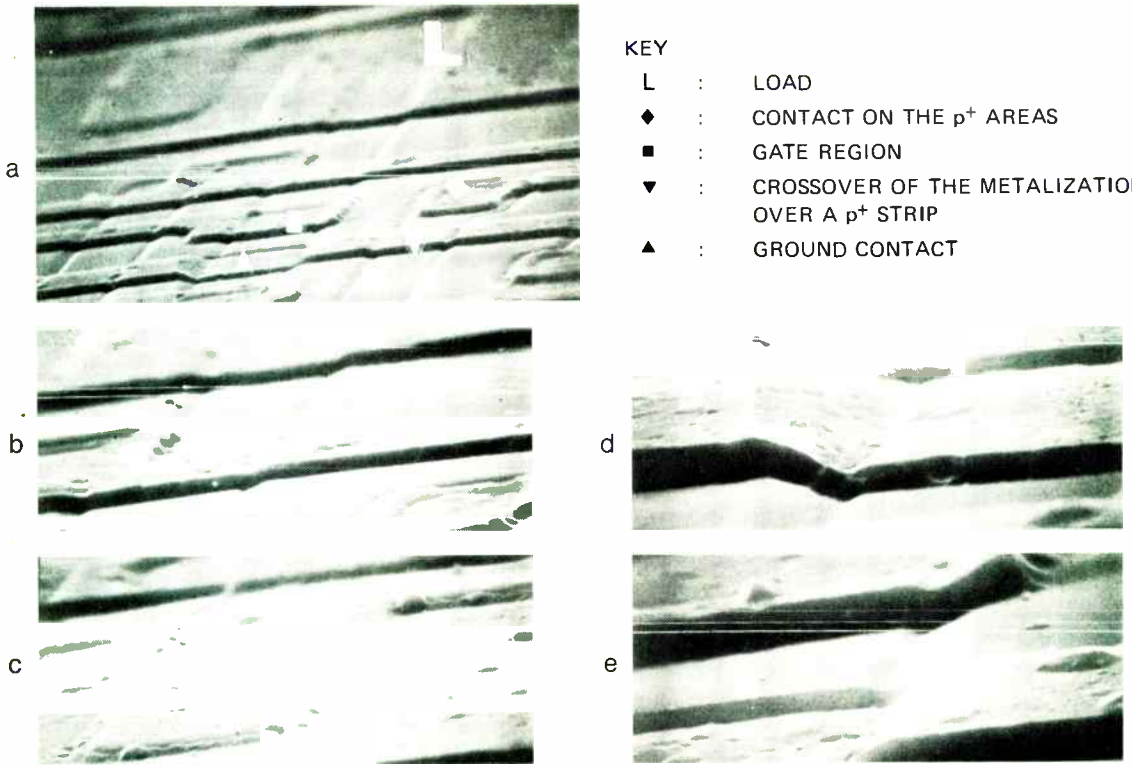
3. Overlap. During the formation of the oxide on the field, the silicon nitride is slightly lifted at the edges of the protected region as shown in the magnified photograph and in the schematic. These rounded edges prevent the process from being completely self-aligning.

and either drain or source. This is because there is no overlap of the thin oxide beyond the contour of the source and drain regions. If it is supposed that an oxide growth of 0.7-micron thickness exists on the source and drain regions, it is easy to show that the parasitic capacitances are reduced by about a factor of three.

Plain benefits

For the production of integrated circuits, the most obvious advantage of the Planox process is the reduction in the differences between levels on the final wafer surface. Figure 4(a) shows that the planarity of the surface is almost perfect, and the aluminum strips are unbroken and regular, making the contacts more reliable. Furthermore, the shape of the step from oxide to silicon, as Figs. 4(d) and (e) show, ensures perfect continuity of the metalization, even in those areas of contact where it is not possible to avoid different levels in the oxide. Because the metal continuity is assured, the minimum width of the strips can be reduced to 0.3 mil. This represents a considerable reduction in chip area that's especially valuable for large-scale integration devices.

The Planox technique also dodges a disadvantage of



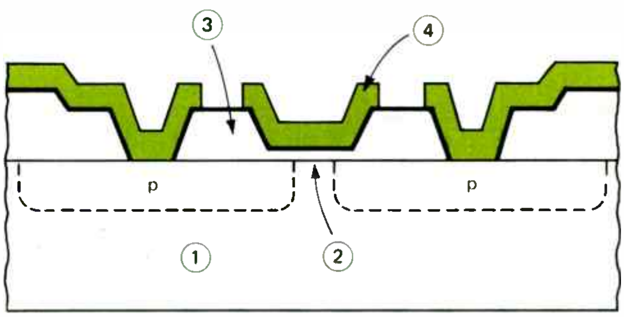
4. Flat out. The most obvious advantage of the Planox process is the reduction of the difference in wafer surface levels. The smooth surface can be seen after the first metal mask step (a). After the gate region is formed (b), ground contacts and crossovers (bottom strip) are put on the p + region. In (c) is shown the surface of the load after the metal mask, while (d) and (e) show ground contacts left and right of the step.

How MOS circuits matured

Of recent years, there have been MOS innovations. In general, the changes have aimed at reducing the threshold voltage and size of each MOS transistor, increasing circuit speed, and providing better compatibility with bipolar ICs.

The figure represents a sectioned MOS device, in which the marked areas have been modified over the years to achieve higher performance:

- Silicon substrates with an orientation of 1-0-0, instead of the more common 1-1-1, reduce surface charge Q_{ss} and lower the threshold voltage.
- The ion implantation technique, by lowering substrate resistivity in the gate regions, permits more precise control of threshold voltage.
- The gate dielectric structure has been modified for protection against accidental contamination; many manufacturers use a double layer of silicon oxide/silicon nitride in place of the simple silicon oxide film.



- Aluminum gate electrodes can be replaced by polycrystalline silicon that's made conductive by suitable doping; this silicon gate process allows faster self-alignment and closer spacing of devices.

These changes have reduced threshold voltages to the 1.5- to 2-volt level necessary for TTL compatibility. In addition, logic-voltage swings have been increased, making logic-sensing easier. And using the silicon gate techniques provides still lower threshold voltages and greater flexibility in interconnecting different circuit elements.

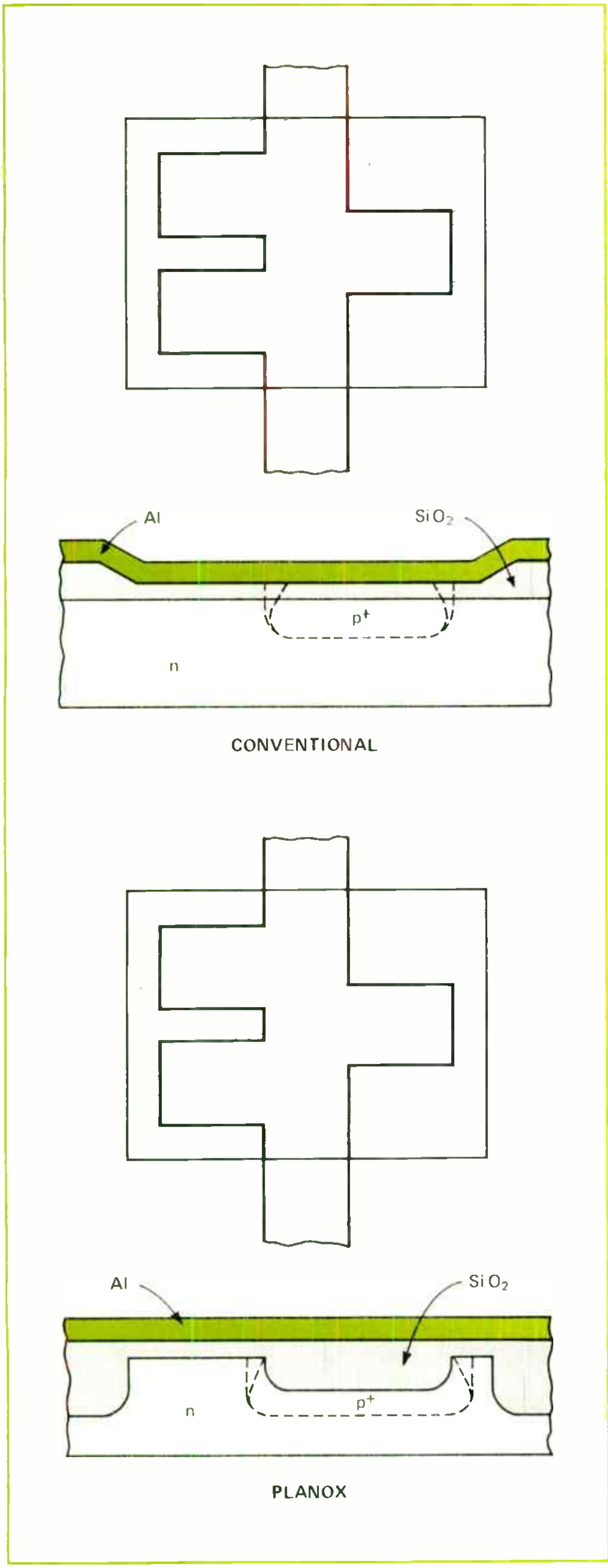
STANDARD p-CHANNEL PROCESS

STRUCTURE	IMPROVEMENT TO BOOST PERFORMANCE
1. SUBSTRATE	n <111> IS REPLACED BY n <100> FOR LOW VOLTAGE PROCESS.
2. GATE REGION	ION IMPLANTATION: THE RESISTIVITY IS INCREASED LOCALLY BY PARTIAL COMPENSATION OF THE SUBSTRATE DOPING.
3. GATE DIELECTRIC	MNOS STRUCTURE: SiO_2 FILM IS REPLACED BY THE DOUBLE LAYER SiO_2/Si_3N_4.
4. GATE ELECTRODE	THE METAL; GENERALLY ALUMINUM, IS REPLACED BY POLYCRYSTALLINE SILICON SUITABLY DOPED.

conventional fabrication methods, which make it difficult to obtain values of layer resistivity in the diffusion areas of less than 100 ohms. Such values are routinely obtained with the Planox process, and lead to lower voltage loss and high logic level swings.

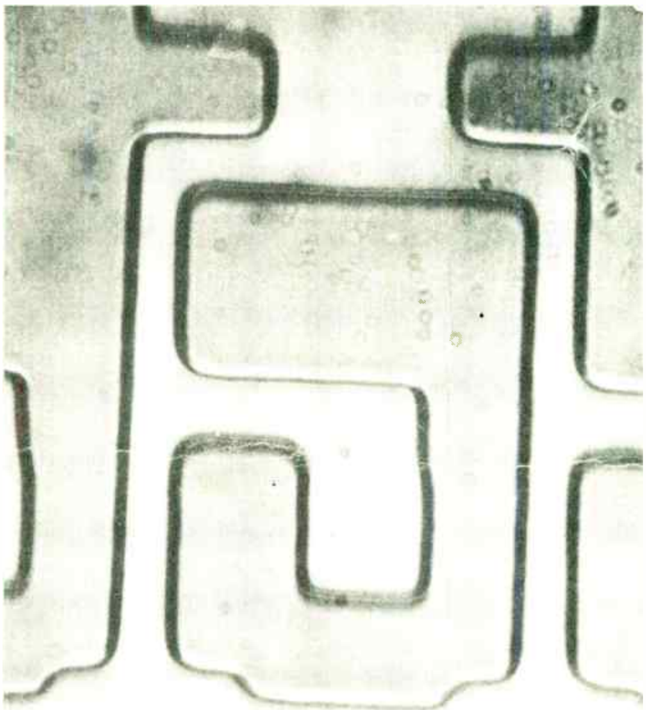
The reason is that the growth of the field oxide conventionally occurs after deposition on the source and drain areas, so that the more fully doped surface layers of the silicon become oxidized and, in the case of boron, the doping element in the oxide is adversely redistributed. It is this redistribution that causes the high, final values for sheet resistivity.

With the Planox techniques, on the other hand, the oxide on the field is grown before the diffusion of source and drain materials, and the doped regions are subsequently oxidized more weakly. Consequently, the final sheet resistivity is less, and can easily be as low as 80 ohms.



5. Better protection. The Planox device provides better diode protection because the overlap of the oxide onto the p+ region—where a strong potential difference could form with respect to the field plate—is minimized. In the conventional process, the grounded field plate creates an accumulation of charge on the p region, so that the breakdown voltage only slightly exceeds the supply voltage.

6. Big RAM. Using the silicon gate process together with the Planox technique yields a 1,024-bit random access memory with lower threshold voltages than possible with conventional processing. Shown here are the details of a single cell magnified 1,000 times.



Finally, the process also protects the oxide better. The inputs and outputs of MOS circuits are generally protected by low breakdown voltage devices, which prevent static accumulation or accidental voltage spikes from damaging the gate oxide. One of the most widely used devices is a diode with a control gate to reduce its breakdown voltage.

Figure 5 shows protection diodes produced conventionally and with the Planox process. In the former, the field plate, which is generally connected to ground, is used to create accumulation of charge on the surface in the p region, so that the breakdown voltage of the structure is only slightly greater than the standard supply

LOW-VOLTAGE PLANOX PROCESS : DEVICE PARAMETERS		
PROCESS	MATERIAL	n-type, 111, ρ = 6.8 to 7.5 $\Omega \times$ cm
	JUNCTION DEPTH	x_j = 1.65 ± 0.15 μ
	OXIDE THICKNESS – FIELD REGION	x_{of} = 1.7 ± 0.1 μ
	OXIDE THICKNESS – p REGION	x_{op} = 0.8 ± 0.1 μ
	GATE STRUCTURE	Xo + Xn ≅ 1000 Å
ELECTRICAL	THRESHOLD VOLTAGE	V_T = 1.8 to 2.5 V at 10 μA
	FIELD INVERSION VOLTAGE	V_{TF} ⩾ 30 V at 10 μA
	p-REGION RESISTIVITY	$\rho_{\square}$ ≅ 80 $\Omega/\square$
	BREAKDOWN VOLTAGE	V_g = 40 ± 5 V at 10 μA
	GATE RUPTURE VOLTAGE	$V_{g(rup)}$ = 115 ± 10 V
	CAPACITANCE :	
	METAL OVER THICK OXIDE	0.017 pF/mil^2
	METAL OVER GATE	0.25 pF/mil^2
	METAL OVER p-REGION	0.036 pF/mil^2
	CONDUCTANCE CONSTANT	$k' = \mu_{eff}\,\epsilon_o / x_o$ = 8.6 ± 0.8 μA/V^2

voltages. With the Planox process, not only is the area covered by thin oxide reduced, but also the overlap of the oxide onto the p+ region (that is, the area in which a strong potential difference could form with respect to the field plate) is minimized. It now extends only for a width equal to the lateral diffusion of the doping element. Thus, although the same breakdown mechanism exists, the structure is less subject to damage.

Process pairing

The Planox method can, of course, be used in conjunction with other methods. To obtain lower threshold voltages, it can be coupled with silicon-nitride MNOS structures. Moreover, devices that combine the advantages of Planox's mechanical reliability with the high voltage swing and good protection against contamination offered by the Si_3N_4 process, can be produced in a plastic-DIP assembly at a considerable cost advantage.

Table 1 gives the basic parameters of the Planox MNOS process. Again, owing to the high dielectric constant of silicon nitride, the threshold voltage is reduced to values around 2 volts (at 10 microamperes), which makes it possible to achieve complete compatibility between MOS and TTL circuits. Furthermore, higher capacitance per unit area can be obtained with the double layer of silicon oxide/silicon nitride than with an equal thickness of oxide alone.

The Planox technique can also be coupled to the silicon gate process. Used to obtain the first mask configuration in the first growth of thermal oxide, it makes it possible to obtain steps of reduced height and of oblique shape with the thickness of SiO_2. In this way, breaks are avoided in the polycrystalline silicon layer to be deposited, and the thickness of the thermal oxide can be increased to provide a planar surface.

With a greater thickness, there is, of course, a corresponding increase in the threshold voltage on the V_T field. Therefore polycrystalline can be freely used as an additional interconnection layer.

Figure 6 is a microphotograph of one cell of a 1,024-bit dynamic shift-register produced by the Planox silicon gate process. With this construction, an area reduction of about 30% and an increase in maximum operating speed of about 50% are obtainable compared to conventional devices. The thickness of SiO_2 on the field is now only 1.6 micrometers, yet full oxide protection is obtained.

At present it's difficult to choose between the advantages and limitations of the various MOS process techniques. Eventually, perhaps, just one p-channel process will win out, or perhaps each will survive to optimize a particular class of circuitry. But regardless of which process is used, implementing it with the Planox method should increase performance. □

Learning the process

The last half of 1971 has seen new processes for building both bipolar and MOS circuits that may prove to be as important as the silicon gate technique. Because new processes often herald new devices, *Electronics* will, in the next several months, publish a number of articles on the most significant of these innovations.

This issue has covered the Planox process. In the next issue a new approach to self-aligned gates in MOS—a self-aligned, thick-oxide (SATO) technique introduced by Texas Instruments—will be explored.

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PCM plus C/MOS spells reliable, low-dissipation data acquisition

Remote data systems require low error rates and a minimum of drain on battery supplies; two established techniques team up to meet all the requirements for acquisition stations

by Alex Young, *RCA Solid State division, Somerville, N.J.*

☐ The data explosion has brought with it a tremendous demand for acquisition stations capable of providing information to a central location for recording and processing. A particular challenge to designers is remote stations for geologic, oceanographic, and space applications, where high data reliability must be combined with low-dissipation circuitry to conserve power supplies.

Pulse code modulation and complementary MOS make an excellent combination for these applications. PCM has inherently high noise tolerance during transmission and interfaces easily with digital data-processing gear. C/MOS, for its part, is already highly regarded for its low operational and standby power requirements, as well as for its excellent immunity to noise even in severe environments [see "C/MOS and the designer," p. 50].

One such digital data acquisition system uses both of these techniques to accept one digital and eight analog inputs from data sensors. The data then is assembled into a sequence of digitally coded eight-bit words. Serial output can feed a computer directly, or can modulate an rf carrier for telemetry to a distant data sink.

Developing the basics

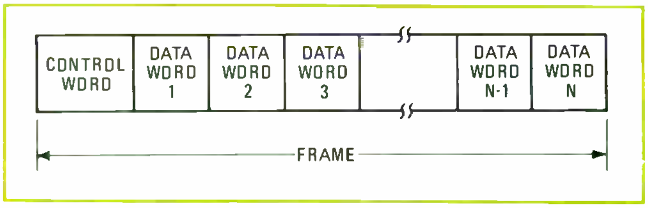
The order in which data channels are sampled is basic to a data acquisition system. This ordering into a predetermined format includes synchronization words necessary to decipher the data. A word is the smallest number of bits handled as a single entity. Word length (the number of bits per word) determines the maximum accuracy of data measurements. Words are subsequently grouped into frames. The frame is an integral number of words and includes a synchronization word. In Fig. 1, a typical format has N words grouped into one frame.

Sampling rate of data words is based on the bit rate to be transmitted, word length, and the frame length:

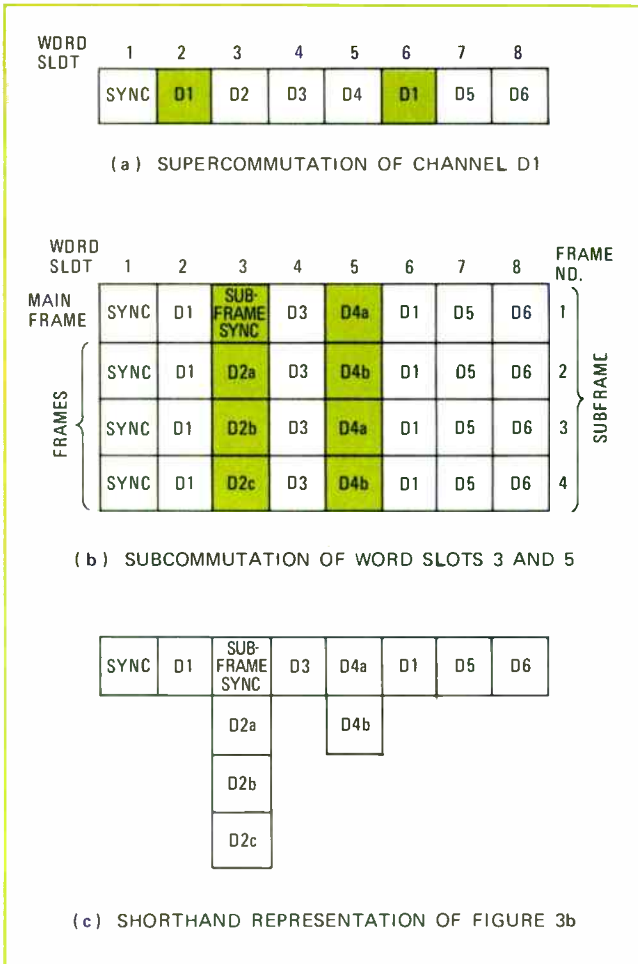
$$\text{Sampling rate} = \frac{\text{bit rate}}{\text{word length} \times \text{frame length}}$$

Thus, for a bit rate of 8 kilobits per second, a word length of eight bits, and a frame of 10 words, the sampling rate is 100 times per second.

The format in Fig. 1 requires that sampling rates are the same for each input. However, many applications require a range of sampling rates for efficient operation. Two fundamental techniques—supercommutation and



1. Format. In the basic format of acquisition systems, a frame consists of an integral number of words and a synchronization control word. A word is the smallest number of bits handled as an entity.

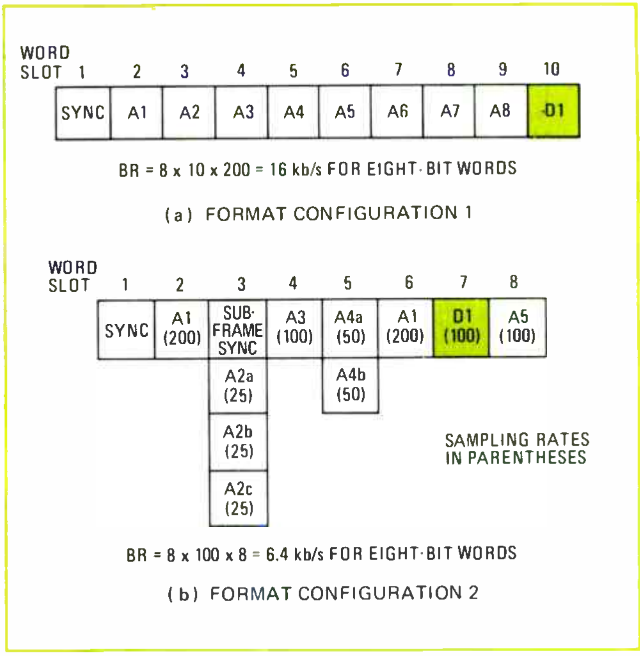


2. Multiple sampling rates. Supercommutation and subcommutation are techniques used to accomplish sampling rate variation for efficient utilization of a system's channel capacity.

subcommutation—accomplish this needed sampling rate variation (Fig. 2).

In supercommutation, as in (Fig. 2(a), data channels in a given frame are sampled repeatedly to obtain sampling rates that are integral multiples of the fundamental rate. For the format parameters shown, channel D1 is sampled at twice the fundamental rate. In effect, the process means dividing the frame-length term of equation 1 by the number of repetitions of a given channel. Proper supercommutation requires that the word slots be evenly spaced in a frame.

Subcommutation, as in (Fig. 2(b), is the alternate



3. Efficient formats. Supercommutation and subcommutation allow bit rate reduction from 16 to 6.4 kb/s in this example.

sampling of data channels from frame to frame to obtain sampling rates that are a fraction of the fundamental rate.

The entire data cycle (the smallest number of words that repeat periodically) is called a subframe and includes the main frame and subsequent frames. Subcommutation can be applied to more than one main frame word but the number of subcommutations must have an integral relationship to all other subcommutation lengths. For example, lengths of two, four, and 16 frames are acceptable, but two, eight, and 10 are not because 10 is not an integral multiple of eight. The integral relationships in subcommutation assure synchronization of subcommutated channels for decommutation.

A practical example

Manipulation of the bit rate, frame length, and subframe length parameters is required to obtain an optimum format from sampling rate requirements. Assume the need to design a format with input requirements of one channel at 200 samples per second (analog); three channels at 100 samples/s (two analog, one digital); two channels at 50 samples/s (analog); and three channels at 25 samples/s (analog).

One solution is to sample all channels at 200 samples/s. This meets the requirement of the most active channel at the cost of oversampling the others. The resulting format has a bit rate of 16 kb/s for an eight-bit word length, as in Fig. 3(a). This format is inefficient and results in having to record and process redundant data.

An alternate format, as in Fig. 3(b), consists of eight 100 sample-per-second main frame words; it uses supercommutation and subcommutation to generate alternate sampling rates. Supercommutation of two word-slots (2 and 6) produces a 200 sample/s channel. Subcommutation of one word-slot (5) twice and another (3)

C/MOS and the designer

Although complementary symmetry metal oxide semiconductor circuits (C/MOS) have found extensive use in military systems, many circuit designers have had little exposure to these devices. Nonetheless, they should find wide appeal in practical circuit applications based on two key features:

- The extremely low power dissipation of the devices permits economical battery operation of complex systems, a point that's sure to make engineers designing aerospace, oceanographic, and other battery-powered systems look up.
- The high inherent noise immunity of C/MOS devices often reduces requirements for complex filtering circuits. This immunity is primarily due to the false-trigger margins between the two logic levels and the triggering threshold that separates these levels. (These and other features of C/MOS, standard MOS, and transistor-transistor logic circuits are compared in the table.)

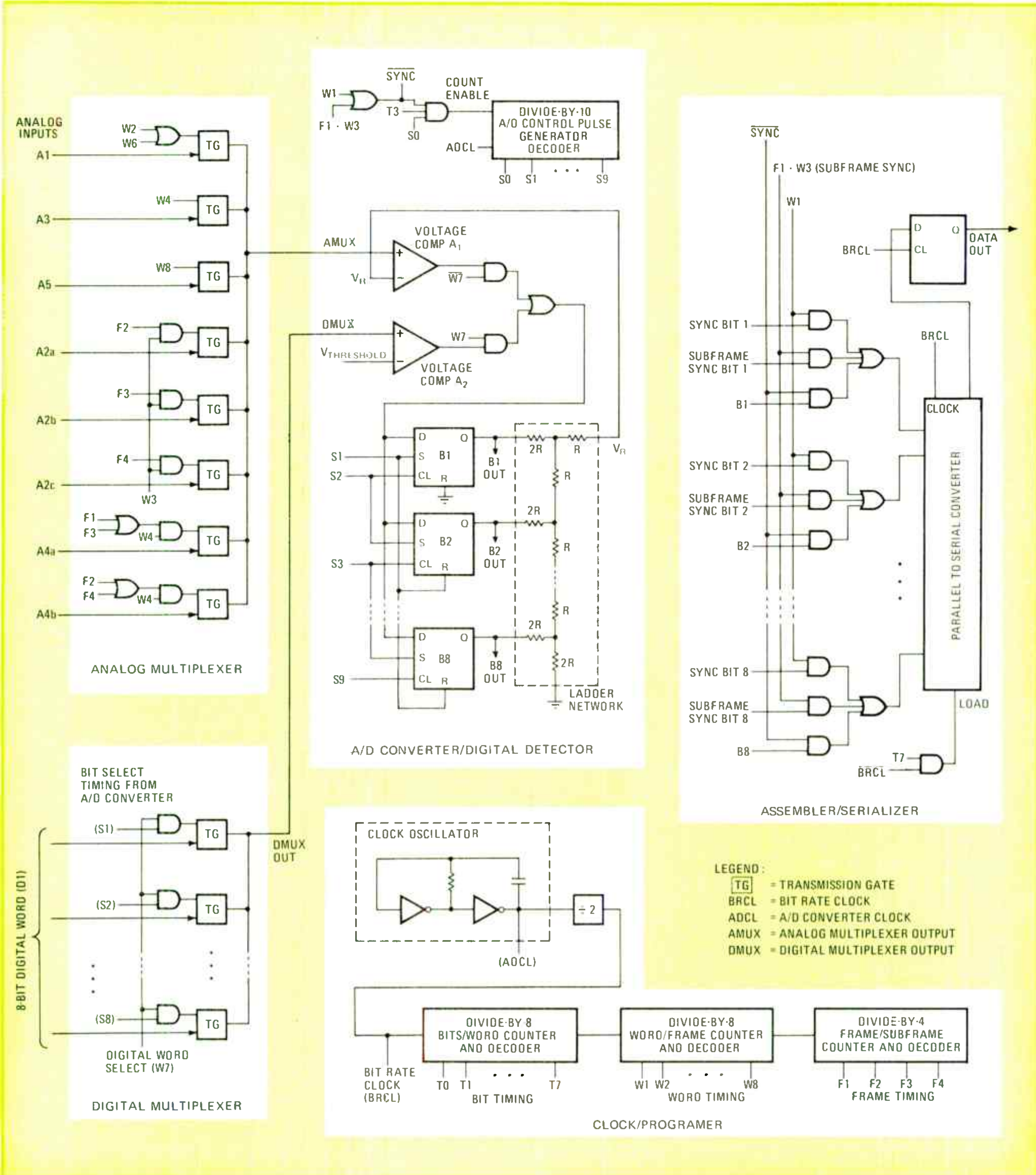
A breadboard of the data acquisition system has been constructed using C/MOS circuits; its total dissipation is 200 milliwatts, less than 10% of a similar system using TTL circuits. Only one-quarter of this 200 mw is used to power the C/MOS logic (150 mw is consumed by the two analog comparator circuits).

The trial system was operated at a typical clock speed of 100 kilohertz in making the comparison above. C/MOS power dissipation depends on operating speed, so the C/MOS power advantage over TTL would be expected to degrade as switching speeds increase. Most data acquisition applications, however, require clock speeds of less than 100 kHz.

In a standby mode, where bias is applied to C/MOS circuits but switching does not occur, power dissipation is virtually zero. For TTL circuits, power is dissipated even when switching does not occur.

The high noise immunity of C/MOS ICs is attributable to their relatively low output impedances (approximately 600 ohms), moderate-speed operation, and trigger levels very near 50% of supply voltage level. C/MOS circuits are guaranteed not to trigger falsely when noise reaches levels as high as 30% of supply voltage for a logic 0 or as low as 70% of supply voltage for a logic 1. Unlike TTL, C/MOS logic can switch to within 10 millivolts of the 1 and 0 levels with fanouts as high as 50 gates.

