Electronics

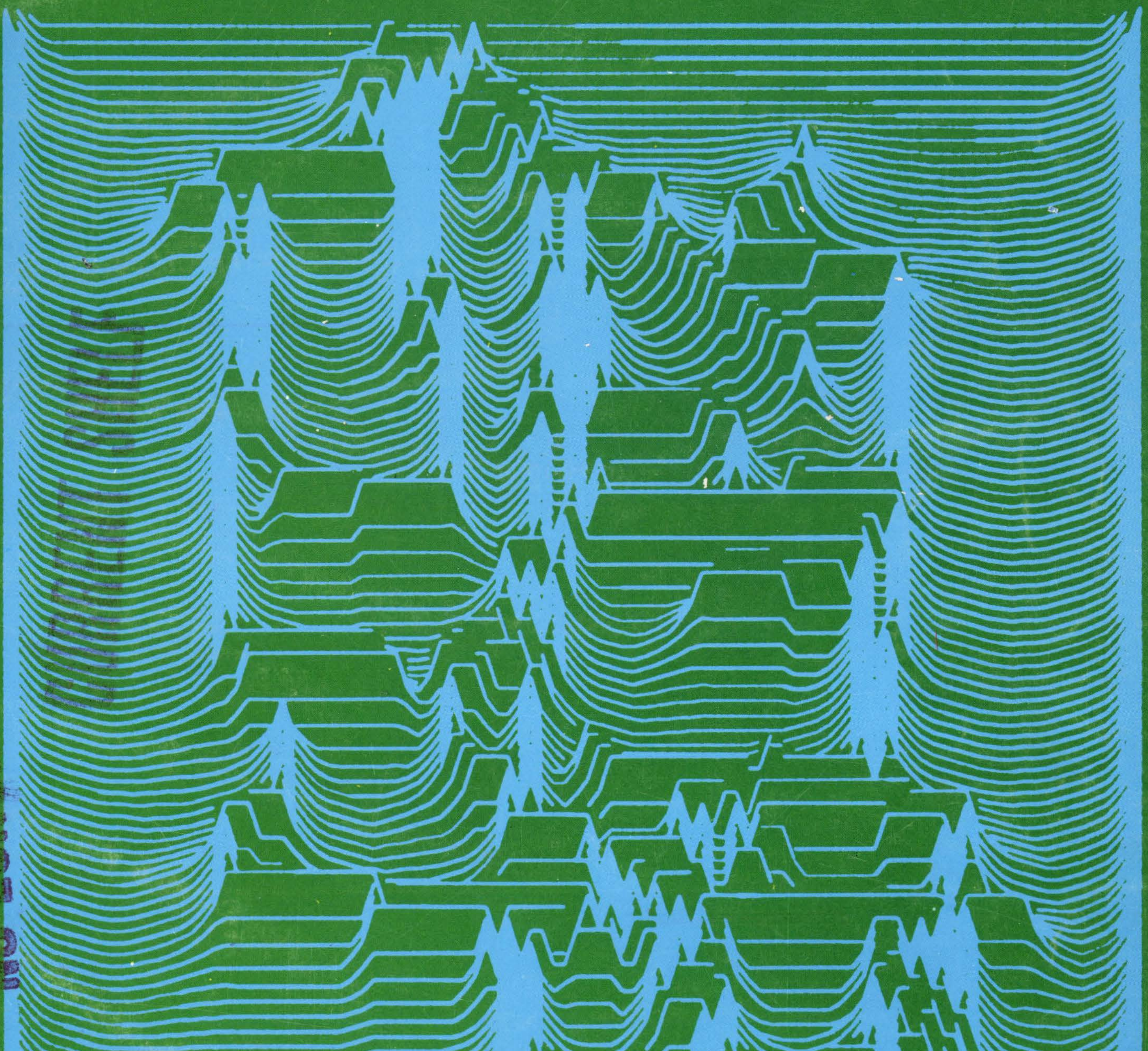
Computers help make circuits: page 70

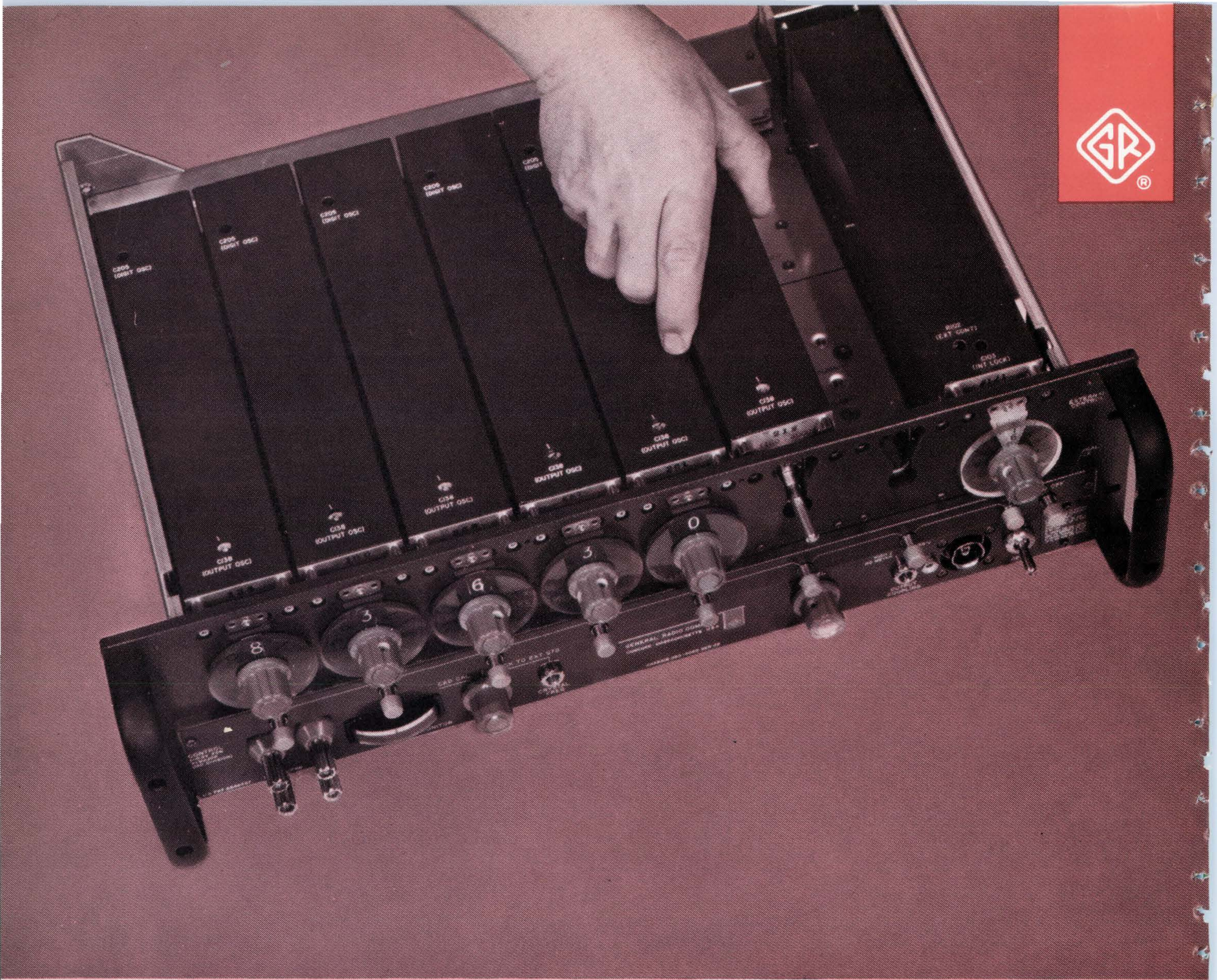
Digitally controlled analog processor: page 99

Preview of IC's in entertainment goods: page 123

September 4, 1967
$1.00
A McGraw-Hill Publication

Below: Map simulates circuit board to speed its layout, page 72





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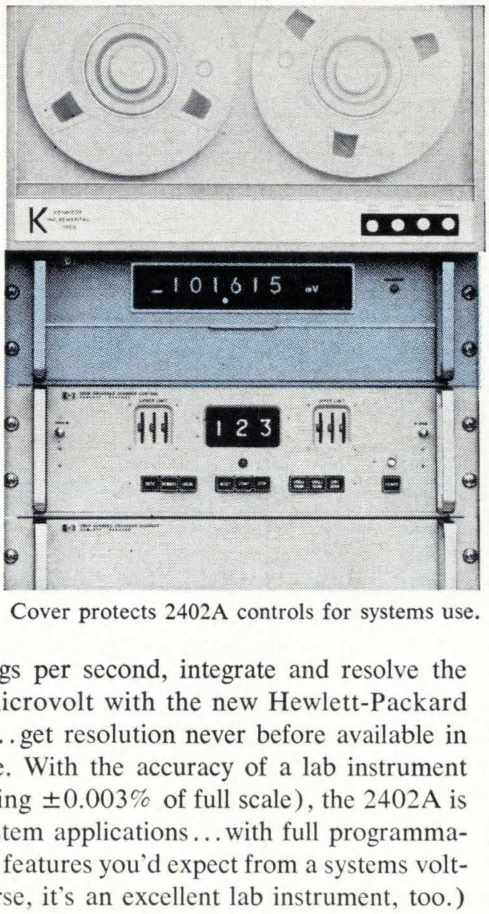

Cover protects 2402A controls for systems use.

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The 2402A: $4800. Plug-in options are reasonably priced—AC, for example, only $450.

For more information, call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.

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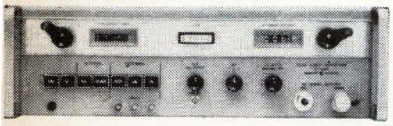
DIGITAL VOLTMETERS

06705

Here's *the* signal generator for whatever microwave range... ...and here's why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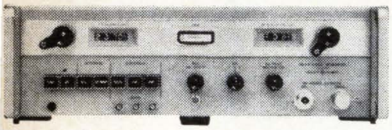
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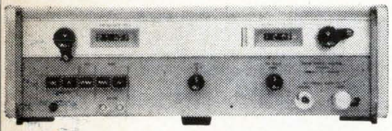
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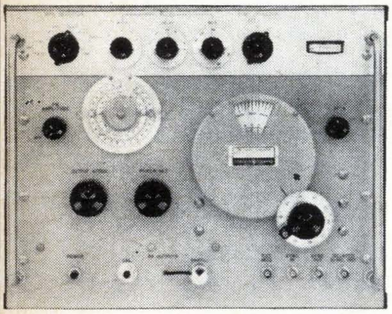
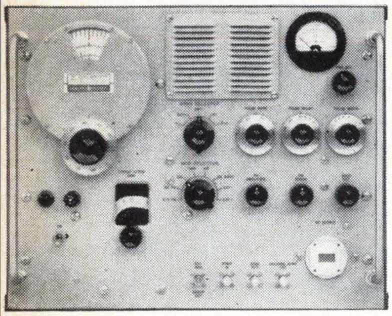
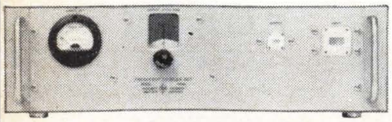

618C


626A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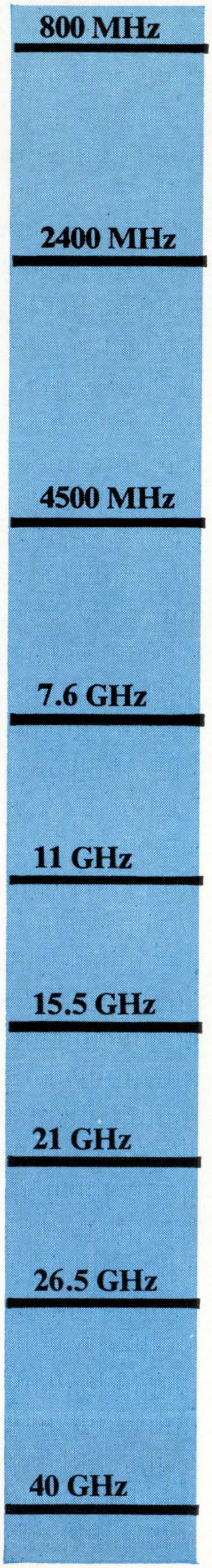

Hewlett-Packard microwave signal generators give you accurate, stable signals from 800 MHz—all the way to 40 GHz. These reliable, economical instruments provide direct reading frequency, output level controls and extremely flexible modulation capabilities.

