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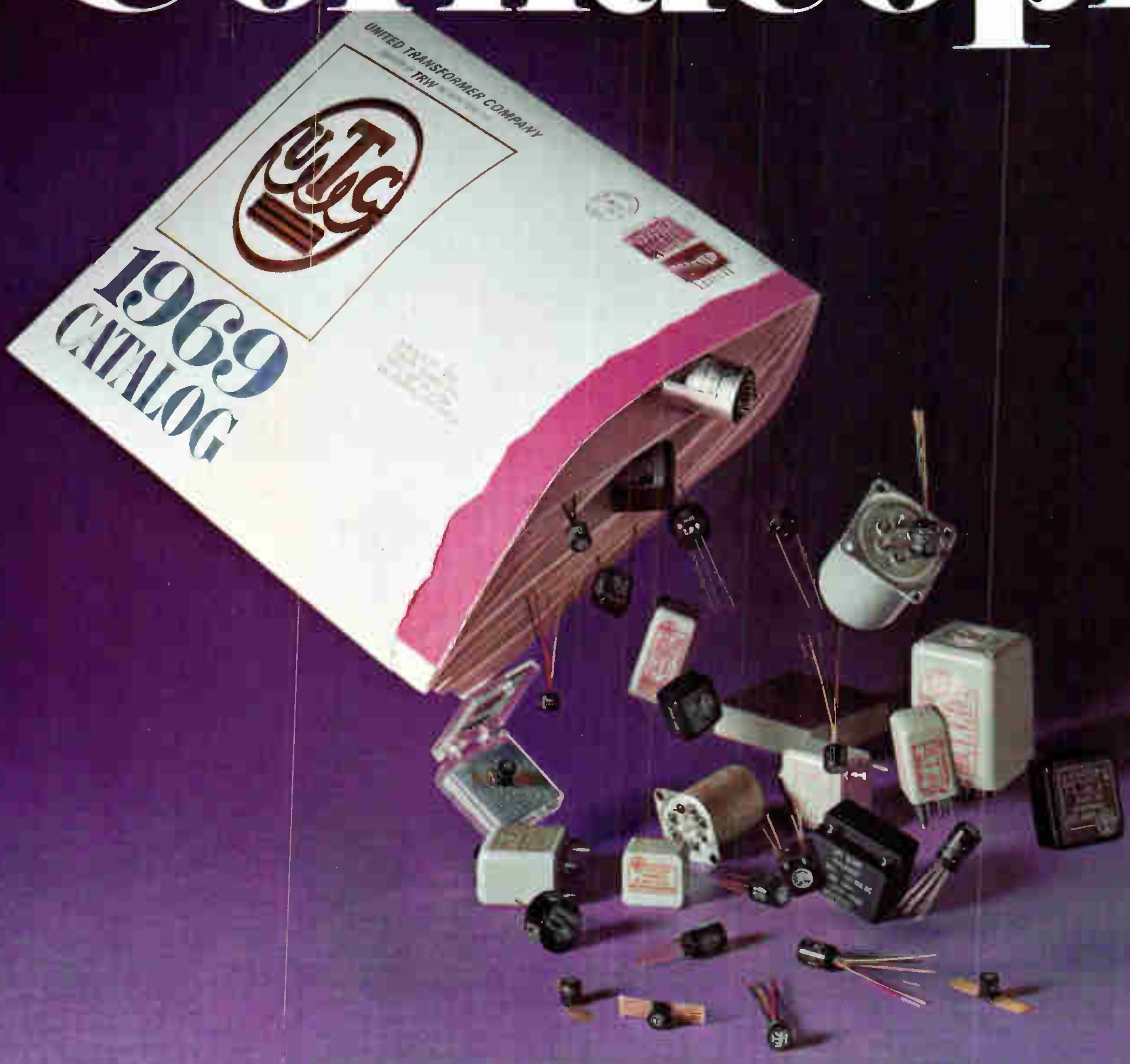
January 6, 1969

Electronics®

Cornucopia



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Circle 900 on reader service card

n 1–1000 MHz work

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The Vector Voltmeter covers the frequency range from 1 to 1000 MHz and automatically locks onto the signal anywhere within an octave—no fine tuning required. It's extremely sensitive—full scale 100 µV. With its 90 dB dynamic range, you can easily measure high gain and high loss networks. It has a 360-degree phase range with 0.1° resolution.

The 8405A also serves as a "frequency translator." How? By transforming the RF inputs to 20 kHz outputs whose wave shapes, amplitudes and phase relationship remain identical to the original RF signals. You can use these outputs for further analysis with low frequency scopes.

You needn't waste time making a tough RF measurement any longer. The HP 8405A does it faster and more completely than ever before. Application Note 91 tells you how. Just call your HP field engineer for details, or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

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FREQUENCY RANGE is 1 to 1000 MHz in 21 over-lapping octave bands; automatic tuning within each band.

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VOLTAGE RANGE FOR CHANNEL B (input to Channel A required) 100 µV to 1 V rms, full-scale. Full-scale meter ranges from 100 µV to 1V in 10 dB steps. Both channels can be extended to 10 V rms with 11576A 10:1 Divider.

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RF TEST EQUIPMENT

04806

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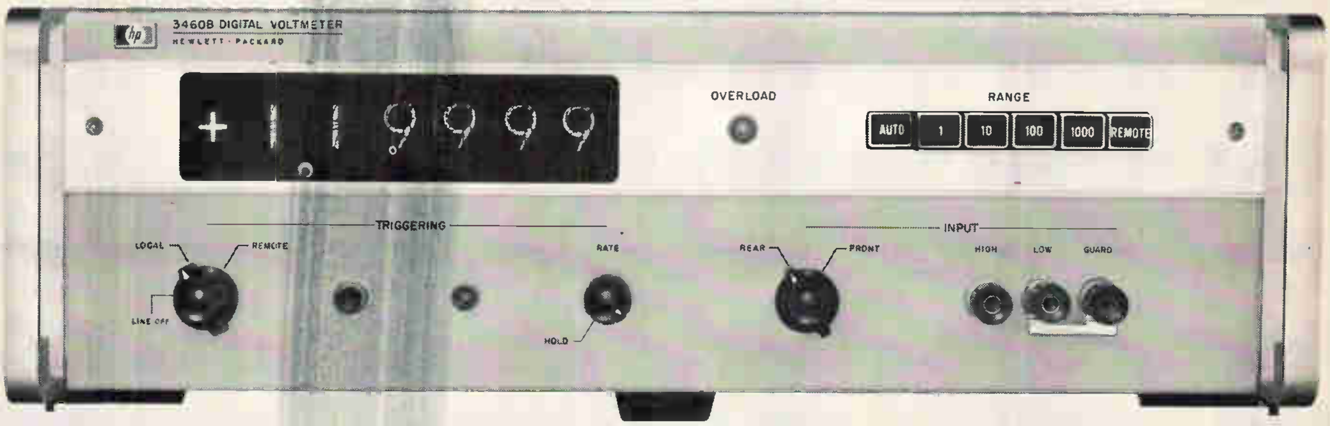
Circle 1 on reader service card

Normal Mode Noise Clouding Your Low-Level DC Measurements?



Not Here! The HP 3460B was introduced as a super accurate, 5-digit voltmeter. To make 0.004% of reading accuracy practical, a dual technique was utilized—integrating and potentiometric. The integration technique in itself gave a high common mode rejection of 160 dB at dc.

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If you're interested in a precision DVM, look up the 3460B in your HP catalog. If you're interested in adding the filter option to pick low level dc out of noisy environments, call your local HP field office. (Price HP 3460B, $3800; 3461A, $2400. 3460B Option 002 or 003 is required for operation with 3461A. Price option 002 or 003, $150. Filter option prices on request.) Or for a data sheet, write to Hewlett-Packard, Palo Alto, California 94304. Europe: 1217 Meyrin-Geneva, Switzerland.

099/1

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DIGITAL VOLTMETERS

Electronics

Volume 24, Number 1 January 6, 1969

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Technical Articles

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Publisher: Gordon Jones

Electronics: January 6, 1969, Vol. 42, No. 1

Published every other Monday by McGraw-Hill, Inc. Founder: James H. McGraw 1860-1948.

Publication office 99 North Broadway, Albany, N. Y. 12202: second class postage paid at Albany, N. Y.

Executive, editorial, circulation and advertising addresses: McGraw-Hill Building, 330 W. 42nd Street New York, N. Y. 10036. Telephone (212) 971-3333. Teletype TWX N.Y. 710-581-4235. Cable address: MCGRAWHILL N.Y.

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Readers Comment

Fluidic future

To the Editor:

Sure, fluidics has its problems, and has been oversold and often poorly applied, but the bleak gloom-and-doom flavor you give this field [Nov. 11, 1968, p. 199] is just as incorrect as the overly optimistic views we had a year or two back.

Also, your article quoted me out of context. Besides noting some of the negative aspects of the technology, I described a good number of highly promising developments clearly indicating that the new trend to plug-in modular fluidic systems bodes well for fluidic applications. No mention was made in your article of the new look that is emerging in the fluidics field and of the great stress I placed on the better future this appears to offer.

I feel your article does very little to acquaint electronics engineers with the steadily developing field of fluidics technology. This is a pity because a continuing cross-fertilization of ideas is often claimed to be the mainspring of North American innovation.

Putting the boot to fluidics seems quite fashionable these days and is about as misleading as going the other way. In reality, the position of fluidics and its potential for the future lies, we believe, somewhere between these two extremes.

A. E. Maine
Director of engineering
Aviation Electric Ltd.
Montreal

Cutting the tape

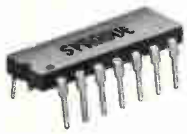
To the Editor:

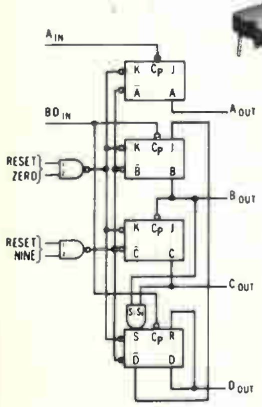
We read with interest the article "Smaller Cores, Bigger Challenge" [Oct. 28, 1968, p. 112]. Particularly deserving of comment is the statement concerning the possibility of cutting ferrite cores from a green (unfired) ferrite sheet.

Core Memories Inc., a subsidiary of the Data Products Corp., has been producing cores in this manner for about two years, first at our facility in Dublin, Ireland, and now at our Mountain View, Calif.,

Three Series 54/74 circuits that really count.

Decade Counter

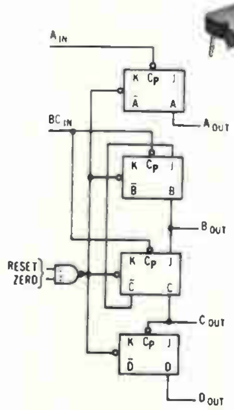




USN-7490

Count Frequency . . . 18 MHz
Propagation Delay . . . . 60 nsec
Avg. Pwr. Consumption 160 mW
Fan-Out 10

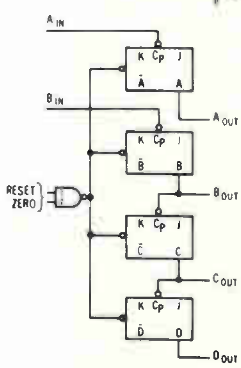
Divide-By-Twelve



USN-7492

Count Frequency . . . 18 MHz
Propagation Delay . . . . 60 nsec
Avg. Pwr. Consumption 160 mW
Fan-Out 10

4-Bit Binary



USN-7493

Count Frequency . . . 18 MHz
Propagation Delay . . . . 75 nsec
Avg. Pwr. Consumption 160 mW
Fan-Out 10

GET ANY OF THESE COUNT MODES

Type Number	Count Mode								
	÷2	÷3	÷4	÷5	÷6	÷8	÷10	÷12	÷16
USN-7490	✓			✓			✓		
USN-7492	✓	✓			✓			✓	
USN-7493	✓		✓			✓			✓

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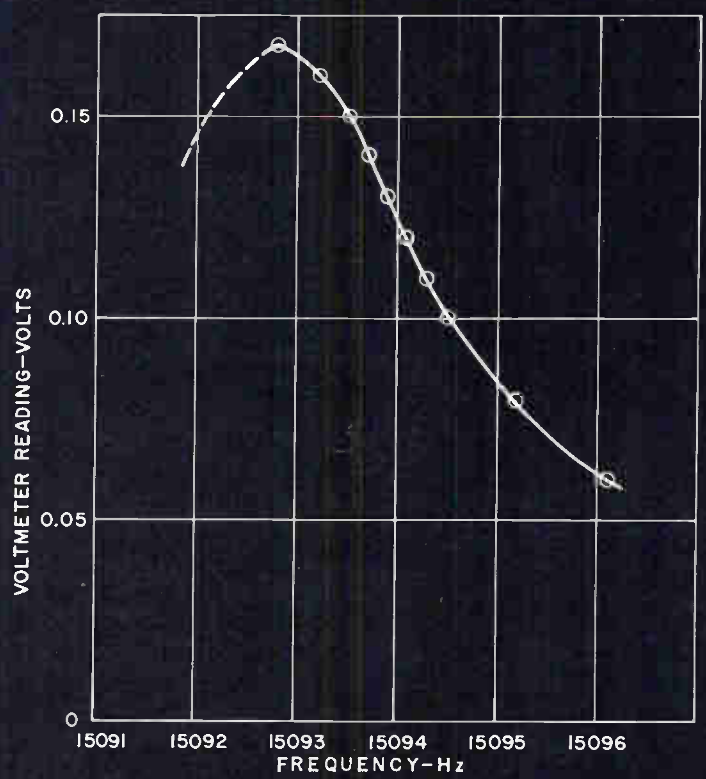
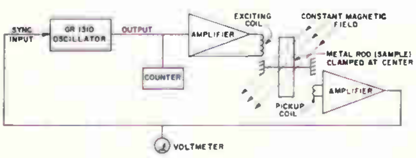


Synthesizer Stability From A Low-Cost Oscillator

This resonance curve is only a few hertz wide at about 15 kHz. You'd expect to achieve this kind of resolution and stability with a frequency synthesizer as a source. But would you expect it from a $325 cscillator?

The curve shows the high-Q mechanical resonance of a sample of metal alloy. It was plotted from actual data obtained with a GR 1310 oscillator in the closed-loop system shown in the block diagram below.



The scheme was submitted by a customer, and it is described more completely in the October, 1968 issue of the *GR Experimenter*. The synchronization capability and the excellent leveling (±2%) of the 1310 combine to make this technique possible.

General Radio makes a whole line of quality oscillators with well-leveled outputs. Each has a distinctive feature to best match your needs. The 1309's ($325) distortion is less than 0.05%; the 1310 ($325) has a 2 Hz-to-2 MHz frequency range and a 20-volt output; the 1311 ($260) offers 1-watt, transformer-coupled output; the 1312 ($415) has in-line frequency readout and 10 Hz-to-1.1 MHz range; and the 1313 ($325) gives you single-dial frequency control (no range-switching transients). All have constant output (±2%), and all are covered by a two-year warranty.

For more information, call your nearest GR office, or write General Radio, West Concord, Massachusetts 01781; telephone (617) 369-4400. In Europe: Postfach 124, CH 8034, Zurich 34, Switzerland.

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plant. The process was developed by Walter Wiechec, head of the firm's ceramics department.

By mixing the ferrite powder with a plastic binder and rolling the mixture to a precisely controlled thickness, an extremely flexible sheet is formed—not at all as brittle as the article suggests. The sheets are then cut into "tapes" about ⅝ inch wide, and these are fed through an automatic machine that cuts a row of up to 12 cores across the tape at a rate of up to 4,000 cores per minute, 40 times the pace of a conventional press.

This technique reduces the cost of cores because it increases yield through better control of core density, lowers tooling expenses, lengthens tool life, and speeds production. And it is particularly suited to producing very small cores (under 18 mils).

William G. Rumble
Engineering department manager
Core Memories Inc.
Mountain View, Calif.

Old hangups

To the Editor:

With reference to Sandia Laboratories' "See-through view" color display [Nov. 25, 1968, p. 50], it may be of interest that Electronics 18 years ago published an article by H. Frank Hicks and me in which we described the principle of electrically controlled color filters [November 1960, p. 112].

Among other things, Hicks declared in his thesis at Rensselaer Polytechnic Institute that it is not possible to obtain saturated colors with one filter stage. I believe this might be the reason for the "weak spots" mentioned in the latest article. And in an article for a British publication in January 1959, I noted thirteen references describing the trials and tribulations experienced in this area by many scientists.

All this, of course, does not and should not take away any credit from the Sandia scientists, Cecil E. Land and Donald G. Schueler, in their ingenious and successful attempt to get around these difficulties by using new materials.

Victor A. Babits
Research management consultant
Palos Verdes Peninsula, Calif.

Vive la difference!

To the Editor:

Concerning the coverage of our Fourier analyzer in your new instruments review [Nov. 11, 1968, p. 239], "gremlins" crept into this release on both your end and ours.

Your error is in the price information. The instrument costs $2,950—not $12,950.

For our part, the headline on the original release incorrectly gives the frequency range as 0.25 hertz to 4.95 kilohertz. The latter figure should have been 495 khz.

Steve Cades
Princeton Applied Research Corp.
Princeton, N. J.

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Who's Who in this issue


Dickson — Shea

The team that wrote the hybrid computer article on page 98 has had quite a bit of experience in designing control systems. John P. Shea Jr. is the engineering manager of the Control Products division of Bell & Howell. He is responsible for the design of custom and standard control systems employing both analog and digital techniques. Before joining Bell & Howell, he designed automatic production-line systems for the Eversharp Corp. Tracy C. Dickson III, director of process controls for the Control Products division, is in charge of all marketing, manufacturing, and engineering activities for process control instruments and function modules. Before joining Bell & Howell, he worked for Baldwin-Lima-Hamilton in signal conditioning and strain gage applications.

Technical articles are nothing new for Hans Keller, author of the article on varactor-diode tuning on page 88. He's published more than 30 papers in European professional journals. Keller has been with Intermetall, part of ITT's West German operations, since 1958. Until 1964 he was an applications engineer in semiconductor circuit design for industrial and consumer product applications; since then he's been head of electronics development. Keller's degree in electrical engineering is from the Technical University of Aachen.

Well before Labor Day, assistant managing editor Eric Aiken began outlining Electronics' 12th annual markets forecast. The job involved sorting through the voluminous reports and memos submitted by 17 editors and correspondents, and poring over reams of statistics compiled by market research manager David Strassler and his staff. The result, a survey of 1969 prospects for the various sectors of the U.S. electronics market, begins on page 107.

For the cover, art director Jerry Ferguson took photographer Murray Duitz to the Bell Telephone Laboratories' Holmdel, N.J., facility to shoot the several faces of AT&T's Picturephone, which will make its commercial debut later this year.

Wet-sintered-anode Tantalex® Capacitors

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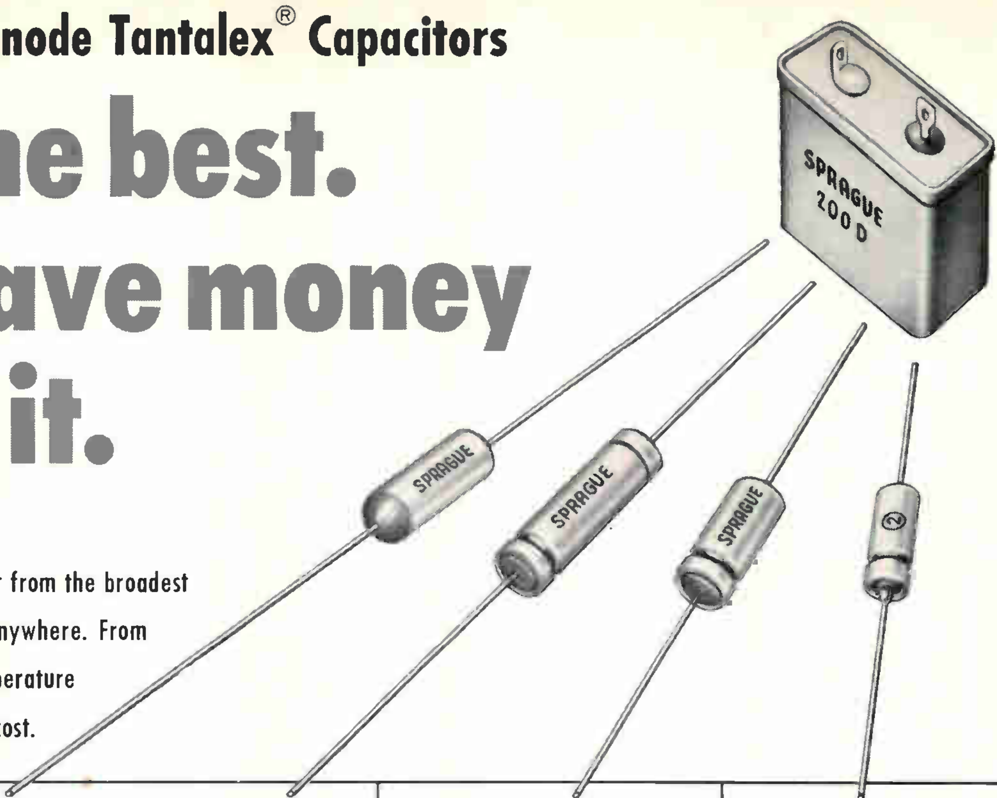

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Type 145D Volumetric efficiency up to 210,000 μF-volts per cubic inch. For use in miniature commercial/industrial printed wiring boards, packaged circuit modules, and wherever else cost and space are prime considerations. Elastomer end seal capped with plastic resin insures against electrolyte leakage and lead breakage. Available in voltage ratings from 6 to 75 VDC.	**Type 109D** A superior design that meets all the basic military requirements for capacitors within this temperature limit. There is no compromise in quality. Voltage ratings from 6 to 150 VDC. For extra large values of capacitance, use Type 200D or 202D package assemblies, which consist of several 109D-type capacitor elements in a hermetically-sealed case.	**Type 130D** Exceptional electrical stability due to chemical inertness of tantalum oxide film to specific electrolytes used, low diffusion of TFE-fluorocarbon elastomer seal, and special aging for 125C operation. Voltage ratings from 4 to 100 VDC. Dual temperature ratings of Type 200D and 202D package assemblies give you extra high capacitance values for +125 C operation.	**Type 137D** Proven glass-to-metal hermetic seal qualifies these outstanding capacitors for use in satellites, missiles, and other critical aerospace applications. They have greater volume efficiency than has been previously available for wet-sintered-anode capacitors in this temperature range. Type 137D capacitors exhibit extremely low leakage currents. Available in voltage ratings from 2 to 150 VDC.
CIRCLE 515 ON READERS SERVICE CARD	CIRCLE 516 ON READERS SERVICE CARD	CIRCLE 517 ON READERS SERVICE CARD	CIRCLE 518 ON READERS SERVICE CARD

Select the capacitor type that meets your temperature requirements. That's how to save money. Specify Sprague Tantalex® Capacitors. That's how to get the best.

For complete information on Type 145D Capacitors, write for Engineering Bulletin 3750 (Type 109D, Bulletins 3700F and 3700.2; Type 130D, Bulletins 3701B and 3701.2; Type 137D, Bulletin 3703A; Type 200D and 202D, Bulletin 3705B) to the Technical Literature Service, Sprague Electric Company, 35 Marshall St., North Adams, Mass. 01247.

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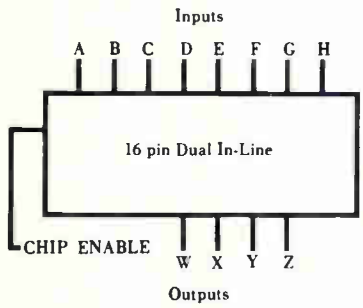
A	B	C	D	E	F	G	H	W	X	Y	Z
0	0	0	0	0	0	0	0	0	1	0	1
0	0	0	0	0	0	0	1	0	0	1	1
0	0	0	0	0	0	1	0	0	1	1	0
0	0	0	0	0	0	1	1	1	1	0	0
0	0	0	0	0	1	0	0	0	1	0	0
0	0	0	0	0	1	0	1	0	1	1	1
0	0	0	0	0	1	1	0	0	0	0	0
0	0	0	0	0	1	1	1	1	0	1	0
0	0	0	0	1	0	0	0	1	0	1	1
0	0	0	0	1	0	0	1	1	1	1	1
0	0	[illegible]	[illegible]	1	0	1	1	1	[illegible]	0	1

TO YOUR MM 521



Use the logic easily programmed into our ROM (Read Only Memory) elements. With a minimum of time (typically four weeks), we can set up the simple interconnection metalization pattern your needs dictate and start shipments. Costs about a thousand dollars.

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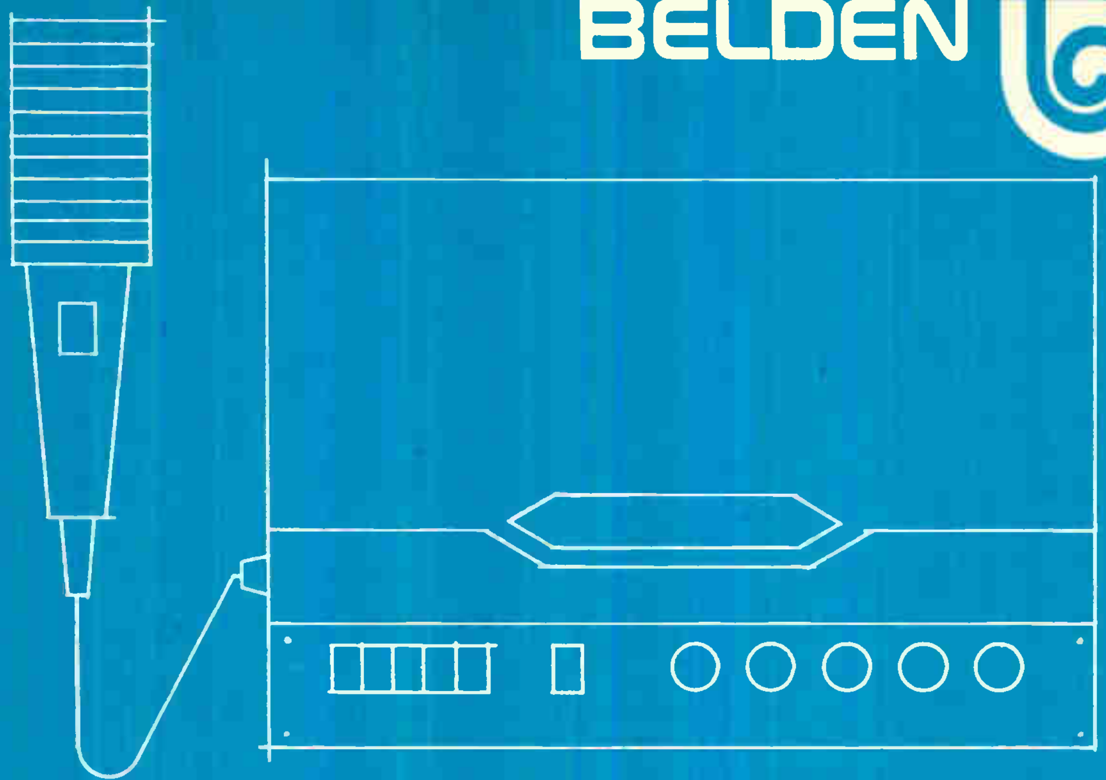
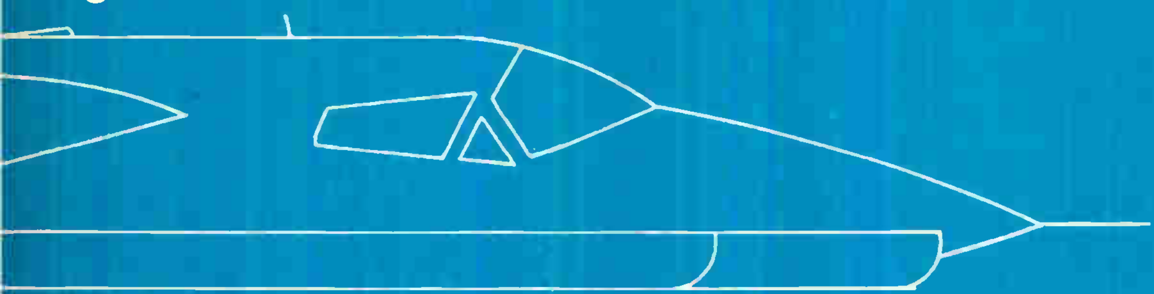


systems turn us on



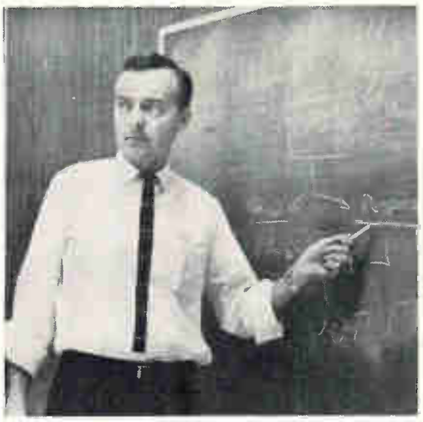
We have an active imagination when it comes to wiring. Because it's sparked by a lot of savvy about wire and cable and its capabilities. With applied imagination we can create fresh ideas that help a customer get a better value for his dollar. Our Wire Systems Specialists are trained to explore every wire-related aspect of a product—compatibility, production, packaging, operating environment . . . the entire system. And then put their imaginations to work. To eliminate a shielding or stripping problem*. Or save money. Or enhance the product's reliability. And whatever type of wire or cable it takes to turn an idea into reality . . . well, we make all kinds of wire for all kinds of systems. Why not see what we can imagine for your product? Call or write: Belden Corporation, P.O. Box 5070-A, Chicago, Illinois 60680. And ask for our catalog, and the reprint article, "Key Questions and Answers on Specifying Electronic Cable."

*For example: We've insulated some of our lead wire with silicone. So no glass braid protection is needed. This means that stripper blades will last much, much longer. And a potential health hazard to stripper operators is eliminated.

8-1-8

Circle 13 on reader service card

Who's Who in electronics



Reynolds

Two years ago, Hewlett-Packard began laying the groundwork for a new division that would build and install automatic test systems. The Systems division finally became a reality several months ago, and H-P named Richard J. Reynolds to be its manager. Reynolds' stated goal was to build and install the computer-controlled test systems in four to six months, about the time it usually takes just to write specifications. And this is what his division has done. So far, in less than six months of operation, the unit has delivered one custom system to Magnavox for the testing of thick-film receiver circuits, and it has four other computerized systems and about 50 custom instruments in its backlog.

Reynolds recalls that H-P's decision to go ahead with the division was based on its belief that there was a demand for a digital computer that could interface with many H-P instruments. During the two years of planning, the company also took into account the need for programable, building-block devices.

Update. The modular approach, says Reynolds, means that a system needn't be considered obsolete because some of its parts become outmoded; it can be expanded and reconfigured as test requirements change. And Hewlett-Packard, adds Reynolds, is in a particularly good position to design custom test systems because of the variety of H-P instruments that can be interfaced with its model 2116B computer. The test system's computers will use the company's Basic language, which reduces programing to verbal rather than mathematical statements.

The Magnavox system employs products from six H-P divisions and requires only two outside components. "Of course, it's a means of selling more H-P products," Reynolds says, "but additionally, the new division represents an attempt to solve some of the testing and measuring problems that plague our customers and that only a well-designed computational system can relieve."

A babel of control languages—about a dozen—are now in use for computer systems. But a group that will meet early next month in Santa Monica, Calif., may lay the foundation for a standard language. This quest for a golden mean will be carried out by an ad hoc committee being formed within the United States of America Standards Institute (USASI). Its chairman is Millard Perstein, head of the Jovial standards and development project at the System Development Corp., which will be host to the Feb. 4 meeting.

Usually avoiding any flights of fancy, control language, among other things, introduces the user to the computer, provides a job description (compiling or executing, for example), and includes information for accounting purposes. It also tells whether special programs for, say, debugging and editing will be required.

Perstein stresses that his committee's charter is limited. "We're to see if standardization of control languages is desirable and feasible. We're not supposed to develop a standard. There are people who view standardization as tending to stifle development. Some of the pioneers remember attempts 10 years ago to develop a preemptive standard programing language, which failed. That was a mistake."

Perstein believes, however, that

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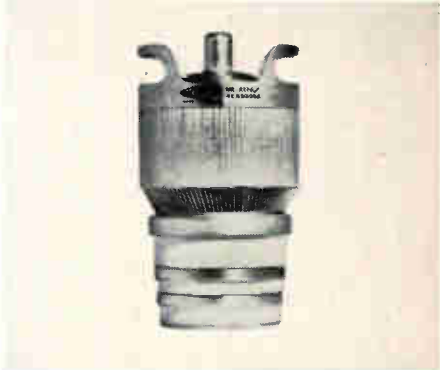

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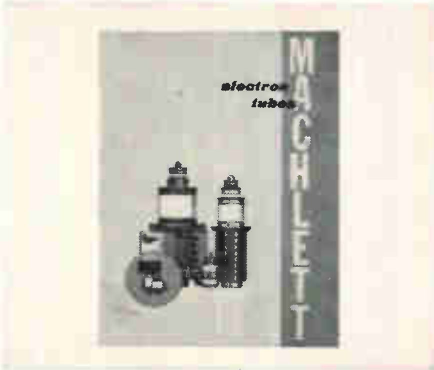

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Who's who in electronics

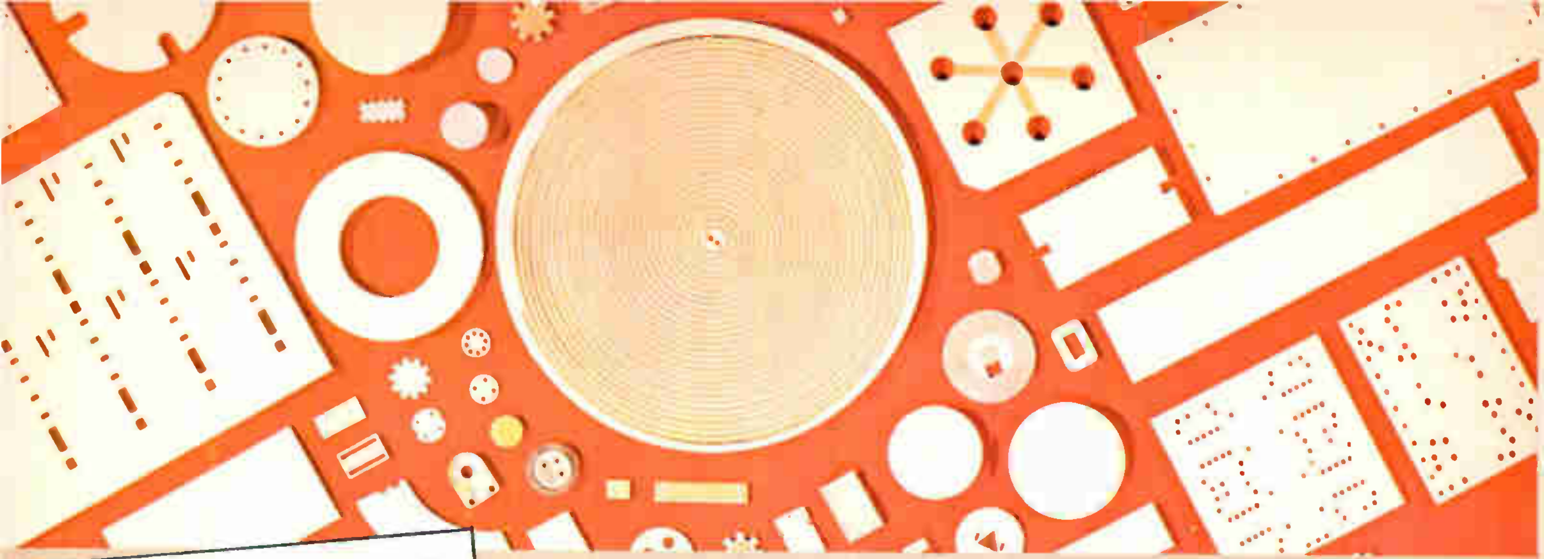
Perstein

while a standard programing language won't work because it can't satisfy all the needs of its myriad users, standardization is needed in control languages.

Reduce the chaos. "There isn't such a diversity of things to say with control languages," he says. "Standardization will help reduce the chaos of going from one operating system to another. A man working with a system has to learn its control language. He shouldn't have to know six or seven different control languages to use a Joss, Basic or Adept system."

Some of the languages are horrendous; standardizing on the existing ones would be disastrous, according to Perstein. "They're too cryptic, they're not mnemonic, and they sometimes have stringent requirements. For example, you may have to run commands up too close to each other on the control card."

If there is to be a standard control language, Perstein believes it should resemble some of the higher-order programing languages —free form, with a great deal of flexibility for arranging commands on the control card, yet simple when compared with current programing languages. He adds, "We don't need a particularly closely designed language; it doesn't have to be fully defined before we begin to standardize. Piecemeal standardization can be the route, but a committee should stay in existence to continue refining the language."



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Ultimate Tensile Strength, psi		23,000
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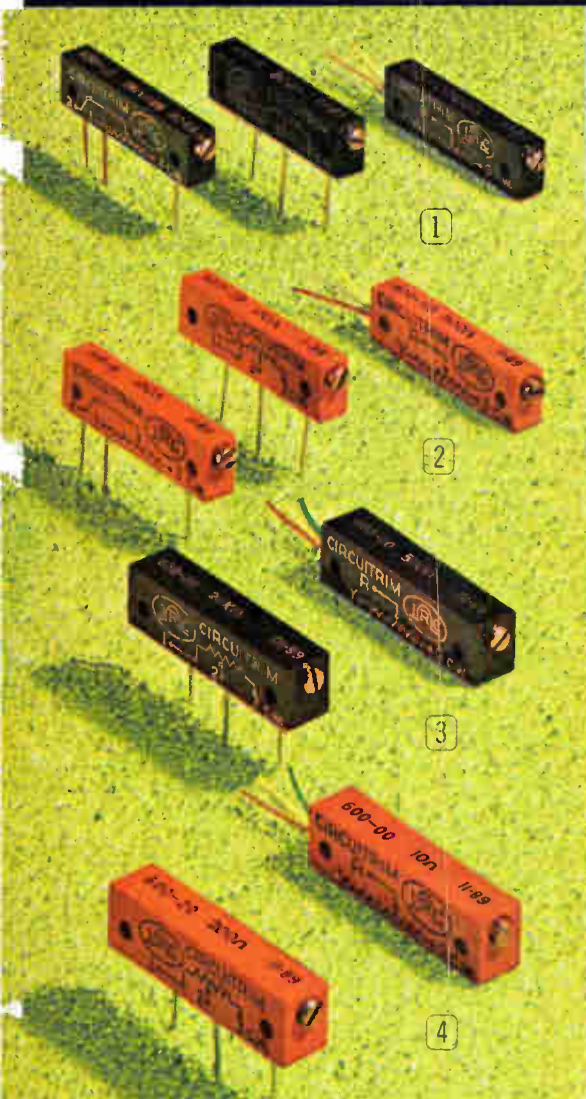

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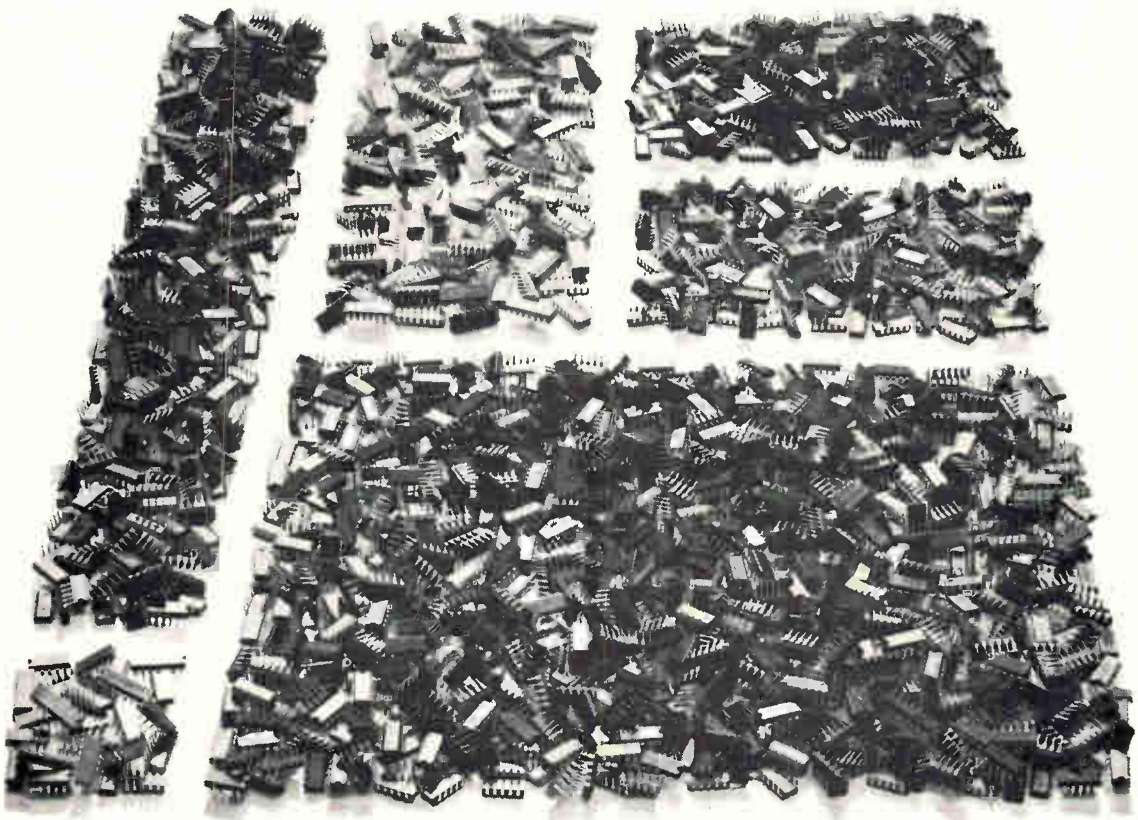

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Meetings

Bulk-effect is looming large

The promise of bulk-effect and avalanche devices is rapidly being converted to practical performance in microwave circuits, to judge by the papers for the 1969 International Solid State Circuits Conference to be held in Philadelphia, Feb. 19 to 21. Designers are exploiting the high-frequency capability of the devices as they learn to deal with power output, gain, and bandwidth in a sophisticated fashion.

M.E. Hines and C. Buntschuh of Microwave Associates, for example, have developed an X-band power amplifier (they'll disclose the exact power level when they give the paper) that uses Gunn-effect diodes as the active element. The bandwidth exceeds 2 gigahertz with 8 decibel gain, and the authors say that their computer simulations indicate that the bandwidth will exceed 40% with simple compensating networks.

One of the problems with Gunn- and other bulk-effect devices has been tuning them. D.C. Hanson of Hewlett-Packard has achieved a wide tuning range in a bulk-gallium-arsenide oscillator by using an yttrium-iron-garnet device to electrically adjust the frequency from 4 to 12 Ghz with a power output of at least 4 dbm. Hanson will describe the tuning circuit, which consumes less than 0.75 watt at the maximum frequency, in his paper.

IMPATT (impact avalanche and transit time) diodes will share the spotlight with bulk-effect devices. W.W. Gray, L. Kikushima, N. Morenc, and R.J. Wagner of Hughes Aircraft will discuss their experience in applying IMPATT power sources to modern microwave systems. They've used these diodes as 35 Ghz pumps for parametric amplifiers, and as multipurpose drivers with wideband modulation capability for data-link transmission systems. Toyosaku Isobe and Masataka Tokita of Fujitsu will report on their success in phase-locking an IMPATT oscillator to an external frequency-modulated driving signal in their microwave amplifier for multichannel fm signals.

This year, the conference maintains its stature as the most authoritative meeting in its field with sessions on operational amplifiers, semiconductor memories, and optoelectronics. Attention will also be given to consumer electronics, digital circuits, and solid state power control. In addition to these, computer-aided design, analog circuits, and circuit and device modeling will also be the subjects of in-depth presentations.

The solid state people will reconvene in the evenings for informal discussion sessions on microwave power generation, analog IC's, and custom versus standard large-scale integration. There will be 12 such sessions in all; other topics will be artwork design and implementation, impact of LSI on memory organization and design, electroluminescent diode alphanumeric displays, and insulated-gate FET's. More than 70 panelists are expected to participate in these sessions, which will also include ultrahigh-speed digital techniques, low-noise microwave circuits, microwave phase shifters for phased arrays, and computer-aided circuit design.

For further information, write: 1969 International Solid State Circuits Conference, c/o Lewis Winner, 152 W. 42 St., New York 10036

Calendar

Winter Television Conference, Society of Motion Picture and Television Engineers; Ryerson Polytechnical Institute, Toronto, **Jan. 17-18.**

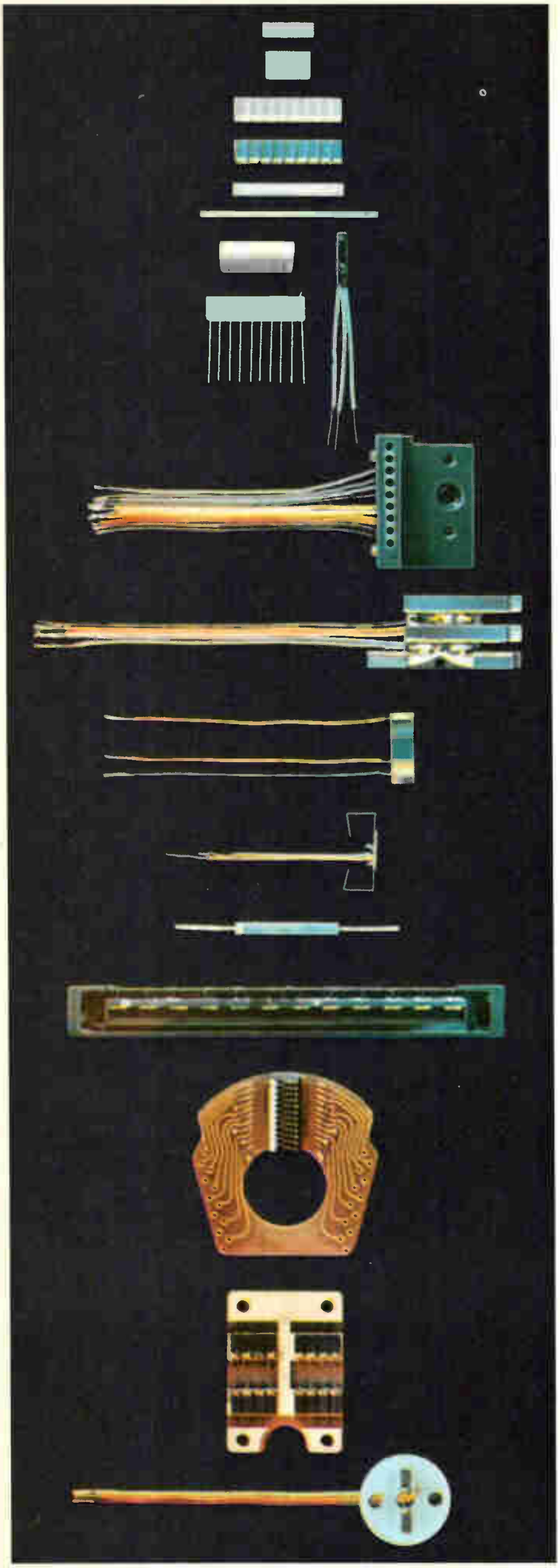
Symposium on Reliability, IEEE; Palmer House, Chicago, **Jan. 21-23.**

Second Hawaii International Conference, Department of Electrical Engineering, University of Hawaii, Honolulu, **Jan. 22-24.**

Winter Power Meeting, IEEE; New York, **Jan. 26-31.**

International Symposium on Information Theory, IEEE;

(Continued on p. 24)



Meetings

(Continued from p. 23)

Nevele Country Club, Ellenville, N.Y., **Jan. 28-31.**

PMA Meteorology Conference, Precision Measurements Association; The Ambassador, Los Angeles, **Feb. 3-5.**

Transducer Conference (G-IECI), National Bureau of Standards; Twin Bridges Marriott Hotel, Washington, D.C., **Feb. 10-11.**

Winter Convention on Aerospace and Electronics Systems (Wincon), IEEE; Biltmore Hotel, Los Angeles, **Feb. 11-13.**

First National Conference on Electronics in Medicine, Electronics, Medical World News, and Modern Hospital Magazines; Statler-Hilton Hotel, New York, **Feb. 14-15.**

International Solid State Circuits Conference, IEEE; University of Pennsylvania and the Sheraton Hotel, Philadelphia, **Feb. 19-21.**

Technological Influences on Communications Conference, IEEE; Washington Hilton Hotel, Washington, D.C., **Feb. 24-25.**

Particle Accelerator Conference, IEEE; Shoreham Hotel, Washington, **March 5-7.**

International Convention & Exhibition, IEEE; Coliseum and Hilton Hotel, New York, **March 24-27.**

Second International Laser Safety Conference, Medical Center of the University of Cincinnati; Stouffer's Cincinnati Inn, **March 24-25.**

Semiconductor Device Research Conference, IEEE; Munich, Germany, **March 24-27.**

Conference on Lasers & Optoelectronics, IEEE; Southampton, England, **March 25-27.**

Numerical Control Society; Stouffer's Motor Inn and Convention Center, Cincinnati, **April 1-3.**

Mathematical Aspects of Electrical Network Analysis, American Mathematical Society; Providence, R.I., **April 2-3.**

Semiconductor Device Research Conference, IEEE; Munich, West Germany, **April 11-14.**

Computer Aided Design Conference, IEEE; University of Southampton, England, **April 15-18.**

(Continued on p. 26)

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Meetings

(Continued from p. 24)

Joint Railroad Conference, IEEE; Queen Elizabeth Hotel, Montreal, **April 15-16.**

International Magnetics Conference (Intermag), IEEE; RAI Building, Amsterdam, Holland, **April 15-18.**

International Geoscience Electronics Meeting, IEEE; Twin Bridges Marriott Hotel, Washington, **April 16-18.**

Conference on Switching Techniques for Telecommunications Networks, IEEE; London, **April 21-25.**

Southwestern Conference & Exhibition, IEEE; Convention & Exhibition Center, San Antonio, **April 23-25.**

Electrical & Electronic Measurement and Test Instrument Conference, Instrumentation & Measurement Symposium, IEEE; Skyline Hotel, Ottawa, Canada, **May 5-7.**

Rocky Mountain Bioengineering Symposium; University of Wyoming, Laramie, **May 5-6.**

Short courses

Computer Programming for Electrical Engineers and Problem Solving for Electrical Engineers Using Time-Shared Computers, following Wincon, IEEE; Biltmore Hotel, Los Angeles, **Feb. 14-15;** $90 fee per course for nonmembers, $75 fee per course for members.

Magnetic Materials and Engineering Applications, University of Wisconsin, Madison, **March 18-19;** $70 fee.

Selected Applications of Computers in Engineering, University of Michigan, Ann Arbor, **May 19-30;** $400 fee.

Call for papers

Photo-optical Techniques in Simulators Seminar, Society of Photo-optical Instrumentation Engineers; South Fallsburg, N.Y. **Jan. 15** is deadline for submission of abstracts to the seminar committee, c/o SPIE National Office, P.O. Box 288, Redondo Beach, Calif. 90277

Electron, Ion, and Laser Beam Technology Symposium, IEEE; National Bureau of Standards, Gaithersburg, Md., May 21-23. **Jan. 31** is deadline for submission of abstracts to Dr. L. Marton, conference chairman, National Bureau of Standards, Washington, D.C. 20234

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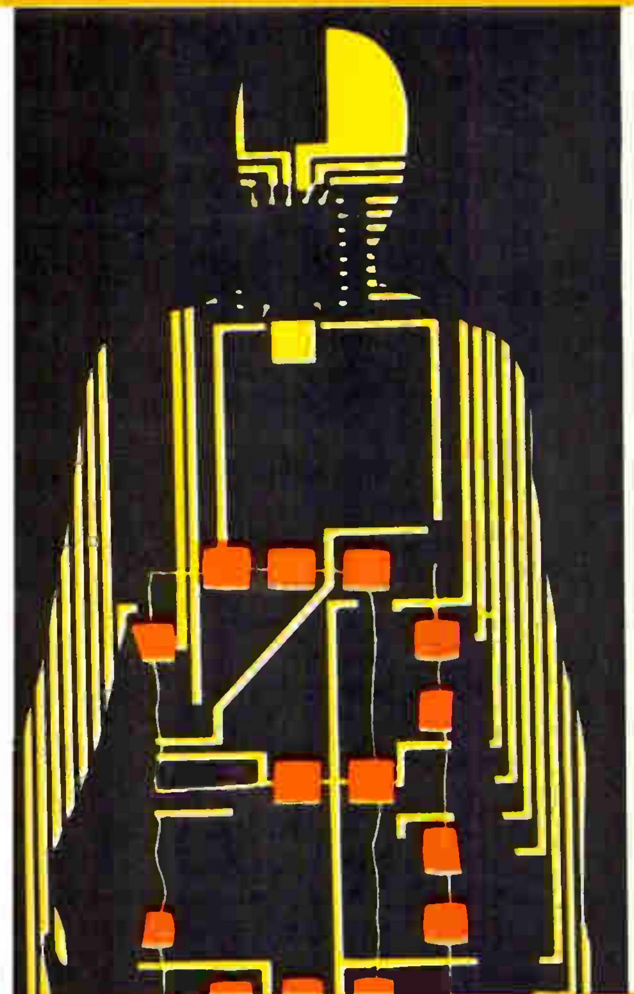

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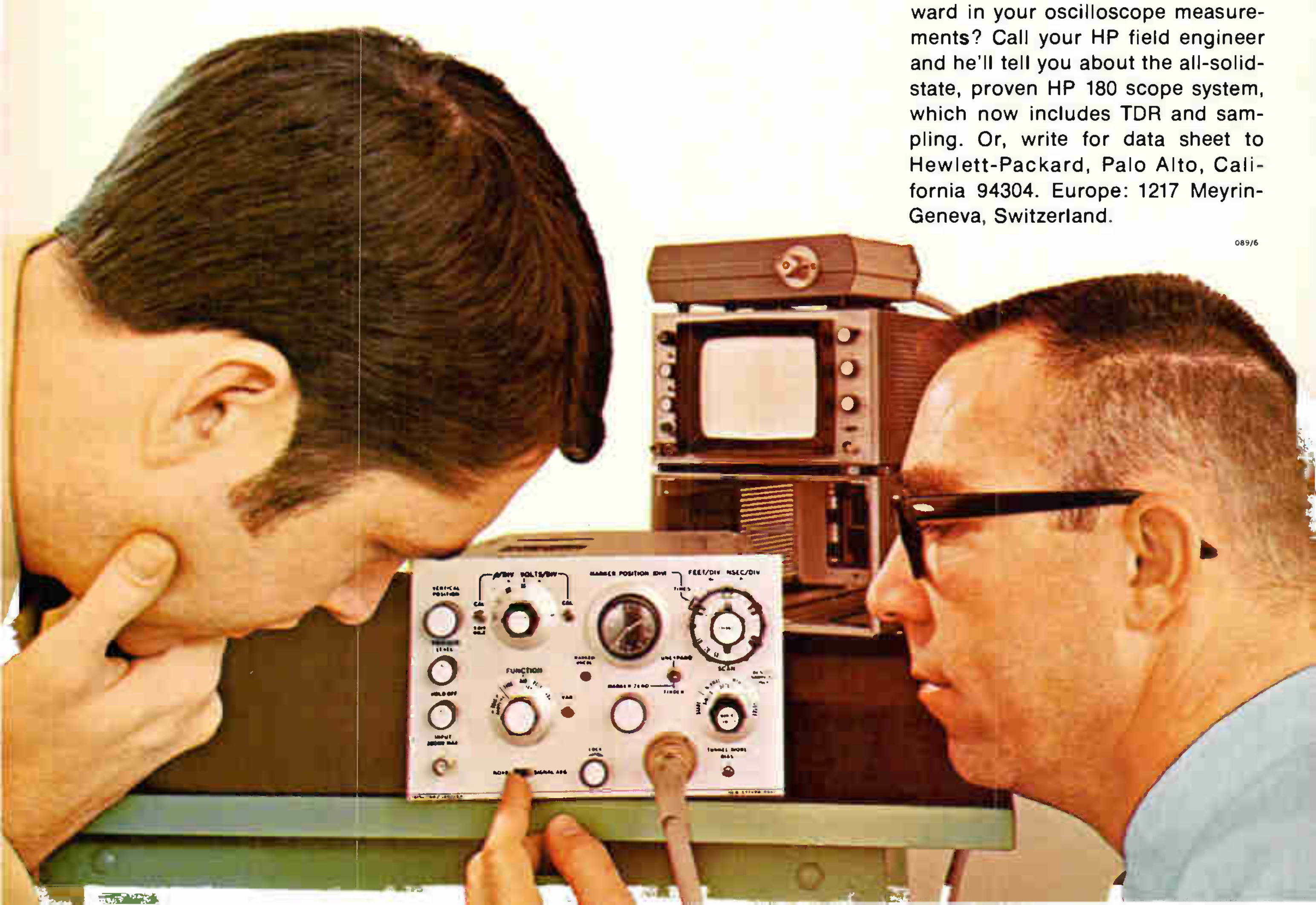


Editorial comment

1969 outlook is bright

The new year is going to be a big one for electronics. The consensus of industry leaders is that over-all sales will rise 6.5% from last year's level to $25.3 billion [see market report, p. 107]. Market sectors of particular significance include:

- Communications. An expected business spurt of 12% will push sales to an estimated $1.85 billion, with digital systems, land mobile gear, and telemetry accounting for much of the gain. The industry this year can also expect to feel the first effects of growing pains in the teleprocessing field and changes in the Government's role in regulating communications.
- Computers. Another healthy increase (about 16%) will boost this market to nearly $4.79 billion. Customers, who are becoming more sophisticated and more receptive to small machines, will encounter more situations in which data systems require communications networks.
- Instrumentation. Despite a slowing of R&D activity in this field due to the Vietnam war, sales are expected to climb 12% to $769 million. Customers are looking for more automatic features and for equipment that will interface with computer setups, data banks, and the like.
- Industrial electronics. Having finally reached the billion-dollar mark last year, this market is set for a further 12% jump to $1.15 billion. Industries using high-volume production and inspection equipment will be prime customers for electronics gear. And the drive to automate on the part of the steel, machinery, and chemical industries will open up more opportunities.
- Medical electronics. The custom nature of most medical electronics gear will keep unit volume low and prices high. Nevertheless, a $406.9 million market is expected, up 11%.
- Consumer electronics. Color television will again lead the field with a gain of about 8%. The total market may rise 5% to $4.4 billion.
- Military/aerospace. If there's a fly in all this ointment, it can be found here. The annual budget briefings scheduled for Jan. 11 will clear up the now-hazy outlook for Federal electronics spending, but this much is already apparent: outlays in this sector, which accounts for about half the total electronics market, will not increase significantly from the 1968 level. Vietnam will continue to create a demand for present-generation military-electronics gear but will curtail development of advanced systems over the near term. And unless the new Administration reverses a recommendation now on the books, NASA's budget will remain at about $3.85 billion.

But the flattening out of Government electronics buying cannot offset the solid gains due in other areas. In sum, the 1969 prospects for electronics are excellent. ■ ■

Call for objectivity

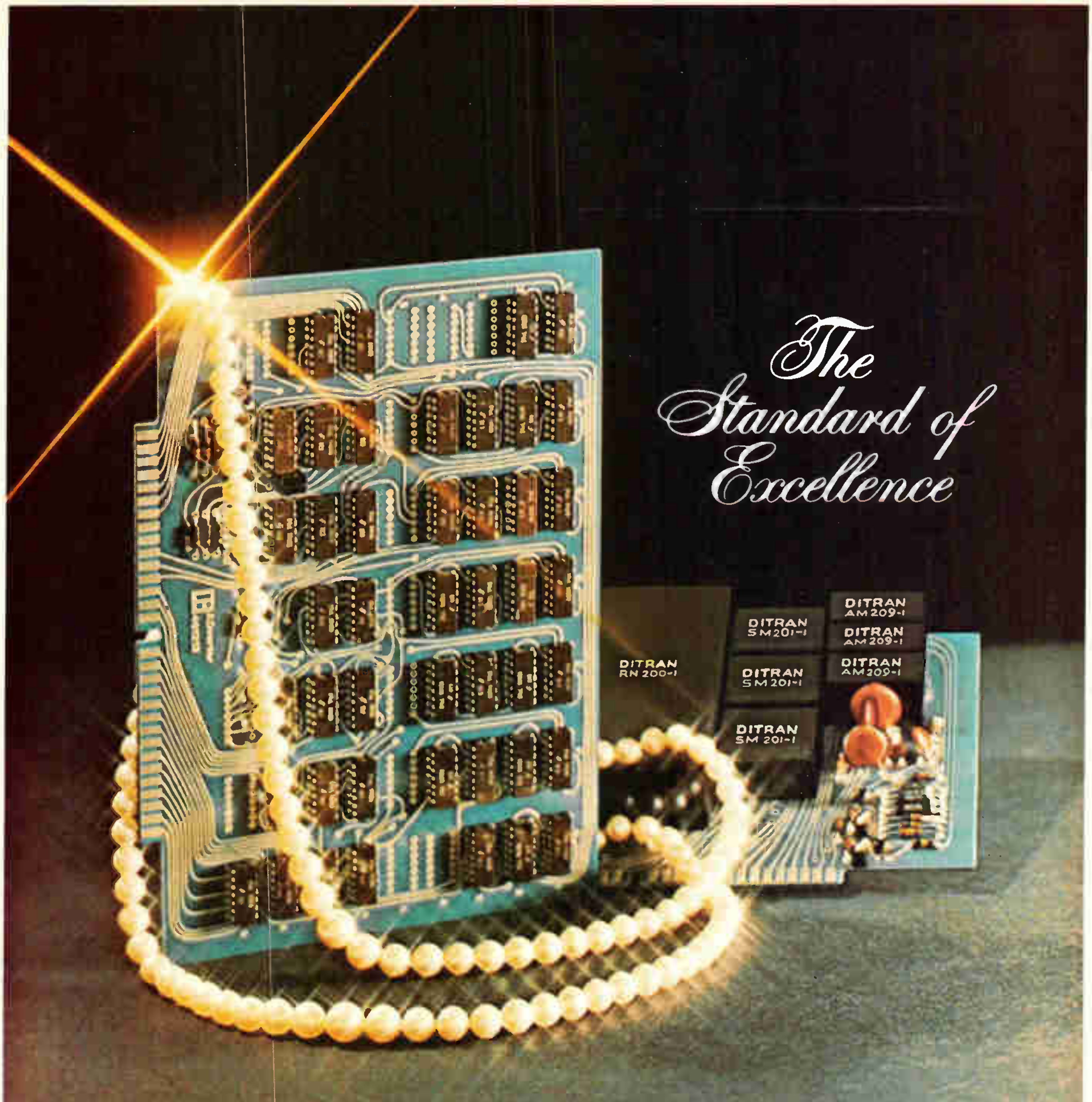
The scientific community gives much lip service to the ideal of objectivity, though the best engineers not only subscribe to it, but practice it. Unfortunately, one often encounters an all-too-human rejection of objectivity when an engineer's personal advancement is involved. Then self-deception and myopia replace clear thinking.

As a case in point, it is surprising what undue significance an author may attach to having an article describing one of his developments published in a technical journal—or for that matter, rejected.

In a recent issue of the prestigious Physical Review Letters, the editor, S.A. Goudsmit, noted that almost every author (not just the young physicist) who submits a manuscript seems to suffer unbearable suspense. "We wish we could convince the community of physicists that having a Letter accepted is not to be taken as proof of great scientific achievement," Goudsmit said. "In fact, we are often reminded that half the Letters should not have been published, though there is no agreement on which half."

Each Letter published is supposed to contain "important new discoveries or topics of high current interest." But Goudsmit doubts that physicists really produce as many advances of high interest as the number of Letters published in each issue of the journal would indicate, and he suspects that the authors and readers agree. "To get their Letters published is often more important for the authors than it is for the progress of physics," he concluded.

We'll cast our vote for a return to objectivity; it ought to be the badge of our profession. ■ ■


The Standard of Excellence
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Electronics Newsletter

January 6, 1969

1969: the year MOS takes off . . .

All signs point to 1969 as the year that MOS starts fulfilling its promises.

Reports from United States and foreign producers and consumers of metal oxide semiconductor circuits indicate that orders will begin to grow rapidly within the next few months. Producers are expanding their MOS manufacturing facilities and customers are **quickening their plans to design MOS into new equipment or to retrofit equipment.**

Last year, MOS producers assessed the 1968 market at $20 million. **But, they concede now, if the totals hit $15 million they'll be lucky.**

. . . for both users and manufacturers . . .

Looming as major customers for MOS are such firms as Burroughs, Honeywell, the National Security Agency, and some Japanese firms, such as Canon Camera.

The suppliers apparently could be anybody with a respectable MOS capability, including Texas Instruments, American Microsystems, Fairchild, Motorola, General Instrument, and Autonetics.

. . . some orders are very large . . .

American Microsystems has seven large development contracts in the works, all with big production potential. **One of these could mature into a purchase running to about a million units a month by July.** The Burroughs facility in Plymouth, Mich., is on the brink of a big buy for memory units that buffer a disc memory; Fairchild is believed to have the inside track, although TI and Motorola can't be counted out of the running. The Burroughs' buy, which could come at any time, would be to retrofit its TC-500 computer terminal with MOS to replace DTL.

In addition, **Burroughs has given American Microsystems a development contract to design 10 large-scale arrays for a calculator.** American, which beat out GI and TI in this competition, doesn't expect a production contract this year.

Honeywell's Computer Control division in Framingham, Mass., is beating the bushes to flush a 512-bit random access memory for terminal equipment—TI seems to have the corner on such a circuit. Again, this order is imminent; one industry source says it could involve up to 100 million bits of storage.

Farther down the road, **Control Data is believed to be shopping for very-high-speed MOS memories for computer main frames,** although the devices may not form the bulk of the main frame memory. The buy is believed to be about two years away. One industry source says it could reach $1 million.

Some of the mushrooming MOS action from Japan will also go to TI. **Canon will switch from DTL to MOS in a calculator it makes, with TI supplying $4 million worth of circuits.** Other Japanese companies are also buying MOS in substantial amounts—100-bit shift registers in lots of more than 100,000 units, possibly for use in calculators.

. . . and some are unusual . . .

And a sleeper could be the new Viatron Computer Systems, which recently introduced its data-handling System 21 [*Electronics,* Oct. 14, 1968, p. 193]. The system—in which large-scale MOS arrays are the heart—caused a sensation at last month's Fall Joint Computer Conference in San Francisco; engineers were backed up in the aisles waiting to view the system. If their marketing plans come true—and many in the industry believe they will—little Viatron may quickly surpass the National Security Agency as the largest customer for MOS. Up till now the super-secret Government agency has been the largest user, with the circuits going to cryptographic computer systems.

This year the security agency will purchase huge lots of MOS circuits for high-speed cryptographic equipment. An all-TI team won a four-way competition for a multimillion-dollar development contract, but a production order expected next year will include other suppliers.

There are also indications that Victor Comptometer is once again looking for a supplier of MOS dice for a calculator despite its disastrous experience with Philco-Ford, which couldn't meet Victor's requirements [*Electronics,* June 24, 1968, p. 25]. In addition, National Cash Register is eyeballing MOS memories for its Century computer series.

... but can MOS producers meet the demand?

However, one potentially big user of MOS devices questions the makers' ability to meet this burgeoning demand. This source says, "We have a request for quotations out now for development lots of MOS arrays—some 10,000 pieces of 50-odd MOS types. Even this is going to strain design and production capacity. When we try to discuss these quantities with possible suppliers, they tell us, 'we would need to divert 75% to 100% of our design people to your problem. If you fail, we could lose six months or more on our competition.'"

Aircraft displays to anticipate danger

Engineers want simplified cockpit displays that show more data on cathode-ray tubes and less on dials and gauges.

Boeing is reviewing crt displays for supersonic transports while United Aircraft is supplying crt situation displays for the AH-56 helicopter.

Meanwhile NASA is preparing for the second generation of cockpit graphics in work being done at its Ames Research Center and the Electronics Research Center. Both are trying to supply display techniques needed for the vertical and short-take-off-and-landing aircraft of the 70's. But at ERC, scientists are trying to develop techniques for so-called adaptive displays.

The most advanced crt displays now contemplated show data only when the pilot calls for it. But at ERC, the future goal is to tell the pilot what he needs to know before he knows he needs it. To do this a computer would be programed to anticipate dangers—by monitoring sensors it would note, for example, a high nose angle coupled with falling airspeed then flash a stall warning before the pilot becomes aware of it.

Addenda

Sylvania hopes it has found an answer to CBS' electronic video recorder [*Electronics,* Dec. 23, 1968, p. 38] in a movie version of its color slide theater [*Electronics,* May 13, 1968, p. 42]. The company will demonstrate the system at the end of March and expects to have it in its dealers' hands by the summer. Costing $1,200, the system uses a Kodak Super-8 movie projector and a cassette tape recorder housed in a 23-inch color tv set. . . . David Packard, chairman and chief executive officer of Hewlett-Packard, was named Deputy Secretary of Defense in the Nixon Administration. Packard, 56, who owns some 25% of H-P, will place his $300 million of securities in trust to avoid conflict of interest.

Component and Circuit Design

IDEAS

FROM SYLVANIA

DIODES

Need Chip diodes? We'll slice them to your spec.

We'll design custom diodes for you, scribe and cut them to your needs and deliver them after a 100% DC test on each chip.

If you're working with hybrid circuits take a look at our capability to supply you with uncased diode chips. We can make them to order and test them to your electrical specs.

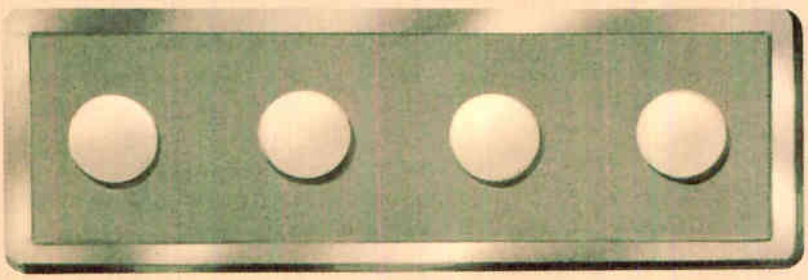
Right now, we are supplying chips similar to many popular finished diodes such as 1N3064, 1N3600, 1N4146, 1N4148 and 1N4448. All of these devices are 100% probe tested to DC specs and are checked for AC parameters on a sample basis. After testing we'll scribe and cut them to your needs and we'll put a suitable backing material on the dice to be compatible with your method of welding or soldering the chips to your substrate.

Typical of the special treatment we can give is the quad N/P diode array we make for a large computer manufacturer. All four devices have a common anode with four separate cathode connections. We can also make quads in the P/N configuration if that's what you need.

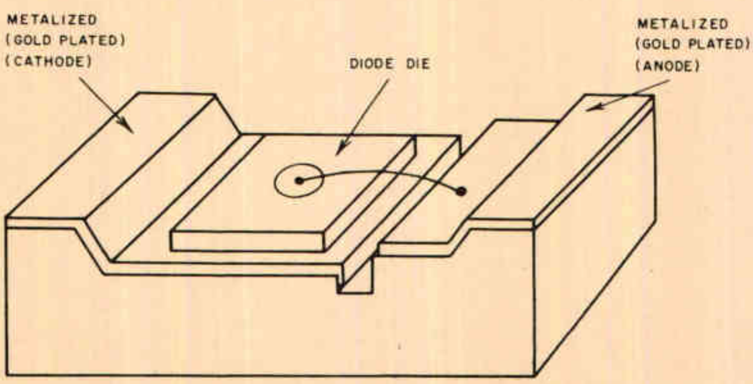
Another way we can deliver diodes is as single or multiple chips in a channel pack. We'll give you common anode or common cathode configurations or even hook up some simple circuits such as bridges, ring modulators, etc. Again, all units are 100% tested to your specifications.

If you are looking at chip diodes as space savers in your circuit designs, talk to our sales engineers. You may be surprised at what they can offer you.

CIRCLE NUMBER 300



Quad diode array packs four diodes into a minimum of space.



Diodes can be supplied in channel packs for ease of handling.

This issue in capsule

INTEGRATED CIRCUITS

Multiplexer/Demultiplexer arrays cut can count.

Two new functional arrays reduce number of gate packages in typical multiplex system from ten to two.

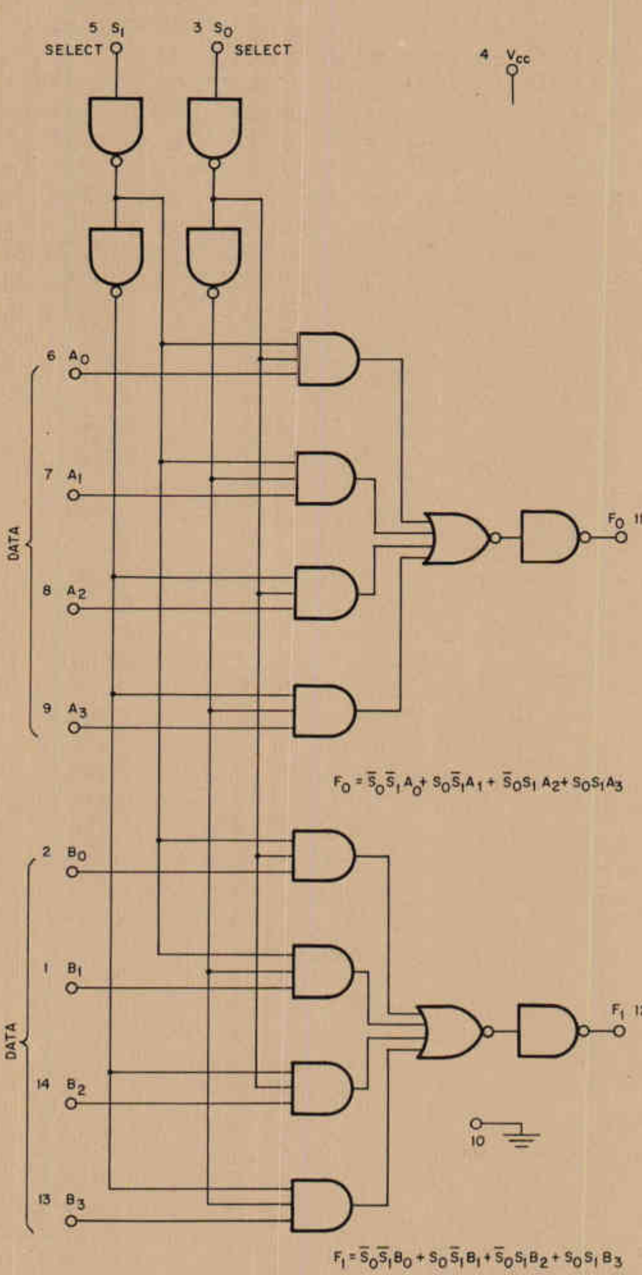


Fig. 1. Logic diagram of SM-210 dual 4-bit multiplexer.

Lower can count, higher speed and less power dissipation are some of the benefits you get from two new functional arrays we have just introduced. The SM-210 is a dual 4-bit multiplexer and the SM-220 is its demultiplexing counterpart. Each replaces up to five gates used in a typical multiplexing operation.

By designing the internal gate structures for speed rather than drive capability we've obtained a high on-chip speed. As a result, propagation delays through several internal gates are comparable to those usually accepted for a single gate. Typically, outputs are produced in less than 12 nanoseconds after the input pulse.

Both devices have the type of inputs and outputs characteristic of SUHL circuits to assure top performance in fan-out, logic swing, capacitance drive, and noise immunity.

Logically speaking, the SM-210 (Fig. 1) is a dual four-bit multiplexer. In each section, two control lines select one of four inputs for presentation at the output. The control lines are common for each section and are buffered from their external connections to prevent excessive loading of drive stages. Data and selection variables are directed to either of two identical quad 3-input AND gates. The results of the "AND"ing are "OR"ed together and double inverted in the output driver stage. The resulting output is the true AND-OR form of the input logic. This means you can drive flip-flops, shift registers, adders and other functions directly, without extra gate inversions.

A typical application of the SM-210 is shown in Fig. 2. This parallel-to-serial converter multiplexes two 16-bit words onto two bus lines. All "A" inputs are bussed into F_0 and all "B" inputs are bussed into F_1. The selection variables are driven by a four-bit counter. The resultant outputs for each clock pulse are shown in the table. Propagation delay is about 24 nanoseconds from data input to data output and 29 nanoseconds from control input to final output.

This system could be expanded to multiplex two 32-bit words by constructing another identical system and directing its outputs along with F_0 and F_1 into another SM-210.

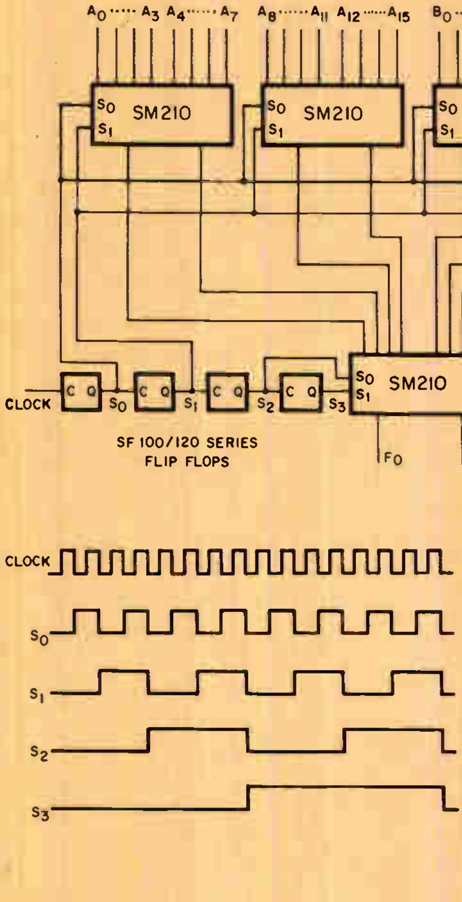
The SM-220 demultiplexer array performs the inverse operation of the SM-210. It consists of two separate decoding sections. In one section, incoming data may be steered to any one of four identical outputs under control of two selection variables. In the second section, another data input can be routed to either of two identical outputs determined by the state of the selection line.

The logic arrangement of the SM-220 is shown in Fig. 3. In the one-into-four section, four 3-input NAND gates are used, followed by output inverters. Each gate receives the data input along with one of the four possible combinations of the selection bits. The data can be steered to one output only for a particular selection input combination since the connections to each 3-input gate are unique. The output inverter/drivers provide the true states of the input data eliminating the need for extra gate inversions and allowing direct data entry into subsequent stages.

Used as a serial-to-parallel converter, as in Fig. 4, the SM-220 decodes 16 parallel bits onto two bus lines, F_0 and F_1. The one-to-two section is used in six of the eight SM-220s and the one-to-four section is used in all. The output bits appear in the chronological order of their subscripts, shifting one to the right with each clock pulse. The SG-130 drivers are used to satisfy the input current requirements of the control lines. Propagation delay is about 33 nanoseconds from input to any output. Delay from control input to any output is about 40 nanoseconds.

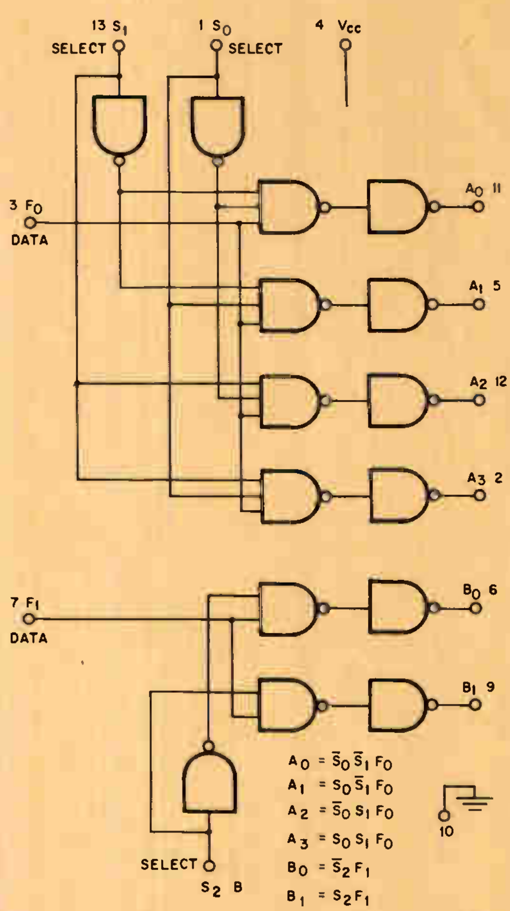
As you can see, the SM-210 and SM-220 make an ideal pair for multiplexing systems where high speed, low power consumption and a low package count are desired. And where aren't these features important?

CIRCLE NUMBER 301



TRUTH TABLE					
CONTROL		INPUTS		OUTPUT	BITS
S_0	S_1	S_2	S_3	F_0	F_1
0	0	0	0	A_0	B_0
1	0	0	0	A_1	B_1
0	1	0	0	A_2	B_2
1	1	0	0	A_3	B_3
0	0	1	0	A_4	B_4
1	0	1	0	A_5	B_5
0	1	1	0	A_6	B_6
1	1	1	0	A_7	B_7
0	0	0	1	A_8	B_8
1	0	0	1	A_9	B_9
0	1	0	1	A_{10}	B_{10}
1	1	0	1	A_{11}	B_{11}
0	0	1	1	A_{12}	B_{12}
1	0	1	1	A_{13}	B_{13}
0	1	1	1	A_{14}	B_{14}
1	1	1	1	A_{15}	B_{15}

Fig. 2. Application of the SM-210 as a parallel-to-serial converter.



$A_0 = \bar{S}_0 \bar{S}_1 F_0$
$A_1 = S_0 \bar{S}_1 F_0$
$A_2 = \bar{S}_0 S_1 F_0$
$A_3 = S_0 S_1 F_0$
$B_0 = \bar{S}_2 F_1$
$B_1 = S_2 F_1$

Fig. 3. Logic arrangement of SM-220 demultiplexer.

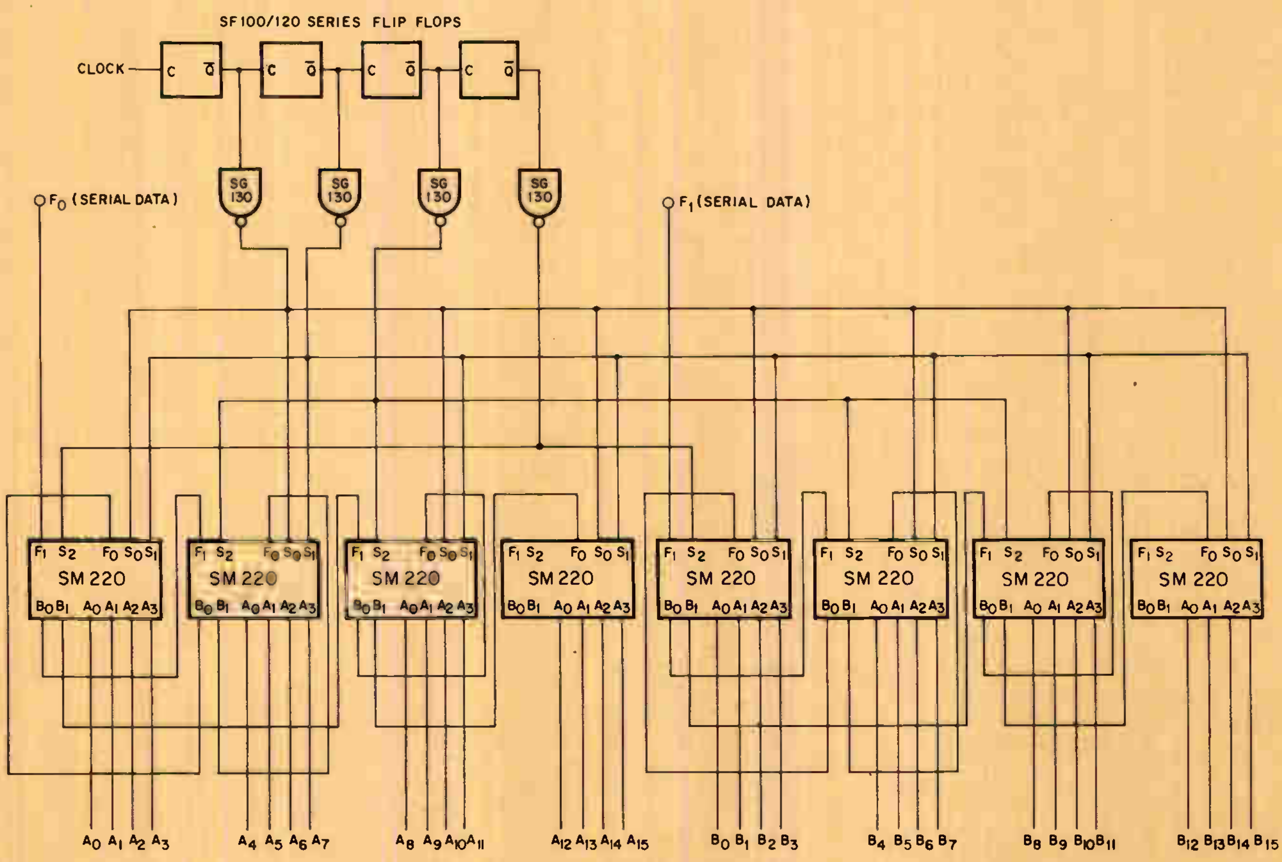


Fig. 4. SM-220 used as a serial-to-parallel converter.