As C/MOS circuit popularity increases, more circuit functions will become available. Presently, RCA, Motorola, Harris, Ragen, and Solid-State Scientific, have announced commercially available product lines. This list will certainly get longer.



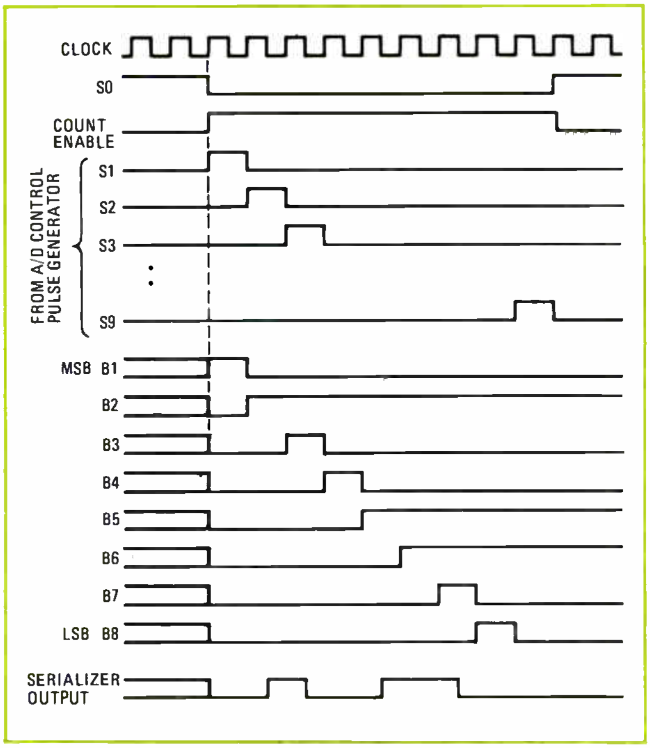
4. Block diagram. Data acquisition systems can be easily implemented using C/MOS logic. The basic system functions include analog and digital multiplexers, a system synchronizer-programer, an analog-to-digital converter, assembler, and output serializer.

four times produces two 50 and four 25-samples/s channels. The bit rate required by this format is 6.4 kb/s, roughly one-third of that required previously, and is achieved with only a small increase in hardware.

This example requires implementation of the primary functions of a data acquisition system and can be used as the basis for a system design. This design can be readily extended to more complex format structures.

The system's basic functional blocks include analog and digital multiplexers, an analog-to-digital converter and digital detector, a synchronizer-programer, and a data assembler and output serializer (Fig. 4).

The synchronizer-programer provides basic timing by reducing the bit rate clock timing into words, frames, and subframes; bit rate frequency is divided by eight in the bits-per-word counter. Outputs are decoded from a 50% duty cycle so that no two outputs are in a logical 1 state at the same time. Similarly, the word-per-frame



5. A-d encoding sequence. The flip-flop outputs (B1–B8) result from the a-d coding for an analog input of 1.410 volts. Parallel outputs are loaded into serializer after control pulse S9 arrives.

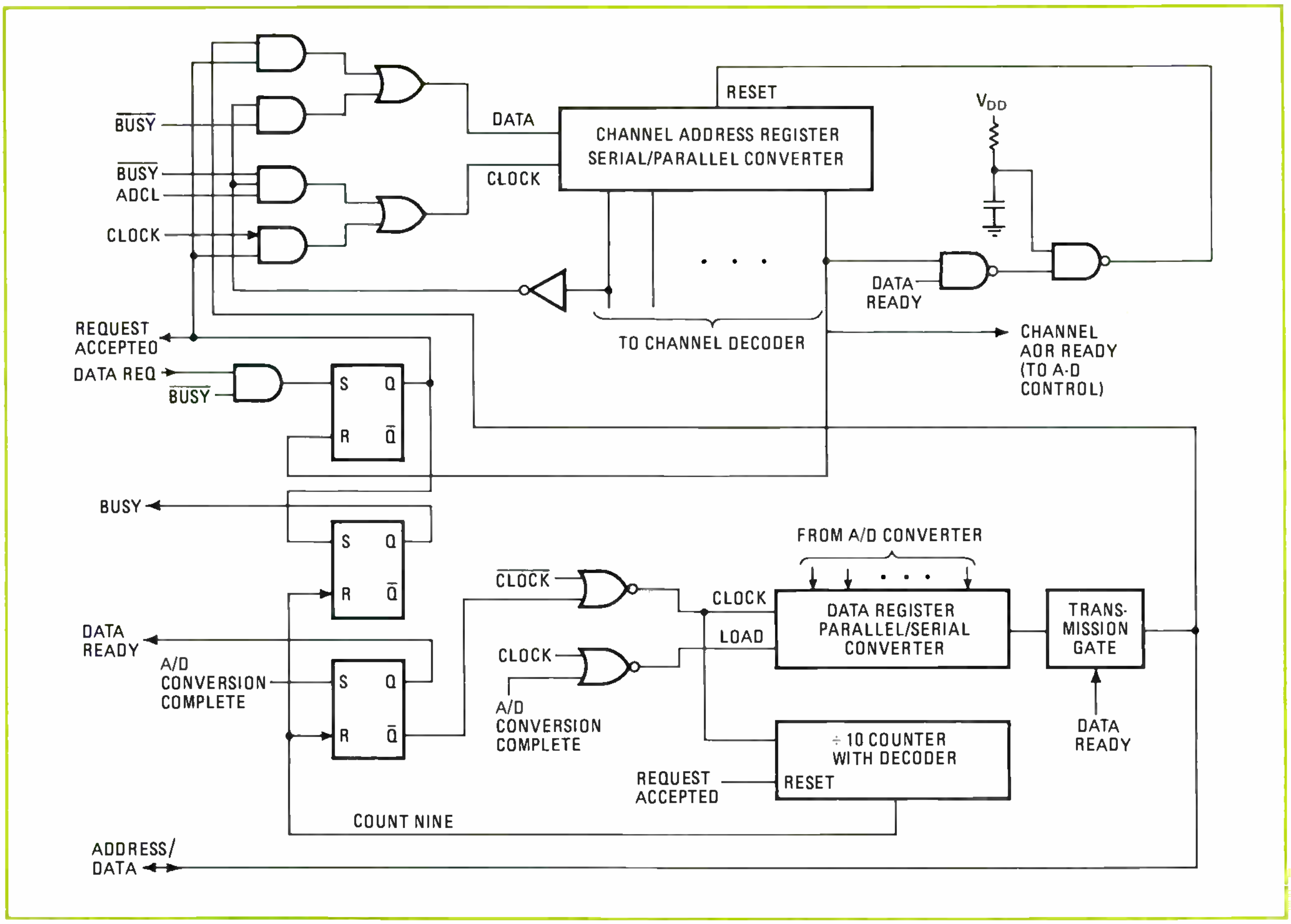
and frames-per-subframe counters generate the required format matrix column and row dimensions. The eight-word-per-frame requirement is satisfied by using a divide-by-eight counter; the low-frames-per-subframe length is provided by counting down from the frame counter.

Combining analog inputs

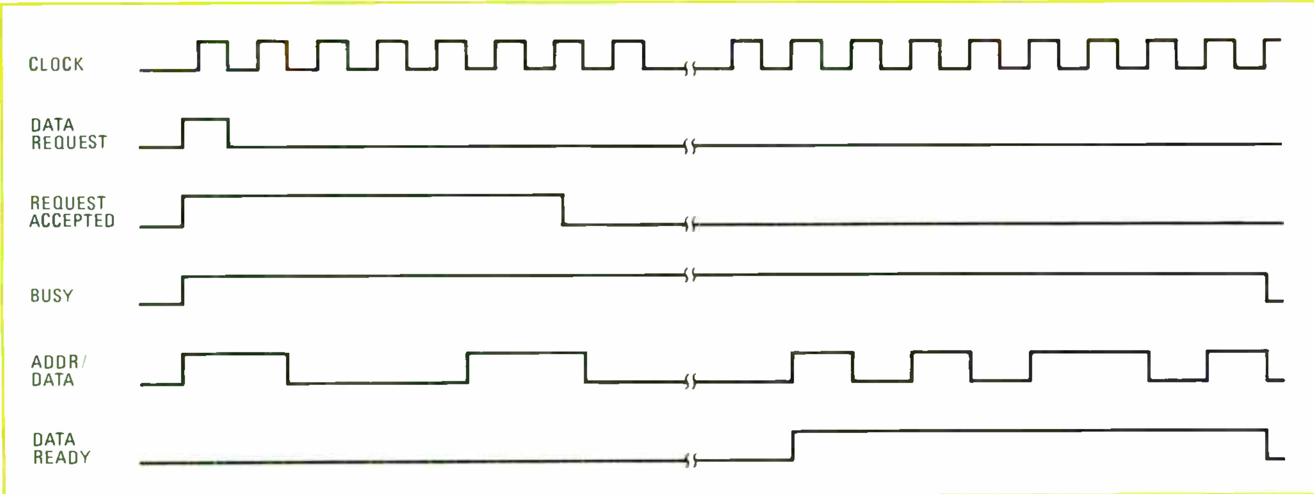
The analog multiplexer samples the analog inputs for transmission to the a-d converter. This process is called "successive approximation." If the input voltage is 0 to 5 volts, a reference voltage (V_R) is given as 5 V in the a-d converter. For an eight-bit system, the input voltage is compared to the reference voltage divided successively by 2, 4, 8, 16, 32, etc. up to 256 (the eighth power of 2). Thus, for a 5-V reference the lowest discrete level of quantization is equal to 19.6 millivolts, so, for an eight-bit system, a zero voltage would mean all 0s; with a 19.6-mV input, the a-d converter would generate a 1 and seven 0s, etc. At 5 V, all 1s are generated.

The timing sequence for encoding an analog input of 1.410 V is shown in Fig. 5. Operation is initiated by the programer when a word-slot is assigned to an analog input. At time S1 the a-d holding register is set to a 1 and seven 0s (half scale). A reference voltage (V_R) of 2.5 volts is applied to the comparator, (A1 in Fig. 4).

The comparator output is 0 if V_R = AMUX (the sampled input voltage from the analog multiplexer); there-



6. Remote control. Options such as the slaved programer shown extend the versatility of the basic data acquisition system. Here, the slaved programer accepts the necessary control signals on request. The acquired data is then telemetered out on the DATA/ADDRESS line.



7. Interface signals. In this slaved system, the control logic services requests on a first-in, first-out basis and ignores any requests initiated while it is in the BUSY state. After accepting a request, the acquired data is transmitted on the ADDRESS/DATA line (see Fig. 6).

fore the 0 inputs to the register flip-flop elements (B1, B2, etc) are 0. At time S2 the first flip-flop is clocked to 0 and the second flip-flop is set to the 1 state. The resulting reference voltage (1.25 V) is less than AMUX, and the comparator output goes to the 1 state. At time S3 the second flip-flop is clocked to 1, and the third flip-flop is set to the 1 state. This procedure continues until all the bits have been considered.

Standard circuits can be used in the analog section of the a-d converter. C/MOS devices can drive ladder networks directly with typical output impedances of 2 kilohms. The a-d network yields accuracy within 1.5% to 2% with eight-bit resolution at rates of approximately 10 kb/s so that the encoder can handle the data requirements of most operational applications. What's more, converter speed or accuracy can be increased by the use of gates or buffers to reduce impedance at the flip-flop outputs.

A-d converters are subject to numerous error sources, many of which go unnoticed. Temperature variation is one of the major causes: changes in temperature as small as 10° can cause an output variation equivalent to a quantizing level. Other sources of error must be considered in a practical design, and include such parameters as sampling rate variations, aperture time, interpolation errors, source impedance and multiplexer leakage. Data is available (outputs B1 through B8 in Fig. 4) for parallel serial conversion for entry into the output bit stream.

Clocking the data out

The serializer gathers data from the a-d converter, the frame sync word generator, and the subframe sync word generator; the assembled data is loaded into a parallel-in-to-serial-out shift register and is clocked out at the bit rate. Data goes into the register and is clocked out at the bit rate. Data goes into the register asynchronously; it's controlled by the bit rate clock. A flip-flop is added to the end of the register to serialize symmetry.

Where fixed-format PCM data systems aren't ideal for many industrial control and data management systems, slaved-data acquisition sub systems may do better. In such setups, data and control are provided on request, substantially reducing redundant data and transmission rates, and providing control capability at remote locations. The PCM telemetry system can be adapted to this operation; in fact, logic implementation of remote slaved-data acquisition systems with C/MOS devices is desirable because power consumption of the system is reduced significantly as the switching activity in the circuits decreases.

Slaved programer adds flexibility

A slaved programer must include a channel address register, as well as data request recognition and output transfer-control logic. The format is defined by an external programing source and is not constrained by the programer format in the acquisition system except for maximum channel capacity; format words-per-frame and frames-per-subframe counters are unnecessary.

The interface can range from a single wire to several parallel buses. A typical slaved programer (Fig. 6) uses a single ADDRESS/DATA line and five supporting control lines: CLOCK, DATA, REQUEST, REQUEST ACCEPTED, BUSY, and DATA READY.

A request is initiated by applying a logic 1 to the data request line (Fig. 7). The control logic services requests on a first-in first-out basis and ignores and requests initiated while it is in the BUSY state. When a request is initiated at a valid time, a REQUESTED ACCEPTED pulse is generated, the BUSY line is set to 1, and the input to the channel address register is enabled for loading by the requesting device. When the channel address information is received, the data is acquired, the DATA READY line is set to 1 and the output data register is enabled for clocking onto the ADDRESS/DATA line by the requesting device. The interface control logic is subsequently reset and the system is ready to acquire a new data word.

Options such as the slaved programer add much versatility to the basic data acquisition system; those available to communications systems designer are as numerous as the applications for such designs. Commonly used options include extended accuracy, sample-and-hold, selectable input levels, high data-input impedance, and remote digital data processing. □

Designer's casebook

Divide-and-sample loop cuts phase-locked VCO slippage

by Charles Deming
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A reference sine wave can be sampled to obtain the control voltage for a voltage-controlled oscillator (VCO) so that lock-in takes only about a dozen cycles. A steady intercycle voltage can be obtained for the VCO without the usual integrating circuit and its attendant delay—a common cause of initial instability.

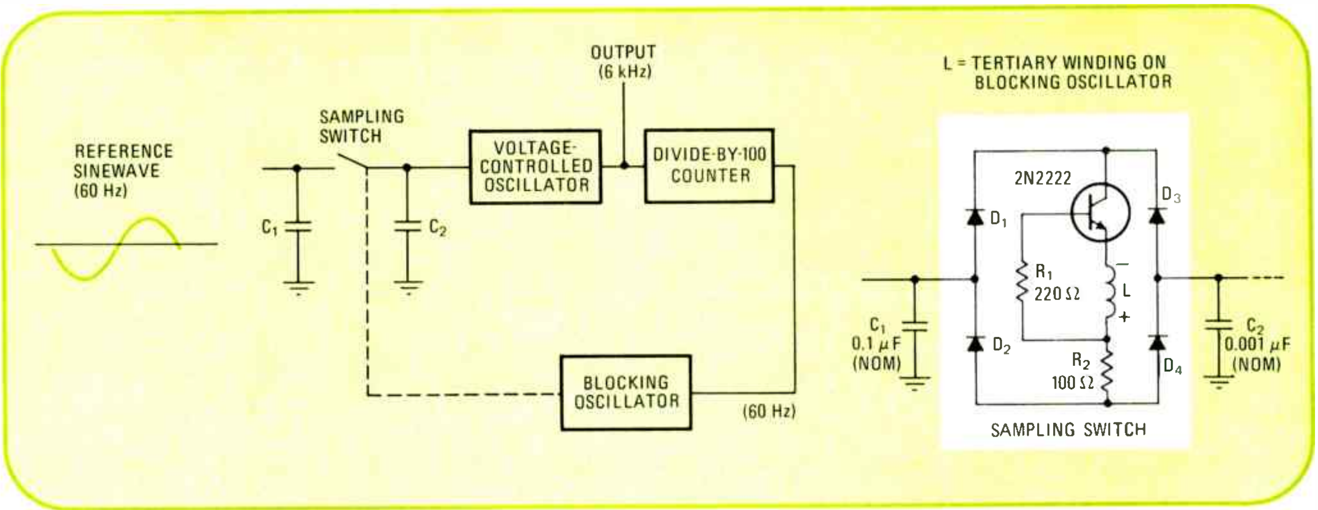
The reference frequency, 60 hertz in this case, appears across capacitor C_1. A sampling switch then transfers C_1's voltage at a given time to capacitor C_2. Sampling time must be short compared to the reference cycle time, and C_2 must be small compared to C_1. The sampled voltage controls the VCO.

Oscillator frequency is initially set to equal the reference frequency times the counter dividing factor. For this circuit, the VCO is set at 60 Hz (reference) times 100 (counter dividing factor) or 6 kilohertz. The counter, whose output is approximately 60 Hz, fires a blocking oscillator once per cycle to operate the sampling switch. The 6-kHz output frequency is now locked to the 60-Hz reference.

Except for its input and output connections, the sampling switch should be isolated from the circuit. The switch makes use of a tertiary winding on the blocking oscillator. In its off condition, the switch is open in both directions because a positive collector voltage is applied to the cutoff transistor. If C_1 is more negative than C_2, diodes D_1 and D_4 are back-biased; if C_1 is more positive than C_2, the back-biased diodes are D_2 and D_3.

During an on pulse, transistor base current is supplied by the tertiary winding and limited by resistor R_1. Transistor collector current is limited by resistor R_2 and flows through all diodes to close the switch. Although the transfer current between C_1 and C_2 is also limited, it can be made quite large because of its low duty cycle. The transfer of voltage, therefore, can be made quickly—within only a few microseconds for the 60-Hz oscillator.

Sine-wave reference. Phase-locked voltage-controlled oscillator employs 60-hertz reference to stabilize 6-kilohertz output. Reference sine wave is supplied across C_1. Switch then samples C_1's voltage and transfers it to C_2 for driving VCO. Blocking oscillator triggers sampling switch so that sampling phase difference prevents output frequency drift. Output frequency is reference frequency times counter factor.



Digital phase shifter maintains quadrature

by Kurt Leuenberger
Stanford Electronics Laboratories, Stanford, Calif.

When analog multipliers are used for phase detection, it is often necessary to maintain a 90° phase difference between the reference signal and the carrier of the modulated signal for optimum dynamic range and linearity. The carrier frequency, which is usually a known quantity that changes only by very small amounts, can be corrected for phase drift (from the desired 90° difference) with a digital phase-locked loop.

The digital phase shifter shown adjusts the reference phase for a zero dc output level so that a quadrature phase relationship can be maintained with the carrier of the incoming signal at frequency f_o. The unshifted reference signal must be available at the nth harmonic of f_o.

Two operational amplifiers, A_1 and A_2, perform as level detectors, sensing any excess dc level at the phase detector output. Detector A_1 supplies a logic 1 if its noninverting input is more positive than V_1; A_2 gives a logic 1 when its inverting input becomes more negative than $-V_1$.

When A_1 goes high, one-shot FF_1 (which consists of four NAND gates) is triggered by a positive output transition of gate G_1, corresponding to a positive transition of the reference signal. The one-shot then generates a pulse whose length, T_1, must be shorter than a half period of the reference signal.

This pulse enables gate G_3, and advances the counter. Therefore, the counter output signal at f_o is shifted to a leading position by 1/nth of a period.

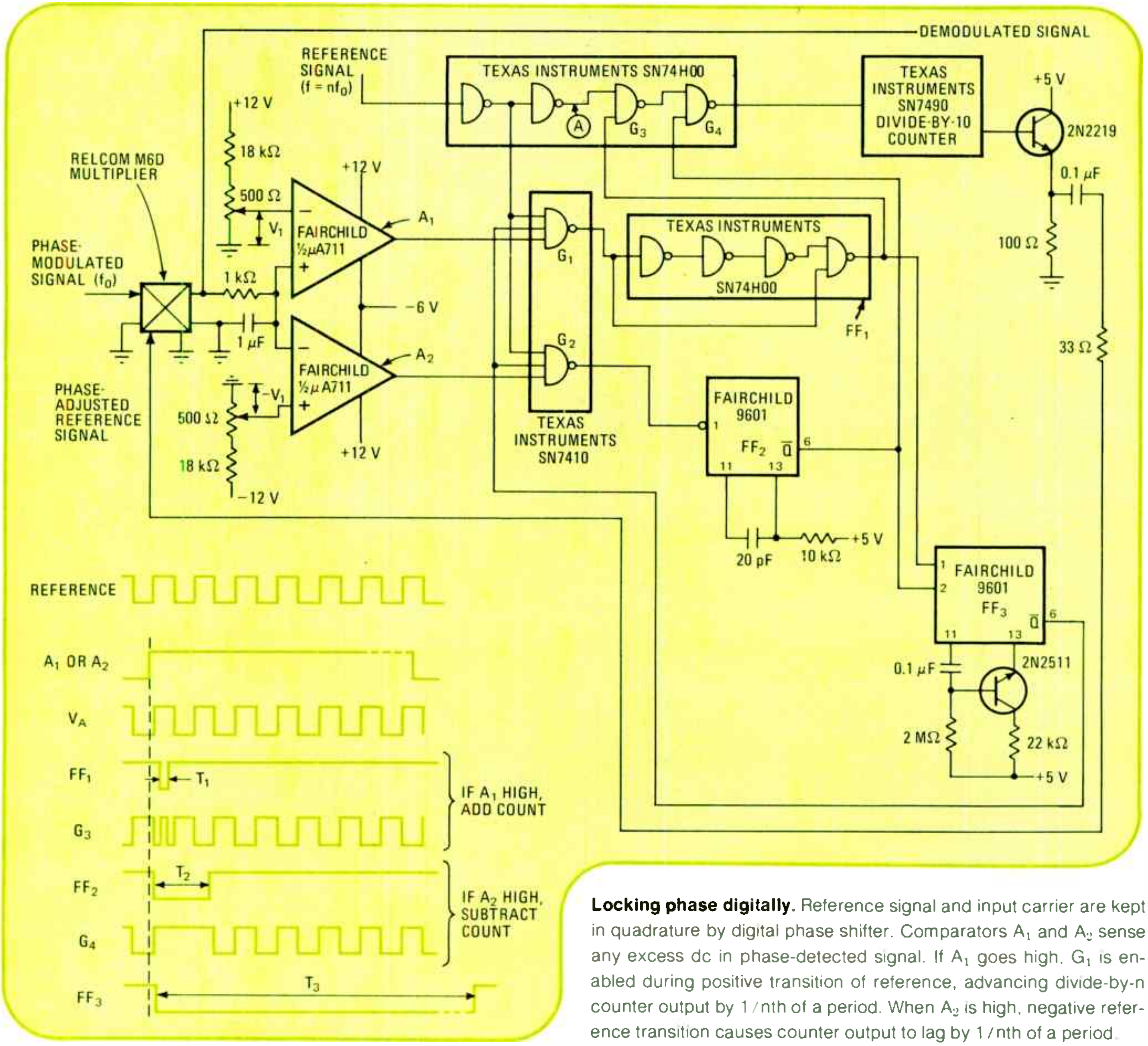
For negative reference-signal transitions, one-shot FF_2 is triggered by gate G_2, if A_2 is high. The one-shot's output is a pulse of length T_2 that enables G_4 and results in a suppressed positive transition at the counter input.

Phase shift now goes to a lagging position at the counter output by 1/nth of a period. Both FF_1 and FF_2 trigger one-shot FF_3, which inhibits the shift process at gates G_1 and G_2 for a time T_3, long enough for the entire loop to recover.

The circuit illustrated can be operated at a frequency (f_o) of 1 megahertz, with a dividing ratio (n) of 10 and inhibit timing (T_3) of 0.1 second. The error voltage to which the loop responds can be decreased by increasing the dividing ratio.

It is also possible to use the digital phase shifter as an open-loop circuit for phase or frequency modulation to tens of kilohertz. Modulation is accomplished by reducing T_3 and by keeping either A_1 or A_2 high to generate a continuous count addition or subtraction.

Output waveforms are shown for several points in the circuit.



Locking phase digitally. Reference signal and input carrier are kept in quadrature by digital phase shifter. Comparators A_1 and A_2 sense any excess dc in phase-detected signal. If A_1 goes high, G_1 is enabled during positive transition of reference, advancing divide-by-n counter output by 1/nth of a period. When A_2 is high, negative reference transition causes counter output to lag by 1/nth of a period.

Instrument amplifier offers high gain

by Richard S. Burwen
Analog Devices Inc., Norwood, Mass.

Intended for use as an input stage for dc laboratory instruments, an amplifier circuit provides a dc gain of 1 to 1,000, while maintaining a gain-bandwidth product of approximately 200 kilohertz. Amplifier gain is switch-selectable in decade steps.

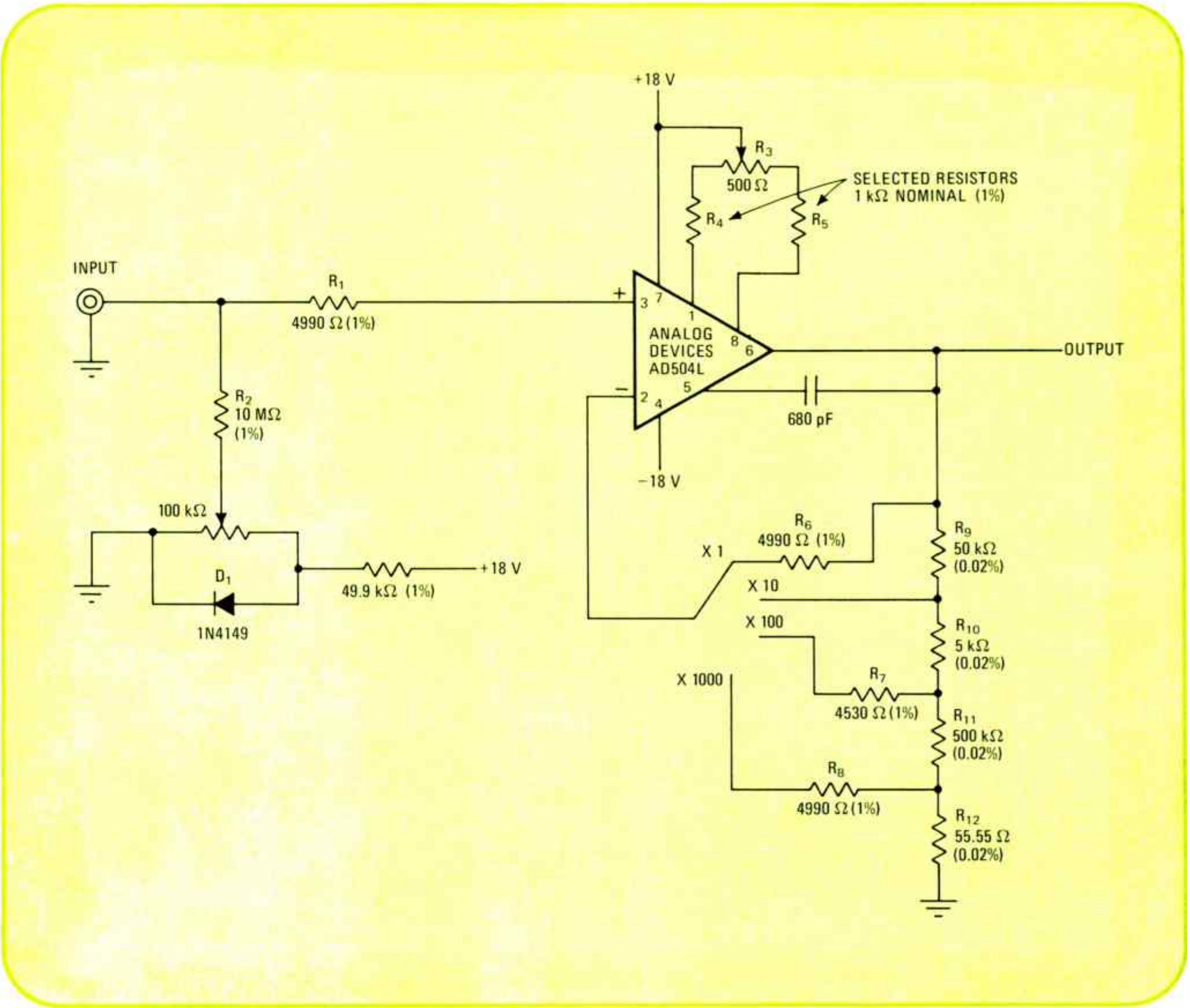
Series input resistor R_1 protects the amplifier against overvoltages of up to ±20 volts whenever the power supplies are turned off. Resistor R_2 determines the circuit input impedance (10 megohms in this case) and is used to zero amplifier input bias current by means of the temperature-compensating (due to diode characteristic) reference voltage developed across diode D_1.

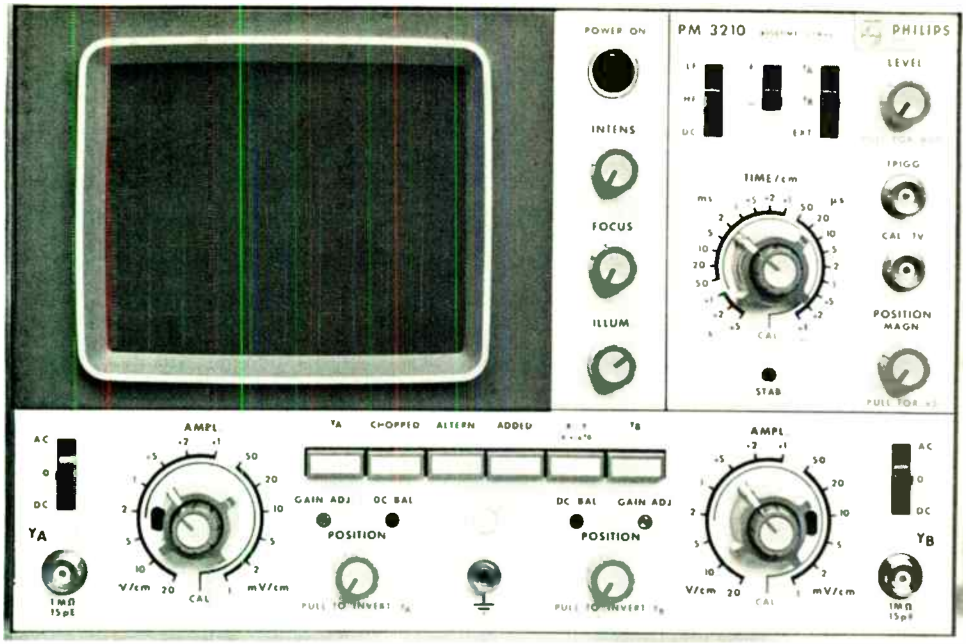
Amplifier offset voltage is zeroed with potentiometer R_3. A pair of selected resistors (R_4 and R_5) reduces the voltage span of R_3 to about 400 microvolts, referred to the amplifier input. Selection of R_4 and R_5 is necessary to permit offset adjustment with R_3 since the amplifier has a rated offset voltage of ±0.5 millivolt. If a coarser adjustment can be tolerated, a single 10-kilohm pot can replace R_3, R_4, and R_5.