- 800 to 2400 MHz: HP 8614A Signal Generator is user-oriented with digital dial frequency and output level setting and pushbutton selection of modulation functions. RF output is held constant with frequency by PIN diode modulator, residual and incidental FM are very low. RF output range is +10 to −127 dBm. Price, $2200.
- 1800 to 4500 MHz: HP 8616A offers all the features of the 8614A, including low residual FM, negligible incidental FM, phase-lock capability. Price, $2200.
- 800 to 4500 MHz: 8614B Signal Source (800-2400 MHz) and 8616B Signal Source (1800-4500 MHz) are economical, wide-range signal sources with digital dials for frequency and attenuation settings and pushbutton function selection. Precision RF output attenuator has >130 dB range. Units can be phase-locked. Prices, $1450 each.
- 3.8 to 7.6 GHz: Model 618C Signal Generator has low (<15 kHz pk) residual FM, plus phase-lock capability. Versatile modulation includes internal pulse generator. Price, $2250 ($2270 rack mount).
- 7 to 11 GHz: Model 620B has same features as the 618C; residual FM <15 kHz pk. Price same as 618C.
- 10 to 15.5 GHz: Model 626A for SHF applications —easy to use, high 10 mW output level, especially versatile for its pulsing capabilities, $3600 ($3620 rack mount).
- 15 to 21 GHz: Model 628A, same features as the 626A, same price.
- 18 to 26.5 GHz: Model 938A Frequency Doubler Set doubles the output frequency of the driving source such as 626A Signal Generator. Driving signal can be CW, swept or modulated. Doubler has internal power monitor and precision 100 dB output attenuator. Price: $1700 (rack mount $1720).
- 26.5 to 40 GHz: Model 940A Frequency Doubler Set; driven by 628A Signal Generator. Same features as 938A, same price.

For more information on these broad-range, high-performance signal generators, call your local HP field engineer or write Hewlett-Packard, Palo Alto, California 94304. Europe: 54 Route des Acacias, Geneva.

HEWLETT hp PACKARD

SIGNAL GENERATORS

04706

Electronics Volume 40, Number 18 September 4, 1967

News Features

Probing the News

Electronics Review

Electronics Abroad

New Products

Technical Articles

I. Design

II. Application

Departments

Electronics: September 4, 1967, Vol. 40, No. 18

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Readers Comment

Laser hazard

To the Editor:

In connection with work on high-power carbon dioxide lasers, we have become aware of a practice apparently widespread throughout the industry: a standard firebrick is burned through to demonstrate the effectiveness of the laser beam or to terminate and dissipate the energy.

Since some firebrick material has a significant beryllia content, experimenters should know that the resulting vaporization of beryllium could represent a significant health hazard.

We use asbestos and recommend the use of materials guaranteed to be free of beryllia for such demonstrations.

Also, precautions are necessary whenever silica is heated to temperatures high enough to result in vaporization.

Richard G. Detro
Electro Optics Associates
Palo Alto, Calif.

Anglo-American problem

To the Editor:

Having worked four years in medical electronics in two hospitals in England, working in close association with doctors, I fully agree with your editorial "Partners in progress: doctor and engineer" [July 10, p. 23].

In the first hospital, the medical profession would not recognize my degree, which is in electrical engineering. They accepted only a degree in physics.

Since I had just finished college I finally decided to take a job there as a technician to gain experience in medical practice. In reality I was carrying out basic research in electronics as applied to surgery and at the same time lecturing the physics department which was supposed to be training me in semiconductor circuits as applied to hospital work.

Later, at a second hospital, I was suddenly told that it could not pay me an agreed-upon salary since I was under an age limit set by

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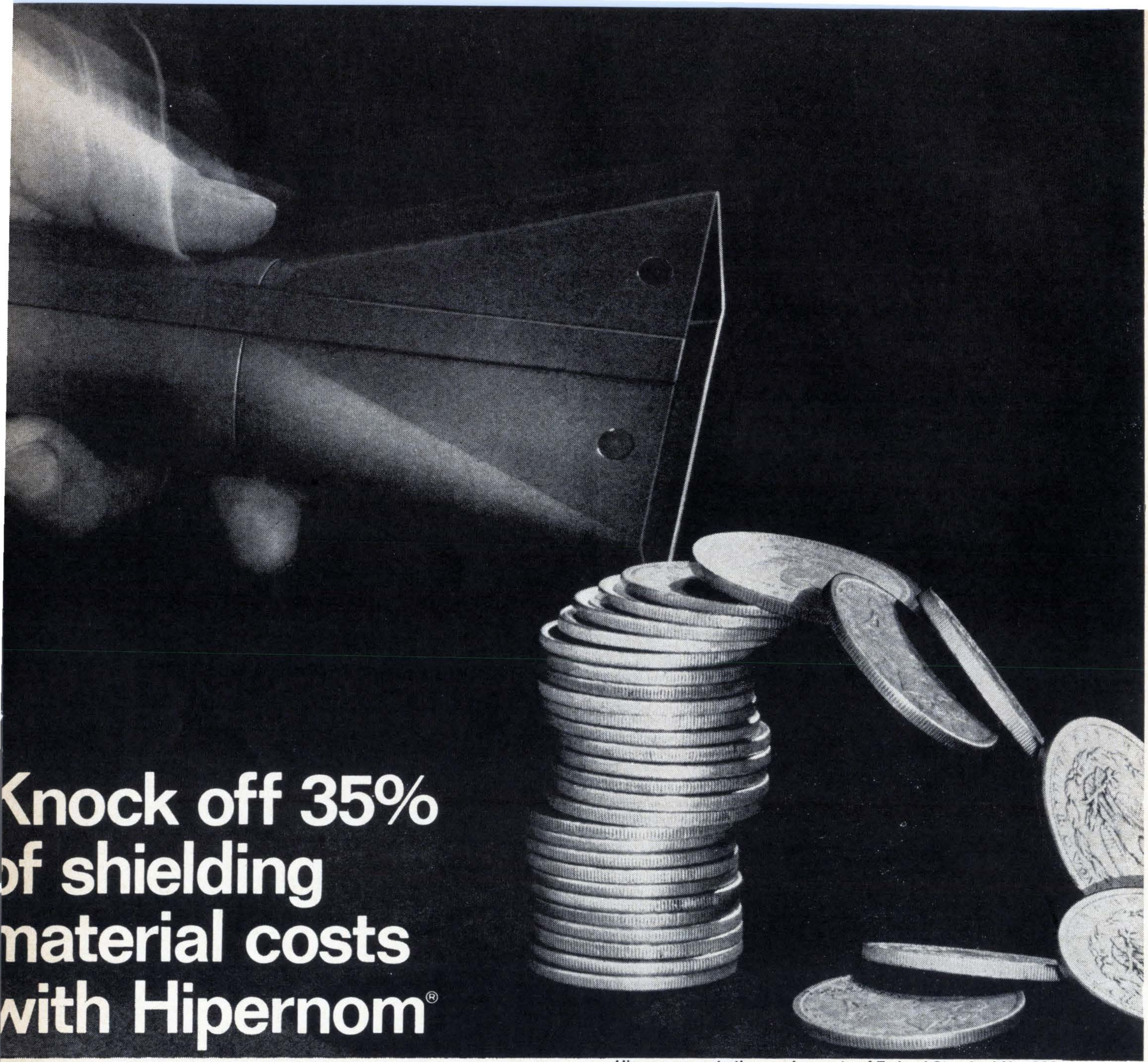

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the hospital, so again I was paid as a technician. After I was married I decided to emigrate to the U.S. to work in industry.

It was my intention to return to medical work, eventually. However, it appears that the relationship between the medical profession and engineers is no better here than it is in England.

David W. Burgess
Engineer
Bendix Systems Division
Ann Arbor, Mich.

Crowded frequencies

To the Editor:

The description of Marconi's new vlf transmitter [July 10, p. 162] says the 3- to 300-kilohertz frequencies are utilized by only a few government and military users.

How I wish this were true! As a matter of fact those frequencies are so crowded that in some instances there is zero hertz spacing between used frequencies. In the majority of cases a 2-khz guard band is a real luxury.

These frequencies are used extensively by power companies on their transmission lines for supervisory control, telemetry, relaying and voice communications. Recently I worked for three days with the Southwest Power Pool Frequency Coordinator, D. Martin. just to obtain frequencies for a new 500-kv transmission line. At the point where this line joins other lines there are 46 frequencies in use between 50 khz and 287 khz.

I might add that the supervisory control involved is not trivial. It controls the major electric power flows and when one of these transmission lines is tripped by a false command many cities may experience a blackout.

While I wish the Marconi Co. prosperity, I submit that it would be better if they joined the other companies in supplying low-power single-side-band powerline carrier communications equipment.

P.F. Flynn
Systems Engineering
Arizona Public Service Co.
Phoenix, Ariz.

Warning

To the Editor:

The article "Blind to danger" [June 26, p. 47] described an incident in which a Fort Monmouth engineer allegedly suffered no ill effects from the direct viewing of the beam from a helium-neon laser. It is not clear whether this viewing was inadvertent or intentional. In either event, I would not encourage any of your readers to draw any unwarranted inferences from this isolated experience. Viewing of either direct or even reflected laser beams should never be undertaken unless a careful analysis of the potential ocular hazard has been performed for the particular situation at hand.

It would be regrettable if cavalier attitudes toward laser hazards are propagated either through bravado or ignorance. Those of us working with lasers have a special obligation to make sure that the tragic history of human injury, which occurred in the ionizing radiation field, is not repeated in this new area of advanced technology.

Leonard R. Solon
Vice president and
Technical Director
Biorad Inc.
New Hyde Park, N.Y.

People

"My first assignment," says NASA's new No. 3 man, "will be to develop an orderly, routine planning approach for the agency. The big problem, as I see it, is defining the major new objectives of the space program." The announcement of the appointment of 52-year-old **Homer E. Newell** as the agency's associate administrator came late last month in the midst of the National Aeronautics and Space Administration's worst financial setbacks in years. [For more on NASA's problem, see page 50.]

Homer E. Newell

Newell's credentials as a space planner and administrator go back to NASA's infancy. His first job was to plan and develop the space science program. That was back in 1958. For the last four years, he had been associate administrator for space sciences and applications, a job that included administration of a large parcel of program areas including lunar and planetary exploration, grants, space applications, physics, astronomy and bioscience, and research contracts. Before taking on the last assignment, Newell was deputy director of space flight programs and director, Office of Space Sciences.