MICROWAVE DEVICES

Beamlead and chip capacitors simplify hybrid circuit design.

New devices are ideally suited to use as series and bypass capacitors in microstrip applications.

Two new silicon-dioxide capacitor designs round out Sylvania's broad line of microwave components for microstrip systems.

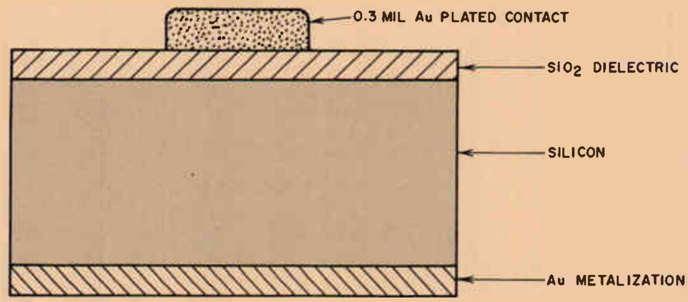
The SC-9001 series are beamlead devices designed for series circuit applications such as coupling or blocking capacitors. Their mechanical design allows the gold beamleads to be spot-welded directly across a small gap in the microstrip line.

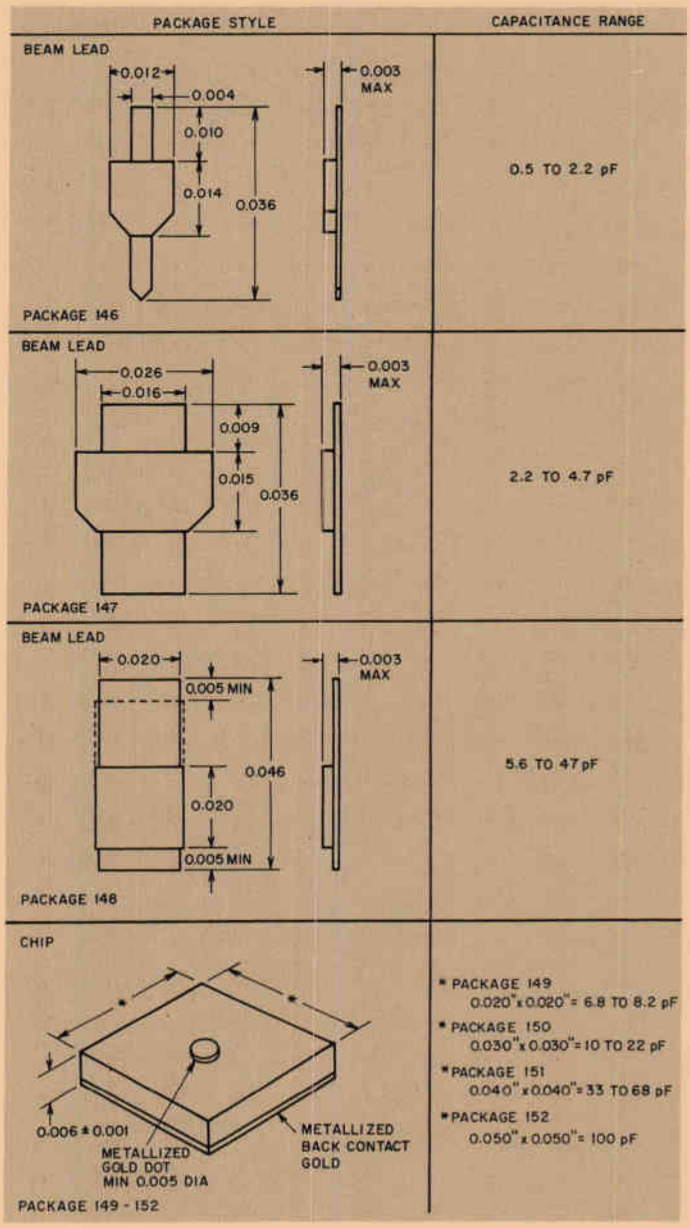
The SC-9002 series of chip capacitors is perfect for bypass applications. The base of the chip can be bonded directly to the ground plane and the other plate of the capacitor can be connected to the microstrip line by a flying lead. These chip devices have gold metallization pads for ease of handling and bonding.

Both series of capacitors have an RF insertion loss equal to, or better than, microstrip line itself. Among the many applications for the two new capacitors are microwave switches, video detectors, RF and IF amplifiers and limiters.

Keep watching the pages of IDEAS for further developments in our microstrip components line. We expect to be telling you soon about a new resistor that will bring the benefits of beamlead devices to the microstrip world.

CIRCLE NUMBER 302





Electrical characteristics:	Beamlead	Chip
Capacitance Range @ 1 MHz	0.5 to 50 pf	6.8 to 100 pf
Temperature Coefficient	200 ppm/°C	200 ppm/°C
Capacitance Tolerance	± 20%	± 20%
Operating Temperature	−55°C to 150°C	−55°C to 150°C
Working Voltage	50 volts min	100 volts min

Characteristics of beamlead capacitors

Type number	Capacitance	Package number
SC-9001A	0.5 to 1.0	146
SC-9001B	1.0 to 2.2	146
SC-9001C	2.2 to 4.7	147
SC-9001DM	5.6 ± 20%	148
SC-9001EM	6.8 ± 20%	148
SC-9001FM	8.2 ± 20%	148
SC-9001GM	10.0 ± 20%	148
SC-9001HM	15.0 ± 20%	148
SC-9001JM	22.0 ± 20%	148
SC-9001KM	33.0 ± 20%	148
SC-9001LM	47.0 ± 20%	148

Characteristics of chip capacitors

Type number	Capacitance	Package number
SC-9002EM	6.8 ± 20%	149
SC-9002FM	8.2 ± 20%	149
SC-9002GM	10.0 ± 20%	150
SC-9002HM	15.0 ± 20%	150
SC-9002JM	22.0 ± 20%	150
SC-9002KM	33.0 ± 20%	151
SC-9002LM	47.0 ± 20%	151
SC-9002MM	68.0 ± 20%	151
SC-9002NM	100.0 ± 20%	152

TELEVISION

'Instant warm-up' heater speeds picture tube turn-on.

Two-second warm-up time more nearly matches CRT to the turn-on characteristics of solid-state TV receivers.

We've come up with a new directly heated cathode design for television picture tubes that approaches the "instant warm-up" characteristics of modern solid-state receivers. And what's more, it requires so little power that it can be driven by a simple link to the horizontal yoke current.

The construction of the new heater-cathode is shown in Fig. 1. The mounting is designed to give maximum thermal isolation for the cathode. The ceramic support is also carefully designed to act as a thermal sink for the cathode support structure. This maintains a relatively uniform thermal gradient along the length of the cathode ribbon. This is very important for long mechanical life of the cathode.

The cathode itself is a ribbon with an oxide-coated button at its center. Since power input requirements are proportional to the mass of the button, the button area is kept to a minimum.

We evaluated the new instant warm-up cathode in a type 12CSP4 monochrome tube and have come up with some remarkable results. Warm-up time, measured in terms of a visible raster, was as little as 1½ to 2 seconds. The test tubes do not show any microphonic properties, nor does severe shock appear to change electrical characteristics. Emission levels are satisfactory with maximum currents in the range of 1 mA.

The low power requirements, 0.5 V at 0.800 A, enabled us to experiment with unusual sources of power. In a conventional arrangement, a portion of the DC power supply load current could provide the necessary heater current. But this approach would rule out use of the heater as the element by which the video signals are applied to the picture tube. This important feature can be retained if the heater is driven by means of a transformer in the yoke circuit as shown in Fig. 2.

In this circuit, a half-inch diameter ferrite toroid is used as a one-turn transformer. The primary is the ground return lead. The secondary is formed by passing the heater lead from the picture-tube socket through the core and connecting it to the other heater contact.

The result is a very low impedance source for powering the heater.

The toroidal transformer adds a minimum of capacitance to the video circuit, thus requiring no modification of the output stage peaking components. The low-impedance source is capable of supplying the higher-than-rated current needed when the cathode is cold. Measured warm-up time of the picture tube using this circuit was less than two seconds.

Although it's not yet an off-the-shelf item, our new instant warm-up cathode is definitely out of the experimental stage. We're ready to talk about designing it into your tubes. It can give you the selling feature you need for next year's models. CIRCLE NUMBER 303

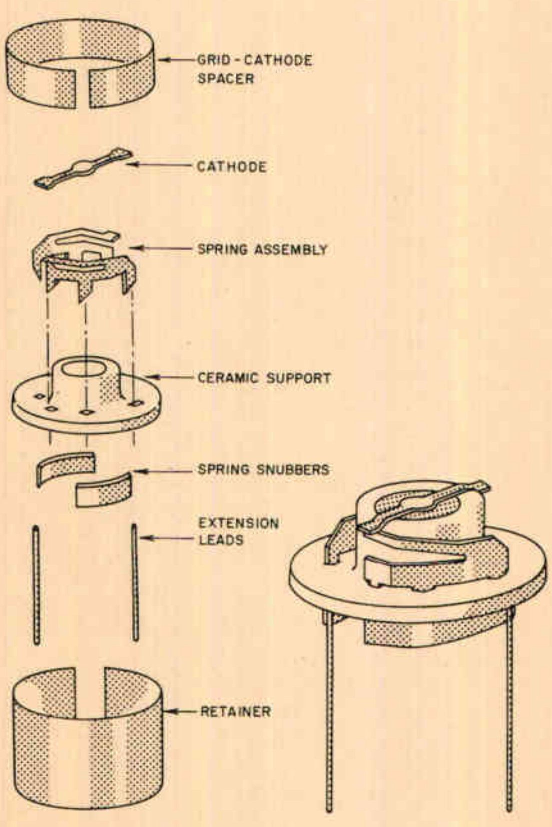


Fig. 1. Construction of the new instant warm-up picture tube cathode assembly.

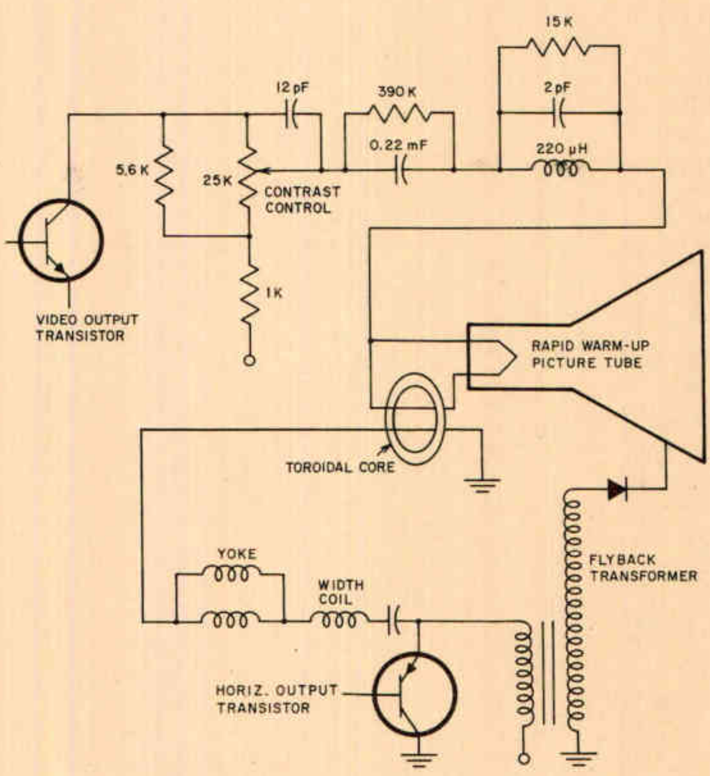


Fig. 2. New heater-cathode can be driven by single-turn transformer from yoke ground lead.

MANAGER'S CORNER

The path to LSI: Who goes first?

Perhaps the best analogy to illustrate the relationship between the design engineer and the integrated circuit manufacturer is that of two children daring each other to perform a certain adventurous act. Each one says "you go first."

As the semiconductor technology advances towards more highly complex circuits, the interface between the design engineer and the IC manufacturer becomes more critical. As the situation exists presently, the design engineer risks the design of a complex system based on the assumption that advanced circuit configurations can be fabricated by the integrated circuit manufacturer. The manufacturer, on the other hand, risks the production of a highly complex integrated circuit based on the assumption that the engineering community will use that package in their system design programs.

This could limit the advancement of LSI as a practical technology. The most apparent question is "who should take the first step." Should the design engineer be willing to take the gamble in hardening his design, hoping that the IC manufacturer can achieve the level of sophistication required to meet his IC specifications; or should the manufacturer go out on a limb and provide a more complex IC chip hoping that the engineering community can work with these more complex building blocks?

Actually, the relationship between the design engineer and the IC manufacturer is critical only if we are considering LSI as the immediate objective. If one looks back on the relationship as it has existed in the past, it is obvious that there is an evolutionary trend present. For example, in the past when an engineer intended to use a flip-flop in his system he merely designed the circuit using discrete components. With the introduction of the monolithic integrated circuit, the IC manufacturer decided to package the flip-flop configuration, thereby offering the design engineer a pretested building block.

In effect, the IC manufacturer made it possible for the engineering community to approach system designs on a higher level. They no longer were restricted to thinking in terms of discrete components since they now had available a wide assortment of functional blocks. The design engineer can now expand his thinking to a point where his general approach to system design assumes the use of these larger building blocks.

As the monolithic technology matured, the IC manufacturer, hoping to serve the engineering community, approached his packaging concept on a larger scale. If flip-flops could be packaged individually, why not complete shift registers and other similar complex circuit functions? Where once an engineer had to design a shift register by using individual IC flip-flops, he can now obtain this fundamental unit ready made.

Once again, the thinking of the design engineer was allowed to expand to a higher level. In approaching complex system design, the engineer is now armed with larger and more sophisticated building blocks. This frees the engineer from the burden of having to design and test previously established circuit configurations. With larger, pretested building blocks available he can use his talent, experience and creative energies in the development of a more efficient and effective system.

It should be obvious at this point that the evolutionary trend has arrived, quite naturally, at the present state of semiconductor technology—namely, MSI (Medium Scale Integration). MSI is a natural extension of the monolithic technology, and is a stepping-stone on the path to LSI. It is this fact which lends so much importance to Sylvania's approach in satisfying the needs of the engineering community for more complex and sophisticated building blocks.

Rather than make an unrealistic leap into the production of extremely complex circuit configurations, which could possibly result in a retardation of semiconductor developments (i.e., trying to force the design engineer to work with building blocks far more advanced in sophistication than those which he is used to working with), Sylvania has followed the more natural line of evolution. We are providing the design engineer with integrated circuit configurations designed to allow him to expand his thinking at a more practical and realistic pace. In this way the same goals can be achieved. The level of LSI is approached for complex system design, while at the same time the design engineer can use practical building blocks to design and fabricate systems using present-day specifications.

What it all boils down to is the fact that the integrated circuit manufacturer serves as a high-level packager. He follows the activity of the system's design engineer, continuously observing system developments. The integrated circuit manufacturer then attempts to package larger portions of these systems, thereby freeing the design engineer to rise to higher levels of design approaches, and to think in bigger terms.

The relationship between the design engineering community and the integrated circuit manufacturer is, therefore, regenerative. As systems become more complex, the packaging of larger portions of these systems will follow. As these packages or building blocks are made more complex, the result will be the raising of the design engineer's level of thinking. This, of course, is a limitless process and will lead, in the future, to levels of design sophistication which today are unimaginable.

H. M. Luhrs
Product Marketing Manager
Integrated Circuits

CRTs

Low-drain heaters save portable power.

High-efficiency heater-cathodes cut CRT power consumption to six percent of that of conventional units.

Our approach to heater-cathode design really takes the strain off battery-powered equipment. Wherever battery drain is a problem—spacecraft, military field equipment or industrial portable testers—our special design can reduce power requirements to 1/16 of that required by conventional CRTs.

These low-power heater-cathodes operate on as little as 0.21 watts (1.5 V, 140 mA) as compared to 3.78 watts (6.3 V, 600 mA) consumed by conventional heaters. The result is longer battery life (or smaller batteries), longer equipment life, and greater reliability. In addition, the lower power reduces equipment operating temperatures.

The low-power heater-cathode is a tiny pancake-like structure measuring 0.050″ in diameter and 0.011″ thick. Compared with conventional units, the low-power assembly has an external radiating surface of 0.0054 square inches versus 0.136 square inches, a ratio of 25:1.

The extremely small mass enhances resistance to shock and vibration, upping reliability in severe environments.

One place where the low-power heater-cathode has been put to good use is in a lightweight, man-portable radar. This application uses two Sylvania low-power CRTs. Another application is in a portable industrial ultrasonic flaw detector. Here, the low-power heater-cathode is used in a CRT with helical-resistor post-deflection acceleration to achieve high writing rates and minimum pattern distortion. The table lists the characteristics of three tubes that make use of the low-power heater-cathode. These are just typical applications since the low-power design is adaptable to practically all present-day CRTs.

The 3BGP—offers high-deflection sensitivity, electrostatic deflection and focus with an optical-quality clear, pressed faceplate. It is a compact direct-view oscilloscope tube with face dimensions of 1½″ x 3″.

The 3BMP—is a 3″ diameter tube with a flat, clear faceplate. It offers post-deflection acceleration, electrostatic deflection and focus.

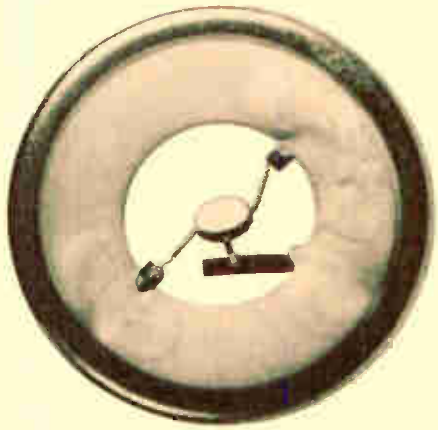
The feature of the SC-3016 is compactness. It's only 6″ long and offers a 1⅛″ circular face. Deflection sensitivity is high with electrostatic focus and deflection.

CIRCLE NUMBER 304

Characteristics of low-heater power CRTs

Key Characteristics	3BGP-	3BMP-	SC-3016	Units
Heater Ratings	1.5V/140mA	1.5V/140mA	1.5V/140mA	Vdc
Anode No. 3 Voltage		6600*		Vdc
Anode No. 2 Voltage	2750*	2200*	2750*	Vdc
Anode No. 1 Voltage	1100*	1500*	1100*	inches
Face Dimension	1½ x 3/1/64	3	1⅛	inches
Over-all length	9¼	10	6	inches

*Absolute max. rating



Low power heater-cathode operates on as little as 0.21 watt.

SEE OUR SPECIFICATIONS IN VSMF MICROFILM CATALOG FILE

Use Sylvania's "Hot Line" inquiry service, especially if you require full particulars on any item in a hurry. It's easy and it's free. Circle the reader service number(s) you're most interested in; then fill in your name, title, company and address. We'll do the rest and see you get further information by return mail.

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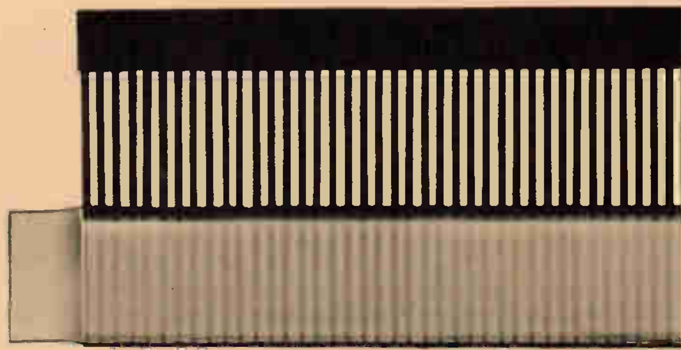
EL READOUTS

How etched leads boost EL bar graph resolution.

Chemical technique allows 50-line-per-inch spacing of bar graph segments, simplifies printed-circuit board connections.



Chemical etch process allows accurate spacing of bar-graph divisions down to 50 lines per inch.

Our recently developed chemical etch technique for making connections to electroluminescent (EL) devices improves the resulting device in two ways. By the use of this technique, we can now produce EL bar graphs with resolutions as high as 50 lines per inch. At the same time, the etched leads make an ideal way to connect the EL device directly to the necessary circuitry by soldering directly to a printed circuit board or to flex circuits.

The chemical etch method allows us to maintain tight control over lead spacing and lead dimensions. Because of this, we can vary the resolution along the length of a bar graph. This allows us to construct bar graphs having a logarithmic characteristic, or any other function desired. Elements of the bar graph can be as small as 0.050″ in width.

Using this technique gives us better capability of stacking or making multiple bar graphs on a single substrate. Again, these can have the same or varying resolutions, widths, lengths, etc.

Chemical etch is just another flexibility added to the already high flexibility of EL display devices. In addition to bar graphs, EL devices are readily adaptable to the display of any type of information. For example letters, numbers, pictorial or analog data displays can be easily designed to meet your specific needs.

New developments in phosphors now enable us to offer EL devices with brightness levels up to 50 foot-lamberts at 250 V, 400 Hz and 25 foot-lamberts at 115 V, 400 Hz. Special glass faceplates allow contrast enhancement to permit viewing under the highest of ambient light conditions.

These features are in addition to the basic characteristics of EL that make it such an ideal display device. EL is a planar display; you don't have to look through a web of non-illuminated characters to see the one that's lit. It is practically immune to catastrophic failure and the spectral characteristic of EL devices closely matches the response of the human eye.

With all these features, isn't EL the best way to solve your display problems? Talk to Sylvania's applications engineers. They will be glad to show you how the flexibility of EL makes it practically certain that a display can be designed to match your exact requirements.

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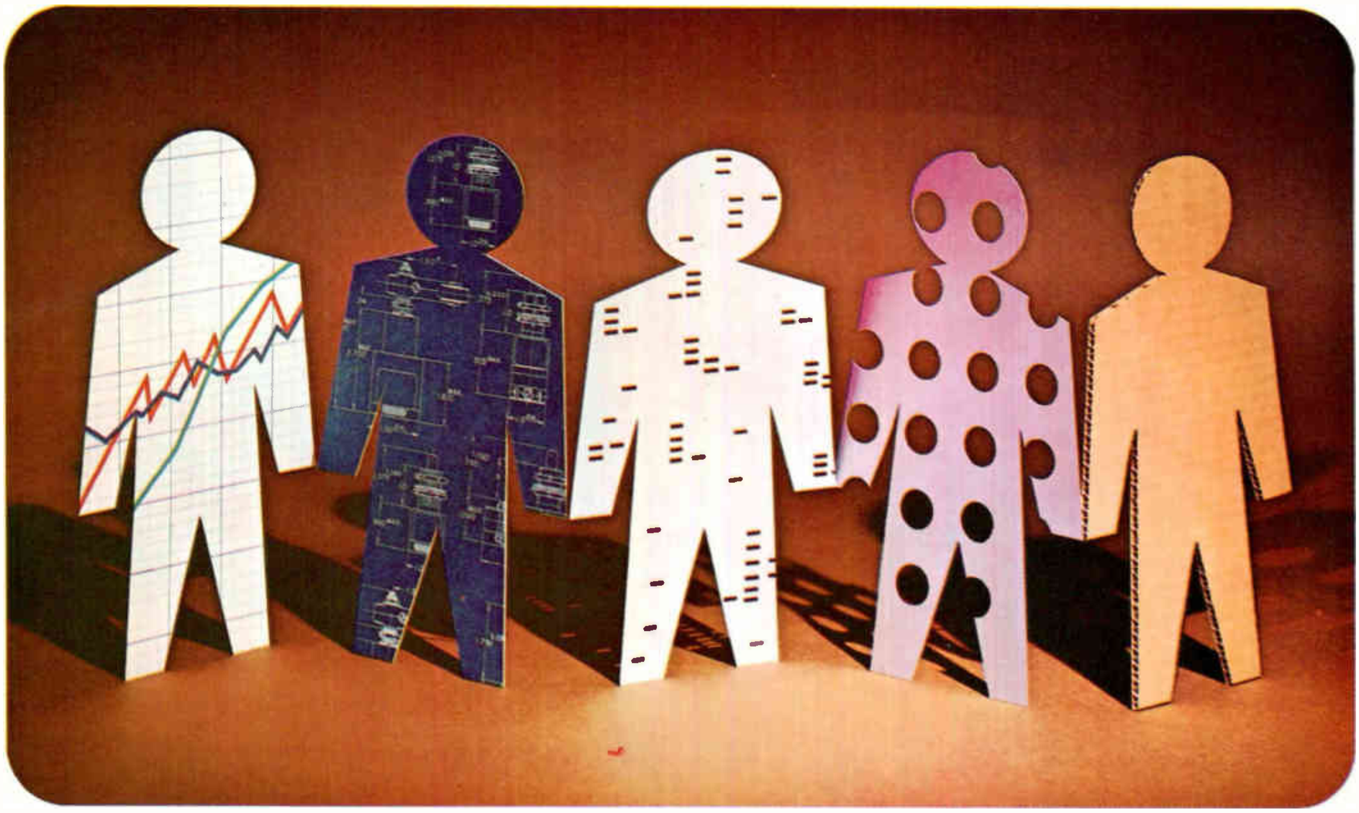
Meet the MICRO SWITCH Quality Assurance Department



Left to right: vice president, design engineer, computer programmer, punch press operator, and shipping clerk. Not present for picture: All the other employees of MICRO SWITCH.

Quality Assurance for the customer is everyone's business at MICRO SWITCH. It is the result of a total concern for the details that make up customer satisfaction. It starts with top management and permeates the entire organization, involving every step of manufacture—from raw materials and design on through production and shipping.

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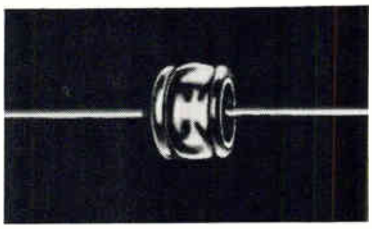
SIEMENS

Do you have the question to this



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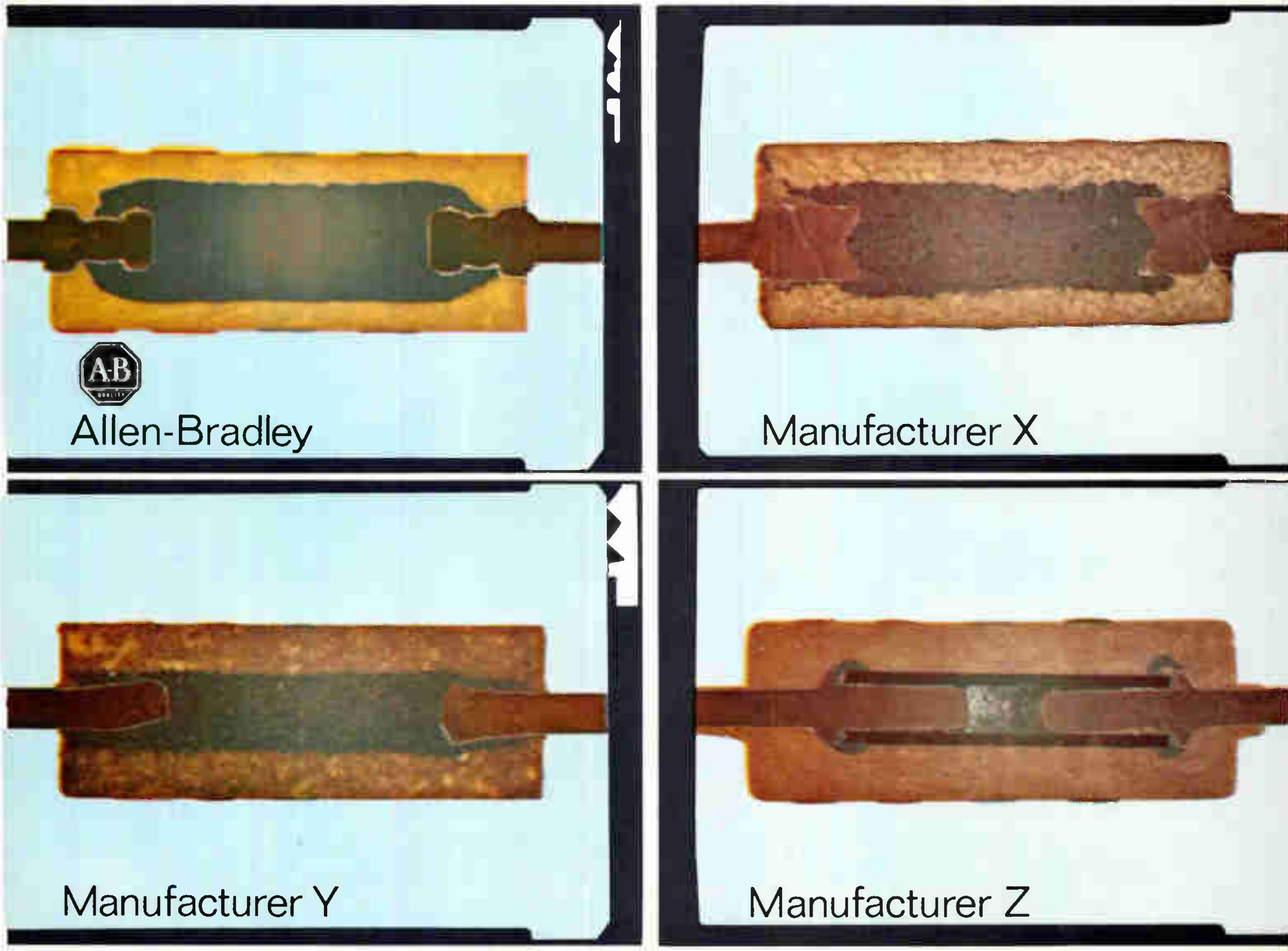
with your reputation at stake, which resistor line would you specify?

take a close look—there'll be no question

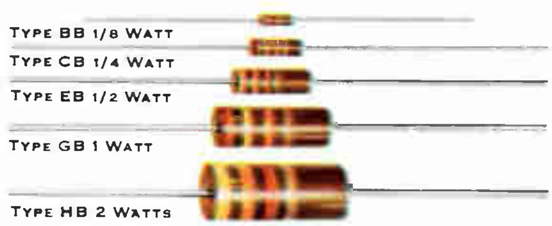


The above illustrations are from unretouched photomicrographs taken of four ½-watt fixed resistors. Compare the anchoring of the leads, the seal provided by the insulating jacket at the ends, the homogeneity of the resistance material, the sharp color code bands—and decide for yourself.

For more details on Allen-Bradley hot-molded resistors, please write for Technical Bulletin 5000: Allen-Bradley Co., 1201 South Second Street, Milwaukee, Wis. 53204. Export Office: 630 Third Avenue, New York, N. Y., U.S.A. 10017. In Canada: Allen-Bradley Canada Ltd.

1067E-4

A-B hot-molded fixed resistors are available in all standard resistance values and tolerances, plus values above and below standard limits. **A-B hot-molded resistors meet or exceed all applicable military specifications including the new Established Reliability Specification.** Shown actual size.



QUALITY ELECTRONIC COMPONENTS A-B ALLEN-BRADLEY

Circle 45 on reader service card

At 12.4 GHz, forget about crosstalk.

This new switch gives 60 db of isolation at 12.4 GHz. You can forget about crosstalk at high frequencies because it's held to an absolute minimum.

Besides excellent isolation across its entire operating range (zero to 12.4 GHz), electrical characteristics are well suited to high-frequency applications. VSWR at 12.4 GHz is 1.5 max. Insertion loss is only 0.5 db max.

Mechanical characteristics make Amphenol's high-isolation switch easy to use. Switches come with standard N or TNC connectors. They measure a small 2⅛" x 2 3/16" x 1" and can be easily stacked. Temperature range is from −55° to 85°C. Altitude range goes from zero to 70,000 feet. Shock and vibration performance meets MIL-S-3928B.

For high-isolation, high-frequency switches, talk to Amphenol RF Division, 33 E. Franklin St., Danbury, Conn. 06810.

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Circle 47 on reader service card →

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Faithful
friend

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The "service on a
silver tray" people

Midtex
The "we'll tackle
anything" people

Midtex
Cracker of
tough nuts

INDUSTRIAL RELAYS	TYPE 155 	TYPE 156 	TYPE 157 	TYPE 48 *Single Coil Latching Action* 
CONTACTS	U/L Recognized 1, 2, & 3 PDT 5 & 10 amp	U/L Recognized 1, 2, 3 & 4 PDT Low Level to 3 amp	1, 2, & 3 PDT 5 & 10 amp	1 & 2 PDT 10 amp
COILS	6 to 240 VAC 5 to 110 VDC	6 to 240 VAC 6 to 110 VDC	6 to 240 VAC 6 to 110 VDC	6 to 240 VAC 6 to 110 VDC
ENCLOSURES	Open and Dust Cover	Dust Cover and Hermetically Sealed	Open and Dust Cover	Open
TERMINALS	Solder, Plug-in, Wire-wrap, 3/16" Quick Connect	Solder/Plug-in, Printed Circuit, #78 Taper Tab	Solder/Plug-in/ 3/16" Quick Connect	Solder, 3/16" Quick Connect

MERCURY-WETTED CONTACT RELAYS	TYPE 159 	TYPE 160 	TYPE 161 	TYPE 168 
CONTACTS	Mercury-Wetted, 2 amp max, 500 V max, 100 VA max 1PDT	1PDT	2PDT	1PDT
SENSITIVITY—Bistable Single-Side-Stable	20 mw 40 mw	20 mw 40 mw	30 mw 60 mw	2 mw 5 mw
TERMINALS	PCB pins	PCB pins	PCB pins	Octal plug

COAXIAL CRYSTAL CAN

TYPE
153

CHARACTERISTIC IMPEDANCES 50 and 75 ohms

RF CHARACTERISTICS:

Frequency	VSWR	Crosstalk
50 MHz	1.05/1	−62 DB
200 MHz	1.06/1	−50 DB
1000 MHz	1.15/1	−35 DB

CONTACTS 2C coaxial or 1C coaxial and 1C auxiliary, 100 watts RF, 2 amp 28 VDC

COILS 6 to 48 VDC

ENCLOSURE Hermetically sealed

TERMINALS RG188/AU Cable or ultra-miniature connectors, Solder hook for auxiliary

MOUNTING Standard varieties of crystal can relay stud, brackets, etc.

ENVIRONMENTAL Mil-R-5757

ELECTRONIC TIME DELAY

TYPE
615

DELAY TYPES	Delay on operate	Delay on release
DELAY RANGES		
	0.1 to 1 sec.	1 to 300 sec.
	1 to 10 sec.	1 to 60 sec.
	1 to 100 sec.	1 to 180 sec.

RESET TIME 25 MS max

REPEATABILITY ±2% at nominal voltage and +77°F

TOTAL TIMING VARIATION ±10% over voltage and temperature range

VOLTAGES AC 120 VAC (105 to 125 VAC) DC 12, 24, 48 VDC ±25%

TEMPERATURE RANGE −40°F to +150°F

CONTACTS 2PDT, 10 amp, 120/240 VAC or 24 VDC

TERMINALS Octal style plug-in, solder, screw

Midtex/AEMCO also designs and manufactures a wide variety of programmers, both standardized and to handle special customer requirements.

Midtex—The broad range relay and timer supplier

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Circle 49 on reader service card→

No other manufacturer offers as large a selection: hundreds of standard types of control knobs, more than 2,000 "specials". Almost every type, style and color combination is promptly available to you from local distributors and large factory stocks.

Turn to color with the new PANELRAMA knobs shown below... mix or match caps and body colors in almost any combination... to harmonize or contrast with every panel decor.

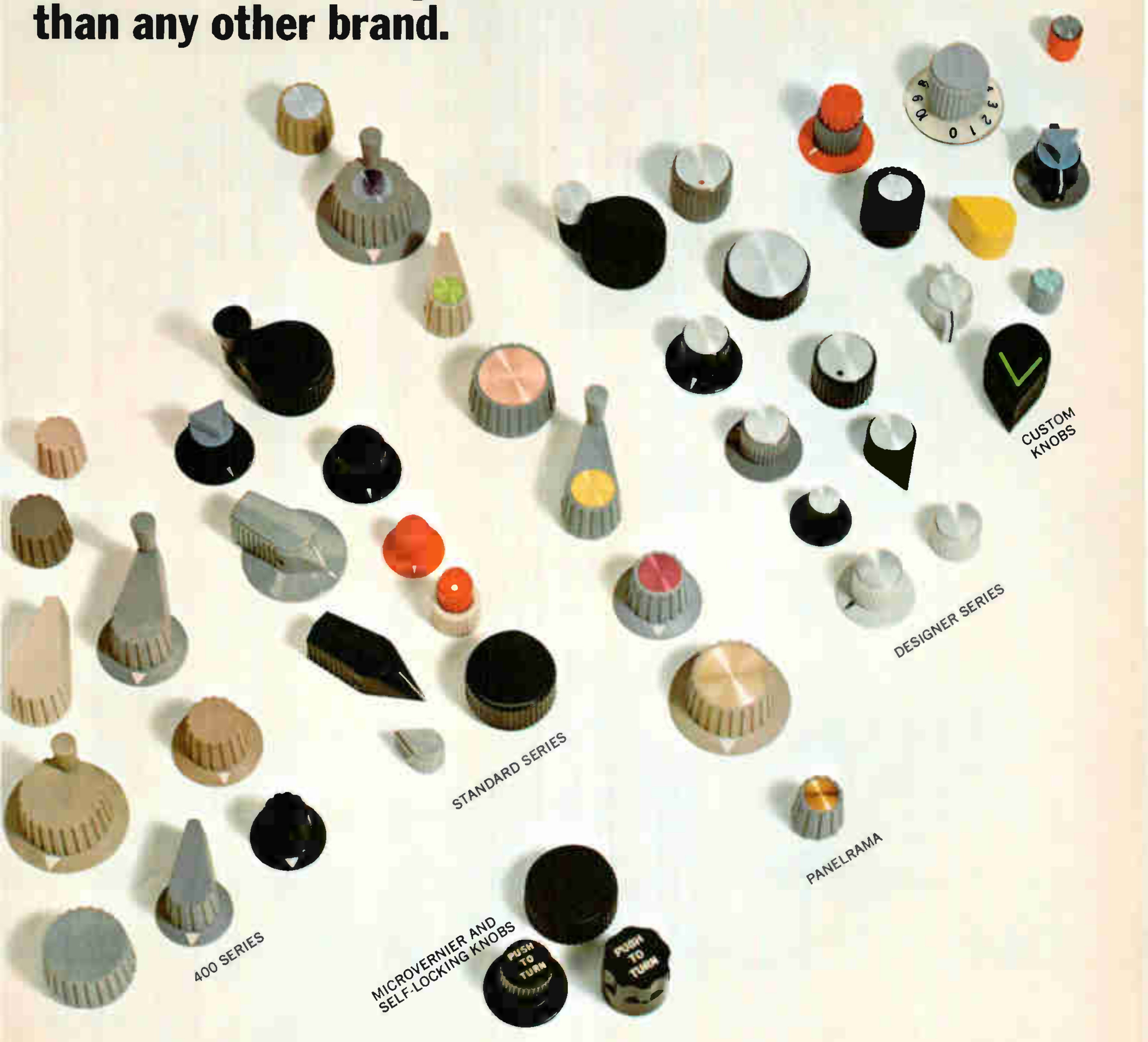
Or, you can choose elegantly-styled Designer Series knobs with spun-aluminum caps on body colors of black; light, medium, or dark grays; and off-white. When you need a solid color, select from the nine decorative colors in our 400 series.

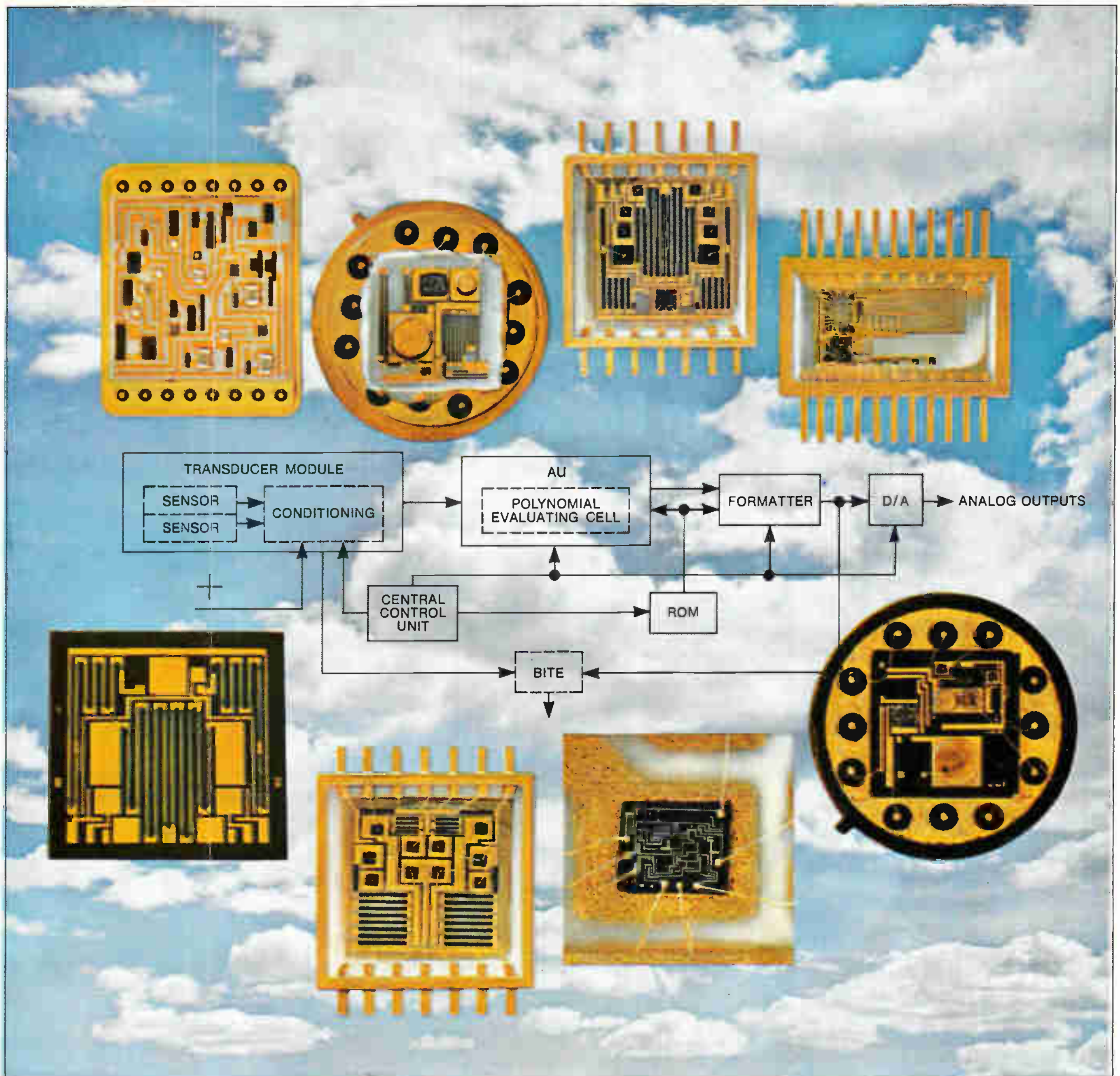
For military applications, specify Standard Series control knobs—thousands of quality knobs that meet MS91528. Or, specify the new self-locking push-to-turn knobs and Microverniers... for accurate, precision control settings. And when you need custom-made knobs, call Raytheon first ...to get the advantages of Raytheon quality and fast delivery.

For a catalog, call your distributor or nearest Raytheon regional sales office. Or send the reader service card. *Raytheon Company, Industrial Components Operation, Quincy, Massachusetts 02169.*

RAYTHEON

Here's why Raytheon knobs control more settings than any other brand.





AiResearch has new ways of applying electronics to solve problems.

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...digital air data systems, airborne integrated data systems, multiplexing systems, engine fuel controls, cabin pressure controls, propulsion monitoring systems, and displays.

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We have found that this kind of total system responsibility demands the highest degree of in-house electronics capability. In our house, this includes development of highly sophisticated electronic circuits through the use of advanced techniques such as thin-film, thick-film, and large scale integration. The result is optimum weight-saving, miniaturization, and reliability.

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AiResearch electronics capability starts at home

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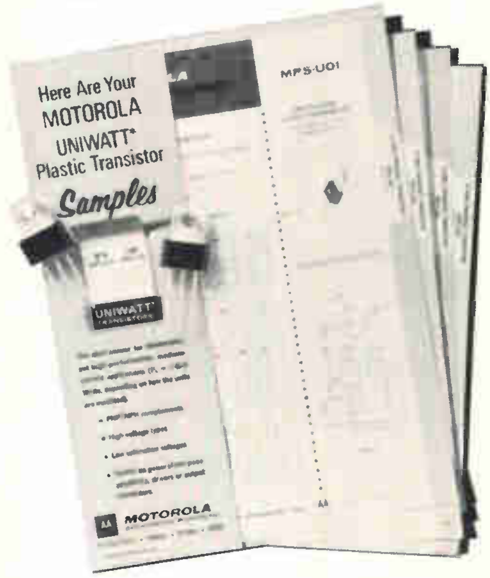
Try A Complimentary Complementary Pair... On Us



UNIWATT* Plastic Transistors Fill The "Economy" Gap In Medium Power.

UNIWATT... Remember That. Uniwatt, Motorola's new plastic package at last provides a truly economical line of silicon annular† devices fully capable of meeting medium-power requirements to 8 Watts. They fill the power handling gap between versatile TO-92 Unibloc* transistors (310 mW) and high-current Thermopad* (to 90 W) plastic types.

Uniwatt transistors occupy only about half the space of comparable TO-5 metal cans, but handle up to one watt at $T_A = 25°C$ without heat sinking. Power dissipation is 5 to 8 times that figure when the integral heat sink is chassis mounted.

And yes, we said truly economical. Prices from 46¢ to 76¢ @ 5,000-up are a good example of what we mean. We have them on the shelf. And we deliver whatever your needs whenever you need it.

Type No.	Polarity	V_{CEO} Rating	P_D @ 25°C		h_{FE} @ I_C (min.)	$V_{CE(sat)}$ @ I_C (max.)	f_T @ I_C (min.)	Price (5,000-up)
			T_A	T_C				
MPS-U01 MPS-U51	NPN PNP	30 V	1.0 W	8.0 W	70 @ 150 mA	1.0 V @ 1.0 A	50 MHz @ 50 mA	54¢ 62¢
MPS-U02 MPS-U52	NPN PNP	40 V	1.0 W	6.0 W	50 @ 150 mA	0.4 V @ 150 mA	150 MHz @ 20 mA	46¢ 54¢
MPS-U03	NPN	120 V	1.0 W	5.0 W	40 @ 10 mA	0.5 V @ 200 mA	100 MHz @ 50 mA	66¢
MPS-U04		180 V						76¢

Now, About That Complimentary Complementary Pair — Write your request on your company letterhead and we will send you a complete set of Uniwatt transistor data sheets — and an NPN MPSU02 and a PNP MPSU52 for prototyping.

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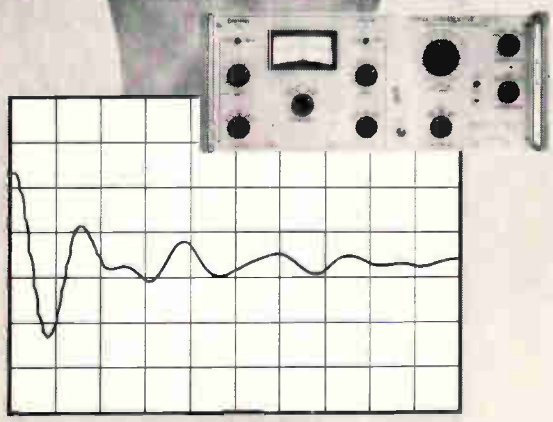
MOTOROLA Plastic Transistors

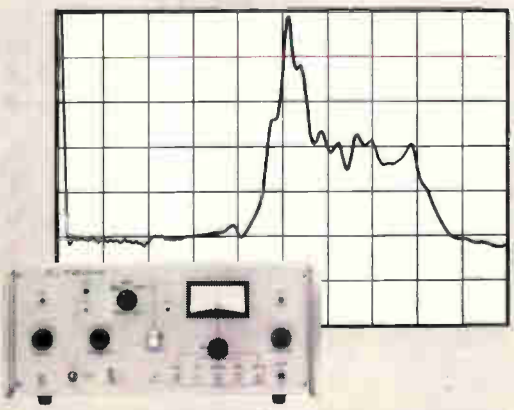
MOTOROLA SEMICONDUCTOR PRODUCTS INC./P.O. BOX 20912/PHOENIX, ARIZONA 85036

Circle 51 on reader service card

ANALYZE EVEN THE MOST COMPLEX SIGNALS . . .



Autocorrelation of bat cry defined by Model 100 Correlation Function Computer (Price: $8,500.)



Power spectral density of bat cry transformed from autocorrelation function by Model 102 Fourier Analyzer (Price: $2,950.)

Recent research into the cry of the bat provides us with an unusual opportunity to demonstrate the ability of our Correlation Function Computer and Fourier Analyzer to analyze and sometimes derive unsuspected information from a complex signal.

The experimenter's objective was to characterize the bat's acoustic transmission to shed light on its sonic signal processing mechanisms. Through the use of the Correlation Function Computer, he derived the autocorrelation function of the cry and found that the bat's range discrimination success curve mirrored the envelope of the autocorrelation of its cry. This supports the hypothesis that the bat ranges by crosscorrelating its transmission with the returned echo.

The experimenter next processed the autocorrelation function through a PAR™ Fourier Analyzer to obtain the power spectrum of the cry. This spectrum is being studied to gain additional insight into the acoustic physics of the bat's vocal apparatus.

Whether you are working with bat cries or other phenomenon such as velocities in flowing turbulent fluids, potentials in an active plasma, pressure density in a boiling fluid or current flow across a reverse biased p-n junction, let us familiarize you with this powerful signal processing system. Write Princeton Applied Research Corporation, P.O. Box 565, Princeton, New Jersey 08540, or call (609) 924-6835.

PAR PRINCETON APPLIED RESEARCH CORPORATION

Memory has unforgettable price

Cost per bit of post-and-film system is only 2 cents, less than half that of core and plated-wire types

Almost nobody worries more about saving pennies than designers of computer memories; these systems use thousands upons thousands of elements. Ferrite cores, still the cheapest, generally cost 5 to 8 cents a bit; close behind are plated-wire memories, at 5 to 12 cents a bit. Computer producers think better mass-production techniques can cut prices of both types to between 2 and 4 cents a bit in a few years. But Litton Industries says it already has a memory that costs about 2 cents a bit.

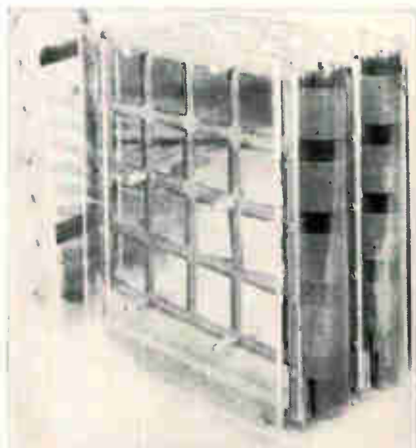
In fact, the memory, which can be batch fabricated, may soon be used. The first candidate will be the L-3050 computer made by Litton's Data Systems division. Officials there say the machine will probably have a fast, alterable read-only memory incorporating the new technique.

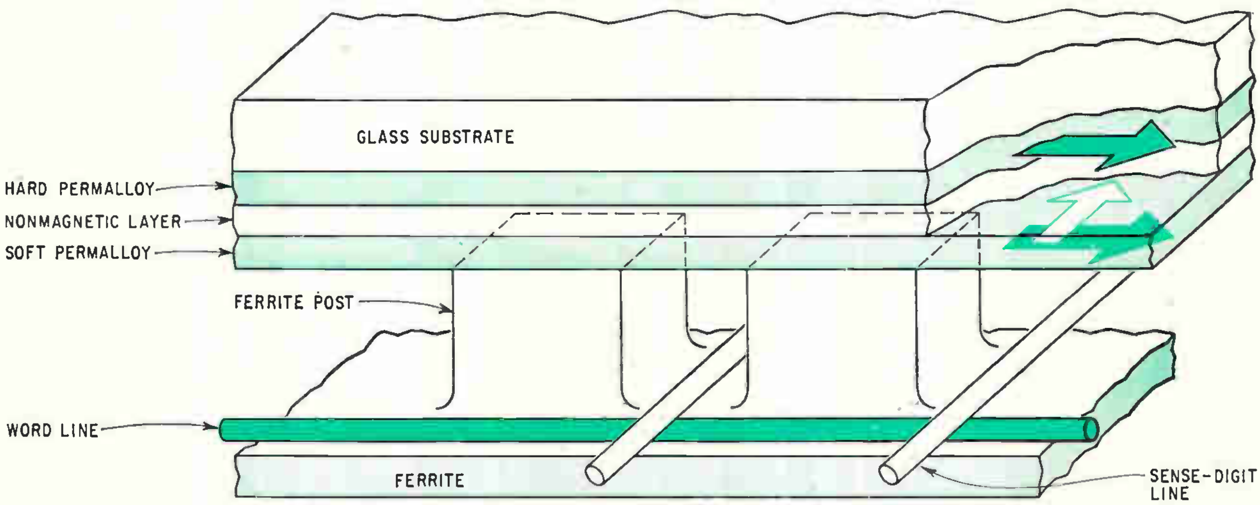
The memory is composed of posts and films. Robert Vieth, manager of magnetics and microelectronics research at the Guidance and Control division, explains the makeup of the memory as follows.

Post time. Two layers of Permalloy film are bonded to a glass substrate, with a layer of nonmagnetic material between the Permalloy layers. The Permalloy layer next to the glass is a "hard" film—that is, it's highly anisotropic, and its magnetic hysteresis loop is nearly square in the easy direction and almost linear in the hard direction. The other Permalloy layer is "soft"; it's also anisotropic, but the difference in its magnetic properties in the two directions is less pronounced. The easy directions of the two films are parallel. In this direction, binary 1's and 0's correspond to magnetization one way or the other.

Meanwhile, two sets of grooves are cut into a ferrite block at right angles, leaving a set of posts. Semiconductor dicing techniques are used in the cutting process. Drive conductors are then placed in the grooves, and the glass substrate carrying the films is flipped over onto the ferrite, film side down, to complete the sandwich.

Because the memory elements contain both hard and soft films, readout can be either nondestructive or destructive. In the nonde-





Post and film. Current pulse in the word line of this batch-fabricated memory rotates the magnetization of the "soft" Permalloy film to generate a readout pulse in the sense-digit line. Readout of the economical memory is nondestructive because the magnetization in the "hard" film restores the direction of magnetization in the "soft" film when the pulse is removed. Registration of glass substrate carrying films isn't critical, as photo shows.

structive mode, a pulse sufficient to change the magnetic axis of the soft film, but too weak to have much effect on the hard film, swings the magnetization of the soft film to one side. Its motion generates a pulse in the sense wire. After the pulse is withdrawn, the magnetism of the hard film drags the soft film back to its original position, retaining the information stored.

In the destructive mode, a bigger readout pulse affects both the soft and hard films. This would be primarily for writing new information in the memory. A pulse in the sense winding, now doing double duty as a bit line, defines the new direction of the films at the end of the pulse.

The posts define the bit positions on the film, which therefore needn't be carefully registered on the ferrite array (see photo). The posts also provide a complete path through low-reluctance material for the magnetic flux, and this gets around the problems often encountered in conventional planar thin films.

No creeps. If the planar film is continuous, repeatedly reading and writing in one location tends to destroy data in adjacent locations, a phenomenon called creep. And all the efforts to overcome or avoid creep—including putting the film down in spots or on a cylindrical substrate (plated wire) – lead to other problems.

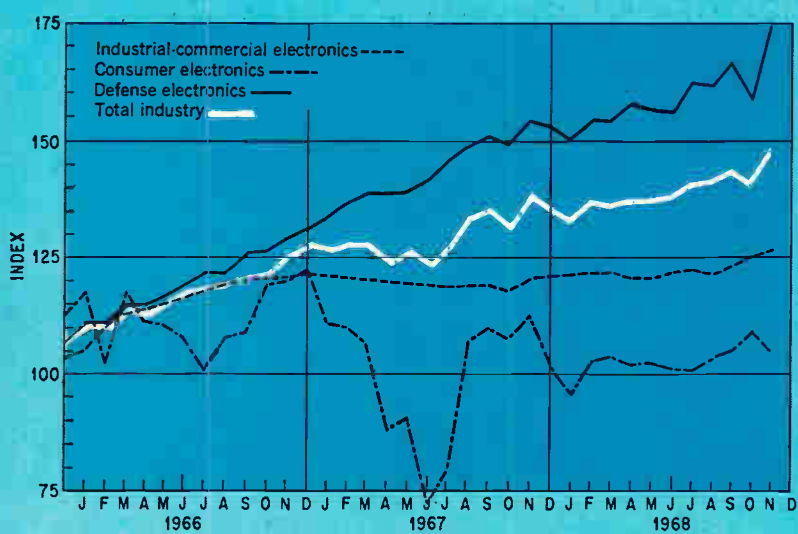
Norman Grossman, manager of materials engineering at the lab, says each part of the memory can be batch-fabricated, separately tested, and separately repaired. Film evaporation is easily done in batches, and the ferrites are fired, molded, and separated in groups. The word and digit wires are fabricated in one large plane; they're connected to each other and to the electronics in a proprietary way that eleminates hand wiring and solder joints.

Monolithic. Charles Womack, manager of the Data Systems division's memory section, notes that the memory's relatively low drive currents—40 milliamperes for the digit wire and 150 ma for the word wire—allow use of monolithic integrated circuits as the drive electronics. This would be difficult with cores and plated wires, he says. Cores require 300 ma on the digit wire and 800 ma on the word wire. Plated wires dictate 125 ma on the digit wire and 800 ma on the word wire.

A 1,024-word stack of 32-bit words has already been built. The goal of the in-house effort is to develop an 8,000-word by 33-bit unit, which, Womack believes, will dissipate 20 watts – a third to a fourth less than a similar plated-wire stack and far less than the 160 watts needed for a core stack of comparable size.

Womack also sees greater speeds and higher bit densities for the new memory: a 250-nanosecond read cycle and a 400-ns write cycle, compared with 500-ns read and 700-ns write for plated wire and 500-ns read and 10-microsecond write for cores. Bit densities of 1,760 per square inch have been estimated; this compares with 1,400 bits for plated wire and 1,200 for cores.

Electronics Index of Activity January 6, 1969



Segment of Industry	Nov. 1968	Oct. 1968*	Nov. 1967
Consumer electronics	105.8	109.5	112.9
Defense electronics	174.2	159.6	150.9
Industrial-commercial electronics	126.7	125.0	121.4
Total industry	148.7	140.9	135.8

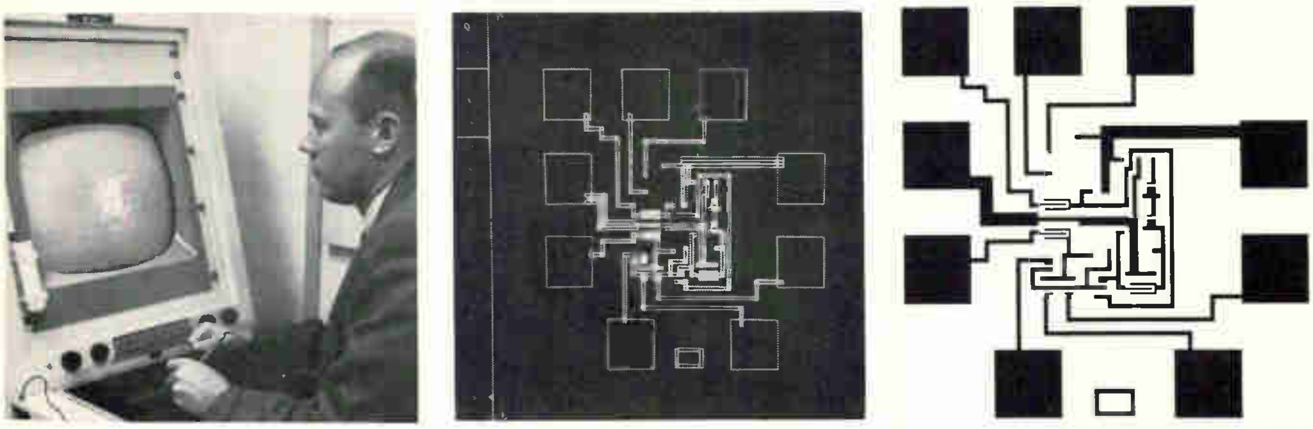
Electronics production rose 7.8 index points in November from the prior month and 12.9 points from the year-earlier level. Gains were posted in all sectors except consumer output, which declined 3.7 points in the month and 7.1 points in the year. Defense electronics soared 14.6 points from October and 23.3 points from November 1967. The industrial-commercial index was up 1.7 points in the month and 5.3 points in the year.

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

Circuit design

Engineer in the loop

The aim of most computer-aided design schemes is to get the engineer out of the loop. But, as some CAD experts are finding to their dismay, that leaves the machine with a lot more responsibility than they'd like. At MIT's Lincoln Laboratory, however, a CAD scheme called the Mask Program succeeds



Before your eyes. A Lincoln Lab engineer's sketch grows into a crt-displayed IC pattern (center) as he programs a computer with a data tablet (left). The computer analyzes his composite drawing, designs masks needed to make the IC, then punches paper tape to feed a mask-making artwork generator. The final result is a mask like the one at right, one of a set for an emitter-coupled three-input AND gate.

in using the computer to complement the engineer, not replace him.

"We wanted a system that could make full use of the engineer's experience," says Fontaine K. Richardson, a lab staff member. "It is a rare computer that can tell the difference between a great design and a marginal one, or one which will build itself or give fits to process control personnel."

"It's taken 15 or 16 cuts at the software to bring us to this point," he says. "Using the laboratory's TX-2 computer, a cathode-ray tube display, and a data-entry tablet, we can now design metal oxide semiconductor and bipolar integrated circuits so complex they require 15 masks or more and three layers of metalization interconnection."

In contrast, one of the best known CAD systems in industry can reach only the eight-mask, single-layer-metalization level of complexity.

Free hand. Most CAD operations begin with a detailed circuit diagram or its equivalent in tape or punched cards. But the Mask Program can work from rough rectilinear sketches entered at the data tablet. And while the sketches themselves are in standard symbols, such as the resistor's zig-zag, the computer-generated crt display—continually developing as the engineer completes his sketch—looks like an artist's concept of a chip photograph.

Engineers using the Mask Program can readily vary geometry and change component values. Designers can also use the program to delete, rotate, or relocate components. Centering of lines is automatic, and the computer picks the proper line width for a resistance or capacitance.

This contrasts with other CAD systems, in which circuit parameters usually are known before layout begins and the engineer can change them only within narrow bounds. These limits are imposed by the amount of memory needed to hold alternate component definitions and the complexity of the software needed to call them up, says Richardson.

He calls the Mask Program "an infinite drafting table with edges imposed only by the amount of memory available", and the TX-2 has lots; it can store 170,000 words of 36 bits each.

One industry source said after a demonstration, "While other men would be writing up circuit specs and component values, these guys are sketching an IC and getting a set of masks." Such speed is important to Lincoln Lab, which often needs special circuits quickly.

Debugging. Final designs are analyzed by the computer, which generates discriptions of the separate masks needed to construct them. The TX-2's output is a punched paper tape used to drive a David W. Mann Co. 10-times artwork generator [*Electronics*, Dec. 25, 1967, p. 41]. According to Mann's marketing director, Aubrey C. Tobey, this tape output allows artwork generation in a fifth to a hundredth the time needed with drafting tables. "A five- or six-mask set for a simple circuit can be readied in a day or less," he says.

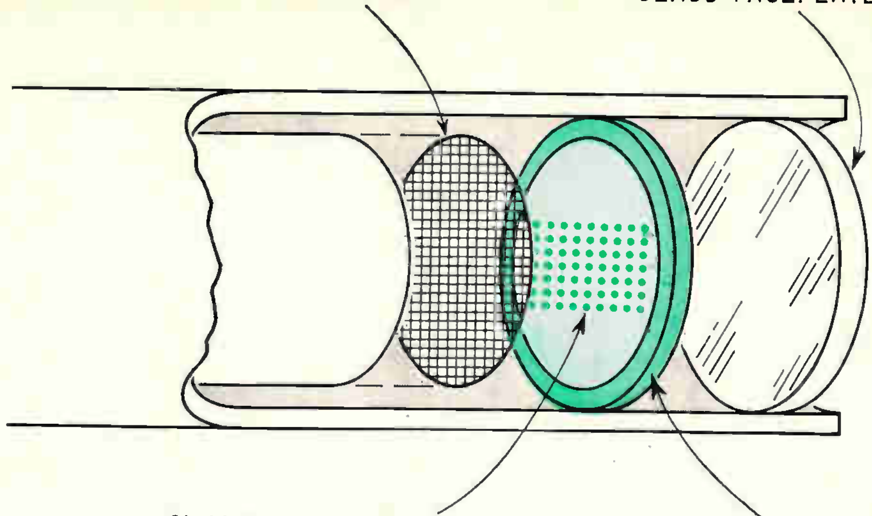
Even before the tapes are cut, the engineer can debug the masks by viewing each one on the display. If he is very cautious, the computer can draw each mask with an x-y plotter for close examination.

From the sketch of a single gate to the final tape might take an hour or two, says Richardson, but the Mask Program isn't limited to simple circuits—though the more complex ones take longer to draw because "we engineers like to be able to change our minds."

Unlike CAD systems sometimes limited to 25 to 35 elements per chip, the Mask Program already allows design of large-scale IC's with double that many gates, each of which contains many elements of its own.

Too big? One of the first LSI circuits to be built with Mask Program is a 16-gate bipolar array with two layers of metalization, and Richardson's group is now about to begin work on a 65-gate dual 4-bit adder. It will have full carry-skip logic to make possible ADD, AND, exclusive-OR, and OR functions. It's expected to require three-layer metalization.

This makes possible what may



Hybrid tube. Infrared imaging device differs from conventional 1-inch vidicon in that it uses an array of single-crystal silicon photodetectors.

be another unique feature of the Mask Program: storage of whole circuits in memory for later use as cells or building blocks in LSI arrays. Such cells can be called out of memory, arranged on the display tube, enlarged or reduced en masse, then interconnected using the data tablet.

This system is so powerful that Richardson envisions using the 65-gate array as a building block and aims to work his way up through a dual 16-bit to a dual 32-bit adder. This is very large-scale integration indeed, so large that one industry spokesman feels that the Mask Program may have outstripped processing technology.

Optoelectronics

Caught in the crunch

The effects of the military's urgent need for low-light-level reconnaissance systems in Vietnam shows up in work under way at Texas Instruments on an unusual vidicon. The company, which only started development of the hybrid tube in June 1967, is now producing the device for a military infrared avionics system.

Because it has to deliver on the contract, TI is currently accepting low yields. But "dramatic improvements" have been made in the past two months, according to Frank L. Skaggs, manager of the project. These improvements, he says, should enable the company by mid-1969 to increase yields to the point where it can reduce the price of the tube and build "a lot more tubes" with just one or two defects. The defects—leaky diodes that show up as small white specks in the display—now run about 10 to 12 per array, or a total of about 20 nanoamperes.

In the 1-inch vidicon, a silicon photodiode array replaces the photoconductive coating normally evaporated on the tube face [*Electonics,* April 29, 1968, p. 39]. Bell Telephone Laboratories first developed the beam-scanned array for its Picturephone system and TI has been doing similar work in the near-infrared region (0.9 to 1.1 microns).

One track. All production tubes are going to the military system, which is also being built by TI. "But we've got several expressions of outside interest," Skaggs comments. Price of a tube with 10 to 12 defects is $6,500; one with one or two defects costs $9,800. Because of the high price, TI "won't get out a spec sheet" and has given "no thought to an industrial line now," Skaggs says. The company hasn't achieved broadcast quality with the tubes yet, he adds, but as far as industrial applications go, "we're there."

One silicon vidicon has a resolution of 350 tv lines and an array center thickness of 0.0012 inch. A later tube with a 0.001-inch-thick array has a resolution of 550 horizontal tv lines. The target array must be mounted mechanically and it takes "a few weeks of work before it is properly installed in the tube," Skaggs says.

An array of 468,000 diodes in a 760-by-600 arrangement on a 0.62-by-0.48-inch rectangle is made by a p-type diffusion into the n-type silicon wafer. The 0.3-mil diodes are on 0.8-mil centers, and small islands of gold are placed upon each one to eliminate electron-beam charging of the insulating surface. The beam, which scans the rear of the target array, deposits electrons to drive the diodes to cathode potential. The diodes thus become reversed biased, and the incident light creates minority carriers (holes in this case) that cause the diodes to lose their charge-storing capability. In the video-producing step, the returning electron beam redeposits electrons to bring the diodes back to cathode potential.

Higher efficiencies. Maximum quantum efficiency of the silicon vidicon is about 25%, peaking between 0.85 and 0.9 micron, but an antireflectance coating increases this to about 40% to 50%. And Skaggs feels that more attention to such factors as surface recombination velocities and the lifetimes of crystal minority carriers can possibly boost the efficiency to 60%. Current reconaissance systems observe infrared-laser returns from a target with the S-1 cathode in image orthicons, secondary-emission conduction tubes, and direct-view storage tubes, but all of these devices suffer either from low quantum efficiency in the near-infrared region or unstable photocathodes above room temperature.

The silicon vidicon—both the tube and target array—can take 325°C without damage, though it can't operate at such temperatures. There's less lag and smear than in a standard vidicon, and there's no need to protect the tube from sudden high light levels.

Since the tube can take high temperatures, a 325°C bakeout should provide longer tube life, Skaggs feels. TI is working on this. This step should raise tube life to

10,000 to 20,000 hours—comparable to that of cathode-ray tubes. Present silicon vidicon life is about 5,000 hours.

TI also looked at the possibility of applying large-scale integration to make the camera fully solid state, but "the time frame on this project (the military production contract) precluded our doing this," Skaggs says. TI is also developing a germanium-type array that peaks at about 1.3 microns, but this system has to be cryogenically cooled.

Space electronics

Shot seen 'round the world

It will still take several weeks for the National Aeronautics and Space Administration to complete its evaluation of the Apollo 8 mission. But NASA's scientists—after discussing and dismissing a few very minute problems—will undoubtedly come to the same conclusion reached by the nation's press and public, the trip around the moon was a smashing success.

One reason the average American can confidently attest to the success of Apollo 8 was the image of the mission portrayed on his television set. In a series of unprecedented spectaculars, the world's tv viewers were treated to real-time views of the lunar surface, the earth from afar, and life inside the space capsule. In the broad field of electronics serving the three astronauts, the obvious star was the communications system.

Unglamorous tasks. Only part of the success of the unified S-band setup was seen on the television screen; the system was also for the transmission of voice messages, recorded telemetry, and scientific data for the spacecraft. The versatile S-band antenna performed well. A high-gain array consisting of four 31-inch parabolic reflectors clustered around an 11-inch-square wide-beam horn, it was developed by the Textron division of Dalmo Victor in Belmont, Calif.

Engineers at Dalmo Victor feel that their system worked well but are hesitant to go overboard in congratulating themselves. It is their contention that the system didn't get the workout it deserved.

Dalmo Victor was particularly interested in the antenna's ability to stay homed in on an earth station. Of the antenna's three modes—manual, automatic track, and automatic reacquisition—the latter was used least on the lunar mission. The reacquisition mode allows the spacecraft to stay on the air continuously—an especially challenging feat since the craft rotates about its roll axis in order to keep its outer surfaces at a constant temperature.

Outer limits. During such rolls, the earth station is tracked until the antenna reaches its gimbal's limit, which keeps the array from pointing at the spacecraft and producing false signals. At that point, integrated logic circuitry drives the antenna to the opposite limit and permits it to quickly reacquire the primary ground station as the antenna emerges from the spacecraft shadow. On the Apollo 8 flight, vhf omnirange equipment was used more than Dalmo Victor anticipated and the automatic reacquisition mode could not be fully evaluated.

Despite this reservation, the flight proved that the unified S-band system could handle the varied and complex communications requirements of Apollo from earth to the moon and back.

Communications

Relaying greetings

The Christmas-New Year's season is the busiest time of year for transatlantic communications. And the International Telecommunications Satellite Consortium didn't want to miss this opportunity to start cashing in with their newest satellite, Intelsat 3A.

Launched "beautifully" Dec. 18, the satellite just missed going into commercial operation by Christmas. But the Comsat officials managing the satellite for Intelsat hoped to have it relaying both television signals and voice and data signals by early last week—in time at least to catch some of the New Year's greeting traffic.

Initial tests and positioning, carried out through Christmas Day, were slowed a little because the earth station at Etam, W. Va., was needed for transmitting Apollo 8 television pictures to Europe. A week after the launch, Comsat officials would not speculate on how the first tests of the satellite were shaping up; the testing is included in Intelsat's contract with TRW, and the buyer obviously wants to be certain that the satellite meets all requirements before giving it a stamp of approval. This is especially so since this is the first commercial satellite made by any firm other than Hughes Aircraft. Furthermore, Hughes has been the only firm until now to build a synchronous satellite.

Language barrier. Another complication is the fact that TRW had a relatively large number of foreign subcontractors working on Intelsat 3A. ITT, one of the four major subcontractors, had three of its foreign subsidiaries—in France, West Germany, and Belgium—providing subsystems. Six other foreign firms—two in France and one each in West Germany, Britain, Switzerland, and Japan—also supplied subsystems.

The satellite, which has a mechanically despun antenna and an effective power of 22 dbw, contains two transponders. Transmissions are received in the 5,920-to-6,420-megahertz band, and are sent back to earth in the 3,695-to-4,195-Mhz band. Intelsat 3A, with 1,200 voice circuits or four television channels, has five times the capacity of the Intelsat 2.

The next in the series of four Intelsat 3 satellites will probably be launched in early February and positioned over the Pacific. Comsat hasn't set a date for the launch of the third satellite, to be placed over the Atlantic Ocean, nor the fourth craft, slated for the Indian Ocean.

The first launch of Intelsat 3, on Sept. 18, failed when the three-stage Delta rocket broke up shortly after liftoff. This means that Comsat has just one "spare" left under

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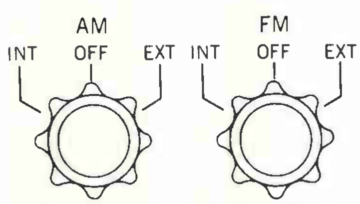
- Selectivity Testing
- Cross-Modulation Testing
- Study of Detector Discriminator Performance
- Measurement of Drift



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the terms of the $32 million contract with TRW, which calls for two reserve satellites.

Consumer electronics

Fingertip control

Television sets with electronic tuning—one of those little extras that set makers would love to offer the consumer but haven't up to now because of the high cost—will start rolling off the assembly line later this year. Both the F.W. Sickles division of General Instrument and Standard Kollsman Industries are now making the tuners, which allow the tv viewer to simply press a button to get the station he wants. All the channels are preset and the switching action is electronic. [For more on electronic tuning for tv sets, see page 88.]

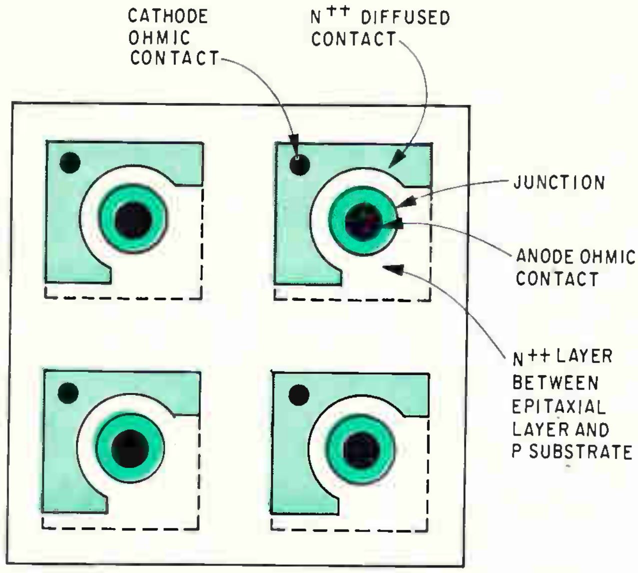
Although neither company will say which set makers are buying the tuners, Albert Schrob, a GI engineer, says the list is impressive. However, one company, RCA, which makes its own tuners, may be the first to market a set with all-channel varactor-diode tuning.

Until now, the chief obstacle to the application of the tuners has been the diodes. For one thing, they are difficult to make with sufficient capacitance variation to cover the very high and ultrahigh frequency spectrum. For another, the diodes' voltage-capacitance characteristics must be carefully matched with each other, a difficult and costly process.

One approach to these problems is to integrate the diodes on a single substrate, a tack adopted by GI's Microelectronics division, which will provide F.W. Sickles with the IC's. Four matched diodes are integrated on a 50-mil chip, which is packaged in a ¼-inch square eight-lead flatpack.

Richard Adler, one of the developers of the new IC, says that this approach should eventually reduce the cost of the entire tuner.

Currently, the electronic tuners are about twice as expensive as conventional devices. For example, Standard Kollsman's conventional tuners are sold to the set maker for $10; its varactor diode tuners are priced at $20, although this includes $5 for the pushbutton bank.



Matching. Four varactor diodes on a single chip designed by General Instrument may lead to development of inexpensive electronic tuning for television.

SCR's in tv

The advantages of the switch from tubes to solid state components in color television sets were clear: improved reliability and performance. But these advantages were just as clearly offset by some disadvantages: price rises of from $100 to $200. Part of the price rise was due to the need for additional or expensive components to handle the high voltages that are beyond the capability of some solid state devices. RCA, however, has found a way to get rid of one costly component—the high-voltage transistors used in the horizontal deflection system—by replacing it with less expensive silicon controlled rectifiers and diodes. Also eliminated is the expensive power transformer and its complementary filter circuit. The savings, for the consumer, is estimated at $20.

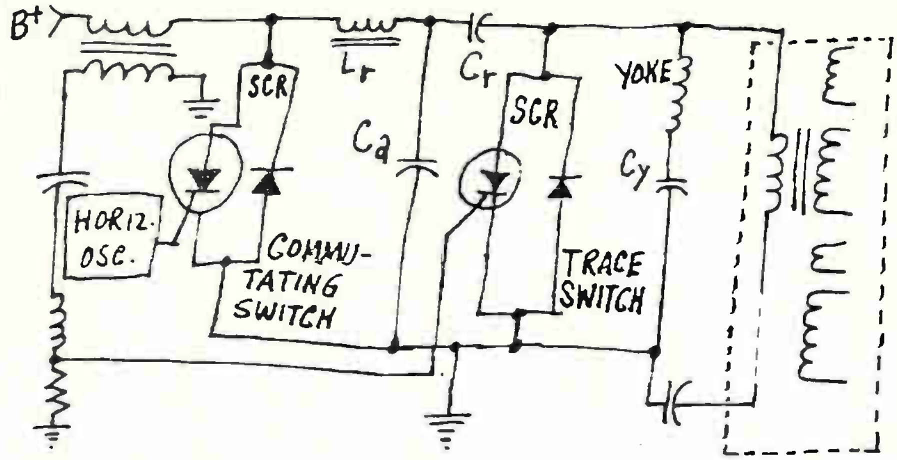
"The circuit produces as much deflection energy and beam current as the best tube circuits available," says Don E. Burke, one of its developers, "but is less expensive than alternate systems since it operates directly from the rectified power line."

The switch. In conventional horizontal deflection systems, current is transferred to the deflection yoke near the end of each sweep trace by a transistor-controlled switch. The beam retrace results from the energy stored by the yoke inductance and retrace capacitance. The only drawback of this method is that most of the available transistors can't handle the high current that's needed to drive the sweep circuits of large-screen color sets.

In RCA's horizontal deflection circuit, the high current is switched off and on by SCR's and fast turn-off diodes. The retrace yoke current is controlled by a commutating switch that turns off the trace SCR and transfers energy to the yoke.

The energy storage and timing cycles are achieved by retrace inductor L_r, (see diagram) with capacitors C_a, C_r, and C_y. The charge path from the set's power supply to the retrace capacitor, C_r, is through the input inductor. The gate trigger for the trace switch SCR is derived from a secondary winding on the input inductor.

Open and shut. The commutating switch enables the yoke current to reverse for retrace and transfers energy from retrace capacitor C_r into the yoke, for the next trace. The switch is closed by a trigger from the horizontal oscillator just prior to retrace, and opens shortly after retrace is com-



Deflecting with SCR's. RCA's new circuit in horizontal yoke winding eliminates need for costly high-powered transistors and power transformer.

pleted. The input choke stores energy when the commutating switch is closed. The choke current then charges the retrace capacitor when the switch opens. In the complete circuit, the commutating SCR acts as a regulator to maintain the sweep and high voltage within acceptable limits in the presence of a-c line voltage and picture tube beam current variation.

For the record

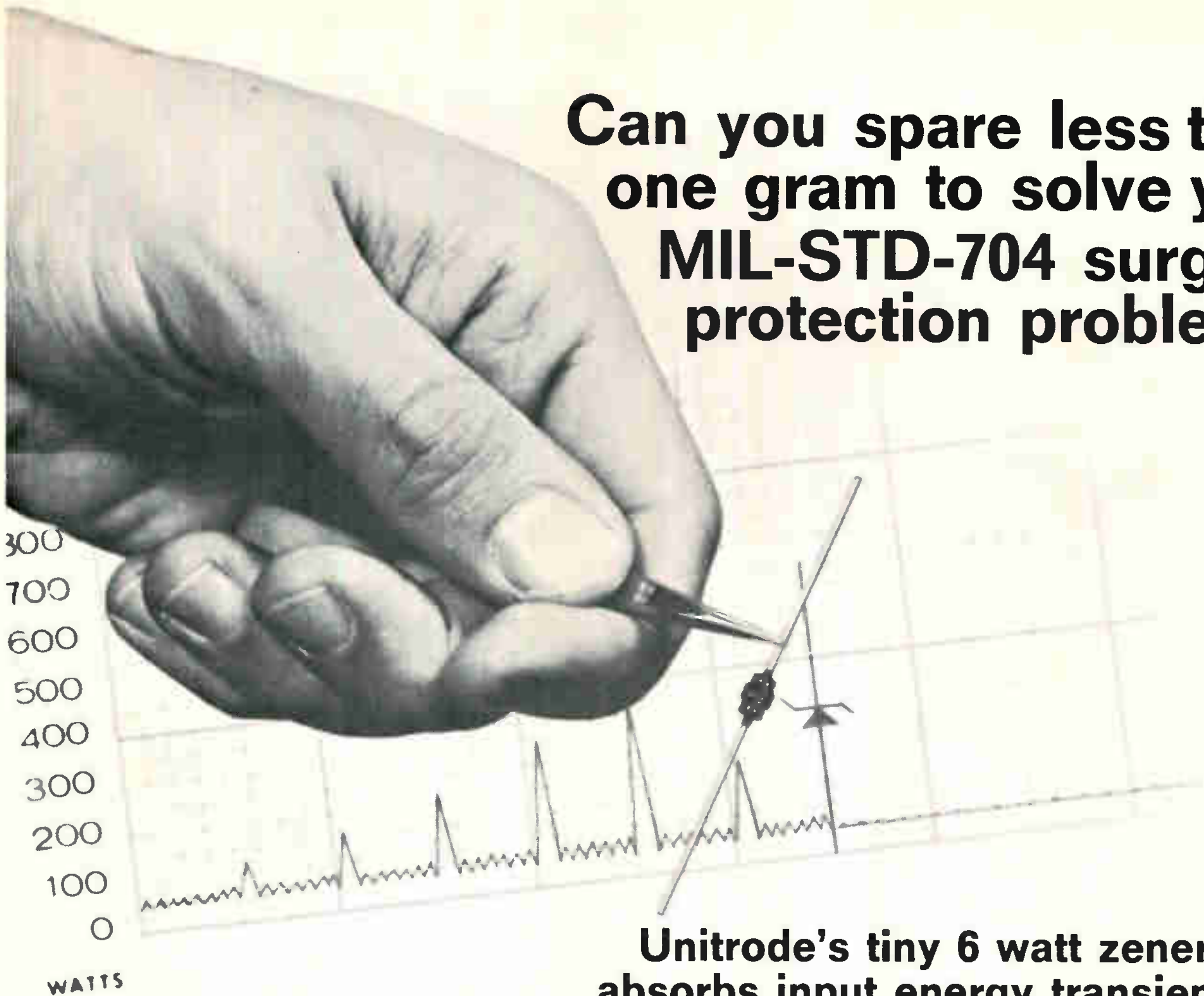
Showers forecast. Radio astronomers at the Air Force's Cambridge Research Laboratories have hit upon a technique for predicting proton showers 4 to 14 hours before they occur, giving plenty of time to readjust surveillance gear.