A feedback network, consisting of resistors R_6 through R_{12}, allows amplifier gain to be switched in decade steps. This network also provides a constant source impedance for the amplifier's inverting input. Because of resistor arrangement, circuit output is zeroed (with no input applied) for all gain ranges if it is zeroed for the highest one.

The circuit can attain overranging of ±150%.

Instrument aid. Reference voltage for instrument input amplifier is developed with diode D_1, compensating for amplifier input bias current through 100-kilohm pot and resistor R_2. Offset zeroing is accomplished with potentiometer R_3 and resistors R_4 and R_5. Feedback resistor network permits gain selection from 1 to 1,000. Impedance at amplifier inverting input remains constant, no matter where switch is set.





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Different ways of driving a pulsed injection laser

Uncooled injection lasers need careful control of current pulse height, width, and rise time; here are six drive circuits that will cope with the requirements of most applications

by Ron Carroll, *Texas Instruments Incorporated, Dallas, Texas*

☐ The large-optical-cavity structure that has recently been developed for injection laser diodes not only has a higher efficiency and power capability, but also makes bigger demands on the circuit that drives it. In fact, all uncooled pulsed laser diodes require current pulses of high quality. [1] In this they are unlike devices cooled below 150° K, which can tolerate fairly sloppy current pulses.

Rise time is the key parameter. Times as long as 500 ns will not reduce the peak power output of a cooled laser diode. At higher temperatures, on the other hand, 80 ns is about the limit—an effect that is even more pronounced in diffused diodes than in heterostructure and LOC lasers.[2]

Next in importance is the accurate control of pulse width. For a particular device structure the optimum pulse width is determined partly by quenching and partly by a not-too-well-understood catastrophic failure mechanism. Essentially, quenching is the complete loss of optical output caused by the rise in temperature during the pulse, while the catastrophic failure mechanism dictates that, for a given emitting junction width and thickness, the pulse width and its height must be inversely related.[3,4,5]

Six ways of doing it

The many ways of producing high-power pulses can be boiled down to six basic approaches: conventional tube circuits, conventional transistor circuits, avalanche transistor circuits, SCR discharge-type circuits, hybrid avalanche-power transistor circuits, and mechanical methods.

While each of these circuits has its own areas of application (see table below and circuit descriptions on pp. 60-61), the first two are particularly valuable if an amplitude-modulation capability is desired. The amplitude of their output pulses can be modulated merely by varying the amplitudes of their input pulses. With the other circuits, modulation of the dc bias on the final driving stage is required.

Since the output impedance of the dc bias supply must be very low to supply the high currents demanded by a laser diode (or diodes), modulation requires appreciably more power—and circuit complexity—than first considerations would seem to indicate.

Let there be light

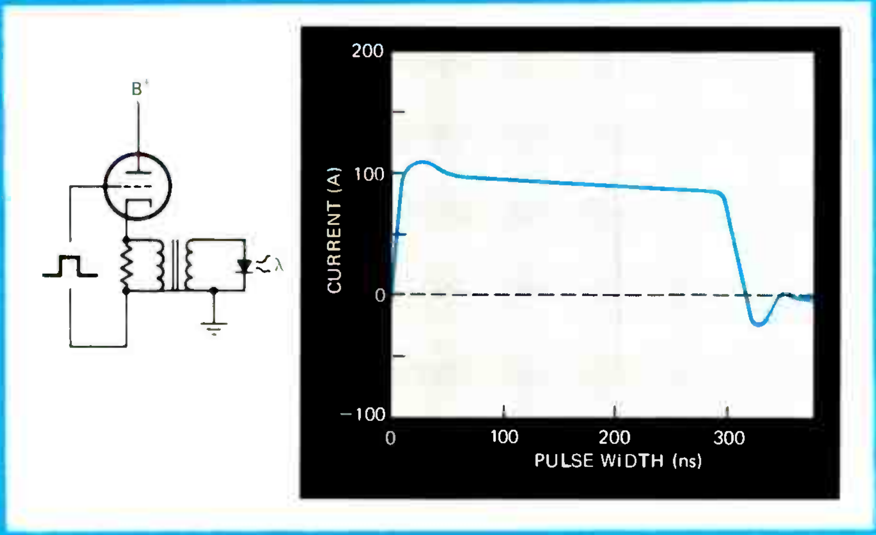
For illumination applications, such as low-light-level television (L^3TV), and systems for undetectable night-viewing, a circuit should be chosen to maximize the laser's average power output. These pulsed active viewing systems have an important advantage over cw illumination systems in that they lend themselves to range gating, which effectively suppresses backscatter from the regions between system and target.

This approach, called gated viewing, allows the viewing range to be varied by varying the time between the transmission of the pulse and the switching on of the receiver.

For L^3TV, as with any illumination application, maximum average power is the principal consideration. But pulse purity (rise, fall, and flatness) are more important than in general illumination applications because good picture quality requires that uniform illumination be

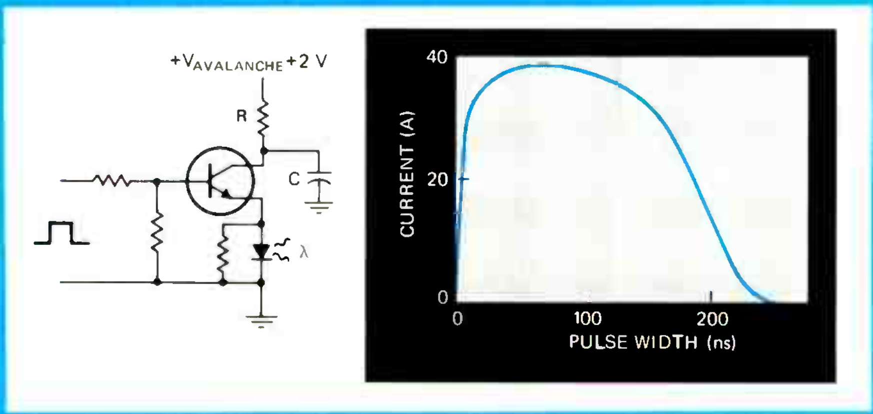
CHARACTERISTICS OF LASER DIODE DRIVER CIRCUITS

CIRCUIT TYPE	OUTPUT RISETIME (ns)	MAXIMUM PULSE REPETITION RATE (kHz)	MAXIMUM PEAK CURRENT (A)	MAXIMUM PULSE WIDTH (ns)	MEANS OF PULSE WIDTH CONTROL
Tube	10–20	500	200	250	Varying input pulse length
Mechanical	0.5	~0.2	20	300	Varying physical length of charged coaxial transmission line
SCR	100–200	10	200	5,000	Varying capacitance of discharge capacitor or lumped delay line
Avalanche transistor	5–10	100	40	300	Varying capacitance of discharge capacitor
Conventional transistor	200	1,000	100	>5,000	Varying input pulse length
Hybrid avalanche power transistor	15–40	100	50	1,500	Varying capacitance of avalanche transistor discharge capacitor



1. Conventional tube pulser circuits can provide good rise times and high voltages, but their high saturation resistances make them a poor impedance match to the laser diodes. As the circuit diagram shows, however, the use of high-quality transformers allows a fair job of impedance matching.

But when transformers are employed, obtaining flat-top pulses longer than a few hundred nanoseconds is at best difficult. At high power levels, it is expensive as well. Also, the attendant undershoot problems can catastrophically exceed the reverse breakdown ratings of laser diodes.

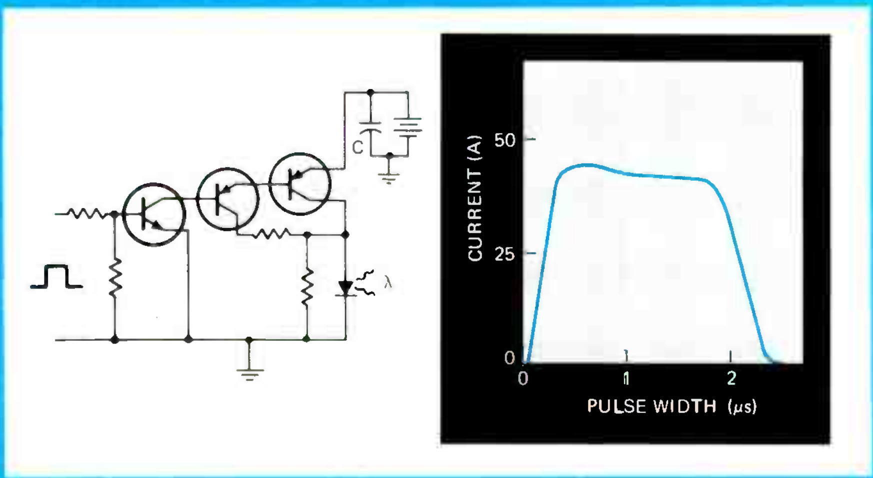


2. Avalanche transistor circuits (shown above) differ from SCR circuits in two important respects. First, if C is 0.02 microfarad or less, the avalanche transistor will turn off by itself once it has partially discharged the capacitor. Therefore, R can be as low as 150 ohms without causing any latching problems. This allows high-frequency operation without any need for special charge up circuitry. The second difference is less favorable. The device will tolerate only a small variation in bias. Increasing the bias does increase the current, but care must be taken as $V_{avalanche}$ approaches V_{CBR}. Good performance and reliability can be obtained by applying a voltage of $V_{avalanche}$ plus 2 volts. The additional 2 V ensures avalanche operation at high frequencies (increased transistor temperature).

The device is normally operated in the negative resistance region of secondary breakdown. If driven too far into secondary breakdown, the device will fail. So it's a good idea to protect it by limiting the value of C.

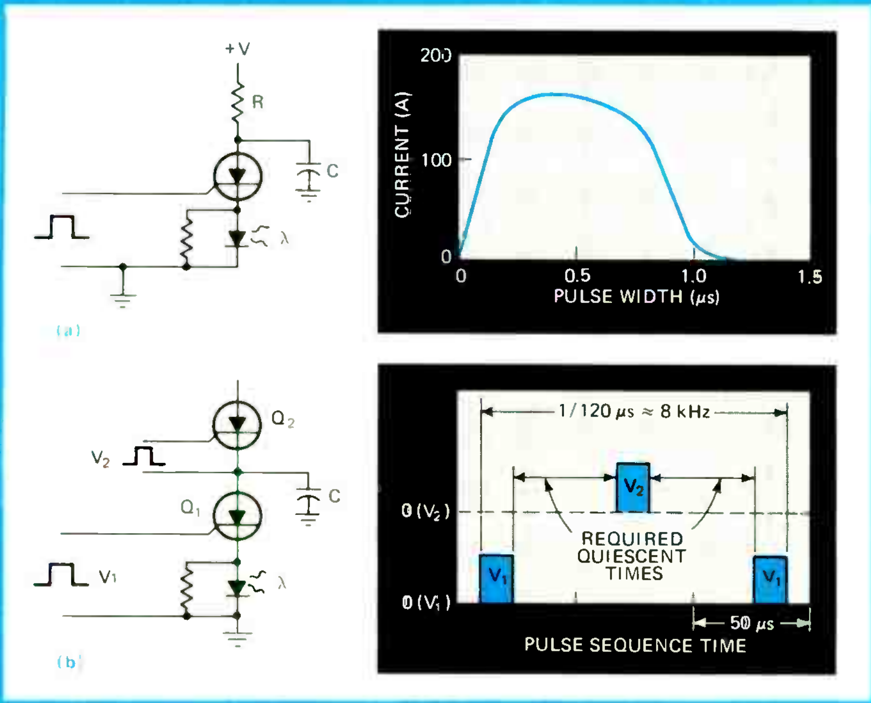
3. Conventional transistor circuits at these current levels (10 to 100 A) are not as clean as might be expected. It is important to bear in mind that at 60 A, a good, fast, high-power switching transistor may have an h_{FE} of less than 5. This will probably result in more stages of amplification than is desirable. Each stage tends to degrade the rise and fall times, and generally widens the entire pulse because of stored-charge effects.

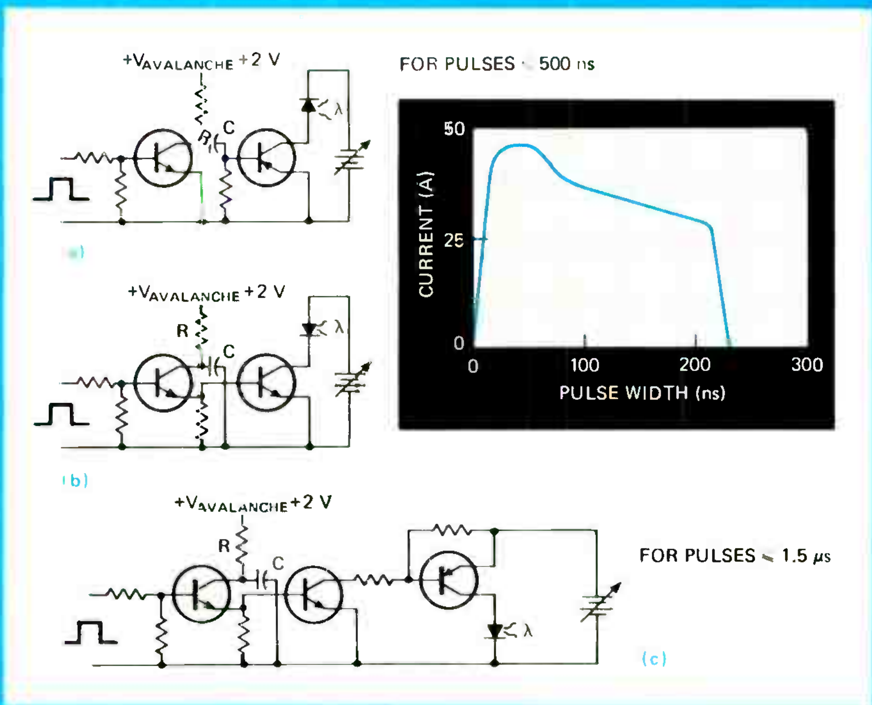
Although the circuit does not produce a discharge-type pulse, some perturbation in the flatness of the top of the pulse is to be expected as the width is increased beyond 1.5 microseconds, because the power supply bias will begin to drop.



4. SCR discharge-type circuits (shown at right) presently offer more power per pulse than any other circuit considered here. The basic circuit (a) is limited to low repetition rates because R must be high enough to prevent latching of the SCR—in other words, V/R must be less than I_H, where I_H is the holding current of the SCR. The frequency limit can be extended to beyond 10 kHz by adding a charge-up circuit (b) which, by allowing the capacitor to charge up through Q_2, makes it unnecessary to use R at all to prevent latching. But the power burden imposed on Q_2 is identical to that on Q_1.

At these power levels, to go much above 10 kHz is very difficult because each SCR must remain unbiased for a finite length of time after turning off. Reapplying the bias too soon will cause both SCRs to latch up, inviting disaster to them, the laser, and the power supply. Thus, a minimum quiescent time must be observed between the application of the laser firing pulse, V_1, and the application of the charging pulse, V_2.

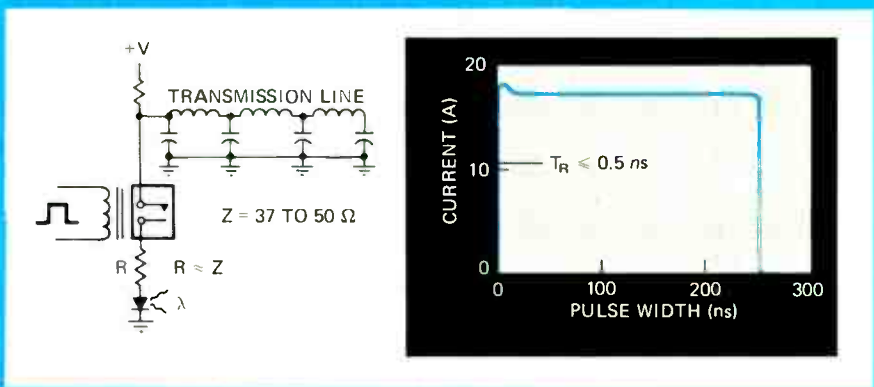




5. Hybird avalanche-power transistor circuits (shown at left) are essentially conventional transistor circuits with fewer transistors and a capacitively controlled pulse width. Overdriving the base of the output transistors with a short, high-current pulse will produce a 15- to 40-ns rise time and a 10- to 50-A pulse. Because of the stored charge in the output devices, the pulse width is stretched. C must be selected for the desired width at the desired drive power, since reducing the output bias will tend to stretch the pulse width further.

If the larger part of the power burden for each pulse is shifted to the output power transistor, the problem of excessive dissipation in the avalanche device is alleviated. Although not a flat pulse, it does not have as pronounced a spike as in the avalanche or SCR circuits. When all factors are considered, the hybrid circuit seems to offer the best match for the electrical requirements of driving laser diodes, though it's surpassed by SCR circuits in peak pulse power.

6. Mechanical pulsing circuits (shown at right) offer excellent rise times but generally have a limited power capability. In operation, the circuit discharges a charged transmission line through the mercury wetted contacts, a matching resistor, and the laser diode. For long pulses, the length of transmission line required becomes impractical. The resistor maintains the fidelity of the pulse shape, but greatly reduces the circuit's current-drive capabilities. The relay and the charge-up circuitry restrict the maximum repetition rate to a few hundred hertz.



The latest word on laser diodes

The recent advances in injection lasers have been many and rapid. Perhaps the most significant is the development of (AlGa)As-GaAs heterojunction diodes, which can be operated efficiently at room temperature.

The four basic types of injection laser diodes are best described in the order in which they were developed. They are the homojunction laser, made either epitaxially or by diffusion; the single heterojunction "close-confinement" laser, which has been commercially available since early 1969; the double heterojunction laser; and the new "large optical cavity" (LOC) laser.

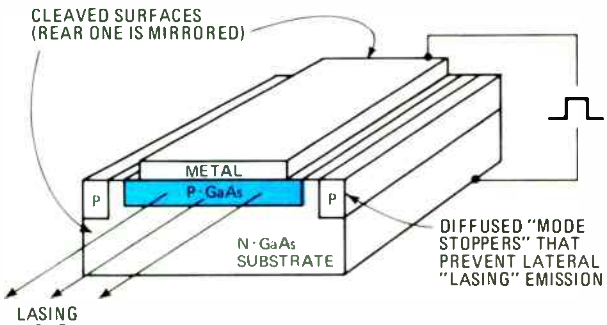
To a certain degree, the heterojunction devices complement each other because they are not all capable of sustained operation at high levels of peak power.

The key feature distinguishing the heterojunction lasers from the previous homojunction types is the greater confinement of the optical radiation to the junction region. To a large extent, the width of the confining region determines the threshold current density—the narrower the region, the lower the threshold. However, the strongly confined radiation also leads to the problem of catastrophic failure. This phenomenon is known to be related to the optical flux density, which is on the order of megawatts/cm². Therefore, the diode designer has to consider the intended application of the laser. In the great majority of cases, laser diodes are most useful when pulsed operation is required.

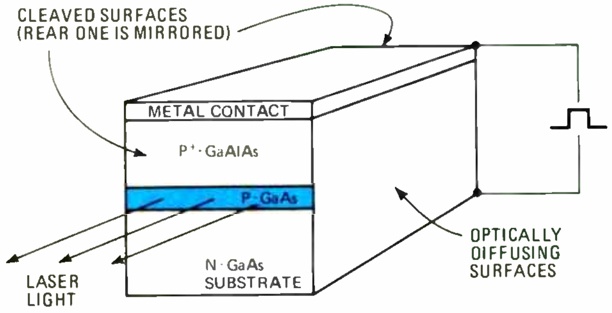
In the single heterojunction laser, the radiation is confined to a region about 2 microns wide. Devices such as these have room-temperature, threshold current densities of 8,000 to 10,000 A/cm², with differential efficiencies of 40 to 50%.

The double heterojunction laser allows the confinement of the radiation to a narrower region (as thin as about 0.2 micrometer) with resulting threshold current densities as low as 1,000 to 2,000 A/cm². But this laser is extremely susceptible to catastrophic damage.

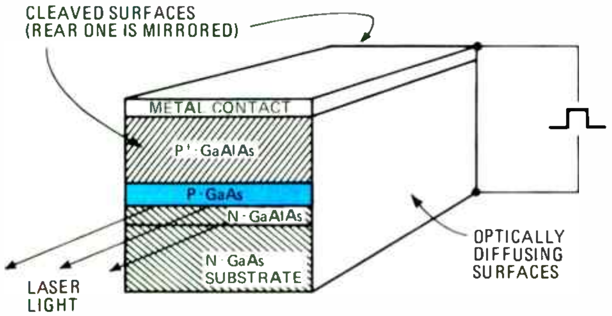
The LOC laser controls the thickness of the radiation-confinement region in a rather different fashion: it uses a thin p-type layer for carrier recombination and a wider n-type layer for light propagation. Since the passive n-type material absorbs the propagating light only very weakly, the radiation can be distributed over a wider region without degradation of the differential quantum efficiency.



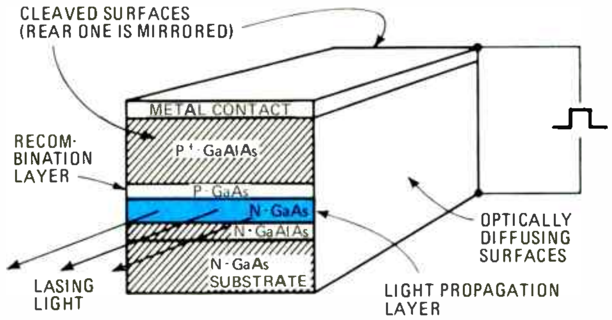
DIFFUSED HOMOJUNCTION LASER



SINGLE HETEROJUNCTION LASER



DOUBLE HETEROJUNCTION LASER



LOC LASER

maintained on many sequential scan lines.

The best circuits to use in these high-average-power applications are the SCR, conventional transistor, and hybrid avalanche-power transistor configurations. All three circuits can produce large, wide pulses at high repetition rates. And average power is directly proportional to the product of pulse height, pulse width and repetition frequency.

In range-finder applications, a high repetition rate is not as important as maximization of the total power in each transmitted pulse. On this basis, the SCR circuit is the obvious choice. However, it is usually desirable to minimize the rise time, size, weight, and cost of the circuit, as well. For these reasons, the avalanche transistor circuit is often better than the SCR approach.

In laboratory applications, where the emphasis frequently is on minimizing the rise time, the mechanical circuit has no peer. But though it is at least an order of magnitude faster than any of the other approaches, its extremely low repetition rate makes it an unlikely candidate for use in the field. □

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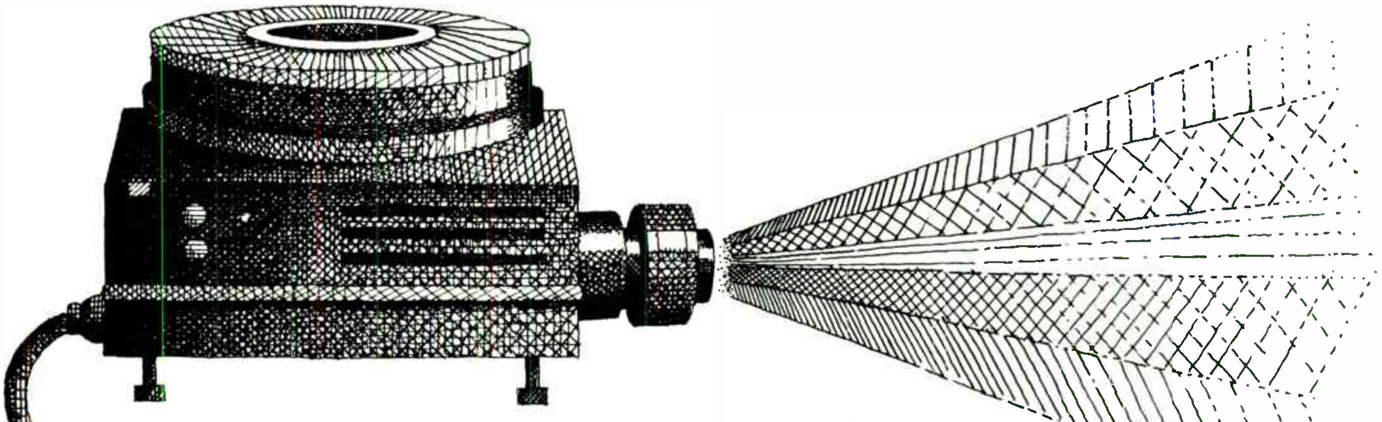

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ARPA registers a big net gain

The defense agency's computer network, now going operational, is opening the door to a new national utility

by James Brinton, Boston bureau manager

A nationwide computer utility may be on the way, now that the Advanced Research Projects Agency's experiment in computer resource sharing, the Arpanet, is nearly operational.

Today the network links about 20 Government and university computer centers across the country. Each center or node contains communications miniprocessors called interface message processors IMPs or terminal IMPs (TIPs), which have access to 50-kilobit lines leased from the Bell System. Only about ten nodes have computers (called hosts) that do more than "log into" the net, but Lawrence G. Roberts, ARPA's information processing director, figures active members will quickly increase in the next six months, and that the number of nodes should rise to about 25 by mid-1972.

Already ARPA is taking steps to put the existing operations on a businesslike footing. Roberts says that ARPA can't continue its role as manager. He makes it clear that when the Arpanet is a fully going concern, some agency—public or private—will have to take over.

How to run it. Network prime contractor Bolt Beranek and Newman, Cambridge, Mass., which developed the IMP and TIP, also is continually recording and analyzing node status data, traffic flow information, outages, service problems, and other network parameters. Frank Heart, vice president of BB&N's Computer System division, asserts, "The net should be run like a power company—someone has to spot problems, service new customers, shoot trouble, and send out bills." Heart implies that BB&N probably would go after the position of network manager if the net went independent.

ARPA began the project in 1969 with the dual goal of (1) aiding its dispersed electronic data processing contractors by communications and resource-sharing processing via Arpanet and (2) locating pitfalls that might trip up the future military computer nets [*Electronics*, Sept. 30, 1968, p. 131]. In addition, ARPA has shown that networking of large computers can succeed even within the confines of the available communications services.

But while the first to benefit are ARPA's EDP research contractors, the unclassified program seems to have anticipated many of the problems that await civilian nets too.

What next? ARPA's Roberts sees three broad trends growing out of the net's success: first, growth toward distributed, network-connected computer services instead of the large isolated centers now common; second, a trend toward network-unified data bases, which otherwise would have to be duplicated in multi-site applications; and third, a sharing of software nationally.

Heart expects not only sharing, but "through a sort of natural selection, an improvement in effectiveness of task-oriented software."

To hardware makers, however, Arpanet is no bonanza. If anything, more nets like ARPA's could cause contractions in the large mainframe and memory markets. Conversely, though, terminal makers could prosper if the TIP is allowed wide use: the ability of users to hook into the network without their own mainframe to access the net's resources could create a new market for graphics consoles, teletypewriters, and other terminals.

The net now is expanding beyond its original research contractor base, and includes "customers" like the Air Force and the National Bureau of Standards.

According to Heart and Roberts, there's a long waiting list that in-

Terminal IMP. The TIP allows users without a large computer to enter the Arpanet with terminal equipment alone. The TIP can accommodate up to 64 terminals.

cludes private companies. Roberts breaks the list down into categories: about two or three who would pay to become net members, about 20 or so who would come in if the Government ponied up the money, and several times that number who have "evinced interest."

But before Arpanet grows into a computer utility, there are still a few problems that must be solved.

One probably due for solution almost overnight is that of network control program software and so-called host-to-host protocols. "We have one of almost every common computer type in the net," says Heart, "and these software problems, once solved for a given unit, can be applied to other computers of the same type with little modification." Since so many network users have or are nearing solutions to these problems, the passing along of solutions will bring active members into the net at a faster rate.

A knotty one. A potentially knotty problem is allocation of resources. The average data processing manager is willing to allocate about 10% of his center's time to the network, according to Leonard Kleinrock, professor of computer science at UCLA and head of the network's measurement center.

For example, an observer notes that "UCLA would like nothing better than to increase utilization of its 360/91 through the net, but computer operations managers at other nodes may feel that incoming traffic is disruptive, less important than their own needs, or that UCLA's use of the net should be shunted to slack hours. But slack hours at one place are probably inconvenient hours at another. This is a human relations policy problem, and it must be solved before resource sharing really becomes meaningful."

Although it is drawing the praise of net members, even the IMP could be improved, according to Heart. "There are no problems that could make the net unworkable," he says, "but there are parts we would like to improve. So far, we're thinking up potential problems and solving them faster than network growth or usage can trigger them."

Making problems. With the IMP as originally programed, it was possible to get what Heart calls congestion—a momentary inability to handle ultra-heavy, multi-user requests. So far, this kind of overload has only been simulated in BB&N's laboratories and never encountered in practice.

Another problem can occur when hosts momentarily overload IMP-to-IMP links. Again this has never happened in practice, but software changes are being made to prevent both problems.

Others note some lesser problems. UCLA's Kleinrock says it's possible to "flood" an IMP as the communications processor tries to service one incoming packet before finishing with its predecessor. Also, he adds, reassembly of messages with many 1,000-bit packets can sometimes be troublesome. Message assembly space within an IMP is at a premium, according to Kleinrock, and while there's enough for efficient store-and-forward movement of message packets between IMPS, Klienrock would also like to see a special preamble to any overly long message, warning the IMP at the destination node that space should be reserved in memory.