Selling an idea. The soft-spoken Newell sees his new role as that of a communicator with those whom NASA serves and works with. "I will be in constant contact with the scientific community," he says, "and will work closely with the new missions boards being set up." He plans to help support other agencies in their space programs and mentions, as an example, helping Federal agencies that wish to study the earth's resources from space. An aide says Newell has the ability to explain and sell programs to Congress, and to communicate with the scientific community.

One program that has fallen victim to the House appropriation ax is Voyager, which was under Newell's jurisdiction in space sciences and applications.

Says Newell: "My only hope is that we've sold Voyager and that we're just experiencing a delay because of war and problems on the homefront.

Newell concedes that the schedule for Voyager was so tight that without funds in fiscal 1968 the first shot to Mars cannot take place until 1975.

An electronics company with $70 million in sales and a goal of $100 million has two principal roads available: acquisition and diversification.

Norman L. Harvey

EG&G Inc. of Bedford, Mass., is going both ways: it acquired four small companies this year and last month named **Norman L. Harvey** general manager of its new Systems Development division to get that unit into high gear. The purchased firms work in the fields of oceanography, weather modification, instrumentation, and geophysical exploration.

"Systems have always been my major interest," says Harvey, who went to EG&G in 1965 from Varian Associates, Palo Alto, Calif. Harvey had headed a Varian venture into computer-based teaching systems, but when the company dropped the project Harvey quit and joined EG&G.

Bomb monitor. Since its founding 20 years ago, EG&G has been the prime Atomic Energy Commission instrumentation contractor.

Of its $70 million volume, EG&G currently gets nearly $49 million under this contract. So the diversification is concentrated on non-AEC systems.

EG&G has already made its debut in digital facsimile systems [Electronics, Aug. 7, p. 42], and Harvey has plans for other graphic equipment, as well as flash systems for navigation and photography, weather modification techniques, and for custom-designed radiation-detection systems based on semiconductor technology.

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Each Series is a carefully designed combination of power, performance and packaging,—to fill your specific requirements. Sorensen's AC regulation capability spans 25 years of experience in the design and production of regulators. Our standard product technology provides the firm basis for an outstanding custom design capability. Whatever your AC regulator problems, — check with Sorensen.

For details on Sorensen AC regulators, or for standard/custom DC power supplies or frequency changes, contact your local Sorensen rep. or: Raytheon Company, Sorensen Operation, Richards Ave., Norwalk, Conn. 06856. Tel: 203-838-6571.

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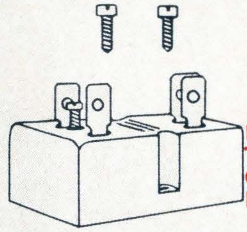

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Meetings

Conference on Solid State Devices, IEEE; Manchester, England, **Sept. 5-8.**

Computer Conference, IEEE; Chicago, **Sept. 6-8.**

Electric Propulsion and Plasmadynamics, American Institute of Aeronautics and Astronautics; Colorado Springs, Colo., **Sept. 11-13.**

Meeting on Space Simulation, American Society for Testing and Materials; Sheraton Hotel, Philadelphia, **Sept.11-13.**

Symposium on Computer Control of Natural Resources and Public Utilities, International Federation of Automatic Control; Haifa, Israel, **Sept. 11-14.**

Instrument Society of America Conference and Exhibit, Instrument Society of America; International Amphitheater, Chicago, **Sept. 11-14.**

International Symposium on Information Theory, IEEE; Athens, Greece, **Sept. 11-15.**

Seminar on Mathematical Systems Theory, Pennsylvania State University; Pennsylvania State University's Residence Hall, Pa., **Sept. 11-15.**

International Congress on Magnetism, International Union of Pure and Applied Physics and American Institute of Physics; Boston, **Sept. 11-16.**

Symposium on Materials—key to effective use of the sea, Polytechnic Institute of Brooklyn and Naval Applied Science Laboratory; Statler Hilton Hotel, New York, **Sept. 12-14.**

Biennial Electric Heating Technical Conference, IEEE; Statler Hilton Hotel, Detroit, **Sept. 13-14.**

Society of Motion Picture and Television Engineers Conference; Edgewater Beach Hotel, Chicago, **Sept. 17-22.**

Conference on Electrical Insulation and Dielectric Phenomena; National Academy of Science; Pocono Manor Inn, Pocono Manor, Pa., **Sept. 18-20.**

Automotive Conference, IEEE; Howard Johnson's Motor Lodge, Detroit, **Sept. 21-22.**

Symposium on Microelectronics Applications, IEEE; Garden City Hotel, Garden City, Long Island, N.Y., **Sept. 21-22.**

International Electronics Conference and Exposition, Canadian Region of IEEE; Automotive Building, Canadian National Exhibition, Toronto, **Sept. 25-27.**

International Telemetering Conference, International Foundation for Telemetering; Marriott Twin Bridges Motor Hotel, Washington, **Oct. 2-4.***

Short Courses

New directions in organic chemistry, Stevens Institute of Technology's Department of Electrical Engineering; Hoboken, N.J., **Sept. 6-8;** $150 fee.

Seminar on the management of new developments: from basic sciences into profitable products, IEEE and Newark College of Engineering; Newark, N.J.; **Sept. 7;** $25 for nonmembers of IEEE.

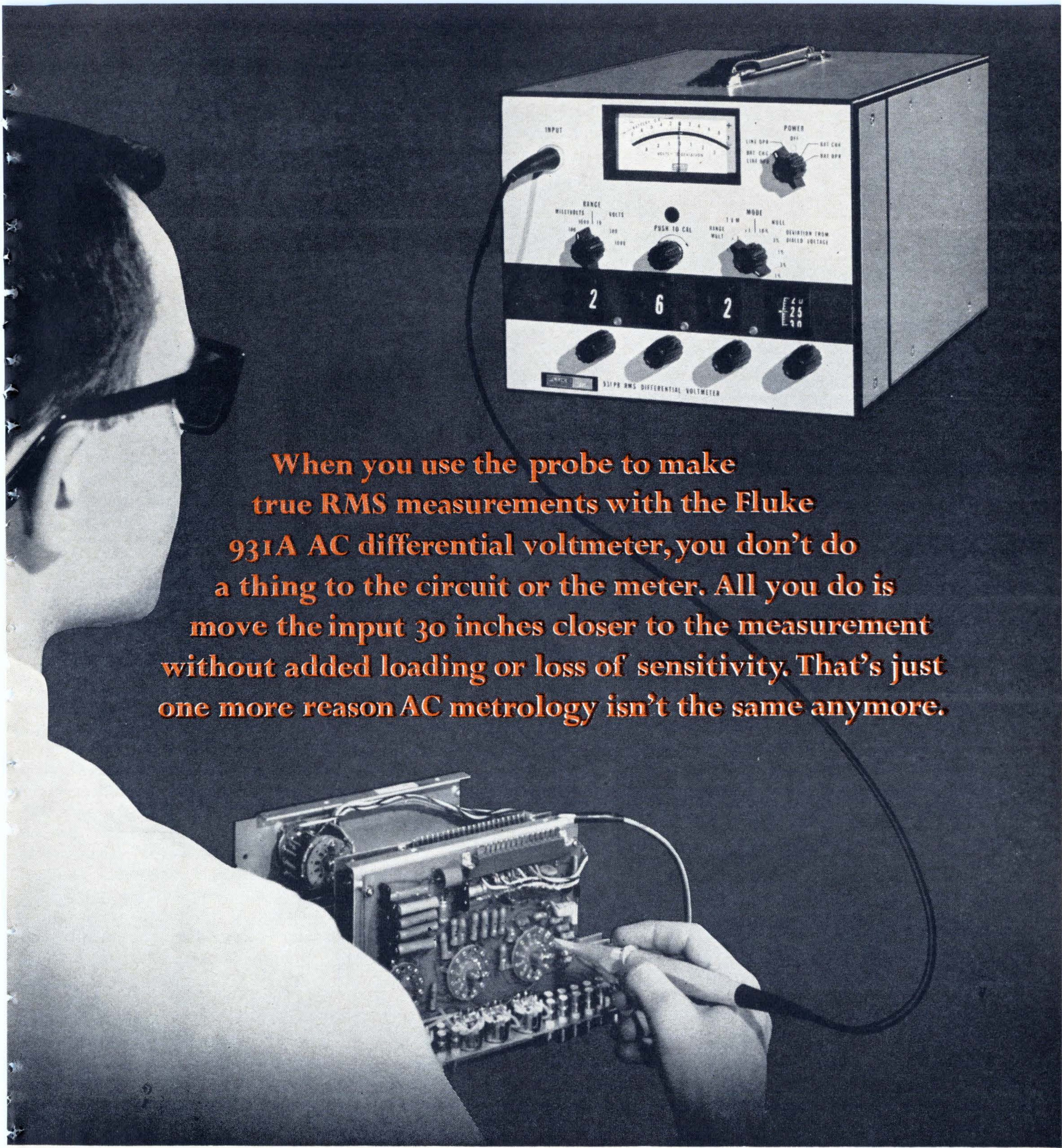
Calls for Papers

Electronic Components Conference, IEEE and Electronic Industries Association; Mariott Twin Bridges Motor Hotel, Washington, May 8-10, 1968. **Oct. 10** is deadline for submission of papers to technical program chairman, Frank Collins, Speer Research Laboratory, Packard Road and 47th St., Niagara Falls, N.Y. 14302

Intermag Conference, IEEE; Sheraton Park Hotel, Washington, April 3-5, 1968. **Dec. 15** is deadline for submission of abstracts to James M. Lommel, General Electric Research and Development Center, P. O. Box 1088, Schenectady, N. Y. 12305

International Quantum Electronics Conference, IEEE; Everglades Hotel, Miami, Fla., May 14-17, 1968. **Jan. 8** is deadline for abstracts to R.W. Terhune, technical program chairman, Physical Electronics Department, Ford Motor Co., P.O. Box 2053, Dearborn, Mich., 48121.