Although not as frequent as solar flares and magnetic storms, solar proton showers are far more destructive and harder to predict. In fact, they can totally black out radio communications. And they occur most frequently in the polar regions, where much of the U.S. air defense radar and missile detection systems must penetrate.

The labs' astronomers will continuously monitor radio-frequency output of the sun over a band from 200 megahertz to 15.4 gigahertz. When the sun's r-f output exceeds 1,000 flux units (a flux unit is 10^{-22} watt per square meter per hertz), and when such a burst is accompanied by a dip in power in the 0.6-Ghz range, there will probably be a proton event. The new system is expected to be more accurate than the optical techniques used formerly.

Memory reconsidered. Westinghouse is taking another look at its experimental metal-oxide-nitride-oxide semiconductor (MONOS); it thought the memory devices could lead to high-speed MOS flip-flops [*Electronics*, Oct. 28, p. 49]. But now the device looks like it can never be applied to high speed read-write computer applications below the microsecond range. Reason: the 75 to 100 volts required to switch the devices in nanoseconds cause "fatigue" in the nitride layers along with loss of the memory characteristics. One of the developers, Hung C. Lin, says, however, that the principle still shows promise for both read-only memories and lower speed read-write uses. Unknown right now, he says, is whether or not other forms of nitride exhibit the same limitation.

Package deal. The Digital Equipment Corp. is now debugging software for a low-cost system including a PDP-8/I computer and a new graphics display terminal. The system, which uses a Tektronix storage tube, would sell for less than $20,000. It may be announced officially as early as February. Digital Equipment's aim appears to be a share of sales now going to graphics systems costing from $40,000 to $100,000.



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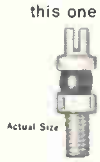

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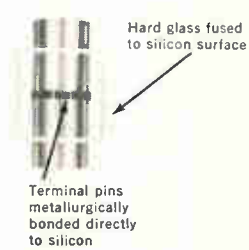

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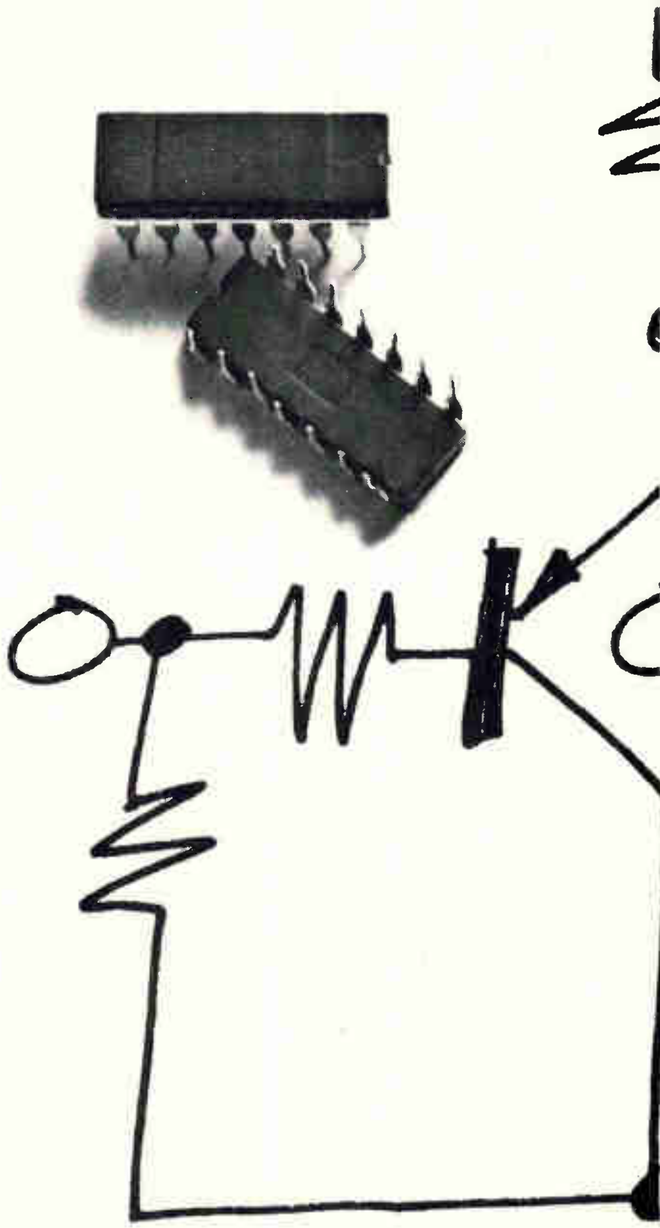

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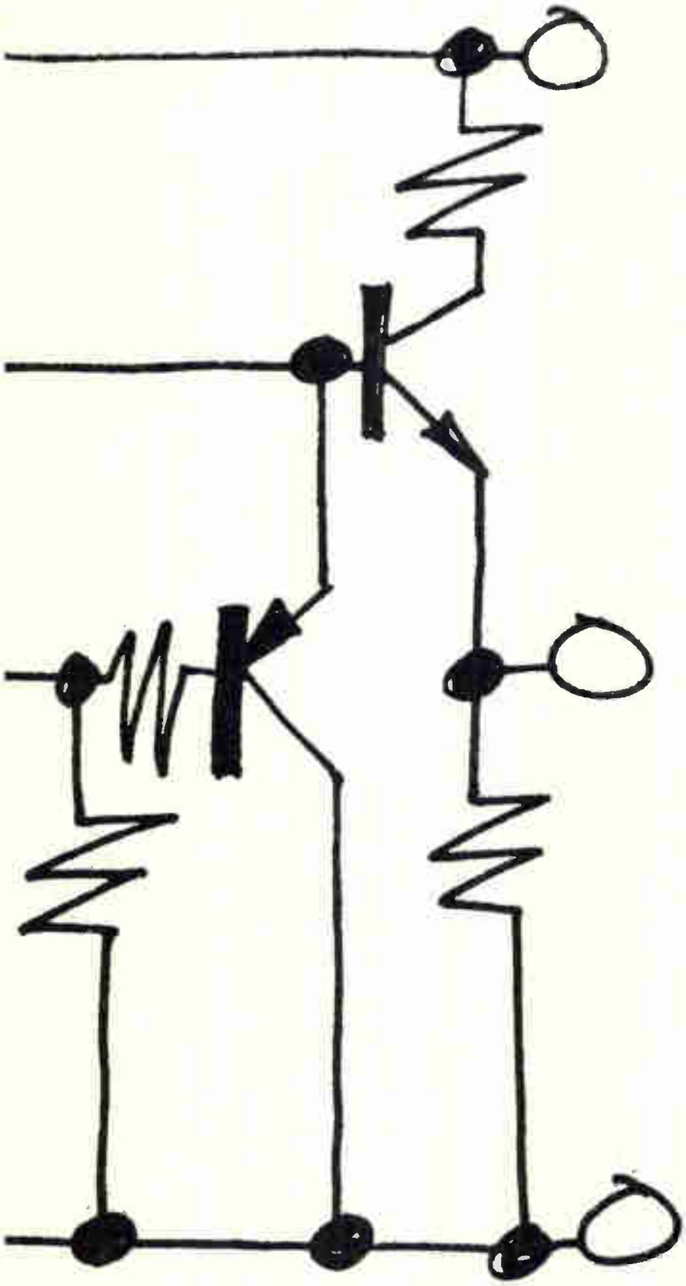

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9964 Dual Three-input and Single-input AND Gates	1.25
9965 Quad Single-input AND Gate	1.25
9966 Quad Two-input AND Gates, one pair with OR-tie	1.25
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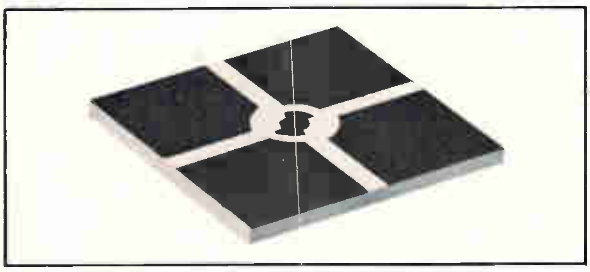
MICROWAVE IC PROGRESS REPORT #5

PACT proves microstrip is compatible for MIC mixers, filters, hybrids

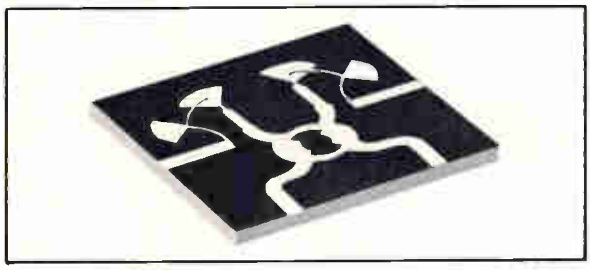
Before microwave integrated circuits can become a reality this important question must be answered — can present stripline technology be converted to microstrip without a prohibitive performance penalty? Engineers and scientists engaged in Sperry's PACT (Progress in Advanced Component Technology) Program have found the answer, and the answer is yes!



TWO-BRANCH MICROSTRIP 3 DB COUPLER

PACT investigations have already produced couplers, balanced mixers and a number of hybrid circuits, all utilizing the basic microstrip technology. Performance penalties have been negligible, and all indicators point to production availability of entire subsystems deposited on a single substrate.

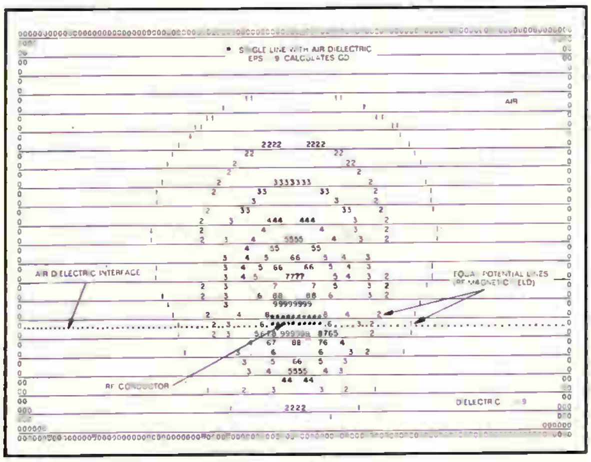
Like other PACT activities, this effort has depended heavily on the proper selection of materials. For multi-function substrates, such as those capable of carrying entire subsystems, Sperry's choice is a composite of ferrimagnetic and alumina substrates. In some cases all-ferrimagnetic substrates are recommended.



MICROSTRIP BALANCED MIXER CIRCUIT

This approach provides maximum size, weight and cost savings, along with significant increases in thermal and mechanical stability.

PACT has also benefited from the use of the computer as a design aid. For example, the computer was programmed to calculate the electrostatic potentials around a microstrip circuit and determine its impedance. Options were then added to the program to obtain a print-out of actual potentials around the microstrip and to plot equal potential lines.



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Washington Newsletter

January 6, 1969

Imps job goes to Bolt, Beranek

The Pentagon's Advanced Research Projects Agency will award the contract for the Interface Message Processors (Imps) for its computer network to Bolt, Beranek & Newman of Cambridge, Mass. **The contract will cover the fabrication, testing, and integration of processors to connect the network's 35 computers and 1,500 remote consoles,** many "incompatible." The coast-to-coast time-sharing network will be the first to unite multilingual computers [Electronics, Sept. 30, 1968, p. 131].

Even though the contract isn't expected to exceed $2 million, it was hotly contested because of the unique nature of the job. **Linking the ARPA network, it is felt, will give a company an entree into complex computer networking jobs both inside and outside Government.** A total of 51 companies showed interest in the job, and 14 bid on it.

Decision on 621B due this summer

The Pentagon is expected to make its decision this summer on whether to continue work on the Air Force's 621B navigation satellite system. Hughes and TRW, which are doing $500,000 parallel studies on the program, will present their preliminary design and analysis studies later this month to the Space and Missile Systems Office (SAMSO).

Original plans were to pick a contractor in fiscal 1969, but the Air Force received only $500,000 this year, just enough to keep the program alive [Electronics, July 22, 1968, p. 34]. RCA had proposed using this money to take one of its Tacsat tactical ground terminals and test the feasibility of a scheme to derive navigational fixes from the Tacsat communications signal. SAMSO, however, has turned RCA down.

EIA may join talks on phone attachments

Although the Bell System won't like it, the Federal Communications Commission's Common Carrier Bureau will probably invite the Electronic Industries Association ad hoc committee on communications interfaces to sit in on discussions of technical standards for customer-owned phone attachments.

While the FCC allowed the phone company's new tariffs on customer-provided equipment to take effect Jan. 1, **detailed technical standards for attachments must still be hammered out.** The new rules—which can be changed—will allow businesses to attach switchboards, phones, microwave systems, and intercom systems to the Bell network. **What remains as a ticklish point of dispute is the requirement in the new regulations that Bell "furnish, install, and maintain" network control and signaling units** that are used for computer switching. The EIA characterizes this as "common carrier featherbedding."

Proposed IC specs could move Pentagon

The Electronic Industries Association is sending out its first draft of proposed general specifications covering all microelectronic devices. **The EIA stresses that drawing up specifications is an industry effort that doesn't include the military.** The present Pentagon policy is to keep hands off the standardization of IC's [Electronics, April 15, 1968, p. 68], except when used in specific systems, such as Minuteman. But industry acceptance of IC specifications will push the military toward changing its policy.

Meanwhile, the Pentagon is having headaches with Military Standard

883, which sets specifications for the test methods and procedures concerning microelectronics. **Contractors are being forced to obtain waivers because some of the specifications are not workable with newly developed IC's.** The EIA and the military are working out proposed changes in 883, but they won't be ready for at least a year.

Digital voice tests slated this month

The Defense Communications Agency this month hopes to begin laboratory and hot-line testing of systems for transmitting voice signals digitally. **Even if the tests prove successful, though, DCA officials aren't optimistic about putting the systems into operation.** Explains one: "There's a dollar problem." The DCA originally had hoped to launch the four-month test program last summer [Electronics, May 13, 1968, p. 30], but the startup was postponed because the agency couldn't get telephone lines from Ma Bell.

One line will link a DCA station in Maryland with Communications & Systems Inc., the Washington, D.C., contractor running the tests, while another will tie the station to the firm's Huntsville facility.

DCA will evaluate systems bought from Radiation Inc., Philco-Ford, and Honeywell in the automatic secure voice communications (Autosevocom) section of the agency's Autovon network.

FCC jobs look safe for top 6 appointees

Although under pressure to make some changes, President-elect Richard Nixon **will probably retain all six top staff members of the Federal Communications Commission.** Three of the six are Democrats: Max D. Paglin, FCC executive director; Henry Geller, general counsel; and Bernard Strassburg, chief of the Common Carrier Bureau. All are long time employees of the FCC. **Geller and Strassburg, known as liberals, have been influential in getting the FCC to open up the Bell Telephone System to foreign attachments, through the Carterphone case.**

Navy will study standard packaging

The Naval Electronics Systems Command is about to award a contract for a wide-ranging study of standardization in electronics packaging. The 12-month project, which will cover everything from the plug-in circuit board to six-foot enclosures for use aboard ship, **is to produce a document advising Navy program managers of the advantages of standardization and apprising them of parts and components already in use that might be chosen over newer proprietary gear.** Ideally, the study could save the Navy time and money on electronics parts by reducing inventory and purchasing problems.

Although the prime object is a look at mechanical standardization, the study will also investigate functional standardization, as with the standard hardware program [Electronics, April 15, 1968, p. 171]. The study contract includes a provision that the contractor will have to give several months of presentations on his findings "to sell them to various parts of the Navy," says one spokesman.

Addendum

Signals were mixed when the Air Force finally got the go-ahead to move into contract definition with Awacs [Electronics, Dec. 23, p. 48]. **The Air Force Systems Command will select either Boeing or McDonnell-Douglas to build the flying command post late next fall, not late next spring as the service first indicated.**

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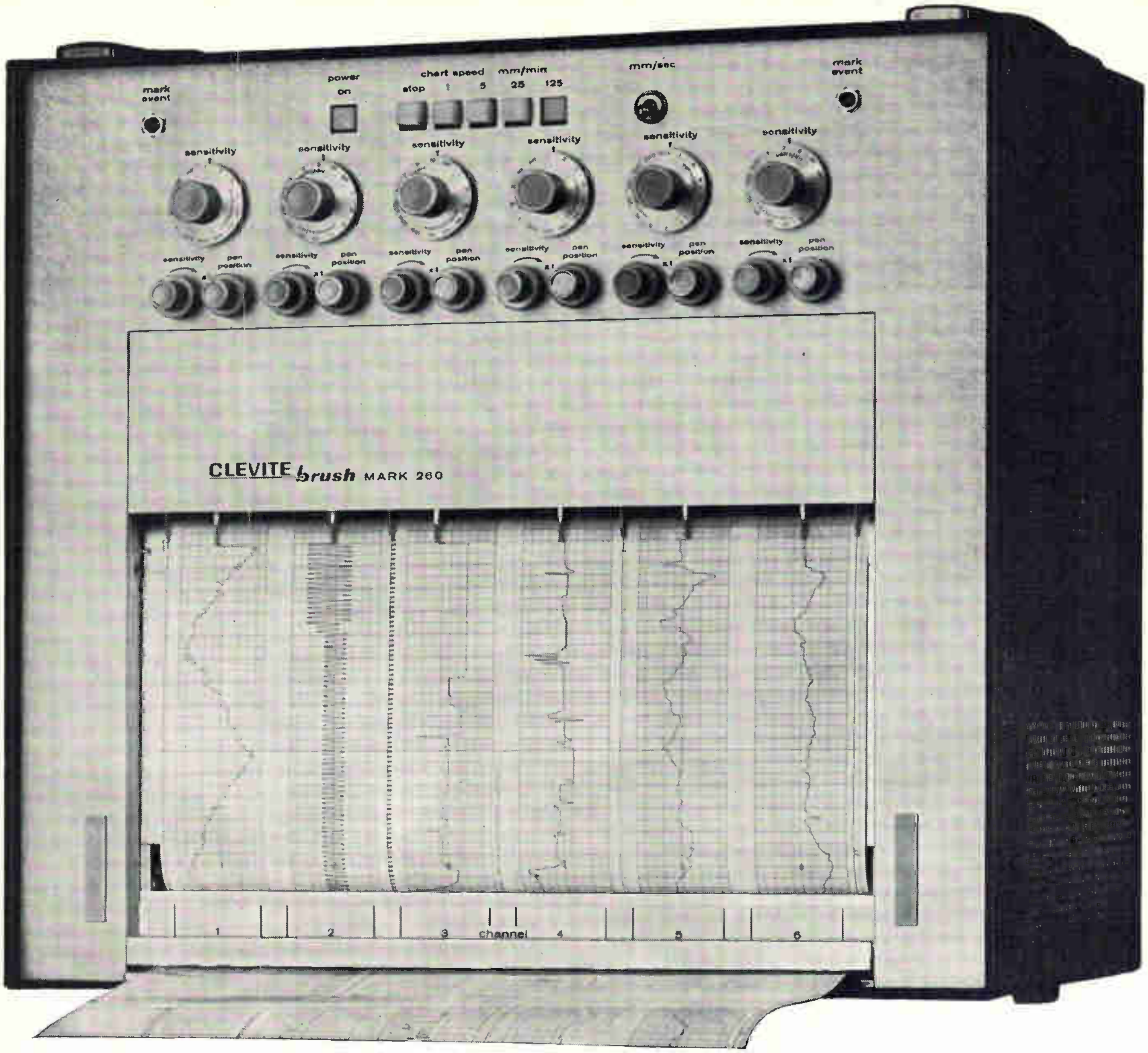

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Circle 81 on reader service card →

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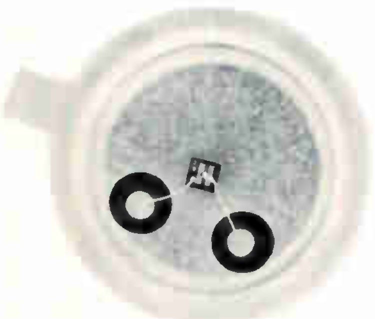

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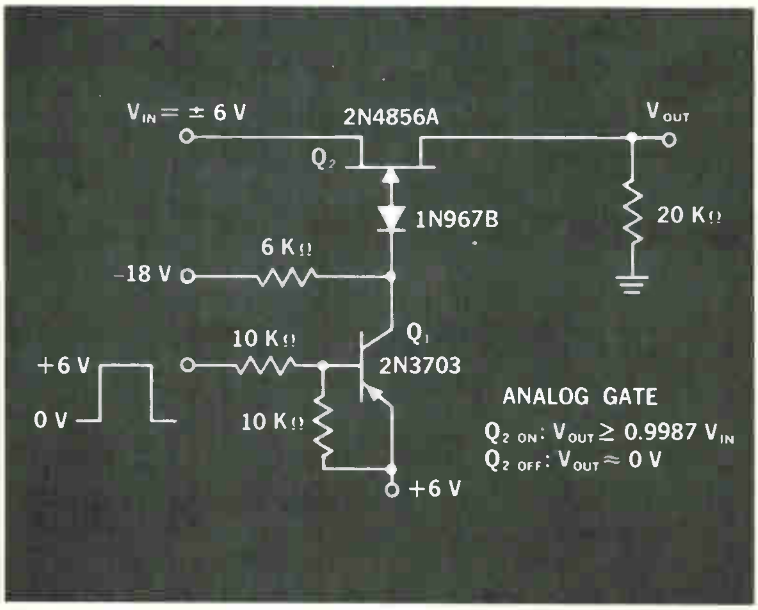
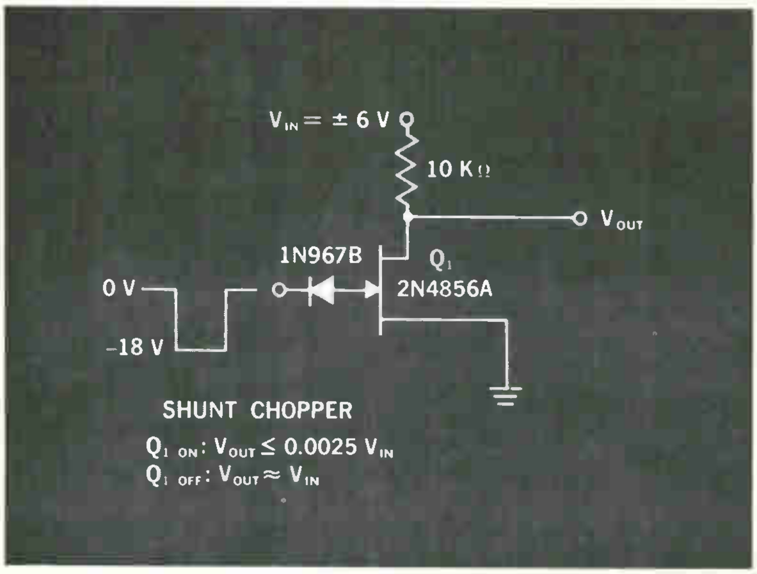


These two circuit applications demonstrate performance advantages of 2N4856A FET.



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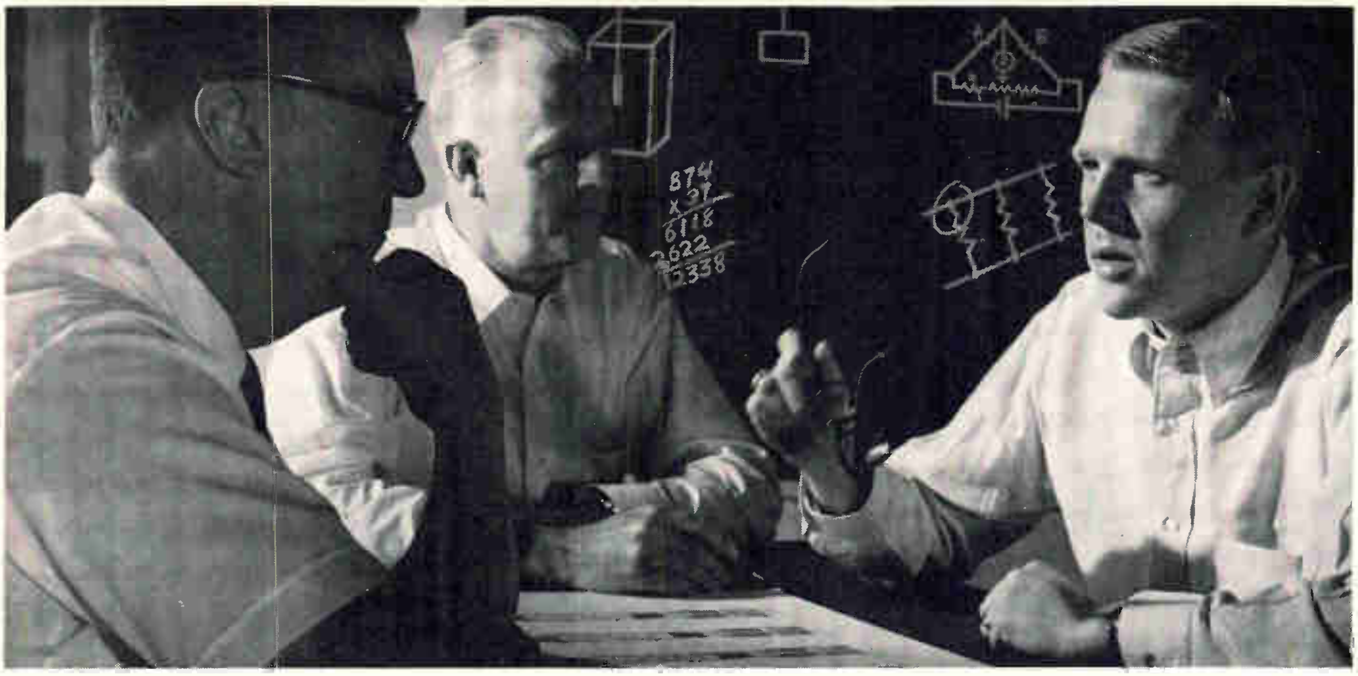

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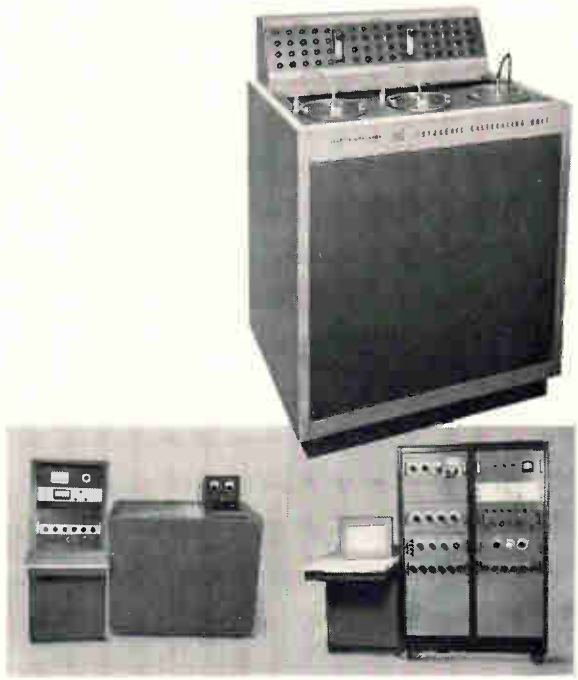

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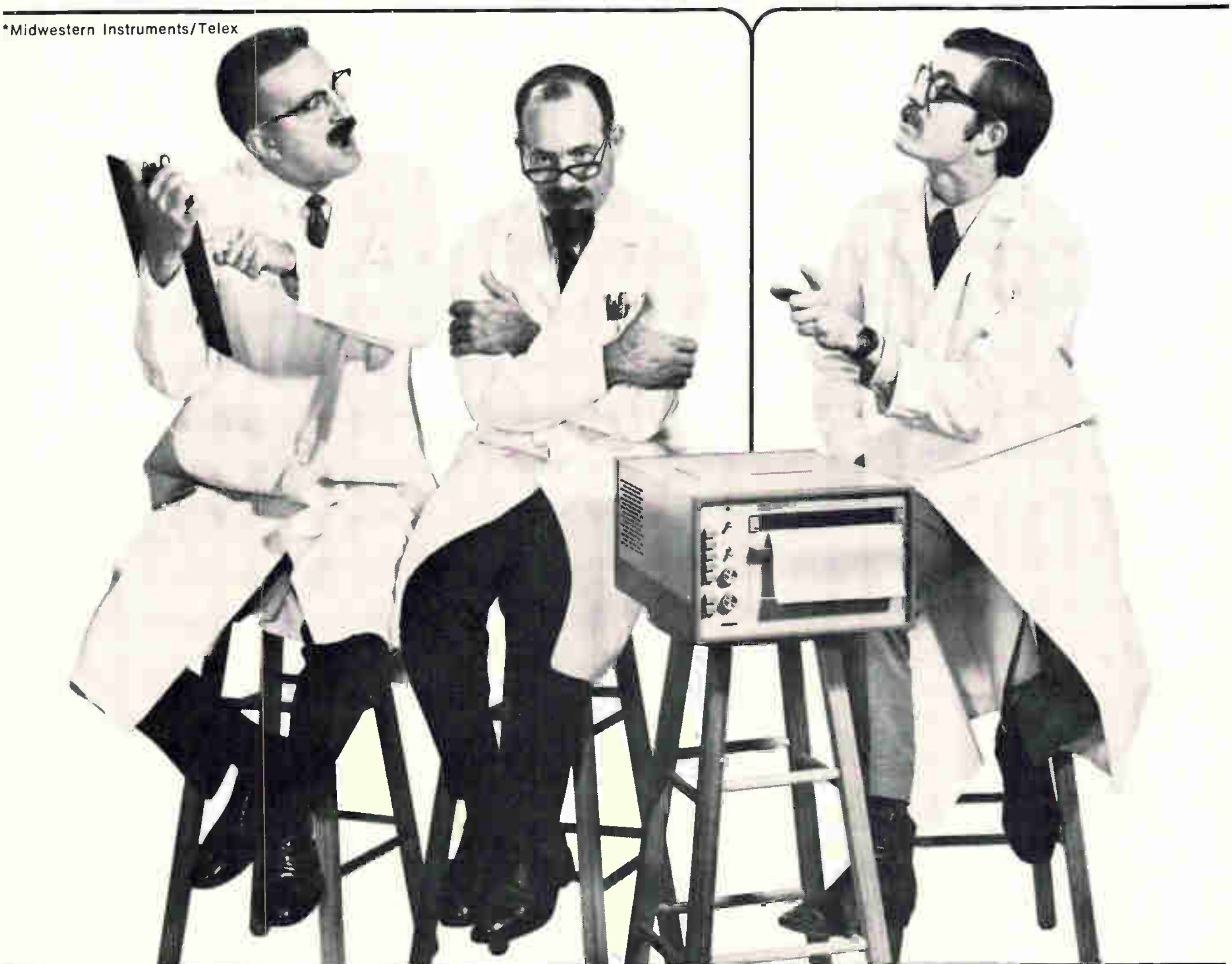

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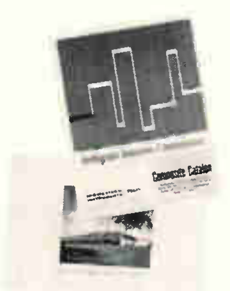

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Color	Clear	Beige	Beige
Consistency	Easily pourable	Pourable	Easily pourable
Viscosity, cps	3500	200,000	8000
Specific Gravity	1.02	1.28	1.18
Solids, %	100	100	100
Shelf Life, months	4	4	4
Cured, ±1 hr. @ 150°C	**RTV-815**	**RTV-830**	**RTV-835**
Hardness, Shore A durometer	35	50	35
Tensile Strength, psi	700	800	500
Elongation, %	150	250	200
Tear Strength, lb/in.	15	100	20

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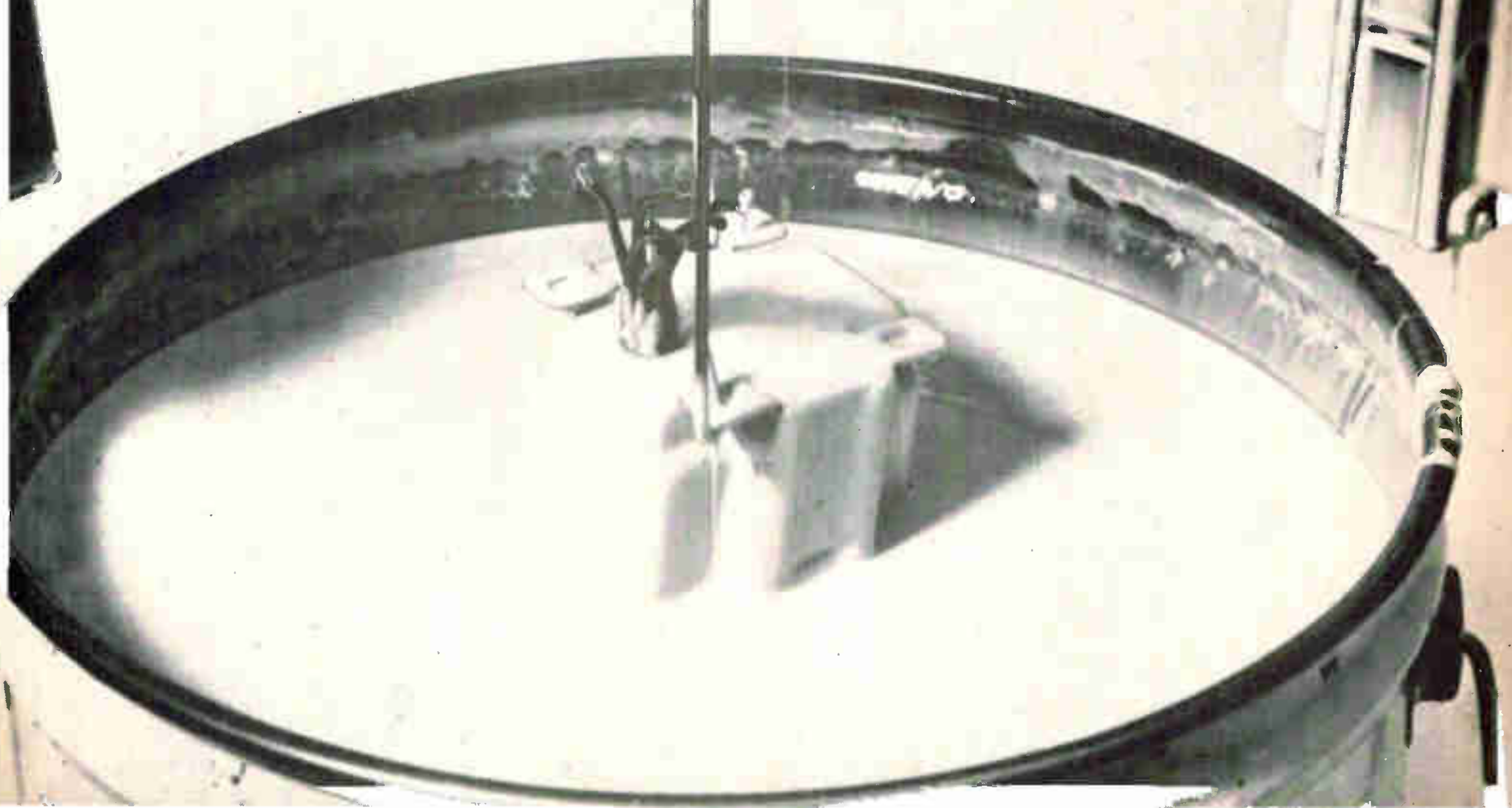
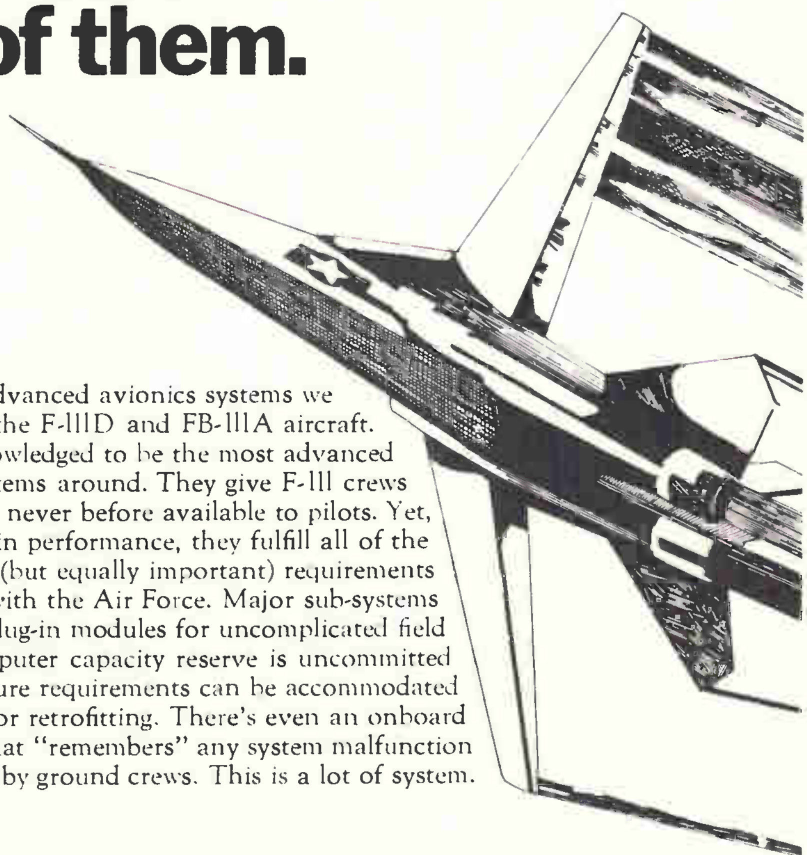


Autonetics plays a vital role in three of the nation's most important defense programs. Here are two of them.



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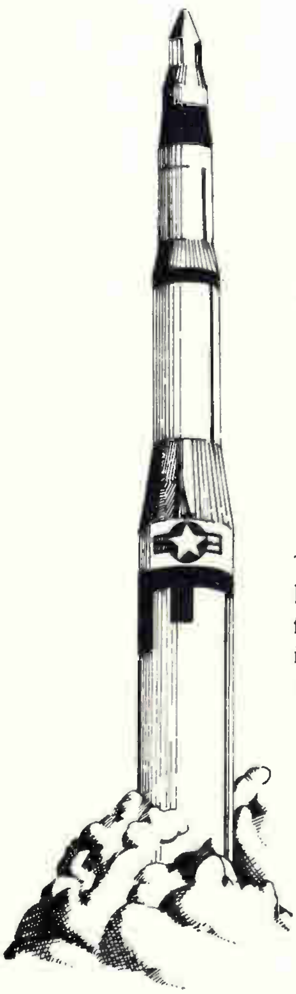

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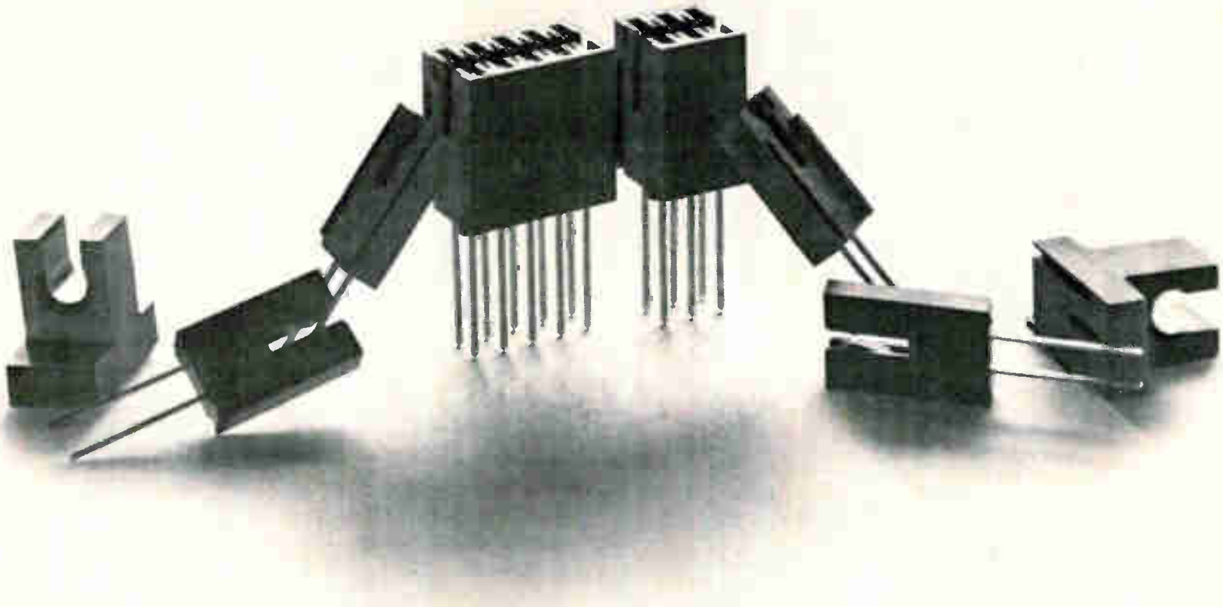
Circle 77 on reader service card→



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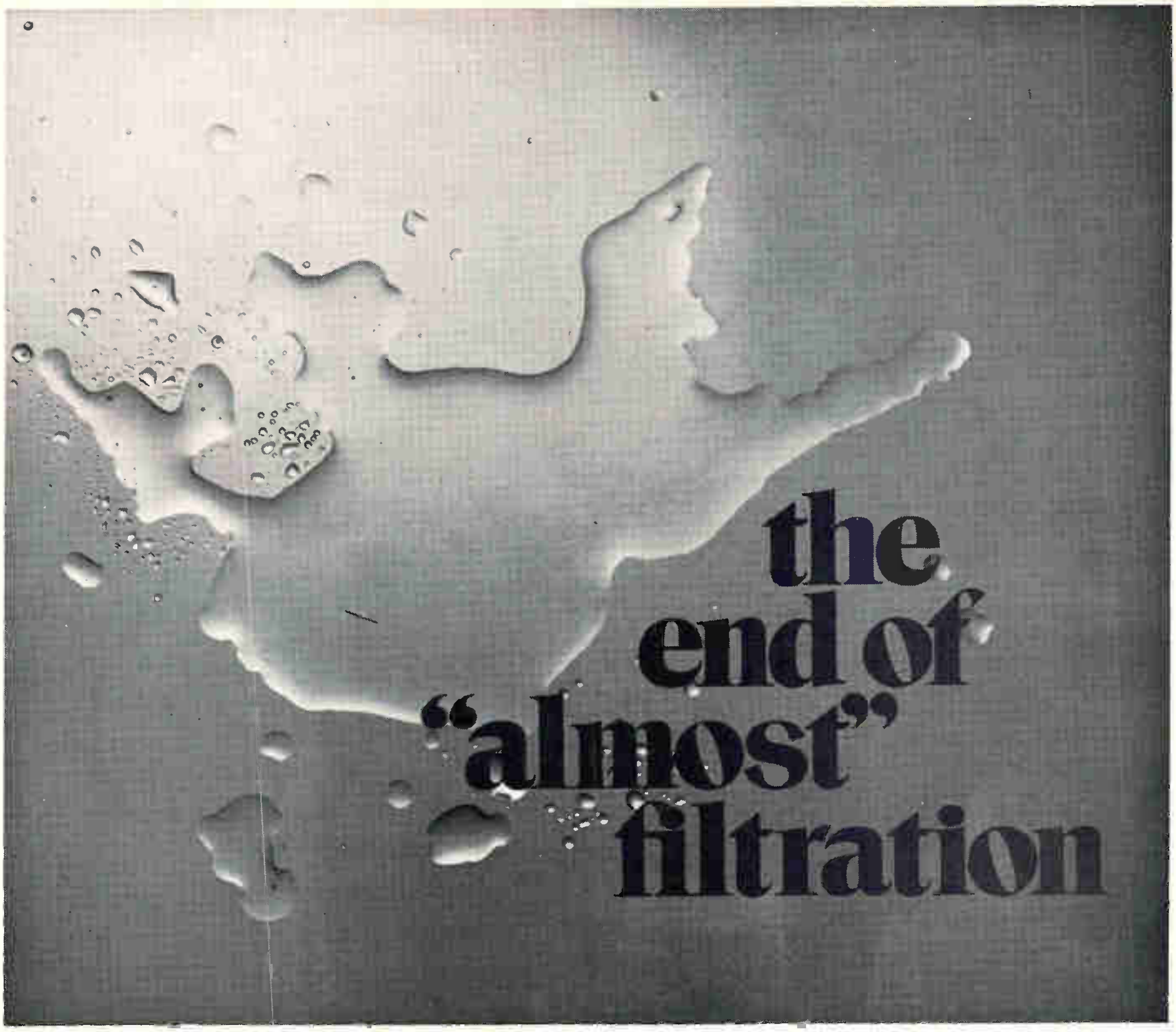

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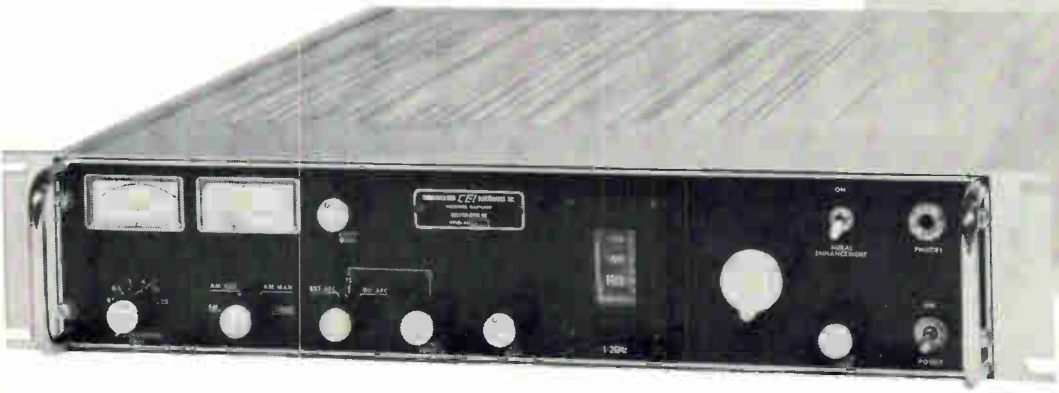

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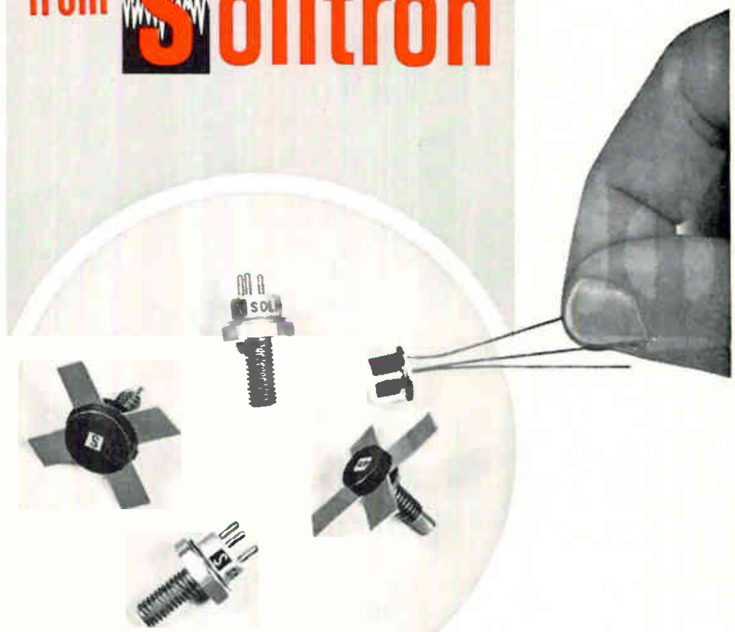

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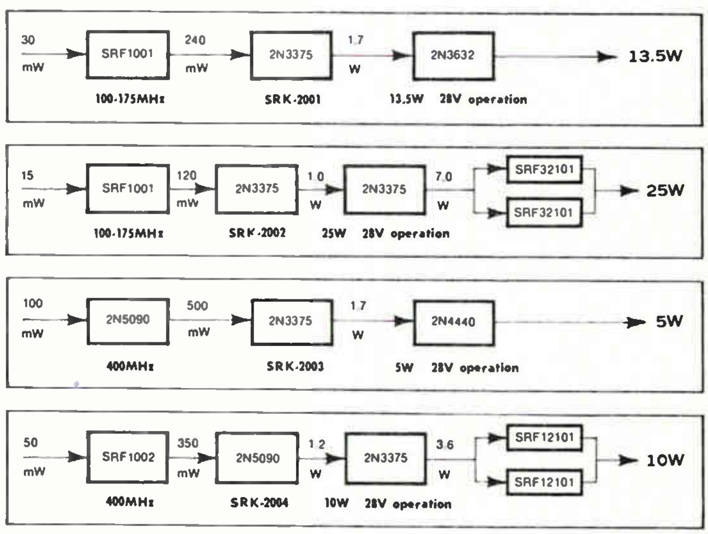

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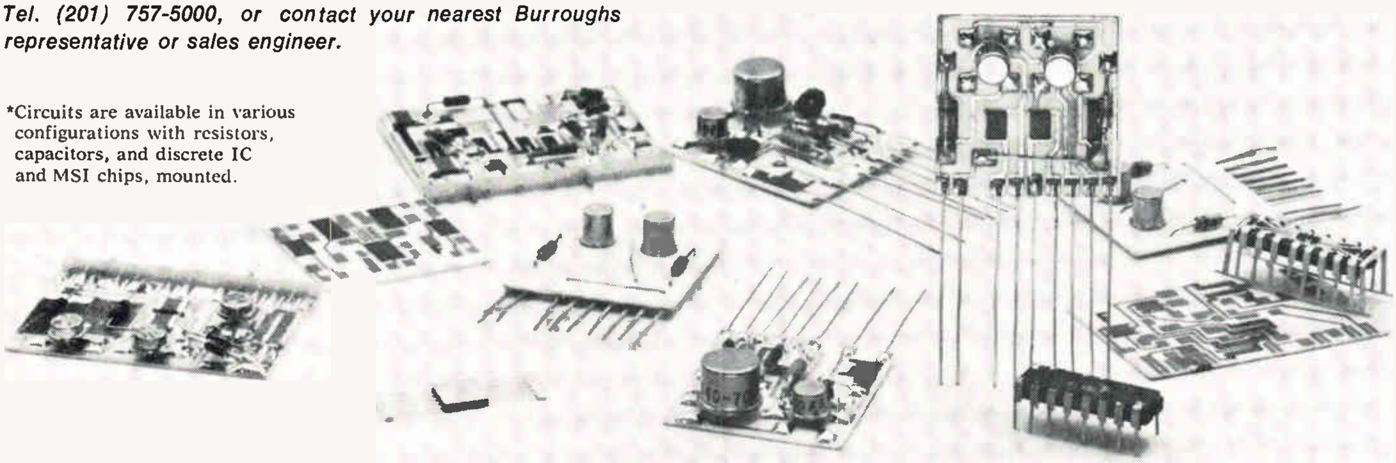


Burroughs

Circle 86 on reader service card

January 6, 1969 | **Highlights of this issue**

Technical Articles

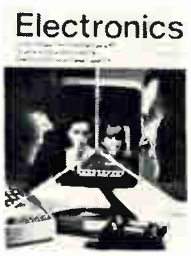
Tuning up with varactor diodes
page 88

European radio and tv set manufacturers are rapidly converting to all-electronic tuning with varactor diodes. But American set producers haven't yet made the changeover, largely because the wider frequency range that must be covered here and our overcrowded spectrum pose severe cross-modulation and selectivity problems. Furthermore, suitable diodes are hard to come by. This article discusses—from a European viewpoint—some of the problems in selecting diodes, and recommends some practical approaches to designing electronic radio and tv tuners.

Hybrid computer takes over control
page 98

Made up of conventional analog and logic modules, this system regulates the flow and pattern of water used to cool fast-moving hot-strip steel. The hybrid computer, which up to now has been a simulation and design tool, has thus graduated to industrial process control. An intriguing feature of this machine, which can also be used to control other types of industrial operations, is a hard-wired, logic-implemented matrix for selecting any one of several operating modes for the plant equipment.

Electronics markets: 1969
page 107
The new math of growth
page 111



Industry revenue this year will advance at about the same pace it set in 1968. Electronics' annual market survey points to another 6.5% rise, this time to a total of $25.3 billion. Although the war in Vietnam continues to hurt sales in several fields, another year of technical gains appears in store. Integrated circuits, for example, are coming on strong in more outlets, notably the industrial. And the computer field, which continues to grow at a dizzying pace, will get a further boost from improved peripheral gear. But despite earlier optimism, large-scale arrays are still several years away from commercial availability.

Coming

IC technology in Britain

Articles in this special report on British advances in integrated-circuit design will cover such subjects as computer-generated interconnections, laser mask-making, multilayer techniques, and ion-implanted circuits.

Overcoming design problems in varactor-diode tuners

Pushbutton tv tuning—rapidly replacing mechanically variable capacitors in Western Europe—requires cancellation of stray capacitances and diode matching to improve reset accuracy

By Hans Keller

Intermetall, Deutsche ITT Industries GmbH, Freiburg, West Germany

Throughout Europe, varactor diodes are rapidly replacing variable capacitors as the main tuning element in radio and television sets. And set producers estimate that more than 50% of all tv sets made in 1969 will be tuned with these diodes. In the U.S., however, manufacturers have had trouble producing electronic tuners [see "The American way" at right].

Diode tuning can sharply increase design flexiblity. For example, because the diodes require only a preset d-c voltage to select each channel, there's no mechanical link between the user's controls and the channel selector, so the tuner can be placed anywhere in the receiver.

And flexibility is only one of many advantages. The use of preset voltages improves tuning accuracy; fine-tuning isn't needed. And the technique makes it possible to easily design a set that can be remotely tuned, because no high-frequency voltages are present on the line between the tuning voltage trimmers and the diode circuitry. And, for sophisticated applications, wireless remote control can be easily achieved without costly motor-driven variable capacitors.

Rounding up the strays

Variable diodes are stable and virtually immune to temperature variations. They perform well in resonant circuits because of their large capacitance variation and high Q-factor. However, for best tracking throughout the tuning range, diodes with identical characteristics must be used. Manufacturers can usually supply diodes in matched pairs, triads, or quadruplets.

The most widely used method of providing the tuning voltage uses inexpensive trimming potentiometers, individually preset, and a pushbutton switching unit to apply or remove the voltage.

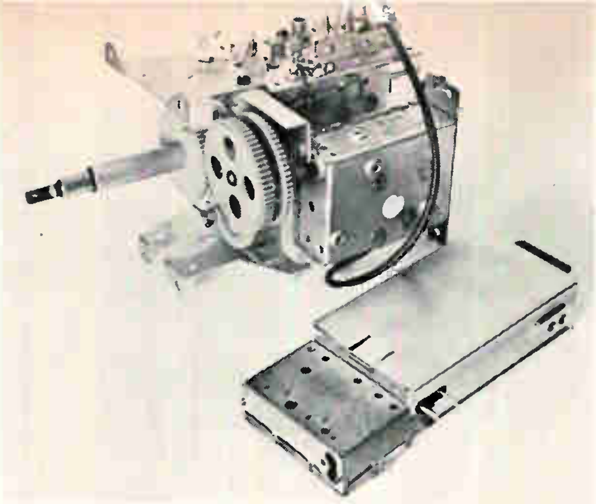
In a typical diode-tuned parallel resonant circuit, on facing page, the tuning voltage is applied to the diode through inductance L and resistor R. Capacitor C_s completes the a-c circuit path. The tunable

The American way

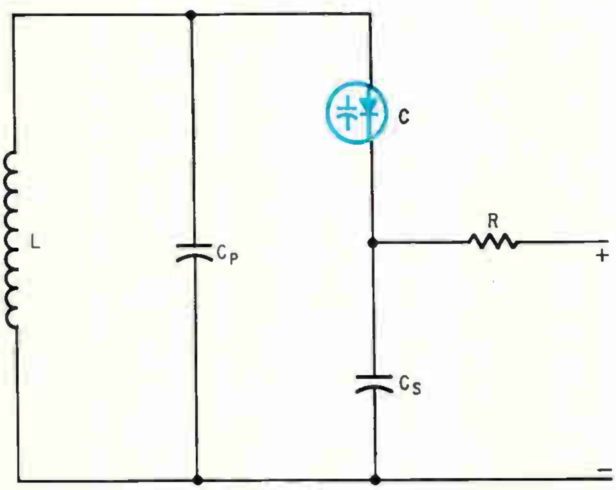
U.S. producers of tv sets, led by RCA and Zenith, are reportedly racing to be first with a varactor diode-tuned set by spring. But of the four independent tuner suppliers—Standard Kollsman, Oak Electro/Netics, Sarkes Tarzian, and General Instrument—only Standard Kollsman and General Instrument have produced varactor-diode tuners. These are now being sampled by the set makers. RCA, for one, will soon use a similar tuner produced in-house.

Some of the difficulties in designing a suitable diode tuner for the domestic U.S. market are attributed to severe cross-modulation problems due to overcrowding of the tv spectrum, as well as the wide tuning range over which the diodes must track. As a result, selectivity requirements are critical. Although most European tv sets are equipped with only about four pushbuttons for the allocated stations, U.S. producers must include 12 buttons for the vhf channels and at least six more for the uhf channels. Switching thus becomes a major cost factor.

"One of our biggest problems," says Edward Midgley, engineering vice president of Standard Kollsman, "is getting suitable varactor diodes."



Small and simple. The all-channel varactor tv tuner from Standard Kollsman is far less complex than the conventional electromechanical uhf-vhf device.



Diode tuning. The circuit's tunable frequency range depends on the diode's capacitance and variation coefficient and on assigned values of C_p and C_s.

frequency range of the circuit is determined by

$$V_f = \frac{f_{max}}{f_{min}} = \sqrt{\frac{1 + \dfrac{C_{max}}{C_p\left(1 + \dfrac{C_{max}}{C_s}\right)}}{1 + \dfrac{C_{max}}{C_p\left(H + \dfrac{C_{max}}{C_s}\right)}}}$$

where C_s and C_p are, respectively, the series and parallel capacitances, and H is the capacitance variation coefficient, given by

$$H = \frac{C_{max}}{C_{min}} = \frac{C(V_{min})}{C(V_{max})}$$

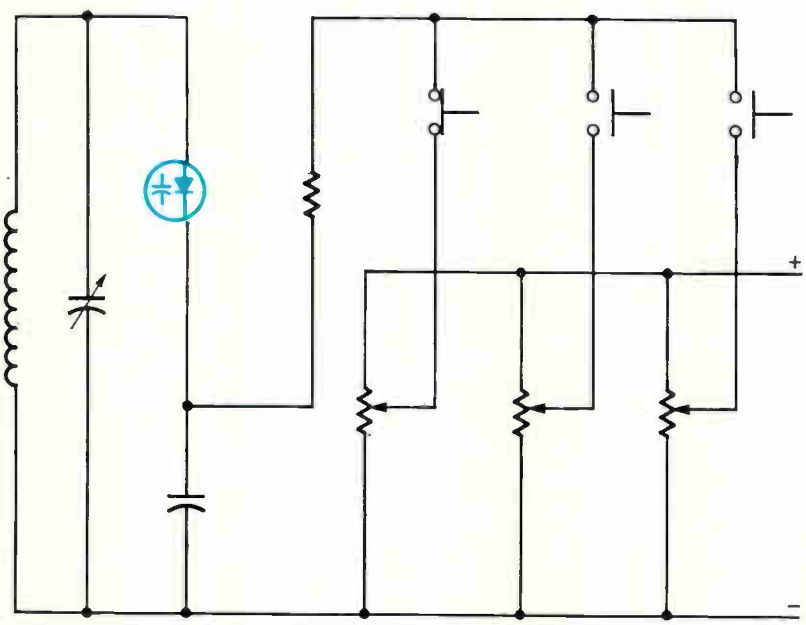
Of course, there's always some additional shunt stray capacitance in the circuit, resulting from the coil winding and wire leads inductance. As the C_s value approaches infinity, the circuit tuning range becomes

$$V_f = \sqrt{\frac{1 + \dfrac{C_{max}}{C_p}}{1 + \dfrac{C_{max}}{H \cdot C_p}}}$$

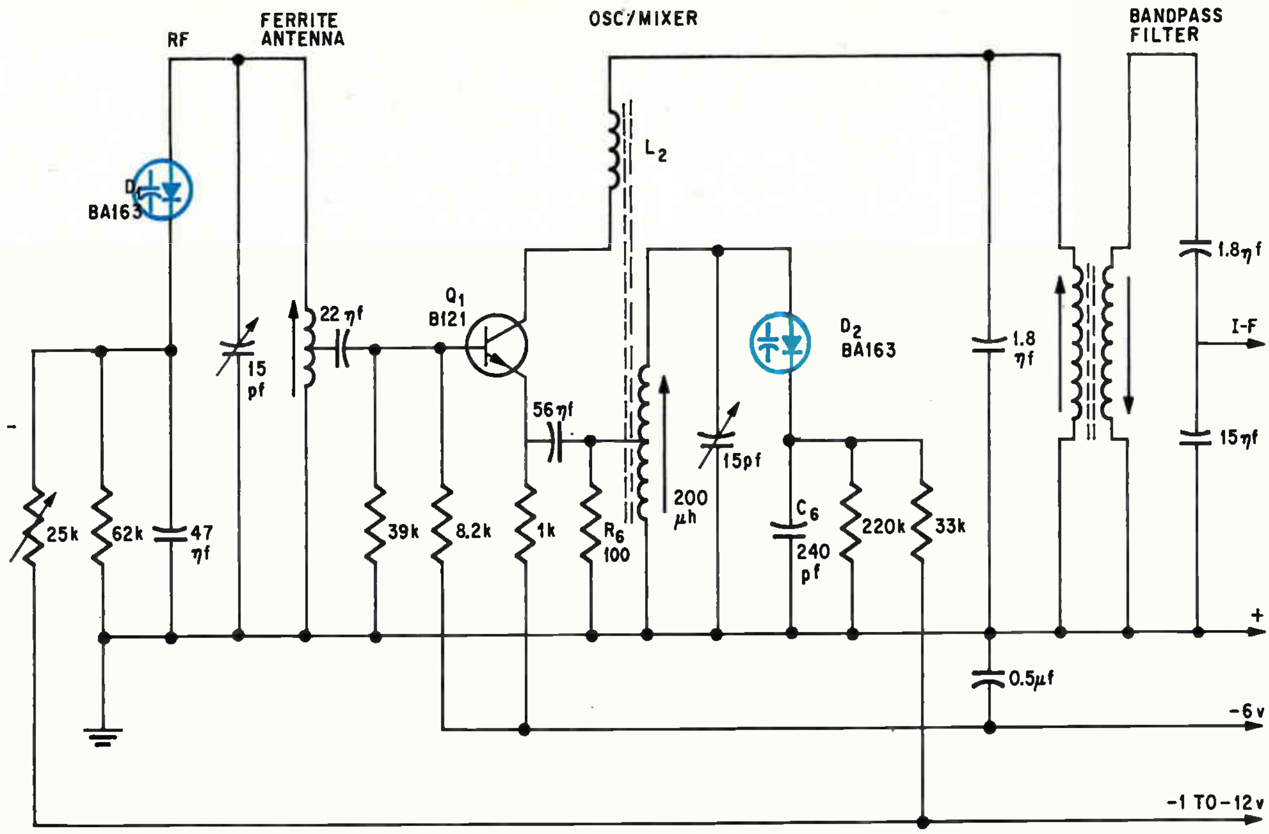
In practice, however, the tunable frequency range, V_f, is known as part of the design problem, as is the approximate parallel capacitance, C_p. Therefore, the preceding equation can be rewritten as

$$C_{max} = C_p \cdot \frac{V_f^2 - 1}{H - V_f^2}$$

The resistance, R, in series with the d-c tuning voltage, appears as a shunt across capacitor C_s.



Pushbutton selector. Trimmer potentiometers are used with small pushbuttons to control the required preset voltages for station selection.



Broadcast band. Designed to cover the 510-to-1610-khz band, the input tank circuit of this a-m tuner has a loaded Q of approximately 180.

The over-all effect is that of an additional resistance in parallel with the tuned circuit. The value of this added resistance, R_x, can be calculated from

$$R_x = R\left(\frac{\omega^2 L C_s}{1 - \omega L C_p}\right)^2$$

From the formula, it can be seen that both the resonance resistance and the circuit bandwidth are frequency-dependent. Therefore, to minimize the effect of R_x, R and C_s must be made as large as possible.

Within practical limits, such a circuit can be adjusted to cover any desired tuning range by trimming the circuit inductance and parallel capacitance in the usual manner. If this doesn't work, the bias voltage can be adjusted.

The current through the resonant circuit will be more or less constant only if the size of the coil corresponds to the wavelength of the signal. But since the coil dimensions cannot be reduced at will, the circuit energy losses, caused by radiation and skin effect, will increase as the frequency goes up. The net result is that the Q factor of the circuit will be seriously reduced.

Saving energy

Energy losses from skin effect, which are high at frequencies above 300 megahertz, can be reduced by using an electrically shorted quarter-wavelength coaxial line resonator instead of a standard coil. The resonator provides larger conducting surfaces, and the screening action of its outer conductor cuts down on energy losses due to radiaton. The important parameters of the resonator are its line length, l, and the characteristic impedance, Z, with which it can be terminated without producing any reflection.

The tuning range for a quarter-wavelength coaxial line resonator is given by

$$V_f = \frac{\tan \frac{l\,\omega_{min}}{C_o}}{\tan \frac{l\,\omega_{max}}{C_o}} \cdot \frac{1 + \dfrac{C_{max}}{C_p\left(1 + \dfrac{C_{max}}{C_s}\right)}}{1 + \dfrac{C_{max}}{C_p\left(H + \dfrac{C_{max}}{C_s}\right)}}$$

where c_o is the velocity of light in the circuit dielectric.

Note that for a given frequency range the capacitance variation coefficient is minimum when the resonator line is made as short as possible and the characteristic impedance as large as possible. In this case the equations on page 89 can be used to design a quarter-wavelength resonator, with close approximation, for any frequency band.

Because the series inductance of the diode forms part of the line, the external circuit can be connected only through a tap on the coaxial line. The effective resonance resistance across the resonator's terminals, therefore, becomes

$$R_p \approx \frac{1}{R_s}\left(\frac{1}{\omega C} + \frac{1}{\omega C_s} - \omega L_s\right)$$

To keep the resonance resistance as large as possible for any given value of C, R_s and L_s, a low-inductance capacitor, C_s, should be placed in series with the tuner diode. The value of this capacitor should be high enough so that the capacitance variation of the diode is just sufficient to cover the desired frequency range. Except for the precautions mentioned, the design and alignment of the coaxial line resonator are the same as for a resonant circuit using an inductance coil.

In designing a diode-tuned front end, the engineer must consider the capacitance variation coefficient and Q-factor of the diodes. The Q factor is determined by

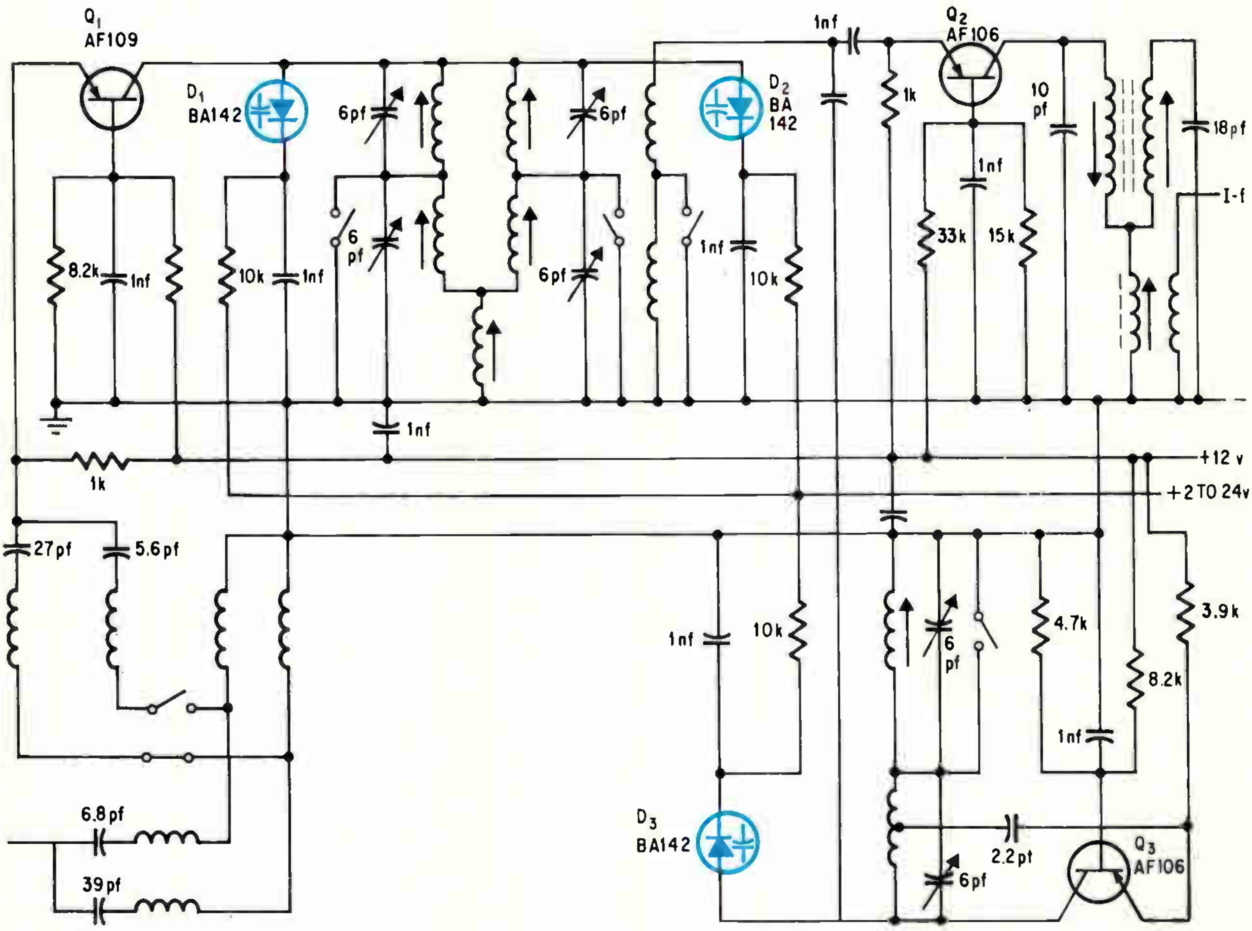
$$Q = \frac{1}{\omega C R_s}$$

where $\omega = 2\pi f$, C is the junction capacitance, and R_s is the diode's internal series resistance. Varactor-diode manufacturers will supply, upon request, charts showing capacitance variation versus applied tuning voltage for each device.

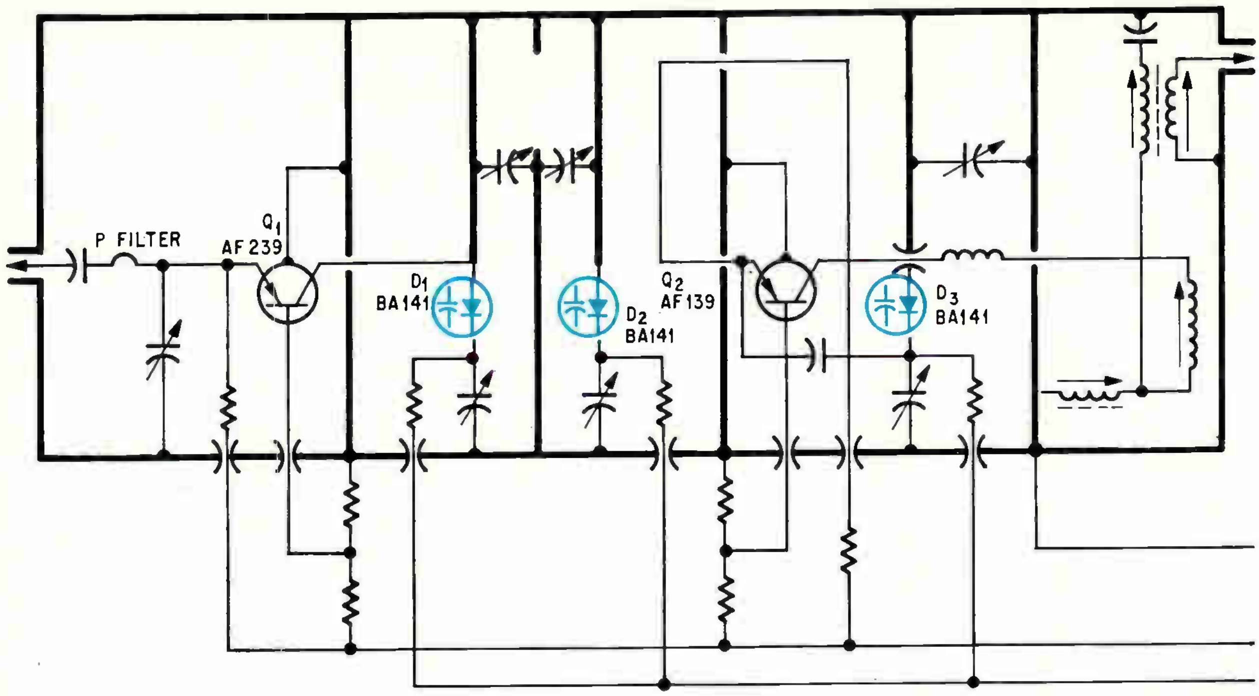
Having established the receiver's tuning range and diode characteristics, the next step is to provide the tuning voltages. The typical method uses the circuit at the bottom of page 89.

Consider the front end of a radio set, below, designed to tune in the European medium-wave band (510 to 1,610 kilohertz). A standard 465-khz intermediate frequency is used. The circuit includes a tuned first stage with a ferrite rod antenna, a self-oscillating mixer and tuned oscillator, and a bandpass output filter. The input tank circuit, which has the same configuration as that on page 89, is coupled through a tap on the coil to Q_1's base. The precise location of the tap is important because it determines the power gain and noise level of the stage.

The unloaded Q of the tank circuit, which is about 180, depends largely on the resistive loss of the coil inductance, because the tuner diode D_2 has very low loss resistance. In the oscillator tank circuit the addition of padding capacitor C_6 limits the tuning range to ensure proper tracking of the oscillator and antenna circuits. The padder



Vhf tv tuner. Two switchable broadband input circuits, together with three varactor diodes and three transistors provide coverage for the 50-to-65 and 170-to-220-Mhz vhf tuning ranges.



Uhf tv tuner. Using three varactor diodes in quarter-length coaxial line resonators and a self-oscillating mixer, the tuner covers the 170-to-790-Mhz uhf frequency band.

capacity turns out to be approximately equal to that of the tuner diode. Thus, in this design, C_6 has a value of 240 picofarads, which matches the diode's 220-pf capacity range.

The self-oscillating mixer transistor, Q_1, operating in a common-base mode, sustains oscillation by positive feedback from collector to emitter through a tap on oscillator coil L_2 winding. The coil's turns ratio is selected so that voltage level at Q_1's emitter will be large enough to sustain oscillation. In this application, the voltage is about 60 millivolts. However, the a-c voltage applied to the diode must never exceed 0.8 volt peak. To ensure a constant oscillator voltage over the diode's tuning range, a 100-ohm resistor, R_6, is shunted across a portion of the oscillator coil to somewhat dampen the oscillation.

The maximum tuning voltage for the 510-1610 kHz frequency band is 12 volts. The minimum voltage is that necessary to increase the oscillator diode's capacitance to its maximum value of 220 pf.

Since a close tracking tolerance is essential for proper tuning of the radio set, it becomes necessary that diodes D_1 and D_2 be a factory-matched pair. The capacitances are precisely aligned by a relative displacement of the two bias voltages; this must be done by the set manufacturer before the usual LC alignment.

The design procedure for an f-m tuner is basically the same as for the a-m tuner. The use of a matched diode pair is also essential to close tracking tolerances, so the diode's capacitance needn't be calibrated against its bias voltage.

Although varactor diode tuning is now widely used in f-m receivers, its greatest advantage is in tv tuners where channels can be switched effortlessly. In the typical circuit for a very-high-frequency tuner, on page 91, three diodes are used to tune in all channels in the lower (50 to 65 Mhz) and upper (170 to 220 Mhz) frequency bands. The tuner consists of two switchable broadband input circuits, a preamplifier stage, a double-tuned bandpass filter, a mixer, and an oscillator circuit. The upper and lower frequency bands are selected by mechanically switching the tuning coils.

The i-f output, 36 Mhz, is coupled out from a bandpass filter in the collector circuit of the mixer. For exact tracking, the tuned circuits can be aligned inductively or capacitively. The tuner has a bandwidth of 8 to 9 Mhz and a power gain of 25 db.

In a typical ultra-high-frequency tuner, above, the diodes must be capable of tuning over the entire 470-to-790 Mhz band. The tuner consists of an r-f, amplifier, Q_1, a self-oscillating mixer, Q_2, and diodes, D_1, D_2, and D_3 in quarter-wavelength coaxial line resonators.

A pi filter in the antenna input is adjusted for minimum reflection. The coaxial line resonator, including diode D_1, is in the collector circuit of Q_1, which operates in a common-base mode. This resonator is coupled, inductively and capacitively, to a second resonator with diode D_2, through a slot in the wall between them.

The self-oscillating mixer transistor, Q_2, also operates in a common-base mode. Its collector is coupled to the oscillator coaxial line resonator containing D_3. A combination of inductive and capacitive feedback maintains a very constant oscillator voltage over the frequency range.

Circuit design

Designer's casebook

Two one-shots control waveform's pulse width

By K. Vijaya Raghavan

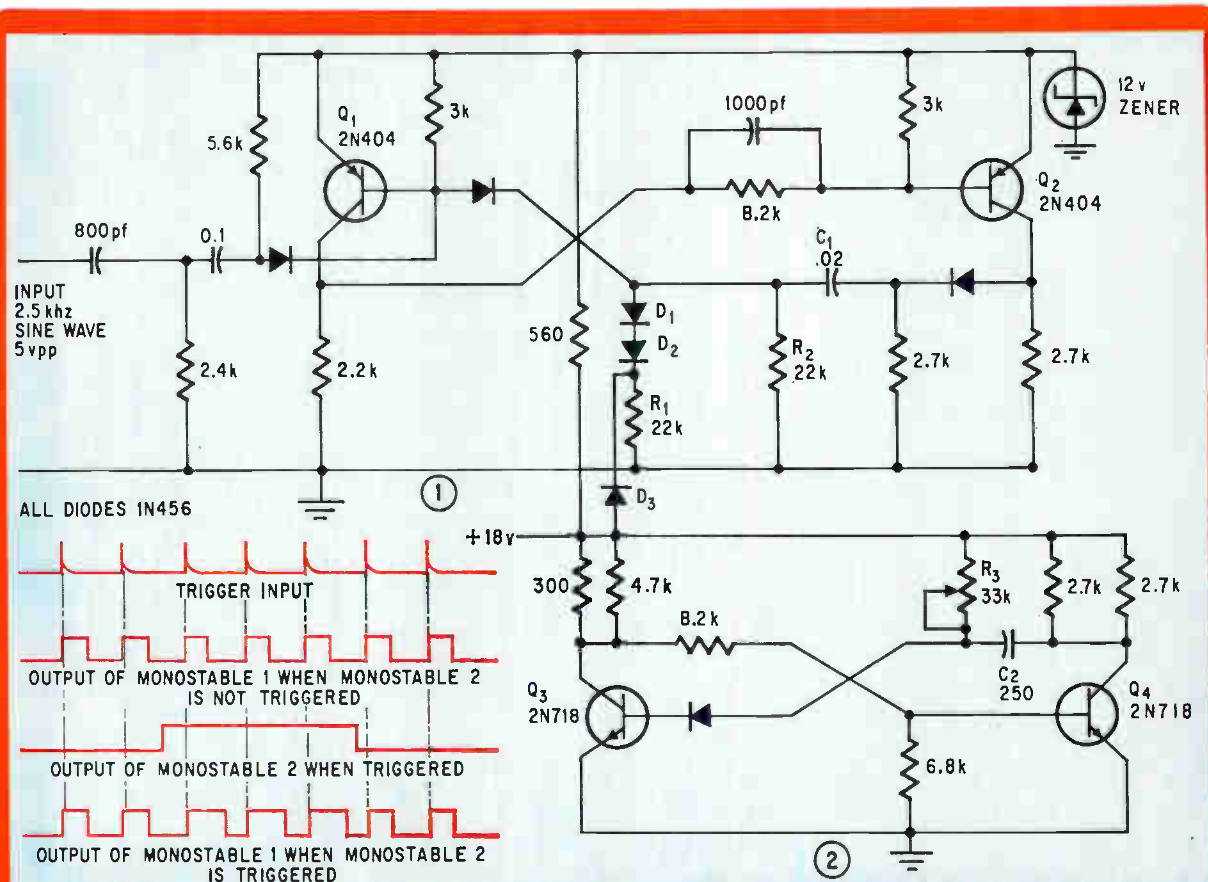
Indian Telephone Industries Ltd., Bangalore, India

A waveform's pulse width can be doubled for a certain time interval simply by cascading two monostable multivibrators.

Initially, Q_1 and Q_3 are on, and Q_2 and Q_4 are off. Switch S_1 is open and the 2.5-kilohertz sine wave triggers the first monostable. The pulse width out is $0.7C_1\ [R_2 \parallel (2R_f + R_1)]$ which approximately equals $0.7C_1\ (R_2 \parallel R_1)$, where R_f is the forward resistance of D_1 and D_2.

To increase the pulse width, S_1 is closed and opened, triggering the second monostable. Its duration, $0.7\ R_3C_2$, determines how long the wider pulses will be gated out. Q_3 is cut off and Q_4 turned on. The supply voltage at Q_3's collector reverse biases D_1 and D_2 via D_3. As the first monostable triggers, its new pulse width, t_d, becomes $0.7C_1\ [R_2 \parallel (2R_r + R_1)]$, where R_r is the reverse resistance of diodes D_1 and D_2. Since $2R_r + R_1$ is much greater than R_2, t_d is about equal to $0.7C_1R_2$. If $R_2 = R_1$, the new pulse width is twice the original.

As long as the second monostable is not triggered, D_3 is reverse biased, thus ensuring that the period of the first monostable is independent of the second's circuit parameters.



Cascading. When switch S_1 is activated, Q_3 cuts off. Diodes D_1 and D_2 become reverse biased, doubling the first monostable's pulse width. R_3 adjusts the period of the second monostable which determines how long the wider pulses will be gated out.