Kleinrock doesn't worry much about either problem, seeing easy software solutions to both. In fact, nobody on the net is unhappy with its communications aspects. BB&N isn't worried either, and notes that from its network control center, it can broadcast software changes to all IMPs at once. Thus the net's very ability to communicate allows paper solutions quickly to become real ones.

Utility. The net's rapid communications capability has other uses, says Richard Watson, manager of the ARPA network's information center at the Stanford Research Institute. This center would act as an active directory of net resources, he says. Using data supplied by other net members, it would take queries and either reply with the node locations of the resource the user needs, or switch him automatically to the node with the program, power, or data he requires. At its slowest, the latter could take about as long as a local phone call.

And if that's not acting like a computer utility, it's coming very close indeed. □

IMP perfects Arpanet

More than any other piece of hardware, the interface message processor (IMP) makes Arpanet workable and cost-effective. The IMPS distribute the load of control among themselves, and allow use of inexpensive Bell System data transmission services.

The first IMP cost about $100,000 and, like its successors, was built around a Honeywell H-516, 16-bit computer with 12,000 words of 0.96-microsecond core, 16 multiplexed input/output channels, and 16-level priority interrupt. Later versions of the IMP are using the less expensive H-316 computer on a more or less experimental basis.

Once several IMPS had been built, it was possible to project a monthly lease price of about $1,700, plus communications line charges. These too were relatively low, because the minicomputer-based IMP interfaced well with AT&T's type 303 lines. Over these 50-kilobit lines it was possible to send a megabit of data over a 1,400-mile link for only about 23 cents—the only cheaper method of data transmission available in 1969 was mailing tape.

The IMP divides outgoing messages into 1,000-bit packets suitable for transmission, passes messages from one IMP to another so that data reaches its destination in minimum time—checking for error as it does so—and assembles messages for its host.

The routing algorithm for one IMP is one of the secrets of the Arpanet's success. Through this software, any message is sent along the fastest available route. For example, if several IMPS pass along a message, each checks a "look-up table" in memory—updated twice a second with notices from other IMPS—to estimate transmission delay for each of its output circuits. This allows the IMPS to transfer messages in only about a tenth of a second.

For those without a computer, there is the terminal IMP, or TIP, which allows a user to hitch up as many as 64 peripheral devices to the net. Since there's a second minicomputer in the TIP to act as a "host" computer, the TIP is about $1,600 a month more than the IMP, but in exchange it offers the ability to get on line with few, if any, software problems.

Avionics

Air Force Navsat takes to the road

The DDR&E will have an alternative to the Navy's Timation 3 for its proposed defense Navsat if tests of the Air Force's system prove out

by Lawrence Curran, Los Angeles bureau manager

How fast the Air Force navigational satellite system—program 621B—will get off the ground will be decided after tests that begin next month at White Sands Missile Range, N.M. If the feasibility tests prove out, the Directorate of Defense Research and Engineering could adopt the 621B system as its Defense Navigation Satellite System, in preference to either the Navy's Timation satellite or a mixture of the two concepts.

No matter which system flies as the DNSS, the impact on the electronics industry will be more compelling in terms of dollars than technology. There will be big money in user equipment since nearly all military aircraft would need new receivers. Also, transmitters and computers constitute a potentially rich plum. The satellite portion will be only a minor part of the system.

Presently, Grumman Aerospace Corp., Bethpage, N.Y., is prime contractor for the 621B tests. Hazeltine Corp., Little Neck, N.Y., is a subcontractor to Grumman for the transmitters and receivers to be used, and Magnavox Co.'s Research Laboratories, Torrance, Calif., is also providing a receiver.

How accurate? The Air Force expects 621B to deliver accuracies of tens of feet. These are roughly comparable with the projected accuracies of the Navy's Timation 3, which, however, will be strictly a research and development technology satellite and not the "ultimate" system the Navy might fly.

Such precision is required not only for aircraft but also for ground-based receivers, because a pilot needs to be able to pinpoint both his own and the target location accurately, especially in close air support strikes, where his fire could endanger friendly forces near by.

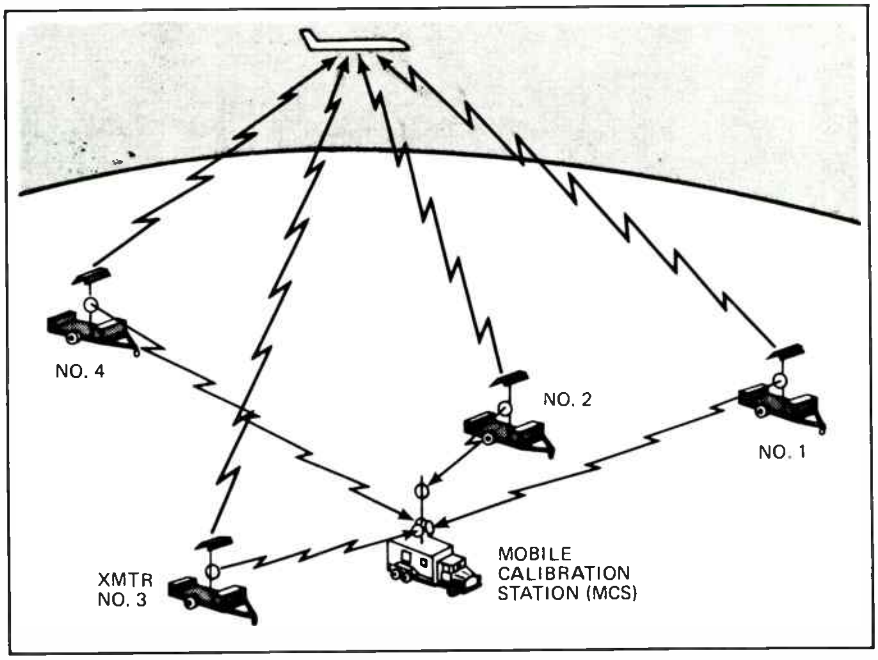
Maj. Richard Jessen, project engineer in the 621B program office at the Air Force Space and Missile Organization (Samso), says that in an orbital system, three or four 621B satellites would form constellations. All of these would be tied into a global grid system to yield precise, three-dimensional position and velocity information.

Computer needed. Because of the accuracy of the system, a computer will be required at the receiver. Jessen says the system could be used by ships, aircraft or foot soldiers, and could conceivably replace Loran and other navigation aids, such as Tacan and conventional instrument landing systems, in 10 years.

It's Jessen's contention that 621B's continuous L-band transmission provides the required spectrum spread of 30 to 40 megahertz needed to preclude jamming. The Navy has held out for a two-frequency system using both uhf (400 MHz) and continuous L-band. One Defense official says that "down at uhf you're lucky to find a couple of useful megahertz." But he's quick to admit that no one has yet found a solution other than the Navy's to the problem of L-band inaccuracies stemming from ionospheric propagation.

Jessen says the Air Force is by no means at loggerheads with the Navy over this. "We may find out from the Timation tests that uhf is better

Inverted satellites. To test the Air Force 621B Navsat without flying it, four transmitters will be arranged on ground as in orbit. The MCS will check system accuracy.



Probing the news

than L-band, and we could go to uhf, too."

The White Sands tests, to be conducted over three and a half months with the support of the 6585th Test Group at Holloman Air Force Base, N.M., are called the user equipment test and demonstration program. These are intended to come as close as possible to putting the whole system together—short of actually launching a satellite. The overall system concept, the instrument landing system, and multipath errors will all be checked.

Jessen emphasizes the importance of the White Sands tests. "If the system works, that's to be expected; if it doesn't, we'll have a lot of explaining to do." He adds, though, that the Air Force will probably have a chance to regroup if they don't succeed the first time.

A grounded constellation. In the overall system tests, the Air Force will invert the satellite constellation it expects to use in an orbital system. Instead of putting four transmitting satellites into orbit, the transmitters will be placed on the ground in the same arrangement as the proposed orbital system, and send 1,575-MHz signals to an Air Force NC-135A aircraft flying at various altitudes, speeds and directions over the ground-based "constellation." There will be a mobile calibration station on the ground with the same kind of receiver and recorder as in the aircraft (see diagram).

The raw receiver outputs will be taped and computer-processed on the ground after the flights. To get a solution from this aircraft data, it's also necessary for the mobile calibration station to provide time-bias information (the difference between the times the different transmitters sent out the signals).

The processed tape information will give the aircraft's position and velocity, and this data will be compared to that obtained from ground tracking of the aircraft to determine

Will DNSS put it all together?

It's been more than a year since the Directorate of Defense Research and Engineering got its first proposal for a Defense Navigation Satellite System, and—because of the complexity of the system—it may be another year or more before a tri-service Navsat system is approved, says a member of the eight-man executive steering group that tracks the effort for DDR&E. Even after a demonstration DNSS has been orbited, it's unlikely to become operational for about five years.

Defense officials insist there will be a "joint service effort under DNSS," based on the Air Force 621B and the Navy's Timation concept. Neither source has "more than a couple of million dollars" for its program this year, says DDR&E's George Solton, who holds the development concept paper draft for DNSS. (The Navy's Transit, of course, has long been operational.) Other money, says Solton, is being spent for studies of satellite system requirements, interfaces with other systems, and concepts for ground-based transceivers.

Though 621B and Timation "appear to be highly competitive," says one Defense official, the two services are thinking in more cooperative terms in view of the budget limitations being imposed on all projects. "It's getting them in the pocketbook where it counts, and they are looking for help."

Experience with existing satellites is certain to answer some of the technological questions, as will the Area Coordination Paper now in the hands of DDR&E. The paper, which is intended to concentrate available knowledge of Navsat technology, was completed about three months ago, and is being modified with comments from participants and other sources. The final version should be available to DOD's top officials next month, sources say.

Attempts to predict the impact of DNSS on such ground-based systems as Loran and Omega would be premature, since no firm recommendation has been made within DOD on a single Navsat, says Solton. Assuming a decision favoring DNSS is made "in a year or two" he adds, it is possible that systems like Loran and Omega may later be "reduced, phased out, or replaced." But that won't be for five years or more, according to sources on all sides.

Ray Connolly, Washington Bureau Manager

the accuracy of the 621B-type information.

Maj. Ernest Miller, Jr., Samso's project officer for the White Sands tests, explains that the ILS portion of the exercise will have the "satellite" transmitter aloft in a balloon at altitudes from 1,000 to 5,000 feet. The NC-135A will fly ILS glide-slope approaches to a runway while receiving position and velocity information from the balloon-borne transmissions.

ILS for Cat 3. After these flights, the data will be reduced, and again compared with ground-tracking information obtained during the same approaches, to see if the 621B system can provide accurate enough signals all the way to a "hands off" touchdown in category 3 landing conditions (when ceiling and runway visual range are very limited).

Miller says the ground user multipath tests are intended to get multipath reflections from different kinds of ground surfaces. To obtain these, the transmitters will be either balloon-borne or located on mountains—arrangements that will give high elevation angles. An omnidirectional antenna on the ground will show any multipath conditions by means of digital data reduction. The tests are expected to show that any signals delayed by more than 100 nanoseconds will be rejected. This is particularly important in ILS.

It will be proved. All three phases of the tests, says Miller, will show "what we've been saying for three years—that the technology is here and it works. We've stressed all along that 621B uses state-of-the-art techniques, and the White Sands tests will confirm what we've been saying about the accuracy of position and velocity information."

The 621B concept has been advocated for years by both the Air Force and Aerospace Corp., El Segundo, Calif., and probably would have flown earlier had it not received a lower funding priority. "Now it's a matter of integrating the hardware and distributing the money according to priorities," says Jessen. "Aircraft programs have been getting a lot of the money lately." According to a Defense official, funding for all Navsat efforts within the services is a bit less than $10 million this fiscal year. □

Avionics

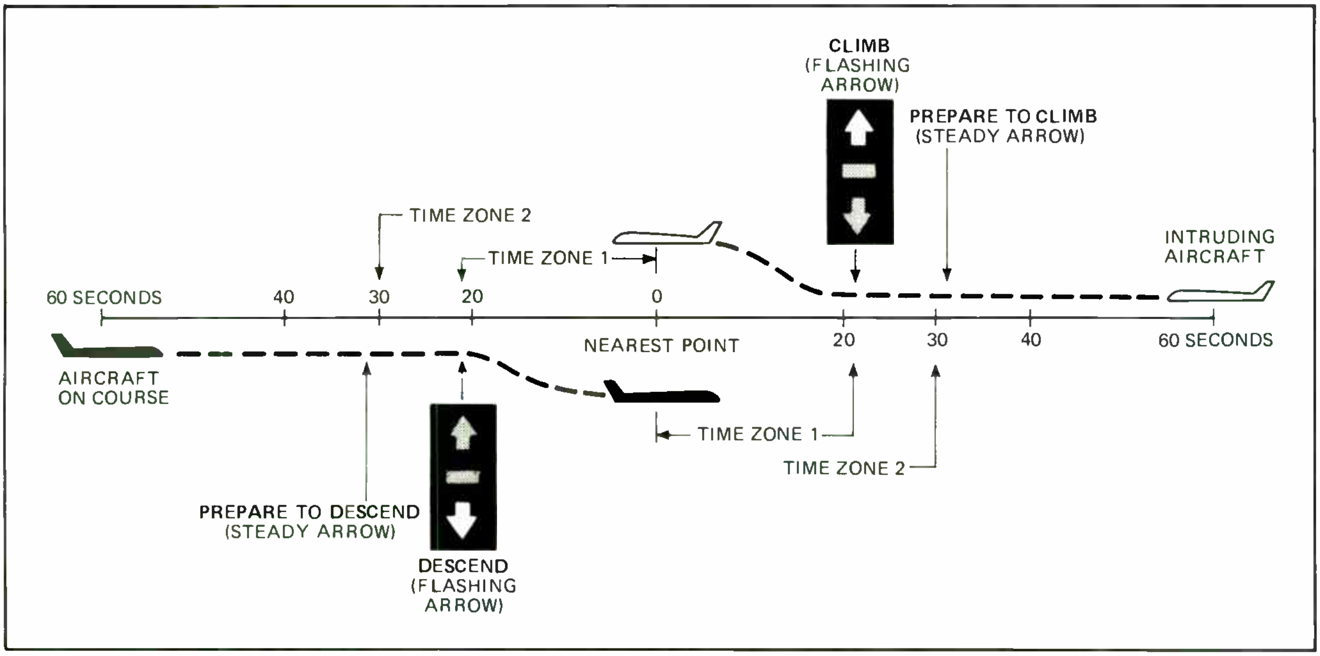
CAS causes conflict

Congress, industry want airborne collision avoidance systems now; the FAA favors improved, ground-based CAS later

William F. Arnold, Washington bureau

Because of its lack of confidence in a purely airborne collision avoidance system, the Federal Aviation Administration is about to clash with Congress and the aviation industry for a second time in recent months. The agency soon will be called before the Senate aviation subcommittee to justify its seeming unwillingness to spell out a national standard for airborne CAS.

This summons results from the recent introduction of a bill by Sen. Frank E. Moss (D., Utah), who charges the FAA with "a remarkable



Final 60 seconds to intercept. In the collision avoidance system favored by the ATA, closing speed is calculated by a doppler shift.

ability to avoid positive action" on the mid-air collision problem. The bill would require the installation, by 1975, of CAS units on aircraft weighing more than 12,500 pounds and of pilot warning indicators on lighter aircraft.

The FAA, however, contends that airborne CAS units, which it sees as a backup to an improved ground-based air traffic control system, need more testing and evaluation before they can be used in commercial aircraft. The airplane industry charges, however, that such a ground-based network is some years away, airborne CAS would make parts of the

Four collision avoidance systems

Airborne collision avoidance systems are based on the tau (time before intercept) concept developed by John S. Morrell of Bendix Radio in 1956. The concept states that CAS units could evaluate the likelihood of a mid-air collision by exchanging data on the altitudes of, and the distance and closing speed between, aircraft carrying them.

If each aircraft randomly asked every other aircraft for its altitude, distance and speed data, chaos could result. So the time frequency concept anchors all CAS communication to 3-second long, 2,000 slot "epochs," and assigns each aircraft one 1.5-millisecond slot in which to transmit its data. Sharing the same time base, each CAS computer can calculate another aircraft's speed by the Doppler shift in the transmitted signal frequency. The precise timing required is achieved by ground-based atomic clocks and a means of resetting simple airborne crystal oscillators developed by McDonnell Douglas engineers in 1961.

McDonnell Douglas began working on CAS when two of its fighters collided in 1960. Today, it claims to have flight-tested EROS (eliminate range zero system) units on over 16,000 pre-delivery flights on its F-4 Phantom jets. United Airlines is flying EROS units on two 727s, and Piedmont Airlines is equipping its 737 fleet with EROS units.

The EROS CAS consists of two antennas, a maneuver indicator to tell the pilot what action to take, and the collision avoidance unit. The last houses a transmitter, exciter, discriminator, receiver, crystal oscillator and low-voltage power supply packaged around the digital logic core. An 8-pound "micro-CAS" version for light planes sorts out possible threats by range and altitude only, dropping the Doppler and allied processing for range rate or speed determination. Like its big brother, the unit can resync its timing from a ground station or from an airline plane.

A similar time frequency system called Image (for intruder monitoring and guidance equipment) has been built by Bendix.

RCA's Secant system is different. It's advertised as a family of units, beginning with an $800 emitter for light planes that simply tells all aircraft "I'm here," a $1,000 pilot warning indicator (PWI) that monitors range and not altitude, a $3,000—5,000 intermediate system for executive aircraft, and a fullblown airline version.

Heart of the fuller RCA system is a transponder technique that allows each plane to interrogate its environment for the presence of other planes. Each query is uniquely encoded so that each aircraft can tell which of the many replies indicates a potential collision. A random noise generator ensures randomness by determining on which of two frequencies the query will be sent and answered.

RCA says that since the system knows the order in which it interrogates, it can convert replies received in the proper sequence into positive signals and filter out interference or signals from nonthreatening aircraft. RCA has conducted some testing on the unit, and the Naval Air Development Center is also testing a version.

Honeywell also is developing a cooperative system, similar to RCA's, and derived from its development of PWIs for army helicopters. The Honeywell system, also a nonsynchronous device, uses a radio frequency transponder rather like beacon radar to derive position and altitude data. Whereas with a time frequency unit only one plane transmits at a time, the Honeywell system uses short transmissions of a few billionths of a second so that all planes can "talk" almost at once but none at the same time.

network unnecessary, and in the meantime lives are being needlessly lost.

This year mid-air collisions caused hundreds of deaths, and the National Transportation Safety Boards estimates that, at present levels, there will be a total of 335 collisions and 792 deaths resulting from them in the decade from 1968 to 1978. The airlines also are concerned with protecting their huge investments in jetliners and insuring themselves against increased legal liability: damage claims approaching $70 million arose from the wreckage of one recent collision.

Big dollars. At stake in the CAS controversy is a potential market in airborne CAS equipment for electronics manufacturers estimated at several hundred million dollars. A CAS unit for each of the 3,000 commercial airliners is now figured to cost $50,000, and some jetliners would need double systems. About 80,000 planes in the general aviation fleet would need either a so-called "mini-CAS" costing between $1,500 and $2,500 or a pilot warning indicator costing between $400 and $800.

Leading the way, two corporate giants—McDonnell Douglas, St. Louis, Mo., and RCA, Moorestown, N.J.—are battling each other to have their airborne CAS system chosen by the FAA. McDonnell Douglas' EROS 2 CAS is a time-frequency-based system. It uses ground signal bursts between aircraft that tell individual CAS units the distance and speed of other aircraft.

RCA's Secant CAS (for separation and control of aircraft by nonsynchronous techniques) does not rely on ground synchronizing signals but uses airborne interrogators and transponders to determine range, range rate, altitude and bearing data. Both systems are cooperative in that they only warn against collisions with similarly equipped aircraft.

What ATA wants. The time frequency concept is being strongly promoted by the Air Transport Association, the airlines trade group, which is just as strongly against the RCA system, partially because it says the system needs too much testing. Some airlines, however, might welcome some delay because the high cost of CAS units are a heavy consideration in a depressed air travel market and such a delay could create a more competitive situation that would drive down CAS costs.

McDonnell Douglas itself argues that its tested EROS CAS should be adopted because "it is here—now," Anatole Browde, vice president of the company's CNI programs told the Senate aviation subcommittee early in December. "We strongly urge that all responsible parties . . . adopt time frequency collision avoidance."

The later arrival in the field, RCA, "is concerned over the pressures to seek an early solution by hastily adopting the time frequency system as a basis for a national standard," Joseph F. McCaddon, division vice president, cautioned the Senate subcommittee. In calling for more testing to determine which is the better system, he proposed that a "competent, objective evaluation group" be formed.

The only evaluation group up to now has been the ATA-led technical working group that has endorsed time frequency CAS concept. In 1969 it contracted with Martin Marietta, Baltimore, Md., to test systems by McDonnell Douglas, Bendix, and a Sierra Research-Wilcox Electric team at the FAA's Atlantic City experimental center. This followed earlier FAA contracts to Bendix, Sperry Rand, and Collins for testing of theoretical and hardware concepts. Collins reported that time frequency was the most promising in 1965, the same year that McDonnell Douglas displayed flight-tested CAS units.

CAS from the ground. What is the FAA's attitude toward the competing systems and pressure from aircraft owners for CAS? Gustave E. Lundquist, associate administrator for engineering and development at the FAA says, "we think we can do the job more effectively from the ground." The former Air Force officer says that "the FAA favors any form of collision avoidance system which is compatible and complementary with the basic air traffic control system." He adds that the present air traffic control system, when upgraded, will provide separation service and collision avoidance by itself.

Meanwhile, the FAA says it will continue testing the time frequency systems, and will watch the Navy's tests of RCA's Secant system and the Army's trials with Honeywell's system. The agency plans to go out for studies on the integration of airborne CAS into the ATCS, PWI development and, importantly for the time frequency system, development of a ground synchronization station.

This approach finds favor with the light plane owners, who prefer a free ground-based CAS because it's unfair to charge an occasional flyer with an expensive "mini-CAS." The airlines, on the other hand, pointing out that many mid-air collisions are between light planes and airliners, argue that light planes must be equipped with some form of CAS to make the jetliners' systems work.

One world not heard from in all the fuss is the Defense Department, which is less than enthusiastic about standardizing the airborne collision avoidance systems for its 3,000 planes flying in civil air space. Industry speculation is that the military, having spent billions for its own programs, doesn't want to buy civilian CAS units, but that if the civil market buys CAS, congressional pressure will force the military to go along. After all, the reasoning goes, it wouldn't look good if a civilian CAS-equipped plane collided with a military craft that wasn't so equipped.

Among the companies that have developed or experimented with CAS are: McDonnell Douglas, RCA, Collins Radio, Bendix, Honeywell, Raytheon, Sierra Laboratories, Wilcox Electric, Texas Instruments, Sanders Associates, IBM, Hazeltine Corp., and ITT Gilfillan. Some can be expected to be vigorous competitors when airborne CAS becomes marketable.

There seems little doubt, however, that some system will eventually be adopted. No matter which one it is, airborne CAS market should provide a bonanza for electronics avionics manufacturers, since none of the prime developers will have a monopoly on the market. □

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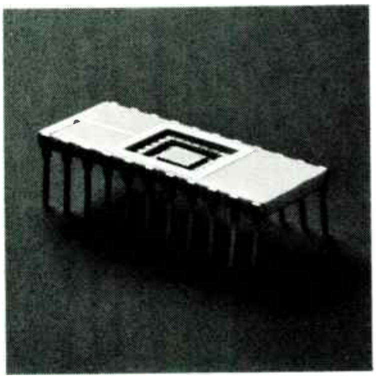

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Beam lights way to high-speed equipment assembly

by Stephen E. Scrupski, Packaging and Production Editor

Semiautomatic machines use projector to spot wiring paths, mechanical makeup, and component location

Automation is a lot like wealth—a little bit never hurt anybody, but too much brings on a whole new set of problems. For those companies not yet ready for full computer control, a new family of semiautomatic production machines handles a variety of tasks from component assembly on printed circuit boards, to making cable harnesses, and even mechanical assembly.

Built by Ragen Precision Industries, the machines are designed around a numerically controlled light projector that can position a spot of light at any point on a surface with a repeatability of a few thousandths of an inch. Ragen uses the same light source already standard in its printed circuit board assembly machines, the PCP-300 and PCP-75. Added features, such as a component delivery system with programable bin positioning, lighted wire bins, and illuminated messages comprising mechanical drawings in transparency form, result in a family of machines that will speed up production of equipment.

Co-founder of the family, the PCP-300 runs from punched paper tape, and performs two functions to aid an operator in inserting a component in a printed circuit board: it delivers one component bin at a time (it can randomly access any of 300 bins), and it indicates the proper position on the printed circuit board with the light spot. The spot is arrow-shaped, its head indicating polarity, in the case of a diode, or keying, in the case of a transistor tab or an IC package.

The PCP-75 is similar except that it delivers 75 bins in sequence to the operator. It's intended for shorter production runs, where the bins are loaded before each run, while the PCP-300 is intended to serve as a parts warehouse, storing components for a whole series of boards. Both machines position the light spot on a 10-inch square with a repeatability of 0.015 inch.

The same light projector is used in the new cable harness machine, but instead of being about 2 feet above the work surface, it will be raised about 7½ feet, since it must cover a larger area—about 36 inches square. The 36-inch-square area would not suffice for large harnesses, but is adequate for many applications in small computer terminals and modems. The light spot will be programed to indicate the starting point of each wire in the harness, critical bend points along the path, breakout points, and finishing points.

The advantage the machine has over the older blueprint-and-nail-board method, according to James Hobbs, Ragen marketing manager, is the ease with which changes can be made in the paper tape. Hobbs points out that once a board is made by driving nails through a print into the board, it's quite easy to forget to change the nails when a new print is issued. Storage of the boards can

Follow the light. Overhead projector beams spot that indicates placement of components. Message panels on model PCP-150, below, can display assembly sketches.

New products

also be bothersome. The paper tape overcomes such problems and also adds a new capability—the light spot can indicate which wire to use in the harness. For example, if various colored wires have to be led into the sides of the machine through wire cutters, the light spot can first move to the cutter for the proper colored wire and then move to the harness area to indicate the correct routing of the wire.

On a smaller scale, point-to-point wiring of component boards or backpanels can also be done with the machine. Here, the advantage would be the low cost of the machine. In addition, users would retain the ability to switch functions and put the machine back in a component assembly mode. The paper tape could be used to energize a lamp above the proper wire bin, or actually to deliver the wires to the operator, says Hobbs.

For mechanical assemblies, the light spot could indicate positions for parts while also displaying sketches of assembly details from programed message panels. The panels measure 2 inches square and can be lighted under paper tape control.

The basic machines, with only an overhead light projector, will sell in the $6,000 to $7,000 range, but Hobbs also notes that Ragen is now giving added emphasis to rental agreements for capital-short customers. Full versions, with parts delivery systems, will be marketed to sell in the range from $10,000 to $11,000.

In addition to the new machines, Ragen is introducing new variations of the earlier component assembly machines. The PCP-75 N1 is aimed at assembly of pc-board cordwood modules. The projector indicates positions of component connections and delivers sequentially up to 75 different component arrays. The PCP-75 N3 will handle boards measuring up to 15 inches square. The PCP-150 series comprises expanded versions of the N1, N2, and N3, except that it offers 150 component trays.

Ragen Precision Industries, 9 Porete Ave., North Arlington, N.J. 07032 [338]

Network analyzer sweeps to 500 MHz

by Michael J. Riezenman, Instrumentation Editor

Test unit for wideband communications measures group delay directly; offers polar, rectilinear display

As the emphasis in communications shifts to high-speed digital transmission, automatic test equipment must be capable of performing rapid, swept-frequency measurements on the wideband components used in such systems. This was one of the major factors behind General Radio's development of its model 1710 rf network analyzer.

The instrument measures amplitude and phase over the range from 400 kHz to 500 MHz in three overlapping bands. This makes it useful not only for the analysis of wideband digital transmission systems, but for CATV, radar i-f, telemetry, and very-high-frequency communications systems.

An optional feature of the instrument—one that makes it particularly valuable in the analysis of digital systems—is its ability to measure group delay directly on a swept-frequency basis. Simply pushing a button produces a display of $d\phi/df$ as a function of frequency over any selected bandwidth.

The instrument's display covers a dynamic range of 80 dB, and it can measure up to 115 dB using rf substitution techniques. This extra dynamic range is needed for the study of filter reject bands, and in the measurement of isolation, crosstalk, and high levels of attenuation (such as the attenuation of 3,000 feet of cable).

Another important feature of the 1710 is a low-cost option that enables it to switch from a rectilinear display to a polar display at the touch of a button. Its only direct competition—the HP 8407A—provides either one or the other. To get both requires the purchase of two display units.

The basic price of the 1710 is $6,850. This includes a tracking sweep generator, a tracking detector, a processor, and a Tektronix 604 CRT display unit. The basic price does not include the polar display capability, which adds $295 to the price, or the group-delay measurement option, also at $295.

Two inputs. A prosaic-sounding but extremely useful feature of the 1710 is the fact that it has two measurement channels (plus a reference) instead of the usual one. These allow the user to examine both the transmission and reflection characteristics of a filter simultaneously while tuning it, or to look at both outputs of a diplexer while adjusting it.

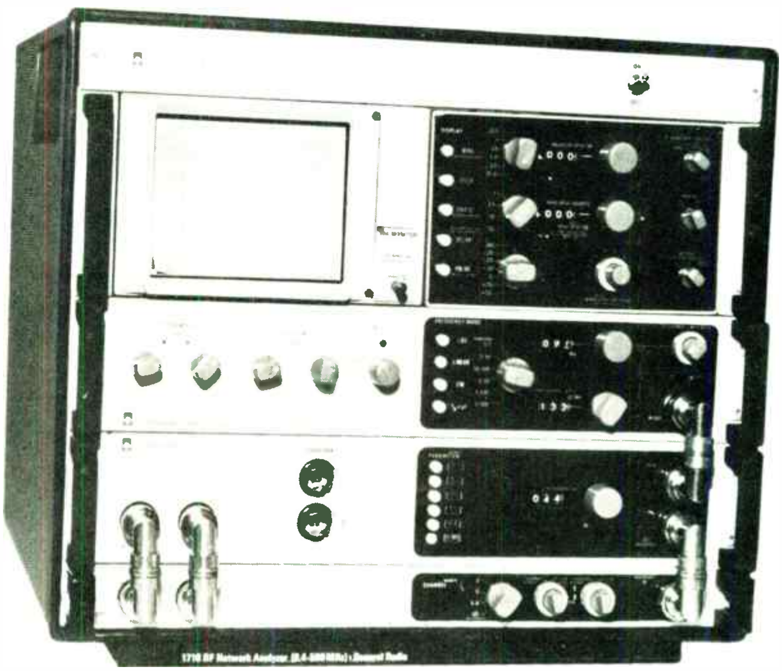
In addition, this feature makes it easy to compare two devices, or to measure one of them against a calibration standard.