*** Meeting preview on page 16.**



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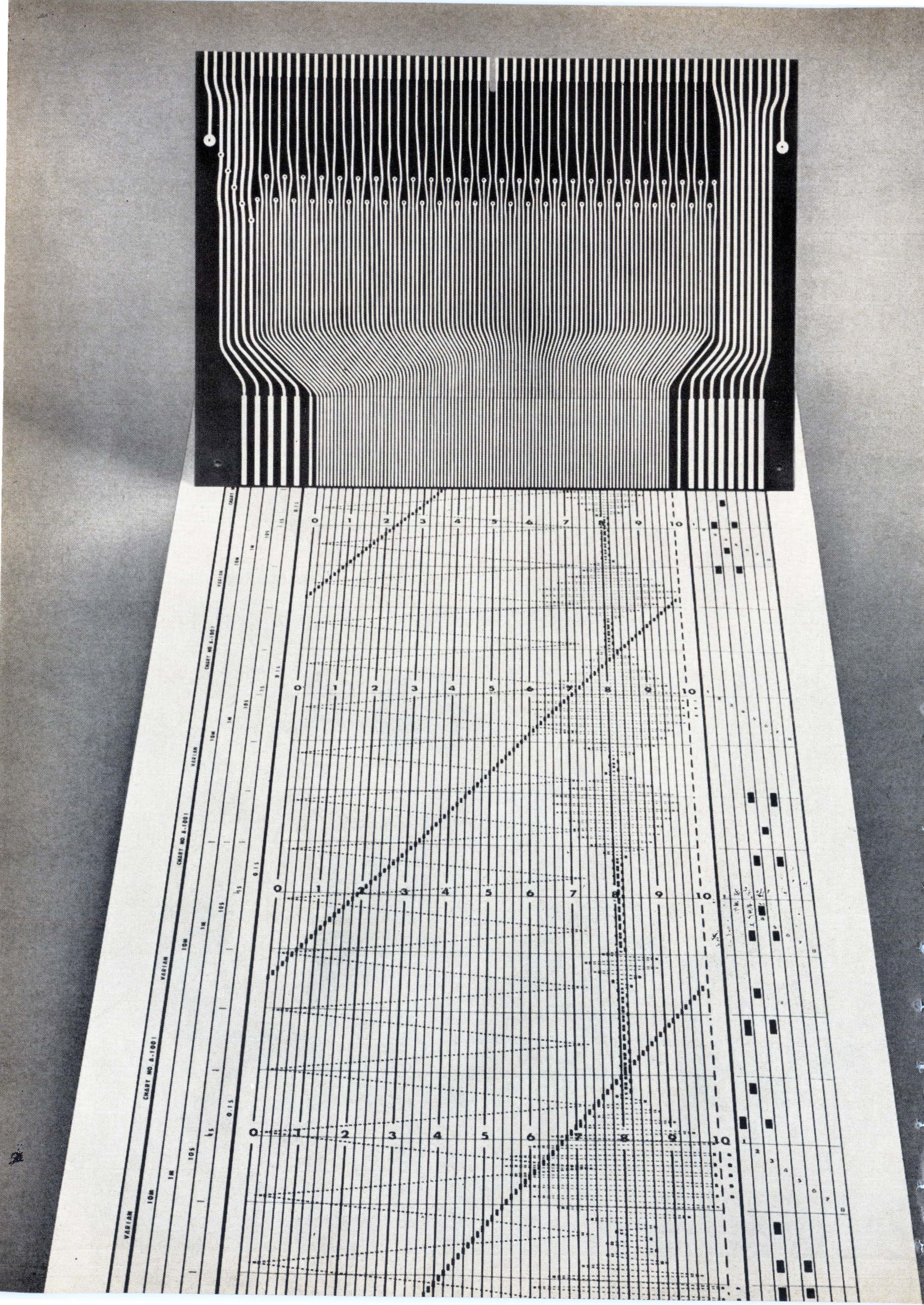
Meeting preview

Eliminating redundancy

Three years ago when the International Telemetering Conference was initiated to supplement the well-established annual National Telemetering Conference, many telemetering engineers feared that two conferences would be redundant. That fear was justified in 1965 and 1966 when many of the papers and topics in one conference nearly duplicated those in the other. This year, the programs are sharply different, with the National Telemetering Conference, held last May, specializing in commercial topics and the International Telemetering Conference, scheduled in Washington, D.C., on Oct. 2 to 4, focusing much of its attention on military topics.

Conversion. One of the major topics will be the switch from X band to L and S bands, a switch that should be completed by the end of this decade. The problems associated with this conversion will be discussed by a panel under the direction of Brig. Gen. Clifford J. Kronauer Jr., commander of the Air Force's Western Test Range. Summaries will be presented covering airborne solid state r-f power generators, antenna design, ground-based L- and S-band systems, and signal search, detection, and acquisition. Representatives from the Pentagon, National Aeronautics and Space Administration, General Electric, TRW, and Aerospace Corp. will be on the panel.

The second area of emphasis will be methods of assuring the receipt of quality data. A panel on this subject will be chaired by Robert T. Merriam, head of an engineering group at the Navy's Ordnance Test Station at China Lake, Calif. Panel members include such prominent telemetry experts as E. J. Baghdady, technical director of Adcom Inc., and Walter Larkin, manager of NASA's Goldstone facility. Another area to be explored is the growing use of microelectronics in telemetry gear. Representatives of Fairchild Semiconductor will describe how IC's can be applied to pulse-code-modulation, pulse-amplitude-modulation, pulse-duration-modulation and f-m/f-m systems.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WIDEST CHOICE OF FLIP-FLOPS—Four dual and two single flip-flops provide optimum choices in logic design and speed/power ratio. DCL offers the only dual low power RS/T binary in the industry, four flexible J-K types, and a dual high speed "D" type. The selection includes DC clocked, AC clocked, leading edge-triggered and trailing edge triggered binaries.

FULLY COMPATIBLE LARGE ARRAYS—Monolithic arrays (containing four binaries and thirteen gates) for counting and storage applications.

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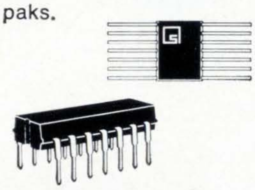

TYPICAL CHARACTERISTICS

TYPE NUMBER	DESCRIPTION	FAN-OUT FUNCTION	Tpd (ns) AND TOGGLE RATE	AVG. PWR. Function (mW) 50% Duty	DC NOISE MARGIN (V)
8162	MONOSTABLE MULTIVIBRATOR (delay from 80 ns to 2 seconds)	12	35	65	1.0
8280	DECADE COUNTER/STORAGE REGISTER	8	25 MHz	25	1.0
8281	BINARY COUNTER/STORAGE REGISTER	8	25 MHz	25	1.0
8415	DUAL 5-INPUT NAND GATE (bare output collector)	9	30	10.0	1.0
8416	DUAL 4-INPUT NAND GATE (input expansion node)	9	25	10.0	1.0
8417	DUAL 3-INPUT NAND GATE (expansion node and optional output resistor)	9	30	9.5	1.0
8424	DUAL, LOW POWER, RS/T BINARY (trailing edge triggered)	9	11 MHz	15.5	1.0
8440	DUAL AND-OR-INVERT GATE (2 AND Gates wide)	9	25	12.0	1.0
8455	DUAL 4-INPUT NAND GATE DRIVER	25	28	11.0	1.0
8470	TRIPLE 3-INPUT NAND GATE	9	25	7.0	1.0
8471	TRIPLE 3-INPUT NAND GATE (bare output collector)	9	30	7.0	1.0
8480	QUADRUPLE 2-INPUT NAND GATE	9	25	7.0	1.0
8481	QUADRUPLE 2-INPUT NAND GATE (bare output collector)	9	30	7.0	1.0
8731	QUADRUPLE 2-INPUT DIODE EXPANDER	—	—	—	—
8806	DUAL 4-INPUT EXPANDER	—	—	—	—
8808	8-INPUT NAND GATE	20	12	13	1.0
8816	DUAL 4-INPUT NAND GATE	20	12	13	1.0
8825	SINGLE PHASE, AND Input J-K BINARY (leading edge triggered)	20	25 MHz	90	1.0
8826	DUAL HIGH SPEED J-K BINARY (trailing edge triggered)	10	30 MHz	40	1.0
8827	DUAL HIGH-SPEED J-K BINARY (full asynchronous entry, trailing edge triggered)	10	30 MHz	40	1.0
8828	DUAL HIGH SPEED "D" TYPE BINARY (leading edge triggered)	20	25 MHz	55	1.0
8829	SINGLE PHASE AND INPUT J-K BINARY (trailing edge triggered)	20	20 MHz	90	1.0
8840	DUAL AND-OR-INVERT GATE (2 AND gates wide)	20	10	15	1.0
8848	AND-OR-INVERT GATE (4 AND gates wide)	20	10	30	1.0
8855	DUAL 4-INPUT POWER GATE	60	10	24	1.0
8870	TRIPLE 3-INPUT NAND GATE	20	10	15	1.0
8880	QUADRUPLE 2-INPUT NAND GATE	20	10	15	1.0
8H16	DUAL 4-INPUT NAND GATE (high-speed)	30	6	20	1.0
8H70	TRIPLE 3-INPUT NAND GATE (high-speed)	30	6	20	1.0
8H80	QUADRUPLE 2-INPUT NAND GATE (high-speed)	30	6	20	1.0
8T18	DUAL 2-INPUT NAND INTERFACE GATE (high voltage to low voltage)	9	15	45	7.0
8T80	QUADRUPLE 2-INPUT NAND INTERFACE GATE (low voltage to high voltage)	9	25	10.0	1.0
8T90	HEX INVERTER INTERFACE ELEMENT (low voltage to high voltage)	9	25	10.0	1.0

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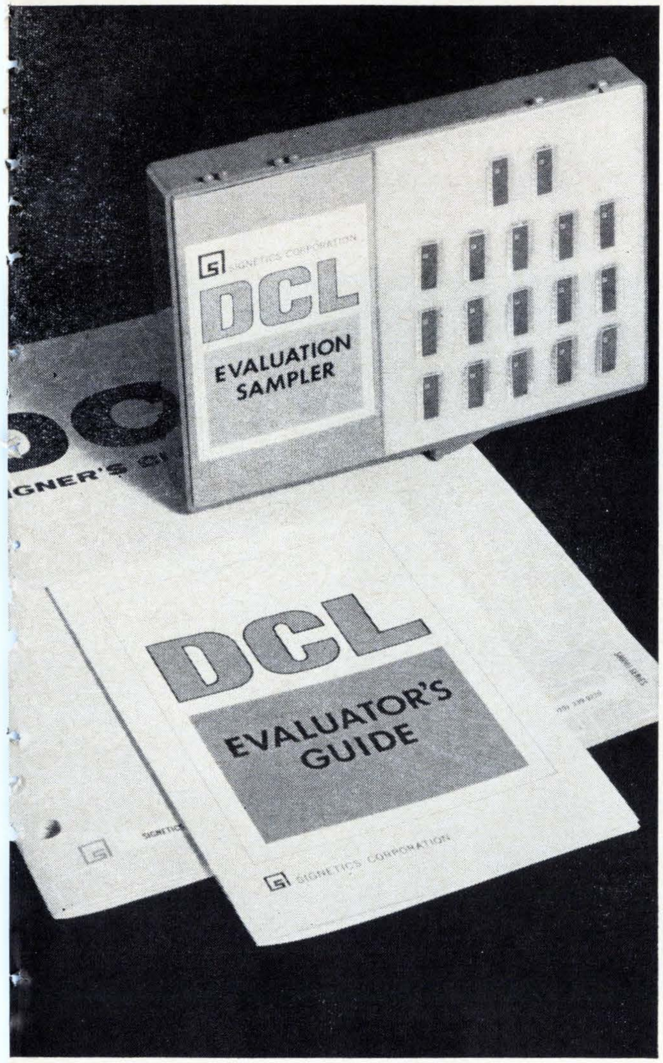

Signetics wants you to find out for yourself just how versatile you can be with DCL. So, we put a representative DCL selection together in an evaluation sampler, complete with a 46-page handbook and evaluator's guide. Then we cut the price in half, to make it even more attractive. The selection includes:

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N8281A	Binary Counter	1	24.00
N8424A	Dual Lo Power RS/T Binary Element	2 at 5.90 ea	11.80
N8825A	Single Phase AND Input J-K Binary Element	2 at 4.00 ea	8.00
N8826A	Dual Hi Speed J-K Binary Element	2 at 5.90 ea	11.80
N8828A	Dual Hi Speed D-Type Binary Element	2 at 5.65 ea	11.30
N8416A	Dual 4-Input Expandable DTL NAND Gate	1	2.25
N8480A	Quad 2-Input Lo Power TTL NAND Gate	2 at 2.25 ea	4.50
N8440A	Dual AND-OR-INVERT Gate	1	2.25
N8455A	Dual 4-Input NAND Driver	1	2.50
N8880A	Quad 2-Input Hi Speed TTL NAND Gate	2 at 2.25 ea	4.50
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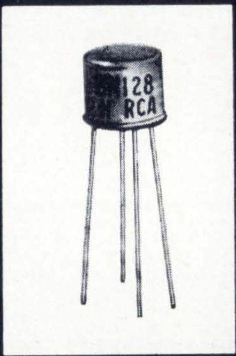
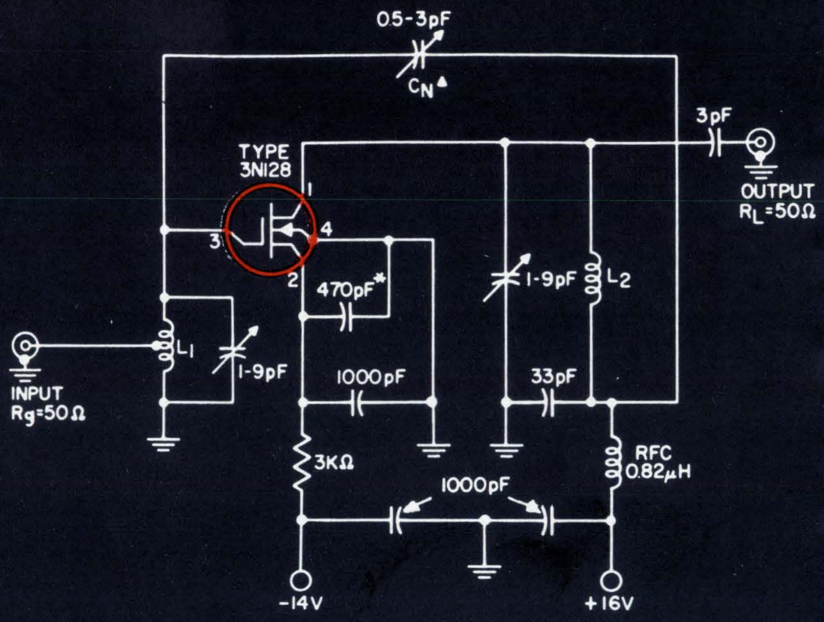


RCA 3N128 is now only 88¢ (1,000+)



200 MHz RF Stage using RCA 3N128

RCA's 3N128 N-channel, depletion-type MOS field-effect transistor actually offers dynamic range 10 times greater than conventional bipolar transistors. Because of the resulting improvement in cross modulation and spurious response, the 3N128 is recommended as an RF amplifier *and* a mixer to further improve performance in these areas. You can use standard vacuum-tube-type biasing and AGC requires virtually no power.

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So call your RCA Field Representative for complete information. For technical literature and application notes AN-3193 and AN-3341, covering RF amplifiers and mixers, write RCA Commercial Engineering, Section EN9-1, Harrison, N.J. 07029. Check your RCA Distributor for his price and delivery.

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HIGH TRANSCONDUCTANCE
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HIGH POWER GAIN @ 200 MHz
18 dB typ.

LOW NOISE FIGURE @ 200 MHz
4 dB typ.

LOW GATE LEAKAGE
50 pA max.

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ɔmmentary

ıe worrisome IC

: integrated circuit is cutting a wide swath in the ·tronics industry this summer, finding its way into ·ems ranging from sophisticated military computers ow-cost phonographs. But as the IC wins overwhelm- acceptance, the concept of integrated electronics is ·owing the brows of engineers at both makers and ·s. Almost everybody is at a crossroads; at stake for ıy firms is their future prosperity. For a few, guessing ·t will mean the difference between life and death.

·'s the rapid acceptance of IC's that's at the root of problem. The dizzying speed hardly gives firms ·gh time to consider all the factors. Makers fear they miss the market if they don't act quickly; buyers ıt the competitive edge that the first IC-equipped gear have. For the circuit user, there is a bewildering ·ety of choices: different kinds of logic, the linear- ·us-digital question, hybrid versus monolithic, bi- ır or monolithic. And beyond lies the promise of e-scale integration. For producers, there are similar sions to make about new products—decisions com- ated by erratic inventory situations and an enormous onnel turnover.

ıke the inventory problem, for example. After almost ·ar of standing customers in line for diode-transistor ·—the most popular digital circuit today—produc- suddenly exceeded demand. And it happened with some speed. In July, Fairchild Semiconductor, the ·stry's largest producer, had customers on allocation. ty days later, the division had nearly 800,000 circuits tock and was looking for buyers. Other producers TL also report burgeoning inventories.

ıe reason is simple. Every producer has been working ·time to increase yields, to improve profits. The work suddenly borne more fruit than expected. Yields · improved so much, so fast, that the marketing men ·n't had a chance to find new customers for all the ıits being turned out. At the same time, many pro- ·rs went to a larger 2-inch-diameter slice of silicon lace of the traditional 1-inch slice, a move that also ·ased production. Some firms have added additional lants. And new second sources like Raytheon Semi- luctor have cut into original suppliers' sales.

·ditionally, in such a situation semiconductor pro- ·rs cut prices. So the industry is nervously awaiting t could be the sharpest price cuts in its history.

ı· oversupply affects only some products. Others are ·e. Customers for transistor-transistor logic, the ·r, faster logic, complain bitterly about late delivery ɔndelivery. Some makers of TTL have fallen far be- on promises because processing has turned out · harder and yields much lower than expected. At stage of production a slight error in estimated yields ·s in big errors in shipments.

addition, many semiconductor producers have been getting TTL lines on the market. Development of ·hild's second-generation line of low-power TTL is behind schedule; Texas Instruments has been introducing its line piecemeal; and Philco-Ford Microelectronics won't have its first TTL products before autumn. Stewart Warner Microelectronics, on the other hand, thought there was a larger potential in DTL, and dropped its TTL line during a management reshuffle months ago.

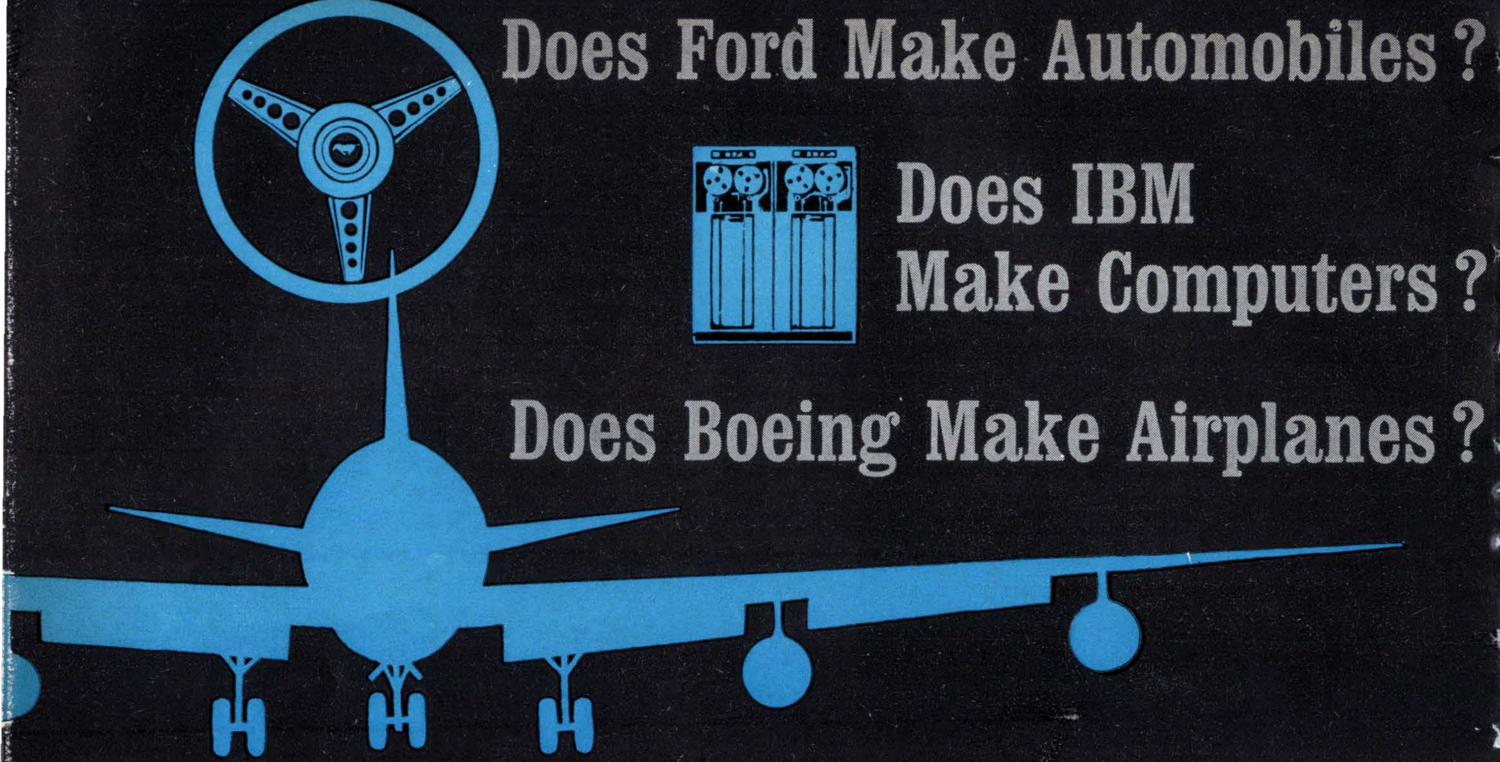
Turnover of top personnel has plagued almost all the IC producers. After Ford Motor bought General Microelectronics Inc. last year, the two top marketing men of the latter company, the operations manager, the materials manager, and half the R&D staff left. Westinghouse's Molecular Electronics division has had three general managers in less than a year. Fairchild Semiconductor lost its general manager and five other key executives to the National Semiconductor Corp. And some executives at its Hong Kong facility have joined ITT Semiconductors' new plant in Portugal. Texas Instruments and ITT Semiconductors in West Palm Beach have changed division managers in the past seven months. Marketing managers have left Fairchild and Philco-Ford this summer. At Signetics, which underwent a major reorganization four years ago, James Riley, president, boasts he now has the senior management team in the industry.

Some of the customers—and potential customers—are having almost as worrisome a time. At consumer electronics firms, engineers are studying a variety of new IC products designed specially for consumer products, but they are going slow on ordering them [see page 123]. One reason is that there still is a question about reliability, and another is cost. But equally important is a reluctance on the part of consumer firms to use something so new they don't completely understand it.

The market for IC's in autos, considered only a few months ago to be potentially the second largest after computers, has foundered on the shoals of reliability and cost. The comedy of errors that marked the development of a voltage regulator [June 26, p. 46] over the past year has set the widespread adoption of IC's by car makers back at least two years—despite Pontiac's announcement of an optional IC regulator for 1968 models. Westinghouse, which started it all when it built a monolithic regulator for Ford in early 1966, has withdrawn from the auto market temporarily, and so has Fairchild. Development activity has cooled even at Philco-Ford's Microelectronics division, despite its tie to Ford Motor.