Power supply regulator uses fewer parts

By F.J. Messina

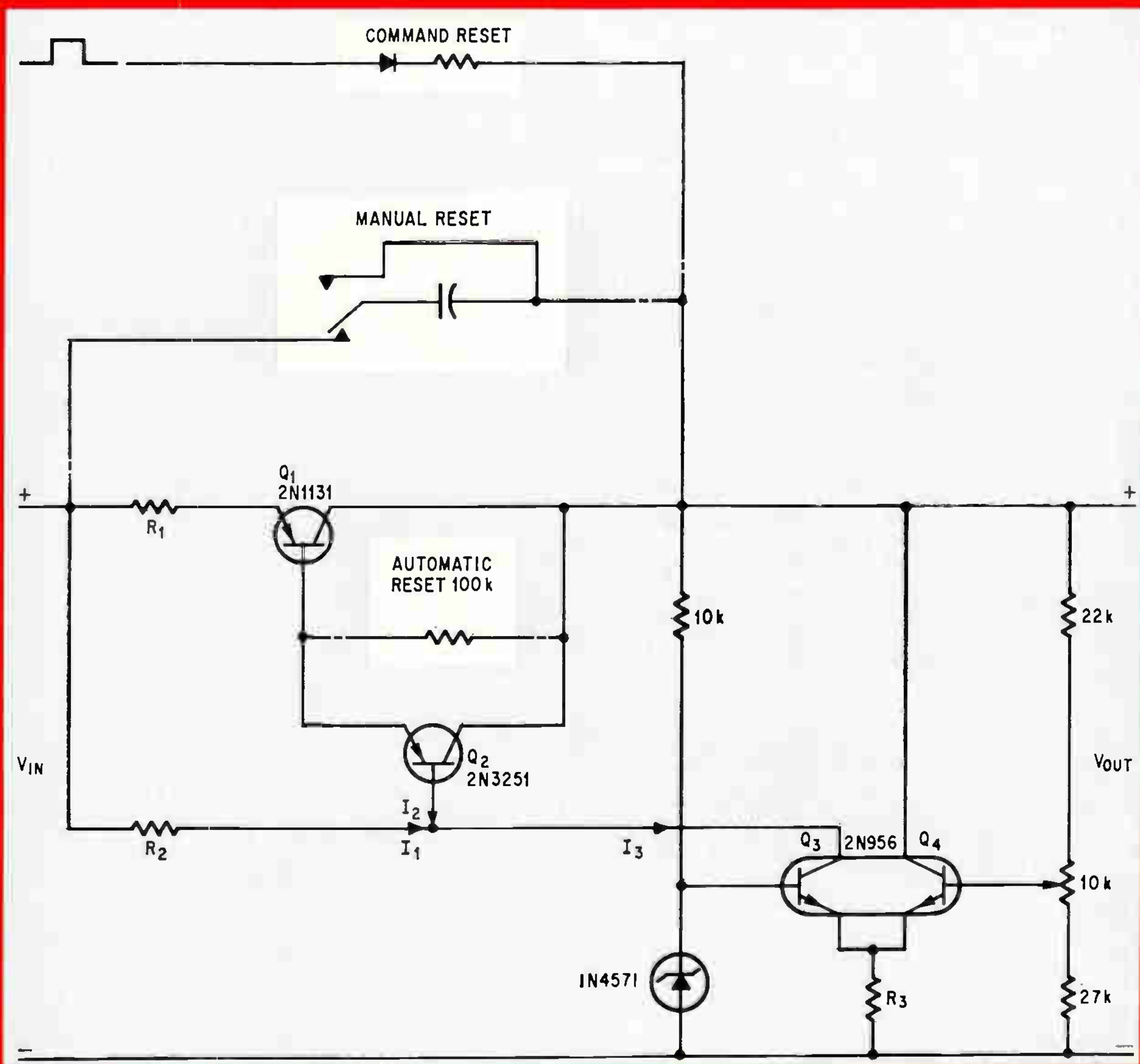
Electro-Mechanical Research Inc., Princeton, N.J.

Series regulators can protect power supplies without added transistors and the silicon controlled rectifier.

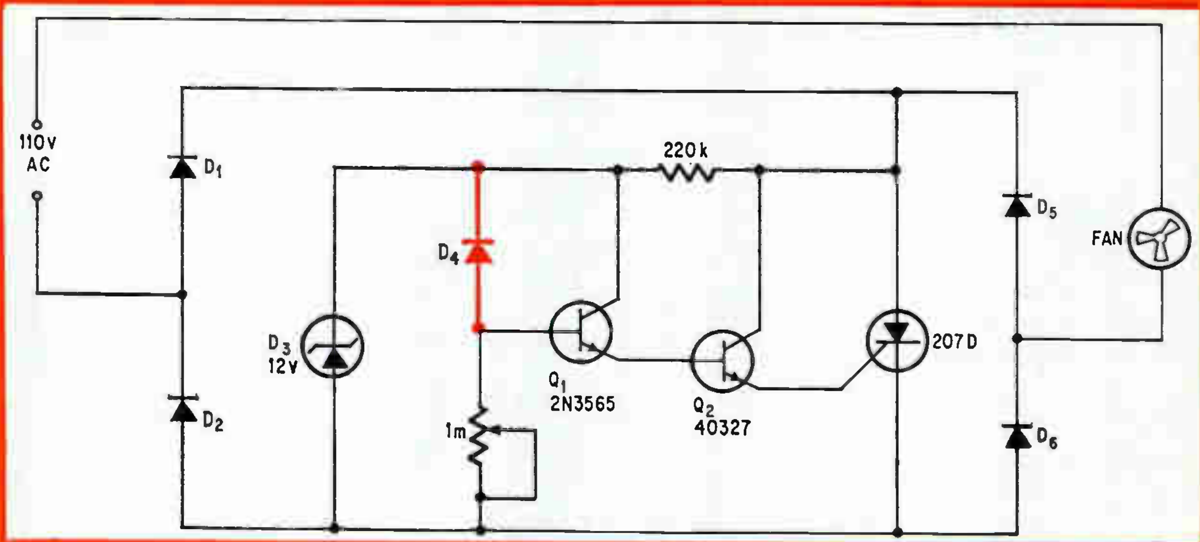
As the load increases, so does Q_3's current. As a result, the conduction in the Darlington pair increases in an effort to support the heavier load. Voltage regulation continues until Q_3 reaches its maximum current, determined by the zener, R_3, and Q_3's base-emitter voltage. This current is divided between I_1 and I_2, and R_2 is selected so $I_1 >> I_2$. Then the maximum input current becomes

$$[I_{3(max)}R_2 - V_{BE(Q1)} - V_{BE(Q2)}]/R_1.$$

The output voltage will continue to drop as the load increases until Q_3 turns off. The Darlingtons then turn off, deactivating the power supply. The circuit does not turn back on after removal of the overload. The power supply can be reset after the overload is eliminated by a manual, command, or automatic reset.



Versatile. The output voltage will drop as the load increases until Q_3 turns off and deactivates the supply. After the overload has been eliminated, any of three methods can be used to turn the supply on again. Each method involves applying a bias to Q_3 so it begins to conduct.



Breezy circuit. The reverse current of the diode is temperature-dependent and is regulated by the potentiometer to vary the firing angle of the SCR, which regulates the current to the fan's induction motor. The circuit allowed very accurate temperature control of the thyratron.

Diode controls speed of fan that cools a thyratron

By Y. Alon and M. Jonas

Hebrew University of Jerusalem

The condensed mercury in high-voltage thyratrons must be kept within specified temperature limits if recurring failures are to be avoided. An ordinary series-connected fan with a simple speed-control circuit kept part of the bulb within 0.5°C of a constant temperature allowing faultless operation of a 20-kilovolt thyratron for six months.

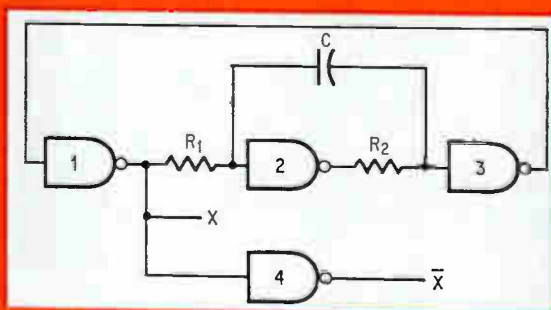
A germanium diode (D_4) is glued to the outside of the thyratron bulb in the condensed mercury region. The temperature-dependent reverse current of the diode, regulated by the 1-megohm potentiometer, is amplified by Q_1 and Q_2. The resulting gate current varies the firing angle of the silicon controlled rectifier in accordance with the sensed bulb temperature. Controlled current waveforms flow on alternating half-cycles through D_1-D_6 and D_2-D_5, changing the speed of the fan.

Free-running multivibrator is made with a NAND gate

By Orin Q. Flint Jr.

Zeltex Inc., Concord, Calif.

Free-running multivibrators can be assembled quickly by adding a couple of resistors and a capacitor to a quad, 2-input NAND gate. The low-cost multivibrator is self-starting and has rise and fall times of less than 50 nanoseconds, complementary outputs, and a wide frequency range. Fre-



Self-starting. R_1 and C control the frequency. Increasing R_2 reduces the duration of the 1 state over 25% to 60% of the period.

quency and symmetry are independently adjustable.

The device is basically a flip-flop (gates 1 and 3) with a high-frequency bypassed inverter in the loop (gate 2). The inverter makes the loop unstable. The capacitor couples gate 1 to gate 3—allowing regeneration to occur even for fast rise times—and provides a time delay for the inverter.

C and R_2 control the frequency. R_1 varies the symmetry of the output. When $R_1=R_2=510$ ohms, and C is varied from 10 microfarads to 100 picofarads, the output frequency varies from a few hundred hertz to several megahertz.

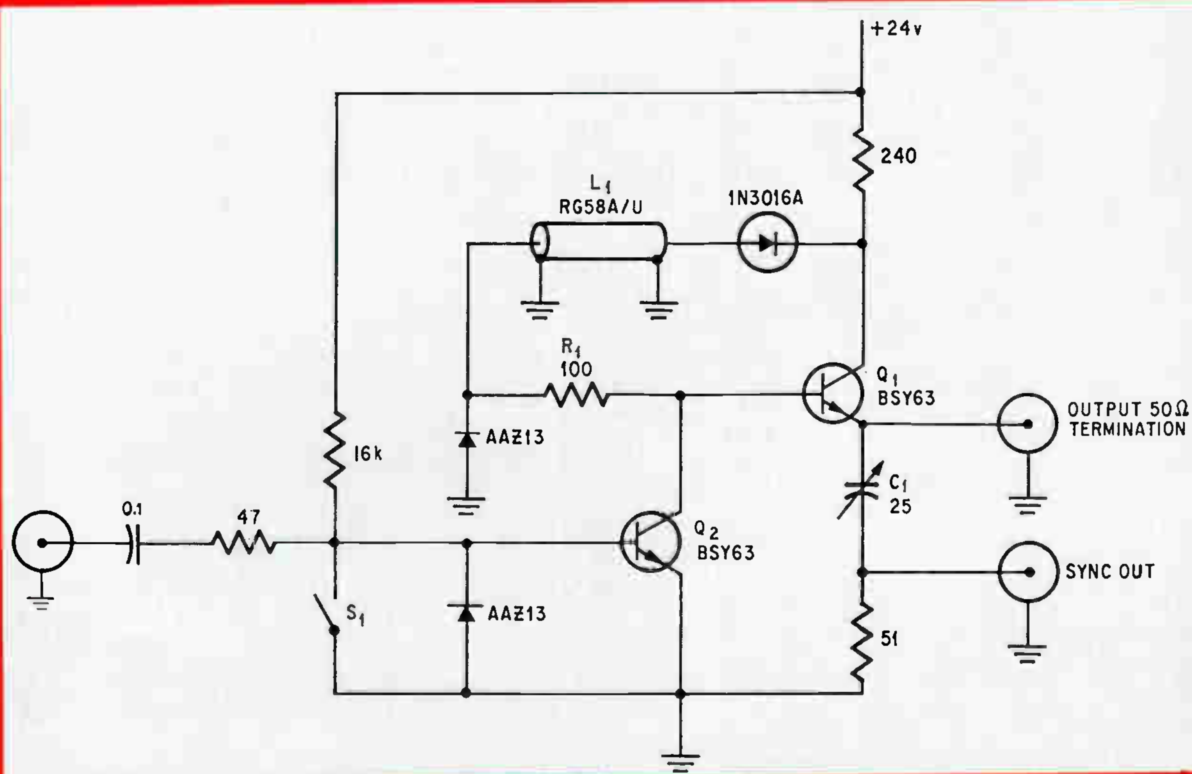
Simple gating yields phase-locked pulse bursts

By J. Kalisz

Institute of Nuclear Research, Warsaw-Anin, Poland

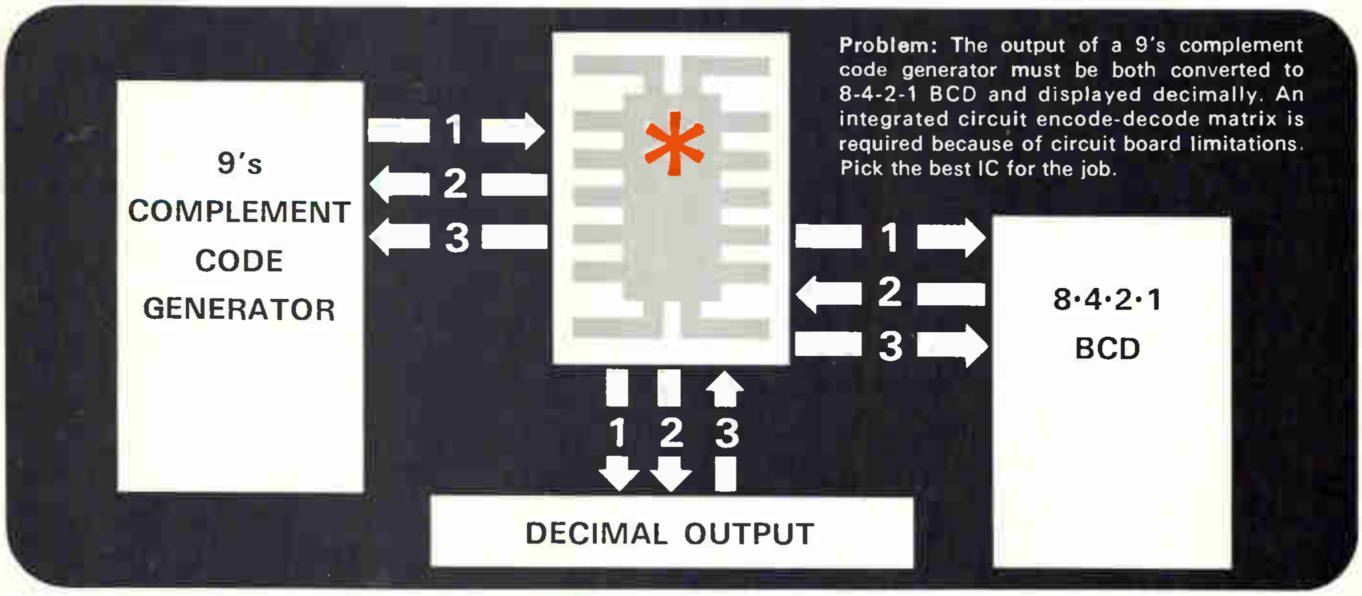
An easy way to synchronize a pulse burst uses a delay line generator to produce the high-speed pulse bursts with their phases locked to the start of the gating cycle. High repetition rates together with fast rise and fall times are obtained at low cost. The generator, to cite one possible application, may be used to trigger the time base of a sampling oscilloscope.

Q_2 and R_1 control the time interval of the oscillations. When the circuit is open and there's no signal at the gate's input, Q_2 is saturated, Q_1 cut off, and no oscillations occur. A negative 1-volt pulse to a matched 50-ohm input by cutting off Q_2 and turning on Q_1, starts the cycle. The period of oscillation is approximately twice the delay of L_1. During free-run conditions when S_1 is closed, Q_2 remains cut off. C_1 aids in shaping the output pulse. The circuit worked at a 20-megahertz repetition rate. Bursts of 1 to 10 pulses of 25-nanosecond width are obtained by varying the gating pulse from 40 to 490 nsec in 50-nsec increments.



Delay. When the switch is closed and a negative one volt pulse is applied at the input, Q_2 cuts off and Q_1 turns on starting the cycle. The output pulse is fed back through the delay line, L_1 and triggers the output transistor. The pulses are locked to the start of the gating cycle.

Pick the BEST IC for the job



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Analog-plus-logic system gets into the control stream

Basically a simulation tool, the hybrid computer has found its way into the industrial plant, controlling the flow and pattern of water—up to 6,000 gallons of it—to cool fast-moving slabs of hot-strip steel

By Tracy C. Dickson III and John P. Shea Jr.
Control Products Division, Bell & Howell Co., Bridgeport, Conn.

A hot-strip mill is a spectacular operation. In about three minutes, the mill squeezes a 15-to-20-ton slab of cherry-red steel into a thin, wide strip that's thousands of feet long. Using an electronic hybrid control computer, specifically designed to operate a new type of water cooling system on the mill, operators produce a better grade of steel at considerably higher production rates in the Youngstown Sheet & Tube Co.'s Indiana Harbor, Ind., mill #3.

The hybrid computer combines continuous analog calculation intimately meshed with logic-implemented on-off outputs. This control system, constructed from conventional analog and logic modules, operates in an industrial environment and performs some functions that could prove useful in other types of applications.

This hot-slab rolls through seven thickness-reducing stands, glides along a runout table where laminar-flow water cools the steel. The strip, now traveling at 30 miles an hour, winds up as a huge coil. While this operation is taking place, the computer solves a heat-balance equation in its analog section, and sets up a desired cooling water pattern in its logic section, thereby controlling the strip's final temperature.

On the 500-feet-long runout table the final operation is performed—cooling the steel to attain its desired physical properties. The strip's cooling rate after it leaves the last reduction stand affects the steel's grain structure and hence its strength and ductility.

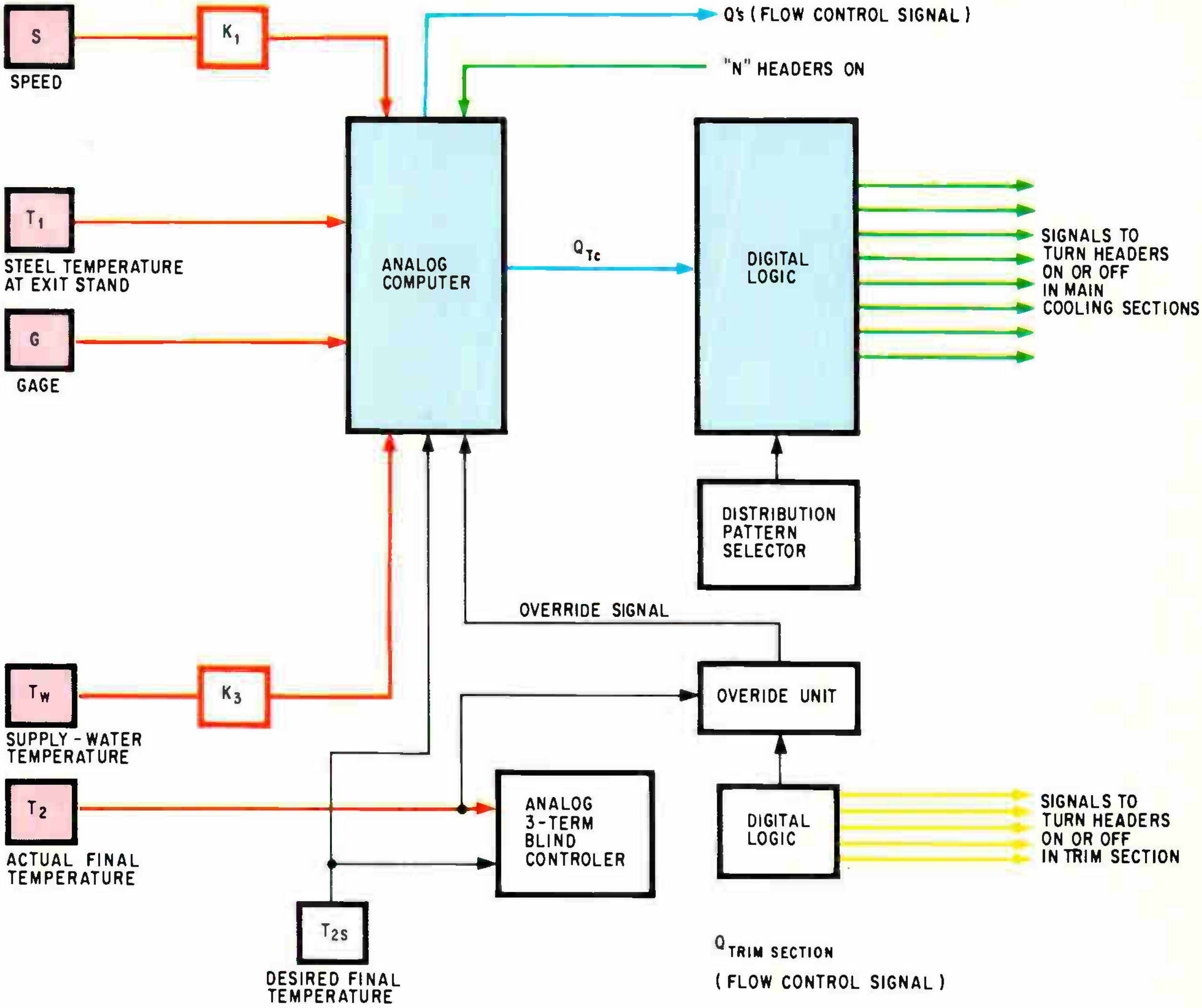
Previous cooling systems were designed merely to provide a sufficient discharge of water. At best, control of flow rate and distribution pattern is fairly coarse. Furthermore, a shroud of steam and drops of water dancing on the strip's 1,500-1,700°F surface prevents efficient cooling. But the new cooling system, developed by Pittsburgh-based Golden Anderson Specialty Valve Co. and installed at YS&T, can vary the flow rate and pattern to approximately match the cooling requirements of the wide range of products going through the mill.

Using laminar-flow nozzles, the cooling system produces multiple high-energy streams of water which hit the strip with sufficient force to pierce the steam and water blanket formed by previous water and thus produce efficient cooling. The final temperature is between 900-1,300°F, depending on production requirements.

The hybrid computer takes into account such factors as the strip's grade and thickness, its instantaneous speed on the runout table, and its temperature before and after cooling, and the desired coil temperature. Automatically, the computer turns on the correct number of headers and sets their initial rate of flow.

The nozzles are closely adjacent to each other on headers that extend across the width of the strip, the net effect being a sheet of water flowing from each header. The 270-feet-long cooling portion of the runout table is divided into nine main sections and one trim section.

Each main section has four headers delivering water from the top and one header spraying from the bottom. Each of the total of 45 headers in the main sections can be turned on or off by signals from the main part of the hybrid computer. The rate of flow from the turned-on headers is a given section is varied by a pressure-reducing valve operated by a closed-loop controller which receives its setpoint value from the hybrid computer.



Computer and control. The analog sections of the hybrid computer determine cooling water needs; the logic sets the flow pattern.

The trim section, whose function it is to furnish the final amount of cooling water before the strip reaches the coiler using the section's four top headers and one bottom header, is manipulated by another part of the computer.

If the final actual temperature doesn't match the final desired temperature, the computer proportions the flow rate of the trim-section headers. If that isn't enough, the computer next pulses solenoid-operated switches that turn on (or shut off) more nozzles until the correct amount of water cools the strip to the desired temperature.

The diagram above shows how the major elements of the hybrid computer relate to each other and to the cooling system's headers and flow-control valves.

The analog portion of the hybrid control computer, after it converts, scales, and linearizes the input signals from the mill and from the logic section, calculates how much heat must be removed from the strip and adjusts the total cooling-water-flow-rate accordingly. The logic portion sets up the water distribution and selects the appropriate headers to turn on.

As the slab is reduced in thickness from stand to stand it also gets longer, forming a strip whose leading edge travels faster and faster relative to the speed of the slab at the first stand. By the time it's caught on-the-fly by the coiling machine, the strip's leading edge is traveling about 1,000 feet a minute. Then the whole mill operation is accelerated until the strip's maximum speed at the coiling machine is about 3,000 feet a minute. As the mill speed increases, a correspondingly greater amount of water must be sprayed on the strip to cool it to the correct temperature. The maximum flow of water is 6,000 gallons a minute.

Operation of the mill's reducing stands is quite complex, and it's handled by a large separate digital control computer. The hybrid computer discussed here is assigned specifically to the control of the cooling system on the runout table. It receives many of its inputs from the mill instrumentation and its commands—pattern selection, for example—from the control desk.

A separate hybrid computer was selected for several practical reasons. Because the cooling system is the first of its kind, the equations and heat-transfer criteria for laminar streams were only generally known. Developing the information on the digital computer would have involved complex software and attendant delays in preparing and debugging the programs. Instead, the analog computer in the hybrid system was built with several variable coefficients, K factors, to permit easy adjustment of equations and thus to arrive at a fast determination of the proper cooling data based on actual operating experience.

Conditioning the inputs

As mentioned, inputs to the hybrid computer are related to the mill's operation. The speed, S, of the strip is actually measured by a pulse-type tachometer mounted on the mill's final stand. A frequency-to-analog converter conditions the speed signal and a digital thumbswitch—set by the operator at the control desk and converted to an analog signal inside the hybrid computer—develops a variable factor, K_1, that scales stand speed to flow per header in gallons per minute.

The temperature of the steel, T_1, as it leaves the last stand is measured by an infrared-radiation pyrometer. However, the analog computer obtains the temperature signal from a retransmitting slidewire of a recorder associated with the pyrometer. Since this signal is highly nonlinear, the computer contains a four-segment function generator to provide the linear relationship between signal voltage and temperature that's required in solving the equation.

The final actual temperature, T_{2A}, the temperature of the strip after being cooled by the water, is handled in a manner similar to that for T_1. This signal goes to the analog controller for the trim section, for it's here that the fine adjustment of cooling water must be accomplished.

The cooling capability of water depends on the supply-water's temperature, T_W, which is measured with a resistance temperature detector. A nonlinear factor, K_3, modifies this signal to provide the heat removed per gallon of water at the measured temperature.

The strip's gage, its thickness in inches, also is obtained from a retransmission slidewire.

The final desired (or setpoint) temperature of the strip, T_{2S}, is set by the mill operator with a digital thumbswitch on the console in the pulpit (control room) suspended high above the mill. The analog computer controlling the nine main cooling sections converts this digital signal to an appropriate analog equivalent. This analog signal also becomes the setpoint value for the analog controller for the trim section.

Using these process signals, the hybrid control computer calculates the total water flow rate required, Q_{Tc}, and—on a closed-loop basis—adjusts the actual flow rate of water delivered from all headers, Q_{Tn}, so that, ideally

$$Q_{Ta} = Q_{Tc}$$

where

$$Q_{Ta} = N_T\,Q_{TH} + N_B\,Q_{BH} + N_{Trim}\,Q_{Trim\ H}$$

and

$$Q_{Tc} = f(T_1 - T_{2S})G \times f(K_3\,T_W) \times f(K_0 + K_1\,S) \times K_2$$

The Q's are in gallons per minute, and the N's are the number of headers on. The subscript T applies to top headers, B to bottom headers, Trim to trim headers. K_0 sets water flow at zero strip speed.

The balance between calculated and actual flow rate could be obtained by many combinations of different values of N's and Q's. For example, under certain conditions, enough cooling water could be obtained with only top headers on and with bottom and trim headers off. Doing so, however, is not desirable from metallurgical or control viewpoints.

Production experience in rolling steel indicates that some water, not necessarily the maximum amount, must always cool the strip's bottom surface. Furthermore, as mentioned earlier, different kinds and gages of steel need different water-distribution patterns. For example, some products might require only the first header in each main cooling section being turned on, thus minimizing the cooling rate of the strip. A pattern where headers come on in numerical order would give the maximum cooling rate,

Turning on the headers

A bidirectional counter, the distribution-pattern selector, and other logic functions turn on the needed number of headers in each cooling section. The analog portion of the hybrid system computes the flow rate for the headers as a function of the strip's gage and speed. The resulting signal goes to the proportional flow controller for each cooling section. Thus, these hybrid-computer operations set the initial flow of water as the strip's leading edge enters the cooling area.

Any difference between actual and calculated flow is detected by an analog deviation comparator whose output drives the bidirectional counter up or down to turn more headers on or off until the total flow equals the calculated flow to within a minimum flow increment. This increment, or dead-band, is automatically adjusted according to the flow rate, which—as mentioned—changes with speed, so that the increment is always more than the minimum flow per header.

The computation of the outputs of the main analog computer—the individual flow rates of the top and bottom headers and the total flow rate—is accomplished with a host of electronic adder/subtractors, multiplier/dividers, comparators, time delays, function generators, coefficient potentiometers, memory units, track-and-hold amplifiers, and the like. All these are arranged to solve the Q_{Tc} equation using procedures that are common in analog computing.

The track-and-hold amplifier performs a particularly interesting function. Recall that temperature, T_1, is measured at the last reducing stand. If this measurement were sent directly to the analog computer it would provide the correct signal as long as there was steel strip emerging from the stands. When the strip's trailing edge passed under the i-r pyrometer, the signal would drop to ambient temperature. Using an ambient reading for the rest of the time that the strip is being cooled on the runout table would of course be erroneous and the water flow would decrease. To circumvent this, the pyrometer signal is sent through a track-and-hold amplifier. This amplifier transmits the instantaneous measured temperature while the strip remains in the stands and then stores the last measured value after the strip leaves the stand. This stored value remains constant and continues as an input to the analog heat balance calculation until the strip is completely cooled and coiled.

Selecting the pattern

The diagram on the next page shows how the bidirectional counter connects with the up or down signals from the analog comparator. The counter is made of 45 flip-flops connected in series as a shift register.

An up signal puts a logic 1 in the register's left-most position, and each succeeding up signal inserts a 1 in the left position and shifts any resident 1's to the right. A down signal inserts a 0 at the right and shifts any resident 1's to the left. Thus, the number of 1's in the counter, N, equals the number of headers needed to be on. Which header a particular flip-flop actually turns on depends on the pattern selector associated with the gate circuits, and the driver amplifier associated with each header's solenoid switch.

The diagram on the next page details the AND, OR, and exclusive-OR gate configuration which—together with a coincident square wave from the clock—sends an enabling pulse to an amplifier which then drives a solenoid switch. Each of the five AND gates can receive one input from the counter and one from the pattern selector.

Consider two typical header patterns. One pattern, denoted by the green color, has only the first header, in each top section, spraying water on the steel; the second pattern, denoted by red, uses the first and third headers in each section to cool the strip. The first pattern sends pulse to headers:

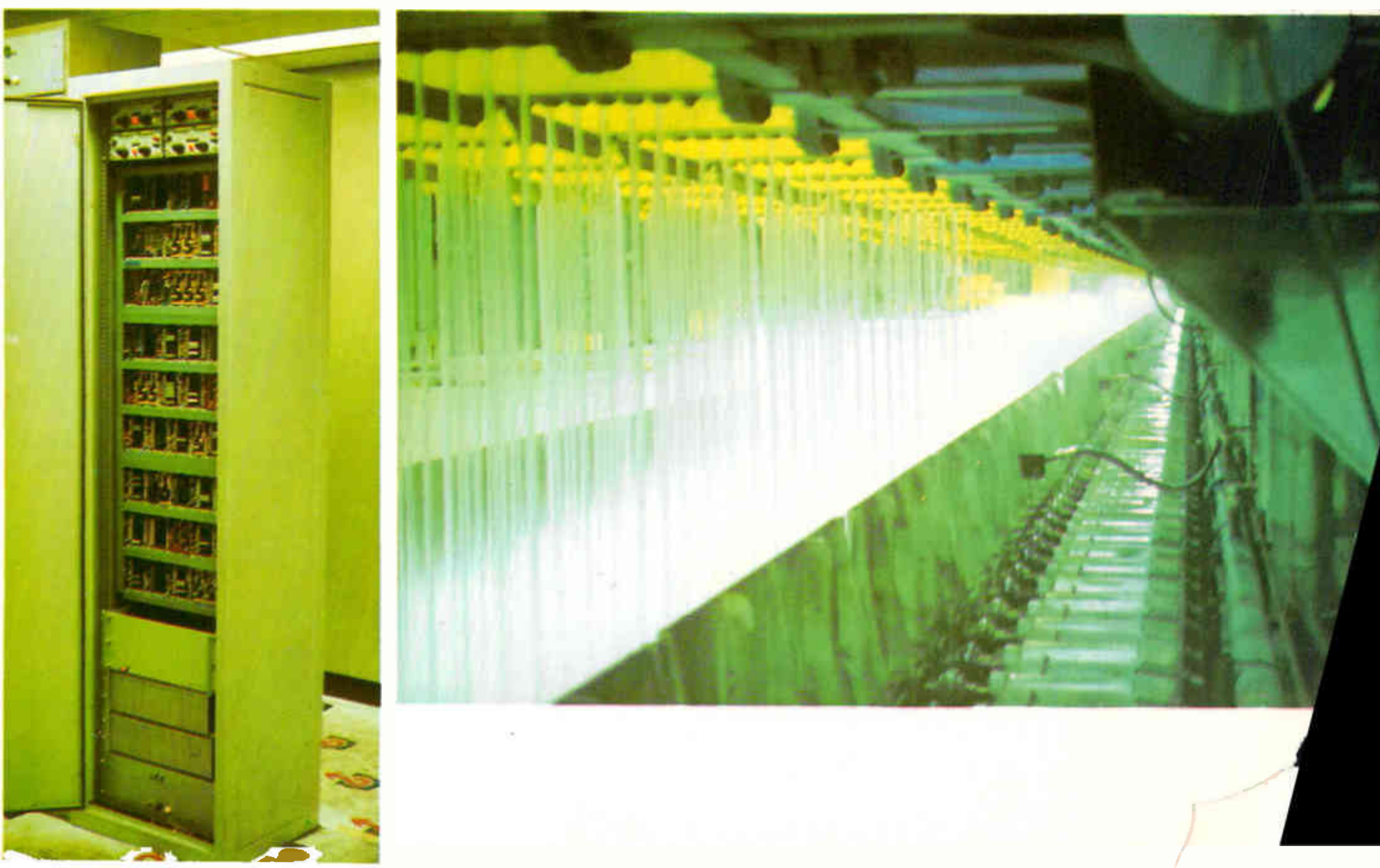
1, 5, 9, 13, 17, etc.

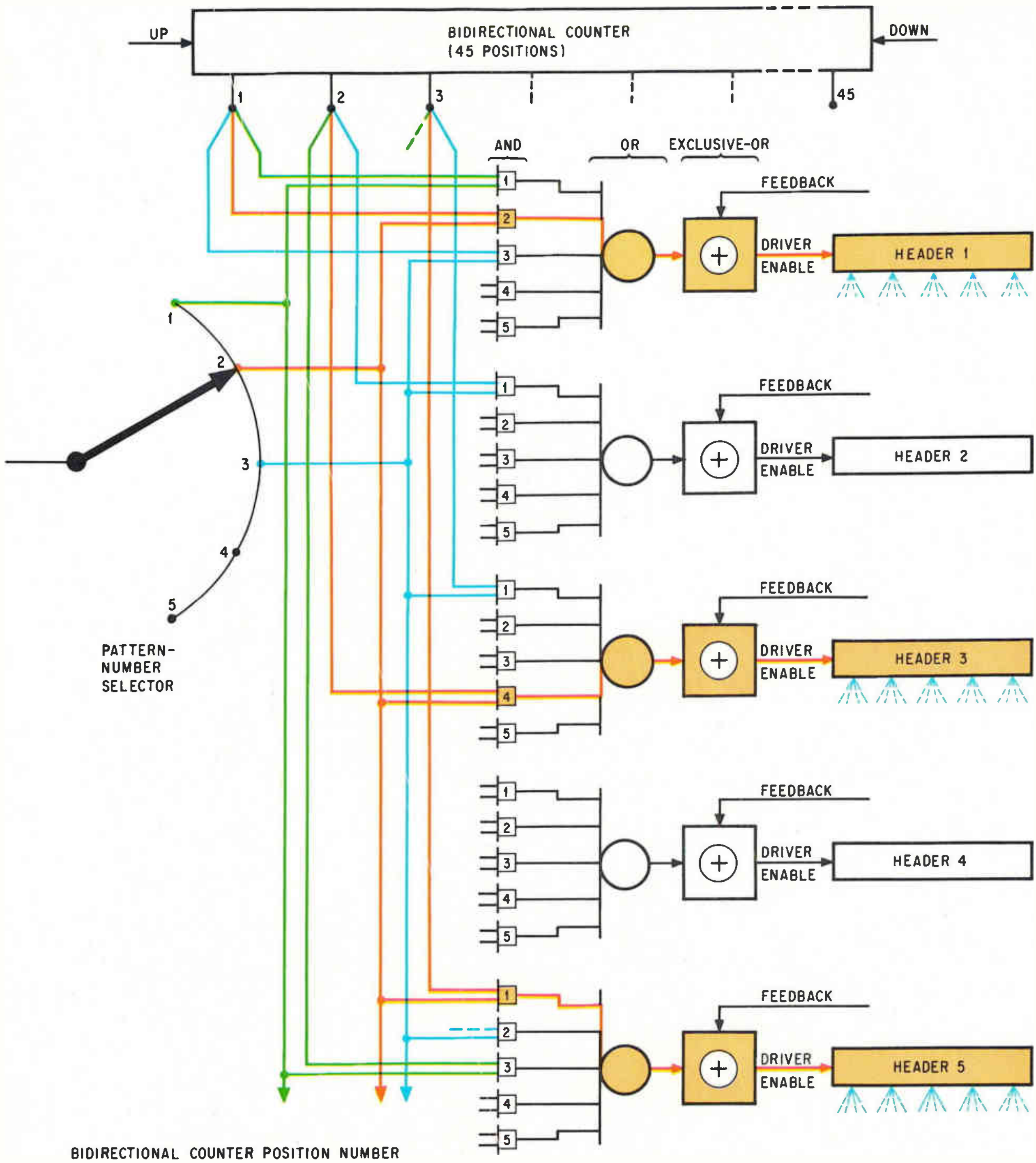
The second pattern looks like: 1, 3, 5, 7, 9, etc.

In both patterns, the first flip-flop's output (position 1) goes to the top inputs of AND-gates 1 and 2 in the logic circuit associated with header 1. However, the input from the pattern selector representing pattern 1 goes to the bottom input of AND-gate 1, while the signal for pattern 2 goes to the bottom input of AND-gate 2. Thus the driver amplifier for header 1 will pulse solenoid switch 1 on when flip-flop 1 is in the on state if either pattern 1 or pattern 2 has been selected by the mill operator.

Now consider the two patterns again, but this time the computer turns on the second header in each pattern, header 5 and header 3 respectively. Header 5 is turned on when the signal from counter-position 2, which is the second flip-flop,

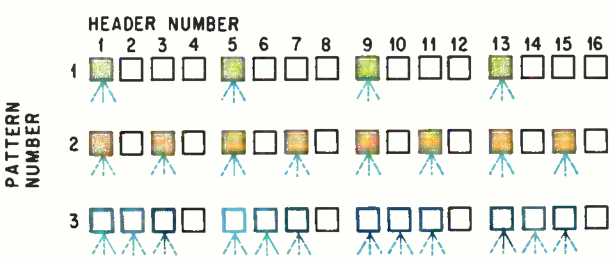
Pacer. Hybrid computer, left, commands 270-feet-long cooling table, right.





BIDIRECTIONAL COUNTER POSITION NUMBER

PATTERN NUMBER	1	2	3	4	5	6	7	8	9	ETC.
1	1	5	9	13	19	21				
2	1	3	5	7	9	11				
3	1	2	3	5	6	7				



Pick and choose. The water-distribution pattern is set by hard-wire connections and logic. When the selector switch and a position on the bidirectional counter enable the same AND gate, the header associated with that gate turns on.

goes to say, the top input of AND-gate 3 in the logic channel for header 5. The first pattern's signal connects to the bottom input of this same gate. Header 3 is turned on when the signal from the second flip-flop goes to the top of one of the AND gates in the circuit for header 3. The second pattern's signal connects to this AND gate's other input terminal.

In this manner, the logic portion of the hybrid computer is wired to accommodate five different patterns for the 36 top and 9 bottom headers in the nine main cooling sections. The diagram shows, in blue, some of the connections for pattern 3. A five-throw, single-pole, switch on the operator's console, connected by five wires to the computer, is all that's used to call up the specific matrix of logic circuits that represent a water-flow pattern.

Backfilling the pattern

The system is also wired to execute a backfill pattern in a given sequence if the selected pattern can't supply enough cooling water or supplies too much. Here's how it works. When the mill operator uses the every-other-top-header-pattern, the first 18 flip-flops in the bidirectional counter handle the odd-numbered headers 1 through 35.
Thus the on-pattern is

1, 3, 5, 7, ... 29, 31, 33, 35

The logic circuit for header 35 receives a signal from flip-flop position 18. Now when more water is needed than can be applied by the trim cooling section, the override signal from the trim control enters the main analog computer. This signal in turn injects an up (or 1) pulse into the bidirectional counter. This shifts a 1 into the counter's position 19. The circuit for header 34, the next header upstream that's off, is wired to accept this signal which—together with an enabling pulse to the same AND gate signifying the second pattern—turns on this header.

If even greater quantities of water were required, an enabling pulse would be sent to header 32, the next one off in the upstream direction. If process conditions were to require less water, the headers would automatically turn off in the sequence 32, 34, 35, 33, 31, etc.

Only one of the five AND gates in the logic circuit for a header at the left can simultaneously have two inputs. Depending on the pattern, none of the five gates may have two inputs. When an AND gates does have simultaneous inputs from both the counter and pattern selector, its output appears at the OR gate.

The output of the OR gate should be all that's needed to actuate the solenoid relay at the output of the driver amplifier. However, the solenoid relay can also be operated manually as a pushbutton switch. The mill operator might want to override the hybrid computer by turning on the header, or he might inadvertently actuate the pushbutton. In either case, the feedback contacts would close without there being a corresponding logical signal coming from the gate circuits. Therefore, practical consideration requires the insertion of an exclusive-OR function between the conventional OR gate and the driver.

If the OR-gate output calls for the contacts to be closed, and they're open, the feedback signal changes the exclusive-OR gate's output to enable the driver amplifier—in conjunction with a clock signal—to pulse the solenoid. If the OR-gate output calls for open contacts, and they're closed, the exclusive-OR gate changes its state via the feedback signal to release the contacts. In short, the exclusive-OR gate forces the feedback contacts to reach the proper on or off state called for by the logic circuit.

The feedback contacts on each solenoid relay also ground a pair of resistors on the input of an amplifier. This raises the amplifier's analog output voltage by an increment equivalent to an N-value of 1. Other resistor pairs, switched by contacts from other solenoids, are also connected to the output of the amplifier. This amplifier adds up the net input voltage resulting from the closure of the contacts to produce an analog voltage proportional to N, the sum of the number of headers turned on.

Trimming the flow

Finally, the hot-strip mill, like all processes, is subject to disturbances and uncertainties which require that some trim headers always be on. They correct for small variations by maintaining, ideally, an initial flow rate of about half their maximum, so that any need for more or less cooling water can be accommodated simply by changing the header flow rate over a small range.

Larger variations between actual and desired coiling temperature are corrected by the hybrid control computer that turns on or off additional headers in the trim section. The flow rate per header in the trim section is set by a three-mode (proportional band, reset, and rate) controller. The set point signal is desired coiling temperature; the process signal is actual temperature. As flow increases, more trim section headers are turned on by the trim section digital control.

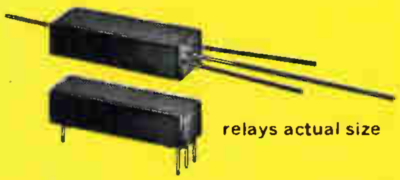
If the trim section is at maximum flow and is calling for more water (or is at minimum flow and is calling for less water) an override signal is generated which changes the overall flow calculation in the appropriate direction. This, in turn, operates headers in the main cooling section and changes the strip temperature to a range where minor variations can be compensated by the trim section. This override correction of Q_{Tc} generates Q_{Tc}' (corrected calculated flow) where

$$Q_{Tc}' = Q_{Tc}\left[1 + \frac{1}{T}\int_{t_1}^{t_2}(T_2 - T_{2S})dt\right]$$

and where 1/T is the time constant for an analo[g] integrator and (t_2-t_1) is the time the trim secti[on] is in the override condition.

COMPATIBILITY

with dual in-line IC and discrete solid state devices



relays actual size

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of any dry reed relay

Exclusive new Clare Picoreed relay operates in 500μs; permits .250″ pcb mounting centers; completely compatible with IC solid-state devices

Maintenance-free, hermetically-sealed contacts in molded-epoxy modules provide positive on-off switching for 100,000,000 operations at low-level loads

Build a straight relay-switched circuit or combine relays with dual in-line integrated circuits—you'll get important plus-factors with the Picoreed. Low profile for close board spacing. Long life. Immunity to transients. Sensible cost. The Picoreed's one Form A contact solves important problems of economical and reliable input-output isolation buffering.

Outstanding characteristics of the Picoreed are:

- **High speed.** 500 μs operate time (including bounce) and 667 Hz repetition rates at nominal coil power. Capable of following 1000 Hz with appropriate coil drive. (See response curves and scope traces.)

- **Low profile mounting.** Your choice of terminal pins for through-board connections, or axial leads for aperture mounting. Pcb mounting on .250″ centers is feasible. Relays are not position sensitive.

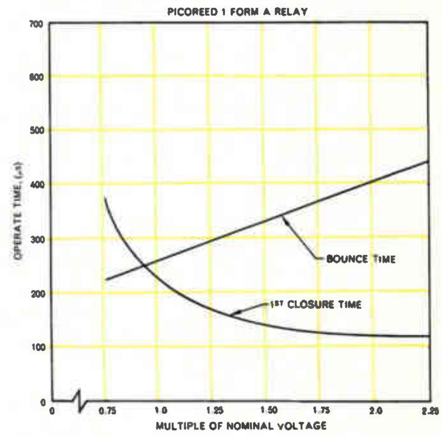
- **Minimal size.** .187″ high, .250″ wide, .781″ long.

- **Positive on-off switching.** ON impedance (contact resistance) 0.1 ohm initially; 1.0 ohm maximum after life. OFF impedance (insulation resistance) 10 KM ohms minimum with 0.5 pf open contact capacitance.

- **Inherent reliability.** Maintenance-free, hermetically-sealed contacts are built for 100,000,000 operations at low-level loads, 5,000,000 at 28 vdc, 0.125 amp.

- **Environmental.** Withstand vibration 0 to 5 KHz at 20g; shock 100g. Temperature range: —40° to +85°C.

TYPICAL RESPONSE TIMES

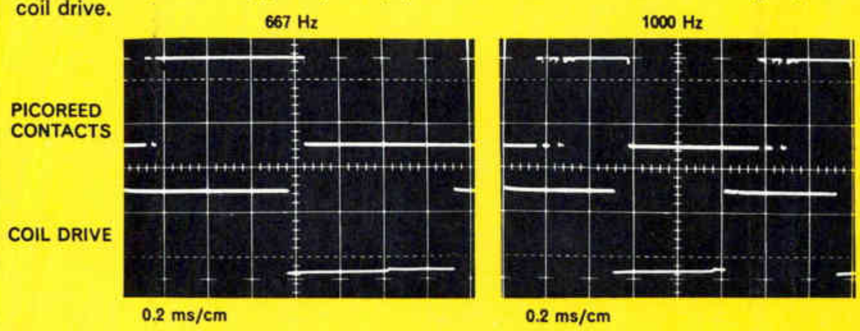


NOTES:

1. Response time measurements made at 50 Hz, 50% duty cycle square-wave coil drive.
2. With diode coil suppression (1N914 or equivalent) release time approximately 100 μs, with nominal voltage zener diode clamping release time approximately 50 μs.

REPETITION RATE CAPABILITIES

Oscillograms below illustrate the ability of the Picoreed to operate at 667 Hz (operate time including bounce typically 500 μs) and to follow 1000 Hz with an appropriate coil drive.



For a sample Picoreed relay, call your nearest Clare Sales Engineer:

East. Needham, Mass. (617) 444-4200; Great Neck, N. Y. (516) 466-2100; Syracuse, N. Y. (315) 422-0347; Philadelphia, Pa. (215) 386-3385; Baltimore, Md. (301) 377-8010; Silver Spring, Md. (Government liaison) (301) 593-0667; Orlando, Fla. (305) 424-9508

Central. Des Plaines, Ill. (312) 827-0151; Minneapolis, Minn. (612) 920-3125; Overland (St. Louis) Mo. (314) 429-7372; Cleveland, Ohio (216) 221-9030; Xenia, Ohio (513) 426-5485; Cincinnati, Ohio (513) 891-3827; Columbus, Ohio (614) 486-4046; Mission, Kansas (913) 722-2441

Southwest. Dallas, Texas (214) 357-4601; Houston, Texas (713) 528-3811

Pacific Coast and Mountain States. Burlingame, Cal. (415) 697-8033; Encino, Cal. (213) 981-3323; Phoenix, Arizona (602) 264-0645; Seattle, Wash. (206) 455-2410 & 2411

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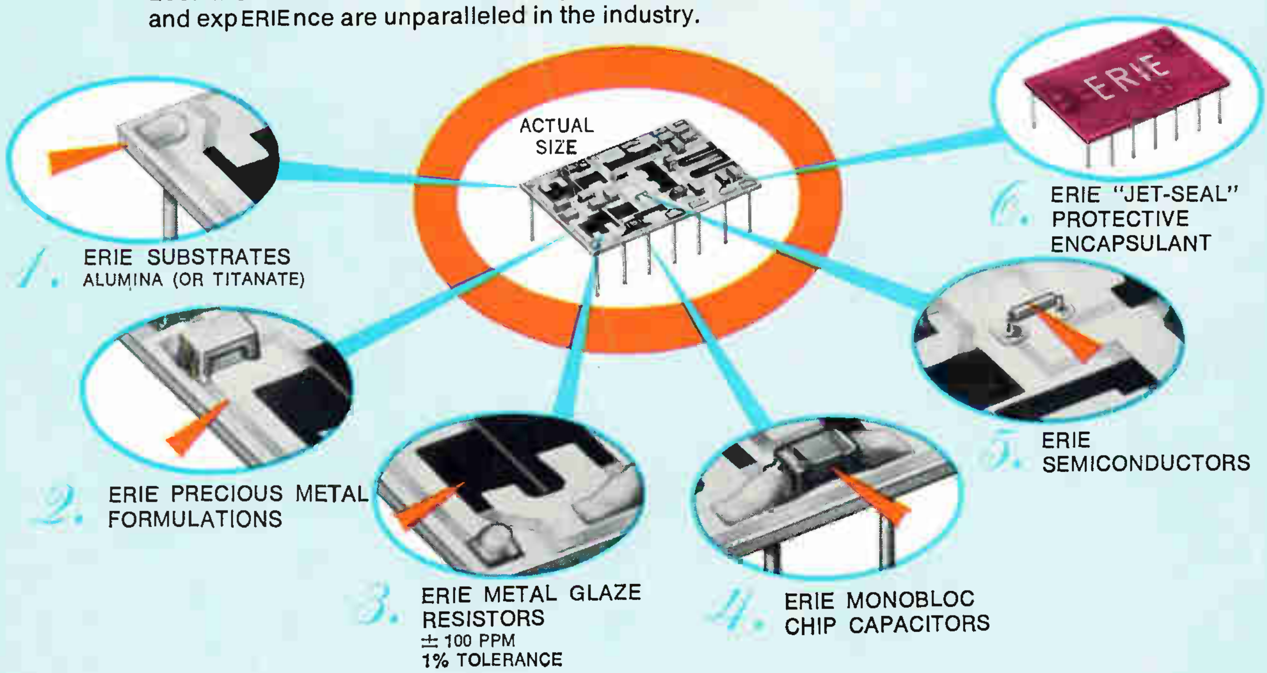

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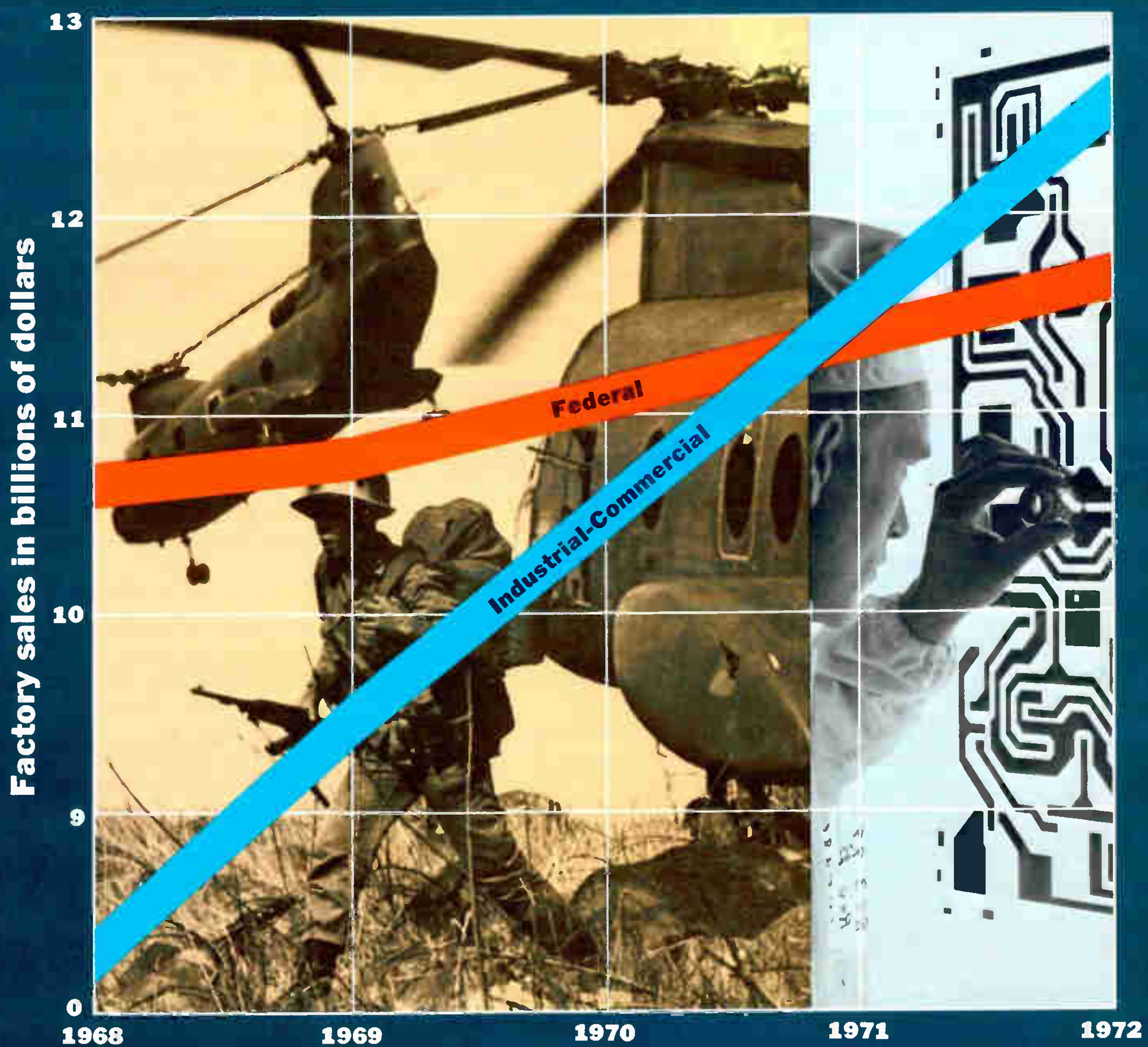
Electronics Magazine's 1969 Markets Report



The market estimates in this tabulation are based on a survey conducted by Electronics magazine. Estimates are of U.S. factory sales in millions of dollars. This survey is not directly comparable to those made in previous years; some categories have been added, others deleted to reflect dominant trends in the field.

Component Markets

	1968	1969	1972
	(millions of dollars)		
Antennas and antenna hardware	412.0	430.4	511.4
Capacitors, total	400.7	434.5	516.2
Paper capacitors	52.0	54.2	58.0
Film capacitors	57.3	63.6	83.5
Electrolytic capacitors	173.0	187.4	244.7
Mica capacitors	26.3	29.0	24.1
Glass and vitreous enamel capacitors	8.7	9.2	7.5
Ceramic capacitors	57.4	61.4	64.3
Variable capacitors	26.0	29.7	34.1
Connectors, total	354.4	379.5	449.0
Coaxial connectors, standard size	33.1	35.2	38.5
Coaxial connectors, miniature	20.6	23.0	34.5
Cylindrical connectors	128.7	138.1	164.5
Rack and panel connectors	75.2	79.7	90.8
Printed circuit connectors	45.8	50.3	58.0
Special purpose and fused connectors	51.0	53.2	62.7
Delay lines	18.0	19.3	24.0
Electromechanical devices, total	561.4	586.4	696.9
Resolvers	10.8	11.5	12.0
Servo Motors	29.6	31.5	33.6
Synchros	30.0	29.5	28.8
Rate generators	5.3	5.6	6.3
Motor generators	14.3	15.1	17.0
Fractional horsepower motors	411.3	417.0	491.8
Solenoids	24.7	26.0	34.4
Encoders and decoders	35.4	50.2	73.0
Electron tubes, total	1,352.2	1,366.1	1,401.1
Receiving tubes	244.0	221.3	148.0
Power and special purpose tubes, total	296.2	295.5	308.1
High-vacuum tubes	65.1	61.7	58.0
Gas and vapor tubes	17.6	17.0	14.8
Klystrons	41.4	41.0	38.6
Magnetrons	39.8	39.1	37.5
TWT's including backward wave types	54.4	54.0	59.2
Light-sensing tubes	37.4	39.6	47.0
Storage tubes	17.5	18.1	23.0
Display tubes, except cathode ray	6.2	7.0	9.7
Cathode ray tubes, except TV	16.8	18.0	20.3
TV picture tubes, black-and-white	119.6	103.3	79.0
TV picture tubes, color	692.4	746.0	866.0
Ferrite devices, total	302.7	329.7	375.0
Computer cores	16.8	19.3	34.0
Transformers and chokes, except TV	242.3	260.7	294.0
TV ferrite components, including yokes, flybacks	43.6	49.7	47.0
Filters, electronic, total	48.1	52.3	67.8
Active filters	3.4	4.9	18.0
Passive filters	44.7	47.4	49.8
Loudspeakers	112.4	114.7	129.0
Magnetic tape, total	175.7	209.9	305.7
Audio tape	54.3	62.5	92.0
Computer tape	63.7	78.2	118.0
Instrument tape	34.8	39.6	48.3
Video tape	22.9	29.6	47.4
Microwave components and hardware, total (tubes and antennas excluded)	108.2	116.3	168.0
Microwave ferrite devices	22.0	23.8	33.0
Multicomponent packages, total (two or more separate active or passive components in a single package)	221.7	296.4	445.0
Logic modules	94.3	144.6	208.0
Other multicomponent packages	127.4	151.8	237.0
Printed circuits, total	224.9	257.7	332.4
Single-layer boards	83.5	93.8	109.0
Two-layer boards	93.1	100.0	125.0
Multi-layer boards	48.3	63.9	98.4
Quartz crystals (including mounts and ovens)	54.4	58.3	67.8
Resistors, total	410.3	423.0	434.8
Fixed resistors, total	220.5	225.3	229.9
Composition resistors, fixed	90.7	88.3	85.4
Deposited carbon resistors, fixed	17.1	15.8	11.2
Metal film resistors, fixed	50.6	54.8	67.3
Wirewound resistors, fixed	62.1	66.4	66.0
Potentiometers, total	164.7	170.7	172.9
Wirewound potentiometers	79.7	82.0	81.6
Non-wirewound potentiometers	85.0	88.7	91.3
Other resistors (including varistors and thermistors)	25.1	27.0	32.0

	1968	1969	1972
	(millions of dollars)		
Relays, total	271.6	287.4	348.1
Solid-state relays	17.3	21.4	42.0
Electromagnetic relays, total	112.1	117.7	139.1
Contact meter relays	6.1	6.0	5.0
Crystal can relays	34.2	33.3	35.8
Dry reed relays	24.5	28.2	39.2
Mercury wetted relays	15.7	18.0	24.6
Resonant reed relays	1.5	1.8	3.0
Telephone type relays	26.1	26.3	27.0
Thermal relays	4.0	4.1	4.5
Other relays	142.2	148.3	167.0
Semiconductors, total	1,376.1	1,488.4	1,959.2
Discrete, conventional devices total	596.5	562.9	464.8
Transistors, total	405.5	375.3	313.3
Transistors, silicon, bipolar	298.4	284.7	241.0
Transistors, germanium bipolar	86.7	64.1	35.0
Transistors, field effect	15.1	18.7	23.5
Transistors, unijunction	5.3	7.8	13.8
Diodes, total	191.0	187.6	151.5
Germanium diodes	22.7	21.6	8.3
Silicon diodes	168.2	166.0	143.2
Discrete, special devices total	277.2	275.7	288.8
Thyristors (SCR's, 4 layer diodes, etc.)	59.7	63.8	89.4
Trigger diodes	51.3	50.1	42.3
Tunnel diodes	4.5	5.1	6.9
Microwave diodes, excluding varactors	24.1	22.0	18.7
Microwave transistors	6.4	8.3	21.2
Varactor diodes	6.7	7.6	13.1
Zener diodes	56.9	55.7	46.3
Multiple devices (duals, diode arrays)	31.2	29.4	21.7
Other special devices (temperature sensing, strain gauge, etc.)	36.4	33.7	29.2
Integrated electronics, total	502.4	649.8	1,205.6
Monolithic IC's total	342.3	425.4	734.2
Linear (less than 12 gates)	76.3	89.2	171.6
Digital (less than 12 gates)	242.9	296.8	435.6
Single chip subsystems active (shift registers, scratch-pad memories, DDA's, etc.)	23.1	39.4	127.0
Hybrid IC's total (Semiconductor devices and thin or thick film components combined on a common substrate)	51.3	61.2	92.0
Digital	31.4	37.0	54.7
Linear	19.9	24.2	38.3
Integrated arrays, total	52.8	108.0	263.4
MSI devices (12 to 100 gates)	49.2	100.0	225.0
LSI devices (100 or more gates)	3.6	8.0	38.4
Operational amplifiers, monolithic	22.8	26.9	41.0
Passive thin or thick film devices	33.2	38.3	74.0
Optoelectronic devices, total	23.0	27.2	35.7
Photovoltaic (solar) cells	5.7	6.5	7.7
Photoconductive cells	8.6	9.5	11.0
Light-emitting diodes	0.8	1.2	2.6
Photodiodes	6.3	7.6	9.7
Special optoelectronic devices (isolators, switches)	1.6	2.4	4.7
Rectifiers, solid state, total	124.1	128.7	151.0
Rectifiers, silicon	96.2	102.0	121.5
Rectifiers, selenium and copper oxide	15.2	13.1	10.5
Rectifier assemblies	12.7	13.6	19.0
Switches, mechanically actuated, total	162.2	176.8	211.3
Coaxial switches	8.3	9.8	12.9
Pressure switches	20.2	21.0	23.3
Rotary switches	37.4	40.8	56.3
Snap-action switches	51.2	54.3	62.0
Toggle, mercury, knife, misc.	31.4	33.1	37.8
Stepping switches	13.7	17.8	19.0
Transducers, total	110.0	122.1	162.1
Pressure transducers	32.4	35.6	48.7
Position transducers	31.9	34.3	46.2
Strain transducers	32.1	37.9	51.2
Acceleration transducers	13.6	14.3	16.0
Wire and cable, total	328.6	358.6	394.1
Coaxial cable	62.5	68.5	78.7
Flat and flexible printed circuit cable	20.2	26.5	37.6
Hook-up wire	147.2	153.6	139.8
Magnet wire	98.7	110.0	138.0

Federal Electronics

	1968	1969	1972
	(millions of dollars)		
FEDERAL ELECTRONICS, TOTAL	10,659	10,789	11,679
Department of Defense, electronics portion, total	8,864	9,051	9,921
Procurement, total	4,577	4,632	5,166
Communications	1,023	1,140	1,289
Aircraft	1,224	1,088	1,268
Missiles	1,473	1,511	1,687
Mobile and ordnance	263	267	284
Ships	594	626	638
Research, development, test, and evaluation	2,291	2,304	2,515
Operations and maintenance	1,996	2,115	2,240
NASA, electronics portion	1,622	1,556	1,495
Federal Aviation Administration, electronics portion	103	110	185
Atomic Energy Commission, electronics portion	70	72	78

Consumer Electronics

	1968	1969	1972
	(millions of dollars)		
CONSUMER ELECTRONICS, TOTAL	4,174.0	4,395.5	5,043.9
Television Receivers, Total	2,525.0	2,628.0	2,983.0
Monochrome TV Receivers	468.0	412.0	273.0
Color TV Receivers	2,057.0	2,216.0	2,710.0
Radios, Total	513.8	535.3	583.4
A-M and F-M radios	249.6	258.3	281.4
Auto radios	264.2	277.0	302.0
Automobile tape players	32.4	36.5	45.0
Phonographs total	587.2	597.0	631.2
Phonographs, monaural	53.2	55.0	57.2
Phonographs, stereo	534.0	542.0	574.0
Tape Recorders, audio	162.0	188.2	248.0
Tape Recorders, video	4.7	6.9	18.3
Tape cartridges	72.0	94.0	148.0
HI-FI components (including tuners, speakers, amplifiers, etc.)	96.0	110.0	135.0
Electronic organs	72.0	76.7	90.2
Guitar amplifiers	34.2	36.0	44.8
Kits, except toys	43.7	48.0	64.7
Light dimmers	8.4	10.0	12.5
Garagedoor openers	18.4	21.8	40.0
Automotive electronics, total	4.2	7.1	29.8
Sequential flashers	1.7	2.3	3.8
IC voltage regulators	2.5	4.8	26.0

Industrial Electronics

	1968	1969	1972
	(millions of dollars)		
INDUSTRIAL AND COMMERCIAL, TOTAL	8,289.1	9,480.5	12,552.0
Test and measuring instruments	684.4	769.0	1,002.4
Medical equipment	366.3	406.9	519.0
Nuclear instruments and equipment	123.8	141.2	198.2
Computers and related equipment	4,134.0	4,787.2	6,608.1
Communications and equipment	1,625.2	1,849.2	2,460.1
Lasers and equipment	55.2	71.6	128.3
Closed circuit television	91.8	108.2	173.9
Dictating devices	110.0	114.4	148.0
Power supplies, OEM	77.0	86.0	112.0
Industrial operations electronic equipment	1,021.4	1,146.9	1,202.0

Industrial and Commercial Markets

	1968	1969	1972
	(millions of dollars)		
Test and measuring instruments, total	684.4	769.0	1,002.4
Spectrum Analyzers, subaudio to 1 Ghz	13.7	15.8	21.2
Signal generators, up to 1 Ghz	19.5	21.0	24.5
Sweep Generators, up to 1 Ghz	7.8	9.5	13.1
Pulse generators, up to 1 Ghz	9.6	11.8	15.4
Oscillators, subaudio through video	21.4	23.7	30.7
Waveform generators, all shapes	13.2	15.5	22.4
Waveform analyzers and distortion meters	5.3	6.1	8.5
Counters, time and frequency	35.3	37.6	45.6
Timers, electronic	76.1	82.4	105.0
Panel meters	41.4	43.8	50.2
Noise measuring equipment, up to 1 Ghz	12.5	14.0	18.5
Frequency measuring instruments, except counters	11.2	13.1	18.6
Voltmeters and ammeters, electronic, DC to 1 Ghz, meter indicating	19.7	22.8	30.7
Digital voltmeters	27.0	29.8	39.3
Power meters, DC to 1 Ghz	6.5	8.0	12.1
Impedance measuring equipment, up to 1 Ghz	13.2	15.0	19.4
Calibrators and standards, active and passive	15.1	17.3	22.3
Oscilloscopes, DC to 1 Ghz, main frame only	98.4	106.1	121.0
Oscilloscope accessories and plug-ins, up to 1 Ghz	22.1	26.2	34.7
Recording instruments, digital and analog	49.3	56.7	72.3
Components testers (capacitor, transistor, tube, integrated electronics, etc.)	22.5	25.8	49.8
Power supplies, lab type	51.0	57.0	72.3
Amplifiers, lab type	8.0	8.8	9.7
Microwave measuring equipment (above 1 Ghz), total	84.6	101.2	145.1
Oscilloscopes, above 1 Ghz	9.4	10.7	15.6
Microwave phase measuring equipment	5.5	6.7	12.3
Microwave impedance measuring equipment	14.0	16.5	22.1
Microwave power measuring equipment	4.3	5.2	7.9
Spectrum analyzers, above 1 Ghz	11.0	13.3	18.7
Frequency measuring and analysis, above 1 Ghz other	9.3	10.6	13.7
Microwave noise measuring equipment	5.2	7.1	10.4
Signal generators, above 1 Ghz	10.4	11.6	14.0
Sweep generators, above 1 Ghz	8.6	10.4	16.5
Pulse generators, above 1 Ghz	4.4	5.7	8.9
Field intensity meters and test receivers	2.5	3.4	5.0
Medical equipment, total	366.3	406.9	519.0
Diagnostic equipment, total	251.2	275.2	349.7
X-ray, fluoroscopic equipment	184.2	197.5	246.0
Electroencephalographs	5.1	6.2	7.9
Electrocardiographs	14.5	17.0	20.3
Ultrasonic	4.8	6.4	9.1
Radioactive tracer equipment	17.1	19.6	26.2
Electron microscopes	9.8	11.2	15.8
Analytical lab equipment, including blood colorimeters	15.7	17.3	24.4
Patient monitoring systems, total	16.6	21.9	34.9
Cardiac	10.5	14.4	24.3
Respiratory	4.2	5.1	6.3
Blood gas	1.9	2.4	4.3

	1968	1969	1972
	(millions of dollars)		
Prosthetic/orthotic equipment, total	62.3	68.0	79.4
Hearing aids	54.7	58.0	65.8
Pacemakers	7.6	10.0	13.6
Therapeutic equipment, total	36.2	41.8	55.0
X-ray equipment, therapeutic	26.3	29.0	36.0
Ultrasonic	4.8	6.0	8.6
Diathermy, shortwave and microwave	2.6	3.5	5.0
Defibrillators	2.5	3.3	5.4
Nuclear instruments and equipment, total	123.8	141.2	198.2
Pulse analysis instrumentation	18.2	19.7	23.0
Power supplies for nuclear equipment	8.7	10.4	18.2
Personal Dosimeters	2.1	2.6	3.5
Radiation monitoring, portable survey instruments	3.5	3.9	5.9
Radiation monitoring, fixed position	4.7	5.6	8.3
Detectors (all, separate unit or part of system), total	7.9	9.5	14.5
Solid state (semiconductors, scintillation, crystals, and organic phosphors)	4.2	5.1	6.9
Tubes (geiger, gas flow, BF_3)	2.9	3.4	5.6
Ionization chambers	0.8	1.0	2.0
Reactor controls	25.5	27.0	30.0
Nuclear instruments and equipment, other	53.2	62.5	94.8
Computers and related equipment, total	4,134.0	4,787.2	6,608.1
Digital computers except process control	3,075.0	3,450.0	4,375.0
Analog computers, except process control	56.3	63.7	110.6
Hybrid computers, except process control	41.2	46.5	67.0
Peripheral equipment, total	705.5	879.9	1,393.2
Converters, A to D	22.4	26.0	41.3
Converters, D to A	16.6	19.8	25.2
Converters, card to tape	7.2	7.0	3.2
Readers, paper tape	32.5	40.0	56.0
Electromechanical readout devices	137.0	168.4	227.3
Electronic readout (digital displays and crt's)	98.2	155.0	288.5
Character recognition equipment (optical, magnetic, etc.)	122.4	153.8	278.0
Mass storage memories, total	269.2	309.9	473.7
Core memories	33.7	46.2	62.0
Magnetic tape machinery	68.1	74.7	92.0
Magnetic drum memories	31.4	35.0	46.5
Magnetic disc memories	136.0	154.0	273.2
Data transmission equipment	85.2	104.5	203.3
Data acquisition equipment	126.0	189.2	387.0
Electronic desk calculators	44.8	53.4	72.0
Communications equipment, total	1,625.2	1,849.2	2,460.1
Radio, total	498.1	573.2	734.5
Airborne, including ground links	141.3	152.6	194.0
Land mobile	184.1	207.5	230.0
Marine radio	21.2	24.6	32.5
Microwave relay	87.5	118.3	188.0
Amateur equipment	27.2	29.8	38.2
Citizens band equipment	36.8	40.4	51.8
Navigation, total	1,127.1	1,276.0	1,725.6
Radar	84.2	96.7	170.0

	1968	1969	1972
	(millions of dollars)		
Other navigational aids (Sonar, Loran, VOR)	39.4	61.7	112.0
Terminal and switching	238.2	274.0	344.0
Carrier current	19.7	23.5	48.0
Intercom	95.2	98.8	112.4
Commercial sound and P.A	219.0	226.4	268.0
A-M Station equipment	14.6	15.7	17.0
F-M station equipment	11.4	12.5	19.2
TV station equipment	125.3	129.7	149.0
Facsimile	26.2	33.0	54.0
Telemetry	191.4	220.0	284.0
Modems	62.5	84.0	148.0
Lasers and equipment, total	55.2	71.6	128.3
Gas laser	38.4	46.8	80.0
Ruby lasers	1.4	2.0	4.0
Semiconductor lasers	4.7	7.8	18.4
Liquid lasers	1.8	3.1	7.5
Laser power supplies	3.7	5.8	8.9
Auxiliary laser equipment, incl. nonlinear crystals	5.2	6.1	9.5
Closed circuit television equipment, total	91.9	108.2	173.9
Industrial CCTV	33.0	37.8	61.0
Education CCTV	22.5	27.6	44.3
Theater CCTV	2.2	3.6	5.8
Medical CCTV	6.2	8.0	13.8
CATV equipment	27.9	31.2	49.0
Dictating devices (for business)	110.0	114.4	148.0
Power supplies, oem type	77.0	86.0	112.0
Industrial operations electronic equipment, total	1,021.4	1,146.8	1,202.0
Motor speed controls	64.0	72.6	94.4
Welding controls	22.0	24.4	32.0
Power supplies (complete equipment)	112.0	123.0	168.0
Photoelectric gauges and controls	16.4	21.6	32.5
Cryogenic equipment	68.3	73.8	98.0
Ultrasonic cleaning equipment	17.3	20.2	29.7
Ultrasonic testing equipment	18.4	23.5	38.7
Infrared inspection and gauging equipment	43.0	47.8	59.0
X-ray inspection and gauging equipment	27.0	30.4	41.0
Nuclear gauging and processing	74.0	82.0	113.5
Process control computer systems, total	338.7	378.9	495.2
Process control computer systems, analog	94.8	110.2	151.5
Process control computer systems, digital	243.7	268.3	341.2
Process control computer systems, hybrid	0.2	0.4	2.5
Machine tool controls, total	60.9	73.6	143.9
Point-to-Point control systems	32.5	39.0	72.0
Continuous contouring systems	28.4	34.6	71.9
Controllers and programers	44.6	50.8	71.0
Electric actuators and solenoid valves	44.9	47.6	57.8
Indicators	6.3	7.1	8.2
Recorders	63.6	69.5	84.4

Electronics markets: 1969

The new math of growth

Sales gains this year will hold at about the 1968 pace, but more important are the further technological advances and reshaped markets down the road

Once again, the electronics industry anticipates a comparatively modest—by past standards, at any rate—year-to-year gain. Sales this year are expected to rise 6.5% from 1968, to $25.3 billion.

The war in Vietnam is no less a factor in the near-term outlook than it was a year ago. Pentagon procurement patterns will inevitably have a significant impact upon electronics companies. Likewise, space projects will probably be wounded by further budget slashes. In addition, recurrent international monetary crises, ambivalent behavior of consumers when it comes to big-ticket items like color television and stereo sets, and the uncertainties that attend the installation of a new Administration also figure in the equation.

But the immediate statistical data seems somewhat less important this year than the industry's dynamics and what they portend. Within the next three years, electronics will become an almost $30 billion industry. And by 1972, industrial and commercial outlets will have overhauled the Government market in terms of dollar volume. The Federal sector isn't going to fall off precipitately as a source of revenue; it will simply decline in relative importance. Clearly, this development augurs well for firms seeking to fatten their profit margins. At the same time, however, the Government's anticipated outlays of $11.7 billion in 1972 indicate the continued and welcome availability of research and development funds.

Behind the industry's expected surge during the period ahead is the increasing rule of solid state technology. By yearend, integrated electronics of all kinds—monolithic, hybrid, film, arrays, and related wares—will claim a 44% share of semiconductor sales. By 1972, when the field will be doing around $2 billion worth of business, this penetration is expected to reach a level of 60% or better.

Integrated circuits have already done extremely well in computer and military applications. The former market should continue to be a tower of strength, but the military is showing signs of becoming more selective in its purchases. Taking up much of the slack will be the industrial market. So important have such sales become that at least one semiconductor house has realigned its marketing efforts to give better coverage to the Midwest, where numerical controls manufacturers are centered. Down the road, consumer goods loom as another volume market for solid state devices. However, price is of paramount importance in this field, and IC's must first prove their mettle on economic, rather than performance, grounds if they're to find entry.

To survive and thrive from here on out, semiconductor houses are going to have to merchandise their wares and create new markets. In this context, the concerted drumbeating for large-scale integration seems premature by at least a couple of years. Most manufacturers are quietly preparing to offer complex, medium-scale arrays that interface with such proven families of devices as transistor-transistor logic.

Meanwhile, the industry in general and semiconductor houses in particular are increasingly uneasy about the blurring of the lines demarcating traditional spheres of interest. As their assemblies grow in complexity, device makers find themselves invading the territory of systems and set makers And many of the latter are seeking to develop in-house skills in semiconductor technology. Similarly, communications firms are encroaching upon the once private preserves of computer concerns. If only for reasons of self-interest and preservation, rapprochements must eventually be worked out.

Markets index

Advanced projects begin to take shape

Defense procurement in 1969 will follow the general patterns of the past few years; in the research and development field, however, there will be a discernible shift in emphasis from tactical to strategic projects. Nuclear submarines and the Advanced Manned Strategic Aircraft, for example, are high on the Pentagon's shopping list. In addition, the Sentinel antiballistic missile system is still slated to receive a healthy infusion of funds. Fully three-quarters of the spending on this program, which could run to $1 billion or more annually, will go to electronics concerns for radar, computers, semiconductor devices, and related items.

In the meantime, if the Vietnam war has done nothing else, it has underscored the crying need for special equipment in brushfire conflicts. As a result, a considerable amount of time and money will be devoted to night-vision gear, countermortar radar, and the like. And if the war were to end tomorrow, there would be little, if any, effect upon electronics suppliers, because of the long-term requirements for tactical equipment and hardware.

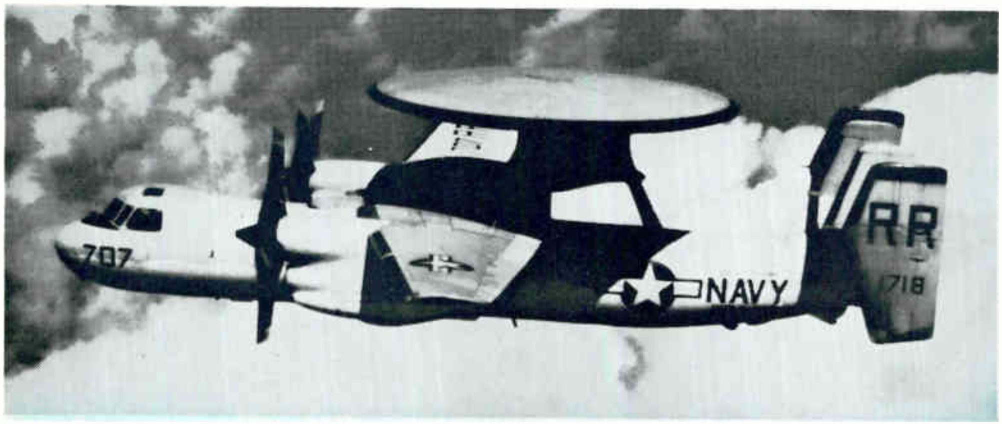
Clear sailing

Tomorrow's Navy, which is being developed today, will feature quiet-running nuclear subs as well as a high-speed surface fleet. In November, the Naval Ships Systems Command awarded a start-up contract worth $35 million to General Dynamics' Electric Boat division for the so-called "quiet" submarine. Secretary of Defense Clifford estimates the production cost of these craft at $150 million to $200 million—about twice the going rate for present nuclear models.

Study contracts have been let for the new multimission DX/DXG destroyers. About half the cost of these craft, whose prices are estimated at $45 million or more, will be accounted for by radars and other electronics equipment. One of the big buys in the DX/DXG program will be for the electronics-laden advanced surface missile system, currently in contract definition. Development and production awards for both programs, which will probably be total-package procurements eventually worth more than $2 billion, are expected by late summer.

It's all ahead full for the Poseidon submarine-launched ballistic missile, which is replacing the Polaris. By yearend, the missile-equipped nuclear sub fleet will have 69 craft. And the preparedness investigating subcommittee of the Senate's Committee on the Armed Services believes the U.S. is falling behind Russia in this area. As a result, attack sub programs could get even higher priority.

Field tested. The PRC-25 family of tactical radio equipment has been a workhorse in Vietnam. But the Army is now working on the future generations of equipment it will use during the mid-1970's.



Comeback. Most of the Navy's air arm budget is tabbed for new systems. Nonetheless, there's going to be money for upgrading craft like the Grumman E2A.

Moreover, a staff assistant on the defense subcommittee of the House Appropriations Committee reports that his organization is also taking a special interest in missile-carrying nuclear subs. Some members are even agitating for MIRV (Multiple Individual Re-entry Vehicles), though a number of military experts still have grave doubts about the accuracy and reliability of such systems.

The Poseidon is of particular interest to electronics suppliers because of the Navy's standard hardware program for modules in the fire-control system. "What it comes down to is that we don't care what the vendors stuff into a package so long as it does what it's supposed to," says an official at the service's Special Projects Office.

The Navy's very-low-frequency navigation system is set for substantial funding in 1969. Clifford recently gave the go-ahead for a second group of four Omega transmitting stations.

The Navy's air arm is also looking ahead. There'll be money for the VSX, which will eventually replace the Grumman S-2 antisubmarine warfare craft. This project is still in a definition stage, but development and production contracts could be let by June. Likewise, the VFX, an interim replacement for the recently scuttled F-111B, will be funded. The Navy wants it for carrier defense and related applications.

Older programs are also showing life. For example, the E2A, an early-warning radar craft built by Grumman, will be fitted out with APS-111 radar equipment.

Air power

The Air Force is cutting back on its purchases of A7's this year; it plans to use the money it saves to buy more F-4E's. The FX, a version of the Navy's advanced tactical fighter, will be underwritten during the year. The precontract definition phase is still some time away; the service is seeking the best tradeoffs among maneuverability, weapons-carrying capabilities, and speed.

With overland radar accepted, the Air Force will probably move into full-scale development of Awacs (Airborn Warning and Control System) to have it operational by 1970. Requests for procurement are expected shortly. In the meantime, however, the Tactical Air Command is pushing for an interim system called Atacc (Advanced Tactical Airborne Command and Control). Awacs advocates fear that a quick-and-dirty implementation of Atacc could wind up hurting available funding for their project.

A project to be funded at relatively low levels—$2 million or so for study contracts—could eventually lead to billions of dollars worth of orders for electronics suppliers. It's the I/CNI (Integrated Communications, Navigation, and Identification) system. An Air Force Systems Command study group, with help from the Mitre Corp. and industry, has concluded that the program is technologically feasible.

In the Army now

Army communications programs will cover a number of fronts. The multination integrated tactical trunking and distribution system of Mallard will continue to be a preoccupation. Additional versions of RADA (Random Access Discrete Address) subscriber units will be purchased. In addition, field radios beyond the PRC-25 family are being developed. "The market for lightweight tactical equipment is growing fast," says Richard Shetler, senior vice president at Sylvania Electronic Systems. "We expect volume to reach $300 million a year by 1975."

Tacfire, a complex computer-based system for automating combat artillery batteries, will be a big buy during 1969. Litton Industries' Data Systems division is prime contractor on the program, which will be operational by 1971. Tacfire automates fire direction and selection by integrating all required data, including trajectory, survey, meteorological, and logistical information.

Although few details are available on most electronic warfare systems, it seems likely that 1969 will be another growth period for this area. Pentagon research emphasis will probably fall on reconnaissance gear, infrared sensors, foliage-penetration radar, countermortar radar, equipment to pinpoint the source of artillery fire, and related items.

IC makers' surge to continue

If and when are finally words of the past for integrated circuits. Monolithic assemblies alone chalked up sales of $342.3 million last year; volume in this year is estimated at $425.4—a 24% jump. Integrated electronics of all kinds, including hybrid devices, arrays, film, and related items are expected to do $649.8 million worth of business this year, an almost 30% improvement over the year-earlier level. What's more the integrated category is zeroing in on the 50% mark in the semiconductor field. By yearend, it should account for better than 44%; by 1972, over 60%.

Discrete semiconductor components, which carried their more exotic descendants through some difficult days, have stabilized somewhat after taking their lumps during the 1966-67 period. But while unit sales will rise, dollar volume will make no headway, declining from last year's $596.5 million to $562.9 million. Discretes still account for a substantial enough portion of semiconductor sales that the industry's total revenue gain this year will be held to less than 9%—$1.49 billion, as against $1.38 billion.

While military applications will continue to be the big sales guns, other markets are on the point of becoming volume outlets. Commercial, consumer, and industrial customers, for example seem prepared to boost their orders considerably. Computer makers and aerospace concerns continue to rank high on the list of industry prospects.