While basically a 50-ohm instrument, the 1710 has a complete line of 75- as well as 50-ohm accessories. Using the 75-ohm cables, bridges, and tees does not reduce the instrument's rated resolution. The analyzer has a sensitivity of 0.025 dB per major division.

In making measurements on active devices, like amplifiers, it is important to know and control the absolute level of the drive signal at the device's input. Otherwise, the device may inadvertently be driven into a region of nonlinear operation. With the 1710, no external equipment is needed to monitor or adjust the drive level. The instrument displays the absolute level at the input to the device under test, and allows the user to vary the drive level from 0 to −70 dBm. The sweep generator actually develops a maximum of +13 dBm to allow for 13 dB of measuring circuit loss without a comparable loss in test level.

General Radio Co., 300 Baker Ave., Concord, Mass. 01742 [339]

Convenient. Analyzer shown includes optional s-parameter measuring set.

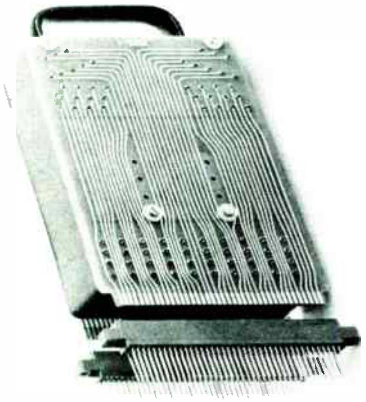


Components

Plug-in houses 72 switches

Package designed for matrix switching eliminates special wiring or pc board design

Connecting and switching computers to computers or to peripherals or modems often requires a massive wiring job. To eliminate this costly task in high-density switching applications, T-Bar Inc. has developed a series of switch assemblies which package as many as 72-pole single-throw switches in a unit that can be plugged into standard printed circuit board connectors.



The series 6800 T-Bar Pluggables are available in steps between 36-pole, double-throw switches and the 72-pole, single-throw size. Each is housed between a pair of printed circuit boards, and measures 6½ by 4½ inches and 1½ inches thick. Output contacts are spaced 0.100 inch apart, and plug into a pair of edge card connectors.

For the gang and matrix switching involved with computer interfacing, data pulses with rise times of up to 100 nanoseconds can be readily passed, the company says. The switches are also applicable to master matrices in voice communications and automatic test systems.

Altogether, a 72-pole unit will occupy about the same volume as a switching system made, for example, from 13 individual four-pole relays, the company asserts. Such an arrangement would include 13 separate coils, with their associated power sources and a printed circuit board on which to mount them. The T-Bar, a design the company has applied in various switching products for more than 11 years, relies on a single solenoid to activate all of the switches simultaneously.

This difference is at the heart of the T-Bar's design. It uses a T-shaped insulator, driven up or down by a solenoid, to make or break the mechanical switching contacts. With contacts placed on both sides of the T's horizontal bar, the contact capacity for a given volume is just about double that of an ordinary relay, according to the company. Large numbers of contacts are obtained by stacking the Ts and their associated contacts and driving them from the same solenoid.

Because only a single solenoid is used, power dissipation is also less. The 72-pole unit dissipates 6.5 watts, about half the power required when individual relays are used, according to the company. Contact ratings range from microamps up to 1 ampere, 28 volts dc. Throughpath resistance is typically 200 milliohms, contact life (at 10 milliamperes, 30 millivolts) is 20 million cycles.

T-Bar Inc., 141 Danbury Road, Wilton, Conn. 06897 [341]

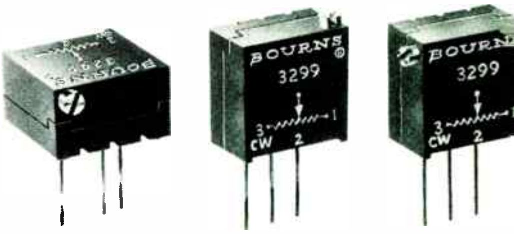
Readout flashes 48 discrete messages on small screen.

Twenty-four different projection systems, each comprised of a light source (an incandescent lamp and an optical system), make up the series 1002 rear projection readout unit. The device can flash 48 discrete messages on a screen measuring 0.45 by 0.53 in. The optical system projects an image from a discrete section of a piece of film containing all message intelligence. The film is moved by solenoids, an increment vertically exposing a new set of 24 messages to the projection paths. Quantity price is $82. Delivery is from stock.

Industrial Electronic Engineers Inc., 7720-40 Lemona Ave., Van Nuys, Calif. 91405 [348]

Potentiometer offers 25-turn settability in ⅜-in.-sq pack

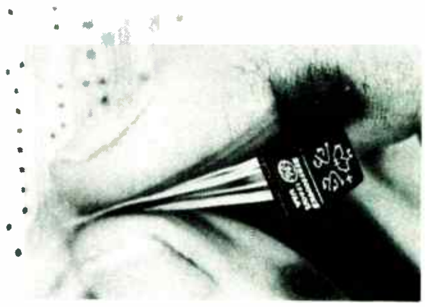
A potentiometer with molded-in terminals, where one terminal also functions as the collector in the wiper system, is rated at 0.5 watt. The model 3299 cermet Trimpot offers 25-turn settability in a ⅜-in.-square package. A choice of three pin styles is available. Resistance range is from 100 ohms to 1 megohm, resistance tolerance is ±10% standard, and the temperature coefficient is ±150 ppm/° C maximum. Price is $1.20 for 500 to 999.



Bourns Inc., 1200 Columbia Ave., Riverside, Calif. 92507 [346]

Hybrid relays come in single-, dual-diode versions

Hybrid relays designated the 3SBS series are available in single- or dual-diode versions. Both types provide suppression of the relay coil by adding diode chips within the relay enclosure. In addition, the dual version protects against the accidental application of reverse polarity. The



relays are built for one million operations at low level, and have shock resistance to 100g.
General Electric Co., 777 14th St. N.W., Washington, D.C. 20005 [343]

Low-priced trimmer resistor mounts directly on pc board

A line of cermet trimmer resistors designated Centrim have an alumina substrate on which the cermet track is bonded. A knob entirely covers the resistance track and wiper, but the unit is also available without the knob. The trimmers come as single, dual, triple or quad with a variety of lead configurations for printed circuit board or point-to-point soldering applications. Centrims are rated at ¾ W per section at 70°, derated to 0 at 125°C. Resistance ranges from 100 ohms to 1 megohm at 350 V maximum. Price is under 20 cents each in production quantities.
Centralab 5757 N. Green Bay Ave., Milwaukee, Wis. 53201 [345]

Shielded adjustable inductor is available in 73 values

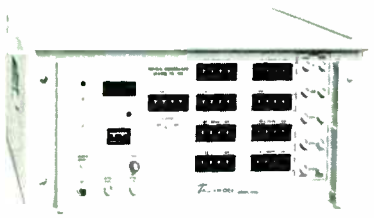
Designed to accommodate close inductance adjustments in high-density circuits, the Wee V-L shielded adjustable inductor is available in 73 values ranging from 0.10 to 100,000 μH. The unit combines high stability and high Q in a 0.400- by 0.300-inch package. The adjustable inductance range is ±10% over the entire span, and minimum Q and f_0 values are not less than 80% of specified value at nominal inductance.
Darlington Div., Nytronics Inc., Darlington, S. Carolina 29532 [344]

Instruments

Test generator is programable

Timing unit controls pulse period, width, delay for IC or data link tests

Despite the spate of integrated circuit test systems, some capable of ultra-fast checking of ultra-large ICs, some makers and users of integrated circuits still build their own testers. This also is true of firms in the com-



munications and communications equipment business, especially as digital data transmission burgeons.

For those who "roll their own", Tau-Tron Inc. has developed the TG-100 programable timing generator. In a system block diagram, the TG-100 would follow a test pattern generator. Its output would be cabled to a test fixture in the case of IC testing, or to a modem in communications applications. The machine has a 10-KHz-to-20-MHz range, and sells for $17,500.

Nominally a four-channel device, the TG-100 actually offers control of pulse period (or repetition rate), width, and delay over eight outputs since it offers both true and complementary bit streams. This control can be maintained to within ±5 nanoseconds, regardless of any programed value, thanks to an internal stable local oscillator running at 100 megahertz and serving as the baseline reference for all timing.

Both manual and remote control are possible with the unit. Panel BNC connectors accept cables and binary coded decimal instructions from any control computers used. Manual settings are made with digital readout switches on the front panel, which also generate BCD instructions for the TG-100's internal electronics.

Four-digit thumbwheel switches select period, width, and delay. Period varies from 50 ns to 99.99 ns; delay can be set from 0 to 99.99 ms; pulse width can be varied from 10 ns to 99.99 ns.

TTL-compatible true and complementary outs are located on the front panel; they have rise and fall times under 10 ns when driving 50 ohms. There are ECL-compatible back-panel outputs with the same specification.

Synch and reset also are controllable at the back panel with TTL input levels, and there is a front-panel push button to do the same job: synchronizing all output signals from the leading edge of the reset input.

Though the basic unit is sold with four width and four delay modules, the mix is variable to suit user needs. The TG-100A, for example, has six delay and two width modules.

Delivery time is 6 to 8 weeks after receipt of order.

Tau-Tron Inc., 685 Lawrence St., Lowell, Mass., 01852 [351]

Miniature scope has 20-MHz bandwidth, sells for $595

A two-year-old San Diego manufacturer of oscilloscopes, Vu-data Corp., has decided to move into one of the newest areas of the business—portable miniscopes— with a 20-megahertz unit that sells for $595.

Two versions of the PS900 are available: the 1¾-inch-high, half-rack-wide Flat-pack, and the 3½-inch-high, quarter-rack-wide Stack-pack. The $595 price does not include nickel-cadmium batteries, which add $50, or alkaline batteries, which boost the price by $25. The scope will also operate on eight standard "C" batteries.

Vu-data has achieved a low price by buying CRT displays in large volume and by cutting the mechanical and electrical parts count.

The PS900 covers dc to more than 20 MHz, within 3 decibels, and verti-

cal deflection is 10 millivolts per division to 20 volts per division in 11 calibrated ranges over the entire bandwidth. Trigger modes are internal or external, with automatic or manual level-slope selection. Automatic operation eliminates trigger level adjustments, and is functional above 40 hertz.

The PS900 will operate for 5 hours on battery power.

Vu-data Corp., 7595 Convoy Court, San Diego, Calif. 92111 [352]

Power source programer can handle six functions

A programable oscillator called the model 830T can provide the interface between a digital computer and an ac power source. It programs frequency, amplitude, and phase angle independently, under direct control of the ac power source. Up to six functions can be programed simultaneously. The 830T is intended for automated component or subassembly test systems and automatic power simulation systems.

California Instruments, 5150 Convoy St., San Diego, Calif. 92111 [353]

Five-digit multimeters are accurate to 0.005%

Two five-digit multimeters, the model 5330 for bench use and the 5333 for systems use, span 5 dc ranges from 0.1 volt to 1,000 v full scale, with a resolution of 1 μV and accuracy of 0.005%. Other features include autoranging, dual-slope integrating with 74-dB normal mode noise rejection, front and rear input, analog output, and 10,000-megohm resistance. Ac voltage measurement capability to 250 kHz and resistance measurement to 10 megohms are options. Price for the 5330 is $1,295; for the 5333, $2,095.

Dana Laboratories Inc., 2401 Campus Dr., Irvine, Calif. 92664 [357]

Square wave generator has range from 20 Hz to 50 MHz

A square wave generator called the model 760 has repetition rates of from 20 Hz to 50 MHz in ten overlapping ranges with fine frequency control. True and complement outputs are provided with simultaneous amplitude variation from +250 mV

to +5 V across 50 ohms with independent switch selection of an internal 50-ohm termination. Each output has rise and fall times of less than 4 ns. Price is $350.

Dytech Corp., 391 Matthew St., Santa Clara, Calif. 95050. [358]

Waveform digitizing system is computer-controlled

Designed for users who need to collect vast amounts of oscilloscope data, the model S-3003 computerized waveform measurement and analysis system is capable of acquiring signals from dc to 14 GHz. Applications include test equipment engineering and checkout of linear devices. The system, largely custom-assembled, is built around a programable sampling oscilloscope, a minicomputer, and a data coupler. Price is $25,000 to $70,000 depending on options.

Tektronix Inc., P.O. Box 500, Beaverton, Ore. 97005 [354]

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- ☐ DCL SSI 84/8800 TTL/DTL Handbook, 112 pages. 50¢
- ☐ MOS Silicon Gate 2500 Series Handbook, 176 pages. 50¢
- ☐ 8000/5400 Chip Catalog, 72 pages. 50¢

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Company
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City
State Zip
Telephone ( )

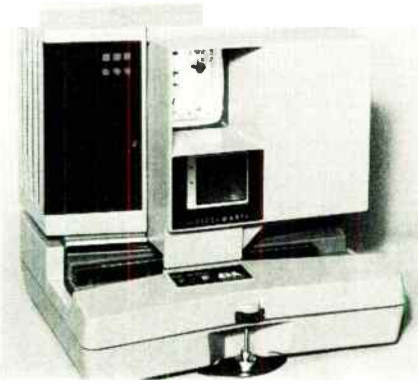
SIGNETICS CORPORATION — A SUBSIDIARY OF CORNING GLASS WORKS

Packaging and Production

ROM speeds up wire bonder

Machine attaches chip pads to 14-pin DIP in 15 seconds, cuts cost to 0.4 cent per IC

One of the most time-consuming and labor-intensive tasks in IC manufacture is wire-bonding the pads of a chip to the lead frame of a dual in-line package. David Davis, marketing manager at Ultimation Inc.,



Sunnyvale, Calif., estimates that "for every 14-pin DIP, the direct labor cost is about 6 to 8 cents if you figure that one girl finishes 50 to 75 packages per hour and is paid $4 per hour." (This does not include costs for die attach, molding, or sorting.)

A machine built by Ultimation and called Multi-Matic completely wire-bonds a 14-pin DIP in about 15 seconds, and since one operator can run three machines, the cost per IC is reduced to 0.5 cent. This beats the cost of off-shore assembly, Davis points out. The Multi-Matic is priced at $28,500.

The secret of Multi-Matic's speed lies in a semiconductor read-only memory. The user lists the coordinates of the bonding pads for the specific IC he is working with—a 14-, 16- or 18-pin device—and converts them into a ROM code. For a fee of $125, Ultimation will do the ROM programing and send the customer the ROMs on a plug-in board, or the customer can buy a ROM programer and do it himself. Once the machine is programed, all the operator has to do is position the chip and push a button; the Multi-Matic then proceeds to bond all of the pads to the lead frame, stepping around the chip until it is completed. A TV camera and a CRT monitor are employed instead of the usual microscope, so the operator can rapidly align the chip and observe the bonding operation from a distance. The chip is aligned with the aid of two cross-hairs on the screen. Chip alignment time is about 2 seconds and the bonding time is about 12 seconds, including the indexing time of the automatic lead-frame feed mechanism.

As far as the actual bonding is concerned, the modularly designed Multi-Matic is a tail-less thermo-compression, gold-ball bonder. Almost any DIP lead frame can be used, and wire size is variable from 0.7 to 2 mils.

Ultimation Inc., 1050H East Duane, Sunnyvale, Calif., 94086 [391]

Tester checks IC packages before lead frame is added

Testing a package before the lead frame is attached can save a lot of time and trouble afterwards, and that's what a test fixture from Pylon Company Inc. accomplishes.

Contact is made to the lead-frame bonding pads of an IC ceramic package via the company's POGO contacts, which are miniature spring-loaded devices. These are then wired to multipin connectors for external access.

The tester first checks for leaks and continuity of the conductors on the ceramic package, and then checks the finished device without lead frame. The result is the manufacturer can be sure that lead frames are being attached to good circuits only, thus saving the expense of having lead frames attached to those circuits that have failed under tests.

Pylon Company Inc., 50 Newcomb St., Attleboro, Mass. 02703 [394]

Wide-angle sockets permit manual or machine insertion

Many users of dual in-line integrated circuits are now depending on sockets instead of soldered connections for improved maintainability or to provide the needed wire wrapping tail. They are also moving to individual socket pins, using the printed circuit board rather than completely molded sockets for providing the insulation between pins.

For such users, Augat Inc. has developed wide-angle, tapered socket terminals that can be inserted either manually or by automatic equipment.

Intended for high-density boards, the devices have a machined opening on both outer sleeve and inner contact that's about four times the entrance size of regular sockets, or 0.060 in. as compared to 0.028 in. This allows the integrated circuits to be automatically inserted at different angles and funneled into the sockets. About twelve times as many sockets as usual can be loaded in an hour. The technique also reduces the number of damaged ICs and panels.

Applications include computers, peripherals, and communications equipment.

Augat Inc., 33 Perry Ave., Attleboro, Mass. 02703 [393]

Flat connectors stackable on 0.100-inch centers

The Flex-Strip line of connector cable assemblies is designed to capitalize on the thinness of flat cable. The connectors can be plugged into either side of back-panel wiring systems, to pins mounted on pc boards, to NAFI-type hardware, and to ends of other cables. They can be stacked row-to-row on 0.100-inch centers. Three types of contacts are available: a female socket for 0.025-inch square Wire Wrap pins or posts, a female socket for 0.020-by-0.050-inch blades, and male blades to

mate with tuning-fork female contacts. A standard 12-in. cable assembly with Flex-Strip connector on both ends is priced at $7.50 per assembly in 1,000-lots.

Ansley Electronics Corp., 4100 N. Figueroa St., Los Angeles, Calif. 90065 [395]

Scriber-dicer cuts through wafer, eliminates breaking

Low-kerf-loss dicing and high-speed scribing have been combined in the model NRC 7111 machine for semiconductor wafer production. Full-depth cutting with a kerf of 0.0025 in. is achieved by thin, high-speed

diamond wheels without a slurry. Not only does cutting completely through wafers eliminate the breaking operation, but the rubberoid wheels are said to be less expensive than plated wheels and are readily ganged, dressable, easily changed, and less prone to clogging. A built-in microscope allows precise alignment in less than 10 seconds.

Varian, 611 Hansen Way, Palo Alto, Calif. 94303 [396]

Semiconductors

Calculator IC is low-priced

Four-function chip designed for 12-digit machine sells for $12; $14 with memory

After deciding it would be very tough, if not impossible, to compete head-on with the Japanese in electronic calculators, Donald Brown, president of Cal-Tex Semiconductor Inc. decided to join them. And out of that move has come a calculator IC for general sale.

The company will start two joint ventures based on MOS/LSI circuits designed and built by Cal-Tex, the first of which is a one-chip calculator circuit selling for $12 each in quantities of 100,000.

One joint venture has been set up with three Japanese companies, and the other with two Italian companies. Brown, who had been with TI for many years before starting Cal-Tex, says, "We will ship the ICs to Japan and Italy and there they will assemble machines for domestic sale. We will assemble machines in our Santa Clara plant for sale in the U.S." Now Cal-Tex is also offering the chips on the open market.

Two versions are available. The model 5001 is a four-function chip for a 12-digit calculator and has no memory. The 5002 is the same as the 5001 except it has a memory and sells for $14 each in quantities of 100,000.

From the start, the chips were designed to be high-yield products, says Brown. Both are made by a standard high-threshold p-channel process, and the total chip area, including the memory, is 180 mils on a side. (Mostek's chip is 180 mils on a side, and TI's chip measures 230 mils, and neither has a memory.) Partly because the process is standard, it took only two and a half months to go from logic design to working chips.

A useful feature of the Cal-Tex chip is the output driver section, which can be described as hefty. Brown says they allotted a little extra chip area for the output drivers so that no buffers are needed between the calculator chip and the display decoders. The chips work well with Nixie tubes, Panelex displays, Digitron tubes, and LEDs. In fact, the 5001 and -2 can drive H-P's 5800 LED display-decoder directly.

The first complete machine employing the Cal-Tex chip is the Eiko calculator [*Electronics*, Nov. 8, p 134], which is priced at about $90 in Japan. A second, pocket-type, Eiko machine will be announced soon.

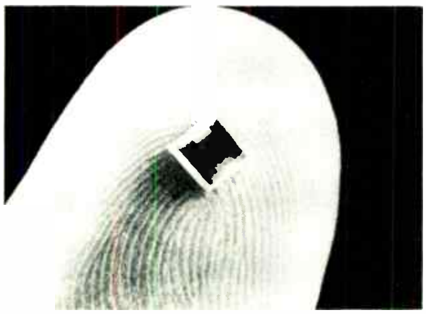
According to Brown, Eiko has a complete family of printing calculators—8-, 10-, 14- and 16-digit—and Cal-Tex is completing work on a two-chip calculator set that will directly drive these Eiko printers.

Both the 5001 and 5002 are available in sample quantities, and Brown says that he can deliver parts in volume by February.

Cal-Tex Semiconductor Inc., 3090 Alfred St., Santa Clara, Calif. 95050 [411]

Photodetectors are made for hybrid circuits, pc boards

Designed specifically for hybrid circuits, a new line of cadmium sulfide and cadmium sulfo-selenide pho-



todetectors, called PC Photochips, are so flexible that the user can make up an array on his own alumina substrate or printed circuit board. Applications include drum programing, prototype arrays, differential drives, sequence switches, and money-changing machines. Three basic materials are offered, with peak spectral responses at 625, 575, and 515 nanometers. Price is 43 cents in quantities of 1,000. Delivery is from stock.

Allen-Bradley Co., Electronics Div., 1201 S. Second St., Milwaukee, Wis. 53204 [418]

MOS static shift registers operate at 3 megahertz

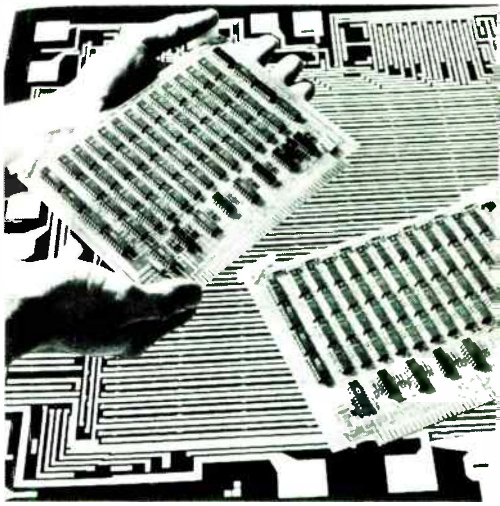
Two silicon gate MOS static shift registers, one organized 6 × 32 bits and the other 6 × 40 bits, are for use in data processing equipment such as line printers, card equip-

ment buffers, and sequential access memories. Each is integrated on a single monolithic silicon chip and is fabricated by p-channel enhancement mode techniques and low-threshold silicon gate technology. Typical clock and data rate is 3 MHz. Both registers, the model 2518B (6 × 32) and 2519B (6 × 40), are priced at $6 in quantities between 250 and 999.

Signetics Corp., 811 E. Arques Ave., Sunnyvale, Calif. 94086 [415]

Complete memory system is on 6-by-8-inch board

A TTL-compatible integrated circuit memory system called the System in-20 is designed to provide random-access buffer storage for a variety of computer peripheral applications. The system stores 1,024 12-bit words on one 6-by-8-in. printed circuit board and may be expanded to four boards storing 4,096 12-bit words. Maximum system cycle time is 900 ns, and power requirements are +5 V and -9 V with an oper-

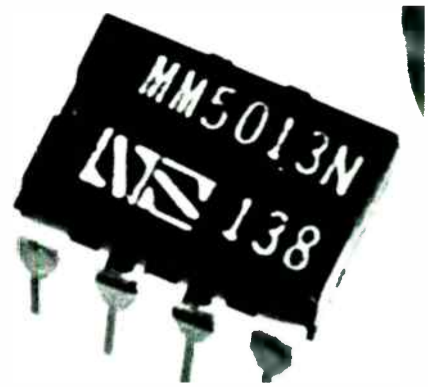


ating temperature range of 0° to 50° C. Price is 2 to 3 cents per bit in quantity.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051 [414]

MOS shift registers put 1,024 bits into small package

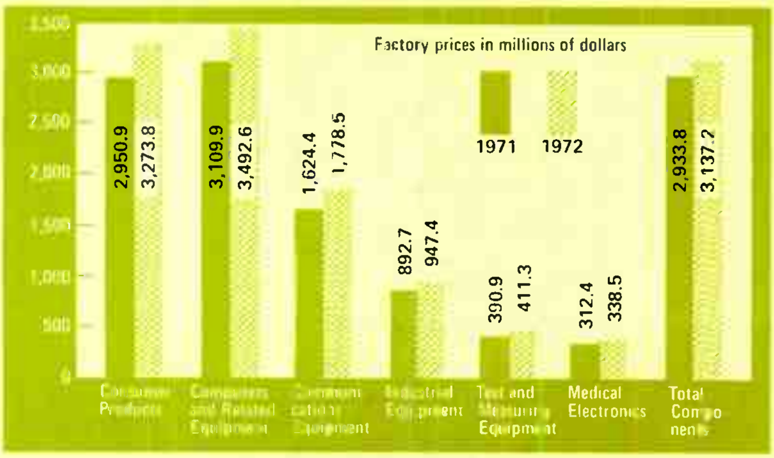
Two MOS shift registers, the MM4013 and MM5013, are packaged in eight-pin mini-DIPs, TO-100 cans, or 10-pin TO-5 cans (with two pins inactive, as a replacement for older 10-pin types). The two pins are elimi-



nated by merging the chip select control function with the read and write controls. Other design features include bipolar compatibility, Tri-state outputs, and a frequency range of 400 Hz to 2.5 MHz. The MM5013 sells for $16.60 in quantities of 100, and the MM4013 for $16.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051 [416]

Electronics markets suffer as Europe's economy sags



CONTENTS

☐ On both sides of the English Channel, on both sides of the Rhine, and on both sides of the Alps, foreign trade has become the lifestuff for a thriving Western European economy. But recently Europe's foreign trade has been in jeopardy as the upheaval in the world's monetary system stifled international business.

Even before President Nixon triggered the upheaval in mid-August—by cutting the dollar's ties to gold and levying an import surcharge—there had been a falloff in world trade because of the slowed economic pace in the U.S. It now looks as if the major industrial nations can work out their parity problems in time to ward off a worldwide recession. But its anybody's guess how soon business will start to snap back after the solution comes. There's practically no chance of solid recovery for 1972.

West Germany, the key economy in the Common Market, registered a true gain of only 3% in its output of goods and services; next year's figure may be as low as 1%. Great Britain's economy grew less than 1% this year and doesn't figure to better that figure by much in 1972. The characteristic pace throughout Western Europe next year will be a hobble.

A $10.2 billion equipment market

Electronics' reporters in Western Europe talked to marketing people from nearly 200 companies, trade associations, and government areas to get a fix on what's ahead. Nearly all were more tentative than ever before.

All told, *Electronics*' consensus forecasts for 1972 equipment markets add up to $10.2 billion for the 11 countries surveyed. That's 10% up on the $9.3 billion estimated markets total for 1971. The nominal expansion, however, loses its luster when discounted for inflation.

Computers and other data-processing hardware add up to the biggest market. With rentals figured in on an "if-sold" basis, the computer category checks in at $3.5 billion, 12% higher than this year's $3.1 billion. For computer makers, however, that's flying low.

As for components markets, they went nowhere this year. The survey logged $2.9 billion both for 1970 and 1971. For next year, the consensus forecast is a 7% rise to $3.1 billion. There's no solid optimism among components producers, but many see hope in the fact that the equipment makers have generally worked off the inventories that have made them order cautiously.

West Germany

Economy slows to a trot, despite racy appearance

☐ The frenetic construction activity in Munich, which is readying for next year's Olympic Games, and in other West German cities strongly suggests a fast-paced economy. But the bustle is deceiving—actually, the economy has slowed to a jog.

To be sure, the number of foreign workers has reached an all-time high—2.23 million—and unemployment is respectably low—around 1%. Then too, consumer spending continues at high levels. But other indicators are quite disturbing: Industrial planners have sharply curtailed their investments for plant equipment. As a result, order books are getting thinner because of slackening demand for capital goods. Many workers are on "Kurzarbeit"—shorter work weeks—or unpaid vacations. And many of the thousands of laborers from Italy, Greece, or Yugoslavia now homebound for Christmas won't be coming back.

Electronics markets outpace economy

All told, the short-term outlook for the West German economy is truly dismal. This year was marked by stagnation and inflation, one of the worst combinations possible. As a result, the country's output of goods and services grew only 3% in 1971, discounting price rises. Next year, the real growth rate may drop as low as 1%.

In times like these, West German industrialists normally would step up their activities in foreign markets, as they did during the slump five years ago. But today's foreign markets aren't what they were then. In the kingpin U.S. market, for example, the Germans now find it hard to keep competitive: they're up against the 10% surcharge slapped onto most imports and de-facto revaluation of the Deutsche Mark, which makes German goods cost about 10% more in the U.S. than before.

Luckily, the stagnation won't last forever. The government has some $3 billion in reserve to prime the economy, most of it from income-tax surcharges, which the government has to pay back by 1973. Some economic sages say that the bulk of the payback will go straight into the bank as German taxpayers cushion themselves against further hard times. Still, enough will be pumped into the economy next year to get industrial growth headed soundly upward again in 1973.

Computers still lead, but . . .

For electronic equipment alone, the outlook isn't quite so bleak: Manfred Beinder, head of the market research department at Standard Elektrik Lorenz AG, an ITT affiliate, pegs the rise in output next year at between 7% and 8%. The market will perform better than that, largely because of heavy deliveries from inventory. *Electronics*' forecast, based on inputs from dozens of West German companies, puts the 1972 market for electronics equipment at $3.27 billion, up 10% over an estimated $2.96 billion for 1971.