Among instrument companies and systems designers, the battle over whether to choose home-grown IC's or off-the-shelf units is raging furiously. Hewlett-Packard and many of the large systems companies feel they must have their own capability to protect proprietary secrets and to maintain their percentage of value added. There are reports of a small boom in sales of such machinery as bonders and microscopes (primarily to make hybrid circuits in small volume) to these companies. Other firms, however, like General Radio and Beckman Instruments, believe equally strongly that they can do everything they need to do with off-the-shelf circuits.

The companies looking for a single answer to all these problems are in for a big disappointment (there ought to be as many answers as there are companies). For how each company adapts to integrated electronics will depend on its management's strengths and weaknesses, its philosophy, its product lines and its resources.



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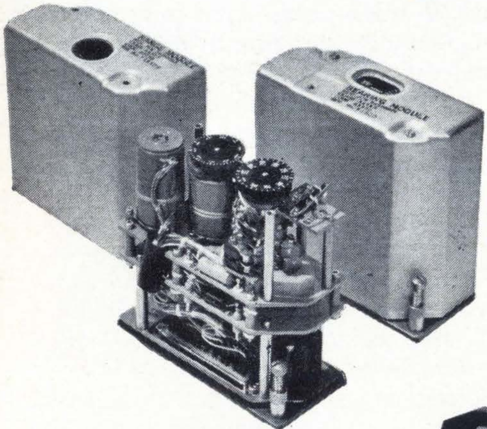

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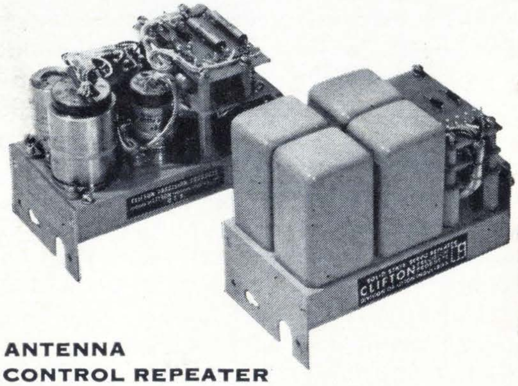

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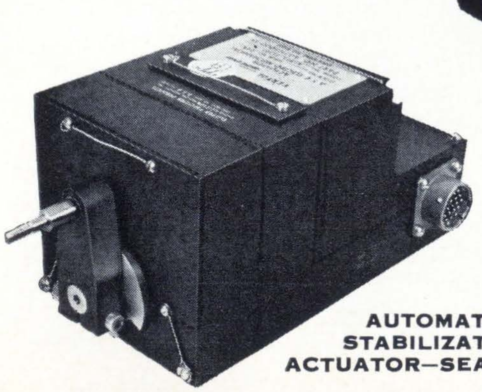

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Electronics Newsletter

September 4, 1967

Monolithic IC's out of MERA radar

Texas Instruments, which has been plugging the monolithic microwave IC approach for its X-band phased array radar being developed for the Air Force under Project MERA, has now decided to use hybrid IC's instead. **The reason: monolithic costs were too high,** says Thomas Hyltin, an R&D manager at TI.

TI made a transmit-receive switch [Electronics, Jan. 23, p. 76], a 500-megahertz i-f preamplifier, and an X-band balanced mixer in monolithic form. Hyltin said they all worked well, but contained such elements as p-i-n diode switches, microwave transistors, and Schottky barrier diodes, which couldn't be fabricated simultaneously by monolithic processing. **Since TI wanted to combine several circuit functions under a single, inexpensive fabrication process, hybrids won out.**

Agonizing over the decision to switch to hybrids caused some delay in the Air Force program, according to some industry sources. The X-band array now is expected to be completed by next April.

New code technique thwarts snoopers

Programable coding is one of the new techniques being demonstrated to law-enforcement agencies for voice-privacy radio systems. Requirements for riot control and stepped-up battles on urban crime have **increased interest in squad car, aircraft, and portable radios which cannot be monitored by eavesdroppers with commercial receivers.** Most scrambling systems invert the voice signal in a balanced modulator, transpose slots in the voice spectrum, or distort the signal in phase. The new technique, developed by Technical Communications Corp., Lexington, Mass., uses an encoder-decoder. **The codes can be changed daily or even hourly,** and the number of possible combinations is so large that the chances of breaking it are remote. In addition, the system's security is protected even if a unit is stolen or copied.

A-c tester challenges d-c wafer probes

The first commercial system for a-c testing of integrated circuits on the wafer has been demonstrated by E-H Research Laboratories in Oakland, Calif. Based on a switching-time converter for making nanosecond time-interval measurements and a strobing voltmeter for fast waveform measurements, **the tester can be used with standard commercial wafer-probes. Its price ranges from $28,775 to more than $100,000 for fully automated versions with core-memory elements.**

E-H is challenging the concept of d-c testing. Earlier a-c testers were designed to make tests on packaged IC's just prior to shipment; wafer testing was handled by d-c testers. But, says E-H applications engineer James E. Fisher, **"except for leakage, we don't see any reason to make d-c tests at all."**

The CBS playback: a revolution in data retrieval?

CBS Laboratories' Electronic Video Recording (EVR) development, which hit the entertainment and education market with a bang last week, **may have an even heavier impact on information storage and retrieval.** For example, EVR, a film process which allows the playback of television and motion pictures through conventional tv receivers, is a natural to be combined with CBS's Linotron electronic typesetter [Electronics, April 13, p. 113]. EVR developer Peter C. Goldmark, CBS Labs president, acknowledges that the new recording and playback technique and Linotron would make a "perfect marriage."

By replacing the Linotron's cathode-ray tube, now used to generate letters and numbers for phototypesetting, with EVR's electron beam scanner, pages of text could be recorded as speedily as EVR records tv signals. An entire encyclopedia could be recorded on a single reel of film, says Goldmark, and any tv receiver could be used to view the filmed pages. **CBS Labs undoubtedly has plans in this area, and probably will develop systems to compete with magnetic tape for computer data storage.** EVR has a storage capacity 15 times that of magnetic tape.

In EVR, electron beam scanning exposes a special film (neither silver halide nor thermosetting plastic) and processing is required. The recording appears as two rows of frames down the 8.75-mm. film. For monochrome recording, each row carries a different program; for color, one row carries chrominance and the other luminance information.

First playback devices should be in schools by late 1968 playing canned educational tv programs. Shortly thereafter, playback units for home tv will go on the market at a price substantially below the originally quoted $280, Goldmark predicts. Film cartridges will cost between $7 and $14.

On playback, the film passes before a flying spot scanner and the resulting amplitude-modulated light is picked up by a photomultiplier tube. The signal is then converted to a video waveform which modulates a tv carrier frequency; this is then piped into the home set directly through the antenna terminals.

Victory expected by backers of parameter shift

Manufacturers of high-frequency transistors who have been pushing revised semiconductor characterization parameters got stronger than expected support at last month's meeting of the Committee on Industrial Signal Transistors (JS-9). **The upshot is that by early 1968 they'll likely have permission from the Electronic Industries Association to use either S, Y, or both parameters on their data sheets.** This will benefit not only transistor manufacturers, but makers of high-frequency test equipment geared to S parameters as well.

Such device makers as Texas Instruments, KMC Semiconductor, and Raytheon have maintained [Electronics, July 24, p. 25] that **S parameters are more realistic than Y parameters with devices operating at 500 megahertz and higher** because they're geared to typical operating conditions, are easier to use and measure, and are compatible with Smith charts, the predominant high-frequency/microwave design aid.

TI gets new lead on heat sinks

A new heat-conducting technique, combining a silver-coated, copper alloy collector lead with a larger copper island on the printed circuit card, may gobble up a part of the transistor heat-sink market. Texas Instruments says it has been able to raise the power-handling capabilities of small-signal devices (less than a watt) to medium power levels of several watts with the new approach. **This arrangement dispenses with costly, cumbersome heat-sink assemblies, TI claims.**

The new lead material is incorporated on a new series of plastic-encapsulated transistors intended for consumer equipment. **TI says the units, when used with the modified pc board, have about twice the heat-dissipating capabilities of higher priced, electrically comparable transistors in metal cans.** TI plans to add the new lead material on more of its discrete semiconductor lines, including industrial units.

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*Name*______
*Address*______
*City*______ *State*______ *Zip Code*______

(Not enough room? Attach sheet of paper with additional names and addresses)

Circle 29 on reader service card→


VAC
RANGE
FUNCTION
INPUT
OVER LOAD
K Ω
V AC
V DC
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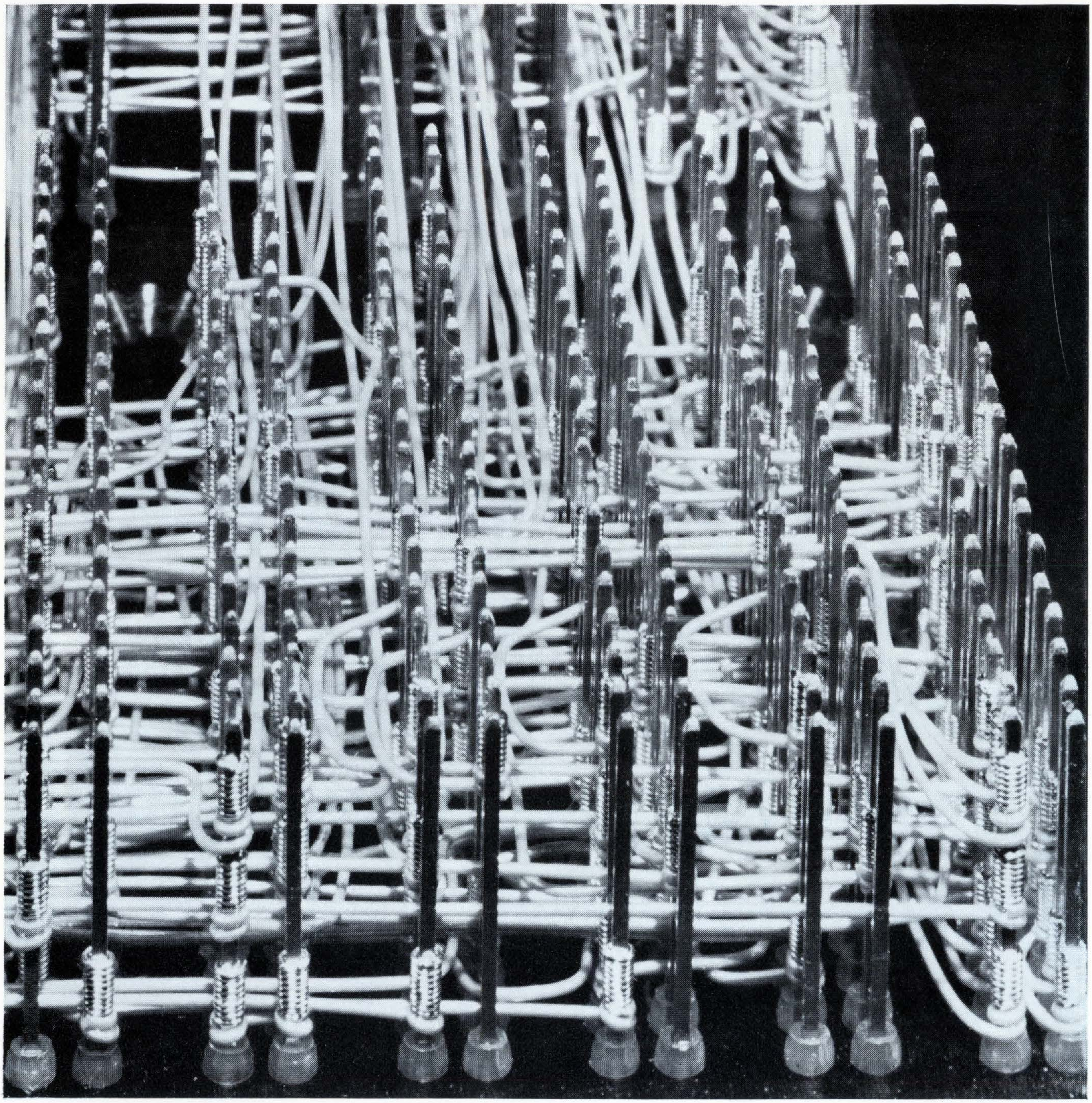
TEST
100
1000
10
LO
PWR ON
GND
DIGITAL MULTIMETER MODEL 7000

IF YOUR PLATES DON'T LOOK LIKE THIS . . .