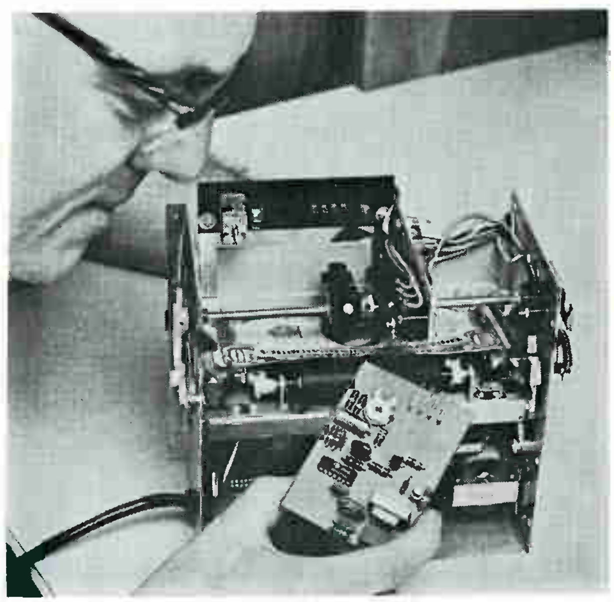
Where it's at

Albert B. Dall, vice president of the Transitron Electronic Sales Corp., sums things up this way: "Computers continue to be the area with the greatest sales potential, and gains in this field are accelerating. Military business is not growing as much as had been hoped; purchases are getting very selective. Industrial outlets, which are working from a smaller base than the computer industry, should grow at a faster pace." Interestingly enough, this latter development has forced a realignment in Transitron's sales activities. The Midwest, once a Sahara, has become an important territory as numerical control makers move from the suspect to the prospect category.

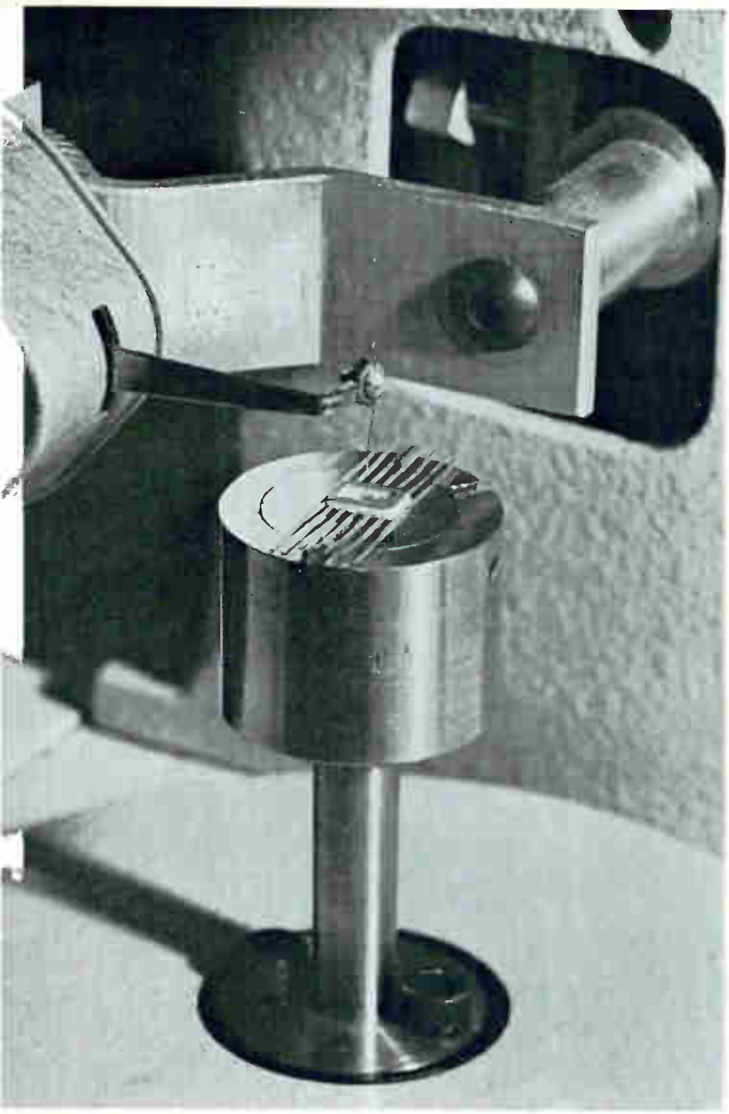
Nevin Kather, who heads semiconductor operations at the Raytheon Co.'s Components division, is also looking for gains in the industrial-commercial field. "IC's for application in electronic data processing equipment are now competitive with discrete devices," he says. "In addition, high-speed memories are feasible and available." Kather also anticipates that an increasing proportion of the industry's output will be going into automobiles and consumer goods. Similarly, the fast-growing National Semiconductor Corp., which has made a lucrative specialty out of the high-reliability military market, has also set its sights on instrumentation and calculator makers with counting elements for desk-top machines, digital voltmeters, and related apparatus. "We concentrate almost exclusively on complex elements with four or more levels of logic," says Donald T. Valentine, marketing manager. "This accounts for our dollar growth —the unit cost stays high."

Floyd Kvamme, product marketing manager at National, likes the looks of the MOS market. "Buyers have confidence in the manufacturers," he says. "A few years ago, the static about delivery was deafening. But users are getting their circuits now." Kvamme points out that shift registers, which got a big play in 1967, are now routinely designed into systems. "During 1968, the stress was on read-only memories," he says. "This year, it will be on random-access memories for computer scratchpads." Kvamme ticks off a number of applications for read-only memories, including cash registers, small computers, and character generators for remote terminals.

Another MOS enthusiast is Bill Berg, domestic marketing manager for the Signetics Corp., a subsidiary of Corning Glass Works. "MOS should do well, particularly in memory outlets, this year," he says. "I don't think we'll see high introductory price tags, though. Rather, circuits will be offered



One for the money. Transmarine bill changer, built with IC's from TI is typical of new commercial applications.



Breakaway. Sylvania spot-checks integrity of lead bonds before encapsulating any IC production runs in plastic.

at a level that can be maintained over a period of time." Berg is also optimistic about prospects in the commercial-industrial sector. "There's a lot of growth potential in peripheral equipment; users have been stuck with discrete devices because of power requirements and voltage considerations," he says. "But this year, we'll see IC's that can handle 200 to 300 volts; dielectric isolation, together with other techniques, will make these devices marketable items."

Widespread consumer applications are apparently not yet in the cards. However, the outlook is improving, and, long-term prospects remain bright. "The consumer field is traditionally slow to embrace new technologies because of the price premiums that are involved," says W. D. Rasdal, assistant manager of the TRW Microelectronics division, an element of the Electronics Group at TRW Inc. "Manufacturers are in no hurry to back away from tubes, much less adopt IC's."

Jim Burns, manager of linear IC marketing at Motorola, agrees with Rasdal's analysis. "When you reach a point where you can match the performance of discrete devices or tubes, it becomes strictly a price fight," he says. "The set maker wants a straight one-to-one rivalry before he'll adopt an IC. He's just not interested in the superior reliability we say we can furnish with linear IC's."

Nonetheless, Clay Tatom, manager of linear IC product planning at Motorola, reports the company is taking dead aim on consumer outlets. Process control improvements leading to price cuts that will let Motorola-made IC's compete with sockets are behind this push. For example, as a result of better yields, an increase in chip size, and greater device density, Motorola was able to slash the quotation on the MC1439G, a commercial op amp, from $5.50 to $1.80 in lots of 100.

Burns figures most linear IC's are now being used to replace discretes. He does, however, say some electromechanical devices are being displaced in automotive applications. Burns believes ignition systems will be the next sizable outlet for linears in this field.

Pro and con

There's still a good bit of controversy swirling about plastic packaging of IC's in the semiconductor field. "There's no question but what plastic encapsulation is the big thing," says an official at Texas Instruments. "We ship more devices in plastic than in any other kind of packaging. And the resistance of the military is not affecting the bright outlook to any great extent. The only point on which plastic can be questioned is hermeticity. But in normal applications, there's no problem." TI, of course, has made a very good thing of plastic-packaged logic circuits in the industrial field. It has been particularly aggressive in merchandising these wares to comparatively small manufacturers who have no prior skills in electronics, much less IC's. Frequently, these accounts turn out to be important customers whose business runs to six-figure levels.

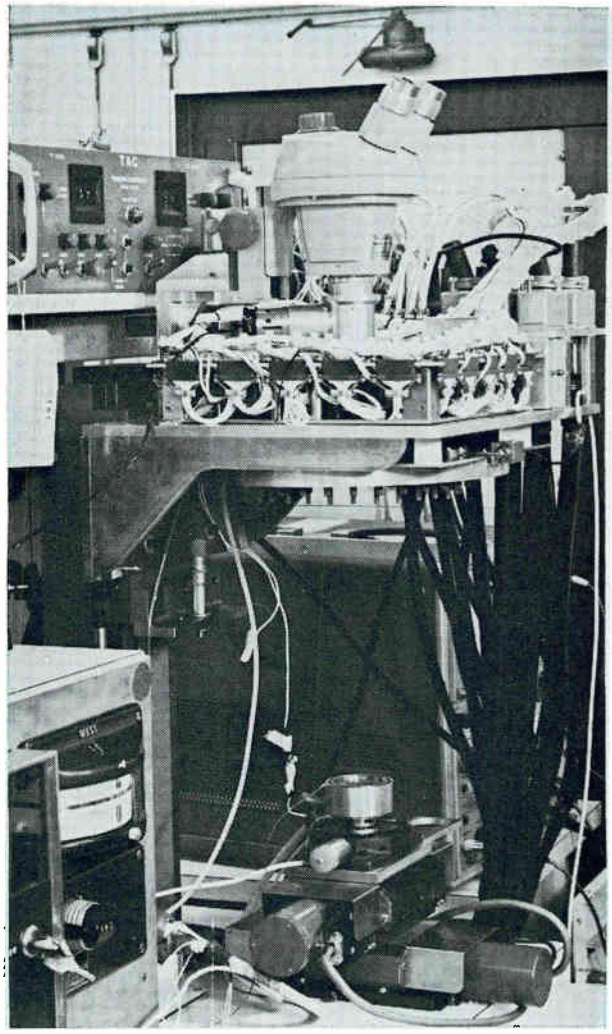
Not everyone, however, is as sanguine about plastic as TI. "We've found much of the concern is justified," says Joseph T. Nola, manager of IC market planning at the Semiconductor division of Sylvania Electric Products. "Plastic presents some complex materials and engineering problems; we've done a lot of study in both areas." Sylvania, for example, is checking the relationships of the chip, the bond, and the package, having observed that contraction or expansion of the encapsulant can tear leads from pads. As a standard sampling procedure, the company has a "yank" test in which the wires are gently tugged to see if the bonds hold or break. "We have specifications that a bond must meet before the lot is packaged," says Nola.

Nola estimates about 48% of all transistor-transistor-logic IC's are now sold in plastic. "But the boom awaits solution of moisture, temperature-cycling, and bond-breakage problems," he says.

Stephen F. Guthman, manager of marketing services at Westinghouse's Molecular Electronics division, agrees: "The Government will eventually accept plastic. But it's up to the IC industry to prove its case. It hasn't done so, and plastics won't be accepted in any kind of high-reliability environment this year." Guthman, however, concedes that such devices will continue to thrive in commercial outlets. TRW's Rasdal anticipates that the military will continue to insist upon hermetically sealed packages—even for beam-lead devices, which are virtually sealed chips requiring no package, according to their advocates.

Jerry Gibbs, product marketing manager at Teledyne's Amelco Semiconductor division, is looking for more widespread acceptance of plastic-encapsulated IC's during the year. He's disturbed, however, about the semantics that are involved. "Plastic is really a misnomer; silicone is the proper term," he says. "Many misconceptions could be overcome if the industry used this term." Gibbs points to the fact that silicone is inert and—unlike epoxies—has no catalyst. In addition, he says, the material is capable of wider temperature ranges than ceramic.

Motorola's Burns virtually dismisses the whole question, saying: "Plastic-packaged devices—whether digital or linear—were never intended for the military market." However, his colleague Tatom points out certain defense applications in which plastic surpasses other materials. Motorola makes linear IC fuzes for a wide variety of ordnance. The greater impact resistance of the plastic package makes it more attractive in this case. This is because the package is "filled," making for greater lead-bond integrity when projectiles are fired.



Check point. To enhance IC yields, Raytheon uses set-up which makes a-c, d-c, and temperature tests on the wafer.

About as far as they can go . . .

As IC producers gain experience in their craft, their yields have improved. Exactly how much, however, is a closely guarded secret. When queried on the subject, spokesmen are inclined to give a percentage improvement over last year's unknown. While there's little reason to doubt that the figures have improved considerably, the industry gives the impression of fretting about where its next breakthrough will come from. "Yields are like a staircase," says Westinghouse's Guthman. "They improve, and then stay at a plateau for a while." Raytheon's Kather reports his company's yields have reached the point where "there won't be any substantial improvements without major process innovations." To this end, Raytheon is running further wafer checks, performing a-c, d-c, and testing on the chip.

"Yields are to the point where we can run IC's off the line like discrete transistors," boasts Dall of Transitron. "Even on complex functions like our upcoming 45-megahertz shift register and 60-Mhz counter arrays, yields are already better than on simple assemblies. Problems with arrays may never be as serious as was the case with the first flip-flops and related devices."

Gibbs of Amelco believes further improvement in yields will be marginal involving better testing at the wafer stage. But, he says, present equipment is close to the practical limit.

Motorola has turned its attention to boosting reliability via mechanical means—for example, application of spider bonding techniques and automation of the lead bonding process. At TRW, which is heavy in hybrids, Rasdal considers assembly still the over-riding problem. "Over the short haul, we'll sharpen controls," he says. "But long term, we think beam-lead devices will be the big thing helping to automate assembly." Many in the industry agree with his analysis. One engineer is reported to have gone to his boss and said: "I think we should make an objective evaluation of beam leads and flip chips—and then choose beam leads."

Confusion on a large scale

Semiconductor houses continue to beat the drums for large-scale integration while preparing to promote medium-scale arrays. A source at Fairchild Semiconductor sums things up this way: "Along with most everyone else, we're set to push MSI this year. Sales will be less than 10% of the integrated electronics total. This is because computer makers are the biggest outlets, and they're still designing the next generation of machines. Volume buys at the moment are for gates and flip-flops. However, the important thing is that MSI determines the balance of the new systems. The design emphasis is on maximum complexity—in other words, the most gates per pin and fewest packages per system."

National Semiconductor is also dubious about LSI. "It's the most complex circuit you can make," says Valentine only half in fun. "But by anybody's definition, no true LSI devices will be used in production equipment for three to five years in any meaningful quantity." Again, however, MSI is something else; National has jumped into this area with complex TTL circuits. Later, it will bring out the simple gates that designers need for filling out their systems. Signetics' Berg agrees, "TTL will continue to grab a bigger share of market, and most MSI designs will be compatible."

Way to go

John A King, manager of marketing operations at Sprague Electric's Semiconductor division, says: "We're not home free on LSI as an industry, and we won't be for a long time. Failure modes, thermal considerations, lattice structure, and the like become critical problems as the wafer size grows. And if nothing else does, that's going to hurt." King believes, however, that work in LSI will pay off by fallout at least. "For example, yields on less complex circuits will improve as we solve process control problems on LSI."

"MSI is the way to go. Yields here are improving steadily to the point where we easily can produce circuits with two layer metalization on pilot lines; three-layer metalization is working well in the lab," says Dall of Transitron. "We're confident enough to anticipate introduction of a 64-bit memory chip within the next few months.

"I honestly don't think that anyone will be able to spot the time at which MSI outgrows its label and becomes LSI. As MSI yields improve, chips will gradually grow more complex."

Dall believes the unwary IC maker could get whipsawed selling LSI. He dips into the past to prove his point: "In the days of discretes, a computer's arithmetic section could be built out of two cards—say, a gate card and a flip-flop card. Then IC's arrived, causing some firms to use a few of them, wired in many different ways in many different circuit board types. Now, LSI is confronted by 100 or more different cards in the more complex and powerful computers. And customers want to take these four or five racks of gear and squeeze them into a shoebox-sized container by exchanging each card type for an LSI wafer. But the seller finds out his prospective customer only wants one or two a year—at a price competitive with conventional IC's. It all adds up to a low-profit, high-risk situation that isn't wholly the fault of the IC house, since if enough attention were paid to system architecture, computer builders could cut card or LSI circuit types by 75%."

Dall believes the real benefit of LSI over the next few years will be as a watershed technology for MSI. "By doing the near impossible with LSI, we'll boost yields and reliability and, maybe, reduce prices as well," he says. "For the moment, there won't be much if any, off-the-shelf LSI. Hybrids using MSI chips will be the LSI of the next couple of years."

"Circuits of 100 gates or more are talked about more than sold; it won't be until the very end of 1970 that these 100 and more gate circuits are introduced," says Berg of Signetics.

But because of the fine geometries required for the MSI that Signetics plans to bring out, masking equipment will be put into use which will provide higher resolution than previously. "We are now producing circuits with 24-lead complexity," says Berg. "It will be late 1969 or 1970 before we move to the next level of complexity of 50 or 60. Twenty-four lead packages will become the standard in IC's as 1969 wears on."

Business side

Prices on any IC family will start down and taper off, but the curve will be much flatter this year because there's not much that can be done to raise yields, says Berg. "We won't see dramatic price cuts anymore; probably prices will go down only by 5% or 10%."

During the year, Berg says, there will be increasing difficulty in getting users to accept product innovations. A new line, he believes, will have to offer something pretty substantial to get accepted.

Because there's not much possibility of cutting costs by improving yields, Berg says that it will be difficult for producers who don't have high volume and high yields to make any money.

"We will see a polarization in the industry which will separate the specialty houses from the broad producers. There will always be room for the small volume specialty house doing a $2.5 million business, but they can't expect any longer to get into a position comparable to the industry's big five," says Berg.

Berg makes an analogy between the semiconductor industry and the automotive industry. The big automotive manufacturers have the bulk of the market sewed up and it would be impossible for anyone to become a GM, but there are numbers of small "specialty" houses which quite profitably produce special-purpose vehicles.

The polarization of specialty houses and broad-market houses in the semiconductor industry will be greeted warmly by Signetics. Berg says that it will be a relief not to have to make both the investment and those costly errors which are required to put a circuit on the market for only small volume sales. "Let the specialty houses do it," he says.

Sweet notes in instrumental theme

Instrumentation firms anticipate another good, if unspectacular, market this year. Sales are expected to rise 12% to $769 million from last year's $684.4 million. The principal reason for the field's comedown from the 20% plus growth rates that characterized the mid-1960's is the war in Vietnam. George Bruns, president of the Systron-Donner Corp., explains things this way: "A big chunk of the money for this war doesn't go to industry for equipment; it's simply spent in Southeast Asia." This sort of Government outlay cuts into military, as well as civilian, research and development activities.

Marketing officials at Systron-Donner, about half of whose business is underwritten by the Government, believe that the dollar value of R&D contracts would be much greater if the war were to end—though, they say, the ratio of military to other work would remain about the same.

Diversion of Government funds to the war effort has forced cuts in the budgets of such agencies as the National Aeronautics and Space Administration and the National Institutes of Health, which have been important instrument customers in the past. Hewlett-Packard's president, William R. Hewlett, says: "An end to the war would stimulate sales of electronic measurement and computation equipment for medical research, air traffic control, space, telecommunications, ground transportation, advanced military projects, urban renewal, and education."

Another depressing influence of as yet unknown magnitude is the 10% surcharge on Federal income taxes. Many instrument companies report that the impost has had no appreciable effect so far, but if it cuts significantly into profits, customers could reduce their spending for instrumentation.

Calling automatics

The moderate gains forecast for 1969 are largely attributable to customers' desire to modernize. They're demanding, for example, measuring equipment that's more automatic. John W. Zevenbergen, marketing vice president at the John Fluke Mfg. Co., reports that more and more of the firm's customers balk at buying "manual" equipment—that is, gear that must be read by a human. He cites Collins Radio as but one account that won't buy any new apparatus that can't be easily interfaced with a digital, automatic system producing computer-compatible data.

"In the future, we'll be concentrating on automatic instrumentation," he says. "About everything we do on a manual basis now we hope eventually to do digitally and automatically."

Robert G. Fulks, engineering group leader at the General Radio Co., considers this demand trend "part of the continuous process of taking the art out of precision measurements and building it into instruments." General Radio expects growing interest in automatic impedance measurements and automatic calibrating d-c digital voltmeters.

"Computer-controlled measurement systems will really catch on in 1969," Fulks says. "The engineer is beginning to realize that a computer is not necessarily a piece of mystery equipment but a useful component that will reduce his measured results to a form meaningful to his application."

"The field is boiling," asserts Robert Brunner, corporate engineering manager at H-P. "By using software imaginatively to augment hardware, we can give engineers fast access to the parameters that are their real concern but which previously they could only derive after the experiment was over by computation or inference."

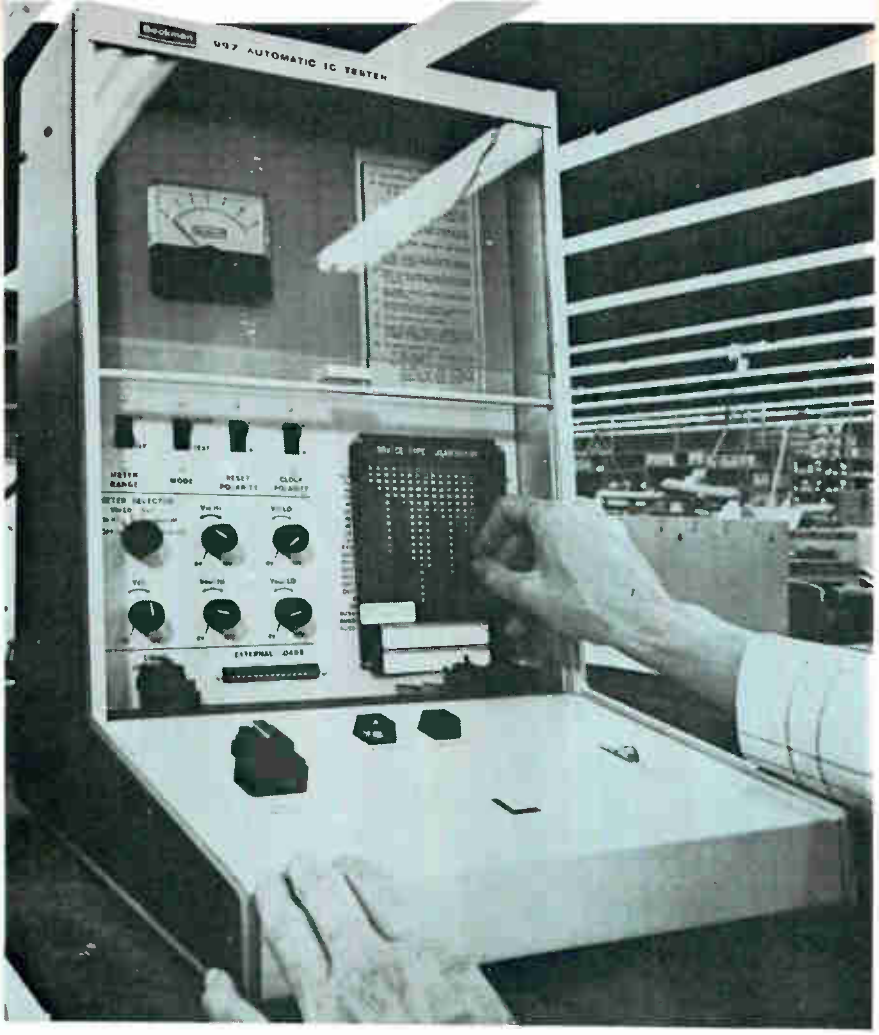
Because of the industry's growing ability to digitize and process data fast, it's now possible, for example, to measure impulse response by testing with noise, substantially in real time. Histograms can be generated to show the way circuits or systems depart from center-line performance with overload, temperature, and other factors.

Improved performance at reasonable cost will also play a role in the anticipated market growth by opening new outlets. In counting and timing, for instance, direct methods can now go up to 200 megahertz. And with scaling and heterodyne techniques, converters can go to 50 gigahertz. Timing resolution on the order of 1 nanosecond will also be available. As a result of such gains, Wavetek, for one, expects more widespread use of instruments previously considered exotic. Spectrum analyzers, for instance, are becoming workaday items of test equipment.

Export sales are another factor in growth; Hewlett predicts continuing high levels of international business for his company. Orders from customers outside the U.S. are now running 23% ahead of year-earlier levels at H-P. And Fred Katzman, director of the electronics department of Monsanto's Electronic Instruments division, is also sanguine about overseas prospects. He expects his firm to ship 20% or more of its production overseas.

Two-way stretch

Integrated circuits will expand their inroads into instrument designs next year, and will have a profound effect in the marketplace. Says Systron-Donner vice president Frank Marble: "The spurt we anticipate is directly attributable to the fact that we've gone for IC's. This has permitted us to market a low-priced instrument in a high-priced market.



Niche. Instrumentation houses and semiconductor firms are seemingly preoccupied with elaborate IC testers; but economy models like this Beckman unit continue to appeal to laboratories and smaller equipment makers.

Cheap labor and discrete components cannot match the cost or performance of instruments made with IC's."

The success of IC's in instrumentation, in fact, is partly responsible for the trend to greater automaticity in measurements. The continuing rise in labor costs and decline in the cost of digital logic will make it practical to automate more and more measurements, notes Fulks of General Radio.

IC's are intensifying competition too. It's possible for the counter manufacturer to do less circuit designing and to simply assemble devices designed by component manufacturers. "This is swinging garage doors open all over the country," says a Beckman official. Wavetek agrees. "With circuit design innovations available to everyone, it will be up to the manufacturer to use ingenuity in packaging the IC's to maintain a competitive edge," a source there declares.

Shakeout

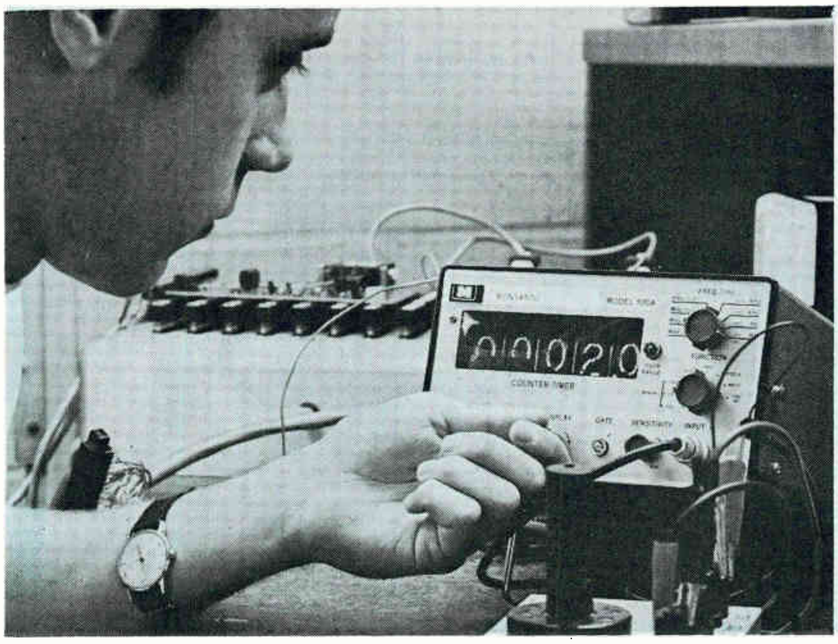
Though IC's will make it easy to get into the instrument business, it's not going to be easy to stay in. "We are seeing increasingly sophisticated instruments with more and more engineering investment," Monsanto's Katzman says. "This can be hard on the small supplier. We'll witness more and more consolidations."

The prevalence of IC's is affecting instrument manufacturers in another way, creating a huge market for testers. And as IC's become cheaper, there's greater pressure to test them more cheaply. "That doesn't necessarily mean simpler and less costly testers. It may, in many cases, mean more elaborate, faster, and surer testers," says H-P's Brunner. He anticipates a trend toward comparative performance testing in lieu of parameter checking.

Large-scale integration poses particularly knotty problems for test-set manufacturers because of the vast number of parameters involved. H-P views the problem as one of making many dynamic measurements rapidly and interpreting the results automatically. "It's hard to see how these systems can be of the 'economy' variety, although they can and will be reasonably priced," says Brunner.

One example of what will be involved in checking future LSI circuitry is the apparatus H-P has devised to check the company's new calculator, the read-only memory of which is a single, sealed array. A computer-controlled system checks the entire 32,768 bits of the memory in seconds, notes if errors exist (and where), and then makes as many as 1.2 million bit comparisons in about two minutes.

Officials at Beckman agree that there will be a good market for complex test systems among big IC makers, who need to know more about their output than do their customers. But, they say, econ-



Time check. Monsanto counter/timer is used to test switching time of thermal relay; increasingly such equipment is being combined in computer-based systems that measure more parameters with greater accuracy.

omy models will continue to appeal to small and medium-size companies, which are more concerned with midrange operating capability than with operation near the outside limits.

So far, only one firm appears to have come up with anything that fills the LSI bill—the North American Electronic Systems division of the Educational Computer Corp. Last fall, the company began offering an LSI test console for between $30,000 and $35,000, depending on the test modules. The computerless system isn't programed conventionally as are the huge, experimental setups being developed by semiconductor houses; instead, it uses a matrix board and diode pins to generate word patterns. It's up to the user to decide which checks best meet his needs. Alfred J. Homann, vice president and chief engineer at NAES, believes the system provides an economical solution to the dilemma of designers who want to test short runs of different circuits, each of which requires individual word drivers.

Status symbols

Digital panel meters are expected to come into their own in 1969. Says one marketing source: "Any original-equipment manufacturer with a digital device looks better than one with analog apparatus. Customers are paying a premium to get a digital function—it's the thing to do."

Whatever the reasons, this market has huge potential, and competition is intense. New firms are invading the field, and those already in will introduce improved versions of their wares. So far, sales are somewhat slow largely because of the cost and size of the meters. But these drawbacks are diminishing. "It's never going to replace the $14 analog panel meter, of course, but among hand-calibrated, high-accuracy meters, the digital unit is going to be moving in rather quickly," says Alan Dallas of Honeywell's Test Instruments division.

"There'll be fairly rapid growth in volume now that they're below the $200 price level," says Robert Turner, a vice president of Tyco Laboratories, Inc. Prices should continue to drop drastically; in fact, experts predict levels of about $100 to $125 a year from now. "The DPM is now a direct threat to the pointer meter," says Turner.

One indication of the intensity of competition in this field is the fact that Tyco encapsulates its digital panel meters in plastic to discourage other manufacturers from trying to analyze their innards.

Other advances in components will also start to be felt this year. Ferrites and such gallium-arsenide assemblies as light-emitting diodes and bulk-effect oscillators are being looked over with increasing interest by instrumentation houses. "Last year saw the development of efficient light-emitting diode structures and of Gunn-effect high-frequency oscillators that appear to be quiet, stable, and reliable. We're sure these developments have important consequences," says Brunner.

Monsanto this year expects to introduce commercially a counter with light-emitting diodes for the numerical display market.

Improved versions of conventional devices can sometimes have near-revolutionary effects, Brunner points out. "Transistors that perform far into the gigahertz region are becoming really useful now that we can incorporate them in chip form directly as transmission-line elements of hybrid microcircuits. These circuits operate at low voltage and can be voltage-tunable. And being small, they afford a wider range of tradeoffs. We have begun to see their effect in new sweep-signal generators and spectrum analyzers. We'll be seeing solid state instruments that'll be more reliable, smaller, and more easily programable than present gear, and which will provide improved electrical performance."

Long-term prognosis still favorable

Even enthusiasts have stopped predicting a runaway boom for medical electronics. What's in store is another healthy gain of about 11% as sales rise from $366.3 million last year to $406.9 million in 1969. Manufacturers will be turning out systems that do everything from handling hospitals' routine administrative chores to monitoring cardiac cases and speeding diagnoses. But a number of obstacles preclude a volume market any time soon.

Buyers can expect somewhat higher price tags on the medical electronics apparatus they buy this year. Aside from inflationary pressures, the industry's low volume is the most frequently cited reason for rising prices. "Medical electronics gear is usually a lot less complicated than, say, a color television set," says William Hagan, director of medical electronics at Baxter Laboratories. "But it still costs a lot more."

Service requirements are also running up costs. "Our customers demand—as is their right—a lot in the way of support," says Dean Morton, medical products manager at Hewlett-Packard's Waltham division. "We think we're doing a good job. But everyone has a way to go, and service costs."

And now the Food and Drug Administration is seeking enactment of a bill permitting it to police electronic equipment used in the medical field. There's no consensus concerning the need for Federal controls in this area, but most observers agree regulation would push up prices and, perhaps, drive some smaller companies out of the field.

Communications gap

Another difficulty is that physicians are all too often unable to express their requirements in precise technical terms, while engineers are wont to over-solve medical problems. "It's not really a matter of what can be measured fastest and easiest with the latest in aerospace technology," says one M.D. "We're after systems the physician will find useful."

Ignorance of the market is also holding a lot of companies back. The head of medical engineering at one company sums up his problem this way: "We could invent the resurrection pill, have them stacked all over the place, and still not be able to sell because we just don't know the market. It's that much different from the aerospace business."

John Truxal, chairman of the National Academy of Engineering's committee on the interplay of engineering in medicine and biology, believes cognizant Government agencies should be doing more to stimulate the market. "There's no set-up inside NIH (National Institutes of Health) to foster the development of electronic devices—nothing like at NASA or the Pentagon," he says. "NIH should be trying to convince industry to come into this unfamiliar market. Companies either have to be given big contracts or the prospect of profit."

Joining the larger, old-line instrument companies and specialties firms that have been in the medical field a good while are pharmaceuticals houses. Early this year, for example, Hoffman-LaRoche, a drug company, will offer a doppler-effect blood pressure monitor.

Cardiac monitoring units are being designed and built in increasing quantities by old timers and newcomers. At the November meeting of the American Heart Association, H-P's Waltham division unveiled an arrhythmia detector, which inspects the waveform of a patient's heartbeat and compares it to a "healthy" version stored in the instrument's memory. At the same show, Westinghouse's new medical department introduced a cardiac monitor.

Heart of the matter. Sales of cardiac monitors like this Honeywell system will jump an estimated 30% during 1969.

Honeywell, Inc. is taking orders for its new monitoring system and will have a blood-pressure module ready by July. Baxter Labs introduced a monitoring system in 1968, and this year plans to offer plug-ins that measure arterial blood pressure, peripheral blood pressure, and fetal heart rate.

NAE's Truxal points out that preventive medicine is another area where electronics can play an important role. "Multiphasic screening is coming on strong," he says. Mass screening demands that instruments be developed that can test for various diseases quickly and simply. One such instrument may be the doppler-effect spyrometer which Statham says will be ready early this year. According to the company, the device will measure all respiratory parameters, including tidal volume and minute-to-minute volume in three minutes.

Commercial markets start to soar

The sky's the limit again for avionics suppliers. Not only will this year's sales top the strong showing made in 1968, but the gains should come across the board—in general aviation, commercial transports, and even space systems. And supporting the anticipated sales success is a solid base of technological progress.

The general-aviation fleet will be increased by another 15,000 or so craft—close to the peak level of 1966. The outlook in this area is further enhanced by the fact that owners are outfitting their planes with more sophisticated systems, according to Victor Kayne, vice president of the Aircraft Owners and Pilots Association. He says 25% of today's pilots have instrument ratings, against only 15% five years ago.

Deliveries of commercial aircraft to domestic airlines will total only about 70 during 1969, according to Air Transport Association data. But activity will pick up toward the end of the year as Boeing begins to ship its jumbo jet 747's and McDonnell Douglas and Lockheed make the first deliveries of their DC-10 and L-1011 airbuses.

The anticipated growth in both the commercial and general-aviation fields promises to have a tremendous impact upon the Federal Aviation Administration Agency, not only in 1969 but also in the years to come. As traffic in the skies increases, so does the agency's problem of directing it safely and efficiently.

But despite the near breakdown of the U.S. air traffic control system last summer, there seems to be no particular sense of urgency at the FAA. The agency continues to sink millions of dollars into installations designed years ago and considered already obsolete by many observers. For example, work will finally start this year on the Automated Radar Terminal System (ARTS-3). An offshoot of the FAA's Terminal Radar Control (Tracon), ARTS-3 features radarscopes that provide automatic alphanumeric readouts on an aircraft's ground speed, altitude, and identification. The system, which is supposed to alleviate traffic jams around busy airports, will be hooked up to the computers in the nation's en route air traffic control network.

As it happens, though, work is still in progress on the latter project. The first installation, at Jacksonville, Fla., won't be turned on until March. When completed, it will have television-type displays with alphanumeric readouts, as well as computer-processed radar data. The en route network won't be finished before 1973 at the earliest. And by that time, all of the 20 or so centers will be overtaxed, necessitating further stop-gap capacity expansions.

As usual, things look better aloft. For example, 1969 will be the year commercial airlines embrace inertial navigation systems. Pan American World Airways will be flying AC Electronics' Carousel 4 aboard Boeing 747's by yearend, and several other carriers including TWA, United, and Finnair will be using operational systems on stretched 707's and DC-8's. Other airlines are waiting to see just how economical inertial gear—at $100,000 a crack—will prove to be.

To make inertial navigation more attractive, AC Electronics is looking at new ways of applying it. For example, the company is studying the possibility of tying the precision velocity and attitude outputs into automatic landing systems and area navigation displays. And both AC and Litton Industries, the other commercial supplier of inertial systems, are working on lower-cost versions of present models.

Within the past year, considerable interest has been expressed in a guidance system whose accuracy would be somewhere between that of gyrostablized tables and the $100,000 inertial gear. Two such "poor man's stable tables," dubbed Heading and Attitude Sensors—HAS-1 and 2—are being breadboarded at a number of concerns. HAS-1 is essentially a better-performing replacement for vertical and directional gyros; HAS-2, which would be more accurate and expensive, provides inertial-sensor position outputs. Both could be used with ground-based aids to drive area navigation displays and tie in with signals from instrument landing systems.

Airline interest centers largely on the HAS-1 system. And approval of a specification making an installation interchangeable with a fully inertial system meeting Arinc's 561 spec is expected at the May meeting of the Airlines Electronic Engineering Committee.

American Airlines is seriously considering HAS-1 for its DC-10's, says Lee C. Keene, the carrier's director of avionics engineering. And there's the possibility, he says, of retrofitting the airline's 707 fleet. American is hoping for a price tag between $15,000 and $20,000.

Lockheed is investigating HAS-2 for the L-1011, says John A. Gorham, the firm's assistant division engineer for flight guidance and control systems. The company asked for proposals for a dual HAS-2 system late last year, and it hopes to select a design by early spring. The system is basically a Shuler-tuned inertial platform with a third vertical gyro, according to Gorham. It will provide such inertial data as latitude and longitude displacement. Lockheed hopes costs can be kept under $30,000.

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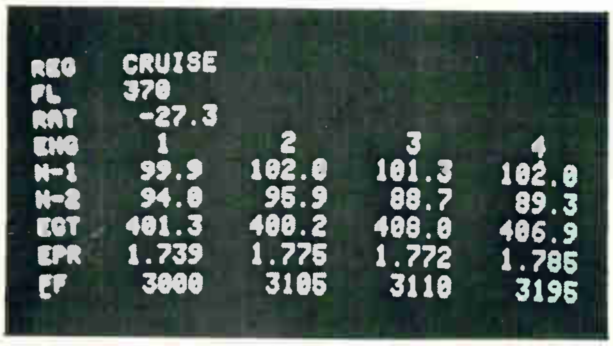


Less talk, more action. Prototype digital communications systems like this Bendix equipment flying on Pan American aircraft transmit routine flight and engine-performance data to crt displays or teletypewriters, cutting voice traffic.

Area navigation, talked about for 20 years, may finally become a workaday cockpit routine starting this year. A half-dozen airlines were flying systems last year, and by spring the FAA will issue a technical equipment standard. And because of increasingly congested airways the agency will probably authorize the use of area navigation over selected routes.

Faster track

Area navigation systems permit aircraft to deviate from established routes—a feature that can make for considerable savings in time. Planes equipped with on-board computers can operate along just about any path without losing their way—provided they're within range of signals from ground-based very-high-frequency omnirange and distance-measuring equipment. The ground stations also handle signals from instrument-landing system transmitters to put an aircraft directly on the glide path to a safe landing.

Eastern Airlines is currently checking Decca Systems' Omnitrack on its DC-9 shuttle flights between New York and Washington. American is testing Butler National Corp.'s Vector Analog Computer system on two 727's operating between New York and Chicago. And United is flying a system developed by Hughes Aircraft.

Area navigation could get a boost from efforts to promote the use of short takeoff and landing (STOL) aircraft for city-to-suburbs and even city-to-city flights. Last November the FAA recommended that 25 STOL ports be built in the New York, Washington, Los Angeles, and San Francisco areas to relieve congestion around terminals.

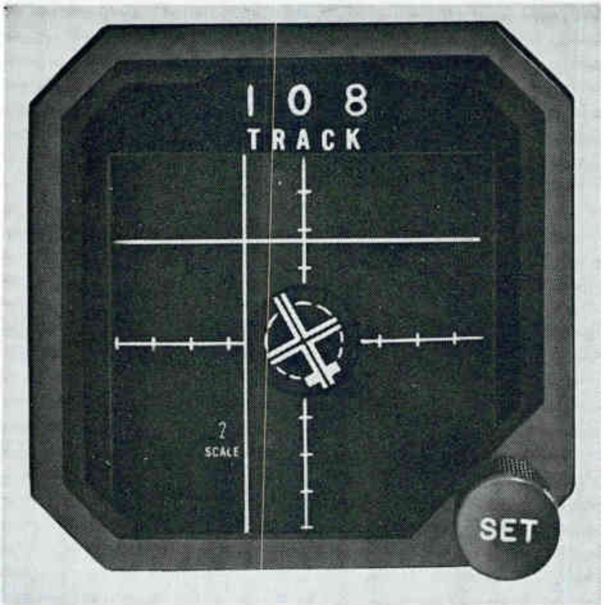
Digital data communications may be standard in commercial aircraft by 1971, says B.F. McLeod, director of electronic engineering at Pan Am, which is now flying a system from Bendix Avionics in a 707. Both the airlines and the FAA are interested in digital techniques because they promise to help reduce the staggering volume of air-to-ground voice communications. Routine reports a pilot now makes orally to his line or to an FAA ground station could be sent automatically over a digital link. In addition, engine performance parameters could be monitored and sent automatically to terminal stations as a maintenance aid.

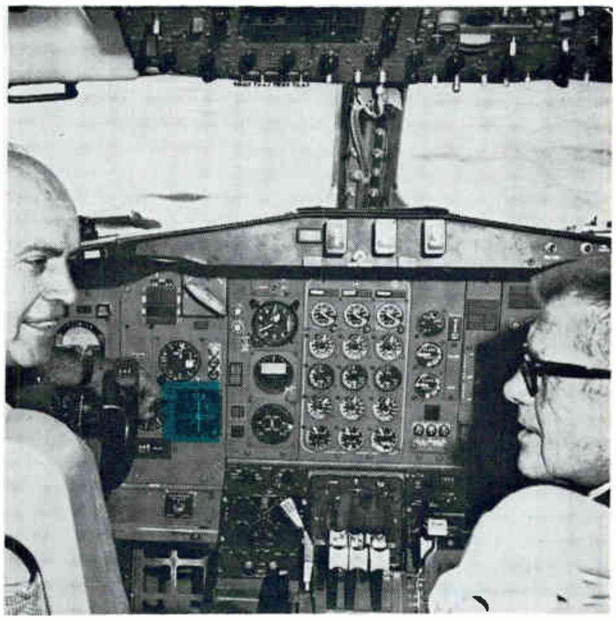
Pan Am's tests will determine the best hardware arrangement and operational procedures for the job. And checks on how an aircraft's operational environment affects digital transmissions will determine the data rate and error-control techniques that are to be used.

This year, Pan American plans to install systems that can be interrogated from ground stations in at least five more planes. The next step will be to outfit the airline's entire fleet, with priority to be given to the new 747's.

Pan Am would like to carry out its experiments via vhf satellite circuits, but conventional and extended-range equipment will be used if a spacecraft link isn't available. Commercial carriers have long talked about orbiting a vhf satellite for their own use. Such a craft would give them more reliable digital data links, as well as better-quality voice communications, than are possible with long-range high-frequency equipment.

Last year, the Communications Satellite Corp. proposed the orbiting of two satellites—one over the Atlantic, the other over the Pacific—in a system that would cost $50 million to $55 million over





Time saver. Many commercial airlines are test-flying area navigation systems like this built by Butler; the hope is that such equipment will cut down on the amount of time wasted both en route and around terminal areas near jetports.

its five-year lifetime. A decision would have to be made now for a 1970 launch, but with industry earnings down and the FAA not committed to share the cost, the outlook for this project is dubious.

Another factor delaying an aeronautical services satellite is the industry's quickened interest in an L-band system. Some observers believe this band would afford better transmission reliability and quality. But aside from the fact that the gear must prove itself operationally, present airborne communications systems and ground stations have been developed only to handle vhf.

Testing time

Further work will be done during the year on collision avoidance systems (CAS). Under the aegis of the ATA, six months of flight tests will begin this June on systems built by: Bendix Avionics; McDonnell Douglas; Martin-Marietta; and the team of Sierra Research and Wilcox Electric.

Although the airlines version of a CAS will probably cost, at least initially, anywhere from $30,000 to $50,000, a general-aviation version might go for only a third as much, according to Frank C. White, ATA's manager of communications and data processing. In five years, he says, with further improvements in integrated-circuit techniques, the price for a general-aviation model might be under $3,500.

Commercial carriers will be paying more attention this year to computer-controlled automatic equipment to shop-test such electronics gear as autopilots and flight directors. The 20 man-hours it might take to check out an autopilot drops to less than two when automatic equipment is used, says William Smoot of Arinc Research.

A British company, Hawker-Siddeley, sold one of the first commercial automatic systems to American Airlines in 1967. Last year, Collins Radio got into the act, supplying equipment to United. Other carriers expected to buy systems, which carry price tags of $250,000 and more, include Pan Am, Continental, and TWA.

And the first commercial flight tests of all solid state digital air data equipment will begin this spring. American Airlines will test two systems—one from Conrac and the other from Garrett AiResearch—for three to six months aboard 707's.

The digital systems, which are slated to replace electromechanical devices, read out such information as altitude, true airspeed, mach number, and temperature. The solid state sensors are expected to be more reliable than their electromechanical counterparts, thereby lowering maintenance costs, says American's Keene. His company is looking into the possibility of retrofitting its 707's with the systems, which go for $20,000.

Digital air data systems have been specified for the DC-10. But Lockheed decided in November to order analog air data computers for its airbus.

The airlines will continue equipping their planes with all-weather landing systems, although their efforts don't seem to be matched by the FAA's pace of ground-station installations. By the end of the year, about 1,640 commerical aircraft will have been fitted out at a cost of $65 million, according to ATA. Right now, perhaps 1,000 are equipped.

According to one industry source, the hope behind the airlines' installation of equipment—which ATA estimates costs $40,000 per aircraft—is that the FAA will be pressured into putting in the more precise instrument landing systems and approach and runway lighting that are needed.

Changing of the guard makes civilian agencies cautious

"If you find out what the Federal Government plans to spend on electronics in 1969, please let us know," says a Senate Appropriations Committee staff member. This is a fair sample of the general feeling in Washington as President Johnson gets ready to present the fiscal 1970 budget—which President-elect Nixon and a Democratic Congress will have to work into mutually satisfactory shape.

On balance, nobody in Washington expects any significant changes in civilian outlays for electronics this year. "We'll be spending about the same for electronics—perhaps a little more," says a source at the Atomic Energy Commission. "This is about the same pattern as in 1968." The comment is typical in that agencies in the market for electronics are playing it close to the vest in discussing new programs. Officials seem convinced that it doesn't pay to rock the boat when a new captain is climbing aboard.

Aside from the military, the FAA, and NASA, the big electronics buyers in Government continue to be the AEC, the Department of Transportation, and the Department of Health, Education and Welfare. For example, the AEC's calendar 1969 budget of about $72 million includes an estimated total of $25 million for computers. The agency, one of the Government's largest computer users, is increasing its expenditures for this purpose by about 25% a year. "And we don't see any end to this," says a source. However, outlays for reactor control and instrumentation equipment, as well as radiation detection and monitoring apparatus, will not increase quite as rapidly.

Although the AEC is among the Government's most active purchasers of computers, it is not the largest by a long shot. For example, the General Services Administration figures it will buy or lease between $400 million and $500 million worth of machines this year. And the Office of Education will start working toward the first model of a system that could have great impact on the use of computers in public schools.

The system, known as Cues (for computer utilities for educational systems), will be built around a large processor at a central site serving up to 100 high schools and junior colleges in a 100-mile radius. Initially, the setup will teach the 200,000 or so students in the Washington school system how to use computers in solving problems in such fields as science and math. It will also be used for vocational training of students in programing in at least the Fortran and Cobol languages.

Until several weeks ago, there was some question about President-elect Nixon's thoughts on the future of oceanology. But in a letter to Edward Wenk Jr., executive secretary of the President's National Council on Marine Resources and Ocean Engineering, Nixon made it clear that the council would continue to exist and that a Federal program for studying and exploiting the oceans would be established. Exactly what form this effort will take—whether a full-scale "wet NASA" or a small, independent agency to coordinate various oceanographic efforts—remains to be seen. The important thing about the letter as far as the electronics industry is concerned is that there will not be any pressure from the top to cut down on present programs.

During the fiscal year ending June 30, a total of $516 million is being spent on 13 Federal marine science programs. This figure includes naval oceanographic work and Pentagon research, which amounts to $150 million. Roughly 40% of all oceanographic expenditures go for electronics. Some programs—for example, sea research buoys—have an even higher electronic content.

There will also be sizable Government outlays in transportation and medicine during 1969. In ground transportation, several automatic highway traffic control projects will reach the field-test stage, but most electronics projects will remain paper studies.

In medicine, no profound spending shifts are anticipated; bioengineering and automation of hospital work will continue to be emphasized. For example, the National Institute of General Medical Sciences of the National Institutes of Health has appointed a 12-man advisory committee to spur R&D for completely automating clinical labs.

Cops and robbers

State and local law enforcement efforts will probably get a major boost this year through the Government's new Law Enforcement Assistance Administration. This agency is authorized to spend up to $400 million in two years, but only $63 million was appropriated for its first year by Congress. An estimated 10% of the $29 million allocated for "action grants" will be used to improve communications.

An official of the International Association of Chiefs of Police says: "Communications are a top-priority need at local departments." There's always interest in sophisticated equipment such as vehicle teleprinters and locator systems, but such apparatus is still a way down the road. "The big budget item for police departments involves personnel," says the association official. "Even if an outfit can't get all it wants, up-to-date gear allows it to make better use of the men it has."

Growth signal is loud and clear

Digital systems will pace the 1969 communications market, providing a healthy boost to dollar volume. At the same time, sales of telemetry and land-mobile equipment will spurt. Revenues in the former category will jump from last year's estimated $191.4 million to $220.0 million; in the latter grouping sales are expected to go from $184.1 million to $207.5 million.

The spurs to growth in these three key fields include: the opening of the telephone network to data modems supplied by non-Bell companies as a result of the Carterphone decision; the proliferation of signaling and warning systems for transit authorities, police, and fire departments; and the armed forces' impatience over the laggard pace of the conversion of air-to-ground communications networks to L and S bands.

Information explosion

One jubilant east coast marketing executive says this about the new data ruling: "We could only sell modems on private lines before. Now the whole world's open to us. Customers are going to discover there are lots and lots of ways to reduce their costs that they didn't know about."

Paul A. Frakenberg, vice president of the Ultronic Data Communications Products division at Sylvania, also expects a sizeable market to result from the ruling. "It costs about $40 a month to lease the Bell System's 1,200-band modem. We sell our version for $475 and for under $400 in quantity. A maintenance contract costs about $5 a month. We've got something to sell now and it's going to be the same at other companies."

Surprisingly enough, even Ma Bell has some positive things to say about the prospective competition. "With more companies in on the act, the technology will probably move ahead faster. The biggest impact isn't going to be felt this year and when it comes it will be in the low-speed field—the hottest market right now because of time-sharing," says William B. Quirk, marketing director for data communications services at AT&T.

Another important factor is the relatively modest cost of the lower speed modems. "Some companies may offer teleprinters with built-in modems," says Quirk. "Of course, it's a different story with higher speed units. They're more complex, and expensive, and it's not so easy to wash through their price in a package deal."

ITT, until recently prohibited from selling modems for the switched network in the U.S., is now eyeing this market. While the company is circumspect about its plans, Frank Barnes, senior vice president and product group manager for telecommunications, says: "This could be the year for data communciations. We've reaching a sort of critical mass, mostly because so many people are using computers and because channels are so available."

This year Bell will market its new 3,600-bit-per-second data modem for the switched network. The set contains an adaptive automatic equalizer, a device that improves transmission quality, allowing more information to be sent over a channel. Bell will also introduce a new solid state teletypewriter and a low-cost modem to be used with this equipment. Several versions of the new sets will use integrated circuits for the first time.

General Telephone & Electronics, Sylvania's parent company, is exploiting duobinary techniques to increase speed; late in 1969 it will market a 4,800-bit-per-second set for private voice lines. Earlier, GT&E will offer a modem with options for either 2,400 bits per second or 40.8 kilobits per second.

And this year General Tel will be installing its new version of Bell's T1 carrier, a 1.5 megabit pcm system. "There are some advantages in coming in second," says Clarance C. Crow, director of systems engineering. "Our system takes advantage of technology developed since Western Electric first introduced T1. Our equipment is smaller and about 50% of its circuitry is either monolithic or hybrid IC's."

Meanwhile, Bell has announced plans to scrap its development effort on T4—a long distance, 284-megabit pcm system—and to start work on T5—a 564-megabit system. At the same time, it's installing

Lofty. Mobile radios like this solid state unit for helicopters from RCA should sell well during 1969.

School days. The Bell System and General Telephone will offer Teleclass and Tele-teaching systems during 1969, pemitting students to get instruction over their phones at home.

the new L4 carrier system, a continuous-wave coaxial facility that transmits 32,400 telephone conversations. L4 will be able to handle digital, as well as analog, signals. Work is under way on a faster L5 system, which will also have digital capabilities.

This year, the Bell System's Picturephone could go commercial. Says Wilfred Rinkor, marketing director of customer telephone services at AT&T: "In February we're starting a trial of Mod 2—the version we're going with—between Westinghouse's New York and Pittsburgh offices. If everything goes well there's an outside chance we'll offer service commercially in 1969. Of course, it will be on a limited basis—a kind of dress rehearsal."

For the first time, Bell's willing to quote prices. Rinkor says that local Picturephone service would have to cost about $100 a month initially. "Our job now is to get marketing information—to find out how many people in a corporation, for instance, would need the service and whether companies are willing to pay for it. We're going to have to go slowly because the capital commitments are awesome even for the Bell System."

If Picturephone catches on quickly, Bell will have to telescope its timetable for high-speed long-distance pcm systems. Engineers generally agree that digital techniques are the most economical means of transmitting visual telephone signals over toll facilities.

Meanwhile, Sylvania's Ultronic division is expanding its data service to brokerage houses. The company sells a drum-type computer data transmission system to provide stock quotations to firms throughout the U.S. and in Canada. During 1969, it will be selling general-purpose computers that will provide expanded services such as information retrieval and calculations. It will also introduce new cathode-ray-tube equipment to replace the Nixie tubes used in its display units.

Digital transmission technology will benefit from an end to the Vietnam War, says Charles Mack, chief of advanced technology at Philco-Ford's Communications and Electronics division. "One of the first things we'll probably see when Government funds are released will be an improvement of military communications systems. That means there'll be an increase in secure, digitalized voice systems." The Defense Communications Agency will test one of Philco's modems this year. Designed for use over a voice channel with a vocorder, the unit transmits 9,600 bits a second.

Even further ahead, Electronic Communications, Inc. is exploring new coding techniques to increase the amount of digital information that can be sent via a given channel; it is also working on the design of digital filters. "We're doing things now that aren't going to pay off immediately, but they're pivotal for future complex, high-capacity systems." says Paul Hansel, vice president of engineering.

Sales of telemetry equipment will rise this year thanks to NASA's Apollo and unmanned satellite programs and the military's conversion to microwave. One engineering executive, however, sounds a sour note: "The switchover has been slow because many of the customers have changed specifications and demanded performance that's stretched the state of the art. Things would have moved a lot faster if the requirements hadn't been changed."

On the move

Vehicular applications for communications gear are growing so fast that companies which have eschewed the field are now eyeing it. Philco-Ford is one such firm. Meanwhile, RCA looks forward to another year like 1968 when its mobile volume grew by 50%. Edward J. Hart, manager of the company's commercial communication systems department, attributes RCA's success in part to its solid state line.

The 1969 mobile market also looks good to Sylvania Electric Products, which developed KarTrak—an automatic identification system for railroad freight cars, which uses optical scanning, and digital transmission. This system will be able to locate any freight car in the country by "reading" multicolored stripes on its side. The railroad industry is investing $20 million labeling two million units of rolling stock; it expects to finish the job by next January. In the meantime, Sylvania expects to sell KarTrak systems in volume lots.

In addition, KarTrak may be used in other applications, for instance, on subways and buses. Jack Barriger, manager of transportation systems at Sylvania, says: "Industry hasn't standardized on a bus system yet, so there's great potential for KarTrak." Right now the system's being tested in experiments on the Garden State Parkway in New Jersey. And this month Sylvania is testing its system—as are three other manufacturers of signaling systems—in Czechoslovakia. "If KarTrak is accepted, this could open up the European market to us," says Barriger.

Brighter picture

Last year's rather gloomy picture for suppliers of television broadcasting gear has changed. "We're looking for a $10 million increase in 1969," says Andrew F. Inglis, division vice president of RCA's Broadcast and Communications Products division. "We've hit the bottom of the trough. The color slump is over, and stations are making greater profits. All of the economic indicators point to increased income—and more equipment buying."

Specifically, Inglis sees a move to update color transmitters and, to a lesser extent, antennas. "Many vhf stations have been on the air for over 10 years and are still operating with their original equipment," he says. "Since the FCC will probably approve remotely controlled vhf transmitters these stations will have to buy new equipment to meet the higher specs. Otherwise they won't be able to take advantage of this new development."

RCA will market a new generation of vhf transmitters this year that offer a two-to-one improvement in performance specs and an order of magnitude increase in reliability. There's also an increase in price. For example, a new 30-kilowatt transmitter will cost about $250,000 while the older version went for about $180,000.

The uhf market doesn't promise anywhere near as dramatic an increase, but it should continue to be strong. "The resale value of existing uhf stations has been increasing steadily," says Inglis. "Broadcasters continue to have faith that uhf is going to develop."

However, the educational market—an important outlet for uhf—won't do so well this year, largely because of the war-caused squeeze on Government funds. Leonard Frakwitz, national sales manager for visual communications equipment at Sylvania, says: "We're expecting an 8% to 12% increase, but that's not going to bring us up to the substantial level of 1967. However, if the Yarborough bill —which seeks as much as $800 million for educational systems and materials—is passed it might help the market somewhat in 1969." Sylvania will introduce new closed circuit television cameras this year. All will be vidicon types.

A sleeper in the tv market is the growing trend to multiple antenna installations like those planned for the World Trade Center now being built in New York City. By summer, the five vhf television stations in Chicago will have antennas installed atop the new John Hancock Building. The installation alone will cost $1.3 million. However, since stations can't move their transmitters overnight and can't afford to be off the air for an appreciable time, they'll buy new equipment. Thus, the total investment in transmitting equipment and antennas in Chicago alone will reach $3 to $4 million.

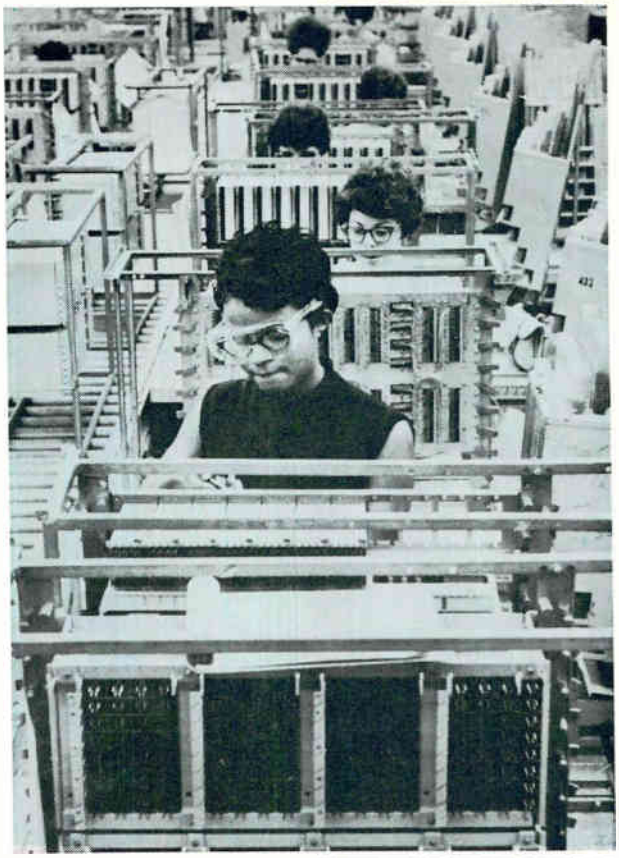
Video tape recorders will continue to move—especially now that there's a trend to lower-priced units. Last year, RCA's TR 50 sold so well that the company brought out an improved version priced at $65,000-$10,000 higher than its predecessor. This model, the TR 60, is a high-band unit. As such it can record a signal modulated on a carrier about 4 megahertz from the color signal's subcarrier.

Cable antenna television has reached a crossroads, according to Lee Zemnick, executive vice president at the Jerrold Corp., now a subsidiary of General Instruments. "The CATV market can't expand further unless we get real relief in the rules. The time's come for that to happen," he says.

Leonard Frakwitz of Sylvania says: "There's an increasing need for CATV operators to originate more programs. The FCC has some restrictions on the revenue they can get from such service. However, this situation is being resolved slowly but surely." In 1969, Sylvania will put a priority on marketing originating equipment. The package prices will vary according to the completeness, running up to $60,000.

Jerrold will be turning out its Starline 20 CATV system, which handles 20, rather than 12, channels, in 1969. The company will also introduce solid state antenna site gear and Flexitap—a unit that makes is possible to build a CATV system and later tap off up to three outlets without cutting cable and interrupting service.

With CATV maturing, reliability and performance demands have jumped appreciably according to Jerrold's Zemnick. "We're now dealing with markets that have gotten class A pictures from rooftop antennas. But we're running cable over long distances, exposing it to many changes in temperature. We have to offer the best pictures and a highly reliable system to boot. So a large chunk of our budget is spent on the environmental testing of CATV gear."



On the line. During 1969, the Bell System will continue to install electronic switching central offices. By 1970, it will have 69 working systems—26 more than last year.

Progress and problems

The once private preserves of computer and communications companies will continue to blur during the year. One Philco-Ford executive says: "The Government is going to take more and more of an interest in this problem. We may have to have a new industry—an information utility."

Late last year Collins Radio announced that it would begin offering computer services and computer-controlled process technology to industry and government. These services would involve the transmission of information—presumably with Collins modems.

Meanwhile Bell continues to install electronic switching central offices; early this year it will begin evaluating its electronic store-and-forward message switching system. By yearend, it will have about 69 working ESS central offices, 26 more than last year's total.

But while electronic stored-program systems appear to be the way to go, some critics remain hesitant. An east coast expert says: "Nobody knows at this stage whether they'll come out in the wash economically. We've got to have reliability. Regardless of who develops these systems, telephone companies can't afford to go through four or five generations like the computer companies did when they were getting started."

General Telephone doesn't have any stored-program systems slated for installation in 1969, but the company is working on several versions. One is an electronic traffic service position console that will perform a number of functions to ease the tasks of the operator. "We're desperate for trained operators today," says Crow. "Electronic systems can help us with the problem."

Services

Other services to be offered in 1969 over the once limited telephone network include an apartment door answering service. Designed for older units that would be expensive to rewire, this service allows a caller to dial three digits in the lobby. His signal is routed through a central office back to the phone of the person he wishes to visit in the building. After talking with the caller, the householder can then "push the buzzer" using his telephone. The service will be marketed widely for the first time this year.

AT&T will also be introducing Teleclass—a cabinet with a telephone card dialer that allows a teacher to instruct up to 20 students in their homes by talking to them individually or all together over a phone. GT&E will offer a similar system.

And this is the year when IC's will be making a real debut in the telephone business. The Bell System is manufacturing beam leaded assemblies slated for use in, among other things, ESS, Touch Tone telephones, PBX's, carrier systems, and traffic service positions.

Still dancing to Pentagon's tune

This year shapes up as another wait-and-see period for the microwave field—a part of the electronics industry that deals almost entirely with the military. "If I flipped a coin, it would probably stand on edge," says a marketing man, assessing the outlook in defense markets.

Last year at this time, microwave firms anticipated the Sentinel antiballistic missile system and the F-111 and A7A aircraft would be volume outlets for their wares. But now that the first two have been caught in the switches of budget cuts and the third begins to look like a stretched-out project, they're not so sure.

Fortunately for the industry, some earlier developments—particularly in electronic countermeasure equipment—bore fruit in 1968. For example, the use of radar-controlled antiaircraft guns and missiles in North Vietnam forced increases in the procurement of backward-wave oscillators and traveling-wave tubes.

The ecm market should continue to be relatively strong in 1969. Howard B. Foster, Parametric Industries Inc.'s western regional sales manager, says: "Ecm already represents about 30% of our business. Even if the F-111 and A7A are cut to the bone, the delay time involved before the Pentagon could replace these aircraft with new programs like FX or VFX means a retrofit market."

Peace and the action

At least one major microwave firm is making its plans on the assumption there will be a June halt to the Vietnam war. This company expects microwave tube sales to drop $15 or $16 million—about 10% below the 1968 level. However, management has a contingency plan which anticipates a 4% to 5% gain in tube volume should the war continue.

Sales of low-powered traveling-wave and klystron tubes were around $58 million in 1968. There will probably be a 12% to 14% drop this year, since solid state devices are finally beginning to make inroads on microwave tube territory. Solid state assemblies already appear in military systems, such as Westinghouse's APQ-120 radar, as well as in community antenna television repeaters, tv relays, and other remotely operated equipment for which reliability is a critical design consideration. However, where maintenance is no particular problem but, instead, large amounts of power are needed, the progress of the solid state will be slow. Glamour items, such as Gunn devices, fall into this last category.

Even Varian Associates, which is readying both avalanche diodes and ferrite-tuned Gunn effect devices for market, shows little optimism about their sales potential. "It's going to be late in 1969 before these oscillators have much impact on the marketplace," says Norman Heistand, marketing manager for tube and electron devices at Varian. "The industry is still in the throes of product development and can't expect any real volume before the end of 1969."

Caution seems to be the watchword next year for bulk effect devices. Says one source: "Transistors have lots of potential left in both power and frequency range. It will be more than a year before the bulk effect device is an economical alternative."

Norman Chasek, president of the International Microwave Corp., admits that the growth of limited space charge accumulation devices (LSA) will also be slow: "For high-frequency operation, say in the millimeter wave region, you can buy gallium arsenide with the proper doping characteristics, but there's no market here. At lower frequencies, like L, S, C, and X bands, there are outlets but no GaAs."

With communications satellites so often in the news, the high powered twt market should be solid. However, the volume still isn't there. As a result suppliers have to depend on military outlets. But Varian's Heistand says: "The satellite market is just beginning, and it's from this source that much of microwave industry's income will flow—when funds become available." This suggests a boom will follow the end of fighting in Vietnam. In 1969, however, it's a very iffy foundation for market estimates. As a result, Heistand isn't making firm predictions for the high-powered communications twt market.

In a different sector of the satellite communications field, Microwave Associates Inc. just signed a contract worth about $500,000 for equipment to relay signals to and from an Iranian ground station. This relatively small program serves as a reminder that there's more to the communications satellite business than spacecraft and antennas, particularly in underdeveloped countries.

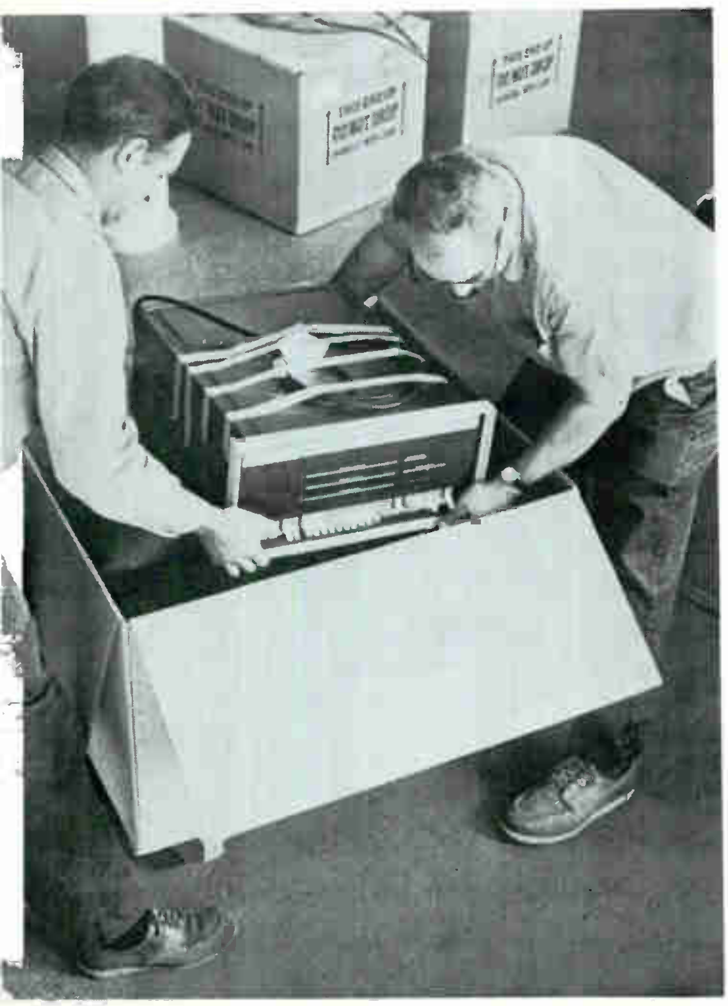
Nonetheless, the "what if's" in the 1969 market equations indicate a record year for antacids as marketing managers' worries mount. For example: "It's hard to plan for production of twt's for the A7A's ecm gear," says one edgy manager. "LTV says it won't be cut, but most of the intelligence we've been able to gather suggests that at least some slashes are due. And I have to be able to jump both ways."

What it comes down to is that microwave firms are still almost completely dependent upon Pentagon largesse. When a budget squeeze is on, they sweat. "And don't think microwave ovens or anything commercial will save us," says one marketing manager. "There still isn't enough here to fill your hat. And all the money goes to tube makers."

Gravy train still rolling along

Generation gaps are beginning to look like a thing of the past—at least in the computer field. From a hardware standpoint, machines built with vacuum tubes, discrete semiconductor components, and integrated circuits represent three distinct divisions. Then, too, successively higher levels of programing language and operating software have been developed. Nonetheless, there's a consensus that most technological advances from here on out will fall into the evolutionary, rather than revolutionary, category.

The evolutionary trends that will buoy the industry are already well established. Makers of computers and related apparatus expect to ring up sales of $4.79 billion in 1969—a 16% improvement over the $4.13 billion worth of business done during 1968.



Best sellers. Small computers like this PDP-8/L, built by the Digital Equipment Corp., have become the hottest thing around in the world of electronic data processing.

Burroughs, for one, points out that large data banks, remote-access systems with thousands of terminals, and elaborate management-information systems are facts of life today. Such equipment requires a high degree of parallel processing, hierarchical memory organizations, advanced operating systems, and fail-safe management—all of which were just words a couple of years ago.

"Customers are no longer impressed with catchwords," says Kenneth Olsen, president of the Digital Equipment Corp. "They want to know how much they will have to pay to get a particular level of data-processing or problem-solving capability." The "level" may go up, and the "how much" may come down, but in context there are no longer any grounds for talking in terms of generations—implying, as they do, order-of-magnitude breakthroughs.

One of the distinguishing characteristics of the computer market during the late 1960's will be its receptivity to small machines. Among others, the bantamweights appeal to users who previously couldn't afford a computer and manufacturers of systems that could be more efficient or more powerful using a computer as a subassembly. Designers of large time-shared networks also use small computers as remote terminals and extended core memory systems, in which the vast monitor programs required can be stored.

Great and small

As recently as last year, the Digital Equipment Corp. was termed "not a dominant figure in the electronic data-processing field." This is no longer the case; reliable estimates indicate DEC ranks number five in total number of installations. The company itself claims to be third, taking into account its order backlog.

Two recent product entries, from the Data General Corp. and from the Viatron Computer Systems Corp., attest to the potential of small and ultrasmall computers. In particular, the financial backing of these two companies suggests that the market amounts to a lot more than "visions of sugar-plums" in the designers' heads.

Overall, the computer industry should continue to grow at a 15% to 20% annual rate for the next several years. Shortages of technically trained personnel—in programing and related services—are potentially the most serious obstacle to achieving such growth. In addition, some observers fret about what they consider a lack of involvement and understanding for computer problems, on the part of their customers' managements.

During 1969, communications nets will become increasingly important parts of information processing systems, thereby enhancing the markets for

Computer aided. During the year, there should be greater use of service installations like this reservation system built by Univac for United Air Lines.

interface hardware, models, and buffer memories. The networks will also contribute to the mushrooming growth of the small computer market.

Another distinguishing feature of this year's computer market—and one that harks back to the field's early days—is the number of customers who will be buying computers for the first time. "Our model 110, designed specifically for first-time users, has been getting a good reception in the marketplace," says Robert P. Henderson, vice president for marketing at Honeywell's Electronic Data Processing division.

And Paul W. Lappetito, assistant marketing vice president at National Cash Register says: "More than half the orders for our Century series are from first-time users. This confirms the existence of a broad base of potential customers ready for the right combination of price and performance."

Price tags on computers and related equipment are expected to remain at relatively stable levels during 1969. Most observers attribute this to the greater use of integrated circuits which tend to reduce costs. But there's another side to the coin. "Although IC's are significantly less expensive than discrete components, quality control and product testing are more difficult," says Curtis W. Fritze, vice president for corporate planning at the Control Data Corp.

Then, too, main frame hardware represents a comparatively small part of the total outlay for a computing installation. "In most cases, the optional equipment ordered to go with a processor costs about as much as the basic processor itself," says Nick J. Mazzarese, a vice-president of DEC. "This hardware cost is only about half the total which includes programing outlays. Then you have to service, maintain, and operate the system. By the time you're through you find out the price of a processor is really only one-fifth or one-sixth of the total cost of a data processing system."

Time sharing, long heralded as "the wave of the future," is now a fact of life. Several of the top computer manufacturers offer time-sharing services as a sideline, and a good number of independent time-sharing networks have sprung up all over.

The growth in this market has proved salutary for just about everyone in the computer field. For example, the manufacturers of large central processors are moving everything they can produce and looking for new worlds to conquer. At the moment, NCR is doubling the number of its time-sharing data centers, and Univac is also expanding its net, as well as improving the capability of its 1108 computer. Control Data Corp., which has long specialized in the heavyweights, recently unveiled its mammoth 7600 machine. Honeywell expects volume sales for its 4200 and 8200 machines during 1969, and General Electric anticipates a comparable spurt for its 600 series.

Command performance

Software houses have done, and will continue to do, well. Faster IC's and memories will produce an improvement in performance as great as 40%, according to some estimates. As a result, better programing—particularly operating system software—and improved peripherals will be needed.

In this latter area, Ampex predicts magnetic tape with a density of 1,600 characters per inch will soon be commercially available; at the moment the standard is 800. Moreover, says the company, speeds of 200 inches per second will be commonplace. In ferrite-core memories—both internal and peripheral—cycle times have already dipped from 1 microsecond to 500 nanoseconds; further decreases to 250 nsecs are in the offing this year.

However, the raw speed of a processor or of any particular hardware assembly isn't going to be the only major consideration. Users want ever faster throughput. Thus, overall system design and software efficiency loom large as well.

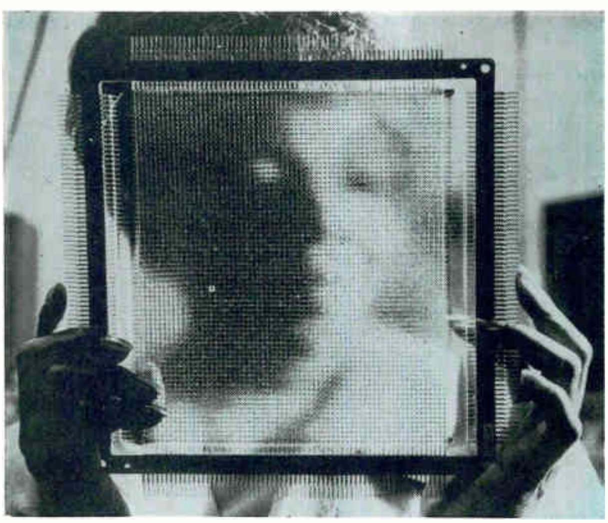
"None of the new processors that have been introduced recently have been dramatically different—from a performance standpoint," says Mazzarese. "Computer makers are just going to chip away for awhile until someone comes up with a breakthrough. This will probably occur in peripheral equipment rather than processors."

Late in 1967, CDC and Scientific Data Systems tried pricing software separately from hardware to determine whether such a policy would prove economically feasible. IBM also plans to take a flyer at this dual pricing policy. It appears that applications software can be separately priced without much difficulty; but executive software, that controls the minute-by-minute operation of a system, generally has to be included with the hardware, which isn't very efficient without it.

Along technical lines, monolithic IC's seem to have become standard items in computers. The use of such assemblies will become even more common in 1969. Gradually there will be more applications of medium- and large-scale integration.

CDC is the only major computer maker sticking with discrete components in its large processors. But the company claims to have achieved a packing density comparable to that of MSI. This is accomplished by using cordwood packaging in which components are turned on end and supported between two printed-circuit cards rather than mounted flat on one card. Thus, the cooling problems that limit the density of otherwise closely-packed components are sidestepped. The company claims that the discrete components in its new giant, the 7600, are packed as closely as the integrated and hybrid circuits in its medium-scale 3500 and certain peripheral apparatus.

But Honeywell, already an extensive user of IC's, expects to expand the number of applications in its wares. It considers IC's an important price stabilizer. Univac will also use more IC's during 1969, but the firm doesn't anticipate high-volume applications of MSI until 1971 or later.



Mementos. Memory plane of NCR's new Century computer series holds 4,608 bits of information on tiny rods.

Ampex is looking for faster memory speeds with cycle times as short as 250 nsec during 1969. Nonetheless, ferrite cores will continue to dominate the scene for some time to come. Semiconductor arrays, which have already had an impact on read-only memory technology will extend their influence, while plated wires and thin films will be the order of the day in extremely high-speed systems.

CDC maintains ferrite cores can now perform nearly as well as thin films—at much lower costs. Burroughs, which has a vested interest, takes an opposite tack. Honeywell, which expects ferrite cores to dominate this year, points to its own and other organizations' continuing research in thin films, plated wires, and optical techniques—implying that great things can be expected from these fields before too long. NCR, of course, is locked in with rods for its Century computers, and will continue with these assemblies. Univac expects plated rods to replace cores slowly over the next three or four years.

Fast registers, to be built from IC's in 1969, will move into the domains of MSI and LSI. However, these will not be available in significant quantities before the early 1970's.

The growth rate of peripherals during the past several years has been considerably higher than that of the computer industry as a whole. The development of time-sharing and of communication networks is contributing to such gains, which will continue in future years. Most new peripheral devices slated for 1969 debuts will be in the remote category.

Electronic apparatus—for example, the familiar cathode-ray tube display—will record gains. But the physical requirements of moving an input or output medium—like punched cards and printed paper—or for gaining access to a large block of storage will prevent electromechanical equipment from being wholly displaced for many years to come.

Upcoming electronic peripherals include, according to Honeywell, nonimpact printers, optical scanners, and advanced art displays—all of which will have some degree of mechanical motion, even if it's only a key on a keyboard. "We keep hoping for a big breakthrough in peripherals," says Olsen of DEC. "But we really expect only slow, steady improvements in reliability and price."

During the year, CDC looks for developments involving data services equipment for both in-house installations and service bureaus. Such apparatus will be used for ticket buying, hotel room reservations, credit checks, and similar applications. Meanwhile, Univac anticipates an improved understanding of all aspects of data processing—better trade-offs between hardware and software in a computer system, as well as better human engineering of the equipment.

Technology gains to outstrip the growth in dollar volume

Color television receivers will again set the pace—albeit a slower one—in the consumer electronics field this year. Sales of color sets will reach $2.2 billion, about 8% ahead of the 1968 level. Overall, the consumer market should register a 5% gain to $4.4 billion from the $4.17 billion of 1968.

The design of monochrome tv sets, which are in for another dismal sales year, is pretty much frozen, and few improvements are in the offing. But color sets are down for a number of innovations. For instance, solid state chassis with modular subassemblies that can be removed quickly for easy service will be reaching the marketplace in volume. RCA joined the industry's solid state pioneer, Motorola, last fall, and Zenith, among others, is reportedly ready to take the plunge. By yearend, most of the name brands should be in the solid state fold.

Plug-in components, including integrated circuits, will be important additions in many 1970 color tv lines. Sylvania pioneered this development, and most other manufacturers are now designing sockets into their receivers. Zenith, for example, offered a plug-in color demodulator on some late-season drop-ins last year; the company will follow up with plug-in pc boards on its 1970 color models.

By springtime, some American-made color sets may be sporting electronic push-button tuning features. RCA, for one, will use a varactor diode tuner produced in-house. And at least two other firms reportedly will be using comparable units supplied by Standard Kollsman. In addition, the industry's first integrated uhf/vhf tuner, unveiled last year by Oak Electro/Netics, will be installed in some of the 1970 color lines. A follow-on version with a detented uhf section is already set for some 1971 models, according to industry sources.

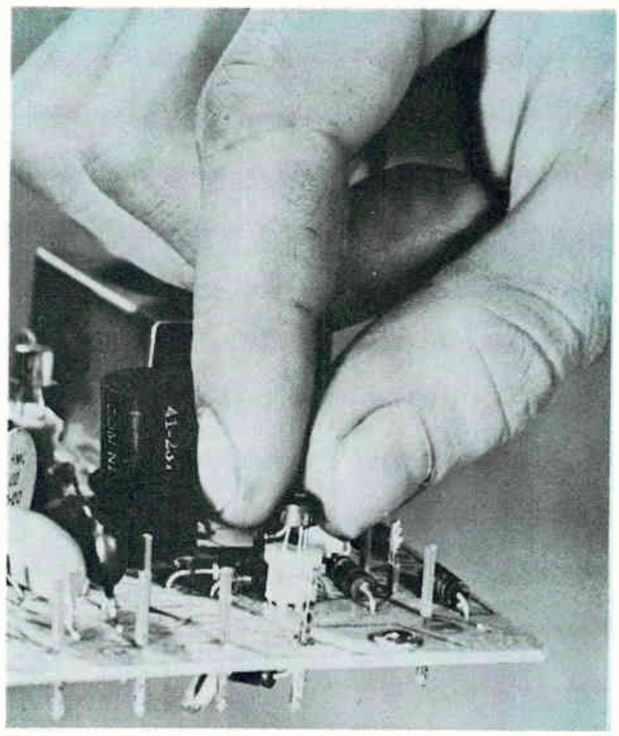
Automatic fine-tuning circuitry, previously available only in top-of-the-line sets, will be incorporated in modestly priced receivers largely as a result of consumers' insistence. However, automatic chroma and tint controls will not be available until such time as broadcasters standardize the color-burst phase relationship. And efforts to produce a 110° deflection color tube won't bear fruit this year because the principal supplier, the Corning Glass Works, is still having trouble producing the envelope.

Sweet music

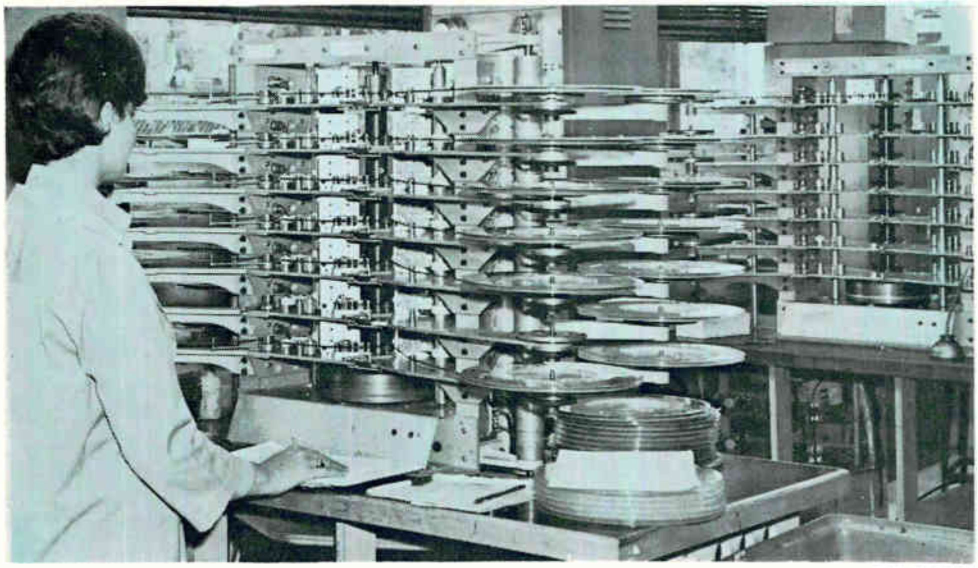
The second most important sector of the consumer field, covering phonographs and hi-fi equipment, is also set for a good year in 1969. Hi-fi sales are expected to jump 15% from last year to $110 million. "Consumers are buying more big-ticket goods than they did a few years ago," says a spokesman for one manufacturer. "They want quality and seem willing to pay for it." Domestic producers will, however, continue to face stiff competition from abroad. In particular, Japanese producers of equipment and components are making inroads.