Computers will continue to outrun other sectors of electronics in 1972, there's no doubt about that. And everybody in the business agrees there's a slowdown on tap next year. There are sharp differences of opinion, however, as to how much.

Some experts believe the growth rate of new installations will slow to somewhat less than 20%. Others see 15% as a more likely figure, and a few put growth even as low as 11% or 12%. *Electronics*' consensus forecast checks in at 15% with an estimated market of $1.11 billion for 1971 and a climb to $1.26 billion for 1972. (For the survey, rented EDP hardware is figured on an "if-sold" basis.)

Next year should see a decided bulge in the market for small machines—hardware with monthly rentals between $1,200 and $6,000. The trend has been going on for some time but now is really gaining momentum, and reasons aren't hard to find. There's increasing emphasis on satellite systems with "intelligent" terminals that can handle part of the data processing. Even very large companies that relied heavily on big, central mainframes are shifting to distributive processing, largely because they don't want to pay for capacity they can't use in a large machine. "Customers are becoming more cost-conscious these days," says Dieter Sauer, marketing director at Sperry Rand GmbH. "They are asking themselves: 'How useful is a computer?' It's this that's changing the nature of the business."

Small computers, terminals score

Not surprisingly, then, the small-machine makers will chalk up the largest sales gains next year. "We'll be well above the average for the industry generally," says an official at Nixdorf Computer AG. Nixdorf, Europe's most successful small-systems producer, has seen its sales skyrocket tenfold over the past five years.

Siemens, the largest native computer maker, is set to tap the low-priced end of the EDP market too. The latest addition to its line, the Model 404, expands the company's market coverage downward.

The spurt in small systems and remote processing augurs well for producers of terminal displays. Some market-watchers, among them the crew at Deutsche Philips, see the number of cathode-ray tube displays for computer applications increasing more than 35 fold over the next four years. As of mid-1971 there were about 1,300 such units installed in West Germany, all accounted for by only 90 computer users. The increase next year will be to 11,300 units: in 1974 32,000 should be installed, and in the following year around 46,500.

Sales of electronic desktop calculators will bounce up some 16% next year. The survey figures: $90 million for 1971 and $104 million for 1972. Little of this money, however, will flow into the coffers of German manufacturers; Japanese firms claim up to 80% of the market. Japanese officials say they will not step up their sales efforts in Europe just to offset their U.S. losses, but German companies are skeptical.

Consumers tighten their belts

Anyone caught up in the crowds surging through the big department stores of the Main-Taunus shopping-center these days would find it hard to believe that Germans could keep their purse strings drawn. But that's what many companies think consumers will do next year. "In our projections for 1972 we are figuring on slower growth rates because of slackening consumer demand," says Johanna von Ronai-Horvath, head of market research for Graetz GmbH and Schaub-Lorenz GmbH, two ITT entertainment-electronics producers.

Her view is shared by nearly everybody in the industry. Joachim Prange, a Siemens marketing official, figures that there will be hardly any increase in production next year. Standard Elektrik's Beinder projects a production increase between 2% and 3% and a rise in domestic consumption of about 6%. *Electronics'* forecast works out to a $1.07 billion market in 1972, up 8% from this year's $997 million.

As for color receivers, the industry's mainstay, 1971 didn't quite live up to original expectations. Last year,

West German Electronics Markets Forecast
(in millions of dollars)

	1971	1972
Assembled equipment, total	**2,963.3**	**3,269.2**
Consumer Products	997.4	1,070.5
Computers	1,106.5	1,264.6
Communications	379.5	411.3
Industrial Electronics	280.2	306.7
Test and Measuring Instruments	90.5	95.9
Medical Electronics	109.2	120.2
Components	**946.2**	**1,012.0**

Exchange rate: $1 = 3.34 marks

many forecasters figured sales could well reach 1 million sets in 1971. They won't. Despite a late summer rally, the market was well out of range of the 1 million market as retailers readied for the Christmas rush. The yearend spending spree will put the final figure around 800,000 sets, judging from the $333 million consensus estimate of the survey. There's no disagreement, though, that the biggest sales stimulant for color next year will be the Olympic Games in August: largely because of them the market should run up to $404 million, *Electronics* forecasts.

In TV technology, the big story this year has been the 110° color tube, which, despite initial skepticism by retailers, is catching on fast. Wilhelm Kahle, manager of domestic sales of AEG-Telefunken's radio, television, and phono division, figures that half of all color sets sold now have the new tube, whose shorter neck and envelope make for slimmer TV sets.

110° tube speeds transistorization

The swing to the new tube has accelerated another technological trend. Because they have to change designs to accommodate the shorter tube anyway, set makers are putting semiconductors into the power output stages of the horizontal and vertical deflection circuits, the last redoubt of receiving tubes in TV sets. Heretofore, German set makers shied away from transistorizing these stages because of relatively high cost and limited reliability of high-voltage power transistors, drawbacks now overcome. Grundig, often the pacesetter, will be the first to have fully transistorized color sets: they will start turning up in shops early next year.

"Radios are still a lucrative business," says Bodo Renne, marketing manager at Norddeutsche Mende Rundfunk KG (Nordmende). What's keeping the market buoyed are millions of teenagers with plenty of cash for items like portable radios. The number of portables and "pocketables" sold next year should reach 5.1 million, von Ronai-Horvath says. That's a rise of about 3% from this year. For all radios, *Electronics'* forecasts sales of $204 million, up from $194 million.

A new consumer electronics market—video tape recorders—will emerge next year. Philips will be the first on the scene with its video cassette recorder (VCR). It will hit the market in April and initially will be available as a playback and recording system for color TV. Philips' marketing people figure they'll sell around

20,000 VCRs at about $850 each next year. The biggest customers initially will be schools and institutions, but by 1980, the company figures, there should be about 1.2 million audio-visual systems in use in West Germany.

About a year after Philips puts its VCR on the market, AEG-Telefunken will come out with its "Bildplatte"—the revolving video disk played with a stylus. It will be available in color. The company has settled on an 8-inch disk as the standard version, good for five minutes of playback time. Up to 12 disks can be held in a magazine, giving an hour of playback.

Components on a one-way slide

Among components producers, "Bad as ever before" is a likely response to anyone who risks asking "How's business?" Indeed, the unthinkable happened this year. Components sales fell from a 1970 level of $1 billion to an estimated $946 million this year. There's some recovery in sight, according to *Electronics'* survey. The forecast is for 1972 sales of $1.01 billion, a 7% gain.

Perhaps the most discouraged lot are the semiconductor makers. Says an official at SGS Deutschland GmbH, "The golden era in our business is past." Prices tumbled more than 50% this year for some devices as excess product spilled from plants in Europe and in the U.S. Then, to make matters worse, there was the early-1971 slowdown at consumer electronics makers, who normally sop up between 40% and 50% of the semiconductors used in Germany. On top of that the new markets—like the automotive industry—haven't come on as fast as expected.

One bright spot is the outlook for MOS circuits. Some 70% of them are custom designs currently and thus are still profitable, but there's a trend towards standard designs as MOS components gain mass entry into memory devices and the like. And in semiconductors standard designs mean rugged price competition.

Communications makers are secure

Communications equipment producers, unlike the set makers, don't face the uncertainties of a market swayed by fickle consumers. The big customer for their hardware is the Post Office, which runs the country's communications utilities and seems blessed with an ever-rising budget.

The agency doesn't get its definitive detailed budget for 1972 until mid-December, but everybody in the industry is convinced that next year's allocation for telecommunications will top the $1.35 billion earmarked for 1971. Much of the money will go for cables, handsets, crossbar exchanges, and the like. There should be plenty left, however, to keep the 30-odd communications hardware makers reasonably busy in 1972.

But not as busy as they've been this year, judging from *Electronics'* survey: it turned up an estimated market of $380 million for 1971, up $40 million over last year. Next year, a lesser rise to $411 million looks likely.

As before, equipping Munich and the country as a whole for the Olympic Games will help communications markets next year. One prestigious hardware item that will help get the words and images out is the third ground terminal at Raisting, about 30 miles south of Munich, scheduled to be ready by midyear. Prime

Relay. With the Olympic Games set for Munich next year, Siemens AG is readying portable TV relay equipment.

contractor for the $9 million installation, which will work through Intelsat 4, is Siemens.

Another Olympics-related project is the "Wertachtal" facility, a $48 million, 12-transmitter short-wave station. AEG-Telefunken is the prime contractor for the station, which will be the largest and most powerful of its kind in Europe when completed in 1974. Five of the 12 500-kilowatt transmitters will be ready for the Olympics.

Than, too, there's the German-French "Symphonie" satellite venture to give the communications market a bit of a lift. A $2.1 million ground terminal for 4- and 6-GHz links with Symphonie will be begun next year.

Data transmission, of course, is coming in for much attention. Siemens, for example, has come up with a computer-controlled electronic data switching system EDS that works with teletypewriter and other digital transmission lines. A prototype version was tried out this year over an experimental link between Siemens' Munich facilities and the Post Office's research labs at Darmstadt. The Post Office says the first EDS system will be in service in time for the Olympics.

Great Britain

Color TV races ahead, but most market segments lag

☐ Prime Minister Edward Heath rates high marks as a racing yachtsman. And he proved this fall he can navigate the ship of state through the rocks and shoals of the English Channel when he skippered Britain into the Common Market. But so far Heath has fared poorly in plotting a course to prosperity for Britain. The economy has virtually stopped growing and there's no sign that it's going to start again.

The government has done all the usual things, like cutting sales taxes and easing credit restrictions, but the only result has been a boomlet in consumer durables. Industrial investment is flat, and largely for that reason this year's gross national product edged up in real terms less than 1% over the 1970 level.

Although the economy dawdles, manufacturing costs are shooting up, so much so that many industrialists have shied away from new plant investments because they fear they could never sell the output at a profit. A big element in the cost push is wages, up about 13% this year. Prices have gone up steeply, too.

Growth rests on consumer buying

All told, capital and consumer equipment markets in the UK will run $2.01 billion next year, *Electronics*' survey shows. That compares with the $1.83 billion logged last year. Just about all the growth here—10%—is chalked up by consumer goods. For most other sectors it's more a question of who'll survive rather than who'll thrive for companies heavily dependent on the home market.

Communications equipment makers will be next-best off. The Post Office Corp. is now getting into stride on expanding and updating Britain's telecommunications networks. The corporation will now invest some $1 billion for new plant in 1972 and at least as much in the four following years. Only a small part will go for electronics hardware at the outset, but there's enough investment in sight to see suppliers through a recession year. Communications-hardware sales to other government agencies will be reasonably firm, too.

The toughest times will be had by companies whose customers are mainly industrial. Whether it's a big computer, an airport radar, a process-control installation, or merely a desk calculator or a voltmeter, industrial buyers are holding off as long as they can, waiting for the economy to turn around. Hence, producers must look more and more to exports for profit in 1972.

Britain goes color-crazy

Color TV is rocketing ahead in Britain. Amidst the accompanying euphoria, enthusiastic forecasters are talking about a 1972 market of 1.5 million sets worth $550 million. This year's figures will work out to 900,000 sets and $340 million, they insist. *Electronics*' consensus forecast doesn't quite reach these heights. But it does come in at $300 million for 1971, with a leap to $420 million for 1972. Either way, there's a heady year in sight for color TV sales.

With color TV demand running high for the foreseeable future, set makers won't bother making technical changes unless there's a clear benefit: lower cost, better performance, or both. Hence 110° color tubes, which looked a good upcoming bet a year ago, won't supplant 90° tubes as fast as they have in some other PAL-system countries.

Cartridge playback TV units will appear in small numbers next year, but they'll be mainly interesting novelties. Most installations will be Columbia Broadcasting System's EVR equipment made in Britain by RBM; deliveries started recently and the company claims to have nearly 1,000 orders for hardware from Britain and West Europe. EVR's major competitor in Europe, Philips' video cassette recorder, won't get to England at least until midyear.

Computers fall short

Time was when solid growth for computer makers in the UK was as sure a thing as the quarter-hour clanging of Big Ben. Now business has turned as erratic as a cheap pocket watch. For most makers, order backlogs are down this year so 1972 deliveries will drop from the 1971 peak. *Electronics*' forecast pegs next year's market at $501 million, $11 million down from the estimated $512 million 1971 total.

Orders for complete systems from new customers have fallen most sharply; when cash is short, a proposed computer system is one of the first things to be slashed. Surprisingly, small systems—$100,000 to $200,00—are taking the hardest knock, no doubt because small systems plans have less inherent momentum than big systems. Alan Wakefield, manager of marketing objectives for International Computers Ltd., says that ICL's orders from UK customers for the biggest systems show no signs of dropping off. However the chill will spread upward if there's no upturn in the general economic climate next year.

Some potential small-systems buyers undoubtedly will turn to midi- and minicomputers, which figure to keep getting cheaper, so makers of sophisticated systems with good all-around support and backup can look forward to a reasonably good year.

Because of the slide in demand for new processors and memories, practically nobody—maker or buyer—is likely to experiment much with new technology. Some American systems with semiconductor memories are likely to get to England in 1972, however. And ICL is carrying on with its 1904S system, which is graced with a Cogar n-channel MOS main store of 96,000 24-bit words. The first system will be completed by summer.

In minis, it's not likely that any British maker will switch from cores to chips for memories. The core makers keep dropping prices enough to keep just a step ahead; prices have dropped 50% in a year. Most of the technical effort next year will concentrate on cutting production costs. One exception: a new Ferranti mili-

British Electronics Markets Forecast
(in millions of dollars)

	1971	1972
Assembled equipment, total	**1,833.4**	**2,009.2**
Consumer Products	643.8	788.3
Computers	512.3	500.8
Communications	448.2	483.2
Industrial Electronics	135.8	139.1
Test and Measuring Instruments	59.7	64.2
Medical Electronics	33.6	33.6
Components	**696.0**	**733.7**

Exchange rate: $2.50 = 1 pound

In the dark. For low-light-level image intensification jobs, the coming thing in England is the channel electron multiplier tube.

tary computer using a Schottky TTL processor—the first British computer to do so.

Communications is hung up

Communications equipment makers as a group can add a new meaning for "group delay" to their glossaries—next year's market. *Electronics*' survey predicts they'll ring up $483 million in domestic sales during 1972, an 8.5% gain over 1971's $448 million and enough to cover inflation but little more.

There are some bright spots. Sales of land-mobile radios should once again log the 12% gain they did this year. And there'll be a trade wind blowing in from the sea as the Post Office starts to replace its double-sideband hf coastal transmitters with single sideband hardware to meet new international regulations. There's some succor, too, from knowing the Post Office has ambitious plans for electronic telephone exchanges.

For their other lines, communications equipment makers will be hard put to hold their gain levels. In space, the government's penchant for making decisions on a short-term, hand-to-mouth basis will keep rocket and satellite builders occupied during 1972 but worried about 1973. The two main firms are Hawker Siddeley Dynamics Ltd. and British Aircraft Corp. (BAC).

Hawker Siddeley is prime contractor on one small British technology satellite and an ESRO satellite. The company also has work on other projects, including Anglo-American space shuttle studies. BAC is prime contractor on a British scientific satellite and has a lot of subcontract work from Hughes Aircraft Co. on Intelsat 4 communications satellites. Both still have some launcher work in a declining British program.

Avionics rides on one advanced plane

Avionics men are worried, too, for basically similar reasons as space men. There's work in hand to keep production lines rolling for a year or two—longer than that if the supersonic transport Concorde gets into full production, which now seems likely. But there's only one advanced technology aircraft on the horizon: the Panavia 200 British-German-Italian, two-seat Multi-Role Combat Aircraft (MRCA).

Advanced avionics R&D next year (and much of British weapons systems from 1975 onwards) depends heavily on the international share-out of orders for this plane. Award of the nose radar contract earlier this year to Texas Instruments Inc. hit the British airborne radar industry hard. As a result, development contracts for other MRCA hardware are vital for Britain.

Meanwhile Elliott, Ferranti and Smiths Industries Ltd.—the third major British avionics maker, which will build MRCA's head-up displays—will produce avionics for Concorde, the Hawker Siddeley Trident, and the BAC 111. In addition to these civil transports there are a few military planes, notably the Jaguar, the Harrier, and helicopters, plus hardware for foreign aircraft such as Elliott's head-up display for the U.S. Navy's A-7 fighter.

Ground radar manufacturers, too, have dull prospects. The primary radar chains and the microwave data link networks for Britain's Linesman (military) and Mediator (civil) integrated aircraft traffic control systems are now complete, so little will happen in primary ATC radar next year except for routine updating.

As for now, action in radar is concentrated at the bottom end: the military is buying magnetron-powered portable battlefield radars from GEC, and a half-dozen companies are selling several thousand Gunn-diode powered intruder-alarm radar systems a year.

Lean year for components

Components makers in Britain figure to fare poorly in 1972. Electronics' survey spots the market at $734 million. That's 5% up nominally on the 1971 figure of $696 million; but discount price inflation and there's no growth.

Semiconductor marketers apparently can count on one consolation: the downward slide of sales this year will be checked next year. Anyway, that's what the survey shows. Sales for 1970 are clocked at $154 million, then down to $142 million this year, then back up slightly to $150 million next.

How well the forecast stands up depends on how well prices stand up. Suppliers say prices have bottomed out; but equipment makers show an increasing willingness to try out cheap imported devices. There are exceptions, usually where there aren't many suppliers, such as rf power and microwave devices.

For standard IC lines, battered during the past two years by a fierce price war, the worst seems to have passed. Prices are steady, delivery times are lengthening for some devices and established buyers are ordering in larger quantities. New and old customers are buying medium-scale-integration ICs which will account for the slight growth in the digital bipolar market next year. Last year's sensation, Schottky TTL, hasn't made much headway, but will appear in a new computer and some instruments next year, and in a combined digital-linear chip by Ferranti for store output driving.

Semiconductor memories have been making the news lately but nobody expects much in the way of sales until late in the year—if then. Both Plessey and Mullard are challenging the U.S. semiconductor memory makers on their own ground: the standard volume chip. A Mullard executive justified it: "You've got to, to get a hold in the computer market, where the big sales will be".

The brightest future is for RAMs. Present chips pack in 1,024 bits, which is almost certainly below the optimum. Mullard says it could make 2,048-bit chips now but would rather wait till it can make 4,096 bits in a new pack, the better to suit computer makers. GEC Semiconductors Ltd. and ITT Semiconductors Ltd. are more cautious, preferring to keep their technologies for custom memory orders.

Look for some interesting developments in low-light-intensifying tubes. The established three-stage cascade tube may have a job to fight off the upcoming channel electron multiplier tube, which is much smaller. Transformerless, and therefore small, power supplies should catch on. Three British makers have them in early production stages.

Hard days ahead for Industrial sector

Industrial buyers have the word straight from the executive suite to keep corporate purse strings taut and that's made life very difficult for sellers of controls and instruments. For industrial electronics, the survey turned up a market that's going nowhere. The figures: $136 million for 1971 and $139 million for 1972, a rise that won't cover inflation.

There'll be a big lift for industrial electronics, everybody's convinced, when the automakers start buying original-equipment hardware like electronic fuel injection systems and antiskid brake controls. But British automakers won't be buying heavily next year.

The best-selling item, as this year and last, will be generator controls, mostly made by the Joseph Lucas Group. And Smiths' IC-based tachometers will get into more cars, including Ford's Capri range.

Sales of test and measuring instruments showed no gain at all this year, dipping slightly below last year's $60 million. At best, this sector will bounce back up a little in 1972. The survey pegs the market at $64 million.

Automated test equipment, a market that looked so promising a year ago, is picking up only slowly. It won't accelerate much next year except possibly in mobile radio: there are now so many sets around that automatic check and fault diagnosis can pay off. Bright spots are spectrum analyzers for communications use and high-frequency counters. Relatively inexpensive ECL-based instruments are getting to vhf/uhf radio users who wouldn't have bothered a year ago. Look for more new counters next year, possibly reaching 1 gigahertz, certainly 800 megahertz.

France

Telephone, TV will help shaky electronics industry

☐ Ask the French man in the *rue* to tick off what's wrong with his country and chances are he'll top his list of ills with telephone troubles. Not too much later—after traffic jams and taxes perhaps—will come a complaint about television programing.

What's bad for the man in the street, though, will be good for the electronics industries next year. The government has mounted a herculean effort to catch up with the rest of the world's highly industrialized countries in telephone service. And French consumers, for their part, have started to show some interest in color TV, although the fare provided by the official French broadcasting agency still doesn't come anywhere near that dispensed by broadcasters in Germany and Britain.

Although Finance Minister Valery Giscard d'Estaing's people are talking about something like a 5.2% growth rate for the country's economy, other forecasters have a gnawing feeling that gains won't be anywhere near that figure in 1972. Inflation is a problem in France and unless there's a turnabout from recent experience the government's 1972 target of only 3.6% price inflation doesn't stand a chance.

With much that's spongy in the overall industrial outlook, electronics markets are hard to peg. If the economy doesn't take an exceptionally hard knock, equipment sales will run $1.71 billion in France next year, *Electronics* survey predicts. That's an 11% gain nominally and an improvement over 1971 when equipment markets rose 9% to $1.54 billion. Price inflation, of course, takes the sheen off these gains.

Color takes off

Color TV, at long last, is starting to move. Sales this year will hit about 320,000 sets and the upward push is expected to accelerate to about 420,000 in 1972, an increase of 31%. Philips, Thomson-CSF and ITT-Oceanic are among those scrambling for a market that they know has to take off eventually. They are counting on the Olympic Games at Munich next year to boost sales. The fanfare that will accompany the inauguration of the third French network, an all-color operation, also will help; but the real effect of the third network won't come before 1973.

The French telephone system planners hope to bring the system into the modern world by 1980. The national economic plan calls for doubling government investment in the phone system between 1971 and 1975—from $736 million this year to $1.45 billion in 1975. The abnormally high investment rate will continue till 1980, when it is expected to level off.

Instrument curve is flat

Test and measuring instruments are in for a flat year in 1972, barely holding their own with 1971 sales in most categories. The overall *Electronics* projection shows a slight probable increase to $73.1 million, up from $70 million this year. Jean-Noel Hervé, marketing manager for Europe at Schlumberger Instruments and Systems, hopes to increase Schlumberger's 22% share of the instruments market in France; but his long-range hope is for the untapped market behind the Iron Curtain. Schlumberger is joining up with the ITT company Metrix SA to open a permanent office in Moscow.

Charles Billet, director-general of Tektronix-France, the company that still dominates the French oscilloscope market, says Nixon's economic plan has touched off a "psychosis of fear" in Europe. "Our customers have already told us their orders will be smaller next year," mainly because of monetary and trade uncertainties, Billet says. But he believes the fear is exagger-

French Electronics Markets Forecast
(in millions of dollars)

	1971	1972
Assembled equipment, total	**1,535.5**	**1,710.2**
Consumer Products	441.0	468.6
Computers	528.4	608.6
Communications	316.5	364.0
Industrial Electronics	117.4	128.1
Test and Measuring Instruments	70.0	73.1
Medical Electronics	62.2	67.8
Components	**483.5**	**529.1**

Exchange rate: $1 = 5.53 francs

ated. "We have registered only a slight decline in orders," he says.

Schneider Electronique, about to spin off on its own from its former parent, Schneider Radio-Television, foresees an invasion by U.S. instrument makers in 1972. Small American companies will lead the penetration, offering multimeters at "prices that bear little relationship with their prices in the United States," says Martin Birnbaum, a Schneider director. While unwilling to accuse his U.S. competition of dumping, Birnbaum says, "The industrial market in France runs the risk of being disrupted." Schneider, of course, has done well in the U.S. with its own low-cost Digitest instruments. Schneider's other strong line, desk calculators, has secured about 15% of the French market.

Good times ahead for peripherals, software

Computer makers in France see a continuing slowdown in the computer sales growth rate, but a healthy increase in peripherals and software business. With an estimated market of $600 million in computer-hardware sales in 1972, IBM, Honeywell-Bull and the national conglomerate Compagnie Internationale pour l'Informatique (CIT) are heading for an increase of only 12.8%, according to *Electronics*' market study. But software and services are climbing at a rate that should hit 25% annually over the next five years.

Maxime Bonnet, marketing director of Honeywell-Bull, expects to feel the effects of Nixon's economic measures in 1972. "The repercussions of the U.S. recession are more psychological than material," Bonnet says, "but they are there. People feel that a slowdown is coming so they spend more prudently."

A crucial factor in the French computer market is the growth of CII, which got a new lease on life this year with the renewal of the "Plan Calcul" and another $100 million in government credits for research and development over the next four years. More ominous, say CII competitors, is the fact that government agencies are under pressure to "buy CII" whether the CII machine fits their needs or not. With French government protection and encouragement, CII more than doubled its turnover since its conception in 1968 and this year is aiming for $121.8 million turnover, up 25% from last year.

In November, CII announced that it will design and build a new medium-large computer that will be marketed in the United States by Control Data Corp. The new machine is expected to be ready in 1974. The agreement gives CII its first opportunity to penetrate the U.S. market, which accounts for 65% of the world's computer sales.

Components makers seek stability

Semiconductor makers still will face the salvos of the device price war early next year but most now think that prices should stabilize by the end of 1972. What will bring about the stabilization is a matter of opinion. François Dufaux, the new Texas Instruments commercial director for France, the Benelux countries, Spain, and South Africa, says some of the dozen semiconductor makers in France are bound to drop out of competition in 1972 due to the country's "production overcapacity."

Dufaux sees no likelihood of recovery for the semiconductor industry as a whole until 1973. "We just have too many suppliers, so we have to export," he says. "And since our main customer is Germany, we can't recover until they do." Dufaux is banking on stabilization of the international monetary uncertainties during 1972. If Germany emerges unscathed, recovery should follow swiftly there, he says.

TI says it has been "very difficult to make money" in semiconductors in 1971. Some integrated circuits that were selling for $4 in 1969 are down to $1 now. A new sector that will be hit by price-slashing will be power transistors over 100 amperes, Dufaux fears.

Claude Hervouet of the commercial division of La Radiotechnique-Compelec, a Philips subsidiary, is less gloom-prone. He sees semiconductors recovering somewhat in 1972 due to rising demand in such fields as color television, telephone production, and computers. "We will clearly be better off than in 1971," he says.

Electronics survey, too, points to some amelioration next year. It shows semiconductor sales in France edging up from this year's $94.8 million to $97.9 million next year. The survey pegs the total components market at $529 million, up from $484 million this year.

Medical gear prognosis is static

Medical electronics equipment makers are projecting growth that will keep them abreast of inflation but little more. *Electronics*' survey points toward an increase in the French market to $67.8 million next year, up from $62.2 million this year. Thomson Medical Telco is promoting its new portable electrocardiograph as one of its main new products. About 200 were sold this year in a market estimated at 1,000 in France. Other new products slated to come out in 1972 include a $1,500 heart-lung-temperature monitoring instrument for premature babies that collects data via three electrodes.

The Compagnie Générale de la Radiologie (CGR), in an effort to boost sales well above the survival level, also has readied a batch of new products for 1972. The new Futura 2000 examining table, equipped with IC controls to change its position, will sell for $60,000; the Neurocentrix, an instrument to provide rapid brain analysis, will sell for $120,000. CGR technical director Edouard Niay says 1972 will be an exceptionally heavy year for new products.

The hospital market, which accounts for 50% of CGR's total sales, could take a leap in 1972 if state financing comes through for equipment for the four new university hospitals now under construction. Niay says some $2 million in contracts should have been awarded this year, but high construction costs used up the budgeted funds prematurely.

Italy

Consumers bank money as production stagnates

☐ The "Italian miracle" went up in smoke during the "autunno caldo" two years ago; since that hot autumn of crippling strikes, wondrous economic growth has ceased. In its place have come more strikes, higher wages, and lower industrial production.

For the moment, Italian trade union leaders seem intent on keeping their cool. But the work force alone can't bring off another economic miracle, particularly now that the country's investors are themselves "on strike." Always edgy about the rebellious work force, they are unwilling to put up new money for plants when industrial output is running below capacity. What's more, consumers seem intent to put their spare lire in the bank rather than spend them.

Government state-of-the-economy figures accentuate the bleak situation. Official economy watchers estimate that the GNP increased between 7% and 8% this year over the 1970 level of $95 billion. This rise, however, reflects price inflation more than anything else. In real terms the growth is between 1% and 2%. "It is liable to be much closer to 1% than to 2%," says Almerina Ipserich of ISCO, a statistical organization that works on macroeconomics for the government. As it looks now, 1972's economic growth rate should settle at 3.5%.

One step forward, two steps back

There's backlash for the Italian electronics industry in all this, of course. Consumer goods manufacturers and the components makers who supply them have been hardest hit. Semiconductor producers have to cope with a flood of cheap U.S. imports washing into an ebbing market. Hoped-for new semiconductor markets haven't materialized. The regularly touted switch to transistorized automobile equipment and household appliances has again been postponed—slack consumer demand has kept experimentation at a minimum. Set makers are balked by the government's perennial indecision over color TV. And despite predictions of strong growth to 1975 for large computers, they have begun to lose ground to mini computers and peripherals.

For 1972, then, the outlook is reserved. *Electronics'* survey spots a rise from $911 million this year to just over $1 billion next for assembled equipment. That's a gain of 10% and seems high until you remember most of the increase is price inflation and not real growth.

There are something close to 3,000 large computers in operation in Italy, and some projections point to three times that number by 1975. All the same, the market right now lacks the luster that it had when growth rates ran 25% and more. The economic downturn has caused management to take a closer look at costs, and the scrutiny often leads to a cooling of interest in large-computer projects.

Awed by the unknown in big computers, many businessmen feel safer with smaller systems and there's been a swing to them as well as to minicomputers this year. Despite the gloomy 1971 economy, minicomputer manufacturers report good sales, some even expect 1972 increases of up to 20%. "It is impossible for this market to go down" says one. With minis and peripherals running strong, the market for computers next year will mark a rise to $475 million from this year's $403 million, according to *Electronics'* forecast.

Color indecision blackens consumer outlook

For entertainment-electronics makers, 1971 has been a grim year. Once more the Italian government has dawdled over the decision whether to choose the German PAL or the French Secam system as the country's color TV standard. There's no sign yet of a final decision, and until one is made, set makers can't exploit the new product that's buoying consumer electronics in northern Europe.