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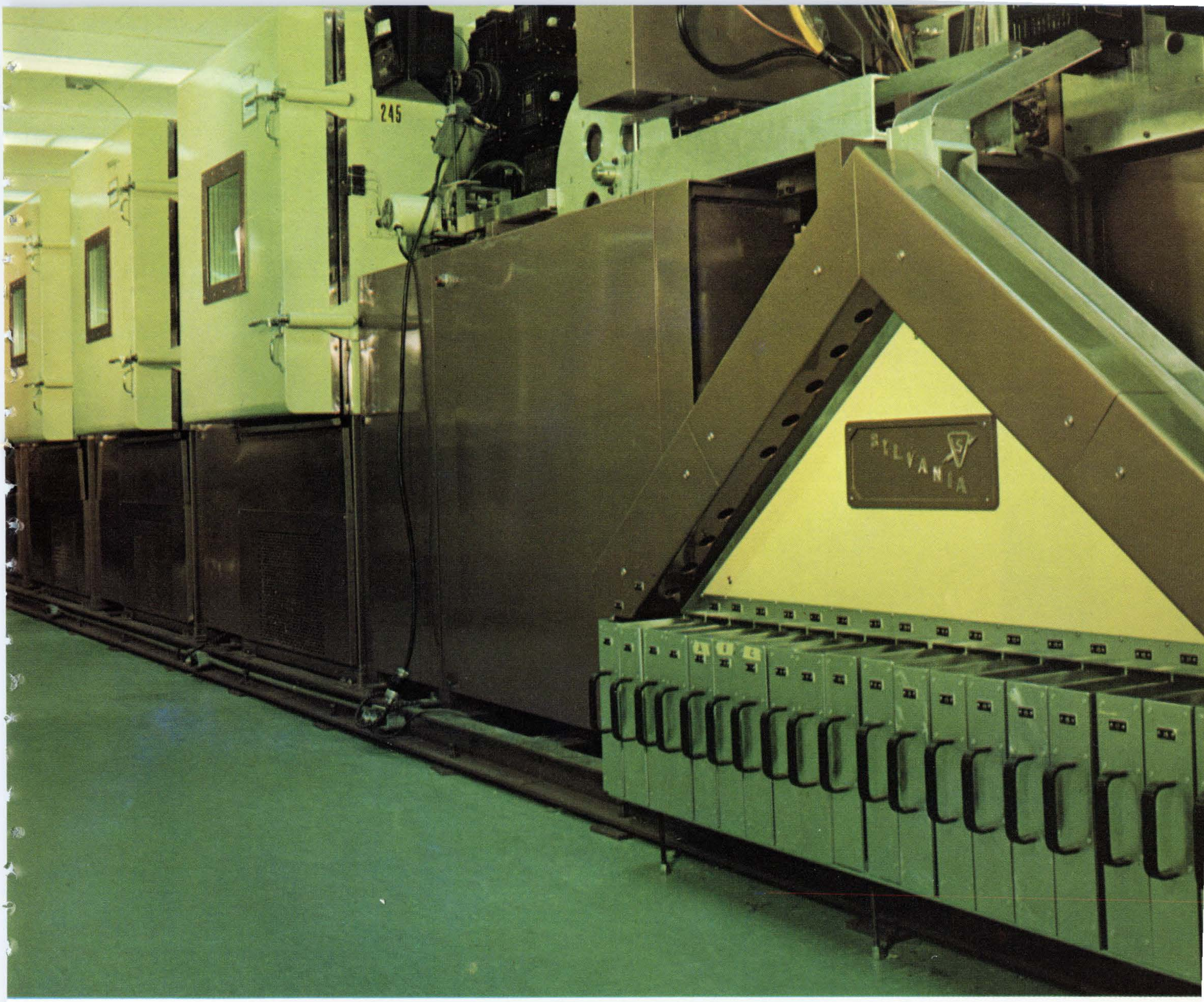
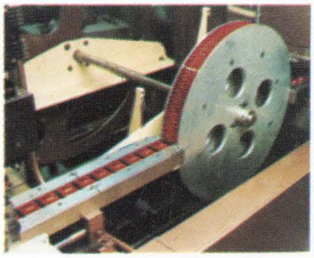


Every military IC must operate at temperatures from -55°C to 125°C in our test chambers.

In order to pass its final test, each Sylvania IC must operate in four consecutive temperature-controlled chambers while a computer records the parameters of each circuit. We call this ultimate testing equipment "Mr. Atomic"—a system with a capacity of about a quarter-million ICs a week.

In each "torture chamber," the ICs are automatically inserted in a wheel that rotates them to the testing point while they're stabilized at test temperature.

The temperature of the first chamber is 75° C. The second is 0° C. The next is 125° C. Then, –55° C. In these four chambers, up to 100 D.C. tests are automatically performed. A fifth testing station, maintained at 25° C, tests up to 30 switching parameters accurately down to a few nanoseconds. (See inset). Each input is individually tested.



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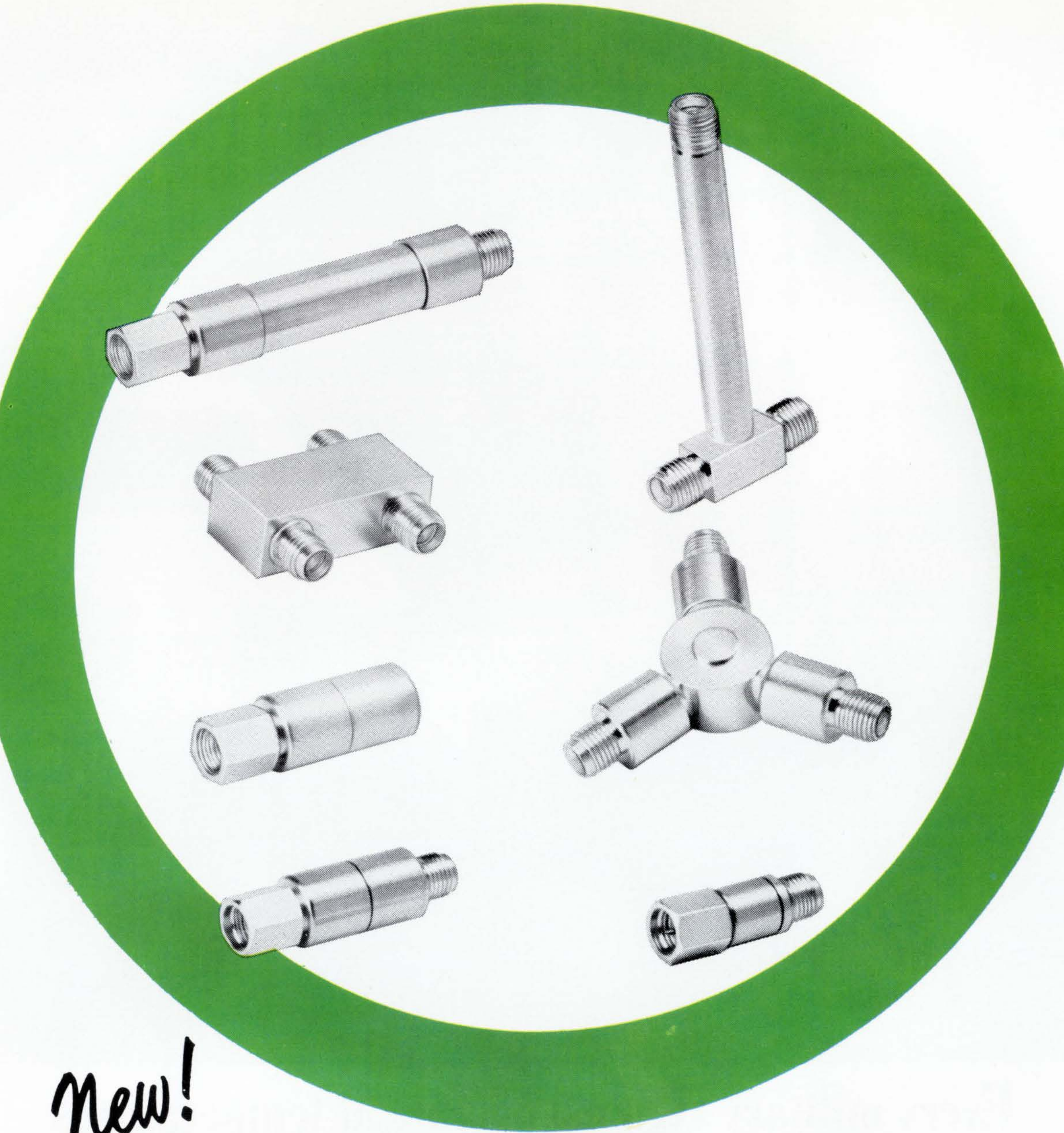

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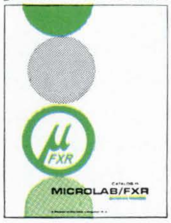
3	0.75	1.5	1.4	0.5	55.00
6	0.75	1.5	1.4	0.5	55.00
10	0.75	1.4	1.4	0.5	60.00
15	0.75	1.4	1.4	0.5	60.00
20	0.75	1.4	1.4	0.6	60.00
30	1.00	1.4	1.8	0.6	65.00
40	1.00	1.4	1.8	0.6	65.00

Right now, 28 models of 8 basic product lines are available for immediate delivery; additional lines are on their way. What's more, wide use of interchangeable parts means that large-quantity orders can be filled readily and "specials" designed for you quickly. Write for complete information.



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- **±5% measurements at 700 MHz (usable to 2 GHz)**
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- **Priced at only $650!**

The Hewlett-Packard 3406A RF Voltmeter provides greater accuracy and sensitivity over a broader frequency range than any comparable instrument available... and at only $650!

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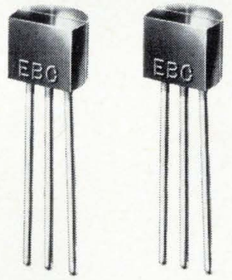

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h_{FE} (I_C = 10 mA) (I_C = 150 mA)	40 min 50 min	80 min 100 min	50 min 50 min	100 min 100 min
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Prices (5,000-up)	28¢	35¢	28¢	35¢

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Bendix Aerospace Products

Electronics Review

Volume 40
Number 18

Computers

Traveling memory

Few people—especially U.S. Customs officials—are startled by the contents of a traveler's overnight case, but how often does anyone see a computer memory tucked away in a 21-inch suitcase? That's how engineers at Bunker-Ramo's Defense System division packaged the 1,024-word, 30-bit low-power metal oxide semiconductor memory they built under contract to the Air Force Systems Command's Avionics Laboratory at Wright-Patterson Air Force Base.