Battery-operated phonographs with radios, units styled for the youth market, will claim a bigger chunk of the market this year. In the main, this equipment will be imported and sold under domestic labels, and will incorporate monolithic IC amplifiers as well as transistors. Nevertheless, self-contained stereo receivers with tuner, phono-preamplifier, and power amplifier in a single housing will again dominate the sales picture in this sector. A good portion of such units will be equipped with cassette and reel-to-reel tape recorders.

IC amplifiers will predominate in the i-f strips of f-m stereo sets. And crystal and ceramic filters will be widely used, replacing the once standard i-f



Socket to me. Plug-in semiconductor devices like this one from Sylvania will be widely used in 1970 tv sets.



Record year. The booming demand for tape players in consumer outlets is keeping things busy on duplicating lines like this one at Dubbings Electronics.

transformer in top-of-the-line goods. Double-balanced hot-carrier diode mixers will show up in the front ends of some sophisticated receivers, but MOS FET's will continue to be the more common mixer element.

Makers of audio tape recorders should enjoy a banner year, with sales expected to jump 16% to $188.2 million. The big reasons for this surge: the low cost and convenience of cassette units; the availability of self-threading, open-reel recorders; and the great variety of prerecorded tapes that can be bought for open-reel, four-track and eight-track cartridge and cassette player/recorders. The automobile industry's promotion of cartridge units as optional equipment for new cars is also providing a big boost.

But the market is far from stable. "Perhaps within five years, the cassette will completely displace the eight-track stereo player as a mass-market item," says Irving E. Lempert, engineering section manager at Westinghouse Electric's Consumer Products division. He believes the shift will come "when car makers opt for cassettes as an industry standard." However, many observers are inclined to insert an "if" in that statement. "There's no change in the wind here," says a highly placed source at General Motors. And Ford recently signed another three-year agreement with Motorola for eight-track cartridge players.

Home entertainment

Video tape recorders for use in the home are still an iffy proposition despite enthusiastic drumbeating in certain quarters. The big drawbacks are cost—up to $50 for an hour's worth of recording—and limited picture resolution.

The vtr picture is also clouded by the advent of the Columbia Broadcasting System's EVR (electronic video recording) system. These units will be offered both as separate attachments that, when hooked up to standard tv sets, play prerecorded programs on the screen, and in combination with receivers. Additional, albeit indirect, competition for vtr's will come from the home movie/tv combinations Sylvania will introduce later this year.

The material presented with EVR is originally recorded on motion picture film or video tape and then transferred to special 8.75-mm film by CBS Labs. An hour's worth of material can be put on a 7½-by-½-inch cartridge; processing costs $20.

Later this year, the first EVR playback units will start rolling off Motorola's assembly lines. Priced between $700 and $800, they're destined for educational and industrial applications. A trim consumer model will be out later in the year with a price tag of about $500. Farther down the road, Motorola, which has a two-year exclusive on EVR, will turn out an EVR/tv combination set; it's expected that economies will be achieved with designs using tv circuits to perform certain electronic video recording functions.

Car makers are fast becoming major outlets for electronics suppliers. Within the past couple of years, for example, the industry has switched virtually en masse from relay-operated voltage regulators to IC designs. Rear-window defrosters now sport electronic timing circuits, and mechanical cruise-control systems have gone electronic as well. Turn signals are giving way to sequential flashers. And Ford is using a tiny computer in its prototype antiskid system.

Though it's difficult to pinpoint upcoming developments with any precision because of the auto firms' predilection for cloak-and-dagger secrecy, the shape of the field's near-term electronics future is already apparent. GM will offer an antiskid control system as optional equipment on some 1970 models, and will also introduce the first silicon IC voltage regulator. Other electronic wares earmarked by the industry for 1970 or 1971 delivery include speedometers, fuel pumps, variable-speed windshield wipers, and liquid-level detectors.

Strong demand to continue for high-performance items

Improved performance at a price will again be the key to success for components suppliers, many of whom are clinging to markets threatened by integrated circuits. Parts makers who can fill this bill should continue to do well. Demand promises to be strong across the board in military, industrial, consumer, and commercial outlets. And original-equipment manufacturers have long since worked off the swollen inventories of components that led to a sickening slide in demand two years ago.

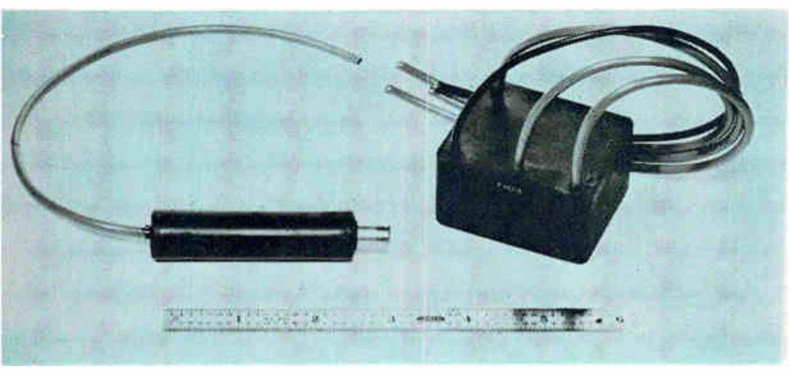
Resisting decline

Though IC's have made some inroads in the market for discrete resistors, the boom in demand for such equipment as desktop computers should provide enough of an offset for sales to rise to $423.0 million in 1969 from $410.3 million in 1968.

Desktop machines use a lot of IC's, primarily in their logic circuitry. Power sections still require fixed-value resistors. And metal-film resistors continue to be used in fabricating hybrid microcircuits; monolithic technology cannot yet produce high-precision devices. Since the computer field is expected to continue its headlong expansion during 1969, there will undoubtedly be an increase in demand for metal-film resistors.

These resistors will also be improved. For example, higher temperature coefficients, better tolerances, and better power-handling capabilities are within reach. Thus, a 20-pulse-position-modulation assembly is feasible for volume applications in analog computers. The metal-film resistor is popular because it offers more resistance per volume than its principal rival, the wirewound resistor.

Aware of the strong competition from metal-film units, producers of wirewound resistors are building better mousetraps. During 1968, they further miniaturized their wares, got the tolerances down to 0.0025% from 0.01%, and achieved stabilities ranging from 20 parts per million a year to 20 ppm every three years.



Rule of three. Voltage tripler, an encapsulated network of diodes and capacitors, eliminates rectifier tubes and secondary coils in flyback transformers of tv receivers.

Capacious market

Last year was one of the best that capacitor manufacturers have ever enjoyed, and 1969 shapes up as equally good. Sales should rise from an estimated total of $400.7 million to $434.5 million. Fixed ceramic dielectric and variable capacitors lead the sales parade. Jack Goodman, vice president of JFD Electronics, says: "These smaller capacitors have high r-f current and voltage features, as well as values ranging from 1 to 3,500 picofarads. They're widely used in communications, telemetry, and medium-power transmitter.

New ceramic formulas are largely responsible for the improved characteristics. Ceramic capacitors have fused leads that don't have to be soldered and stand up well to the temperature extremes encountered in space. Such units will continue to move in on mica, fixed glass dielectric, and vitreous enamel capacitors.

Dollar volume of tantalum capacitors should increase during 1969 even though unit prices have dropped to competitive levels. Likewise, high r-f current capacitors will continue to be widely used in the outputs of cathode-ray tubes, as well as medium-power transmitters.

Challenge round

IC's continue to play a role in the operational amplifier field. But units made with discrete components are still very much in demand. To meet the challenge of IC competition, manufacturers are offering better performance at lower cost. For example, Analog Devices now has a new op amp, the model 118, with lower bias current and better frequency response than its general-purpose 111. The 118 sells for $11, the 111 for $13.

Similarly, with the model 230, the company has almost halved the price of a previous chopper-stabilized op amp while improving the performance [Electronics, May 27, 1968, p. 181]. The 230 is priced at $67 per 100, as against $125 for the 210. The new unit is half the size and has superior current-drift characteristics.

Models with IC's also boast improved quality. Analog Devices' 801 unit, for example, was designed to compete with the standard 709 op amp. The new unit has: a bias current of 4 nanoamps, compared with 500 nanoamps for the 709; open-loop gain of 15,000, as against the 709's 25,000; and an input impedance of 25 megohms, compared with 0.15 megohm for the 709.

Triple play

Like most other components, diodes and related specialty devices should continue to grow. Among the best bets for success is a network of discrete diodes and capacitors called a voltage tripler that will be in many 1969 television receivers. Set makers are using the network to step up the voltage on the picture tube from 8,000 volts to 25,000 volts, eliminating some of the secondary coils in the fly-back transformer. The tripler also eliminates the need for a high-voltage rectifier tube and a focus rectifier tube. In addition, it reduces the X-radiation effects that have proved a major problem in some color sets.

Although widely used in Europe, the tripler is new in the U.S. Manufacturers using it can build almost completely solid state receivers that require only high-voltage rectifier and picture tubes.

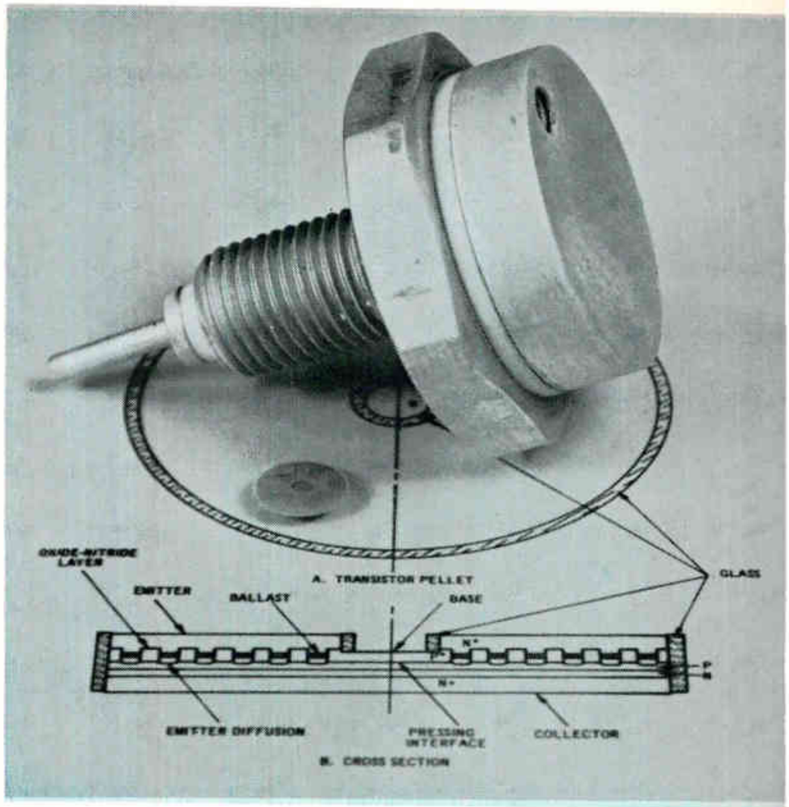
Triplers have a longer life expectancy than conventional assemblies because of cooler operation and lower power drain. Besides tv, prospective applications include high-voltage power supplies for electrostatic copiers, precipitators, and filters, as well as other crt equipment in the industrial and military fields. Prices are competitive with those of vacuum tubes and selenium assemblies. Triplers are supplied by such domestic firms as ITT, Varo, Sempeck, and Atlantic Semiconductor, as well as European concerns such as Siemens.

Aside from the voltage tripler, such special devices as log diodes will be in demand during 1969—especially for equipment that requires multipliers. In addition, silicon diodes should move ahead of germanium units. The operating advantages of the silicon diode—more speed, better thermal effects, broader operating range, and longer life—have always been popular, but high costs have tended to limit its application. Now, says Jerry Kalman, vice-president of marketing at Computer Diode, "Prices have been reduced and values increased. As the computer market continues its growth throughout 1969, more and more of these devices will be used." Other volume applications will be in automobile alternators and radios.

Transformation

Computers are playing a larger roll in the design of new components. A case in point is Varo's new ferroresonant transformer. The computer helped Varo design a unit that requires less core material, less copper, and a smaller resonant capacitor than conventional units. And, the company reports, these savings were obtained without degradation of performance.

An important development in the semiconductor sector is RCA's perfection of a technique to build extremely high-power transistors. This achievement makes transistors, for the first time, a direct rival of the high-power vacuum tube.



Big time. Semiconductor engineers at RCA have developed experimental transistors putting out 800 watts of power; even larger outputs at high frequencies are anticipated.

Although the technology is still experimental, engineers have produced breadboard models that have generated radio waves oscillating at 1 megahertz with a power of 800 watts—over three times the power generated by many radio stations. Considerably higher powers and frequencies are expected during 1969.

Units are formed on two separate silicon wafers—the emitter base and the base collector. The wafers are then fused, or laminated, under heat and pressure into a monolithic structure. The features of an overlay structure, including ballast resistors to guard against secondary breakdown, are retained in the new devices. After lamination, the entire wafer is hermetically sealed in glass. Individual hermetically sealed pellets are separated and can be mounted in nonhermetic packages for various applications.

The active regions of the device are in the center plane of the semiconductor pellet; in conventional devices, the active regions are generally at the surface. This geometry provides an emitter contact area that has a solid and continuous surface suitable for heat sinking.

The pellet, 250 mils in diameter, contains 222 emitter sites. A larger pellet, now under investigation, is about 330 mils in diameter and contains 330 emitter sites.

IC's to gain a foothold

Having broken into the billion-dollar class this past year, the industrial electronics field appears ready to improve upon its performance. Sales are expected to hit $1.15 billion, a 12% gain from the 1968 level.

The little integrated circuit promises to be the big news in the industrial sector this year. IC's have finally made it to the market, permitting the design of original new products, offering clever ways to redesign old wares, and serving as means for companies—from component makers to end users of electronic equipment—to expand their businesses.

One of the effects of this IC proliferation will be the disturbance of some historic—and comfortable—marketing traditions. Thus, for a while at least, component houses and product makers won't be looking at sales to the continuous-processing industries as a barometer of business conditions.

Starting from a lower base, admittedly, manufacturing firms are pouring capital into their plants at a faster rate than are, for example, chemical and petroleum companies. Processing companies already boast of a capital investment of between $60,000 and $100,000 per employee. But other manufacturing plants are rapidly approaching these levels, and a significant amount of this investment is going for electronic controls, excluding numerical controls, to program and operate machinery.

The best prospects are in the industrial submarket composed of makers and users of high-volume production and inspection machinery. One supplier estimates the total electronic and electrical control sales in this area at about $500 million dollars—with an annual growth rate of 25% to 30%. And electronic equipment, using integrated circuits, discrete components, and silicon controlled rectifiers, can vie for about $100 million worth of the action. This amount includes the value added to the basic electronics to produce functional equipment and systems ready for installation by the customer.

Since similar production and inspection machinery can be found in many kinds of manufacturing plants, electronics suppliers may have to revise their marketing viewpoints and tactics. Instead of hawking their wares in a vertical market, they'll search out all possible outlets for electronic control in, say, package inspection machinery.

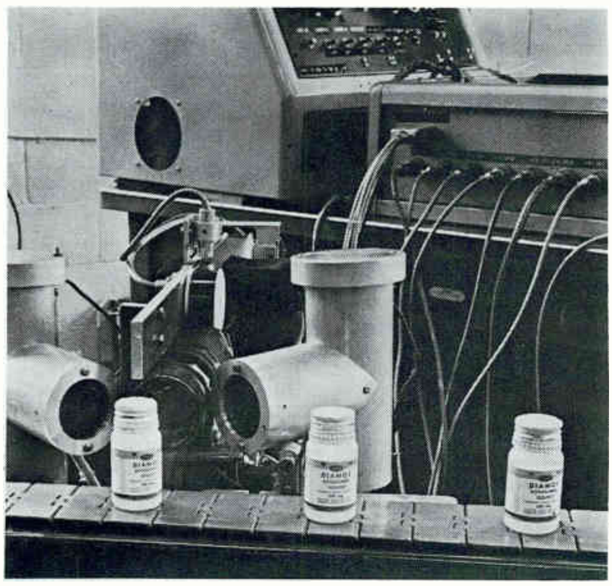
Some producers of manufacturing machinery have elected to develop their own circuits and build their own electronic equipment starting at the integrated-circuit or discrete-component level. This requires an engineering staff well versed in electronics technology. But since most machinery makers are mechanically inclined, there's a strong tendency to farm out the electronics development and production to companies skilled in providing functional modules and systems. To an extent then, machinery makers are putting their sales in the hands of their electronics suppliers.

Target areas

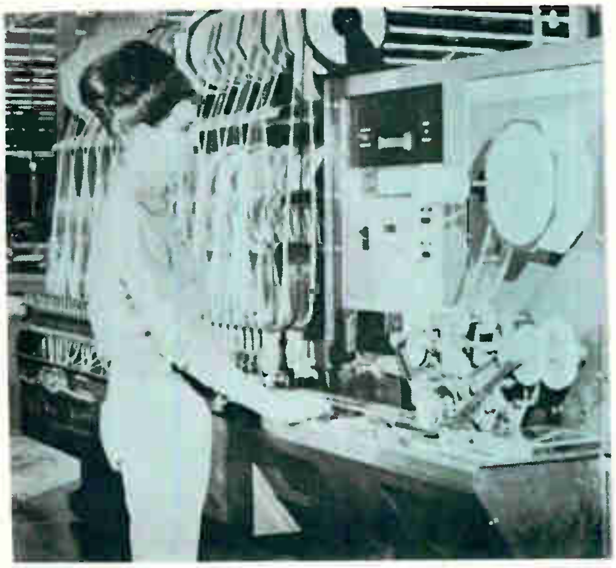
OEM (original-equipment makers) outlets should prove a growth area for electronics companies. The Digital Equipment Corp, for example, has set its sights on machinery-control portion of the OEM market. It wants to sell functional modules—products that put IC's-and other electronic components into a form the customer can use.

Allan T. DeVault, module product line manager at DEC, notes that with their greater reliability and smaller size, packaged functions made with IC's can command a premium price up to 2½ times that of an equivalent relay-type control system. However, most electronic machine control systems sell for about 1½ time the tab on conventional apparatus. DeVault looks forward a few years to the time when prices of IC control-function modules reach the point where the modules compete head-on with relay-type machine controls.

Just how fast the portion of the industrial electronic market that's centered around the IC will grow in the next few years is indicated by data compiled by Texas Instruments. According to the Dallas-based semiconductor giant, total industry sales for digital-type industrial IC's during 1968 came to about $83 million; in 1969, the level is



Fallout. Industrial concerns are trying to capitalize on their technological know-how; this American Cyanamid system "reads" luminescent product codes on bottle labels.



In turn. Component sequencer takes up to 39 different values of resistors and diodes at GE and places them in order on reels for installation on pc boards.

expected to double to $160 million, and 1970 volume may double again to $320 million.

While these figures are impressive, they don't tell the whole story. The number of circuits and packages will increase even faster than dollar sales. Unit prices are sure to tumble this year and maybe again next year as production capacity expands. In fact, J. Fred Bucy, TI vice president, says his company will cut prices 25% on high-volume, low-complexity devices like flip-flops and gates during the first quarter this year.

Maximum effort

One of the reasons for such growth is the component makers' diligence in helping their customers get started—even arranging for deliveries at a time the customer can pay for the packages. TI's application group alone will account for a large part of the increased IC usage by industrial companies. This organization has helped design motor controls, machine-tool controls, stock market equipment, draw-and-speed indicators (for the paper industry), digital measuring systems, and the like for machinery makers whose products used to be made of gears, levers, relays, and vacuum tubes.

Because of its massive efforts, TI claims that 80% of the recently designed products using digital IC's employ transistor-transistor-logic techniques. When these products get into production this year, according to TI, TTL will account for more than half of the logic-package sales to industry.

Interestingly, major process-control suppliers have substantially ignored IC's integrated circuit in their present products. In fact, any kind of electronics seems to find the going hard in conventional process-control equipment. Sales of pneumatic controls still outpace their electronic counterparts, mainly because—for a particular installation—the electronic versions don't offer distinctive benefits to offset the lower cost and historic acceptance of pneumatics. Pragmatic customers, it seems, buy process controls, not the glamor of electronics.

This is not to imply that users of process-control equipment haven't gained from semiconductor technology. Lower costs and better performance have resulted from specific equipment designed around IC's. Much of this gain is offered by smaller, possibly more energetic companies that sell peripheral items used in process control but not listed in the catalogs of major suppliers.

For example, Deltron Inc. of North Wales, Pa., provides a line of IC annunciators—devices that visibly indicate normal conditions of process variables. The company's sales manager, Robert Lewis, says that the use of IC's dropped the price of annunciators about 10%. Less metal work and easier assembly are the big reasons. Because of the annunciator's smaller size, the customer needs less space on very expensive panel boards to keep the operator informed of process conditions.

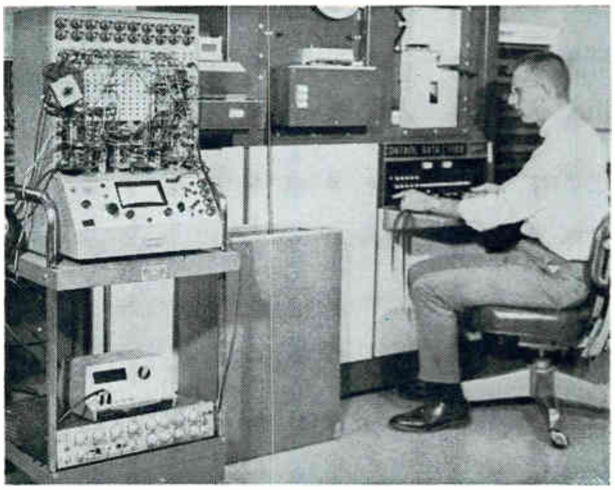
Lower product cost isn't always the goal. IC's can lead to better performance. Gabriel J. Luhowy, chief engineer of Transmation Inc., of Rochester, N.Y., says linear IC's afford a higher open-loop gain per dollar than discrete-component devices. Because of the higher gain, it's feasible to use more feedback in the circuits, resulting in instruments with better linearity, regulation, and temperature compensation. Thus, for a modest increase in price, the customer can get a 0.1% instrument instead of the usual 0.25%.

Honorable discharge

Because the integrated circuit is an offshoot of Government-funded development work, the devices tend to reflect military requirements. But the fast switching speed of IC's, needed, for example, in airborne digital computers, can prove troublesome in industrial electronic equipment. Says Luhowy: "IC makers have gone overboard in making wide-band devices. Industry doesn't need 100-megahertz bandwidths. Rather, 50 kilohertz should be adequate. Further, IC makers ought to place more emphasis on a better noise figure—a couple of decibels at 1 hertz—and more reliability in plastic-packaged IC's."

Transmation—which does its own designs—doesn't use plastic-packaged IC's in its products. But such conservatism is by no means universal. Don Metz, a staff engineer at Litton Industries' Louis Allis division, selected plastic-packaged TTL IC's—with help from TI's application group—for the firm's Dynapar Custom 600 draw-and-speed indicator. He says these assemblies work reliably in the heat, humidity, and sulfur-laden air around paper-making machines.

For products built around a few packages, the quality of the IC—not the chance to pinch pennies—is of paramount importance. When a 709-type operational amplifier can be bought for less than



First phase. AAI's experimental work on adaptive control may lead to commercial systems for process applications.

$2, saving a few cents isn't going to mean much on a product that winds up costing the end user more than $100. To industrial electronic engineers like Luhowy, reliability applies to the IC and to suppliers—those who deliver on time.

Major process-control suppliers' avoidance of integrated circuits may be a sometime thing, a reflection of unwillingness to redesign old products. More than likely, market strategy is centered around the future introduction—and the future may be very close—of products in which IC's can implement some of the control ideas and concepts that up to now have been within the province of large and expensive digital control computers. Thus, without having to know much about such complex techniques as feedforward control, adaptive control, self-tuning, time-sharing, and the like, the user will be able to derive the benefits of these methods through new kinds of control devices.

Mead Bradner, technical director at the Foxboro Co., provides some clues to what might "appear in the next couple of years" in process-control equipment. He anticipates new types of hybrid controller packages that will be time-shared, will combine analog and digital techniques—high gain analog for low-level inputs and digital integration—and will come in modules to service four, six, or eight loops. "The control system will use integrated circuits," he states.

Breakouts

But while control companies are keeping their ideas simmering on the back burner, other firms are moving theirs to the front of the stove. Significantly, some of the biggest buyers of clectronic equipment are now starting to sell both hardware and process-control know-how. Just as these companies have capitalized on research efforts by licensing their processes, they will sell their hard-won process-control knowledge in the form of special products and systems containing unique functions implemented with IC's and other electronic packages.

Late last year, for example, the American Cyanamid Co. announced the formation of its Decision Making Systems department, whose initial venture will be to apply photoluminescence technology in industry. Using photoluminescent inks, which Cyanamid makes, the department will market machinery and electronics for printing, detecting, and processing coded information in invisible ink. Scanning and logic circuits, energized by ultraviolet light shining on the ink, will detect labels and sort packages during both production and final inspection operations.

Applied Automation Inc., formed in mid-1968 by Phillips Petroleum, will merchandise expertise in processing and process control. While a lot of its revenue will come from systems studies for customers, the firm also plans to sell electronic hardware it has already developed or is working on. AAI engineers continue to study and apply adaptive control with the stored-program digital computer. And it's not unlikely, they hint, that someday they'll be able to implement such complex schemes on functional cards rather than through software programing.

In addition to analyzers for measuring the composition of process streams, AAI will sell functional cards it developed for some Phillips computer control jobs. These cards, built from IC's, will perform such input-output functions as filtering, high-low limit detection, and storage of signals during multiplexing.

Numbers game

But what of numerical control? Historically, NC has been considered a major adjunct to metalworking. With 14,000 such systems in operation, there's a new push coming. According to Louis Rader, vice president and general manager of the General Electric Co.'s Industrial Process Control division, numerical control, which got its start as stand-alone equipment, will someday constitute only one part of an integrated approach to running a factory. Eventually, these systems will include a process-control computer, NC, materials-handling gear, and telemetering. Anticipating the need for such an integrated setup, GE designed its recently announced Mark Century 7500 numerical-control system from logic packages that can be used throughout a wide range of factory-control equipment. The packages are, of course, made of integrated circuits.

Probably the most notable nonmetalworking application of numerical control is at the Ford Motor Co.'s glass plant in Nashville, Tenn. This facility turns out 800 tons of automotive and commercial glass every day. The NC system—the largest ever built by General Electric—performs on-line, cutting glass with no reduction in production line speed. Taking into account the location of imperfections, it cuts the glass to tight specifications with a minimum of loss and waste.

NASA tightens its belt another notch

Unless the Nixon Administration arrives with a set of proposals for some new starts in space, as well as the will and the cunning needed to get them through an unsympathetic Congress, 1969 will be another comparatively slow year for space spending. Few planners really expect a last-minute reprieve. As a matter of fact, most anticipate that hardware outlays will slip below this year's levels.

The National Aeronautics and Space Administration has little money to spend during the first six months of the year, and the second half scarcely looks brighter. Less than 35% of the agency's fiscal 1969 budget of $3.85 billion will be spent through June 30; most of the money went last year, and what's left will go largely for studies and services. At the moment, NASA plans on submitting a fiscal 1970 budget of $3.875 billion. Officials hope to boost this amount once Nixon takes office.

There are few surprises at the agency's Office of Space Science and Applications (OSSA). "New starts" will be ideas that have been around for a season or two. Says an official with eight years on the job: "You can't expect anything too imaginative when our primary concern is to keep existing programs alive. Ideas will flourish—as they did a few years ago—when we can get some more money."

Flight plans

One of the programs OSSA will try to get off the ground during the second half is the earth resources technology satellite. If Congress approves, contracts for two spacecraft could go out later this year. Officials estimate that the whole program, including studies and launch vehicles, will cost $47.7 million, $18 million of which will be requested in fiscal 1970. OSSA would also like some low-level study funds for "omnibus" ERTS programs to be run during the late 1970's. The rationale is that there will eventually be a need for big earth resources satellites for dozens of unrelated tasks.

NASA men would also like to resurrect another pet project of theirs, the 1973 Mars probes—now known as Project Viking—which have suffered so at the hands of budget-cutters that a go-ahead at this point would amount to a new start. OSSA has a list of eight experiments to be placed on Mars with soft landers; to get started, officials want at least the $20 million that was cut out of the last budget.

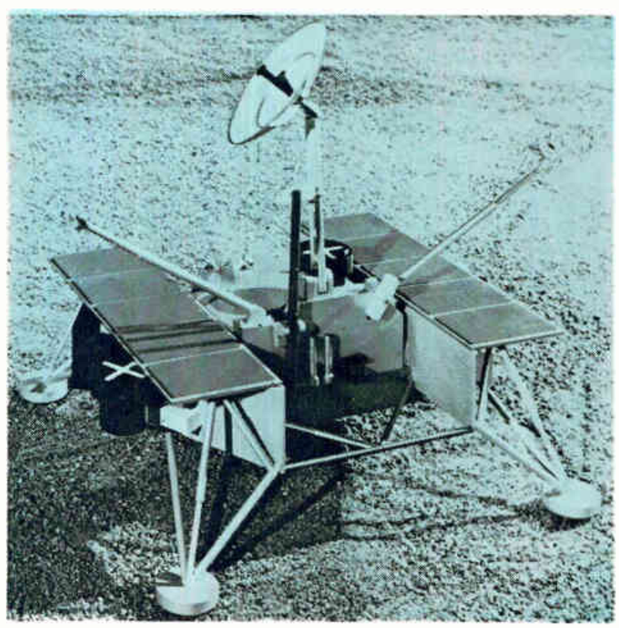
Just about every project office is jockeying for seed money to get started on programs for the early 1970's. Among the ideas now being considered: Applications Technology Satellites H and J; advanced Nimbus and synchronous-orbit meteorological spacecraft, as well as biosatellites and new geodesy vehicles.

Funds will be requested for studies and early design work for 1973 missions to Mercury, as well as swing-by missions to outer planets during the 1976-79 period. This so-called "grand tour" of Jupiter, Saturn, Uranus, and Neptune will be pushed hard because the planets won't be back in line again for another 179 years.

Funds for the Office of Advanced Research and Technology in 1969 will remain at about the same level—$156 million—as this year. Electronics research will get around $35 million worth of the action, though officials at the Electronics and Control division would dearly love to boost the ante to $38 million. Frank J. Sullivan, who heads this activity, says the money will be used for a variety of projects, including stepped-up efforts in avionics. In particular, pilot warning indicators and clear air turbulence detection systems will receive attention. Both laser backscatter and laser doppler techniques will be investigated for CAT applications, and prototype hardware will be tested.

Straight up

A major effort will be devoted to developing vertical/short-takeoff-and-landing systems at NASA's Electronics Research Center in Cambridge, Mass. Says Sullivan: "If we can develop efficient and reliable V/STOL aircraft, we can pave the way to generally improved air transportation." V/STOL elements due for attention during 1969 include:



Model. Space agency's 1973 Mars missions may include soft landers like this—if the project is finally approved.

inertial navigation systems, displays, and on-board data processing gear, as well as associated air traffic control electronics. Work on L-band communications, including antenna configurations and transmission techniques, also figures in ERC's 1969 plans.

Space electronics projects on tap include optical techniques for orbital observatories, high-data-rate communications to and from orbiting vehicles, and advanced sensors for earth applications work. Data processing aboard satellites will be examined, as will video compression methods and schemes to increase channel capacity. Sullivan says, "Our data studies will range from simple casting out of redundant bits in transmissions through examination of transmissions of holograms from a spacecraft orbiting a planet."

Electronic component and device research will have a practical cast in the coming year. According to Sullivan, there will be an effort to apply such recent developments as large-scale integration, Gunn-effect devices, and lasers in space systems. "But our principle project during the year will involve microelectronic reliability," he says. ERC is charged with the responsibility of devising more efficient ways to develop electronic systems. "The burden of hardware verification falls on the user—usually at a time when the designer is off on another project," Sullivan says. "We want to foster better communications among designer, fabricator, and user." ERC will issue suggestions for coordinating systems work, contracting with electronics firms for detailed studies.

The trend away from hardware procurement perhaps is most evident in NASA's manned space flight program. The office in charge of the program estimates that only 10% to 15% of its $2.1 billion budget will go for hardware, and that only a small amount of this will be for electronics. Says Walter S. Grosyck of the program's control directorate: "Even if Congress came through with a $4.7 or $4.8 billion appropriation, we'd still not be able to spend much on hardware in the next year and a half. Our funds will have to go for items already contracted for, services for Apollo, and studies of new endeavors. We work with long lead times and we can't get major hardware purchases back into the pipeline in the next year."

Funds for Apollo will continue to dwindle while outlays for the drastically reduced Apollo Applications Program (AAP) rise. About $1 billion will be spent in the first half of 1969, with most of it earmarked for Apollo bills and about 10% for AAP. During the second half, the proportion will be reversed—albeit on shorter rations.

The first of four projected AAP missions is slated for 1971. In the fiscal 1969 budget request, $439.6 million was sought for AAP but only $253.2 million was authorized. Unless a substantial increase is forthcoming, officials predict the once grandiose scheme will either have to be further limited or stretched out considerably.

Faced with a generally grim year for new projects, the Office of Manned Space Flight will attempt to get some new projects in the works. NASA now plans two lunar revisits a year during the early 1970's and wants money to study ways to extend stays beyond 24 hours and produce vehicles permitting astronauts to venture beyond a quarter of a mile—the current limit—from their spacecraft. In addition, there will be a new line item requesting funds for a national space station. But funds will only cover studies and preproduction work.

The Office of Data and Tracking Acquisition anticipates spending around $280 million in 1969. About $200 million is for the organization's existing network; the balance would be largely devoted to equipment replacement. Only $20 million is earmarked for new stations with 210-foot dishes in Spain and Australia. RFP's have been issued.

Comrades in arms

Military space programs will get less than $2.0 billion in 1969. Spending for the Air Force's Manned Orbiting Laboratory—the largest armed forces' project—is expected to peak during 1969 at about $600 million.

The general budget squeeze, however, has kept many Pentagon space projects in limbo and put others in the stretched-out category. The fate of certain Pentagon programs will not be clear until the fiscal 1970 budget is unveiled. For example, such ambitious projects as the Air Force's integrated communications, navigation, and identification system and 621-B navigation satellite are in the balance. But the Defense Satellite Communications System is down about $200 million in 1969 as contracts are let for six spacecraft.

In the civilian sector, Comsat will be spending heavily during 1969. Almost half of the $32 million budgeted for six Intelsat 3 satellites will be paid to TRW Inc. and its subcontractors, and large installments of the $72 million due the Hughes Aircraft Co. for four Intelsat 4's will be made. Unless the FCC denies Comsat's request for two new ground stations, contracts will be signed early in the year for installations on Guam and in Alaska. The new stations will have 97-foot steerable dishes and be designed to incorporate modifications for operation with the Intelsat 4 series.

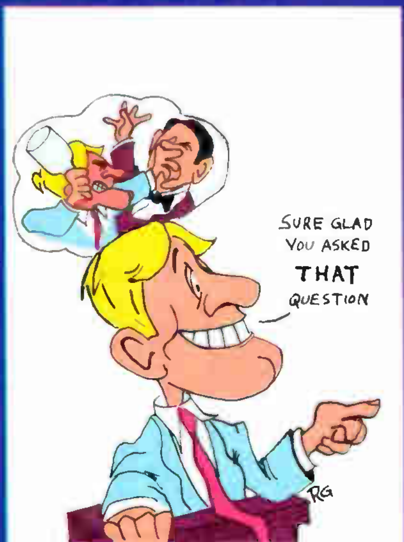
Two major undertakings—an Aeronautical Services Satellite program and a U.S. domestic satellite program—are still as doubtful as they were a year ago. However, the former may get a definite no within the next few weeks; the latter has the approval of the President's task force on telecommunications.

Another big question mark involves the nature of permanent arrangements for Intelsat, which Comsat is managing on an interim basis. Renegotiation of the temporary agreement begins Feb. 24; until the matter is settled, Comsat will not know exactly where it stands within Intelsat.

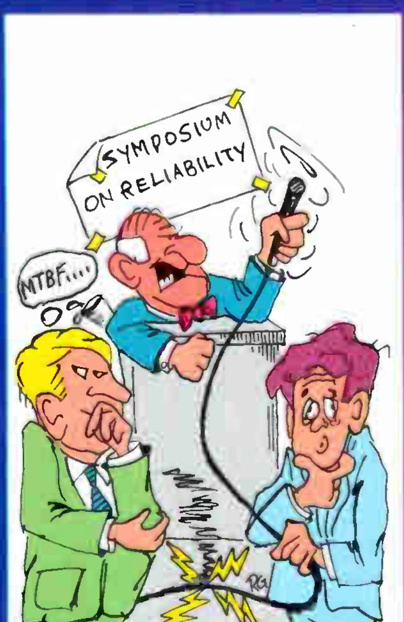
Electronics guide

Major 1969 confe

January

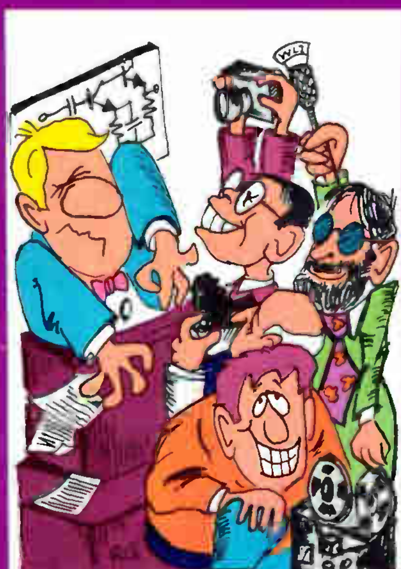


Reliability Symposium
January 21-23
Palmer House, Chicago



February

Transducer Conference
February 10-11
Washingtonian Motel and National Bureau of Standards, Washington



Aerospace and Electronic Systems Winter Convention (Wincon)
February 11-13
Biltmore Hotel, Los Angeles

International Solid State Circuits Conference
February 19-21
University of Pennsylvania and Sheraton Hotel, Philadelphia

March

National Association of Broadcasters
March 23-26
Sheridan Park Hotel and Shoreham Hotel, Washington

IEEE International Convention & Exhibition
March 24-27
Coliseum and New York Hilton Hotel, New York

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April

Midwest Symposium on Circuit Theory
April 21-22
University of Texas, Austin

National Telemetering Conference
April 22-24
Washington Hilton Hotel, Washington

Southwestern IEEE Conference & Exhibition
April 23-25
Convention Center and Palacio Del Rio Hotel, San Antonio, Texas

Electronic Components Conference
April 30-May 2
Shoreham Hotel, Washington

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International Microwave Symposium
May 5-8
Marriott Motor Hotel, Dallas

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Sheraton Boston Hotel and the War Memorial Auditorium, Boston

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Laser Engineering & Applications Conference
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June

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University of Colorado, Boulder

Computer Conference
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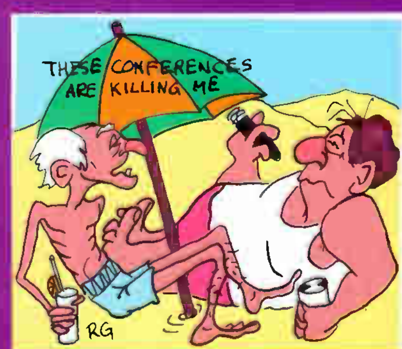
Leamington Hotel, Minneapolis, Minn.

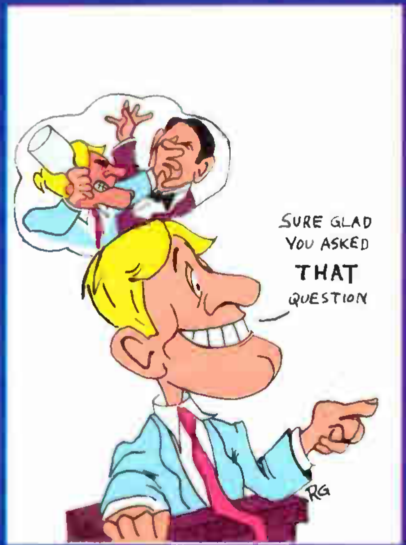


Electromagnetic Compatibility Symposium
June 17-19
Berkeley Carteret Hotel, Asbury Park, N. J.

ging Interface: an IC/systems seminar, Mar. 28. Details on reverse side.

Major 1969 conferences: January-June

January



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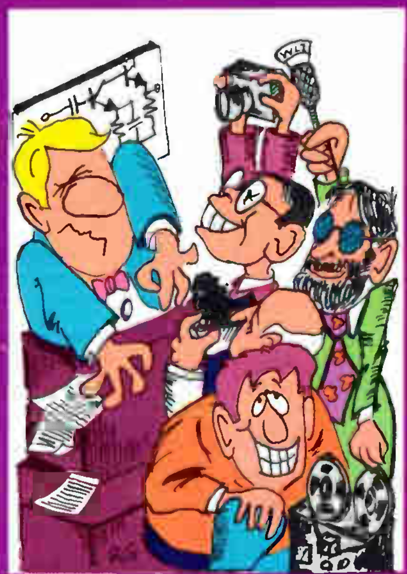

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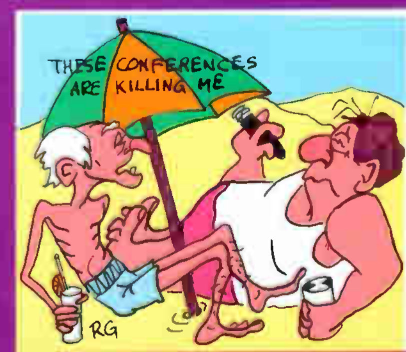

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Details on reverse side.

Transducer Conference

A potpourri of 14 papers on measurement and conversion techniques will be served up, some new, some review, and most electronics-oriented. MIT's Prof. Kurt Lion will lead off with "Transducers: Problems and Prospects," and W.V. Miller of TRW Systems will describe a new development, a frequency-modulated electric-to-fluidic transducer. The schedule includes tour of the National Bureau of Standards.

First National Conference on Electronics in Medicine

February 14-15
Statler-Hilton, New York

Aimed at both engineers and physicians, this meeting will be sponsored by a trio of McGraw-Hill publications: Electronics, Medical World News, and Modern Hospital. The meeting will provide a forum where medical scientists and practitioners can gather with electronics engineers to discuss the problems and progress of medical care and the application of electronic technology to medicine. The program will include the presentation of papers, panel discussions, and equipment demonstrations.

International Solid State Circuits Conference

If previous gatherings of the solid state people are any indication, the Philadelphia conference should be a lively affair. The evening panel discussions, which are often marked by arguments, will cover, among other topics, microwave power generation, analog IC's, custom versus standard LSI, the impact of LSI on memory organization and design, and electroluminescent - diode alphanumeric displays. Progress in devices and applications will be reported in sessions on operational amplifiers, bulk-effect and avalanche circuits, semiconductor memories, and many other subjects.

IEEE International Convention and Exhibition

The biggest electronics conference in the country will have a slightly modified format this year. For one thing, the directors of the IEEE show have reduced the number of technical sessions from last year's 70 to 52 to give the more than 65,000 visitors more time to look over the 800 exhibits. However, those technical sessions scheduled will cover a broader range of topics than before. Among other changes: a series of applications sessions and the presentation of two short courses.

The Changing Interface: an IC/systems seminar

March 28
Park-Sheraton, New York

A meeting sponsored by Electronics magazine will explore the new relationships developing among components manufacturers, circuit design engineers, and systems houses. The need for a critical look stems from the growing complexity of IC technology. Presentations by men from each side of the interface will be followed by panel discussions.

Midwest Symposium on Circuit Theory

Both theoretical and practical subjects get an airing at this annual meeting, though in recent years, the papers have leaned more to the practical, dealing with such things as computer-aided design and integrated-circuit technology. The symposium, held in a different location each year, is guided by a steering committee of members from Midwestern universities and industries acting in cooperation with the circuit theory group of the IEEE. The first symposium was held at the University of Illinois in the spring of 1955.

SWIEEECO

Attendance is expected to be around the 4,000 mark at this conference. There will be 100 exhibitors and about 20 sessions. Many of the papers presented will deal with biomedical electronics because this is a sectional meeting and there are a large number of medical facilities in the area—Brooks Army Medical Center, Texas Medical Center, and the Southwest Research Center, to name a few. The meeting will coincide with fiesta week in San Antonio, and the convention's organizers hope to see engineers from Latin America participating in the program; all papers will be presented in both English and Spanish over closed-circuit television.

International Microwave Symposium

New advances in microwave technology are being stressed this year, although there'll also be the traditional coverage of standard theory and techniques. Magnetoelastic and acoustic devices will be discussed, reflecting the recent interest in praetersonics. Millimeter-wave discussions, formerly limited to detectors, will be broadened this year. For example, a paper has been solicited on a 94-gigahertz radar. And there'll be a new look at Gunn-effect devices and avalanche diodes. Familiar subjects include ferrite materials and components, filters, switches, fabrication techniques for integrated circuits, and transmission lines.

National Aerospace Electronics Conference

To mark its 21st year, Naecon will take a look at the 21st century. Airborne communications, navigation and guidance systems, integrated electronics, and laser applications will get lots of attention. So will the avionics problems related to the designs of future swept-wing, supersonic transports and V/STOL aircraft.

Laser engineering

Potential applications of picosecond pulses, parametric oscillators, and laser-acoustic interactions are among the new topics the conference will cover this year; the added features reflect substantial engineering done recently. Also being solicited are papers on modulation and detection, the latter being another area that's seen considerable progress lately. Other topics will include communications techniques and the components of communication systems, ranging, information processing, and measurement methods.

Computer Conference

Biomedical applications will be a major topic at this year's conference. Hospitals need equipment for continuous monitoring of patients and for data retrieval. Physicians and engineers at the conference will discuss the success of prototype systems in hospitals, deficiencies to be remedied, and future requirements for the automation of hospital services. The over-all theme of the conference will be real-time systems; other topics include graphic displays, programing techniques, and modelir.g analyses of time-shared systems. Several papers, most presented by professors, will cover the use of queuing theory to relieve congestion in time-shared systems.

New this year: National Conference on Electronics in Medicine, Feb. 14-15; The changing Interface: an IC/systems seminar, Mar. 28.

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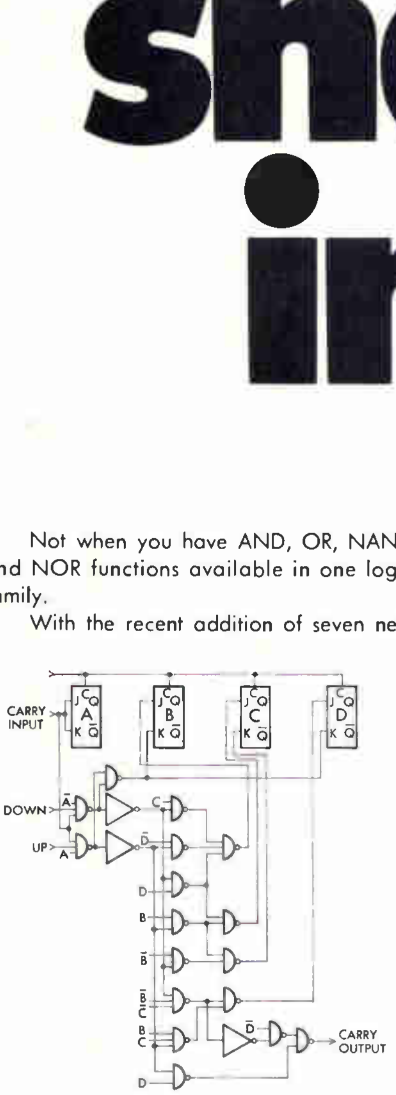
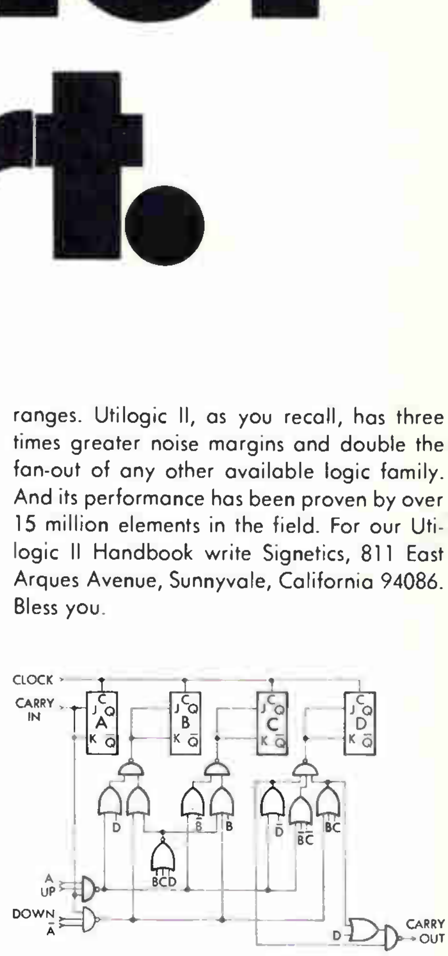


DTL implemented up-down counter



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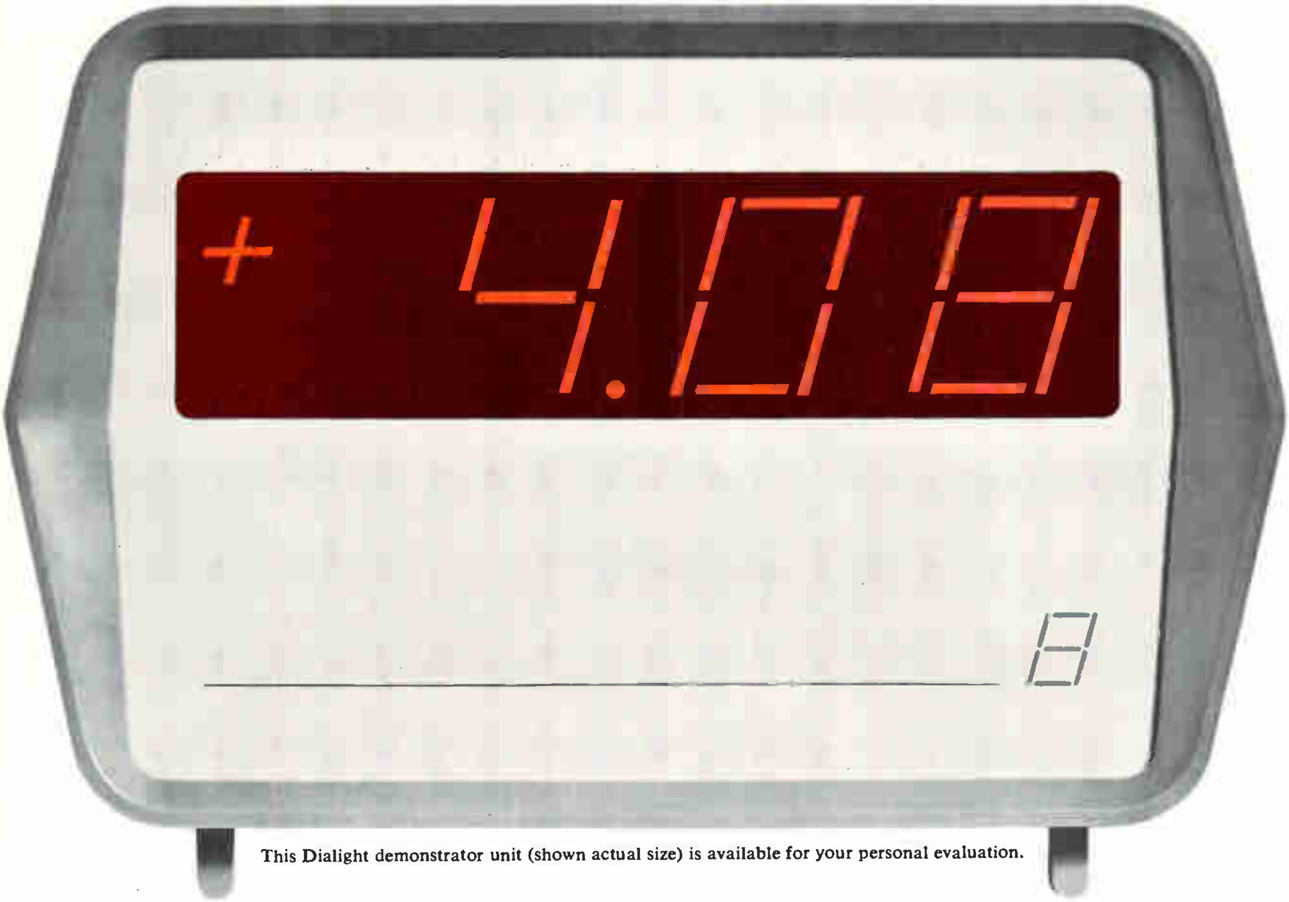

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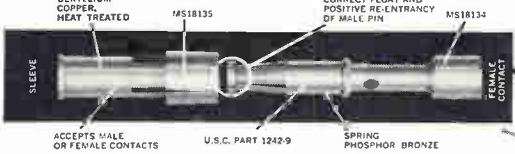

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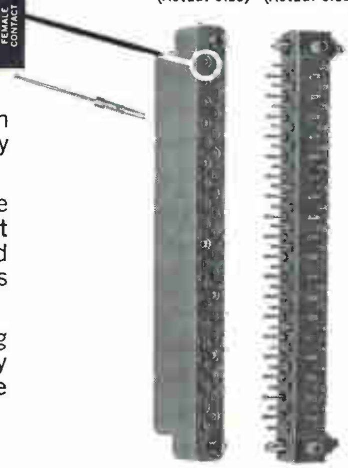

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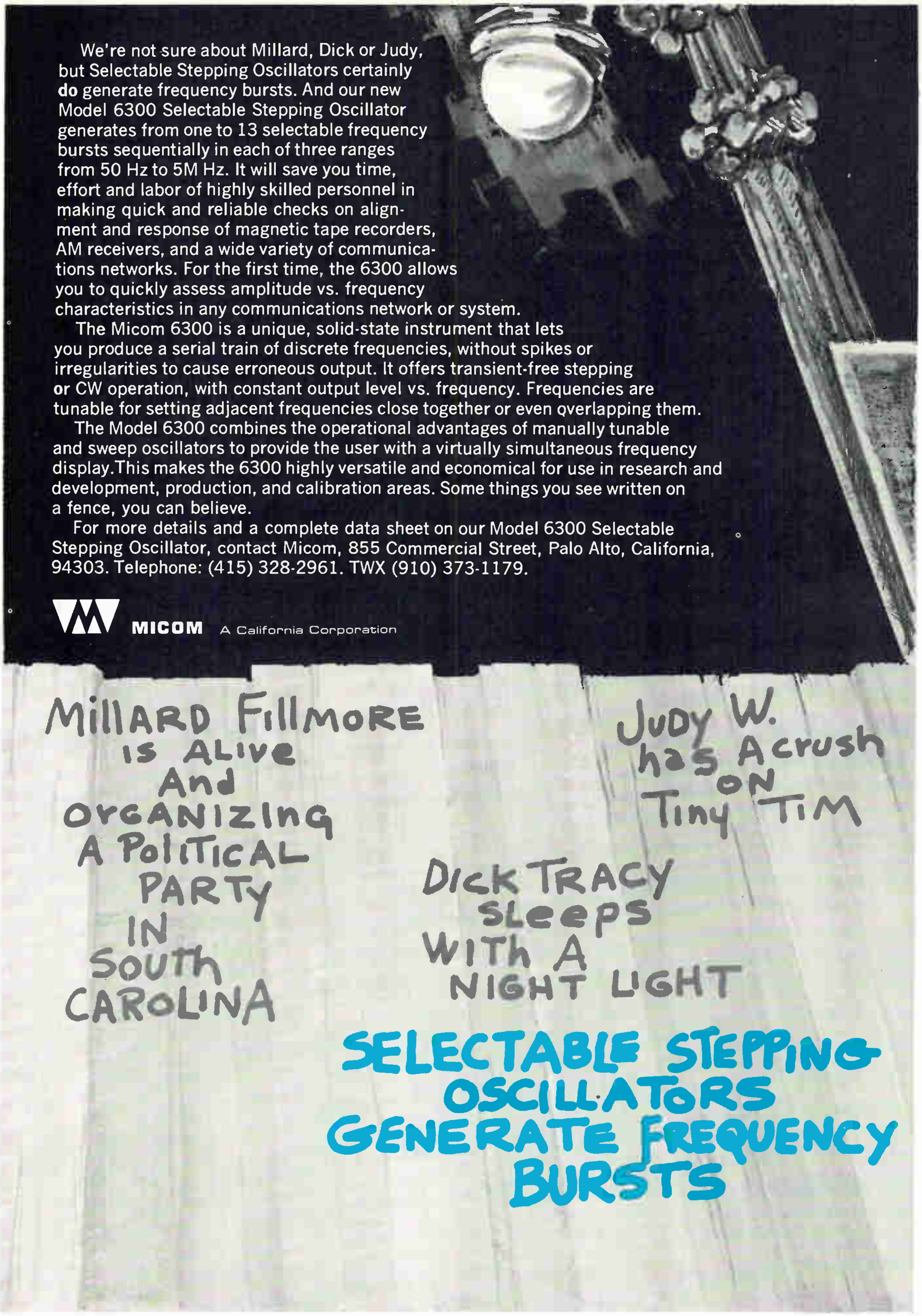

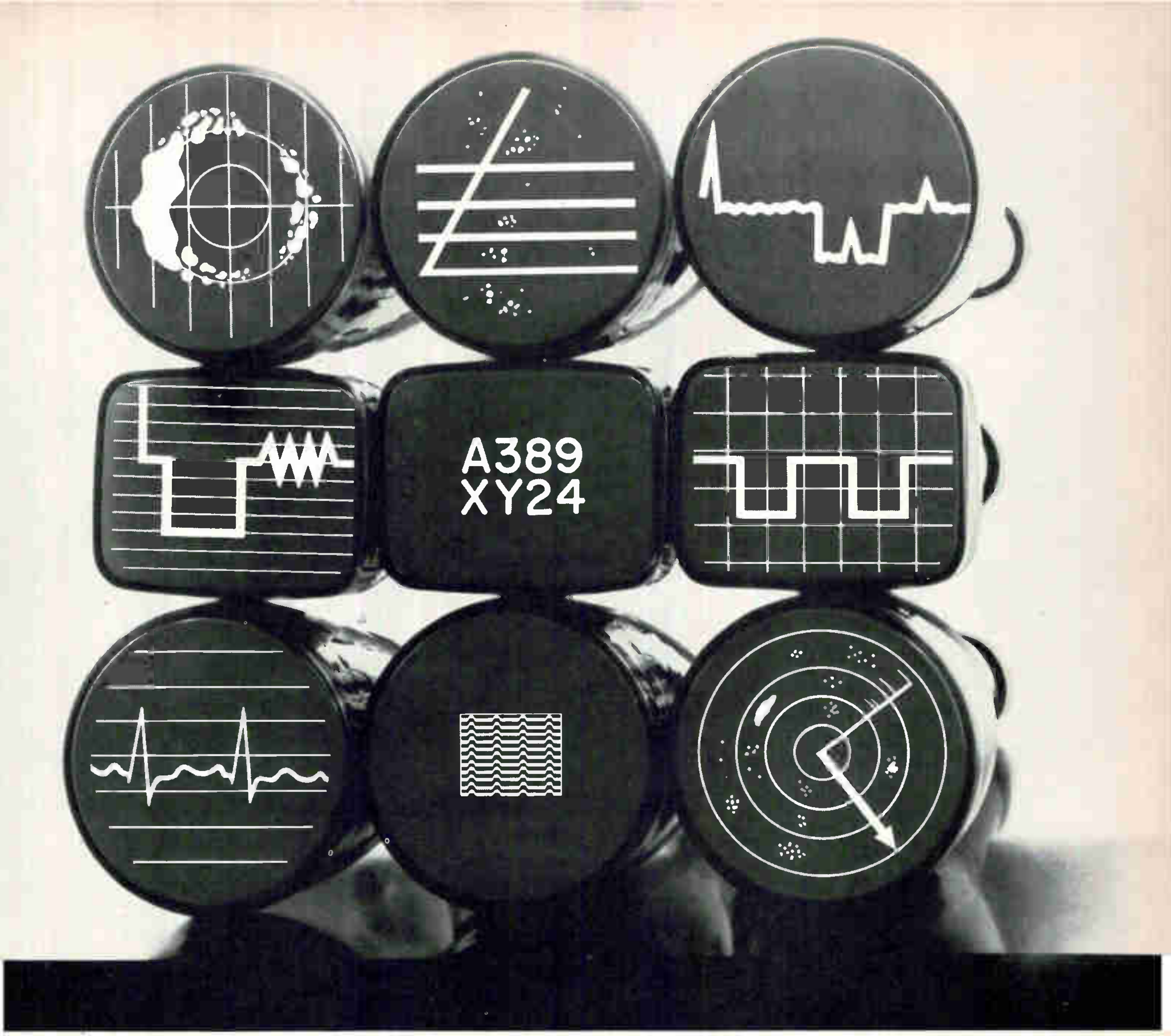

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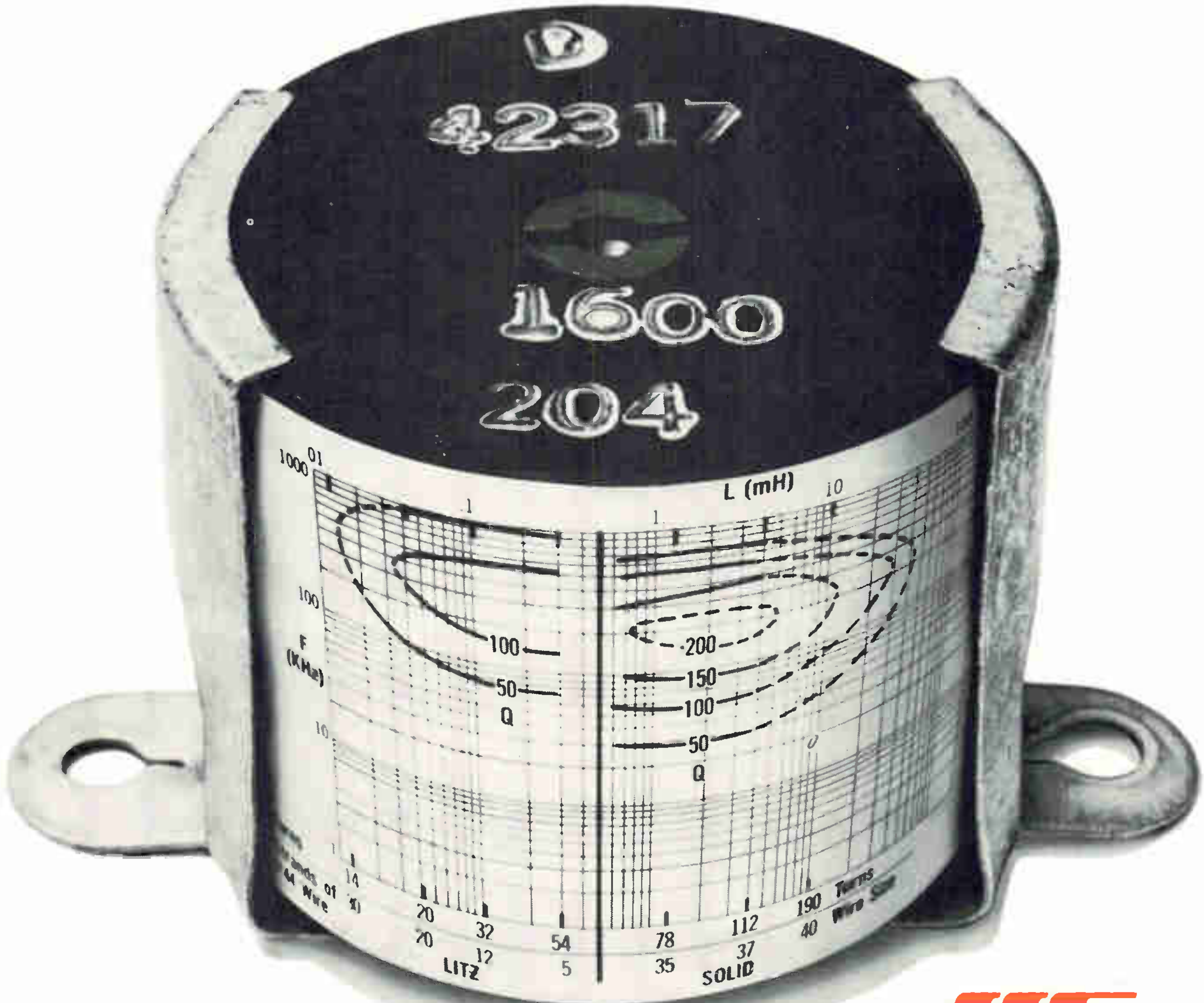

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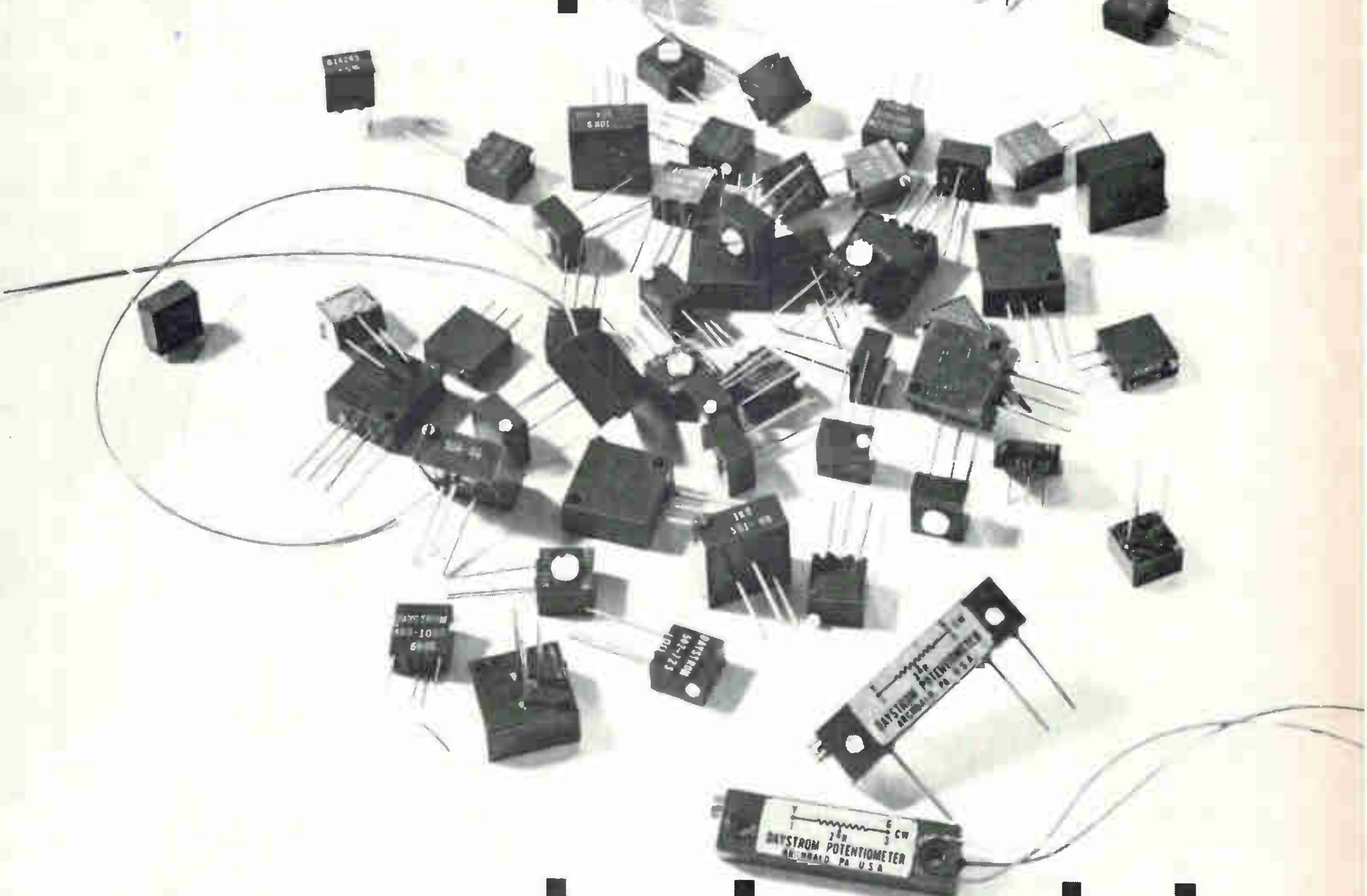
If you thought all Daystrom pots were squares



...look again!

Rectilinear components are still a necessary requirement in many circuit applications. That's why Weston has rounded out its high-performance potentiometer line with two new rectilinear models. RT-12 styles 534 and 535 are designed for both general-purpose and military applications. They feature the same ±5% tolerance, 10 ohm to 50K range, and slip clutch stop protection that are standard with Daystrom Squaretrim® units, plus 24-turn adjustability and humidity proofing. Also new this year . . . models 553 half-inch and 543 three-eighth-inch Squaretrim potentiometers in military and commercial versions. Save board space as well as money with our field proven 501 Series multi-turn and 504 Series single-turn 5/16" Squaretrims offering values to 20K in a 0.02 cubic inch case. All Squaretrim Diallyl-Phthalate cased pots give you Weston's patented "wire in the groove" construction and your choice of flexible leads, pin and screw configurations. Whether your trimmer needs are military, industrial or commercial, you'll find the answer in this complete new low-cost line. Write today for data sheets and evaluation samples. DAYSTROM potentiometers are another product of WESTON COMPONENTS DIV., Archbald, Pennsylvania 18403, Weston Instruments, Inc., a Schlumberger company

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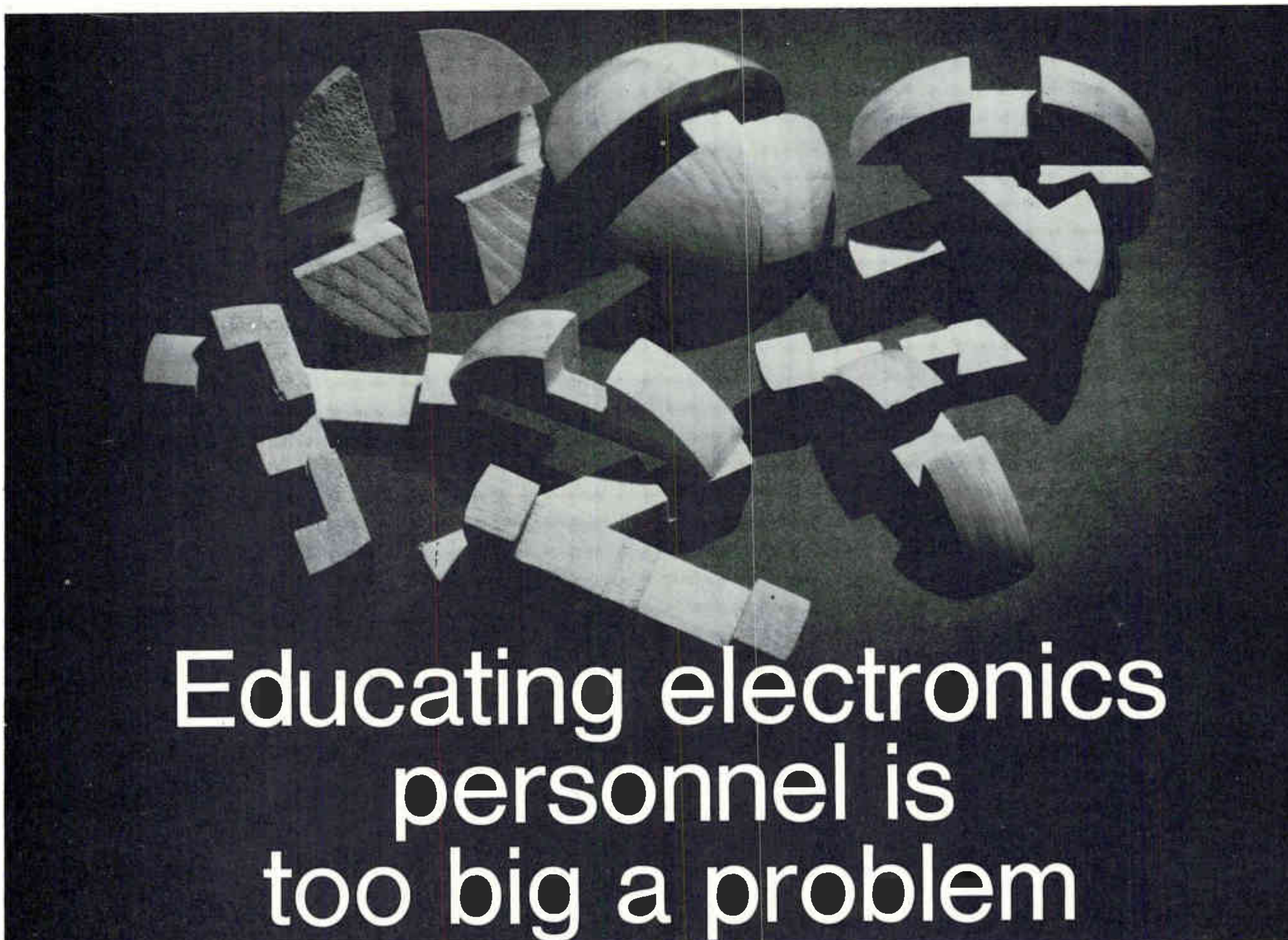

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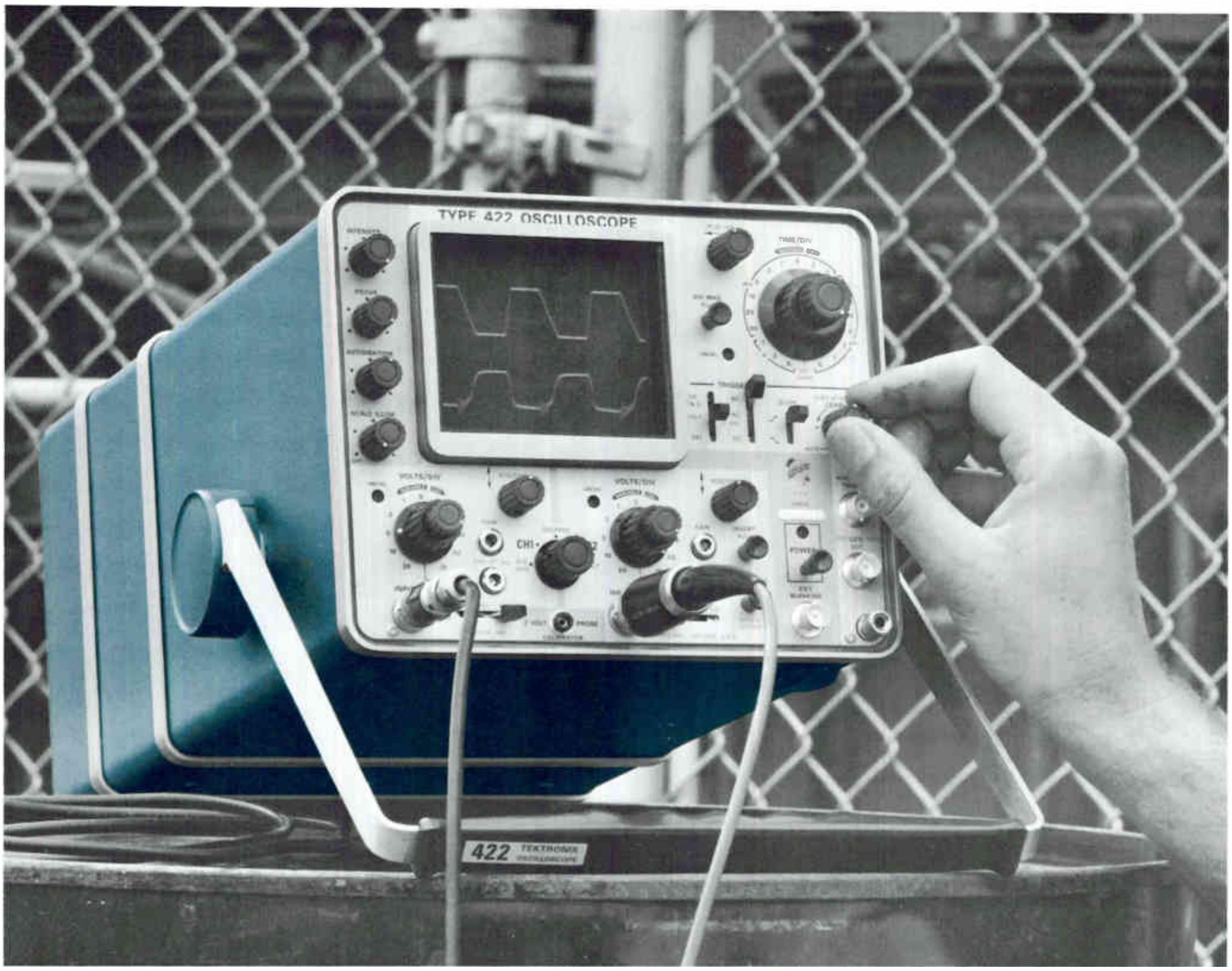
15-MHz, Dual-Trace Portable Oscilloscope



AC, DC or Battery Powered!

Your waveform measurements no longer need be compromised by adverse field conditions or the absence of a convenient power connection. The Tektronix Type 422 Portable Oscilloscope brings the precision of the laboratory "on site" to meet your measurement requirements.

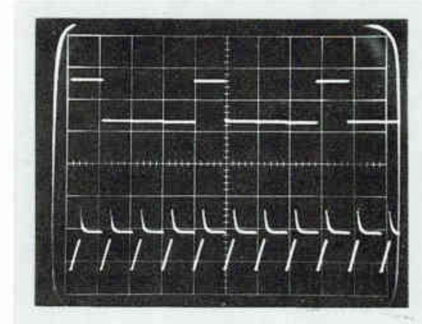
This compact, rugged oscilloscope combines small size and light weight with 15-MHz, dual-trace performance! Two models are available. One is powered from AC; the other from AC, DC, or internal rechargeable batteries. The AC version weighs less than 22 pounds including accessories and operates from 115 or 230 VAC ±10%, 45 to 440 Hz, 40 watts. The AC/DC version (MOD 125B) with built-in battery recharger weighs 30 pounds including accessories and batteries and operates from an internal 24-volt rechargeable battery pack; from 115 or 230 VAC ±20%, 45 to 440 Hz, 27 watts; or from 11.5 to 35 VDC, 23 watts.

please turn page for additional information

Making the Measurement . . . with the Tektronix Type 422 Portable Oscilloscope

PERFORMANCE

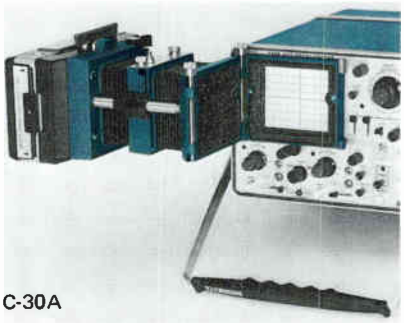
Dual vertical input amplifiers cover major use areas with 23-ns risetime and DC-to-15 MHz bandwidth over the 10 mV/div to 20 V/div deflection range. For observing low level signals, 1 mV/div deflection factor with 5-Hz to 5-MHz bandwidth is provided on Channel 2. Sweep rates are 0.5 s/div to 0.5 μs/div, extending to 50 ns/div with the X10 magnifier. Easy-to-use trigger logic provides stable triggering to above 15 MHz. A Tektronix 4-inch rectangular CRT presents sharp, bright displays on an 8 x 10 div viewing area (0.8 cm/div). A parallax-free, illuminated graticule contributes to accurate measurements. Two miniature 10X attenuator probes are included and are stored in the front panel protective cover.



Dual-trace performance of the Type 422 Portable Oscilloscope permits convenient waveform comparison.

RUGGED CONSTRUCTION

The Type 422 is ruggedly constructed to withstand shock, vibration and other extremes of environment. Electrical specifications are valid over an ambient temperature range of —15° C to +55° C (AC version), —15° C to +40° C (AC/DC version).



C-30A

200-2

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CAMERA . . . The C-30A, a compact, lightweight trace-recording camera, mounts directly to the Type 422 and provides photographic prints in 10 seconds.

SCOPE-MOBILE® CART . . . The Type 200-2 has an adjustable tray which friction-locks in any position from 0° to 60°.

PROBES . . . A full complement of voltage and current probes are available. Two P6012 10X miniature general-purpose probes are included as standard accessories. The P6019 current probe and 134 amplifier illustrated below permits 1 mA/div current measurements up to 15 MHz with the Type 422.

P6019/134

Your Tektronix Field Engineer will demonstrate the performance of the Type 422 Portable Oscilloscope in your application. Please call him, or write: Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005.

Type 422 Oscilloscope (AC version)	$1425
Type 422 MOD 125B Oscilloscope (AC/DC without batteries)	$1775
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P6019/134 Current Probe and Amplifier	$ 275
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Building a business in the ghetto spells Progress with a capital letter 'P'

Working in their spare time, managers from the General Electric Co. have helped set up a black-controlled aerospace firm in Philadelphia

By Peter J. Schuyten
Staff writer

The question was startlingly direct. It was put to Mark Morton, a General Electric vice president and general manager of the firm's Missile and Space division, last April during one of his regular breakfast meetings with the Rev. Leon Sullivan, a leader of Philadelphia's Negro community. For five years they had been getting together to plan job-training programs for the city's minority groups, but at this particular session, Sullivan broached the idea for a far broader effort. What, he asked, would GE do to help start an aerospace firm in Philadelphia's black ghetto.

The answer was quick and positive. So was the action.

The dream . . . Progress Aerospace Enterprises' prime movers are the Rev. Leon Sullivan, a leader of Philadelphia's Negro community; Mark Morton, GE vice president and general manager; and Ben Sallard, general manager of Progress.

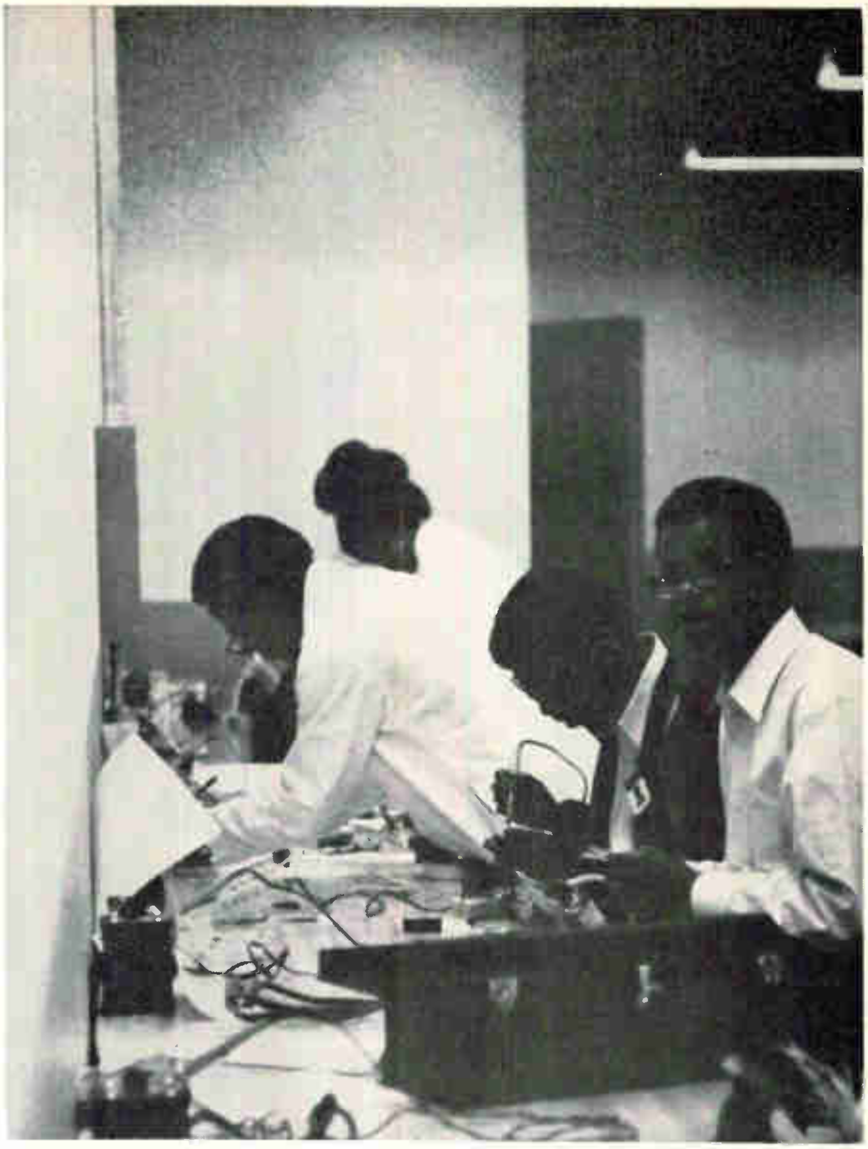
Fast start

In the words of another GE executive, Charles Dates, manager for reentry systems, "We were astonished by the rapidity with which things got moving. Morton said he would make people and skills available, and that's when we come in."