Meanwhile, consumers have been holding off purchases of new black-and-white sets. And *Electronics'* survey predicts that sales of black-and-white TV sets will slide to $128 million next year from this year's $132 million. If it happens, it will be, in effect, an improvement: this year's figure was $29 million below 1970's $161 million. All told, the consumer electronics market will run dead flat this year and next at $224 million, according to the survey.

Meanwhile, there's a "second-set" market developing—small portable TVs with screens 12 inches and under that already have captured 25% of the market. Silvio Sansilverinati of Philips S.p.A. feels that 1972 could see this market open up in Italy and Europe, with Italians the main European manufacturers. It is with small TV sets, though, that Japanese producers are making big

Slowed to a walk. Strikes have held back the Italian economy this year, and electronics producers haven't been spared.

inroads. Import of TVs and radios from Japan are limited to $310,000 annually by bilateral agreement, but they are all the same an added pressure for smaller companies trying to survive in trying times.

Communications up again

Telecommunications-equipment makers can count on steady growth whether times are good or bad. As in France, there's a lot of catching up to do in Italy for the telephone network. Heavy spending by SIP, the state telephone agency, will buoy the communications sector even though most of the money goes for nonelectronic hardware. *Electronics'* survey pegs the 1972 market for communications equipment at $132 million, up from $123 million in 1971.

There is plenty of work ahead in telephone switching and transmission equipment in 1972 and beyond. The 1971 strikes badly retarded telephone installations by SIP, which generally receives 600,000 new applications for phones annually. The backlog of applications ran up from 50,000 to 250,000.

To meet the demand, SIP plans to invest something like $600 million next year to improve its telecommunications network. Some $40 million will go for transmission equipment and some $150 million for switching equipment. Electronic exchanges are still experimental hardware in Italy; sophisticated electronic transmission hardware, by contrast, is becoming standard. Next year, between 8,000 and 10,000 pulse code modulation circuits will be installed; by 1974, there'll be more than 30,000.

Components firms run to stand still

Italian components makers have a multitude of headaches. Their big customers—the set makers—are having it rough and are therefore not buying heavily. What's more, there's heavy price pressure from all sides. As a result, the components market is stagnant: *Electronics'* survey registered a very slight drop to $229 million this year and forecasts a modest rise to $238 million next.

For semiconductor producers, the 1972 figures mean more migraine. This year they fell some 10% to $40 million; next year's market looks like $38 million.

Main casualty of the crisis has been Italy's major semiconductor manufacturer Società Generale Semiconduttori (SGS) S.p.A. It has been taken into the fold of Italy's state holding company, IRI, and is currently being merged with Ates Componenti, another IRI group components outfit. Giancarlo Maimone, managing director of Ates and now also of SGS, foresees many mergers in European electronics over the next few years.

ICs, although in some cases down to a third of their price of two years ago, still cannot compete in price with discretes in the consumer-oriented Italian market. Sergio Minoretti, international marketing manager for General Instruments-Europe, thinks that ICs will get their big chance in TV when the 110° tube makes it.

Italian Electronics Markets Forecast
(in millions of dollars)

	1971	1972
Assembled equipment, total	**910.7**	**1,005.9**
Consumer Products	223.8	224.2
Computers	402.5	475.2
Communications	123.0	131.6
Industrial Electronics	93.4	99.5
Test and Measuring Instruments	39.8	43.4
Medical Electronics	28.2	32.0
Components	**228.8**	**237.5**

Exchange rate: $1 = 612 lire

Sweden

Economists sweat figures rationed by foreign trade

☐ Market forecasters in Sweden are as anxious about their 1972 figures as calorie counters confronted by a sumptuous smorgasbord.

For Sweden's economy, much depends on how world trade goes. President Nixon's dollar-defense moves have hurt Swedish exports of heavy electrical machinery to the U.S. And there've been repercussions in other major markets. Until foreign trade picks up, the economy will dawdle.

At home, there's worrisome unemployment, close to 4% and the highest level in some 20 years. Prices are rising much faster than the economy is expanding. It now looks as if the best growth possible next year for the gross national product is something like 2% or 3%, even though the government has launched a $400 million program to stimulate business and to create more jobs.

Against this general background, the outlook for electronics markets in the Land of the Midnight Sun next year is mostly shadows. There's one bright spot, though—the glow from the color TV screens. Largely because of a bound in sales of consumer hardware, *Electronics'* survey pegs the total 1972 market in Sweden for assembled equipment at $485 million, up from an estimated $430 million for 1971.

Consumer market rests on color TV

Set makers will go into 1972 with tremendous momentum from 1971. Color TV sales this year have, in fact, topped even optimists' estimates and should run some 200,000 sets when the yearend buying splurge has finished. This year's sales move Sweden into top spot among European countries in the color-sets-per-capita rankings. One Swedish family in six now has color TV.

Next year, the Olympic Games are sure to spur sales in a land of sports enthusiasts. What's more, there will be plenty to see in color. Half the TV programs of the Swedish Broadcasting Corp. (and nearly all new films) go out in color. The outlook is for 300,000 color sets next year. That will push sales of consumer electronics, according to the survey, to $214 million next year.

To Svenska Philips will go the biggest purse in color market. Philips has a large production facility in Norrköping, a city 60 miles southwest of Stockholm. The only other domestic Swedish maker is Luxor, a privately owned company that has been doing extremely well against Philips and the West German giants. Both Swedish makers are moving toward greater use of ICs in their color TVs.

Computer contracts fall to outsiders

Computer sellers, too, should fare reasonably well. *Electronics'* survey puts the market at $104 million next year. That's a rise of 12% over the estimated $93 million logged this year.

To the distress of many Swedes, though, much of the computer business will go to U.S. companies. Saab-Scania AB is the only native maker of general-purpose computers, but it has been having trouble picking up what would seem to be almost-sure business. Indeed, the Statskontoret, the agency that handles government computer purchases, recommended that IBM, not Saab, get a $4 million order for a system destined for the military's administrative services. Saab has since offered another, newer computer and may yet get the business.

In peripherals, it's another story—and a more satisfying one for Sweden. The major banks in the country are well along with big on-line systems, and their early start has nurtured development of terminals, which are fast becoming a high-growth item in data-processing hardware throughout Europe. Svenska Philips, which is supplying the terminals for the Svenska Handelsbanken, has an order to supply 80 terminals for the Dutch savings bank, Nutsspaarbank. They'll work with a pair of computers built by the parent company in Holland.

"We'll be the first foreign maker to hit the U.S. market," says Art Carney, Addo's U.S. sales manager. "By 1975, we aim at having 25% to 35% of the multi-station, data acquisition market." The complete station will sell for between $4,000 and $5,000, which Carney says will be competitive on the U.S. market.

Government to boost communications

Communications-equipment makers should get some fallout from the government's $400 million package to perk up the economy. Part of the package will go for new construction and that should bolster sagging sales of intercom equipment, long a Swedish specialty.

As in Europe generally, there's a strong lift for communications-hardware builders from the state-run telephone network. Land-mobile communications, for example, will get a boost from the Board of Telecommunications' automobile-telephone system, which started up late this year. The system is semiautomatic and going first into the populous central area of Sweden. The fast-growing state-owned company Sonab, among other, has equipment ready for this market.

Swedish Electronics Markets Forecast
(in millions of dollars)

	1971	1972
Assembled equipment, total	**429.8**	**484.8**
Consumer Products	175.2	213.7
Computers	93.2	103.7
Communications	44.1	48.7
Industrial Electronics	52.4	53.0
Test and Measuring Instruments	22.9	22.0
Medical Electronics	42.0	43.7
Components	**111.7**	**119.3**

Exchange rate: $1 = 5.02 kroner

Components: time to start moving again

Components makers, too, go into the new year tinged with uncertainty. "Nobody knows what's really going to happen in 1972," says Ingvar Ferner, managing director of Erik Ferner AB, a large Swedish distributor of imported components and instruments. "On the components side, the market must come up; companies have been living with what they have in stock."

Electronics' survey backs up Ferner's assessment. The components market this year slid off slightly to $112 million and should climb back up to $119 million next year.

Although the natural reflex is to cut down on product lines during rough times, two of the major Swedish components companies are venturing into new fields this year. Ericsson's parts-making subsidiary RIFA, for example, has readied, for a 1972 debut, thick-film hybrid ICs for telephone handset amplifiers.

HAFO, another major components maker, is moving into custom MOS circuits. HAFO managing director Dick Lundquist, notes however, "We said last year that MOS applications would grow—we knew there was interest. But now, one doesn't know. Industry is uneasy."

Netherlands

Wage, price tides dampen 1972 economic outlook

☐ Holland's famed dikes, undoubtedly, will stand up next year to whatever battering the North Sea brings. But the country's economy figures to spring some leaks.

It's hard to see, for example, how the rising tide of wages and prices can be checked. On the average, Dutch workers got a 14% boost in pay this year. Next year's pay packets could go up between 11% and 13.5%. Consumer prices presumably will move up nearly 7%, as they did this year. To add to the undercurrent of pessimism coursing the country, the growth rate is expected to sag to about 2.5% next year from this year's 5%.

The situation isn't all bad, of course. Color TV seems set for a good year in 1972 in Holland as in the other North European countries. Telecommunications, too, is running strong. Largely because of the gains in these two sectors, the Dutch market will move up to $478 million next year, according to *Electronics'* survey. That's about 8% better than the estimated $444 million for this year.

Video cassette recorders are in the offing

Although the big money still is in television sets, Philips, the Netherlands-based giant, will be keeping close tabs on a product making its real market debut this year in Western Europe—the video cassette recorder (VCR). K.T. Jongelie, VCR product manager for the firm's electroacoustics division, says at least eight manufacturers, including Philips, will have hardware for sale next year using the Philips system. Jongelie estimates initial sales will be mainly to schools and other institutions, but he sees an interesting market developing for "group watching" in places like hotels, pubs, clubs, and professional organizations. Software companies are gearing up for rentals of prerecorded cassettes in the Netherlands, Jongelie says.

Audio cassettes, too, will get special attention from Philips next year. The company is pushing to keep cassettes compatible at a time when some hi-fi equipment makers have started to introduce players with faster-than-standard speeds to improve sound quality.

Philips insists that hi-fi quality can be had at the 1⅞ inch-per-second speed now standard for cassettes and has developed a prototype stereo player that meets the German DIN 45500 standard, the accepted norm in Western Europe for reel-to-reel equipment.

Phone gear paces telecommunications market

There's a strong market ahead for telecommunications. Philips Telecommunicatie Industrie, the communications equipment subsidiary in Hilversum, expects to have its first PRX 205 semielectronic telephone exchange in operation in Utrecht in October 1972. Telecommunicatie expects to start production runs of the system in 1973. The Dutch Post Office (PTT) plans to order some 100,000 lines per year of semielectronic exchanges from Philips beginning in 1975. J. J. Mulder, assistant director of the commercial department at Hilversum, predicts production of electromechanical exchange equipment will peak in 1972-73, phase out by 1978.

Dutch Electronics Markets Forecast
(in millions of dollars)

	1971	1972
Assembled equipment, total	**444.2**	**478.2**
Consumer Products	126.1	138.3
Computers	112.3	120.5
Communications	95.4	105.5
Industrial Electronics	54.0	54.8
Test and Measuring Instruments	44.7	45.9
Medical Electronics	11.7	13.2
Components	**132.8**	**143.7**

Exchange rate: $1 = 3.35 guilders

The PRX equipment, developed jointly with the Dutch PTT, is Philips' answer to ITT's Metaconta system. The U.S. firm is also vying for a share of Dutch telephone business. ITT's Dutch subsidiary, Nederlandsche Standard Electric Maatschappij, is installing a 1,000 line Metaconta-type telex exchange in The Hague. In addition, after considerable teething troubles, Sweden's L M Ericsson has started up its experimental exchange in Rotterdam and also seems in the running for part of the Dutch telephone business.

In all, business for Philips' Telecommunications and Defense Systems (TPS) division hit the $330 million level in 1970 and is expected to increase 15% annually in 1971 and 1972. A soft spot for Philips: microwave links. Because of heavy foreign competition, IPS has pulled out of microwave production in Holland.

Look for some sort of restructuring, too, in Philips' computer activities. As they released third-quarter results last month, company officials confirmed they would take a loss of $50 million on their computer operations this year. This brings the cumulative loss since Philips went into the computer business in 1968 to $170 million. Philips says it will specialize its computer lines to cut future losses. Since the company went into the black on its office computers this year, they look like one specialty.

Switzerland

Inflation diverts economy from orderly growth plan

☐ In Swiss economic annals, 1971 will go down as the year when the country's orderly economic growth ran into treacherous going due to inflation.

Real growth of the gross national product this year will check out between 3% and 3.5%, off from the 4% and higher registered in the last few years. At the same time, prices have climbed steadily. Last year the consumer price index jumped up a record 5.4%, and the 1971 figure will be even higher—an absolutely un-Swiss state of affairs. Indeed, the president of the staunchly free-enterprise Swiss Union of Commerce and Industry actually proposed this fall that the country consider price and wage freezes.

As a Swiss executive at an American electronics company in Zurich puts it, "The edge of the boom has been broken. There's a fair year, but maybe not a good year ahead." That's an assessment that few would quarrel with, components suppliers excepted. Consumer goods, computers, and communications will boost the market enough for it to rise 11% nominally to $290 million, according to *Electronics*' survey. But the survey predicts a components market of $78 million, up only $3 million on this year's figure.

Swiss bankers and businessmen computerize

The forecast rise will come despite a general tightening of corporate purse strings. Growth rates for industrial spending, for example, fell from 10% last year to 6% this and seem headed further downward in 1972. Nonetheless, computer equipment makers see a good year ahead. The survey predicts a rise to $102 million for 1972, up from an estimated $85 million registered for 1971.

Banks and insurance companies continue strong investors in computer systems, along with machinery makers, watch and instrument makers, and chemical producers. The Swiss Post, Telephone, and Telegraph Office (PTT) is doing its part, too. The PTT runs Swiss communications and over the last few months has put into operation in Zurich an automatic telegram exchange with computer control.

Affluent buyers buoy consumer goods

"No big change" is the prevalent opinion about consumer electronics markets in Switzerland next year. The survey spots the market at $70 million, up nicely from this year's $63 million. Color television sets have sold better than expected in 1971, and a new spurt is expected early next year as viewers get ready for the Winter Olympics. Sales of some 140,000 TV sets, at least 80,000 of them color, look certain this year. That's a rise of 10% to 12%, and one that promises to hold in 1972. Retail dealers report a trend to Japanese small-screen black-and-white models as a second set for the family.

In other consumer electronic goods, like radios, tape recorders, and record players, the Swiss market remains brisk. The Japanese, with their lower-priced tape recorders, are reported to have some 70% ot this market in Switzerland. Philips AG remains the big supplier of TV sets. The market for home video cassette recorders appears on the verge of opening up here.

In communications, the PTT continues to expand the telephone and telex networks. The number of telephones in Switzerland now has reached some 48 per 100 inhabitants, which puts the country third in the world after the United States and Sweden. The density continues to rise and for 1972, the PTT has budgeted some $228 million for telecommunications expansion and modernization. The goal is a system of fully-integrated telephone exchanges. There's a steady buildup of the country's color TV network too. Swiss cable TV also is growing, but the PTT is not actively a participant.

Electronic watches are humming

The Swiss electronic watch industry is moving nicely. Ebauches Electronics expects to double its output in 1972, reaching a level of 2 million electronic watch movements. "No one can deny that the electronic wristwatch is the future of the industry," says the commercial director of one of Switzerland's largest prestige watch companies in Geneva. Ebauches continues to turn out three different generations of electronic wristwatches—with transistor-controlled balance wheels, with mechanical resonators, or with quartz crystals as the basic timing element. The higher output is for the lower-price balance-wheel movements. Faselec SA continues to supply most of the semiconductors for Ebauches.

Experts in watch technology foresee that both complementary MOS and bipolar ICs will remain in contention during the coming year. The new Swiss prototype to watch for in 1972 is a completely electronic wristwatch with a display—electroluminescent or liquid crystal—that stays on.

Swiss Electronics Markets Forecast
(in millions of dollars)

	1971	1972
Assembled equipment, total	**261.0**	**290.5**
Consumer Products	62.7	69.9
Computers	85.0	101.6
Communications	55.0	56.0
Industrial Electronics	37.3	39.5
Test and Measuring Instruments	13.0	14.6
Medical Electronics	8.0	8.9
Components	**74.8**	**78.0**

Exchange rate: $1 = 4.00 francs

Spain

Franco's brow furrows as inflation paces growth

□ Despite the affluent-looking bustle in car-choked cities like Madrid, Barcelona, and Sevilla, Spain's economy hasn't been perking the way the Franco government thinks it should.

To be sure, the gross national product this year moved up past $30 billion for the first time, putting Spain in the same class as highly industrialized north European countries like Belgium, the Netherlands, Sweden, and Switzerland. But the 1971 growth—5.5%—was accompanied by an even higher inflation rate of 6%.

The target government planners are shooting for is 7% growth without inflation. It seems overly optimistic, but the government has unlimbered its big guns for a third four-year development plan that starts with the New Year. And Franco's economy-guiders say they'll go into "El Tercer Plan" with some momentum. The industrial production index turned upward at the end of the summer, they note, perhaps signaling the end to the sluggishness that has marked the economy since late last year.

Under the four-year plan, electronics and telecommunications have been earmarked as a sensitive sector. The aim here is for growth just under 25% yearly in the country's production. On paper, then, Spanish electronics output is slated to grow from $345 million next year to $840 million by the end of 1975.

Military likes made-in-Spain label

A big chunk of this big boost will come from military electronics hardware if the plan pans out. Like military men everywhere, Spanish brass feels considerably more comfortable when its equipment is coming from domestic suppliers. Details are classified, as you'd expect, but the military target is to get home production up to the $260 million level by the end of 1975. A big order, since the figure is now next to nothing.

Along with production targets, the plan also predicates annual jumps of 23% in Spain's electronics markets. This would carry them past the $1 billion mark by the end of 1975. *Electronics*' consensus forecasts fall far short of the official figures. They log $313 million for equipment markets this year, moving up 11% to $348 million in 1972. Communications and computers figure to mark fairly strong rises, but consumer electronics will mark time. Spain has made the decision to adopt the PAL system for color TV broadcasts, but they won't start

Spanish Electronics Markets Forecast
(in millions of dollars)

	1971	1972
Assembled equipment, total	**313.2**	**347.7**
Consumer Products	130.7	136.0
Computers	98.3	119.2
Communications	45.0	51.0
Industrial Electronics	28.9	30.9
Test and Measuring Instruments	6.9	6.9
Medical Electronics	3.4	3.7
Components	**72.6**	**76.6**

Exchange rate: $1=68.6 pesetas

next year. "Maybe in 1973," say official sources.

The government's industrial holding agency Institute Nacional de Industrial (INI) had a small go at going it alone in electronics during 1970 and even had a name for the company that would have had things under its wing—Empresa Nacional Electronica.

That didn't work, and now INI is trying to get some joint ventures going, with Empresa a partner with foreign firms. INI now has talks going with U.S. and European electronics companies. One of the most promising prospects, apparently, is a deal with Motorola Semiconductors Inc.

Computers are favored

INI's new policy could bring a shakeup in the computer market, which IBM now dominates. The government, apparently, plans to throw most of its business to companies that will eventually manufacture computers in Spain and back up that aid with a tariff wall. IBM has acquired a site near Valencia, but the company won't confirm whether it's for a computer components plant.

Spain's government-controlled telephone company, Compania Nacional Telefonica de Espana, also is pushing joint ventures in the communications field. A $10 million cable manufacturing plant in Saragossa, held in partnership with General Cable Corp., is now in production. Talks with Sweden's LM Ericsson for a switching-equipment plant are nearing fruition. Telefonica has earmarked $12 million to build a research and development facility. Other upcoming plans: a mobile radio system for Spain in 1972, and expansion of the $3 million pilot data-transmission network.

Belgium

Foreign plants move in, growth rate moves up

☐ Belgium's industrial propagandists make much ado about the country's being at the hub of the Common Market. And it's true that Belgium boasts an impressive list of foreign companies that have headquartered their European activities in the country.

But even when you're at the hub, you can't turn faster than the rim. Belgium thus goes into 1972 with the prospect for very moderate growth in her economy—about 3% in real terms. The nominal growth will run well above that since there'll be price inflation. This year, consumer prices rose 6%, and the pressures that forced prices up persist.

Equipment markets will move up to $289 million in 1972, *Electronics'* survey forecasts, compared to $263 million this year.

Cable TV helps PAL color inroads

Color TV business in Belgium got off to a slow start this past year after broadcasting started too late for the Christmas selling season. However, sales moved up faster than expected and will reach $16 million this year. The forecast is $24 million in 1972.

So far in Belgium's complex multistandard market, the share of PAL-only sets has been moving up rapidly and they now account for some 50% of total color set sales. One reason of course, is their lower retail price: about $400 to $500 on the average, compared with $700 to $800 for multistandard PAL-Secam units. But steady inroads in Brussels and other major cities of community-antenna television (CATV) operations, which transcode the Secam signals of French broadcasts into PAL format, probably means that PAL sets will eventually account for the bulk of the Belgian market. Some Belgian electronics firms think sales of combined PAL-Secam sets will be confined to small communities where CATV systems are not practical.

With their lift for PAL, the CATV networks will speed the demise of the multistandard set that's been the mainstay of Belgian producers. Belgian, German, and French telecasts can all be picked up in the country, and a receiver that can handle them all thus needed PAL and Secam decoders, 625- and 819-line time bases, and French, Belgian, and European black-and-white standards.

This year, Belgium shifted to the 625-line standard for vhf, thus wiping out one reason for multistandard sets. Another will go when the French finally shift to 625 lines for their first network, which is currently on 819 lines. At that time, a PAL set will do for anyone tied into a CATV system. All this is much to the benefit of German and Dutch set makers who export their wares to Belgium.

Electronic switching systems click

As with color television, the Belgian market for electronic switching is expected to move forward next year. ITT's Belgian affiliate, Bell Telephone Manufacturing Co. (BTM), delivered 10,000 lines of electronic switching capacity to the Belgian Régie des Télégraphes et des Téléphones (RTT) in 1970 and will add 50,000 more lines this year. The figure will probably double with installation of an additional 80,000 to 100,000 lines in 1972. In all, ITT expects to install a total of about 230,000 lines by the end of 1973.

In addition, ITT's outlook for electronic switching outside Belgium is bright. The Dutch government will move toward electronic switching next year, and ITT already has part of this business. Its Dutch subsidiary, Nederlandsche Standard Electric Maatschappij, will put a 1,000-line Metaconta electronic telex exchange into operation early in 1972. Spain, France, and Germany are expected to move to electronic switching by the mid-1970's.

In order to meet anticipated demand, ITT has shifted part of its Metaconta production outside Belgium, setting up production units in Norway, France, and Austria. It will start up manufacturing in Spain, Italy, and Germany by 1975.

Other activity included startup last July of a Metaconta-type toll-switching center in Austria. BTM and Iskra, a Yugoslav electronics manufacturer, have a $20-million-plus joint project, involving installation of 15 toll exchanges in Yugoslavia over the next three to five years. Bell also has an order from Bermuda's telephone system for a 6,000-line exchange to be ready by 1974-75. A Metaconta telex system is also on order in Norway.

Computer sales will rise, despite casualties

West Europe's economic turndown has produced some negatives for Belgium's electronic sector. Memorex Corp. has cut back plans to step up disk memory and tape production at its plant near Liège. In addition,

Belgian Electronics Markets Forecast
(in millions of dollars)

	1971	1972
Assembled equipment, total	**263.3**	**289.1**
Consumer Products	60.0	65.6
Computers	85.9	98.6
Communications	37.0	42.3
Industrial Electronics	47.8	48.1
Test and Measuring Instruments	25.4	26.7
Medical Electronics	7.2	7.8
Components	**100.3**	**110.9**

Exchange rate: $1 = 46.6 francs

new production facilities for computers planned by Manufacture Belge de Lampes et de Matériel Electronique (MBLE), a Philips affiliate, and Philips' Electrologica in the region of Mons have not materialized. That project was part of a progress contract under which the Belgian government agreed to take 25% of its new computer needs from Philips and West Germany's Siemens AG over the next five years in return for expansion of their production facilities in Belgium.

However, last year MBLE started work on new facilities in Liège for production of channel selectors, varicap diode tuners, and deflection units. The first part of the plant should be fully on stream in 1972. Siemens, the other company to benefit from the government contract, expanded its telecommunications facilities at Oostkamp this year, adding about 1,000 workers. Scheduled for construction in April, 1972, are a relay plant near Namur and consolidation of workshops and a technical center near Brussels. Last October, the firm opened Europe-wide applied research facilities at Ghent.

The computer market in Belgium will bounce up 15% next year to reach a level of $98 million, according to *Electronics'* survey. A major boost in the computer business came in October when RTT moved into time sharing, the first such scheme by a European telecommunications authority to become operational.

Denmark

Government moves seek to right foreign trade imbalance

☐ Even Hamlet could discover in a trice what's rotten in the economic outlook for Denmark—the balance of payments. This year the number behind the perennial minus sign will be about $480 million, the highest ever.

There are some slight signs, though, that Denmark will do better in 1972. The government's campaign this year to slow the rise in private consumption had some effect: imports rose only 7% during the first half of the year, compared to a 14% rise for the corresponding year-earlier period. Exports grew better than 7% during the first half, the first time they've outstripped imports in growth since 1968. Just to make sure there'd be no relapse, the government slapped a 10% surcharge on nearly all imports late this summer. All told, there should be an improvement of some $130 million in the balance of payments in 1972. Official forecasts put the deficit next year at $345 million.

Market slide due next year

As usual, Denmark's small but staunch crew of measuring instrument makers figure to do their bit toward righting the balance of payments. The latest official figures, for last year, show an output of $38 million and exports of $35 million for the group, led by A/S Bruel and Kjaer, Disa Elektronik A/S, and Radiometer A/S. The same sort of record was logged this year and should be repeated again next. Storno A/S, the country's leading communications-equipment producer, also has been scoring good export success with its land-mobile gear. Overall, though, electronic equipment and components have been adding to the deficit for the past six years.

The Danish market will show a very slight slowdown in 1972, *Electronics'* survey predicts. Consumption of

Danish Electronics Markets Forecast
(in millions of dollars)

	1971	1972
Assembled equipment, total	**190.8**	**204.4**
Consumer Products	66.6	71.6
Computers	44.6	51.8
Communications	42.4	43.2
Industrial Electronics	23.7	24.0
Test and Measuring Instruments	10.1	10.1
Medical Electronics	3.4	3.7
Components	**54.1**	**59.6**

Exchange rate: $1 = 7.26 kroner

equipment will total some $204 million, up from an estimated $191 million this year. This year's growth ran slightly above 11%; next year's gain, if the forecast holds true, will run slightly under that level.

Norway

Smooth sailing predicted despite gusty economic winds

☐ Norway ranks in many respects as Europe's most nautical nation. And the country's official navigators see fairly smooth sailing for the economy in 1972.

There's no flood tide of prosperity in view, by any means. But the gross national product (GNP) will rise 4.7% to a level of $14.5 billion if the current plots are right. That's not too bad, although it's a dip of 0.4% on this year's GNP growth. There's a slight dip, too, in the offing for the rate of growth of investments—but not much below this year's 7%. Industrial output is tagged to move up 5.5% in 1972 over this year's level.

The electronics markets will show fuller sails than the economy generally. A committee chaired by the present minister of industry, Finn Lied, looked into long-term prospects for electronics production in Norway this year and forecast average growth of 20% yearly through the 1970s.

Norwegian Electronics Markets Forecast
(in millions of dollars)

	1971	1972
Assembled equipment, total	**136.0**	**152.9**
Consumer Products	23.6	27.1
Computers	40.9	48.0
Communications	38.3	41.7
Industrial Electronics	21.8	23.7
Test and Measuring Instruments	7.9	8.5
Medical Electronics	3.5	3.9
Components	**33.0**	**36.8**

Exchange rate: $1 = 6.85 kroner

The markets for electronics presumably should grow more or less apace. But next year's market increase will fall short of that, according to *Electronics'* survey. It forecasts equipment consumption totalling $153 million, up 12.5% over this year's estimated $136 million.

Government orders spur computer sales

Look for a strong lift in computers. The survey forecasts a 1972 market of $48 million, a spurt of 17% over this year's $41 million. One big order coming up next year is a central data-processing system for the government. It will be worth $2.5 million initially, and the company that gets it can almost surely count on another $4.3 million more over the next five years to fill out the system. Burroughs Corp., Control Data Corp., Honeywell-Bull, IBM, and the Univac division of Sperry Rand Corp. are vying for the job, but IBM seems the front runner.

Control Data already has its consolation prize, a $2.9 million system that is Norway's biggest data-processing facility yet. It will be used jointly by the government's weather bureau, Oslo University, a military research institute, and the Institute of Nuclear Energy.

There is also a potential big-system market in the country's hydroelectric generation network, which is moving to computer control and should one day be fully integrated. One hardware maker even thinks the string of shipyards along Norway's 2,000-mile coast can be persuaded to buy terminals to link up with a big central computer.

It's not in big systems like these, though, where the big computer potential in Norway lies. In the long run, small ship computers figure to add up to a bigger market. There are some 100 new ships coming off the ways yearly for the country's fleet owners and about three-fourths of them have some sort of automation in the engine room. Computers are also going into ships for navigation and for anti-collision systems.

There's enough potential that the shipowner's federation and two semiofficial organizations have earmarked $5 million to develop sea-going data-processing systems. "I think this market will be ten times as big in 1974 as it is now," asserts Lars Monrad-Krohn of A/S Norsk Data-Elektronikk, one of the country's ship-computer suppliers.

Color TV broadcasting is just ahead

Consumer electronics, too, seems set for a rewarding cruise next year. The survey pins the rise to $27 million, 13% over this year's estimated $24 million.

Color television will provide most of the headway. Unless there's a last-minute hitch, Norway's monopoly broadcasting corporation will start test colorcasts early in 1972. Up to now, all the color viewers could get came from Sweden.

Color set sales, then, are sure to bound upward. The question is how much higher sales will go above this year's 10,000 sets. Some peg the market at 30,000 sets next year, and some forecasts run as high as 50,000. *Electronics'* forecasts a much-less-heady rise, to $7.5 million next year from this year's $4.2 million.