The result: Progress Aerospace Enterprises, a company with 94 employees and 39 trainees. Operating with GE subcontracts, it's doing work for the Air Force and NASA, work that includes the calibrating and checking of test equipment and the assembling of cables, harnesses, and consoles.

The initial GE contribution consisted of executives who volunteered to work with PAE. Says one: "It was just like the Army. Only here the volunteers were screened for prejudice." And there was precious little time for even the screening. Dates points out that "from that breakfast last April to the first delivery of hardware took less than six months. In that time procedures had to be established, a facility had to be located, and personnel had to be found and trained."

Nicholas Dragann, GE's special projects manager, worked with PAE general manager Ben Sallard to get things moving. He recalls: "Our initial task was to determine what



. . . becomes a reality. Some of Progress Aerospace's 90-plus employees. The Philadelphia firm, organized with the help of General Electric, does subcontract work for NASA and the Air Force. Some early work was completed ahead of schedule.

type of activity the new company should go after and then to figure out what type of work we could subcontract to them. After we set up a base for what the product should be, we had to figure out equipment, personnel, and facility needs—everything from walk-in ovens to where the ladies' room should be."

Because no one had ever done anything quite like this before, much of the planning had to be done on a trial-and-error basis. Says Dragann: "At first, PAE's managers, all of whom left secure jobs at GE, tried to do most of the work—like setting up procedures and devising job classifications—on their own. But they soon found they needed help and that's when we began taking a more active role."

Now GE's role is shrinking, and it will gradually phase itself out entirely. "Of course, since PAE is one of our vendors, we'll have to keep a close watch on their procedures, but then we do that with all our vendors and so does everyone else," observes Robert Norwood, finance manager of the reentry systems department.

Along with publicity and national attention, GE has received letters from other large aerospace contractors requesting information on the project. Such firms as Martin-Marietta, Boeing, North American Rockwell, Lockheed-Georgia, and Hughes Aircraft have all shown an

. . . No complaints yet from other GE vendors . . .

interest in the PAE concept.

Open door. There have been a few letters asking if PAE was an equal opportunity employer. It is; both blacks and whites work there.

One group that hasn't been heard from yet is GE's other vendors, from whose pie PAE is taking a slice. Says one GE spokesman, "There may be some opposition on the part of our vendors, but we haven't heard any complaints yet."

In its role as adviser to the new company, GE has discovered that most of the problems that have cropped up thus far are similar to those encountered when setting up, say, a new subsidiary or new division.

For instance, Edward Curtis, GE's manager of personnel relations and the man who wrote the new firm's job specifications, says, "We were keying PAE's personnel requirements to our own, so we left out certain jobs we shouldn't have, and other classifications had to be revised." Curtis' department is currently conducting a full review of all of PAE's requirements in order to anticipate future needs.

Not all the problems were that standard, though. For example, Curtis' department had geared PAE's salary scales to those of GE, without taking into account that along with, say, a $2 hourly rate, GE provides another 50 cents an hour in benefits that PAE couldn't afford to give.

Staying aboard

Among the pleasant surprises has been the low dropout rate from the PAE training program. Sallard has been drawing his technicians mainly from the hard-core unemployed. After receiving their initial two or three weeks of orientation and training at PAE, the trainees move on to advanced instruction at GE's facility in Valley Forge, Pa. PAE pays GE for this service. Final training for specific jobs is completed at PAE. "So far," says Dragann, "only two out of 60 people have left the program. We expected a much higher rate."

Most GE men feel that the PAE project has gone so well to date that within six months the new

'. . . All the jollies end in 2 or 3 months . . .'

company will be able to go it alone. "For the most part, we've accomplished our original goals on time," says Dates. "In some cases—in producing its first piece of hardware, for instance—PAE was even ahead of schedule." The next step, according to the timetable, is to get contracts from other firms in the aerospace industry.

Most of the GE personnel involved in the project feel that once PAE starts getting contracts from other aerospace vendors, something Sallard and his staff are working on right now, the fledgling firm will more or less be on its feet. "That'll be the ultimate satisfaction for most of us, seeing PAE performing completely on its own," says one of the GE people. "And maybe our wives will get to see a little bit more of us when that happens."

Damper. At least one GE manager, however, is guarded in his optimism. "We're stll on the honeymoon," he says. "The backslapping is still going on, and it's all a little removed from the hard realism of the aerospace business. But all the jollies will end in two or three months when PAE has to deliver its first hardware in quantity."

But when asked whether he thought the undertaking would succeed, this manager replied, "Of course it will, because we won't let it not succeed."

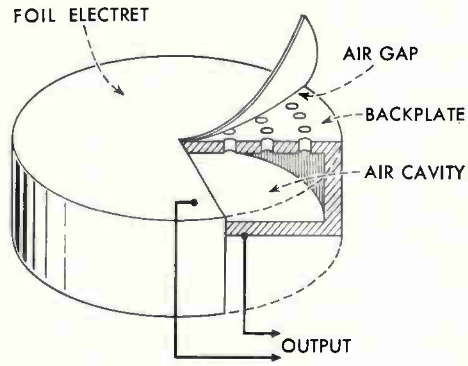
Indeed, its commitment to PAE's success is such that after all the fanfare, GE cannot afford to let the project fail. Dragann and his team will have to prepare Sallard and his staff for the hard realities of aerospace competition. And that may be the key to the ultimate success of PAE.

Quite naturally, because of PAE's early progress, Dragann and others are convinced that the project can be a prototype for future programs, the kind that the Nixon Administration says it intends to promote. "We've all been hearing about different approaches to socio-economic problems. This approach is one of the best any of us has seen yet and has perhaps the best chance to succeed," says the optimistic Dragann.

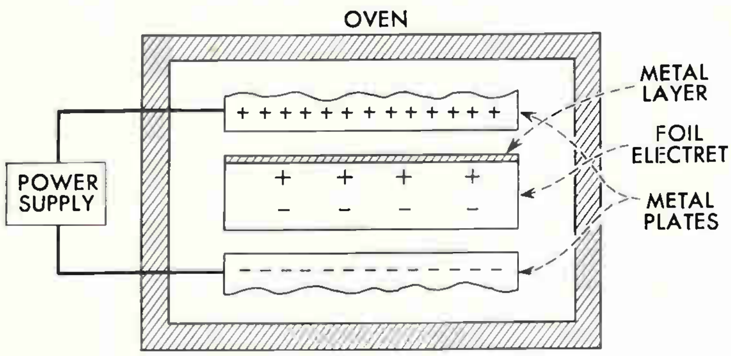
Report from

BELL LABORATORIES

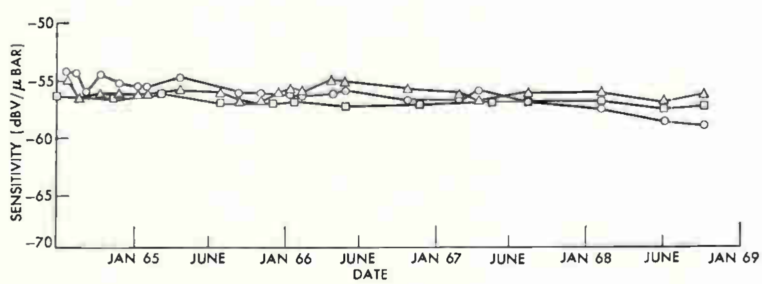
A simple, better microphone



Essentials of the new microphone: The microphone's diaphragm is a charged dielectric foil upon which a thin metal layer has been deposited; it is called a foil electret. The electret touches a metal backplate in several places and, due to surface irregularities, air pockets form between the electret and the backplate. The backplate is perforated so that the air layer can communicate with the larger cavity, increasing the vibration amplitude (and thus the sensitivity) of the system.



Simplified cross-sectional diagram showing how microphone "electrets"—permanently charged dielectric foils—are made. The metallized foil is heated to about 200°C while between a pair of charged metal plates which create an electrostatic field of between 10 and 100 kV/cm. Charges, identical in sign to the adjacent plates, migrate from the plates to the electret, where they remain after cooling. This method of foil electret preparation was announced by Bell Laboratories in 1962.



Sensitivity of electret microphones using fluorocarbon foils is nearly constant. Extrapolated lifetime is about 100 years.

A new kind of condenser microphone with several valuable features has been invented by Gerhard M. Sessler and James E. West of Bell Laboratories. It has the excellent sound fidelity of former types of condenser microphones, but does not need a d-c supply, and has much lower electrical impedance; this permits good low-frequency response without the need for special circuits.

Like previous designs, the new microphone depends on a varying capacitance —produced as sound vibrations impinge on one flexible plate of a capacitor. But there's a difference: here, the flexible plate is a "foil electret"—a thinly metallized sheet of fluorocarbon or polycarbonate. The electret contains a permanent static charge. As the electret moves, it varies the electrostatic field across the air gap (drawing). This produces a varying voltage at the output. Thus, the microphone needs no d-c supply.

In any capacitor, the thinner the dielectric, the higher the capacitance. Dielectric films can be made 0.00012 to 0.001 inch thick. So, the capacitance of the electret microphone is about triple that of conventional types of condenser microphones, and the impedance is comparably lower. This simplifies accompanying circuitry.

The microphone is inexpensive, exceptionally rugged, and immune to wide temperature fluctuations.

As the graph (left) shows, the microphone's sensitivity remains essentially constant for very long periods. This is due to an inherent compensation only possible with thin-film electrets: as the charge on the electret decays—and measurements indicate that it will take about 100 years to fall 50 percent—electrostatic attraction between electret and backplate is reduced. This diminishes the restoring force on the electret, allowing it to vibrate at greater amplitude. Electrical output remains, therefore, nearly constant.

As with all promising devices the electret microphone is being evaluated by our development and systems engineers. Because of its simple construction and low cost it may well find application in future telephones.

Bell Telephone Laboratories
Research and Development Unit of the Bell System

High stakes on Capitol Hill

By Robert Skole
Washington bureau manager

As the 91st Congress convenes this week, it not only will be facing crucial national and international issues—but on a more parochial level will have to find answers to some of the most ticklish and significant questions facing the electronics and aerospace industries. As a matter of fact, the 91st could have a greater influence on these industries than any Congress of recent years.

Adding a note of uncertainty to the outcome of those questions is the fact that this is the first time since 1824 that a new President's party does not control at least one House. Because of this, and because of the uncertainties of how the factions within the two parties will line up on crucial issues, predictions about the outcome on most questions must be cautious.

The significant issues—excluding Defense, the Vietnam War, and NASA (see Market Report, page 141)—range from the future of Comsat to the future of consumers, and from air pollution to air traffic. Almost every governmental agency or department is affected to one degree or another.

Moving. Atop a heap of questions concerning transportation is what to do about the supersonic transport. Federal Aviation Administrations officials are optimistic the Boeing Co. has worked all the bugs out of the fixed swept-wing design.

Boeing must submit its final design plans by Jan. 15. When accepted, the program will head into the more expensive prototype stage. Boeing and the FAA say that an appropriation of $300 million for fiscal 1970 will be necessary to meet the costs of the first year of this stage. This is roughly a 50% increase over annual costs during the design stage.

The SST may face a rough trip through a budget-minded Congress. Sen. William Proxmire (D., Wis.), who has been chairman of the Joint Economic Committee, has already urged President-elect Nixon to stop the SST spending. Proxmire suggests getting Uncle Sam out of the marketplace; he continually points out that President-elect Nixon has often urged that free enterprise should get a larger role in national policy-making. The Wisconsin Senator—one of the few in Congress who appears concerned over the SST's technical and noise problems that have yet to be solved—might possibly call for hearings this year on the question of how the aircraft's contract was handled. Although stepping down as chairman of the full committee, he will remain chairman of the subcommittee on economy in government. He would like to find out why Boeing got the contract on the basis of a swing-wing proposal, as opposed to Lockheed's fixed-wing design, and then dumped the swing-wing for the fixed version.

Adding to the speculation that the SST might be in for a rough flight are the pre-election Nixon statements that the plane could be one of the programs cut back if there is need for belt-tightening.

Stacked up

Another major aviation issue facing Congress is how to clear up the air traffic jams over busy terminals. The FAA, which will be getting a new administrator, will probably be taken over the coals for not pushing air traffic control systems with greater technical improvements. The FAA will also come under fire for its slow motion

How bills might fare

Here's a breakdown of electronics and aerospace issues facing the 91st Congress—which opens next week—that are likely to reach a vote.

- Revision of U.S. patent law, making it compatible with those of other industrialized nations.
- Funding of supersonic transport with $300 million in fiscal year 1970 to build prototype.
- Limiting overhead charges by companies and universities working on Federal R&D projects.
- Giving Food and Drug Administration regulatory powers over medical treatment devices.
- Establishing 20-man National Medical Devices Standards Commission.
- Providing Department of Commerce with $500,000 to study converting U.S. to metric system.
- Amending Comsat's charter, clarifying Comsat's right to build own satellites, and changing Comsat's board of directors.
- Appropriating a record high Defense budget, including start of design and production work on advanced manned strategic aircraft, airborne radar warning network, and new fighter aircraft.
- Increasing Department of Transportation research and development funds for rail propulsion systems, high-speed air cushion trains, linear induction motor test vehicle, ground traffic control.

. . . Legislators to hear demands to clean up . . .

in getting collision avoidance systems in operation.

On the ground, the two East Coast high-speed train demonstration projects will finally get into operation this year about a year and a half late, which is typical of the speed at which American railroads move. Once the systems are working—and if, indeed, they do work properly—Congress can be expected to be touched for more money.

The FAA can be expected to get about $37 million in fiscal 1970 for research and development—about the same it got for the current year. However, a system of aviation user charges might be allowed by Congress, which would make more money available for long-range research activities, such as new radar and beacon systems.

Pollution problems. Congress will be called on to provide both tax incentives for pollution abatement and Federal grants for solid waste disposal.

Although Congress will be placed under great pressure from industry to give tax breaks for firms installing equipment to reduce air and water pollution, there will be strong arguments raised by conservationists and liberals that taxpayers' money should not help big business clean up a situation it should never have created in the first place. One technical problem that would have to be overcome is how to determine whether equipment is strictly for pollution abatement. Another argument against the tax break is that such a program would discourage process changes and improved manufacturing methods that might result in less pollution. If the tax break were allowed, there would be a bigger market for electronic monitoring and control equipment.

Sen. Edmund Muskie (D., Me.) who is chairman of the air and water pollution subcommittee, will be getting much attention this year when he holds hearings on a bill to provide Federal grants to local governments for solid-waste disposal equipment. Muskie's fast rise to national eminence as Vice Presidential candidate will add much weight to this proposal. He unsuccessfully introduced a similar bill several years ago, and it called for an appropriation of $900,000. If Congress approves a new bill, it will eventually mean a good piece of business for electronic control and monitoring equipment.

There will probably be moves in Congress to create a single separate agency dealing with environmental control. Right now, the Air Pollution Control Administration is part of the Department of Health, Education and Welfare, while the Water Pollution Control Administration is part of the Interior Department.

President-elect Nixon has called for "coordinating" all Federal programs to eliminate "duplication and red tape." If water pollution control is moved back into HEW, this can make life a lot easier for systems salesmen.

However, manufacturers of electronic equipment might come under fire in this Congress in hearings by the House science, research, and development subcommittee, headed by Rep. Emilio Q. Daddario (D., Conn.), and the air and water pollution subcommittee, headed by Sen. Muskie. The hearings will take a look at ways to assess the environmental impact of new products before the products are introduced on the market. Although the hearings will primarily touch on air and water pollutants, there is a good likelihood that the subcommittees will look at radiation-emitting products, such as microwave ovens, radars, and color television receivers.

Comsat up in the air

Since 1962, when the act establishing Comsat was passed, the company has never been in a greater state of flux. First, the President's Task Force on Communications is reporting suggestions, which, if implemented, would change most elements of the corporation's way of doing business. Second, negotiations will open in February, for the long-awaited permanent arrangements for the International Telecommunications Satellite Consortium (Intelsat). The negotiations may last a year.

There is sure to be at least one bill affecting Comsat submitted to Congress in the early days of this ses-

. . . Can the carriers clip Comsat's wings? . . .

sion. The bill would permit the company to change its "mix" (or ratio) of public and carrier board members. The bill was prompted by the sale by International Telephone and Telegraph Co. of 316,000 shares of Comsat stock in June, and another 400,000 shares in December.

ITT announced it was unhappy with Comsat's aggressive efforts to gain more responsibilities for providing international communications services. The bill, to be introduced by Sen. John Pastore, (D., R.I.), would allow the board of directors to better reflect share ownership. The big issue behind the bill is whether ITT and other carriers will be able to cut Comsat down to size by changing the entire charter.

Comsat was originally conceived as a "carrier's carrier"—a wholesaler of raw transmission services. But the company has assumed other functions: the Federal Communications Commission, for example, has temporarily sanctioned ownership by Comsat of 50% of ground terminals. Also, Comsat would like to sell services—"retail" directly to users of communications services—thus cutting out the existing carriers. As it looks now, the carriers will be pushing hard to get Congress to clip Comsat's wings.

The Task Force Report, however, proposes that Comsat would assume all international transmission facilities of all carriers—cable, radio, and satellite. This would mean taking over the facilities of ITT, RCA International, Western Union International, and the voice circuits of AT&T. It also proposes that Comsat should build the "pilot" domestic satellite system—but be barred from owning the eventual operational domestic system. The report also proposed that Comsat should be barred from owning either domestic transmission facilities of any kind, or satellite production facilities. Its research and development facilities should examine only broad technical issues.

All these points in the report will probably get before Congress in the debate over Pastore's controversial bill.

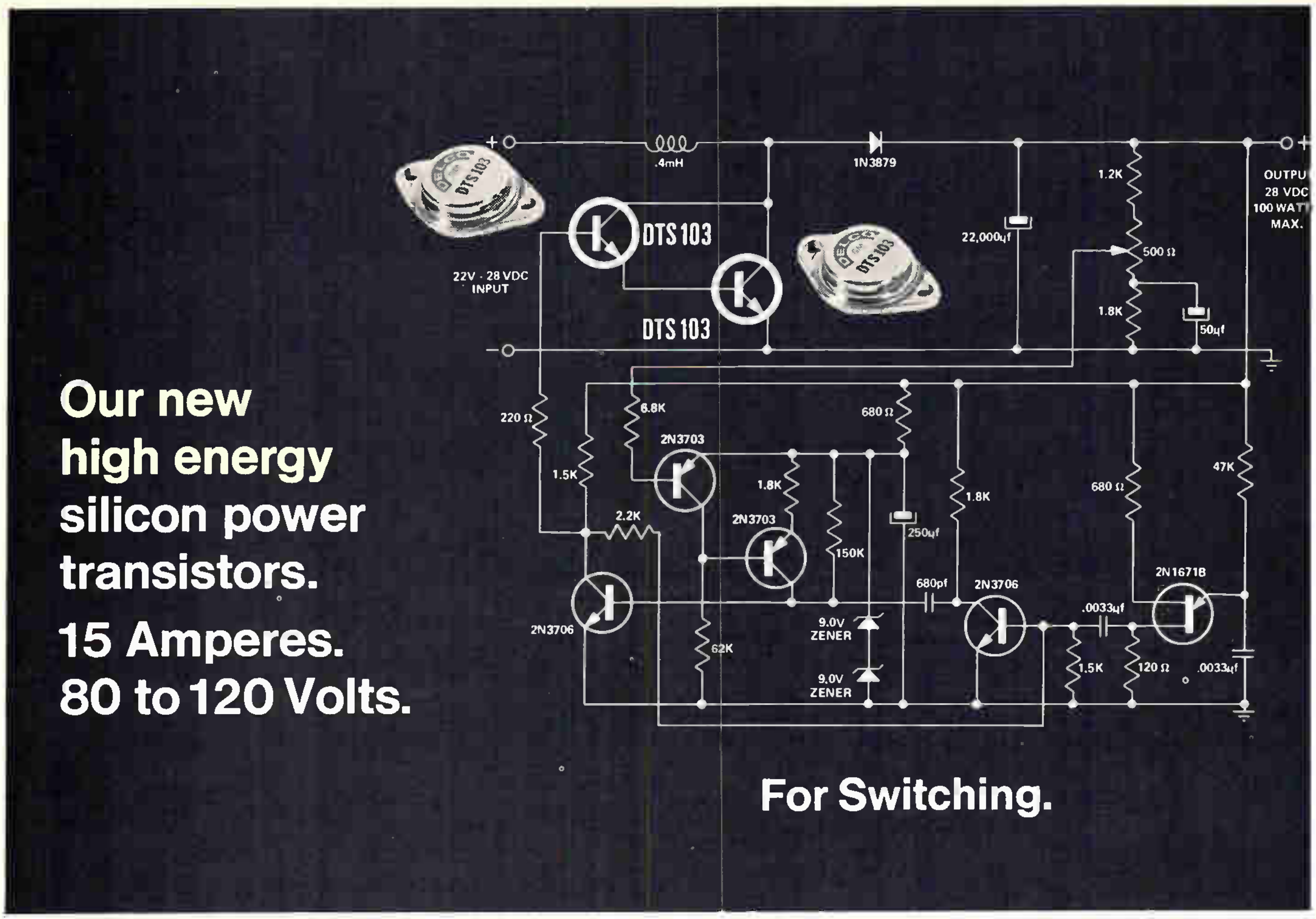
Consumerism. The 91st Congress, like the 90th, will undoubtedly be faced with a long list of consumer-protection bills. Although few Republican presidents have won any laurels for their efforts to police business and industry, Nixon will probably take a "liberal" attitude toward consumer-protection—for the sake of some harmony with Congress, if for no other reason.

One of the major bills that Congress will probably act on will be a comprehensive measure covering guarantees and product servicing. The proposed legislation will emerge from the Senate Commerce Committee—which is chaired by Sen. Warren Magnuson (D., Wash.), who used as one of his campaign slogans during this past election, "Keep the big boys honest." The legislation will be the result of what President Johnson calls for in his State of the Union message; what his consumer-adviser Betty Furness recommends in her special report on guarantees; the outcome of hearings by Sen. Philip Hart (D., Mich.) on auto repairs, and the Federal Trade Commission's investigation of auto warranties.

The bill that eventually emerges will have a significant effect on the consumer electronics business, particularly the design of new products. If manufacturers are forced to really live up to their guarantees—and provide service as contracted for by the purchaser—there obviously will be a demand for designers to turn out products that not only are more reliable, but also are easier to service. Some television receiver manufacturers already emphasize serviceability in their advertising.

In another consumer-protection area, there might be some moves in this Congress to toughen the Radiation-Protection Law, which squeaked through the 90th Congress. Sen. Ralph Yarborough (D., Tex.), chairman of the labor subcommittee, was most unhappy that the bill did not provide for protection of workers using radiation-emitting equipment.

And the Food and Drug Administration will try again to gain regulatory power over medical devices.



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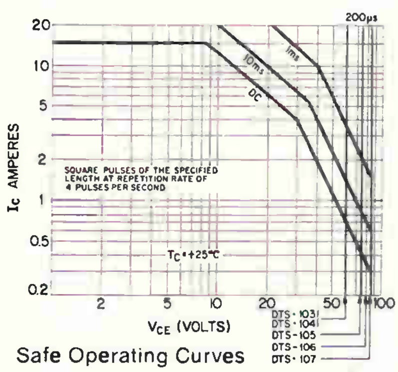

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In the direct coupled audio amplifier above right, the DTS-107 displays the excellent frequency response, gain linearity and transconductance of this family. This circuit is covered in our application note No. 43.

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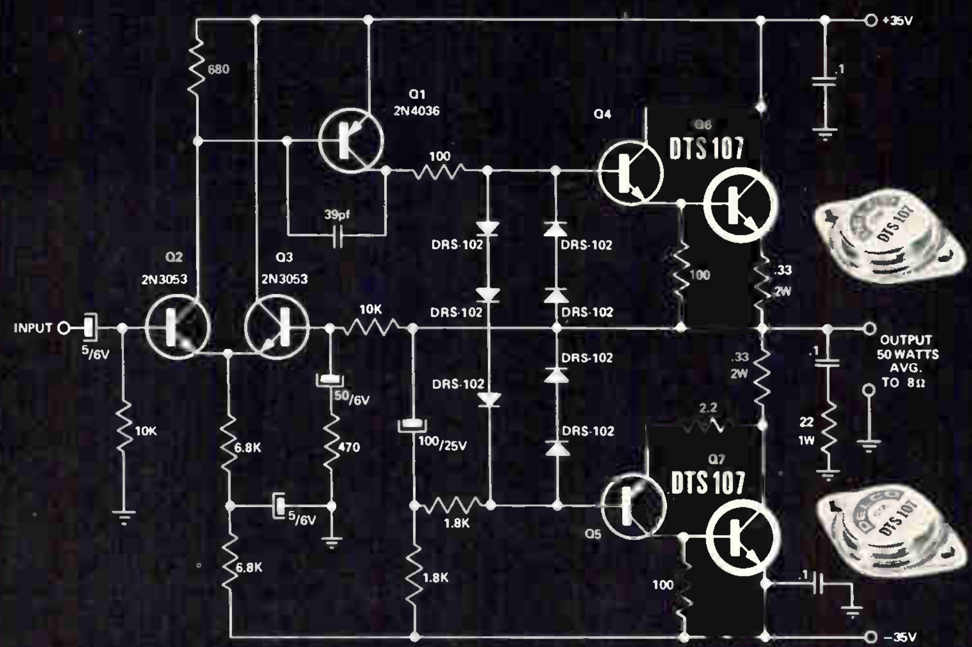

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DTS-103	15	20	80	60	60	20-55	5	1.8	4	125
DTS-104	15	20	80	60	60	50-120	10	1.5	4	125
DTS-105	15	20	100	80	75	20-55	5	1.8	4	125
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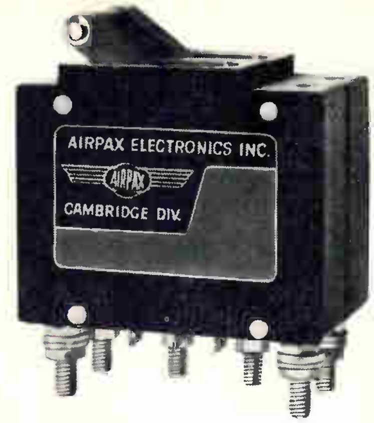
Circle 177 on reader service card

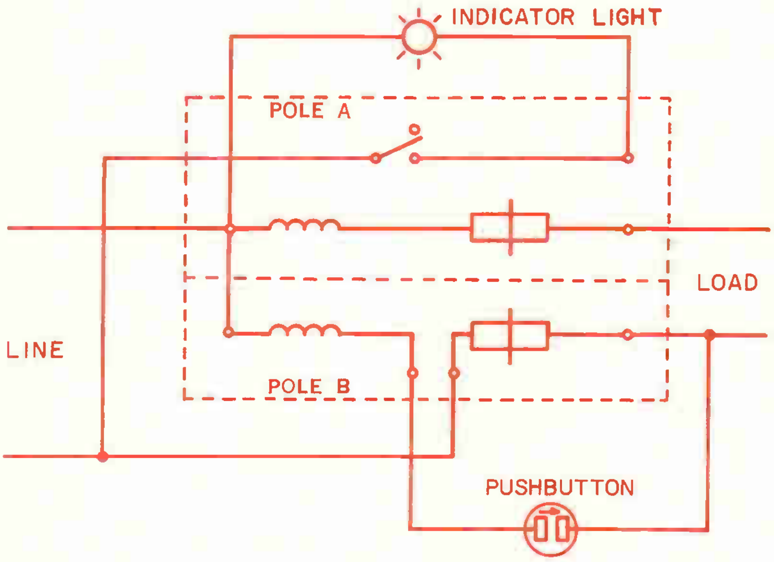
DUMP CIRCUITS

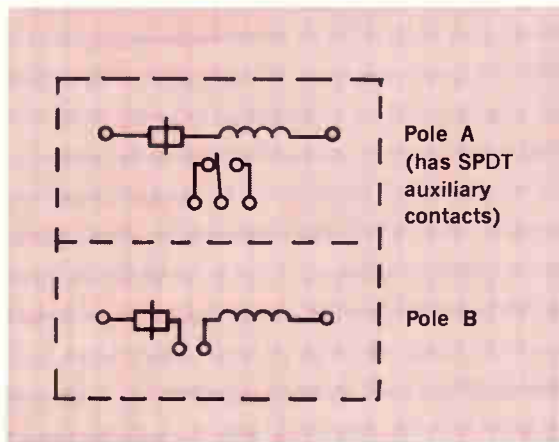


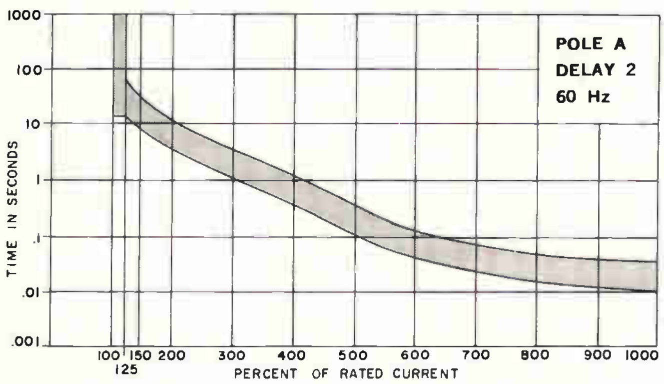
APL MAGNETIC CIRCUIT BREAKER
Double Pole with auxiliary signal contacts

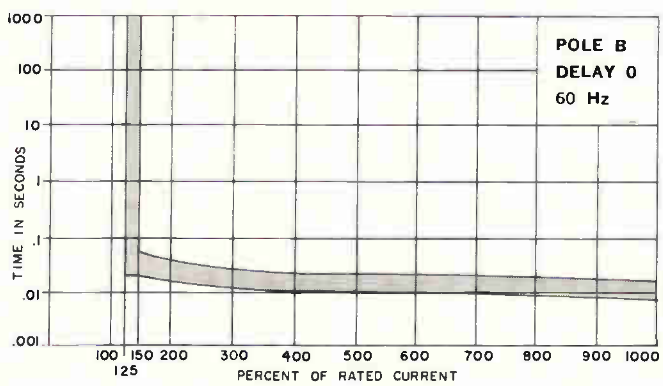
Magnetic circuit breakers lend themselves to SCRAM circuits, panic button circuits, or any such application where it is desired to quickly and reliably remove the load from the power source.

APL type breakers can be had with standard 50 ma AC coils which have about 420 ohms impedance. Operated directly from 115 volts AC the coil current of Pole B will reach 275 ma for a few milliseconds. (Pole A is in the other side of the line and provides time delayed protection against overloads.) Somewhat lower pushbutton currents can be obtained, if necessary, by the use of circuit breakers with impedances up to 11K ohms. These would be non-standard, but our non-standard costs are modest indeed.









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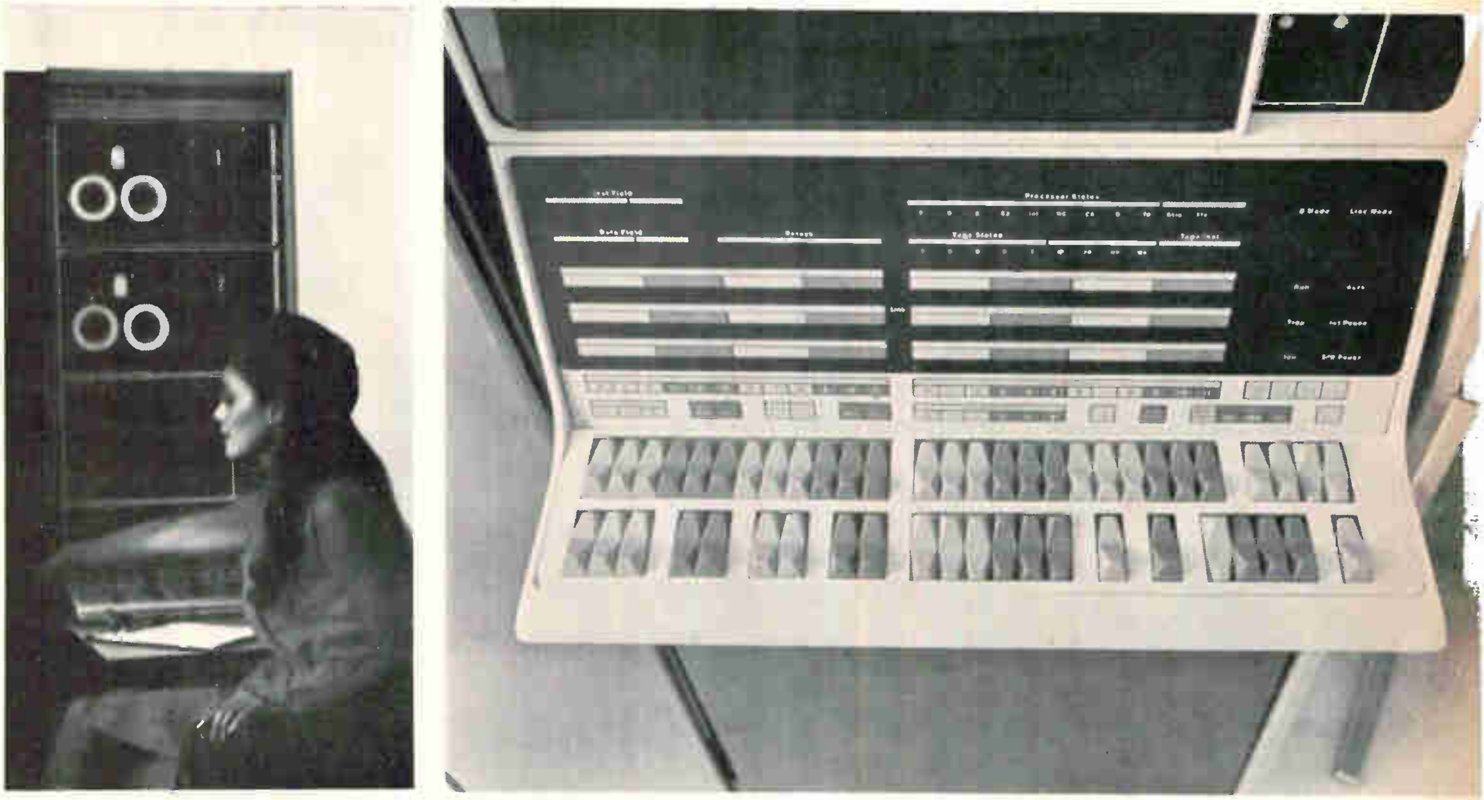
At last—a computer with a heart

"Less impersonal" machine patiently guides even a novice user along; it reprograms itself, is easy to talk to, and does its processing in real time



Family resemblance. Operator console combines features of PDP and LINC series. The upper banks of switches are for loading instructions and data manually; those below are for executing special functions.

Four summers ago, a few dozen biologists, biochemists, and other experimenters in the life sciences went to MIT for six weeks to get acquainted with a special new computer—one they could become as familiar with as they were with the microscope.

The machine, called LINC for Laboratory Instrument Computer and developed with Government funds, was designed to be easy to talk to and work along with, even for a novice.

The Digital Equipment Corp. decided to develop the machine further and market it, and this developmental work evolved along a path paralleling that of DEC's more powerful PDP-8. This week, DEC announces the PDP-12, which combines the analytic capabilities of the PDP-8/I and the interactive characteristics of the LINC-8. The company is aiming at markets where dialogue with an unskilled user is crucial, such as hospital information systems, computer-aided design, and inventory control.

Electronic tutor. "The PDP-12 is designed to lower the barriers between men and computers—to make the computer less impersonal and more of an electronic aide-de-camp, technician, or tutor," says Edward A. Kramer, PDP-12 marketing manager.

But DEC also has another goal in mind: cutting into the time-shared computer market. Says Kramer: "The price of the PDP-12 is low enough to compete with consoles in many time-sharing applications, and there is the additional advantage of always having an open port—time-shared computers haven't proven to be as readily shareable as many users had expected. We hope to sell to people who would like to trade their position in a queue for some stand-alone computation.

"PDP-12's spotted around a plant may be more economical and flexible than a large time-shared computer plus its peripheral consoles." Kramer adds that spotting com-

. . . heavy emphasis on graphics and dialogue makes things easier for unskilled user . . .

puter power where it's needed eliminates the cost of cable connections.

Very like a hybrid

First deliveries of the new machine will be in late February or early March. The most powerful and most comprehensive PDP-12 will sell for $27,900, down from $38,500 for the LINC-8.

Despite the price cut, DEC says, the buyer gets more computer. "The usefulness per dollar ratio is about double that of the LINC-8," according to Richard J. Clayton, PDP-12 product line manager.

He also points out the user needn't buy more than he wants. Although the model A has hardwired options, models B and C are available with fewer items of peripheral equipment.

The model C includes only memory, central processor, teletypewriter, sense switches, index registers, and enclosure and sells for just $14,900; tape, cathode-ray tube display, analog-to-digital conversion gear, and the like can be added as desired.

The PDP-12 replaces the LINC-8 and includes its heavy emphasis on graphics, its ability—almost like that of a hybrid computer—to manipulate data and experimental conditions in real time, and its capacity for question-and-answer dialogue with the user.

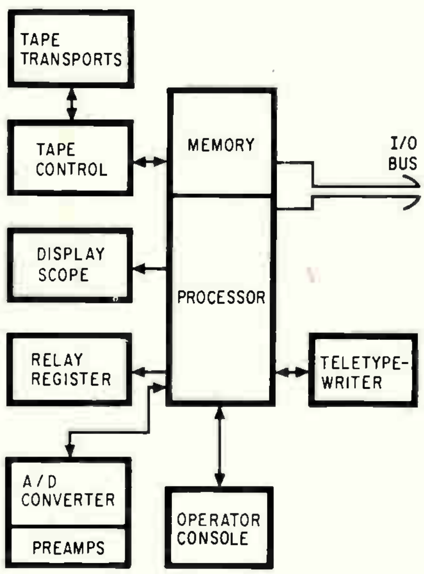
New architecture. The PDP-12 is a 12-bit machine and can use software that's been written for either the LINC-8 or PDP-8/I; this totals about 400 programs that are already debugged. DEC thus expects the PDP-12 to have immediate applications far beyond those of the LINC's, which were designed to aid biomedical experimentation and research.

Although the PDP-12 has most of the characteristics of the LINC's, it uses a new architecture much like that of the PDP-8/1, says Clayton. "This architecture requires about 10% more hardware than used in the PDP-8/I to enable the computer to obey both PDP-8/I and LINC-8 instruction sets." The processor can thus operate in either LINC or PDP-8/I mode on user or program command.

The machine has a standard 2,096-word core memory with a 1.6-microsecond cycle time. This makes possible 312,400 additions per second. Multiplication, which takes about 9 microseconds, is built into the machine and needn't be programed, as it was in the PDP-8.

Display logic can fill the 11-inch (diagonal) crt display with 400 alphanumeric characters—without flicker, DEC says—or 1,000 points of graphic data. The display is refreshed from the core memory.

Following orders. Clayton notes that most characters can be defined with only 6 bits. Character words, therefore, are stacked; characters are stored in the first six and last six bits of a core-word location. "To generate a character, the processor selects between the first half or second half of a word as it's read out of core," says Clayton. "This makes for more efficient use of memory. The PDP-12 can manipulate such six-bit bytes directly."



Flexible. System organization permits processor to execute programs with PDP-8 or LINC coding, or both.

Processor architecture also is more economical in its use of core. The LINC-8 computed in either a LINC or PDP-8 type processor, and the encoding and decoding needed to move a problem from one processor into the other and out again used up about a fourth of the LINC-8's 4,096 words of core. With the PDP-12's "unified dual mode processing system," these kilobits of memory are freed, and program assembly proceeds whether the program is in LINC-8 or PDP-8 order codes.

Morton E. Ruderman, manager of biomedical marketing at DEC, says the new machine will be easy for unskilled users to work with mainly because it has "the most powerful order code of any 12-bit computer, and one more powerful than those of many 16- and 18-bit machines." The PDP-12 has 43 basic orders, and the variations on them can add up to instructions numbering in the hundreds, Ruderman says.

Name and number. As the machine is turned on, the crt lights up with the query "Execute program?" The answer will be the name and number of the tape-sorted program, which the user can type into the machine from the teletypwriter. If the user doesn't know the program designation he can request a display of the names of those available by asking for the "library list."

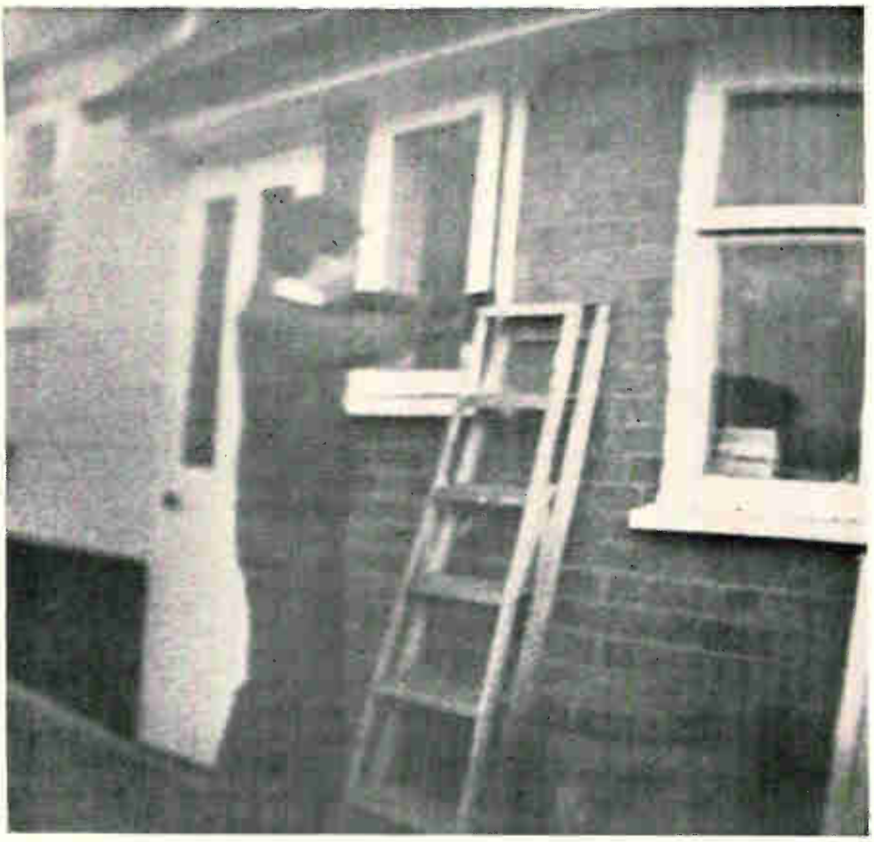
After the computer finds the program, it transfers the tape to the core memory and starts work. Relays and data converters are built in; the 16-channel a-d converter has eight channels equipped with level-setting potentiometers, which can be used for manual programing or control of parameter inputs. It's possible, for example, to call up a cursor and use one of the knobs to help trace a waveshape or graph displayed on the crt. At the same time, the display can be made to show the numerical value of any point on the displayed curve.

The PDP-12 is built with TTL monolithic integrated circuit logic modules. It is self-contained, requiring no special power sources. Internal power supplies develop all needed operating levels from 115-volt, 60-hertz single-phase line power at 20 amperes. Other voltages and frequencies are available.

Digital Equipment Corp., 146 Main St., Maynard, Mass. 01754 [338]

Isocons make their move

After 20 years as a lab curiosity, tv image tubes that can see in the dark appear on the market



No privacy for the workingman. Since the isocon responds to as little as 10^{-6} foot-candles, it can be used in tv cameras that keep watch at night.

A star twinkling in the sky and a crook breaking into a house are both low-level performers. The star—because it's far away—and the crook—because he prefers working at night—send out light that is too weak to be picked up by conventional tv cameras. But now both of these reluctant performers may find themselves appearing more and more on tv screens.

The reason is the rebirth of the isocon, an extremely sensitive image tube. Truman was president when the first isocon was built by P.K. Weimer at RCA. But about the same time that the isocon appeared, another image tube, the orthicon, was also being developed.

The tubes look alike and, to a point, work in the same way. In both, a beam of electrons is bounced off a glass membrane, and in both the reflected beam contains information about the scene being televised. But in the orthicon, the reflected beam goes straight to a photomultiplier; in the isocon, the beam is split into two components, and only one component goes to the multiplier.

Engineers found the orthicon much easier and cheaper to build. So despite being able to work at much lower light levels, the isocon stayed on the lab bench while the

... the brighter the scene, the higher the charge ...

orthicon went into tv cameras.

Over the years engineers have refined and modified the orthicon, but the tube could never be made to detect illumination levels less than a few foot-candles. So interest turned back to the isocon.

In the last few months RCA has started selling "developmental type" isocons. Also, the English Electric Valve Co. has introduced two models.

Angling in. Both orthicons and isocons gather light from the scene to be televised and focus the light on a photocathode. The electrons generated are collected on a thin glass membrane, the target. Secondary electrons come off the target and are collected on a positively charged mesh between the photocathode and the target. This results in the target being positively charged; the brighter the portion of the scene associated with a given section of the target, the higher the charge at that section of the target.

At the other end of the tube, be it orthicon or isocon, is an electron gun. A magnetic field sweeps the gun's beam over the back surface of the target. Some electrons in the beam hit the target and neutralize some of its charge; others, the scattered electrons, bounce off the target, while others are repelled before they get there. The scattered and the repelled electrons form a beam that travels back towards the gun.

Here's where the difference is. In the orthicon, the beam from the gun approaches the target perpendicularly, and both the scattered and the repelled electrons return along the same narrow-diameter path. At the end of the tube a photomultiplier collects them and generates an output signal.

So the orthicon modulates negatively—maximum input to the multiplier corresponds to dark areas of the scene. Besides, the lower the light level, the higher the noise.

In the isocon, a magnetic field bends the beam so it approaches the target at an angle. The repelled electrons come back along a narrow path, but the scattered electrons spread out and return over

. . . X-rays can be taken with less radiation . . .

a much wider road.

In front of the multiplier is an aperture-electrode system that separates the scattered from the repelled electrons, and feeds the scattered electrons into the multiplier.

Modulation is positive, and noise decreases as the light level goes down.

Logging in. The bending and separating systems push isocon prices to two or three times those of orthicons. The RCA tubes cost from $1,500 to $6,000, and focusing and alignment assemblies add $800 to $2,500.

But the money buys a tube that can almost see in the dark. For example, one RCA isocon, the C21095, has a log-log plot of output versus illumination that goes linearly from 0.02 microamp to 2.0 μamps when illumination goes from 2×10^{-5} to 2×10^{-3} ft-c.

English Electric offers two models, the P850 for $4,700 and the shorter, less-sensitive P880 for $4,200. The tubes are being sold in the U.S. by the Visual Electronics Corp.

The log-log output curve of the P880 linearly goes from 0.001 amp to 4.0 amps when illumination goes from 10^{-6} to 2×10^{-3} ft-c.

Both RCA and English Electric expect that the isocon will be used in night reconnaissance systems, particularly in aircraft. The British tube was developed for military systems, and there has been much classified work done with isocons by the U.S. Army.

Another application is night security systems for banks, factories, and similar institutions.

Doctors and radiologists may also find use for the tubes since their high sensitivity allows X-rays to be taken with much lower doses of radiation.

Astronomers are also working with the isocon; the British model is being tested on telescopes at the Royal Observatory in Herstmonceux.

RCA, Camera Tube Marketing, Lancaster, Pa. [339]

Visual Electronics Corp. 356 W. 40th St., New York, N.Y. 10018 [340]

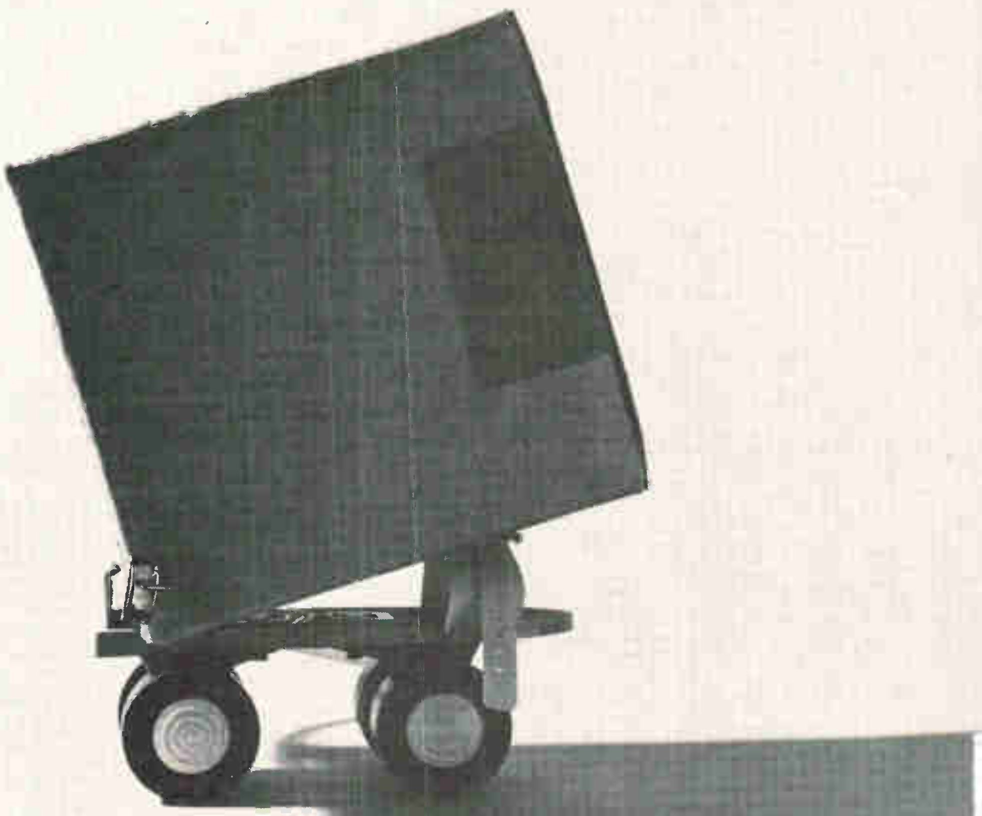
Meet a new kind of T^{2}L. It's twice as fast.

Introducing Ray III. The fastest TTL on the market. Samples available now.

Ray III halves the best T^{2}L speed-power product you previously could get. It has a 5½ nanosecond maximum propagation delay with only 22 mW dissipation per gate. Where older T^{2}L flip flop frequencies reach about 50 MHz, Ray III hits 100 MHz. It's pin- and function-compatible with Ray I and Ray II, our standard T^{2}L series. And we've added clamp diodes to all gates and active pull-down networks to improve noise immunity.

By April our distributors will be stocking 19 logic functions: expanders, inverters, gates, flip flops. All available in commercial or mil-type temperature ranges, in flatpacks and DIP cases. And by mid year we'll be producing even more functions as well as Ray III MSI. Send for data sheets, designer's handbook and list of distributors from the company that gets the ideas—and delivers them.

RAYTHEON



Samples available from distributors:
RG 3220/3222 Quad 2-Input NAND Gate. RF 3200/3202 AND-Input JK Flip Flop. RF 3210/3212 OR-Input JK Flip Flop.

New microwave products

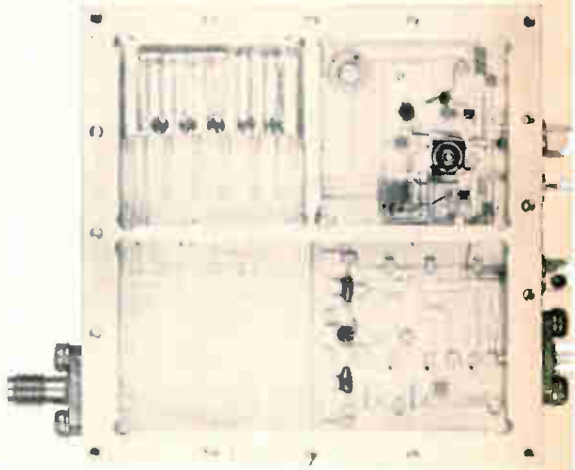
IC produces i-f on the spot

Inputs from 1,435 to 1,535 Mhz are knocked down by a 5-ounce converter with a drain of only 2 watts

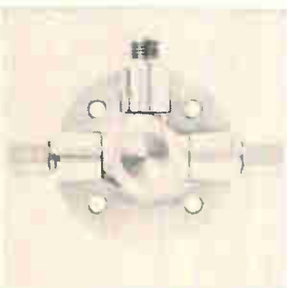
Missionaries aren't the only ones looking for a way to make on-the-spot conversions. Engineers at Varian Associates' LEL division have been looking, too, and now they think they've found a way.

The conversion these engineers want is from r-f to i-f. Their integrated-circuit converter takes up only 2½ cubic inches and weighs 5 ounces, so it's small and light enough to be packed with small microwave antennas, such as the dipoles in phased-array radars. Because a receiver that down-converts at the antenna has only i-f signals flowing in it, it's less susceptible to interference.

The device's size and weight also make it a good bet to appear in air-



Down, then out. R-f input is converted and amplified in IC's lower half. Upper part has the oscillator.



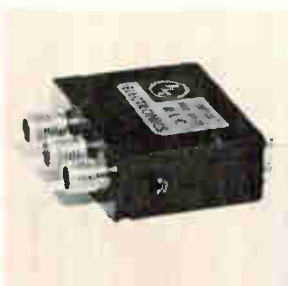
Coaxial power divider DA-C36 is for use from d-c to 10 Ghz. An integral panel permits it to be fastened securely to any standard chassis or any other similar flat surface. The divider has a nominal resistive loss of 3 db, with output symmetry of 0.2 db max. Vswr in any arm is below 1.35 over the full frequency range. Microlab/FXR, Microlab Road, Livingston, N.J. [401]

Integrated mixer model MWT-9375 employs three-arm branch hybrid design that saves weight and space. The device operates at a center frequency of 9,375 Mhz with a 10% bandwidth. Input vswr is 1.50 to 1 maximum and input to local-oscillator isolation is 15 db. Maximum noise figure is 7.5 db with a 1.5 db i-f. Raytheon Co., 152 Floral Ave., Murray Hill, N.J. 07974. [402]

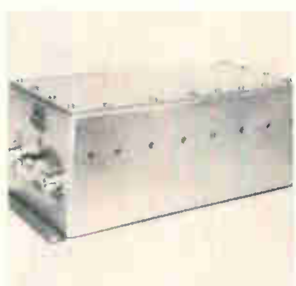
Two channel S-band (2.2-2.3 Ghz) telemetry multicoupler model S-201 allows simultaneous operation of two 50-w transmitters into a single antenna. With channels separated by 25 Mhz, the unit provides 24-db isolation with 0.6-db passband insertion loss. The unit measures 1.90 x 2.35 x 5.70 inches, weighs 0.65 lb. Wavecom Inc., 9181 Gazette Ave., Chatsworth, Calif. 91311. [403]

Compact, lightweight voltage variable attenuator AM7000 is useful where low vswr and system accuracy are requirements. It is available with standard p-i-n diodes or optional p-n types for greater switching speed. Frequency range is 1 to 4 Ghz. Insertion loss is 2 db max. Vswr is 2 max. Alpha Industries Inc., 381 Elliot St., Newton Upper Falls, Mass. 02184. [404]

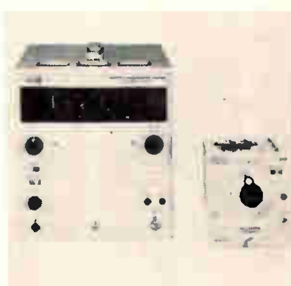
Broadband thermocouple mount model 550 covers from 8.2 to 12.4 Ghz. The thermocouple sensor is field replaceable requiring no special tool or adjustments. The mount weighs less than 8 oz and has passed typical MIL specs for shock and vibration. Price is $145; delivery, 2 weeks after receipt of order. MSI Electronics Inc., 34-32 57th St., Woodside, N.Y. 11377. [405]



Remote Miti-Min coaxial switch series SRM is a single pole, two position type for use over the range of d-c to 12.4 Ghz. Insertion loss is 0.4 db max.; vswr, 1.5 max.; isolation, 60 db min.; r-f power rating, 50 w average; r-f connectors, RSM female; life, 1 million cycles min.; price $125. RLC Electronics Inc., 25 Martin Place, Port Chester, N.Y. 10573. [406]



Varactor multiplier model UHM-2 (TX)-3580/500-32 is a solid state device that has a 32 times multiplication ratio with an output bandwidth of 500 Mhz. Input frequency is 104 to 119.7 Mhz and output frequency is 3.33 to 3.83 Ghz. Nominal power is 20 mw for an input driving signal of 100 mw. Applied Research Inc., 76 S. Bayles Ave., Port Washington, N.Y. 11050. [407]



Heterodyne converter model 635 is designed to plug into the portable model 616 frequency counter and boost the range from 225 Mhz to 3.3 Ghz. The plug-in features a converter frequency range from 0.1 Ghz to 3.3 Ghz, with continuous tuning in 0.1-Ghz steps from 0.2 Ghz to 3.2 Ghz. CMC, Div. of Pacific Industries, 12970 Bradley Ave., San Fernando, Calif. [408]

borne radars and radios, telemetry systems, and transponders.

Mixing it up. LEL engineers make the converter on two 1-by-2-inch substrates. On one are a mixer and an i-f amplifier; on the other are a crystal oscillator, a multiplier, and a five-section comb filter.

The mixer combines the r-f input, whose frequency can be 1,435 to 1,535 megahertz, with a filtered signal from the crystal oscillator. The i-f signal from the mixer goes to an amplifier whose output is the output of the converter.

It takes 9 volts to run the converter, and maximum drain is 2 watts. Input and output impedance are both 50 ohms, and the voltage standing-wave ratio is 1.5. The maximum noise figure is 8 decibels, and the frequency stability is 0.01%.

I-f frequencies available are 30, 60, and 265 Mhz, and possible bandwidths are 10, 20, and 100 Mhz. Gain ranges from 15 to 30 db.

Putting it down. LEL engineers make the converter the same way they make other microwave IC's. A resistive layer of chromium-chrome oxide is coated with gold. Resistive and conductive paths are etched, and active devices and discrete capacitors and inductors are bonded to the substrate.

Chip capacitors are used in the r-f section.

The converter's price is about $2,000, and delivery time is 3 to 4 months.

LEL Division, Varian Associates, Akron St., Copiague, N.Y. 11726 [409]

New microwave

Crystalline units delay Ghz signals

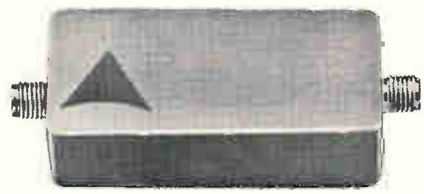
Film-sapphire-film devices handle 100 milliwatts c-w; losses down 50 to 75 db

The brute-force approach is the common way to delay a microwave signal—pass it through a predetermined length of coaxial cable. Crystalline delay lines by compari-

son are more sophisticated. Only inches in length, they offer space and weight advantages over bulky piles of cable. However, high loss factors and low power ratings have, so far, kept these devices out of gigahertz systems.

The latest additions to the delay-line family of Andersen Laboratories Inc. are designed to get into the Ghz systems. The crystalline devices operate at any specified frequency between 7 and 11 Ghz. They provide delay times of 200 to 2,000 nanoseconds, and bandwidths up to 20%. Input/output isolation is 100 decibels. They can handle 100 milliwatts continuously and 50 watts peak, and spurious signals are below 20 db. Performance meets MIL-E-54000 Class II.

Presently the loss is between 50 and 75 db, but this will be down to 35 db by the middle of 1969, says Walter Crofut, head of microwave systems at Andersen. With the new units, the company's line covers the range from 100 megahertz through X band.



Slowdown. A piezoelectric film at the input converts an electrical signal into a slower-moving acoustic one.

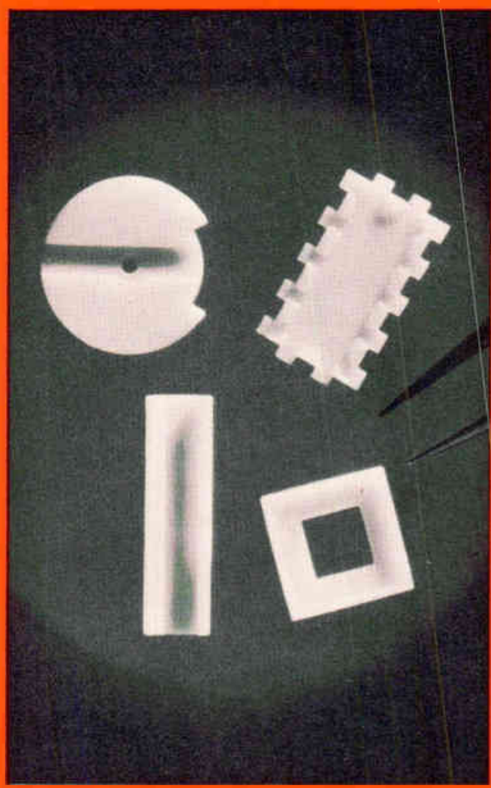
A sound film. At the input of the delay lines is a piezoelectric film which converts electrical energy into acoustical energy, thus slowing down the signal. The sound wave travels through a delay medium—usually sapphire—and then to the output where another piezoelectric film converts the energy back to electrical form.

Specified delay times are accurate to within 10 nsecs, but Crofut says that the actual error is negligible in devices whose delay mediums are cut from the same crystal.

The new devices sell for $3,000 each. A prototype takes 6 weeks, after which the production units can be delivered as needed.

Andersen Laboratories, Inc., 1280 Blue Hills Ave., Bloomfield, Conn. [410]

increase ic yield



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Coors CERAMICS

Circle 190 on reader service card

New instruments

All together now: a microvolt potentiometer

Julie Labs offers a completely self-contained device costing $625 and accurate to within 10 parts per million

Second-sourcing doesn't necessarily mean supplying identical copies. Julie Research Laboratories, for instance, went a prime supplier one better when it successfully bid to become a Government agency's second source for a microvolt potentiometer. For about the same price charged by the other supplier, Julie offered a completely self-contained instrument. Instead of the separate indicator, power source, current reference, and galvanometer offered by the first source, Julie built all of them as part of the main frame. And the company is now putting the potentiometer on the market.

It's the second product from Julie—known as a maker of high-priced instruments—on the medium-priced market. The first, a differential voltmeter, was introduced last October. The new potentiometer costs $625 and its accuracy is 10 parts per million, compared with 1 ppm for the firm's expensive line, which sells for $3,000 to $4,000.

Two versions. There are two

Differential potentiometer 7564 combines a precision potentiometer, a solid state null detector, a guarded power supply, a precision volt-box, and a thermally-lagged standard cell, all in a compact case. It measures voltage from 0.5 μv to 1,600 v. Emf value is displayed at a central readout window with a resolution of ±0.5 μv. Leeds & Northrup Co., North Wales, Pa. [361]

Time interval detector model 101 reduces the complexity and man-hours normally required for detection of chatter or intermittent contact openings and closings during environmental testing of electromechanical devices. Times from 0.1 μsec to 9.99 msec can be detected. Accuracy is ±0.1 μsec. Prices start at $420. Digital Networks, P.O. Box 817, Pomona, Calif. 91769. [362]

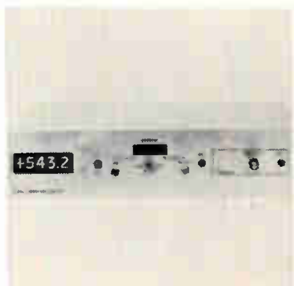
Test sine generator model F312A employs the Wien bridge oscillator technique to achieve low distortion sine wave output over a 10 hz to 10 Mhz frequency span. A wideband a-c voltmeter provides accurate monitor of the output signal which is capable of delivering 3.16 v rms into 50 or 600 ohms. Price is $695. Data Royal Corp., 8014 Armour St., San Diego, Calif. 92111. [363]

Combination FET and conventional transistor tester TF151 is easy to use. Flip the function control knob in the middle to the left and the unit is a regular in and out of circuit transistor tester; testing for beta gain and I_{cbo} out of circuit leakage. Flip the knob to the right and the unit tests FET's for transconductance in or out of circuit. Sencore Inc., Addison, Ill. [364]

Rotating electrostatic voltmeter model 12008 measures magnitude and polarity of electrostatic fields up to 500,000 v/meter. Range switch adjusts sensitivity from 0-500 v/meter to 0-500,000 v/meter in 4 decaded steps. Individual recorder outputs are available for each decaded output. Comstock & Wescott Inc., 765 Concord Ave., Cambridge, Mass. 02138. [365]

Transistor curve tracer PM6507, with magnetically deflected crt, can display 2 to 8 characteristic curves from any four terminal semiconductor device, including power transistors. The dynamic curves may be run over a broad power range, to 20 amps max collector current, 500 v collector-to-emitter voltage. Philips Electronic Instruments, 750 S. Fulton Ave., Mt. Vernon, N.Y. [366]

Audio frequency meter 503 is a portable unit that measures sine or square wave frequencies to 50 khz. Accuracy is ±1%. It accepts signals of less than 1 v to 120 v rms without sensitivity adjustment. Built-in overload protection to 250 v rms is featured. Price is $129 complete with test leads and operator's manual. Maricopa Controls, 8013 E. Roosevelt, Scottsdale, Ariz. [367]



Digital temperature indicator DT-600R provides precise readings over the full range of the input thermocouple. Linearization is accomplished by digital sampling techniques that provide dynamic linearization throughout the thermocouple range. Price is from $1,350; delivery, 3 to 4 weeks after receipt of order. Anadex Instruments Inc., 7833 Haskell Ave., Van Nuys, Calif. [368]

models of the new instrument, the NVS-503A, which measures 10 nanovolts to 500 millivolts in six ranges, and the NVS-1103A, measuring 11 μv to 1.1 volts in six ranges. Both have a maximum error of $\pm0.05\%$ of full scale or ±0.1 microvolt, which ever is larger, and both can be used as a voltage source to generate a reference level that's accurate within $\pm0.04\%$ of full scale or ±0.1 μv, whichever is greater. The instruments can operate for a month without calibration.

Input isolation from the case is better than 10^9 ohms, and the input resistance is infinite at null. When the instrument is used as a source, the output impedance is 50 ohms for all ranges. An internal mercury battery pack provides 200 hours of continuous duty. Size is 3½ by 19 by 5½ inches.

Comprehensive. Entire voltage-measuring system is built into main frame.

Polarity is reversible for both "measure" and "generate" modes. The instrument—both potentiometer and null detector—dissipates less than 0.5 watt and the null detector can be removed from the main frame and used in other measuring systems.

Dennis Cope, Julie's sales manager, describes the potentiometer as "a very compact and handy" voltage measuring system. "It will be useful in any standards lab or testing lab," Cope predicts, "and could be used for production-line testing—it's a very rugged little instrument." It's particularly suited to measuring voltages of low-power circuits, he notes, because it operates potentiometrically and thus has no insertion loss.

Julie makes all the critical resistors used in the instrument, and this is a major factor in reducing costs while maintaining acceptable accuracy, according to Cope. Manufacturing the resistors to the firm's own standards of precision "eliminates a lot of trimming," he says. "We can provide a very stable instrument with a minimum number of parts."

Delivery time is three to four weeks.

Julie Research Laboratories Inc., 211 W. 61st St., New York 10023 [369]

New instruments

Dutch multimeter says it digitally

Instrument from Philips handles a-c and d-c, measures up to 1 megohm

Latest from the Low Countries for design engineers is a digital multmeter made by Philips' Gloeilampenfabrieken. Called the PM2420, the meter is a three-digit instrument and costs $420 in the Netherlands.

The instrument has a floating input and can handle voltages up to 500 volts above ground. It measures d-c voltages in five ranges from 100 millivolts to 1,000 volts, and a-c voltages in four ranges from 300 mv to 300 volts rms.

Maximum resolution is 100 microvolts for d-c measurements and 1 mv for a-c checks. Accuracies are 0.5% of range ± one digit and 1.0% of range ± one digit, respectively.

The meter's five d-c current ranges go from 100 microamps to 1 amp, with resolution of 100 milliamps and accuracy of 1.5% ± one

Well protected. The PM 2420 takes overloads up to 1,000 volts.

digit. The four a-c ranges go from 300 μa to 300 ma rms; resolution is 1 μa and accuracy is 2.0% ± one digit.

The PM 2420 also measures resistance in five ranges from 100 ohms to 1 megohm.

There's an additional digit provided for over-range protection. The meter also has a polarity indicator and an overload signal.

The meter can stand overloads up to 1,000 volts on the higher d-c ranges, and 300 volts rms on all a-c ranges. For the two lowest d-c ranges, the instrument can take 150 volts.

Generated internally is a 9.99-volt signal that can be used to calibrate the meter. Philips says that the PM 2420 is very stable; one calibration a day is enough.

Industrial and Scientific Div., Philips' Gloeilampenfabrieken, Eindhoven, Netherlands **[370]**

New instruments

Active filters sift sounds

Audio spectrum analyzer marketed for voice-pattern, sonar, and noise studies

The sonar echo is difficult to analyze because its characteristics can vary if its analog waveform is sampled at different times. Yet the analysis is potentially very rewarding; the return signals could be as important in identifying a ship to a properly programed computer as a reference in Jane's.

A filter bank that prepares a signal for analog-to-digital conversion by breaking up the frequency bands into a number of segments and analyzing the energy level in each has been announced by Kinetic Technology Inc., a company formed last spring to manufacture active filters. Designated the SB-55, the system was designed for sonar analysis, voice pattern studies, and noise analysis.

The heart of the audio spectrum analyzer is a fourth-order (two-pole pair) Butterworth filter that produces a flat passband with no ripple. The filter is electronically tunable from 80 hertz to 12 kilohertz, in three decades. At any frequency setting, the bandwidth is adjustable from 0.5% to 100%. Each filter has two single-tuned sections that can be adjusted to achieve the flat top and sharp skirt characteristic of the Butterworth response.

Size tradeoff. Kinetic Technology currently uses its own active filters, which have two sets of gain-filter-attenuation stages, limited to some extent by the characteristics of the linear MOS circuits used. The operational amplifiers themselves generate 250 microvolts of noise, and the relatively slow slew rates keep peak response to a maximum of 20 khz. Discrete components, while improving response, would make the filter bank unmanageably large; in its hybrid state, with five channels per rack panel, the 64-channel system fills two racks.

To obtain the fast-varying d-c voltage that's fed to the a-d converter, the signal is passed through both a full-wave rectifier, which gives a d-c level proportional to the energy out of the filter, and an RC filter that integrates the d-c signal to eliminate ripple. The rectifier has a 66-decibel dynamic range, giving the output an accuracy of 10 bits.

Function generators, which produce an output voltage equal to either the logarithm of the input, or to the input raised to a power between +10 and −10, are also available. This section of the system weights the spectrum to accommodate nonlinear signals.

Price of the SB-55 is $1,500 per channel; this breaks down to $950 for the attenuator-filter-detector-integrator segments, $235 for the log generator, and $315 for the exponent generator. The generators are optional. Also as an optional feature, a scaler network having a 10-bit accuracy can be supplied.

Kinetic Technology will start making deliveries in March.

Kinetic Technology Inc., 17,465 Shelburne Way, Los Gatos, Calif. 95030 [371]

LOWER PRODUCTION COSTS with the TRW LASER IC TRIMMER

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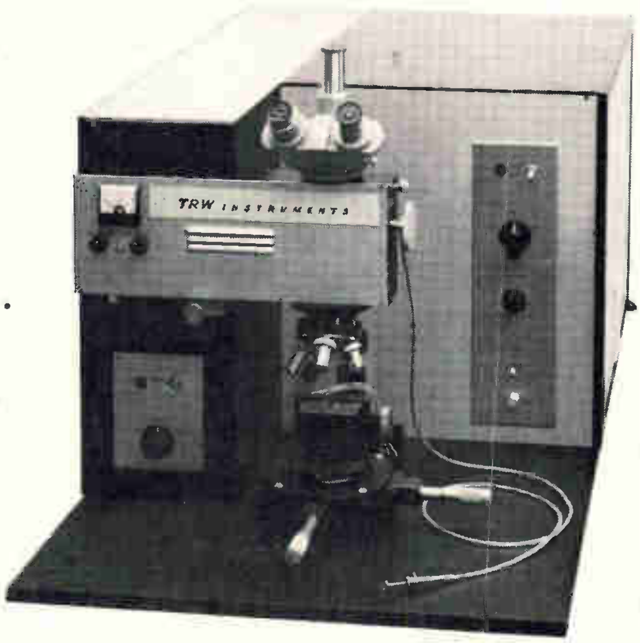
Accurate . . .

Efficient . . .



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The Model 84A Laser IC Trimmer utilizes a totally concealed pulsed argon laser for the trimming process. A trinocular microscope provides safety interlocked viewing and is adaptable for TV viewing.

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TRW

Spectrum analyzer goes to 1,250 Mhz

Frequency-base scope has absolute calibration in voltage and db scales

Every electronics lab needs at least one oscilloscope. Right? Wrong, say engineers at the Hewlett-Packard Co.'s Microwave division. A lab should have at least two scopes, they say—one with a time base and the other with a frequency base.

The ubiquitous time-base scope is easy to operate and has very fast sweep times. Frequency-base units, usually called spectrum analyzers, aren't as simple to work and have a comparatively narrow operating range.

But things may be different now; H-P is building a spectrum analyzer that it calls a frequency-domain twin of the standard time-base scope.

The key to this instrument is H-P's new plug-in unit, the 8554L r-f section. Combined with the 8552A i-f section and the 140S display section, the 8554L makes an analyzer with a wide operating range—1 to 1,250 megahertz—and with absolute amplitude calibration in either a voltage or decibel scale.

Versatile scanning. According to H-P, no other analyzer can operate anywhere near 1,250 Mhz; the best the older H-P instruments could do was 40 Mhz. Amplitudes from 0.3 microvolt to 8.0 volts can be read on the scope face. When the instrument is set to log display, 60 db of calibrated dynamic range, in a span from —120 db to +10 db above 1 milliwatt, are shown on the scope. The frequency response is ±1 db, and for most types of measurements, accuracy is 1.0 to 1.5 db.

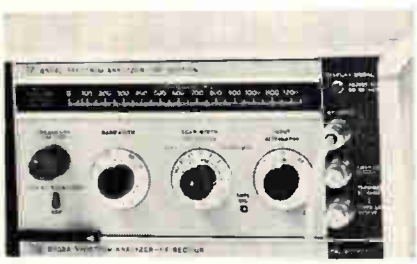
The horizontal scan is also adjustable. The entire 0-to-1,250 Mhz scan can be shown, or the operator can select any center frequency in the range, then pick one of 10 calibrated scans, from 2 kilohertz to 100 Mhz per division. Or repetitive scan can be turned off, and the operator can manually interrogate an incoming signal.

The displayed center frequency is within 10% of the frequency indicated on the dial of the 8552A. And the frequency difference between two points on the display can be read to within 10%.

The bandwidth is also adjustable among seven calibrated values, from 300 hertz to 300 khz. If the bandwidth chosen is too narrow for the selected scan width and rate, a red warning light comes on.

The scan can be from 10 seconds to 0.1 millisecond per division, and the scan can be internally or externally triggered, or synchronized with line frequency or the video envelope. A front-panel pushbutton puts the device into a single-scan mode for use with a camera or plotter. The scan voltage itself can be supplied externally.

Versatile testing. The scope allows for fast determination of the Fourier coefficients of a high-frequency signal; the amplitude and frequency are simply read off the scope. The level and shape of a pulse spectrum, as well as the absolute and relative levels of individual communication channels, can be quickly measured.

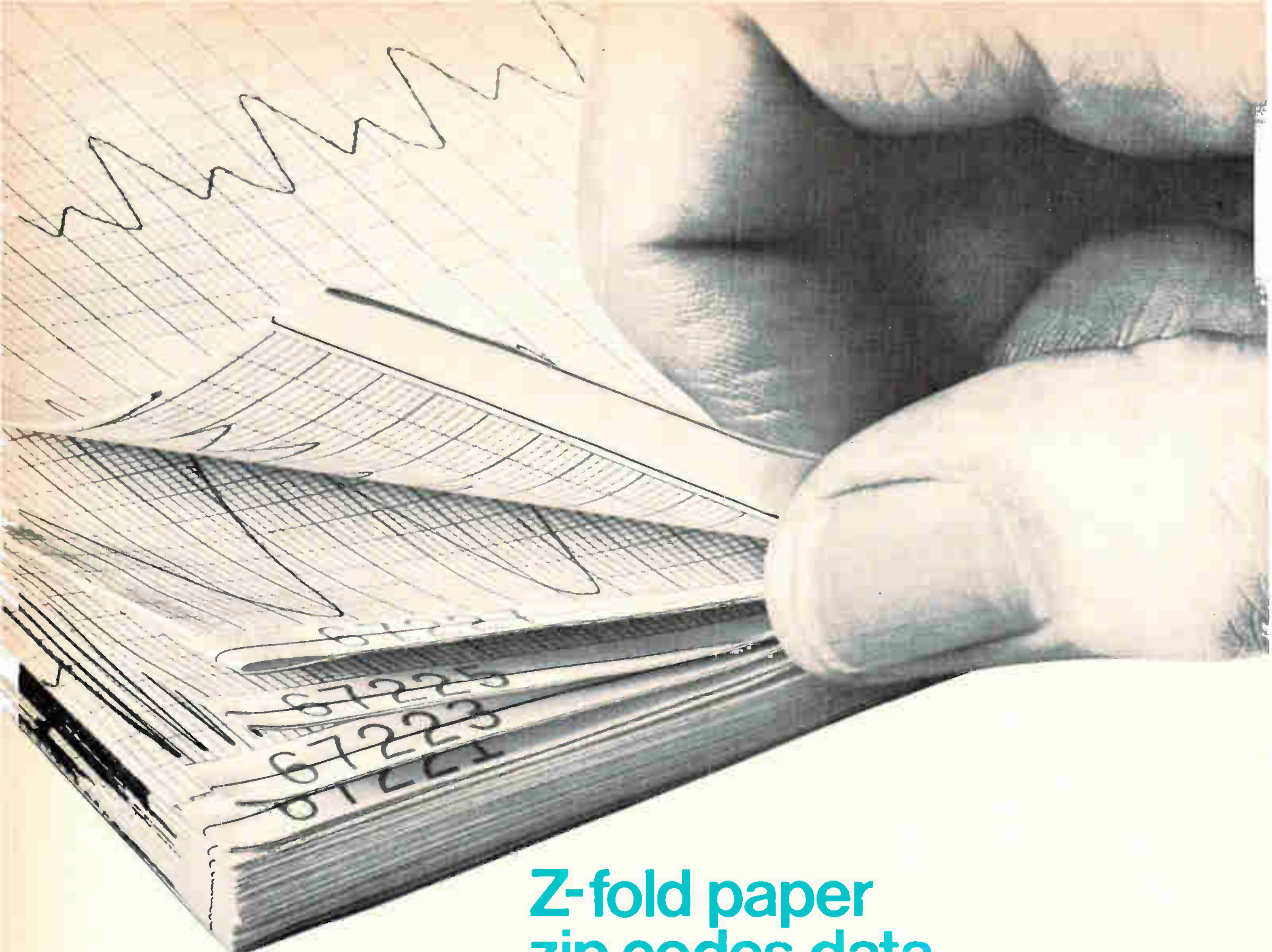


Pick the middle. The knob on the left is used to select the center frequency of the scan.

The system is intended primarily as an aid in r-f circuit design. Among other tests, it can measure the flatness, harmonic content, and spectral purity of an oscillator, the gain, frequency response, and distortion of an amplifier, and the response of a filter.

The price of a complete system is $6,000. The 8554L by itself costs $3,300; deliveries of the plug-in unit will start in March.

Hewlett-Packard Co., Microwave Division, 1501 Page Mill Rd., Palo Alto, Calif. 94304 **[374]**



Z-fold paper zip codes data for quick retrieval

Data recorded on Z-fold paper by the Hewlett-Packard 7800 Series Rectilinear Recorder is instantly retrievable. Each page is numbered to simplify reference to recorded data. Z-fold chart packs store easily in their original cartons.

Contactless pen tip sensing and a *modulated pressure ink system* produce traces of equal density from all signals and throughout the recorder's variable speed ranges of .025 to 200 mm. per second. *You get blue ink reproducibility compatible to diazo or any similar process.*

Designed with modular, solid-state electronics, the 7800 Systems provide high-resolution, permanent, rectilinear recording of up to eight variables from dc to 150 Hz.

Eight 8800 Series Preamplifiers provide signal conditioning to the driver-amplifiers which drive the recording pens. The recording system is available with eight different or eight identical preamplifiers of your choice. Frequency response of the recorder is 150 Hz for 10 div p-p deflection and 58 Hertz maximum for full scale deflection. Maximum ac or dc non-linearity is 0.5% full scale. Additional features include: choice of chart paper in Z-fold packs or rolls; 14 electrically-controlled chart speeds; built-in paper take-up; ink supply warning light; disposable plug-in ink supply cartridge that may be replaced while the recorder is in operation and modular construction for easy maintenance.

For complete information on the 7800 Series, optional and related equipment, contact your local HP Field Office or write Hewlett-Packard, Waltham Div., 175 Wyman St., Waltham, Mass. 02154. In Europe: 1217 Meyrin-Geneva, Switzerland.

HEWLETT hp PACKARD

RECORDING SYSTEMS

Circle 198 on reader service card

17802B

Converting 10 bits in 1 microsecond

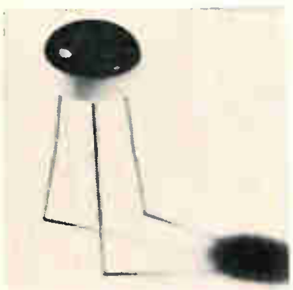
Successive approximation gives a-d device high speed and high resolution for real-time processing jobs

Speed versus resolution is an almost universal tradeoff, and analog-to-digital converters are no exception. Those that work very fast—at 4 to 5 megahertz—have a resolution of only 6 to 8 bits. Those with a resolution of 14 or 15 bits dawdle along at 15 kilohertz.

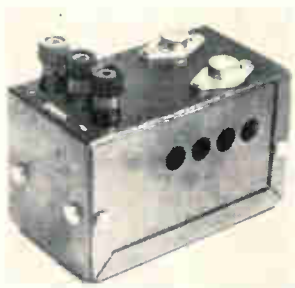
Until recently, this tradeoff was tolerable, but now, says James Pastoriza, president of Pastoriza Electronics Inc., digital processing of radar data, real-time interaction with data processing equipment, and new forms of pulse or wave-shape analysis require converters of both high speed and high resolution.

A new fad. That's why the firm has developed its FAD-10 converter, which takes only a microsecond to complete a 10-bit conversion.

"The FAD-10 is a complete converter module," says Richard A. Ferrero, sales manager. "Everything is on one board." This includes the reference power supply, high-speed switches, resistor network, comparison amplifier, and integrated-circuit TTL.