For the long haul, professional electronics looks like a better bet than consumer equipment to many manufacturers. Tandbergs Radiofabrikk, for example, has won world renown for its tape recorders. But, to diversify, Tandberg has teamed up with Norsk Data-Electronikk to develop a control system for nuclear reactors.

The market for automobile telephones, too, is tagged as a comer with growth of 15% to 20%. About 40% of the country is covered by mobile phone service and the government telecommunications agency plans to have all main highways covered before too long. There's a new international airport coming up in the 1970s for Oslo, and that promises a long-term lift for communications-equipment makers. Meanwhile, there's the telephone system, which has a continuing expansion and updating program. ☐

1972 European components markets

	Belgium 1971	Belgium 1972	Denmark 1971	Denmark 1972	France 1971	France 1972	Italy 1971	Italy 1972	Netherlands 1971	Netherlands 1972	Norway 1971	Norway 1972	Spain 1971	Spain 1972	Sweden 1971	Sweden 1972	Switzerland 1971	Switzerland 1972	United Kingdom 1971	United Kingdom 1972	West Germany 1971	West Germany 1972	Total 1971	Total 1972
Passive components																								
Antennas and antenna hardware	2.0	2.0	4.0	4.3	24.0	31.0	5.0	6.4	3.4	3.7	1.4	1.3	3.7	3.8	3.0	3.4	3.2	3.2	7.8	7.8	55.0	61.0	112.5	127.9
Capacitors, fixed	8.4	9.2	8.5	8.6	54.0	58.2	26.2	29.0	12.0	12.7	3.2	3.4	11.0	12.1	17.1	17.3	7.9	8.5	81.3	85.1	125.6	138.2	355.2	382.3
Capacitors, variable	1.3	1.4	0.6	0.7	3.3	3.5	4.1	4.3	1.3	1.3	0.3	0.4	2.7	3.0	1.4	1.4	0.4	0.4	4.8	4.8	11.3	12.1	31.5	33.3
Connectors, plugs, and sockets	1.3	1.4	2.0	2.1	40.6	43.0	10.8	11.0	5.7	6.0	1.9	2.0	3.4	3.1	5.0	5.2	3.9	4.2	55.1	60.1	44.1	49.0	173.8	187.1
Crystals and crystal filters	1.1	1.2	0.7	0.8	3.2	3.6	1.8	2.0	1.3	1.4	0.6	0.7	0.3	0.3	1.8	2.1	1.9	2.1	9.8	11.3	6.1	6.7	28.6	32.2
Delay lines	1.2	1.4	0.8	1.0	2.7	3.4	1.4	1.7	1.4	1.5	0.4	0.4	0.2	0.3	0.6	0.6	0.4	0.4	3.8	3.9	4.8	4.8	17.7	19.4
Ferrite devices	2.0	2.1	0.7	0.7	3.7	4.2	4.5	4.8	3.2	3.5	0.8	1.0	1.3	1.5	1.0	1.0	3.1	3.4	9.8	12.5	23.2	24.5	53.3	59.2
Filters and networks (except crystal)	0.8	0.9	0.8	1.0	4.7	6.2	1.8	2.0	0.9	1.0	0.9	1.0	0.7	0.8	2.6	2.9	0.4	0.5	3.1	3.2	6.0	6.6	22.7	26.1
Loudspeakers (OEM type)	3.4	3.7	1.6	1.7	8.7	9.6	10.0	11.0	4.8	5.4	0.9	1.0	1.8	1.8	3.9	4.1	1.3	1.4	11.2	12.7	18.1	18.8	65.7	71.2
Potentiometers, composition	2.1	2.2	2.0	2.1	8.2	9.0	4.8	5.0	3.4	3.7	0.7	0.7	2.4	2.8	2.2	2.4	2.6	2.6	14.9	15.8	45.0	47.3	88.3	93.6
Potentiometers, wirewound	0.6	0.6	0.5	0.6	2.9	3.2	1.0	1.0	1.2	1.3	0.3	0.3	0.4	0.4	1.0	1.2	0.4	0.5	5.5	5.9	15.0	15.7	28.8	30.7
Power supplies (OEM type)	2.9	3.2	1.6	1.7	10.5	11.2	6.4	6.5	4.3	4.5	1.4	1.4	1.3	1.4	2.5	3.0	1.9	2.0	7.8	8.6	19.1	20.0	59.7	63.5
Printed circuits	6.0	8.0	1.8	1.9	18.0	20.5	21.8	21.0	5.0	6.2	1.7	1.9	1.0	1.1	4.3	4.5	5.0	5.2	12.8	14.0	19.1	21.0	96.5	105.3
Relays	5.4	6.5	2.5	2.6	34.5	37.3	9.9	10.5	7.7	8.3	2.5	2.5	5.0	5.3	11.0	12.0	4.0	4.1	41.2	43.1	48.5	48.5	172.2	180.7
Resistors, fixed and wirewound	5.1	5.2	2.7	2.9	26.0	28.5	7.9	8.0	6.4	6.5	1.1	1.2	2.3	2.5	5.8	6.0	3.7	3.8	33.1	37.0	60.3	62.9	154.4	164.5
Servos, synchros, resolvers, and solenoids	0.8	0.8	0.3	0.3	5.5	6.1	2.0	1.7	1.6	1.6	0.1	0.1	0.7	0.7	1.0	1.1	2.5	2.9	12.0	13.0	8.5	8.8	35.0	37.1
Switches (for communications and electronics)	3.5	3.9	1.5	1.6	9.1	10.0	2.6	3.0	2.6	2.9	1.4	1.5	1.3	1.4	2.3	2.4	1.6	1.7	15.0	15.9	30.6	31.9	71.5	76.2
Transformers, chokes and coils (includes TV yokes and flybacks)	7.0	7.6	4.8	4.8	26.1	28.0	13.0	14.0	9.0	9.6	3.1	3.2	3.0	3.2	9.2	10.0	5.7	5.8	34.5	37.3	42.4	44.0	157.8	167.5
Semiconductors, discrete																								
Microwave diodes, all types	0.3	0.3	0.2	0.2	2.1	2.4	0.6	0.6	0.6	0.6	0.1	0.1	*	*	0.2	0.3	0.3	0.3	2.4	2.6	3.1	3.3	9.9	10.7
Rectifiers (including diodes rated more than 100 mA)	1.1	1.1	0.9	1.2	12.5	12.9	3.7	3.8	1.8	2.0	0.7	0.8	2.8	3.1	1.5	1.6	1.1	1.1	17.6	19.0	12.5	12.5	56.2	59.1
Signal diodes (rated less than 100 mA, including arrays)	1.9	2.0	0.6	0.7	6.5	5.3	1.9	1.5	2.6	2.4	0.4	0.5	1.6	1.8	1.5	1.6	2.2	2.1	13.6	13.1	19.7	17.7	52.5	48.7
Thyristors (SCRs, four-layer diodes, etc.)	1.0	1.0	0.5	0.8	4.9	5.4	2.4	2.9	1.4	1.5	0.4	0.4	0.6	0.7	1.2	1.3	0.7	0.8	7.5	7.9	12.5	13.7	33.1	36.4
Transistors, power	1.7	1.9	1.0	1.1	11.0	12.5	4.0	4.0	3.4	3.6	0.8	0.8	1.0	1.1	2.0	2.1	1.5	1.6	13.2	14.0	15.5	17.0	55.1	59.7
Transistors, small signal (including FETs and duals)	4.5	4.0	2.6	2.5	21.2	20.0	12.8	9.0	6.0	6.0	1.5	1.8	4.2	4.9	4.5	4.8	3.7	3.3	40.5	40.7	61.6	56.6	163.1	153.6
Zener diodes	0.6	0.7	0.6	0.8	3.7	3.7	0.6	0.7	0.9	1.0	0.4	0.5	0.7	0.6	0.9	1.0	0.6	0.5	7.6	7.6	7.4	8.0	24.0	25.1
Semiconductors, integrated circuits																								
Hybrid ICs all types	0.3	0.4	0.3	0.5	5.6	6.2	1.0	1.3	0.5	0.6	0.2	0.3	*	*	0.4	0.4	0.4	0.4	4.8	5.7	4.3	4.4	17.8	20.2
Digital bipolar, small (less than 12 gates)	1.8	1.9	0.6	0.9	14.0	12.5	9.0	8.0	3.1	3.0	0.6	0.7	0.1	0.2	1.1	1.1	1.8	1.6	14.2	14.2	19.0	18.0	65.3	62.1
Digital bipolar, MSI (12—100 gates)	0.5	0.6	0.2	0.4	3.5	4.0	1.3	1.5	0.8	1.2	0.3	0.4	*	*	0.9	1.0	0.5	0.7	6.1	7.0	3.2	4.8	17.3	21.6
Digital bipolar, LSI (more than 100 gates)	0.1	0.2	*	0.1	1.9	2.8	0.1	0.3	0.3	0.5	0.1	0.1	*	*	*	0.2	0.2	0.3	1.0	1.9	1.6	3.2	5.3	9.6
Digital MOS, small and MSI	0.3	0.6	0.1	0.2	1.6	2.6	0.3	1.2	0.1	0.2	0.1	0.2	*	*	0.3	0.4	0.1	0.2	1.8	2.0	3.6	5.0	8.3	12.6
Digital MOS, LSI	0.2	0.3	0.2	0.3	0.6	1.6	0.2	0.6	0.3	0.6	0.1	0.1	*	*	0.4	0.6	0.2	0.8	3.2	4.3	1.0	1.5	6.4	10.7
Linear ICs, (except op amps)	0.7	0.8	0.5	0.7	3.4	3.7	1.7	2.2	1.0	1.1	0.4	0.6	0.3	0.5	1.1	1.2	0.8	0.8	5.9	6.9	4.8	5.9	20.6	24.4
Op amps, monolithic only	0.3	0.5	0.3	0.4	2.3	2.3	0.5	0.5	0.3	0.4	0.1	0.2	*	*	0.4	0.4	0.2	0.3	2.5	2.5	3.0	3.5	9.9	11.0
Semiconductors, optoelectronic devices	0.5	0.6	0.3	0.6	1.9	2.8	0.3	0.6	0.4	0.6	0.1	0.1	*	*	0.4	0.4	0.2	0.3	3.9	4.1	4.5	6.0	12.5	16.1
Tubes																								
Cathode ray tubes (except for TV)	0.1	0.1	0.1	0.1	2.3	2.8	1.0	1.1	2.0	1.9	0.1	0.1	0.3	0.4	0.5	0.5	0.3	0.3	8.6	9.2	4.4	4.5	19.8	21.0
Power tubes	3.0	3.0	1.9	1.9	26.5	29.5	7.4	7.5	6.7	7.0	1.0	1.0	2.0	2.1	5.3	5.4	2.9	2.9	40.1	44.0	22.8	23.5	119.6	127.8
Receiving tubes	4.0	3.8	1.8	1.8	20.0	18.1	11.0	9.6	6.0	5.5	0.4	1.0	6.4	5.6	2.0	2.0	2.0	1.8	30.0	25.0	20.1	17.2	103.7	91.4
TV picture tubes, monochrome	13.2	12.0	0.8	0.7	19.5	17.5	29.0	28.0	7.3	6.9	1.0	1.0	10.1	10.1	1.2	1.2	2.6	2.0	33.0	25.0	26.9	18.9	144.6	123.3
TV picture tubes, color	9.3	13.8	3.2	4.3	32.8	44.0	5.0	9.7	12.1	16.0	1.5	2.1	*	*	10.2	11.2	2.6	3.2	75.0	85.0	112.0	145.0	263.7	334.3
Total components consumption	100.3	110.9	54.1	59.6	483.5	529.1	228.8	237.5	132.8	143.7	33.0	36.8	72.6	76.6	111.7	119.3	74.8	78.0	696.0	733.7	946.2	1,012.0	2,933.8	3,137.2

Factory prices in millions of dollars

Note: Estimates in this chart are based on market data supplied by more than 180 companies, government agencies, and trade associations. The figures show the consensus forecasts for consumption of components used to produce equipment destined for both home and export markets.

Participants were asked to value components at factory prices if of domestic origin and at cost-insurance-freight (CIF) if imported. Some categories included in earlier surveys have been dropped in this one and some categories, particularly for semiconductors, have been revised to reflect changes in market patterns. For this reason, and because the parity of most European currencies has changed during the past year, figures on this chart should be compared with those on earlier charts only after making the necessary allowances. The estimates in this chart were converted into dollars at the following rates. (for $1):

Belgium 46.6 francs
Denmark 7.26 kroner
France 5.53 francs
Italy 612 lire
Netherlands 3.35 guilders
Norway 6.85 kroner
Spain 68.6 pesetas
Sweden 5.02 kroner
Switzerland 4.00 francs
United Kingdom 40 pence (1£ = $2.50)
West Germany 3.34 marks

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European 1972 equipment markets

Factory prices in millions of dollars.

Note: Estimates in this chart are based on market data supplied by more than 180 companies, government agencies, and trade associations. The forecasts are for equipment consumed in the country whether manufactured there or not.

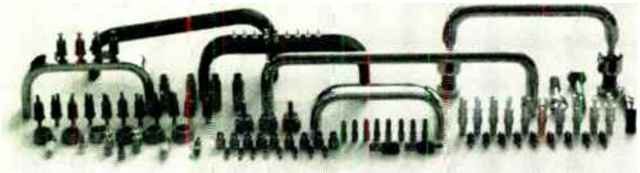
There have been revisions in the chart categories and the conversion rates from European currencies into dollars have changed from previous years. Both factors should be considered when comparing these figures with those of previous charts. The conversion rates used this year are (for $1):

Belgium 46.6 francs
Denmark 7.26 kroner
France 5.53 francs
Italy 612 lire
Netherlands 3.35 guilders
Norway 6.85 kroner
Spain 68.6 pesetas
Sweden 5.02 kroner
Switzerland 4.00 francs
United Kingdom 40 pence (1£ = $2.50)
West Germany 3.34 marks

[1] Computers that are integral parts of navigation, process control, and like systems are not included here; they are counted as part of the system.

*Less than $75,000

	Belgium		Denmark		France		Italy		Netherlands		Norway		Spain		Sweden		Switzerland		United Kingdom		West Germany		Total	
	1971	1972	1971	1972	1971	1972	1971	1972	1971	1972	1971	1972	1971	1972	1971	1972	1971	1972	1971	1972	1971	1972	1971	1972
Consumer products																								
Audio tape recorders and players	3.2	3.4	10.0	10.5	33.1	36.5	21.5	22.0	8.1	8.9	3.9	4.5	6.3	7.8	14.3	15.7	7.1	7.5	22.5	30.0	157.2	157.2	287.2	354.4
Hi-fi equipment	3.5	4.0	13.2	14.6	17.5	21.0	5.7	7.2	2.8	3.2	1.6	1.9	2.5	3.0	13.5	13.5	5.5	6.0	60.0	80.0	53.1	64.5	178.9	218.9
Phonographs and combinations	4.5	4.0	3.9	4.0	40.0	37.0	23.0	23.0	7.5	7.4	2.3	2.4	10.0	9.0	15.8	17.9	4.0	4.5	42.5	43.8	45.5	45.5	199.0	198.5
Radios (including car radios)	6.0	6.2	15.0	15.2	75.0	73.0	40.2	43.0	11.7	11.8	5.3	5.3	17.0	17.2	16.7	16.7	9.1	10.9	63.8	67.5	193.5	203.5	453.3	470.3
TV sets, black and white	26.8	24.0	8.8	8.9	147.9	130.0	132.0	127.6	33.0	29.0	6.3	5.5	94.9	99.0	19.9	15.9	15.0	12.0	155.0	147.0	214.8	195.2	854.4	661.8
TV sets, color	16.0	24.0	15.7	18.4	127.5	171.1	1.4	1.4	63.0	78.0	4.2	7.5	*	*	95.0	134.0	22.0	29.0	300.0	420.0	333.3	404.6	978.1	1,288.0
TOTAL	60.0	65.6	66.6	71.6	441.0	468.6	223.8	224.2	126.1	138.3	23.6	27.1	130.7	136.0	175.2	213.7	62.7	69.9	643.8	788.3	997.4	1,070.5	2,950.9	3,273.8
Computers and related equipment																								
Digital computers, central processors (except minicomputers)[1]	40.0	46.0	21.7	25.0	204.8	235.5	152.0	185.0	47.3	48.5	20.4	23.9	31.5	38.0	44.5	49.5	35.5	40.0	260.0	250.0	431.0	469.8	1,288.7	1,411.2
Digital minicomputers (value less than $10,000)	0.5	0.6	NA	NA	27.9	31.1	12.0	17.5	7.0	8.0	0.8	1.1	14.0	16.0	NA	NA	1.5	3.0	12.0	12.5	147.9	174.5	223.6	264.3
Mass memories	21.5	24.5	16.7	19.5	140.0	161.2	111.2	127.0	34.6	38.0	12.0	13.5	31.5	38.5	26.4	29.5	25.2	30.1	90.0	84.0	301.8	362.1	810.9	927.9
Remote terminal equipment	12.0	13.8	3.6	4.2	93.3	107.0	97.1	110.0	11.2	12.8	3.4	4.0	7.2	8.6	10.5	12.0	8.1	10.5	78.0	78.0	93.8	100.3	418.2	461.2
Analog and hybrid computers	7.3	8.4	1.6	1.9	27.0	31.1	15.8	20.0	6.3	6.9	1.9	2.2	8.2	11.5	6.7	7.0	5.5	7.3	30.0	30.0	30.0	40.5	140.3	166.8
Read-in and read-out equipment	1.2	1.2	0.2	0.2	5.2	5.4	1.2	1.2	1.6	1.6	0.9	1.0	0.9	0.9	1.1	1.0	3.5	4.0	4.3	4.8	8.9	9.8	29.0	31.1
Converters, analog/digital and digital/analog	0.9	0.9	0.1	0.1	7.5	8.3	2.4	2.5	2.4	2.8	0.5	0.6	0.6	0.7	0.5	0.5	3.9	4.2	3.0	3.0	3.3	3.6	25.1	27.2
Electronic desk calculators	2.5	3.2	0.7	0.9	22.7	29.0	10.8	12.0	1.9	1.9	1.0	1.7	4.4	5.0	3.5	4.2	1.8	2.5	35.0	38.5	89.8	104.0	174.1	202.9
TOTAL	85.9	98.6	44.6	51.8	528.4	608.6	402.5	475.2	112.3	120.5	40.9	48.0	98.3	119.2	93.2	103.7	85.0	101.6	512.3	500.8	1,106.5	1,264.6	3,109.9	3,492.6
Communications equipment																								
Broadcast equipment	3.2	3.4	5.0	3.0	18.0	35.0	6.0	6.0	7.0	7.5	6.0	6.0	7.1	7.6	2.0	2.0	6.1	6.5	14.9	15.4	10.4	11.9	85.7	104.3
Closed-circuit TV	1.8	2.6	0.7	0.8	9.0	9.5	8.0	8.8	1.8	2.0	0.5	0.6	2.1	2.5	0.6	0.7	1.1	1.3	4.5	5.0	10.0	10.5	40.1	44.3
Intercoms and intercom systems	4.6	5.5	2.4	2.5	23.0	24.0	2.6	2.8	7.7	8.0	2.3	2.6	1.4	1.6	1.4	1.4	4.5	5.0	34.0	35.0	7.5	7.5	91.4	95.9
Microwave relay systems	1.2	1.2	3.6	4.4	43.5	50.0	8.0	8.0	11.8	13.6	3.1	3.5	7.0	8.0	11.8	13.9	3.4	4.3	6.7	5.5	38.0	44.0	138.1	156.4
Navigation aids (except radar)	12.2	14.2	11.5	11.5	29.0	29.0	35.0	35.0	41.0	45.0	10.0	10.1	11.1	12.0	5.0	6.0	20.0	18.0	92.4	94.5	57.2	57.2	324.4	332.5
Radar (airborne, ground, and marine)	8.4	8.9	5.9	6.2	90.0	90.0	16.0	17.0	12.8	14.5	8.0	9.5	7.0	7.5	3.5	3.5	10.0	10.0	92.5	96.3	106.5	120.5	360.6	363.9
Radio communications equipment	5.0	5.7	8.4	9.5	50.0	55.0	11.2	12.7	6.9	7.7	4.6	5.3	4.8	6.0	13.0	14.2	4.4	5.0	99.0	117.5	106.4	110.2	313.7	348.8
Telephone switching, electronic / semielectronic	0.4	0.6	0.1	0.1	6.0	11.5	1.2	1.3	0.5	0.5	0.8	1.1	*	*	1.0	1.0	0.5	0.5	23.7	26.0	3.5	3.5	37.7	46.1
Wire message equipment	0.2	0.2	4.8	5.2	48.0	60.0	35.0	40.0	5.9	6.7	3.0	3.0	4.5	5.8	5.8	6.0	5.0	5.4	80.5	88.0	40.0	46.0	232.7	266.3
TOTAL	37.0	42.3	42.4	43.2	316.5	364.0	123.0	131.6	95.4	105.5	38.3	41.7	45.0	51.0	44.1	48.7	55.0	56.0	448.2	483.2	379.5	411.3	1,624.4	1,778.5
Industrial equipment																								
Industrial X-ray, inspection and gauging	0.8	0.8	1.1	1.1	6.1	6.5	2.5	2.8	2.2	2.2	0.6	0.7	0.6	0.6	1.9	2.0	0.7	0.8	6.4	6.4	13.5	14.2	36.4	38.1
Infrared inspection and gauging equipment	3.2	3.2	0.8	0.9	8.5	8.8	5.8	5.8	3.3	3.2	1.2	1.4	1.0	1.1	1.6	1.6	1.6	1.5	14.0	14.0	29.0	30.0	70.0	71.5
Machine tool controls	1.2	1.3	1.5	1.5	5.5	7.0	5.2	5.2	1.6	1.7	1.2	1.2	1.2	1.2	1.8	1.9	4.0	4.4	11.5	12.8	17.6	20.8	52.3	59.0
Motor speed controls	5.0	5.0	2.7	2.8	4.3	4.5	5.0	5.0	6.1	6.2	1.9	1.9	3.6	3.7	5.3	5.4	4.3	5.0	13.9	13.9	14.4	15.8	66.5	69.2
Photoelectric controls	0.2	0.2	0.3	0.3	2.1	2.1	1.2	1.2	0.6	0.7	1.1	1.2	0.4	0.5	0.9	0.9	1.5	1.8	4.0	4.3	7.9	8.6	20.2	21.8
Power electronics equipment	0.9	1.0	0.4	0.5	5.2	6.2	2.4	2.7	1.7	1.9	0.3	0.4	1.1	1.2	0.8	1.0	0.7	0.8	4.1	4.0	8.9	9.8	26.5	29.5
Process controls and related equipment	35.9	36.0	16.5	16.5	78.0	85.0	68.8	74.1	35.0	35.0	14.9	16.3	18.0	19.5	39.0	39.0	23.5	24.2	74.5	76.0	174.8	191.9	578.9	613.5
Ultrasonic cleaning and inspection equipment	0.2	0.2	0.1	0.1	2.7	2.7	0.6	0.7	2.2	2.5	0.3	0.3	0.4	0.4	0.3	0.3	0.3	0.3	1.2	1.2	2.6	2.9	10.9	11.6
Welding equipment (with electronic control)	0.4	0.4	0.3	0.3	5.0	5.3	1.9	2.0	1.3	1.4	0.3	0.3	2.6	2.7	0.8	0.9	0.7	0.7	6.2	6.5	11.5	12.7	31.0	33.2
TOTAL	47.8	48.1	23.7	24.0	117.4	128.1	93.4	99.5	54.0	54.8	21.8	23.7	28.9	30.9	52.4	53.0	37.3	39.5	135.8	139.1	280.2	306.7	892.7	947.4
Test and measuring instruments																								
Amplifiers, laboratory type	0.2	0.2	0.1	0.1	1.9	2.0	0.6	0.6	0.7	0.8	0.1	0.1	0.1	0.1	0.3	0.3	0.4	0.4	1.1	1.2	2.4	2.7	7.9	8.5
Calibrators and standards, active and passive	0.6	0.7	0.2	0.2	2.8	2.9	1.9	2.0	3.4	3.5	0.3	0.4	0.3	0.3	1.3	1.3	0.8	0.8	2.9	3.1	3.0	3.0	17.5	18.2
Components testers	1.4	1.5	0.9	0.9	4.8	5.5	2.5	2.7	4.2	4.3	0.6	0.6	0.3	0.3	2.4	2.4	0.4	0.6	1.5	1.7	3.0	3.3	22.0	23.8
Counters and timers	3.2	3.2	0.9	0.9	4.6	4.7	4.4	4.6	2.9	3.0	0.4	0.4	0.5	0.5	2.0	2.1	1.1	1.1	5.6	6.2	6.7	7.5	32.3	34.2
Electronic meters, analog (except panel types)	1.7	1.8	0.7	0.6	2.5	2.3	1.7	1.8	2.2	2.0	0.4	0.4	0.3	0.3	0.8	0.7	0.3	0.3	3.9	4.1	3.2	3.6	17.7	17.9
Electronic meters, digital (except panel types)	2.1	2.3	1.0	1.1	5.0	5.5	1.7	1.8	1.9	1.9	0.2	0.2	0.2	0.2	1.8	2.0	0.5	0.6	4.1	4.2	4.4	4.6	22.9	24.4
Generators and synthesizers (pulse, signal, sweep—to 1 GHz)	1.4	1.5	1.0	1.2	5.8	6.0	4.2	4.5	3.3	3.3	0.5	0.5	0.9	0.9	2.8	2.6	1.3	1.5	3.3	3.5	6.3	6.4	30.8	31.9
Microwave test and measuring instruments (above 1 GHz)	0.1	0.1	0.9	0.9	5.5	5.5	4.5	5.0	7.0	7.0	1.8	1.9	0.3	0.3	2.0	2.0	0.5	0.6	6.5	7.0	9.6	9.8	38.7	40.1
Oscillators	1.0	1.1	0.2	0.2	4.7	4.8	2.2	2.5	1.7	1.7	0.2	0.2	0.3	0.3	1.2	1.0	0.5	0.6	2.5	2.9	4.0	4.5	18.5	19.8
Oscilloscopes and accessories	7.2	7.4	1.9	1.8	17.0	18.0	10.0	11.1	7.2	6.7	1.4	1.5	1.5	1.5	3.6	3.5	2.4	2.8	16.2	17.0	17.5	20.0	85.9	91.3
Power supplies, laboratory type	3.2	3.4	0.4	0.4	4.3	4.5	1.8	2.1	1.5	1.5	0.4	0.5	0.5	0.5	1.0	0.8	0.6	0.6	3.6	3.7	7.2	7.2	24.5	25.2
Recorders	2.4	2.5	1.7	1.6	9.3	9.4	2.0	2.2	6.9	8.2	1.1	1.2	1.2	1.2	3.1	2.6	3.4	3.9	5.0	5.8	22.1	22.2	58.2	60.8
Spectrum analyzers (audio to 1 GHz)	0.9	1.0	0.2	0.2	1.8	2.0	2.3	2.5	1.8	2.0	0.5	0.6	0.5	0.5	0.6	0.7	0.8	0.8	3.5	3.8	1.1	1.1	14.0	15.2
TOTAL	25.4	26.7	10.1	10.1	70.0	73.1	39.8	43.4	44.7	45.9	7.9	8.5	6.9	6.9	22.9	22.0	13.0	14.6	59.7	64.2	90.5	95.9	390.9	411.3
Medical electronics equipment																								
Diagnostic equipment (except X-ray)	1.2	1.3	1.3	1.3	11.0	13.0	4.8	5.8	3.0	3.6	1.3	1.4	1.2	1.3	18.4	19.0	1.8	1.8	3.8	3.8	10.0	10.4	57.8	62.7
Patient monitoring equipment	0.6	0.8	0.2	0.3	4.7	5.6	3.5	4.5	2.0	2.8	0.4	0.5	*	0.1	4.6	4.8	0.7	0.9	5.2	5.2	10.4	13.4	32.3	38.9
Therapeutic equipment (except X-ray)	0.5	0.7	0.1	0.2	3.0	3.7	1.2	1.2	0.7	0.8	0.3	0.4	0.4	0.4	2.0	2.1	0.5	0.5	7.6	7.7	6.8	7.4	23.1	25.1
X-ray equipment, diagnostic and therapeutic	4.9	5.0	1.8	1.9	43.5	45.5	18.7	20.5	6.0	6.0	1.5	1.6	1.8	1.9	17.0	17.8	5.0	5.7	17.0	16.9	82.0	89.0	199.2	211.8
TOTAL	7.2	7.8	3.4	3.7	62.2	67.8	28.2	32.0	11.7	13.2	3.5	3.9	3.4	3.7	42.0	43.7	8.0	8.9	33.6	33.6	109.2	120.2	312.4	338.5
Total equipment consumed	263.3	289.1	190.8	204.4	1,535.5	1,710.2	910.7	1,005.9	444.2	478.2	136.0	152.9	313.2	347.7	429.8	484.8	261.0	290.5	1,833.4	2,009.2	2,963.3	3,269.2	9,281.2	10,242.1



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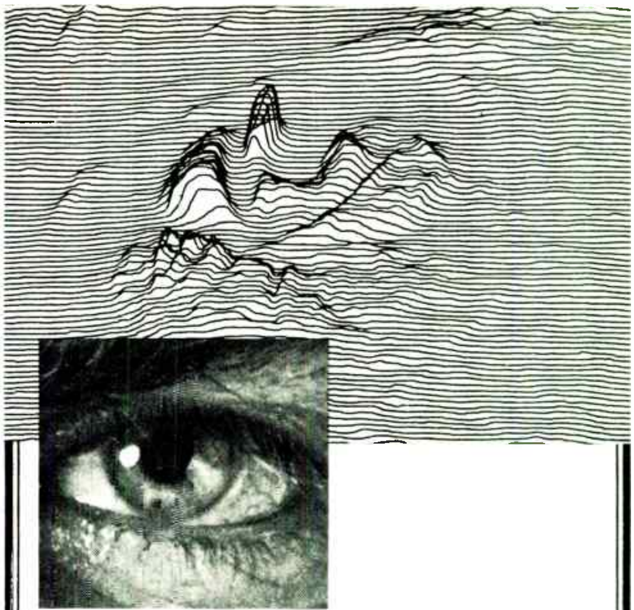

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- # **Condor Foto** — 46E
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