Silicon monolithic voltage regulators 2103, 2104 and 2105 include internal short-circuit protection, with a thermal feedback circuit to prevent excessive operating temperature. Each is designed for a positive regulated output at +15 v, and contains its own voltage reference element for voltage regulation to 0.1%. Philbrick/Nexus Research, Allied Drive, Dedham, Mass. [381]

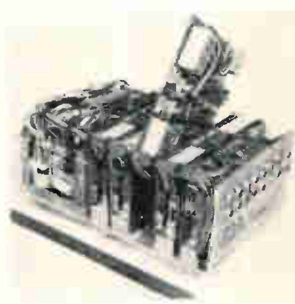


Regulated power supply model 15-15-100 uses silicon solid state throughout. It provides two outputs, nominally +15 v and —15 v d-c, separately adjustable over a ±10% range, and regulated to within 0.05% for both load and line variations. Output is 100 ma max. from each output terminal. Accelerated Electronics Industries Inc., 233 Orchard St., New Haven, Conn. 06511. [382]

YAG laser system 400Y comes in over 12 different configurations to fill many needs. From several hundred mw of continuous green light at 5,300 angstroms for underwater tv, holography and aerial mapping, to over 20 w of continuous infrared power at 10,600 angstroms for materials fabrication work, are offered. Control Data Corp., 535 Broad Hollow Road, Melville, N. Y. [383]

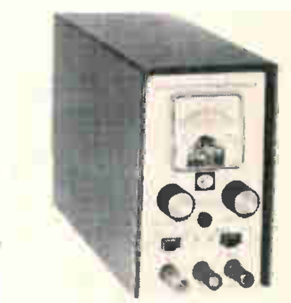
Fully assembled power systems use standard IC power components and accessories. They consist of a thin-line rack adapter, which can accommodate up to 8 power modules, 8 overvoltage protectors, 8 individual power control panels, a metering panel with 2 meters, fuses and selector switch, 4 connecting cables and 2 chassis slides. Lambda Electronics Corp., Melville, N.Y. [384]

Modular power supplies series AN3000 measure 2¾ x 6 x 3$\frac{1}{16}$ in. over-all, and provide all voltages necessary for the operation of practically any combined analog-digital, discrete, hybrid, or integrated circuitry. All four models in the series use silicon semiconductors and operate from 0° to 70°C. Prices, $94.50 to $124.50. Analogic Co., Newton St., Waltham, Mass. [385]



Subminiature, switching type airborne power supply features efficiencies of 60 to 70% through use of latest type IC's. It is capable of 25 amps at ±5 v. It can operate at full load at ambient temperatures as high as +115°C and down to —55°C without derating. Unit is 2.5 x 4 x 6.2 in. It meets MIL-I-6181. Bergen Laboratories, Inc., 60 Spruce St., Paterson, N.J. [386]

Plug-in analog multiplier model AM701 combines solid state integrated circuitry with the proven magnetoresistor bridge to obtain analog multiplication. It accepts ±10-v signals and delivers ±10-v output at 5 ma with a one quadrant accuracy of ±0.40% of full scale. Price in lots of 1 to 24 is $98.50 each. American Aerospace Controls Inc., Farmingdale, N.Y. [387]



Regulated d-c power supplies are available in two models: PSR-12-25 with output from 0 to 25 v d-c, 0 to 500 ma, and PSR-12-50 with output of 0 to 50 v d-c, 0 to 250 ma from input of 105 to 125 v 60 hz. Line regulation is 0.01% +2 mv, load regulation is 0.01%. Ripple is less than 100 microvolts. Electro Products Laboratories Inc., 6125 Howard, Chicago. [388]

Closing the gap. Converter has both high speed, 1 megahertz, and high resolution, 10 bits.

FAD-10 uses a successive-approximation rather than a cyclical technique, with each comparison (or bit) completed within 100 nanoseconds. Thus 10 bits take about a microsecond for an operating speed around 1 Mhz.

For a given switching-speed and a full-range signal, successive approximation requires fewer conversions—and thus less time—than the cyclical technique.

Comparisons. In the FAD-10, input current is compared with up to 10 reference currents. The first current is the largest, the second is half the first, the third is a quarter as large, and so on. The comparison amplifier rejects each current in succession until one is found smaller than the input. FAD-10 then adds succeeding smaller references to close the difference between input and supply currents.

Since successive approximation is used, each conversion takes place in a fixed time. With the cyclical technique, conversion time depends on the ratio between the data being converted and the level of the previously converted signal. The speed of a cyclical converter depends on how much and how quickly its input changes in amplitude.

Ferrero says that in multiplexed applications, where sampling is done at a set clock rate, the cyclical technique can be a disadvantage but that successive approximation lends itself to a fixed-rate multiplexing.

No buffering. The use of TTL IC's makes FAD-10's output levels compatible with today's fastest commercial computers. Pastoriza notes that with most memory systems capable of storage in the 1-microsecond range, the FAD-10 could be used to convert analog data for direct consumption by a core memory. No buffering would be required, so the scheme could save money for main-frame builders and their customers.

Radar pulse analysis represents another potentially large market, according to Pastoriza. Accurate digital processing of returned pulses requires good resolution in a converter that will have completed its job before the next pulse arrives. And with some radar systems using pulse repetition rates of hundreds of kilohertz to boost average power, something like FAD-10 has become a necessity, Pastoriza says.

He lists as other application areas the input stages of fast Fourier computers, the converter sections of fast character-recognition systems, and digital filtering sections of doppler radar systems.

Specifications

Input voltage range	0 to +10 v
Input impedance	2.5 kohm
Trigger	50-nsec pulse
Differential linearity	± 0.5 lsb
Output code	10-bit parallel binary
Output levels	0, less than 0.5 v 1, more than 2.5 v
Price	$2,975

Pastoriza Electronics Inc., 385 Eliot St., Newton, Mass. 02164 **[389]**

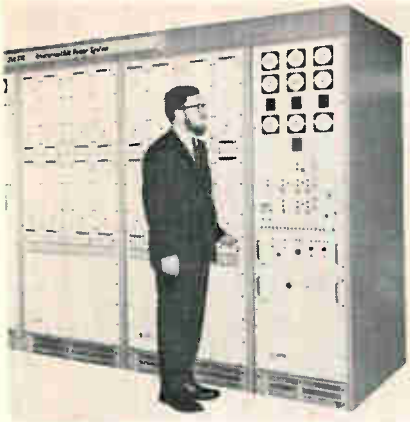
New subassemblies

System steps in when power fails

Battery-driven source assures continuous 250-kva input

The advent of real-time data systems has brought with it the need for power sources that can't fail. Many users of these data units have met this need by installing uninterruptible power systems (UPS)—battery-powered sources of three-phase power that supply energy to a load when the commercial power's voltage or frequency is out of tolerance.

A recent entry in the UPS market is the Avtel Corp., a division of Airtronics Inc. Bruce Ballard, the division's marketing director, says



Always ready. The 250-kva system has battery chargers that are run from the commercial power lines.

that Avtel will be competing with four companies, but he feels that his firm's new 250-kilovolt-ampere system tops the opposition in many critical areas and is still competitively priced.

That competitive price is 70 cents to $1 per volt-ampere, which means the Avtel system costs around $200,000. This sounds steep but Ballard points out that many potential customers just can't tolerate power failures, no matter how short their duration. Avtel has already sold one system for use in a computer message-switching application. Other places the system might be needed are at radar and communication centers, in airline reservation systems, and in hospital data-gathering systems.

UPSmanship. Avtel's system takes up, including room for the operator, 250 square feet of floor space. Ballard says that this is about one fourth the area needed by competitors.

Like competitive units, the Avtel system has a bank of batteries that drives a solid state inverter, which in turn generates the system's output. The system also has battery chargers which are driven by commercial lines, or whatever else is being used as primary source.

Ballard says that the Avtel inverter design is one of the principal features that sets the 250-kva system apart from competitors. Silicon controlled rectifiers are used by most manufacturers of UPS to generate the a-c output. Avtel also uses SCR's, but in a manner different from its competitors.

One competing system, says Ballard, needs a large filter on the inverter output to get rid of unwanted harmonics. Another, he says, uses SCR's in a way that requires that the output be fed through a ferroresonator. "This is fine if the frequency and voltage are exactly right, but if the line fails and you have to go to battery operation, you need a big bank of batteries, which means more floor space and more cost."

Avtel's approach is to fire the SCR's in the inverter so that a 24-step waveform is generated. "These are proportional," Ballard explains, "so that the first harmonic we see on the output, without any filtering, besides the fundamental harmonic is the 23rd. By using a minimum of filtering on the output, we allow the unit to be insensitive to reactive loads. We can use a much smaller filter and the system is impervious to voltage and frequency changes."

Ballard also points to some specs when explaining why he feels Avtel has the best in show. The voltage transient is 5% when the load changes by 50%; there's no transient when the load is switched from UPS power to commercial power. The system's acoustic noise is low, says Ballard, so it can be used in a laboratory.

The first system that Avtel sold had lead-acid batteries but the system can also use nickel-cadmium and lead-acid calcium types.

Avtel Corp., 1130 E. Cypress St., Covina, Calif. [390]

New subassemblies

Inverter delivers 300 watts at 60 hz

Solid state device can be power source in the field or backup in the laboratory

Like a veteran song-and-dance man, the 1057 inverter can be the star of a small road company or the understudy in a big production.

Built by the Wilmore Electronics Co., the 1057 is a solid state device that converts d-c inputs, from 11 to 14.5 volts, into a 115-volt, 60-hertz signal. Output is 300 watts and frequency stability is 0.25%.

One type of customer that Wilmore built the inverter for is the engineer who works in such fields as oceanology or geology, where equipment ruggedness and portability is at a premium. The 1057 is powerful and stable enough to drive instruments such as oscilloscopes, videotape recorders, and

Cleanup. An optional plug-in filter cuts harmonic distortion of the inverter's output to under 5%.

seismographic devices. And in a pinch, it can even run motors and other gear usually driven by a small generator. The 25-pound unit is 7 by 7 by 11 inches.

Homebody. But Wilmore believes engineers who stay indoors will also find use for the 1057. When fitted with an optional automatic-switchover connection and a battery charger, the converter can be used as a backup source in a laboratory or operating room.

The company says the device's switching-mode waveshaper provides a three-level approximation of a sine wave that has the same ratio of peak to rms voltage as a normal sine wave. Where this approximation isn't close enough, Wilmore can supply a plug-in filter that's 85% efficient and reduces harmonic distortion to under 5%.

For input variations in the 11-to-14.5 volt range or a change of no load to full load, the out-put varies by no more than ±5%.

In quantities of one to four, the 1057 costs $200; delivery time is less than 30 days.

Wilmore Electronics Co., Box 2973, West Durham Station, Durham, N.C. 27705 [391]

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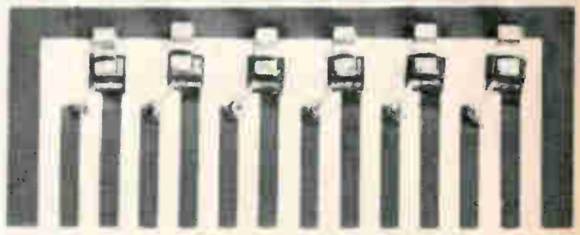
Electro Rents

Multichip triac package replaces relays

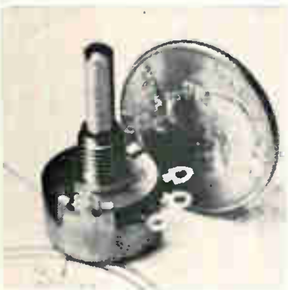
Single epoxy case holds six devices for applications in tv sets, home appliances, and automotive controls



All in one. Six Quadracs mounted on a single substrate are ready to challenge electromechanical relays.

Packaging costs have been a big drawback in making semiconductors for control jobs. It's common for packages to cost three times as much as the chip, says Harry Goff, a vice president of the Electronic Control Corp. ECC has an answer, though. It's putting six 1.6-amp triacs in one epoxy package. And to make things simpler as well as less expensive for the user, the triggering devices for the triacs can be included in the package. The company calls this combination a Quadrac.

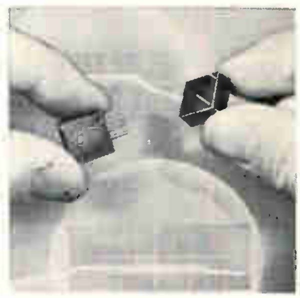
The problem of sealing the triacs in a plastic package has been overcome by the use of substrate-mounted semiconductors. The company applies what it calls a "unique



Low-noise commercial potentiometer model 381 is a ⅝-inch 1-w device with 1% dynamic noise and 5% maximum independent linearity. Resistance range is 100 ohms to 5 megohms linear, 500 ohms to 2 megohms tapered. Resistance tolerance is ±10% through 0.5 megohm, ±20% over 0.5 megohm. Voltage coefficient is 0.008%/v max. Clarostat Mfg. Co., Dover, N.H. [341]

Single-turn resistance trimmers type AFR are designed for 0.1-inch p-c grids. Rated at ½ w, the units' design includes a hot-molded resistor track and low resistance collector track bridged by a single moving contact brush. Fifteen models cover the resistance range of 100 ohms to 5 megohms, ±20%. Price (1-9) is $3. Ohmite Mfg. Co., 3601 Howard St., Skokie, Ill. 60076. [342]

Small, rugged up to 165 w, 400 hz Thin-Tran power transformers are designed to meet MIL-T-27B Class V for operating temperatures to 155°C. The thin shape of the units (1⅜-inch thick) is achieved by use of widely distributed, shallow windings of high temperature wires. Price is from $139. Arnold Magnetics Corp., 11264 Playa Court, Culver City, Calif. 90230. [343]



Miniature suppressor LVP-6 protects printed circuits from transient voltages. Connected to the d-c input of the printed circuit, it is effective against very slow rising as well as very fast rising voltages. It can be provided with nominal clamping voltages from 6 to 25 v with tolerance of 5, 10 or 20%. Price (100 lots) is under $3. Dale Electronics Inc., P.O. Box 180, Yankton, S.D. [344]

All-purpose, compact vacuum relay H-11/S2 is for h-v applications commonly associated with radar, communications, pulse-forming networks and medical electronic systems. Specs include spst contacts, rated operating voltage of 12 kv in air and 18 kv in oil. Price (1-9) is $110 each. High Vacuum Electronics Inc., 538 Mission St., South Pasadena, Calif. 91030. [345]

Precision thumbwheel switches series TIR offer a convenient push-button instant-reset-to-zero feature. Uses include industrial and military applications requiring presetting of thumbwheel switches from a zero position. The instant reset feature saves time and avoids errors. Single module prices begin at $14.75. Chicago Dynamic Industries Inc., 1725 Diversey Blvd., Chicago [346]

Cermet-element adjustment pot model 3009 is a 20-turn E-Z-Trim type measuring 0.75 x 0.19 x 0.35 inch. Data code traceability and ±0.05% settability are featured. Resistance range is 10 ohms to 1 megohm. Power rating is 0.75 w at 25°C. Temperature coefficient is ±150 ppm/°C max. Price (500 lots) is $1.45 each. Bourns Inc., 1200 Columbia Ave., Riverside, Calif. [347]

Ten-position continuous turn rotary switch type 3 is designed for use with IC's. Basically a single-pole configuration, the switch is also available with stops to limit rotation to 2 through 10 positions. It offers up to ½ amp at 28 v d-c, 0.1 amp at 120 v a-c noninductive. It measures 5/16 inch in diameter, 0.687 inch high including leads. Oak Mfg. Co., Crystal Lake, Ill. [348]

←Circle 204 on reader service card

. . . tv makers plan to use them in remote controls . . .

glass passivation technique" in which the wafer is completely covered with glass that's then removed from all areas except junctions. These remain filled with glass to provide the necessary sealed protection.

Savings. The technique reduces packaging costs, and ECC is also realizing labor economies by manufacturing its devices in Matamoros, Mexico.

Goff describes the device as a direct replacement for mechanical relays in many applications. The substrate fits directly into slotted printed-circuit boards and can be hand- or flow-soldered. Made of alumina with precious-metal contacts, it comes in 1- or 2-inch-by-0.850-inch configurations.

At least two major television manufacturers plan to replace the electromechanical relays in the remote-control systems of their 1970 color sets with the new device. One is now paying 68 cents each for U.S.-made relays, while the other is laying out 40 cents for devices imported from Hong Kong. According to Goff, ECC will be supplying Quadrac modules to both firms at a cost of about 40 cents per function.

Easy assembly. The semiconductor controls, besides matching or undercutting the prices for electromechanical relays, are expected to save the set makers considerable labor expenses and other costs. The remote-control systems require six relays now, with all the attendant soldering and connection steps, but the semiconductor module can be installed in a single assembly step.

Car makers are also eyeing the Quadrac module as a replacement for relays, variable resistors, and switches. As one auto industry spokesman puts it, "What we need is a multifunction unit with all of the triacs in one cheap and rugged package."

ECC expects its device to find a place in a wide range of switching and timing applications in home appliances. The cost in applications where more than a single switching function is required is

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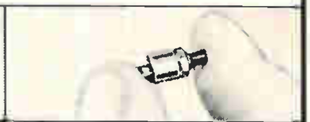

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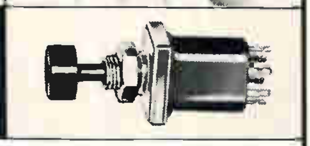

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lower than or competitive with that of most conventional single-pole relays, according to ECC. The company can supply SCR's in the same configuration. And on special order, more than six chips can be packaged together.

Electronic Control Corp., 1010 Pamela Drive, Eulesso, Texas **[349]**

New components

Fast switching in the K-band

Series of 27 switches boasts nanosecond speed; work up to 15,500 Mhz

When it comes to making switches, engineers at the G-L Microwave Corp. don't take any chances on slighting someone. Instead of bringing out one or two new devices, the company has introduced a line of 27 single-pole-single-throw switches covering a range from 30 to 15,500 megahertz. All, according to the company, feature low insertion loss and fast switching speeds.

The S1110L, for example, handles signals ranging from 30 to 1,000 Mhz; its insertion loss is 0.6 decibel, and switching speed is 5 nanoseconds. This switch has 50 db of isolation, and a voltage standing-wave ratio of 1.30; it handles 10 watts average and 30 watts peak.

One of 27. This model, the S15459L, switches 5,400-to-5,900-Mhz signals in 50 nsec. Vswr is 1.25.

At the other end of the line is the S115016L. This switches sig-

. . . video signals turn a diode off and on . . .

nals in the 15,000-to-15,500-Mhz range at a speed of 50 nsec. Its isolation is 0.9 db and its vswr is 1.50. Average power which can be handled is 5 watts; peak is 100 watts.

The S112L has the lowest insertion loss—0.3 db—and the lowest vswr—1.15. The fastest switches turn on or off in 5 nsec, and the slowest in 100 nsec. Also, some models can take 6 kilowatts peak.

Blocks. All the G-L switches are strip-line devices. The switching element is a diode which goes from the blocking to the conducting state when a video signal passes through it.

The on-state bias is +50 milliamps or —50 volts; off-state values are +25 ma or —18 volts.

Nine models of the switch come in packages that are 3½ by 2 inches by ½ inch; the others, higher-frequency devices for the most part, are in packages 2½ by 1½ inches by ½ inch.

The company says the devices can be used anywhere it's desired to turn microwave power off and on at high speed; chopping a wave or blanking an antenna are two examples.

Prices vary from model to model but typical unit price for small quantities is $145. Delivery time is 2 to 3 weeks.

Specifications

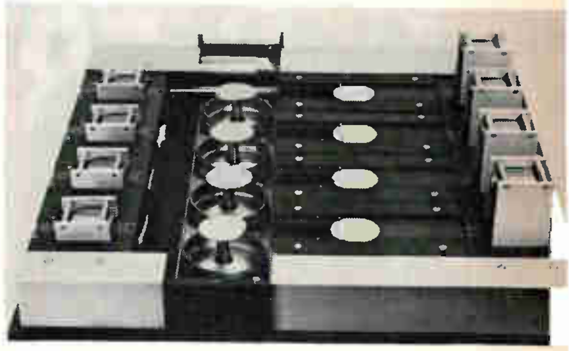
Model number	Frequency range (Mhz)
S1110L	30-1,000
S112L	100-250
S112H	100-250
S125L	250-500
S125H	250-500
S151L	500-1,500
S151H	500-1,000
S11020L	1,000-2,000
S11011H	1,020-1,100
S11416H	1,400-1,600
S11724L	1,700-2,400
S11040L	1,000-4,000
S12223H	2,200-2,300
S12080L	2,000-8,000
S17040L	2,000-4,000
S13337H	3,300-3,700
S14450H	4,400-5,000
S14450HF	4,400-5,000
S14080L	4,000-8,000
S15459L	5,400-5,900
S15459H	5,400-5,900
S17484L	7,400-8,400
S18012L	8,000-12,400
S18596L	8,500-9,600
S11012L	10,000-10,250
S113514L	13,500-14,500
S115016L	15,000-15,500

G-L Microwave Corp., 825 Black Oak Ridge Rd., Wayne, N.J. 07470 [350]

New production equipment

Air makes the going great for IC slices

Pneumatic currents of a photoresist-coating machine handle 1,360 units an hour without surface contact

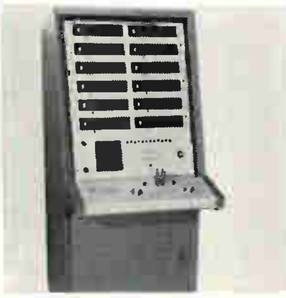


Airborne. Wafers at right move toward raised chucks for photoresist coating.

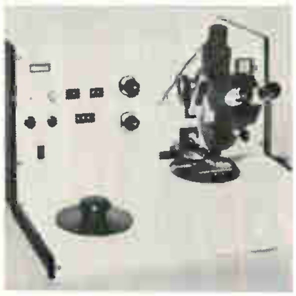
Contact is fine for lovers and switches, but not for integrated circuits during fabrication. Now there's a new way to keep the IC wafers away from surrounding surfaces: a coating machine that transports them on air currents through the photoresist process and returns them to their carriers automatically. No handling is required.

The device is made by the Industrial Modular Systems Corp., whose president, C. Arthur Lasch Jr., says it offers a wide range of possibilities for introducing new production techniques to wafer fabrication. The air currents permit abrupt speed changes at any point along the conveyor system, and transportation of parts through fluids

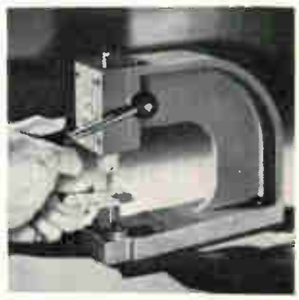
Automatic centrifugal tinning apparatus is for spin-coating p-c boards. It utilizes the advantages of hot tinning to form the intermetallic compound layer essential to reliable solder joints, and then a centrifugal force to remove excess solder and control layer thickness accurately. Results achieved meet with NASA specs. Electrovert Inc., 86 Hartford Ave., Mount Vernon, N.Y. [421]



Automatic tester model DA provides rapid test and sort of diodes. It will measure leakage currents as low as 1 na and peak inverse voltages up to 2,000 v. Forward voltage is measured with currents up to 10 amps. Standard test time is 16 msec, making it desirable to interface the tester with mechanical handlers. Lorlin Industries Inc., 30 Pandanaram Road, Danbury, Conn. [422]



Flip chip bonder model 2000 incorporates IC logic control. High production rates are due to the use of an automatic dice back up operation and positive alignment achieved through the use of an optical mirror system. Total cycle time of a complete bonded chip is less than 5 sec. Unit handles sizes from 1/4 to 3 sq. in. Hugle Industries, 750 N. Pastoria Ave., Sunnyvale, Calif. [423]

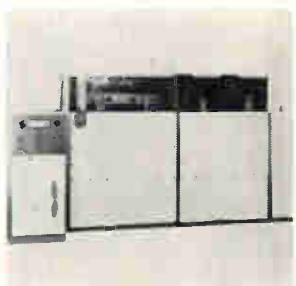


Staking machines called Accu-Ram are for eyeleting a variety of sizes including the 0.021 inch i-d used in printed circuitry. Two models, one hand actuated and the other pneumatically driven, feature a highly accurate ram and compensators to assure consistent mechanical fit to 0.0005 inch, and a limited travel spindle. Mark Eyelet & Stamping Inc., Wolcott, Conn. [424]

Circuit scrubber and cleaning machine model 500 is designed for cleaning copper and gold, or solder plated circuit boards. It uses 3 sets of adjustable non-loading abrasive brushes in its scrubbing section to produce simultaneous, two-sided cleaning action as well as a variety of surface finishes. General Products Laboratory, 111 Lock St., Nashua, N.H. 03060. [425]

Automatic wafer cleaner model 900 is designed to improve yields by removal of contamination between various steps in the processing of silicon semiconductor slices. The timed cycle includes a slow spin with deionized-water spray while blanketed with nitrogen, followed by a high-speed spin with dry nitrogen blowoff. Macronetics Inc., 220 California Ave., Palo Alto, Calif. [426]

Semiautomatic operational amplifier tester model 5102 is useful for production line checking. It will test both the dynamic and static characteristics, including common mode rejection and power supply rejection of linear integrated circuits as well as discrete operational amplifiers. Price is $1,400. Philbrick/Nexus Research, Allied Drive, Dedham, Mass. 02026. [427]



Medium-size conveyorized spray etcher model V-20 is for production of printed circuits and small metal parts. It provides automated double-sided etching of material 20 inches wide and of continuous length. The system's 44 spray nozzles, 4 inches apart on 4 manifolds on top and 4 on the bottom give complete acid coverage. Pemco, 4930 West 35th St., Minneapolis 55416 [428]

. . . in an hour, out come 1,360 coated wafers . . .

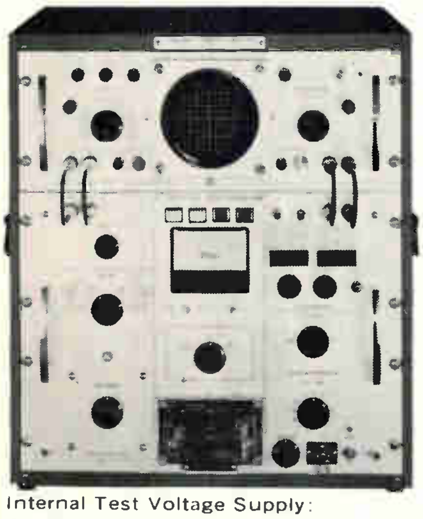
and in a wide variety of temperature ranges.

No standing. The company is negotiating with a semiconductor company to develop a handling system that will operate at diffusion-oven temperatures and, according to Lasch, "result in big differences in semiconductor device characteristics." Moving the wafers throughout the entire furnace by air would eliminate diffusion variations that result when the wafers stay at a particular spot in the furnace. Lasch says the wafers could be brought up to temperature rapidly, permitting shallower diffusion for higher-frequency operation.

In addition to the machine, called the 6604, the company is developing an etcher and a photoresist stripper that will use the air-transport mechanism. Lasch says any industry that requires transportation of parts or material through an unusual environment or requires delicate handling can use air bearings. With this technique air currents at relatively low pressure (typically 65 pounds per square inch) arrive at the transportation surface through a single row of 10- by 20-mil holes; the air ducts bend in the direction in which the part will move.

Change in direction. As air passes through the holes to the surface, its flow tends to diverge from the transportation surface of the conveyor. However, a phenomenon first described by Henri Coanda and called the wall attachment effect forces a change in the direction of flow so that the air current flows parallel to, and just above, the transport surface. In fact, a vacuum is created on the bottom of the air flow. This vacuum combined with the atmospheric pressure acting on the top of the air current deflects the flow. Semiconductor wafers are supported by the air current and move with it; the speed of parts moving along the conveyor is determined by the pressure of the flow.

The machine, which can handle 1,360 units an hour, costs $15,000. It has four vacuum chuck spindles fed from four wafer carriers, each



of which holds 25 wafers. The wafers are moved from the carriers on air bearings to the vacuum chuck, upon which they are automatically centered. The photoresist is applied and the chuck spins to provide uniform coating. When the process is finished, the wafers are moved on air bearings to empty carriers for storage and handling.

Pushbuttons on the front panel control the process.

The system comes complete with power supplies and—mounted on separate printed-circuit cards—spin-motor controls, valve drivers, and logic circuits.

Industrial Modular Systems Corp., 10440 N. Tantau Ave., Cupertino, Calif. 95014 [429]

New production equipment

Sputtering system coats 90 wafers

Both target and substrate are held vertically; coating uniformity is ±5%

A target that turns may help transform sputtering from a laboratory technique into a production-line process. Until recently, says John Flood, sales manager at the Norton Co.'s Vacuum Equipment Division, sputtering has been a low-volume operation. But now a technique to speed up this versatile method for depositing thin films has been found. According to Flood, Norton's new system handles six times as much substrate as older units.

Sputtering is a process in which high-speed electrons strike some target material and knock off flakes, which deposit on a substrate. In most sputtering systems, both target and substrate are horizontal; but everything is on the up and down in Norton's new system.

The target, a thin metal plate, is held vertically, and can be rotated during the operating cycle. So if there's a different material on each side, the operator can change

MIL spec performance...in half the space!

Type 990 miniature solid tantalums typify TRW's creative engineering. They're *designed* to fit in half the space. *Designed* to give better shock and vibration resistance. *Designed* to MIL specs. They're *designed* to be the best hermetically sealed tantalums you can buy. Values from 8.2 to 330 mfd, 6 to 35 V.

Get the TRW tantalum story on space-savers like the 990, on standard MIL types and tantalum hi rel capability. Contact TRW Capacitor Division, TRW INC., Box 1000, Ogallala, Nebraska. Phone (308) 284-3611. TWX: 910-620-0321.

TRW

Circle 215 on reader service card

the material being sputtered by turning the target. He doesn't have to shut down the system.

Norton says this feature can cut cycle time in half.

And anything that eliminates the need to take off the bell jar increases reliability. Anytime the cover is off, there's the danger of oxidizing and contaminating the film.

Five turning faces. Substrates are also mounted vertically, on a five-sided holder which can be rotated during the operating cycle.

The holder weighs 7 pounds and is conduction-cooled by water circulating through the pedestal on which the holder is mounted.

Each side of the holder frames a removable copper faceplate which has small pegs positioned to hold substrates of specific size

Target ready. A technician positions the target. On his right is the five-sided substrate holder

and shape. So when an operator wants to work on a different substrate, he switches faceplates. Plates are available that handle substrates ranging in diameter from ¾ inch to 2 inches.

The system, for example, can coat up to 90 substrates, 1 inch in diameter, in a cycle. The volume varies according to the diameter of the wafer. Norton says that the coating uniformity is ±5% over the entire area of the substrate.

The system costs $25,000 and delivery time is 8 to 10 weeks.

Norton Co., Vacuum Equipment Div., 160 Charlemont St., Newton, Mass. 02161 **[430]**

New production equipment

Bonder searches automatically

Ultrasonic machine can step back chip by as little as 0.02 inch

Locating the spot on a substrate to connect leads takes time and slows down the action on the production line.

But an ultrasonic wire bonder made by Kulicke and Soffa Industries Inc. cuts this search time in half, if the bonding pattern is symmetrical. The operator manipulates the chip until he centers the spot where one end of a wire is to be bonded; the bonder, called the 484, will find the spot where the other end is to be connected.

Easy off. The ultrasonic generator is mounted in the top part of the system so it can be removed quickly.

Kulicke and Soffa says the 484 is the first bonder with this feature, which the company calls automatic setback. The setback distance, changed by switching cams, can be set from 0.02 to 0.125 inch.

The system can bond most kinds of wire, including 0.0015-inch-diameter gold.

The ultrasonic generator itself is mounted on the top part of the system, so it can be replaced in a matter of seconds.

Kulicke and Soffa Industries Inc., Fort Washington, Pa. 19034 [431]

New Books

Bigger and better

Reference Data for Radio Engineers, Fifth Edition
ITT Federal Laboratories
Howard W. Sams & Co., $20

Here's a book that for 25 years has provided the busy engineer with fast access to equations, graphs, tables, and other data. Of previous editions, 350,000 copies have been sold. But if the background is impressive, the state of the art is even more so. For now, 12 years after the last revision, this engineer's bible has been expanded and improved.

The latest edition contains 50% more information than its predecessor, and is easier to read on its larger—about an inch all around—completely retypeset pages. And its index contains more than twice as many entries as the previous edition. For instance, the topic of microwaves, subdivided only into the subjects of links and tubes in the old edition, is now divided into 18 separate subtopics from amplification through wavelength. Just about all of the previous edition's 38 chapters have been expanded, and five have been retitled. Further, new chapters have been added on the subjects of: international telecommunications recommendations; microminiature electronics; switching networks and traffic concepts; navigation aids; space communications; quantum electronics; and reliability and life testing.

Geared to meet the needs of design and systems engineers, most of the new chapters discuss definitions and terminology before launching off into the specifics of design and application.

The chapter on microminiature electronics covers such topics as design considerations, film materials and processes, photoresist applications, packaging, and the applications of linear integrated circuits.

Another of the new chapters, the one on telecommunication recommendations, is a compendium of the major positions of two international committees dealing with telephone, telegraph, and data-transmission circuits and equip-

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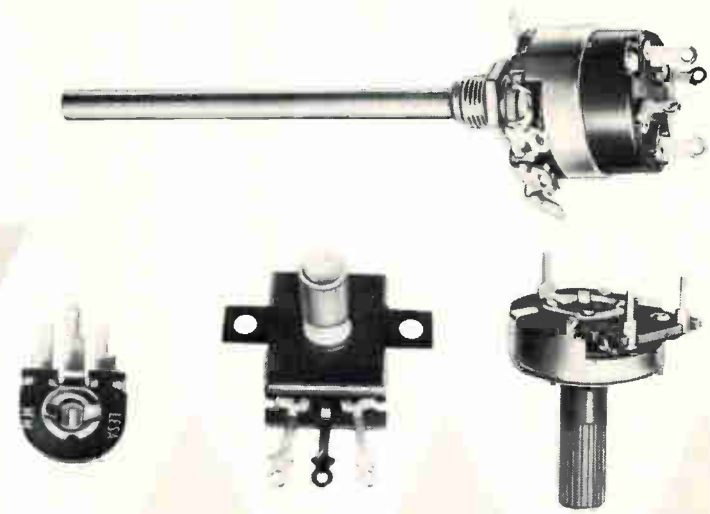

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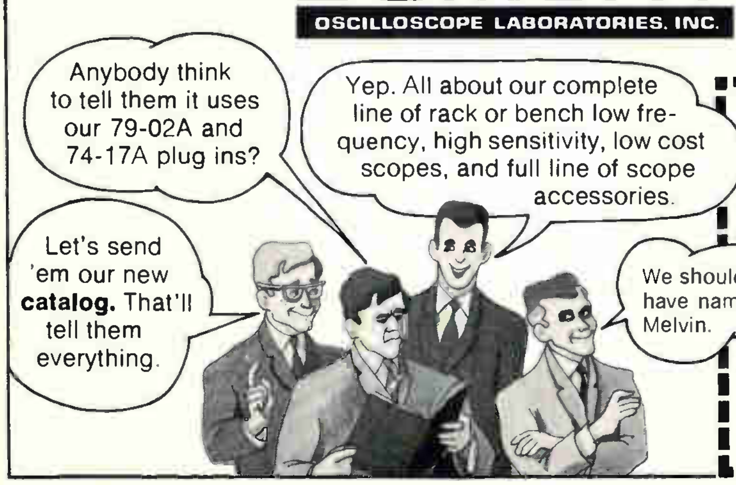

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New Books

ment. The chapter on quantum electronics covers in fair detail the different types of masers and lasers, while the chapter on space communications describes ground-to-spacecraft, spacecraft-to-ground, and spacecraft-to-spacecraft systems.

The chapter on reliability and life testing includes a summary of reliability specifications, a table on the failure rates of components, and a discussion of confidence levels and limits, distribution functions, component reliability, and the derivation of the theoretical distributions used. The switching networks and traffic concepts section describes both single and multistage switching networks and contains traffic equations and tables. And if the new chapter on navigation aids contained nothing more than its excellent glossary of navigation terms, it would be a welcome addition.

The updating of the older chapters has, in some cases, resulted in a vast expansion of the material presented. The chapter on digital computers, for example, has jumped from nine pages to 38 larger pages and even has a section on debugging computer programs. And the chapter on antennas now include a section on such frequency-independent units as log periodical and on scanning systems. New charts appearing in the chapter entitled Filters, Modern Network-Theory Design cover the relative attenuation for one- and eight-pole networks, and the delay and phase distortions of the Butterworth response shape.

A section on toroidal and ferrite-pot-core audio filter coil design has been added to the chapter on magnetic-core transformers, and the chapter that was originally called Broadcasting has been updated to include sections on CATV, instructional and color tv, and sound and video tape recording. Material on earth-space communications, line-of-sight propagation at optical frequencies, and the effect of nuclear explosions on radio-wave propagation has been included in a chapter that's been renamed Electromagnetic-Wave Propagation.

Recently published

Systems and Transforms with Applications in Optics, Athanasios Papoulis, McGraw-Hill Book Co., 474 pp., $19.50

Explores the relationship between systems and optics. Covers the general theory of systems and transforms in one and two dimensions, including singularity functions, Hankel transforms viewed as Fourier transforms, sampling expansions, and stochastic processes. Aimed at developing analytical techniques and showing their relevance in a large number of applications. For graduate students in engineering and optics.

Digital Systems Logic and Circuits, Basil Zacharov, American Elsevier Publishing Co., 160 pp., $3.95

Intended for the engineering or science student with some knowledge of electronics. Covers number systems, simplification of Boolean expressions, transistor implementation of logic operations, magnetic-core logic, and switching matrices. Describes AND, OR, and flip-flop circuits and how they perform digital computer functions.

Advanced Linear-Programming Computing Techniques, William Orchard-Hays, McGraw-Hill Book Co., 355 pp., $12.50

Geared to the needs of the practitioner. Details the dual simplex algorithm, post-optimal ranging algorithms, and parametric algorithms. Emphasis is placed on algebra and logic. Organized into definitions, theorems, algorithms, and techniques.

Geometric Optics, Allen Nussbaum, Addison-Wesley Publishing Co., 132 pp., $7.50

Simplifies the traditional algebraic approach to analyzing lens systems by using matrix techniques. Covers the theory of aberrations, and includes a few Fortran programs to show how some sample problems can be solved. College and trade school text.

Error Detecting Logic for Digital Computers, Frederick F. Sellers Jr., Mu-Yue Hsiao, Leroy W. Bearnson, McGraw-Hill Book Co., 295 pp., $15.00

Defines the logical building blocks in a computer and the kinds of failures. Develops the equations, proofs, and logic needed for detection schemes. Parity and residue checking are emphasized for arithmetic units. Includes error detection in counters, data paths, combinational and sequential logic, and memory and storage, with a final chapter on problems and checks on the system level. More than 100 references. For the engineer and researcher.

Annual Review of Information Science and Technology, Vol. 3, Carlos A. Cuadra, Encyclopaedia Britannica Inc., 457 pp., $15.00

Edited review of 1967 meeting proceedings of the American Society for Information Science. Discusses progress and cost effectiveness of information systems in such areas as education and medicine. Notes recent developments in computer graphics, medium and large scale multiaccess computer systems, and storage systems. Evaluates proposals for universal code of recorded knowledge and classification scheme for mechanized searching. Investigates language structure and its simplification.

Frequency Modulation Receivers, A.B. Cook and A.A. Liff, Prentice-Hall Inc., 527 pp., $15.00

Discusses all circuits in an fm receiver. Descriptions cover the vacuum tube, transistor, field effect transistor, and integrated circuits. Emphasizes operational aspects of fm receivers, covering both past and present practices. Each sections ends with a detailed summary and is augmented by practical sample problems. Reference for communication and broadcast engineers and an aid for service technicians.

Circle 221 on reader service card

Avoiding traps

Degradation of Gunn-effect GaAs devices
S.V. Jaskowski, M.A. Seitz, and P.H. Wackman, Marquette University, Milwaukee

Gallium arsenide has been fashioned into a variety of semiconductor devices—tunnel diodes, coherent-light emitters, bulk-effect microwave generators. In general, though, these devices don't last very long.

Marquette University's College of Engineering, in investigating this problem in connection with Gunn-effect oscillators, found that the addition of a highly doped n^+ buffer zone greatly increases longevity.

N-type, continuous-wave GaAs Gunn oscillators were used in the study. They were deposited epitaxially with a 10-to-50-micron-thick-layer of carrier concentration in the range of 10^{14} to 10^{15} per cubic centimeter.

Over a period of 18 months, conventional devices, which have a tin electrode directly alloyed to the high-resistivity n^- active region, deteriorated seriously. Specifically, the voltage threshold needed to initiate oscillation increased, power output dropped, noise increased, and the oscillation frequency declined.

The net effect of this degradation was that the devices eventually ceased to operate in any mode—pulsed microwave, quenched, pure Gunn transit time, or impact ionization. Failure was caused by two things: heat generated in the device and, more significantly, a trapping mechanism.

Heat causes realloying of the contacts into the bulk material. At the same time, atoms of tin from the electrode diffuse into the bulk material, not because of excessive heat but because the atoms tend to move toward a region of low concentration. The tin atoms create donor and acceptor levels in the forbidden gap of the GaAs—traps that permanently remove carriers from the conduction band. In time, enough traps are created so that the number of available carriers drops below the level critical for Gunn oscillation.

But, if a highly doped n^+ buffer zone is placed between the bulk material and the electrode, the traps can't get into the active region. All of the devices with this buffer-zone design were still operating when the Marquette tests ended.

Texas Instruments is now using this new design for all their bulk-effect GaAs devices. It's been found that just about any kind of contact material can be used.

An extra dividend is that the buffer-zone devices are less susceptible to burnout. In the conventional design, the contact, alloyed directly on the active layer, produces a thin high-resistivity region. If it's biased in the wrong direction, the field intensity is enough to burn out the device. The buffer, however, completely eliminates this effect.

Presented at the Seventh Annual Reliability Physics Symposium, Washington, Dec. 2-4, 1968.

Groovy projection

A new approach to color television display and color selection using a sealed light valve

William E. Good
General Electric Co.
Syracuse, N.Y.

A sealed light source using a single electron gun and raster can improve color fidelity and brightness in a television projection system. Unlike other projectors, which require either two or three sets of guns and rasters to produce a color image, the new system produces the red, green, and blue picture elements simultaneously eliminating registration and convergence problems.

The basic system contains a light source, a set of input slots, a fluid surface, a schlieren lens, output bars, a projection lens, and an electron gun. Grooves or diffraction gratings written within each picture element represent color and brightness. To minimize interactions, the red and blue gratings must be written at right angles to the green grating.

A reflector collects as much as half the light from a 500-watt sealed-beam xenon light source. The sealed construction protects the optical surface of the light source from the arc.

The associated circuitry is no more complex than that of a conventional color tv monitor without the deflection yoke and convergence circuitry. Even so, the primary colors produced are very close to those of a phosphor-type color tube. The projector is capable of a 50-to-1 contrast ratio, with a resolution limited only by the 525-line National Television System Committee standards. The color display can go up to 6 by 8 feet, with front or rear projection.

Presented at NEC, Chicago, Dec. 9-11.

Big waves

Amplification of magnetostatic surface waves by interaction with drifting charge carriers in crossed electric and magnetic fields

Ernst Schlomann
Raytheon Research Division,
Waltham, Mass.

Magnetostatic waves propagating in ferrites are an unusual type of electromagnetic radiation. Most of the energy density is associated with the magnetic field, and almost none with the electric. These waves are used in microwave-frequency delay lines because their phase and group velocities are much smaller

Technical Abstracts

than those of ordinary electromagnetic waves.

One way in which the magnetostatic waves propagate is along the surface of a magnetic crystal. It's possible to amplify these surface waves, instead of just allowing them to pass through passively as in a delay line. In a microwave delay line, this gain reduces the insertion loss.

Amplification is achieved by allowing the waves to interact with charge carriers drifting through a semiconducting layer placed in contact with the crystal. A d-c voltage is applied to the semiconductor in the direction of propagation. And a d-c magnetic field is set up in the plane of the crystal surface perpendicular to the direction of propagation.

Low-loss magnetic materials, such as yttrium iron garnet, can be used with high-mobility semiconductors such as indium antimonide. At room temperature, a carrier density of 2.5×10^{17} per cubic centimeter and a semiconductor film thickness of 3,000 angstroms produces a net gain when the d-c current per unit width of the film exceeds 2.2 amperes per centimeter. This corresponds to a dissipation per unit area of approximately 75 watts per square centimeter.

Presented at the 14th Annual Conference on Magnetism and Magnetic Materials, New York, Nov. 18-21.

Light manufacturing

The laser as a manufacturing tool for the semiconductor industry
R.M. Lumley and S.S. Charschan
Western Electric Co.
Princeton, N.J.

Feasibility studies of using lasers in semiconductor production have encompassed areas such as mask generation and inspection, welding, component trimming, scribing, substrate separation, and thin-film shaping.

Resolutions of a micron or less should be possible when a laser is used to generate a photomask. One technique generates a mask by moving a thin film under a laser beam and selectively vaporizing areas of the film by turning the beam on and off. Another method exposes a photographic film with the laser radiation. Or a laser beam can heat and vaporize a thin-film material in ambient, rather than vacuum, conditions and deposit it on an adjacent substrate.

Photomasks can be quickly and accurately inspected with a laser technique called spatial filtering. The mask is illuminated by laser light; if the mask is perfect and the light falls upon the proper spatial filter, no light will pass through. However, if the mask is imperfect, the spatial filter blocks portions of the diffraction pattern that correspond to the pattern of the perfect mask; light from portions that aren't identical passes through. This light can be used to determine the number and type of defects in the mask.

Lasers can be used for microwelding if their beam power densities are controlled so that the heat will melt but not vaporize. Many dissimilar metals can now be welded without physical contact. Such microwelding has been used in bonding beam-leaded integrated circuits.

It's also feasible to trim thin-film and other components with a laser. Pulsed ruby lasers are currently being used to trim deposited carbon resistors through glass envelopes. A pulsed argon-ion laser is about to be used to adjust IC's after the devices have been encapsulated and while they're operating.

Great promise is being shown in separating materials, especially brittle ones, with a laser beam. Laser beams are scribing semiconductor wafers at up to 60 inches a minute, about as fast as diamond dies can scribe silicon. And because there's no pressure on the material, the technique should give more uniform results with much less breakage.

Thin-film circuits can be separated from their substrates by using a laser for controlled fracturing. This technique relies on surface heating of the material to generate stresses strong enough to fracture it.

Presented at NEC, Chicago, Dec. 9-11.

Power supplies. Sorensen Operation, Raytheon Co., Richards Ave., Norwalk, Conn. 06856, has released a 12-page illustrated catalog covering 173 d-c power supplies, a-c line voltage regulators, and high voltage d-c power supplies.
Circle **446** on reader service card

Industrial control. Diversified Electronics Inc., P.O. Box 6231, Evansville, Ind. 47712, has published a catalog on industrial control products consisting of voltage band monitors, phase sequence and phase loss monitors, and a phase indicator. **[447]**

Photocell-lamp modules. Clairex Electronics Inc., 1239 Broadway, New York 10001. A 12-page bulletin covers an expanded line of Photomod protocell-lamp modules. **[448]**

Reed switches. Gordos Corp., 250 Glenwood Ave., Bloomfield, N.J. 07003. Detailed specifications for a full line of magnetic reed switches are given in an eight-page catalog. **[449]**

Laser components. Oriel Optics Corp., 1 Market St., Stamford, Conn. 06902. A four-page brochure offers specifications and prices on a wide line of 10.6-micron optical components for use with CO_2 lasers. **[450]**

High-impact resin. Isochem Resins Co., Cook St., Lincoln, R.I. 02865, has published a technical bulletin on Isochemrez 408SA high-temperature, high-impact resin, which is now fortified with Super Airout air release agent. **[451]**

Automation center. Microsystems Technology Corp., 203 Middlesex Turnpike, Burlington, Mass. 01803, offers a brochure detailing services, capabilities, and equipment of its computerized design and production automation center. **[452]**

High-voltage wire. ITT Wire and Cable Division, Pawtucket, R.I. 02862. A four-page brochure describes the high-voltage and high-temperature capabilities of the company's silicone wire. **[453]**

Data generator. Datapulse Division, Systron-Donner Corp., 10150 W. Jefferson Blvd., Culver City, Calif. 90230. Advance specifications bulletin 214 covers model 214 data generator, a 13-channel pattern generator with a 10-Mhz stepping frequency. **[454]**

Transistor testing. Teradyne Inc., 183 Essex St., Boston 02111, has available a 12-page illustrated brochure on its T217 automatic transistor test instruments. **[455]**

Shaft hardware. James Millen Mfg. Co., 150 Exchange St., Malden 48, Mass. 02148. An eight-page bulletin, listing both standard-size and miniature shaft hardware, includes such items as dials, knobs, couplings, shaft locks, and shaft bearings. **[456]**

Nickel cadmium batteries. Nife Inc., 21 Dixon Ave., Copiague, N.Y. 11726. Complete specifications for a line of long-rate nickel cadmium alkaline batteries are covered in bulletin AG-424. **[457]**

Adjustable toroids. Vanguard Electronics Division of Wyle Laboratories, 930 W. Hyde Park Blvd., Inglewood, Calif. 90302. Applications and operating characteristics of miniature high-frequency adjustable toroids are described in a specifications brochure **[458]**

Tiny display lights. Pinlites Inc., 1275 Bloomfield Ave., Fairfield, N.J. 07006, manufacturer of microminiature digital display readouts and tiny incandescent lamps, has published its 1969 catalog. [459]

Heat sink. Astrodyne Inc., 207 Cambridge St., Burlington, Mass. 01803. Bulletin NC-524 covers a heat sink with low thermal resistance and side-panel mounting. [460]

Metal-forming service. Hydroforming Division, Perfection Mica Co., 740 Thomas Dr., Bensenville, Ill. 60106, has issued catalog H-68 describing a new low cost ferrous and nonferrous metal-forming service with short delivery cycles. [461]

Aluminum electrolytic capacitors. Sangamo Electric Co., Pickens, S.C. Axial lead, aluminum electrolytic capacitors that are said to make tantalum foil capacitors obsolete are described in bulletin 2240A. [462]

Microwave components. Kevlin Mfg. Co., 26 Conn St., Woburn, Mass. 01801. A 20-page catalog covers solid state switches, miniature coaxial hybrids, couplers and mixers, and rotary couplers, plus a line of associated microwave components. [463]

Micrologic cards. Control Logic Inc., 3 Strathmore Rd., Natick, Mass. 01760, has available a 44-page catalog dealing with 5-Mhz micrologic circuit cards and accessories. [464]

Piezoelectric transducers. PCB Piezotronics Inc., 3311 Walden Ave., Depew, N.Y. 14043, offers a catalog illustrating and describing a line of piezoelectric transducers for measuring dynamic pressures. [465]

Interval timers. Hi-G Inc., Spring St. and Rt. 75, Windsor Locks, Conn. 08098. Bulletin 161 covers three series of interval timers that include both solid state and electromechanical output configurations. [466]

Electromagnetic shielding. Emerson & Cuming Inc., Canton, Mass. 02021, has issued a folder on Eccoshield r-f shielding materials, showing a wide variety of approaches to shielding requirements. [467]

MOS shift registers. Texas Instruments, 13500 N. Central Expressway, Dallas 75222, offers a 20-page application report that describes MOS static shift registers and tells how to use them in bipolar logic systems. [468]

Digital servo. Theta Instrument Corp., 22 Spielman Rd., Fairfield, N.J. 07006. An instrument servomechanism with digital outputs is described in six-page bulletin 66-11D. [469]

Semiconductor screening. Associated Testing Laboratories Inc., 200 Rt. 46, Wayne, N.J., 07470, has available two-page bulletin T-18 giving a detailed description of the capabilities of its new semiconductor screening facility. [470]

Bench etcher. Chemcut Corp., 500 Science Park, State College, Pa. 16801. Data sheet E-16 contains features and technical specifications of bench-type model 315 conveyorized horizontal spray etcher. [471]

Signal averager. Fabri-Tek Instruments Inc., 5225 Verona Rd., Madison, Wis. 53711. A four-page catalog explains what signal averaging is and how it works and describes the low-cost model 1010 signal averager. [472]

Stepping motors. Computer Devices Inc., 11925 Burge St., Santa Fe Springs, Calif. 90670, has prepared a 16-page brochure describing state-of-the-art stepping motors. [473]

Data acquisition systems. Datatron Inc., 1636 E. Edinger Ave., Santa Ana, Calif. 92705. A technical brochure describes two recently introduced analog/digital data acquisition and recording systems. **[474]**

EMI measurements. Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304. A 26-page application note discusses the principles of electromagnetic interference measurements and shows how modern calibrated spectrum analyzers can be used as tuned r-f microvoltmeters with visual display to speed these measurements. **[475]**

Instrument modules. Monsanto Electronic Instruments, 620 Passaic Ave., West Caldwell, N.J. 07006, has issued a technical bulletin on its fourth-generation series 100 system-compatible instruments and the series 500 accessories. **[476]**

Vhf tuner. Telefunken Sales Corp., South St., Roosevelt Field, Garden City, N.Y. 11530. Brochure 6701134 describes a television vhf tuner using variable capacitance diode tuning. **[477]**

Connectors. AMP Inc., Harrisburg, Pa. An expanded series of rectangular pin and socket connectors for rack and panel/cable applications is described in 52-page catalog No. 940. **[478]**

Circulators and drivers. E&M Laboratories, 7419 Greenbush Ave., North Hollywood, Calif. 91605. High-speed switchable circulators and drivers are described in a four-page short-form catalog. **[479]**

Cable assemblies. General Reliance Division, General Relay Corp., 20 Mercer St., Dover, N.J. 07801, has available a four-page, two-color booklet entitled "Custom Cable and Molded Cable Assemblies." **[480]**

Echo suppressor. Lenkurt Electric Co., 1105 County Rd., San Carlos, Calif. 94070. A four-page brochure describes the 931C echo suppressor, which eliminates the echo encountered in satellite, transoceanic, and transcontinental circuits. **[481]**

MOS integrated circuits. National Semiconductor Corp., 2975 San Ysidro Way, Santa Clara, Calif. 95051, offers a report describing its quality and reliability program, including recent test results on its integrated MOS products. **[482]**

Industrial static switching. Jordan Controls Inc., 5607 W. Douglas Ave., Milwaukee 53218, has released a 66-page

New Literature

handbook on industrial static switching techniques and applications. [483]

Microwave filters. DeMornay-Bonardi Division of Datapulse Inc., 1313 N. Lincoln Ave., Pasadena, Calif. 91103. Technical data sheet DB-282 describes waveguide bandpass and band-reject filters. [484]

Wire and cable. Garrett Wire & Cable Corp., 24 Central Dr., Farmingdale, N.Y. 11735, has released a 36-page catalog listing nine major wire and cable groups and related products. [485]

Dipping material. Isochem Resins Co., Cook St., Lincoln, R.I. 02865, has released a data sheet on Clear Dip, a dipping material that has optical clarity, excellent thixotropy, and long pot life. [486]

P-c connectors. U.S. Components Inc., 1320 Zerega Ave., Bronx, N.Y. 10462. An illustrated eight-page catalog shows newly developed connectors in two-unit, grid-spaced, printed-circuit designs. [487]

IC terminology. Sylvania Electric Products Inc., 100 First Ave., Waltham, Mass. 02154, has published a pocket dictionary for most of the terms used in the integrated-circuit field. [488]

Silvered-mica capacitors. Sprague Electric Co., 35 Marshall St., North Adams, Mass. 01247. Bulletin 1010A covers a line of dipped single-film, silvered-mica capacitors for entertainment and commercial equipment. [489]

Brushless d-c motors. Siemens America Inc., 350 Fifth Ave., New York 10001. A four-page brochure describes a line of miniature brushless d-c motors with solid state controls. [490]

Rotary switches. Electro Switch Corp., King Ave., Weymouth, Mass. 02188. Bulletin 30 covers the series 24 solenoid-drive rotary switches for remote control up to 30 amps, 600 volts. [491]

Corona detectors. Hipotronics Inc., Brewster, N.Y. 10509. A two-page brochure discusses corona detectors designed for wire and cable industry applications and over-all industrial use. [492]

Portable vibration meter. Reliance Electric Co., 24701 Euclid Ave., Cleveland 44117, has issued data sheet P-2524 on the model 638 vibration meter for in-plant measurement. [493]

Discrete devices. Fairchild Semiconductor, 313 Fairchild Dr., Mountain View, Calif. 94041, has published the 1969 catalog giving a complete listing of its discrete devices, including diodes, FET's, and power transistors. [494]

It's one thing to make a low cost digital tape unit, it's something else to make a low cost digital tape unit without compromise. Tally did.

From bare bones to full dress, Tally's new low price Series 4000 computer compatible digital tape units were built from the ground up with no compromises in design.

Series 4000 digital tape units are available and in production now. You can order the transport only with servo and capstan electronics. Or you can order the full dress version with read/write data electronics and complete interface logic.

Performance? Just Check All these Key Features.

• High speed rewind with servo controlled tape tension (another no compromise) takes 1½ minutes for a full 10½ inch reel of tape.

• Compact design handles full 10½ inch reels yet uses only 26½ inch panel space in a standard 19 inch rack. Hinged transport for easy access and front-end service.

• DTL logic or 7 and 9 channel formats. Special read only version can handle both formats without head change.

• Tape deck constructed from a rugged temperature stabilized precision casting. (Unique in the low cost field.)

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Electronics index

Volume 41, 1968

NOTES: EA (Electronics Abroad); ED (Editorials); EI (Electronics International); ER (Electronics Review); NP (New Products)

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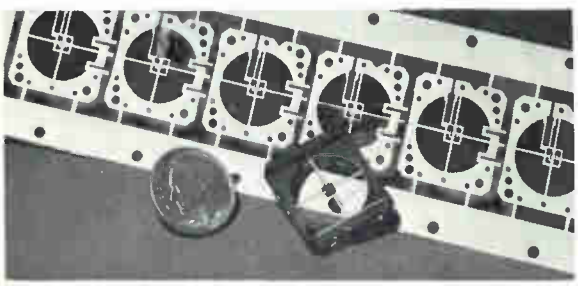

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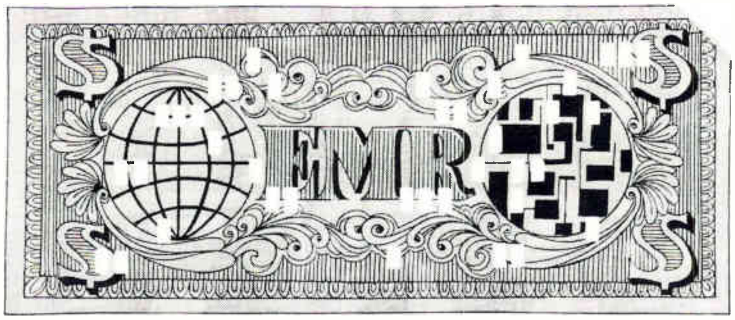

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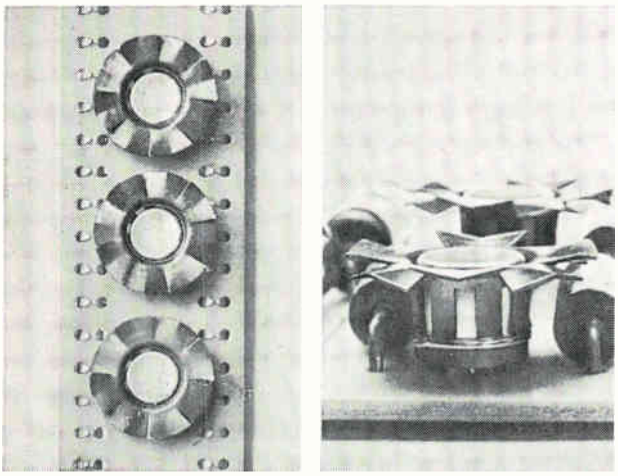

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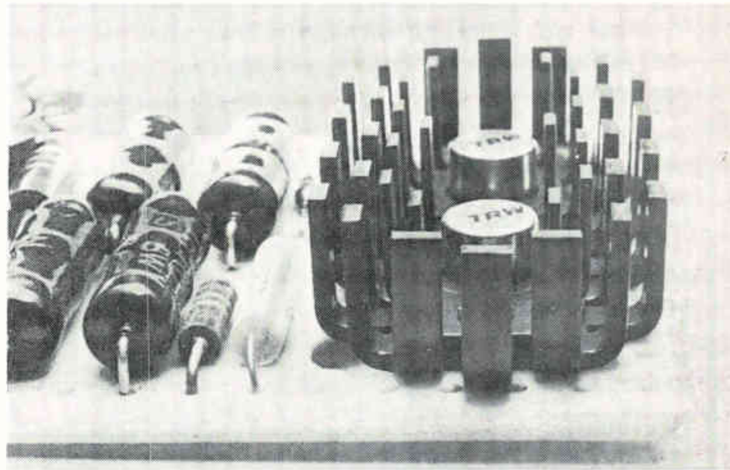

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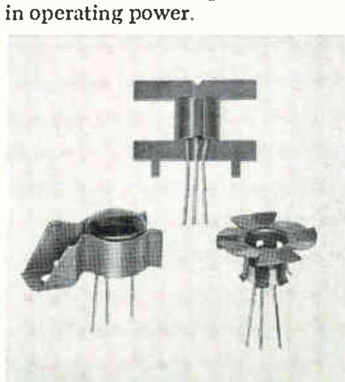

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International Newsletter

January 6, 1969

Soviets slate show for foreign IC gear

About a half-hundred U.S. firms will soon receive an unusual invitation—a bid to show integrated circuits and IC production equipment at a special exhibition in Moscow's Sokolniki Park this spring. **All the major semiconductor producers can expect invitations, say Soviet sources.**

The show—Mashintegralschema—reflects a new tack in Soviet procurement of hardware from Western countries. Unlike normal Moscow trade shows, **the IC Salon will be limited to invited foreign companies and Soviet specialists in semiconductors.** The purpose is to bring foreign sellers and Soviet buyers together in relatively quiet circumstances, something that can't be done in the bustle of a show open to the public.

Both the Soviet Chamber of Commerce and Western businessmen (few Americans were asked) hailed the first "invitation-only" salon—held for automotive equipment in November. **The IC salon, though, could come a cropper because of the U.S. embargo on strategic materials.**

Budget hangups threaten ELDO

The staff of ELDO is operating under a pall of gloom once again because of the failure of the organization's council to come up with a budget. Said one staff member after the latest Paris council meeting: "We're right back where we were before the November Bonn meeting" at which a $626 million austerity budget was outlined. Council president General Robert Aubiniere went even further and declared that if a decision wasn't forthcoming before the end of February, ELDO might not be able to continue in its present form.

The failure of the Paris meeting was underlined by the reluctance of Britain and Italy to approve the austerity proposal. The British said they could afford only $24 million of the $40 million they were assessed; the Italians balked at the elimination of the Europa rocket's made-in-Italy apogee motor as part of the austerity program.

Germans ponder computer utility

The West German Post Office, already the largest user of computers in Western Europe, is taking a hard look at the feasibility of a nationwide data-processing network. Intended mainly for small companies that can't afford their own computers, **the proposed utility would spot computers in industrial centers and tie subscribers into them over existing lines.**

The agency is expected to have details on the extent and cost of the computer grid worked out sometime this spring. The computers for the grid, presumably, would be independent of the 38 third-generation machines that the post office now has in service at 10 data-processing centers and money-order-handling facilities around the country.

Plessey may become UK leader in NC

Rebuffed in its bid to take over the giant English Electric Co., the Plessey Co. has been looking for strong, small companies to take into its fold. Apparently one of the **first will be Controls and Communications Ltd., a $10.5 million firm particularly strong in numerical controls and radio communications. Insiders say a merger between the two firms is an almost-sure thing.**

Picking up C&C apparently would move Plessey up into the top spot among British NC producers, now led by Ferranti Ltd. Although these companies don't divulge their NC business volume, market watchers figure Plessey and C&C together account for more than half of NC sales in the UK.

The merger is the sort of thing that the Wilson Government and its Industrial Reorganisation Corp. have deemed good for Britain and may even be speeded with some IRC money. **Nearly all of Plessey's NC hardware is made under a license from Bunker-Ramo; C&C, by contrast, developed its own designs.**

Rx for overtalk: cable the sea

Nippon Telegraph and Telephone Public Corp. may enlist submarine cables in its effort to keep up with Japan's fast-growing communications demand.

The government-owned carrier, which runs the world's densest microwave-link network, will put a multichannel sea cable into service next September between Muroran and Mori, both on Uchiura Bay on Hokkaido, the northermost main Japanese island. The 22.5-mile link will have a repeater about every 3¾ miles. **NTT says the cable, with 900 channels, will set a world record for submarine cable capacity.**

If the Muroran-Mori link passes muster, NTT intends to switch aggressively to submarine cables for domestic communications. Most of the country's population is concentrated on the coast and the underwater links avoid costly cable-laying in the mountainous countryside.

Toshiba tools up for NC venture

Fujitsu Ltd., Japan's leading producer of numerical control equipment, almost surely will face formidable new competition this year.

Toshiba Machine Co., currently a Fujitsu NC customer, plans to set up a joint venture with Kearney and Trecker, an American machine-tool producer, to build Milwaukee-Matic machining equipment. The new company intends to use domestic NC's in its machines but **Fujitsu might see most of the business going to Toshiba Machine's parent firm, Tokyo Shibaura Electric Co. (Toshiba), which is thinking about a deal with General Electric that would give it the right to build GE's numerical control systems in Japan.** Many Milwaukee-Matics come fitted out with GE controls.

Toshiba Machine hopes to get government approval of the joint venture by April or May. The new company would import Milwaukee-Matics until a plant can be built. Mitsui and Co., one of Japan's largest trading companies will hold a 5% share in the venture. Toshiba Machine will hold 45% and K&T 50%.

Addenda

West German engineer Georg Greger, inventor of the Lectron instruction kit marketed in the U.S. by Raytheon, has **three other kits nearly ready for production: digital circuitry, a Geiger counter, and a low-voltage oscilloscope.** Raytheon will build and sell all three under license . . . Norway's small but vigorous electronics industry picked up a new company this week, Telox A/S. The company will specialize in communications and navigation systems and will **team up with Hughes Aircraft, Sweden's L.M. Ericsson, and Denmark's Terma Elektronisk Industri on the Scandinavian satellite communications ground station** . . . Matsushita Research Institute reports it has developed light-emitting gallium arsenide diodes with an external efficiency of 2%. **The figure was obtained at a device current of 5 milliamps and matches the performance reported earlier by Bell Telephone Labs.**

China poised for 'great leap' into the forefront of science

Swedish engineer-diplomat reports strong technological progress, but says pace of production lags far behind scientific achievements

The natural habitat of the China-watcher is Hong Kong, but the species can be found in almost any capital in the world. Stockholm, for instance, is the present headquarters of Jon Sigurdson, an electronics engineer who's been an observer of Chinese science ever since he served at Sweden's embassy in Peking in the mid-sixties.

Sigurdson last month had much good to say about Red Chinese science. In a report published by Sweden's prestigious Royal Academy of Sciences, he predicted that China would move up into the "front line of science within the foreseeable future." But he noted that a place in the forefront of scientific progress does not insure a place among the leaders in industrial production.

Sigurdson hammers home that point with some facts about computers. "A breakthrough was scored in large, fast models around 1965," Sigurdson says, "and the computer industry in China is now, at most, five years behind that of Western countries." But he guesses that production is perhaps only a dozen machines a year—although precise figures can't be had.

Inference. Little is known about the country's most modern machine, except that it's a transistorized digital computer and presumably represents a real advance over the earlier Chinese computers, which were versions of Russian-designed analog machines. Even more significant, Sigurdson points out, is the fact that the latest computer indicates a Chinese components industry sophisticated enough to produce quality hardware.

The machine's transistors are germanium, the material most commonly used for semiconductors in China. But the Chinese are up on their silicon technology, too. When Sigurdson wrote his report last year, he noted that production of integrated circuits had not yet begun. But he now believes the Chinese have started turning out IC's.

In fact, Sigurdson's view is that the minions of Mao can produce almost anything. He says the Chinese will "definitely" be able to launch a satellite within a decade. But again he points out that the ability to build one unit doesn't mean the builders can organize series production.

Factories first. At the moment, Sigurdson says, the emphasis in China is on developing process-control equipment for chemical and

Teacher's helpers. "Acting in accordance with the teachings of Chairman Mao" (with some additional tutoring by scientists from the University of Sydney, Australia), Chinese technicians are building a 40-dish radiotelescope that stretches 1.9 miles.

petrochemical plants. And there's a push to get electronic controls into the metal-working industries; but this effort, Sigurdson says, is "still in its beginning stages."

Another sector that's been getting particular attention is telecommunications, and Chinese electronics engineers have been having a fling at instrumentation. One notable achievement: an electron microscope with a magnification of 200,000.

And the Chinese have under construction what Sigurdson says is "one of the best" radiotelescopes anywhere. Made up of a 1.9-mile-long chain of 40 antenna dishes with diameters between 20 feet and 30 feet, the telescope will be able to track celestial bodies over a 12-hour period.

The Chinese are getting some help on the radiotelescope from scientists from Australia's University of Sydney. But dependence on outsiders has been on the wane since the onset of the Cultural Revolution in 1966. For all the havoc the still-continuing revolution has wreaked on the country's economy, it has also brought new respect for Chinese scientific achievements and has forced foreign-trained scientists to concede that Chinese-made hardware has some worth, Sigurdson feels.

Looking out. Despite the stress on home-grown technology, Peking keeps a close watch on developments abroad. At the city's Institute of Scientific and Technical Information, there's a special section that collects catalogs of foreign manufacturers. In addition, the institute gets more than 7,000 foreign technical and scientific publications, and a great deal of this material is translated and distributed to the Chinese technological community. In 1965, for example, the Chinese published 262 books on electronics, and 40 on automation.

The Chinese still import many advanced instruments—particularly from Japan and West Germany. And despite American efforts, some U.S.-made equipment slips into China.

This bootleg instrument business is on the decline, Sigurdson thinks. Over the past 18 months, Japan's Ministry of International Trade and Industry has been squeezing the flow, presumably at the behest of Washington. Because of this, however, there's been a switch in Japan toward exports of know-how, and small groups of Japanese experts have been going to China recently to train engineers and technicians there.

Great Britain

Schools systems

Pity the poor Loch Ness monster. It may be on the way to dropping in status from an infamous mystery to just another unusual sea creature.

If it does, much of the credit—or blame—will go to a research team at Birmingham University and the digital sonar it has developed. In initial tests, the sonar picked up in the deep Scottish lake targets too big and too fast to be ordinary fish. One, for example, checked out as several yards long and was moving 18 miles an hour along the range axis—all the while diving at about 450 feet a minute.

And if the Birmingham sonar could be bad news for the Loch Ness monster, it should be even worse for herring and other fish that school relatively near the surface. The sonar was conceived mainly to ferret them out; most fish-finding sonars search straight down to the bottom.

The researchers worked out their digital-sonar scheme to get around the expensive analog circuitry required for "within pulse" sonars. In these types—the first sonars with a wide, out-front scan fast enough to detect schools of fish—the outgoing beam is as wide (say 60°) as the sector to be scanned. Echoes are picked up on an array of transducers, and the phase of signals from each element is shifted rapidly to determine the bearings of the sound echoes. The entire sector covered by the beam can thus be scanned electronically during the return-pulse duration.

The Birmingham researchers, led by David Creasey, worked their variation on this basic scheme by putting into hardware an idea of Donald Nairn, now with the Admiralty: use digital computing techniques, rather than phase shifting, to figure the bearing of echoes picked up on an array. After the successful tests in the Loch Ness, the experimental system has been taken out to sea for further tryouts. Along with possible monsters, the sonar resolved in bearing and range a 1-inch sphere at 50 yards and a 7-inch sphere at more than 200 yards. At the same time, the sonar picked up the edge of the loch, more than 2 miles away. Creasey says no conventional sonar can match this performance.

Half-dozen. The Birmingham sonar operates at 47.5 kilohertz and scans a 60° sector with seven transducers spaced about one wavelength apart. Phase differences between echoes arriving at adjacent transducers are measured and the six measurements used to make sure the incoming signal is valid and to determine its bearing.

Signals from the transducers are first amplified and then applied to gates. The positive-going zero-crossing of the amplifier output for transducer number one, for example, opens gate number one, and the same condition at amplifier number two closes it. Thus the six gates are switched on and off successively as the echo moves along the array.

How long each gate stays open depends upon the phase difference between signals at adjacent transducers. A count of the time a gate stays open is made by means of a 6.08-megahertz clock pulse used to quantize the time into one of 128 levels. The level is fed to a digital counter, which stores it.

On the average. To make the validity check, each set of six quantized gate samples stored in the counters is averaged and each sample compared to the average. If the sum of the deviations lies below a preset threshold, the set is accepted. When three successive sets are accepted, the value—whose magnitude depends on the bearing of the incoming signals—is fed to a cathode-ray tube display. It takes about 250 microseconds to process three sets of samples, so the duration of the sonar pulse must be at least this long.

The digital technique, Creasey concedes, has a major drawback compared with an analog "within pulse" system. Only the target returning the strongest echo is displayed by the digital sonar, but analog systems can pinpoint several targets within their scan sectors. But Creasey is certain that the system's potentially lower cost—the components for its digital circuits cost less than $500—more than offsets the drawback. The cost of logic packages is dropping so fast, he points out, that the digital sonar one day could be built for a price fishermen will pay.

West Germany

A lighter contact

Once they're up in orbit, the solar cells that power satellites are riding dry as well as high, making any protection against ground humidity just wasted weight.

Most cells do, in fact, pack some spare avoirdupoids: a layer of solder to protect the contacts—a layer of titanium and a layer of silver deposited on the photovoltaic silicon—against electrochemical corrosion that can occur when the silver and titanium are next to one another in a humid atmosphere.

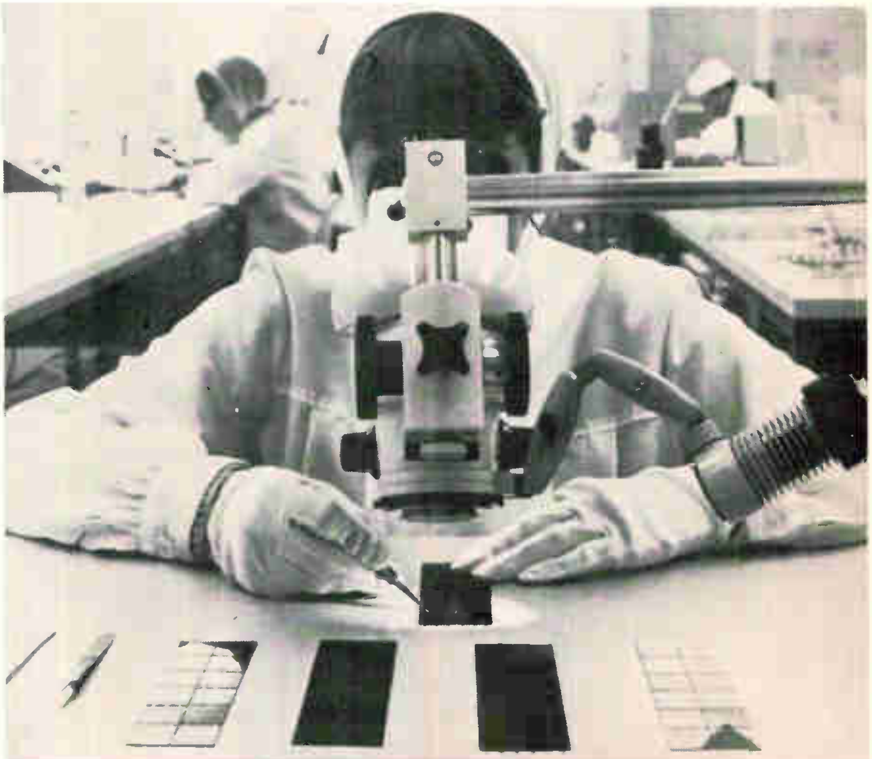
To be sure, solderless cells are fabricated and stored for long periods in relatively dry areas like Southern California. But if the cells are destined for a satellite slated for a Cape Kennedy launch, they need elaborate safeguards against the moisture-laden sea breezes until the satellite is up and away.

A new and simple safeguard against humidity, however, has been worked out by AEG-Telefunken at the behest of the European Space Research and Technology Center (Estec) at Noordwijk, the Netherlands, where it's damp. Telefunken's technique: put down a layer of palladium between the titanium and silver layers. The palladium layer shifts the electrochemical potential between the titanium and silver layers to a range where the titanium, which ordinarily corrodes, doesn't.

Hot and cold. In laboratory tests, the new solderless cells have worked without losing any efficiency for 600 hours at temperatures to 90°C and humidities up to 100%. Furthermore, the cells still can convert photons into electrons after exposure to temperatures of 400°C. This suits them particularly for deep-space missions, where temperatures are higher than for earth orbits. Cycling between −196°C and +150°C doesn't faze the cells.

What's more, thermocompression bonds or resistance welds can be made on the new contacts; both are better than soldering. In the solderless cells, a tear strength greater than 700 grams is achieved for a bond area measuring only one-third millimeter square. This small bonding area greatly reduces the temperature stresses in solar-cell contacts. Better still, the bonds or welds point to considerable savings in fabrication costs, compared with soldering, although Telefunken still hasn't figured out how much the savings might be.

One, two, three. A typical solderless solar-cell contact is made by successively depositing onto the cell's silicon surface a 350-angstrom film of titanium, a 50- to 200-angstrom layer of palladium, and finally a 5-micron layer of silver. These three layers are put down in one evaporation run with the silicon substrates at temperatures near 150°C. No special equipment or techniques are needed for the palladium, so the advantages of this trio of layers can be had using equipment that's already around.



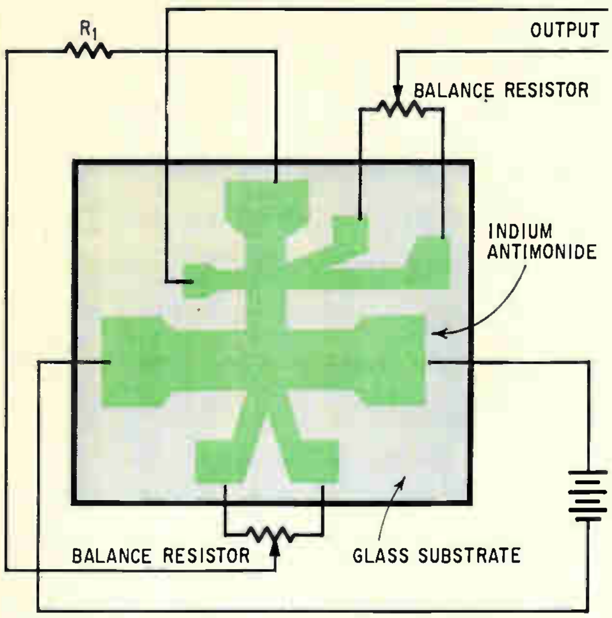
Cell block. Technician at AEG-Telefunken checks connections on plates of solar cells made with solderless contacts.

Japan

On the square

There's long been a need for a simple device that can square or cube an analog input function, and a way to meet this need has been found by the Denki Onkyo Co.

What Denki has done is build a sort of functional integrated cir-



Bootstraps. Hall voltage developed across horizontal arm drives current through vertical arm, whose Hall voltage thus becomes a function of the square of the magnetic field.

cuit—a slice of single-crystal indium antimonide on a very thin glass substrate. The InSb is shaped to form a multiple Hall element, and the interaction of the Hall currents and voltages in effect multiplies by itself the value of the input, a magnetic field.

Straightforward. Unlike most new bulk semiconductor devices, Denki's functional IC is easy to understand. The square-law version combines a pair of Hall elements at right angles to one another [see diagram]. One is fed with a constant-current power supply and thus generates a Hall voltage when there's a magnetic field applied. This Hall voltage drives current through the second Hall generator. But it, too, lies in the magnetic field, so its output voltage is proportional to the square of the applied field.

Higher-order functions can be had by repeating the process. Denki already has cubic-law circuits, obtained by using the output of the second Hall generator to drive current through a third. The precision of the squaring units is about 0.2% if the magnetic field is kept below 3 kilogauss. For cubing units, the figure is 0.2% with the same proviso. And Denki thinks satisfactory levels of precision are possible with higher-power units.

To fabricate the functional IC, Denki cements a 6-micron-thick slice of single-crystal InSb to a glass substrate 100 microns thick. The Hall-generator pattern is then etched into the InSb using conventional photoresist techniques.

Small gap. The thin glass substrate keeps the air gap in the magnetic circuit small and thus helps solve one problem that pops up when the devices are put to work in practical circuits—getting adequate sensitivity. The narrowness of the air gap between the InSb and magnetic field partly compensates for the loss in sensitivity that goes with a large load resistance. The over-all circuit needs this resistance to make negligible the changes in resistance caused by the magnetostrictive effect of the Hall elements upon one another.

Another source of trouble is the voltage imbalance that develops if the voltage takeoff contacts aren't directly opposite one another. Denki zeroes this out by means of a split contact with a tapped resistance across it.

Gunn for hire

Many of the world's major semiconductor producers have announced with considerable fanfare during the past year that they were ready to sell "commercial" Gunn-effect diodes. But there are conspicuous absentees from the list of Gunn-oscillator houses; until last month Hitachi Ltd. seemed to be one of them.

The company should, however, have been on the list long ago. While its competitors were readying themselves to peddle Gunn diodes, Hitachi was using them as local oscillators in television-relay links built for Nippon Hoso Kyokai, the Japan Broadcasting Corp. Hitachi says the diodes have operated continuously for 8,500 hours at 13 gigahertz. Rated power output is 50 milliwatts.

Achievers. The company's engineers say the diodes have an edge over reflex klystrons, the tubes generally used for the local oscillators in K-band microwave links. The freqency deviation of the diodes caused by changes in temperature, for example, is only 160 kilohertz per degree Centigrade at 13 Ghz.

They also show better linearity for frequency modulation than the reflex klystrons, whose frequency swing is usually 20 megahertz per volt. With a varactor diode biased at 4 volts modulating the Gunn diode, this sensitivity is 30 Mhz/volt. It's even better with a diode bias of 6 volts.

The Gunn-diode local oscillators are fabricated from gallium arsenide with impurity levels of about 10^{15} atoms per cubic centimeter. This makes electron mobility in the GaAs crystal 8,000 $cm^2/v\text{-}sec$, close to the theoretical limit. Hitachi worked out the method for purifying GaAs crystals to this level in a joint program with the Electrical Communication Laboratory of the Nippon Telegraph and Telephone Public Corp., the state-owned communications carrier.

Outgoing. Hitachi also plans to develop transmitter oscillators using Gunn diodes. In tests so far, the oscillators have been run at 8.7 Ghz with output power of 400 milliwatts. Much higher frequencies can be had at the usual penalty—a drop in output power that approximates the $1/f^2$ power frequency relationship predicted by theory. At 25.3 Ghz, for example, the diode's output goes down to 51 mw.

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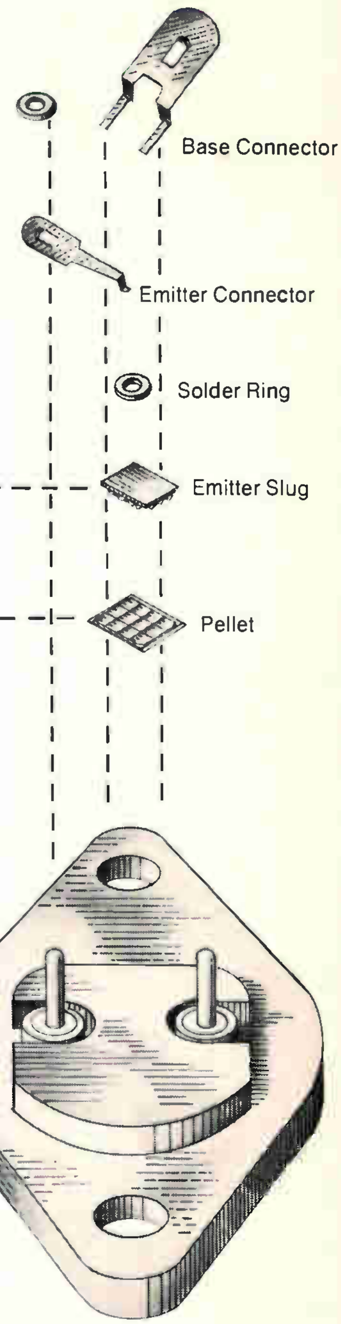

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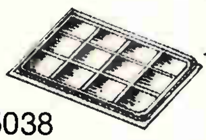

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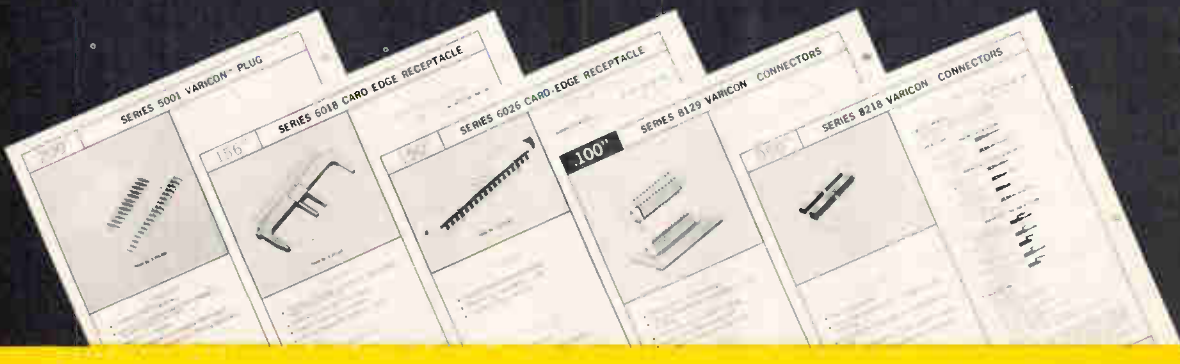

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