The memory is significant for several reasons: it operates on much lower power and it's priced competitively with conventional memories. Although no applications have been spelled out by the Air Force or the company, M.E. Mohr, Bunker-Ramo's president, noted recently that completion of the project led to another Air Force award "to study the technology in implementing a low-cost inertial guidance computer for air-to-surface missiles."

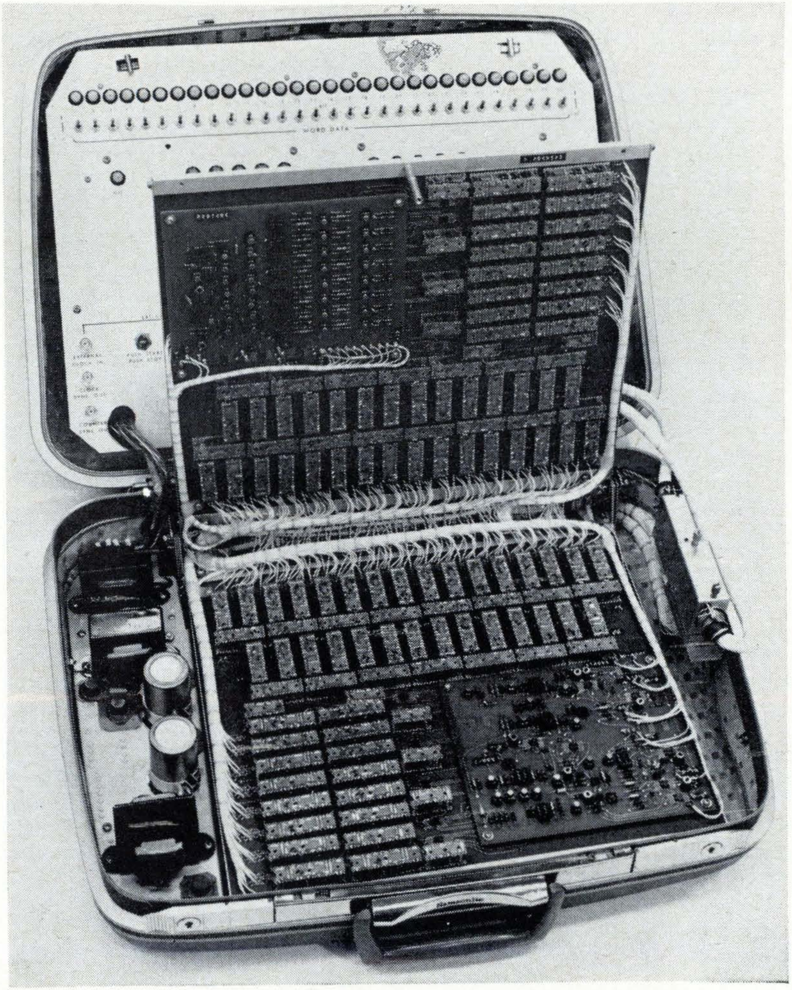
George V. Podraza, an engineer for the Canoga Park, Calif., firm, says the nondestructive readout memory was put into a suitcase to simplify transporting it. Podraza is on a team headed by Samuel Nissim, manager of advanced computer technology, which developed the memory.

A feasibility model—including a breadboard exerciser that isolates faults down to the individual flatpack level—was given a preliminary evaluation by the Air Force and is now back at Bunker-Ramo for further demonstrations. It faces extensive evaluation at Wright-Patterson in about a month. Dewey Brewer, a computer subsystems project engineer at the avionics laboratory, described the memory's performance during initial tests as very good.

Could be smaller. The memory consists of 480 flatpack integrated circuits, each with 64 memory elements on an 80-by-100 mil chip. Podraza emphasizes that no attempt was made to shrink the size of the memory array, adding that the 480 chips, made by Philco-Ford's Microelectronics division, could be further reduced to a 1½-inch square thin-film substrate, if the Air Force says it's necessary.

The objective is to develop a low-power random-access scratchpad MOS memory priced competitively with other types of memories. The entire memory, excluding the exerciser but including the peripheral circuitry—address, write drivers, sense amplifiers, and timing circuits—consumes only 3½ watts; the MOS memory storage requires just 1 watt. The demonstration model uses a standard 115-volt a-c power supply.

One industry observer says that



Suited for apace. Bunker-Ramo's experimental memory, which fits into a 21-suitcase, operates on very low power.

comparable memories, using plated wire or magnetic cores, require power an order of magnitude greater than the Bunker-Ramo unit.

"This memory gets competitive with magnetic cores at small sizes," claims Podraza, "because we have a high-amplitude readout signal. We don't need very elaborate sense amplifiers." He says the chip cost works out to about $1 per bit, but expects the cost per bit can be cut to 25 cents as yields and processing techniques improve. This compares with present costs of between 50 cents and $10 per bit for registers and high-speed scratchpad memories.

Faster yet. Podraza explains that faster memories have been built, but that with a cycle time of 1 microsecond, the Bunker-Ramo memory speed is significant when balanced against power dissipation. He says that core memories have been built with 100 nanosecond cycle times, but they require three times as much power as the suitcase memory.

Brewer notes that complementary MOS memories should be faster than Bunker-Ramo's p-enhancement unit, but nobody has built such a memory, as far as he knows. He says the suitcase memory could find application in scratchpad aerospace computers where extremely low power is important.

Bipolar technology is employed in the peripheral circuitry, with some bipolar IC's in the address decoder. The bipolar devices drive the large memory capacitance—several hundred picofarads—at fairly high speeds, says Podraza. But bipolar technology doesn't allow application of large-scale integration to the memory chips, says the Bunker-Ramo engineer. "We're getting three to four times as many memory cells on a chip with MOS techniques."

Real-time Fourier coefficients

About a year ago two scientists dreamed up a way to compute the Fourier coefficients of a complex waveform thousands of times faster than ever before [Electronics, Oct. 3, 1966, p. 52]. And engineers at Bell Telephone Laboratories subsequently asked themselves, "Why can't we build the Cooley-Tukey algorithm (named after the scientists who worked it out) into a machine that computes Fourier coefficients in real time?"

They could and they did. The processor, built for research in signal processing, generates the discrete Fourier transform for audio signals as fast as the signals come in.

It is connected to an IBM 1800 computer, a small machine generally used in process-control applications, but it is producing results as much as 20 times as fast as the laboratory's giant GE 635 computer.

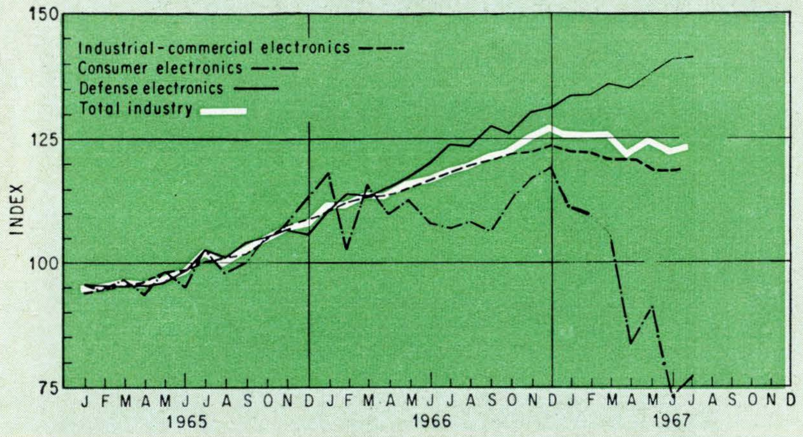
Richard Shively, an engineer at Bell Labs, will describe the machine at the IEEE Computer Conference in Chicago this week.

Samples of segments. The processor divides up a waveform, which might be that of a voice on a telephone wire, for example, into segments a fraction of a second long. It then samples each segment at a frequency which is at least twice the bandwidth of the incoming signal. From the amplitudes measured at each sample the processor computes the Fourier coefficients for that segment while the following segment is being sampled.

The highest Fourier coefficient that the machine can generate is related to the sampling frequency and to the desired resolution. For example, if the input signal is divided into segments 1/25 second long, the machine will provide the Fourier coefficients for a funda-

Electronics Index of Activity

September 4, 1967



Segment of Industry	July 1967	June 1967*	July 1966
Consumer electronics	**78.8**	72.3	100.7
Defense electronics	**140.9**	141.4	124.1
Industrial-commercial electronics	**119.7**	118.3	118.3
Total industry	**124.0**	122.9	118.4

Volume of electronics production increased more than 1 index point in July and stands almost 6 points ahead of the July, 1966, level. Consumer production was the strongest gainer, surging more than 6 points in July but remaining more than 20 points below the year-ago pace. Output of defense electronics dropped half a point in July, but it still shows the strongest year-to-year gain of any industry segment, up nearly 17 points.

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.

mental frequency of 25 hertz and for multiples of 25 up to half the sampling frequency. If the signal has a bandwidth of 5 kilohertz, then the sampling frequency must be at least 10 khz; for that sampling frequency, the highest harmonic will be 5 khz.

Longer segments of the input signals will provide better resolution. Suppose a signal of 8-khz bandwidth is divided up into 1/10-second segments and sampled at 20 khz; the machine then generates the Fourier coefficients at 10 hz and multiples thereof up to 10 khz —a string of 1,000 numbers that defines the waveshape of the original signal with great fidelity. And this is nowhere near the capacity of the machine, which can process up to 8,192 samples of one segment.

Band aid. Bell Labs plans to use the new machine only as a research tool. But the Fourier coefficients of any kind of signal could be transmitted digitally as part of a frequency-multiplexing scheme, and the signal could then be reconstructed at the receiver. Or the coefficients could be transmitted directly in analog form, particularly where higher frequencies are involved. Either method of transmission would make more efficient use of the transmission bandwidth than direct transmission of the signal itself.

In another application the Fourier processor could be connected to a seismic monitoring system to produce a continuous string of coefficients for seismic noise. When a different signal arrives, masked to some extent by the noise, the changing coefficients would signal a distant mild earthquake or perhaps an underground nuclear blast —and the indication would be now, not tomorrow or next week.

Best route. The processor could also help achieve the best data-transmission rate on lines whose parameters vary from route to route. A telephone connection between two computers in New York and Los Angeles may be via Memphis in the morning and via Chicago in the afternoon, and the characteristics of the two lines may differ.

Space electronics

Repair on the wing

Computer designers, who are aware that there are no repairmen in space, are turning to machines that both diagnose and repair breakdowns without outside help and without significantly interrupting computations.

In one project, called STAR for self-testing and repair, Jet Propulsion Laboratory researchers are going one step further: they're developing a computer that performs most of its diagnosing work with hardware—not software—thereby cutting costs and saving computer-memory space.

Directed by Algirdas Avizienis, who is also on the engineering faculty at the University of California at Los Angeles, the project is funded by NASA. The goal is a computer unattended in a spacecraft for 10 years. As yet, a specific mission for the computer hasn't been chosen.

First step. So far, the arithmetic processor and one of the "bus checkers" vital in the system's concurrent diagnosis scheme—diagnosis during computation—have been breadboarded. The goal is to have the entire computer breadboarded by the end of 1968. "We felt the arithmetic processor had to be built first because it's the most demanding part of the task," says Avizienis.

Avizienis cites two critical design problems to be solved before an arithmetic processor can perform concurrent diagnosis: devising a way to indicate when a functional unit in service needs repair, and choosing the most reliable way to deactivate the faulty unit and activate a standby unit. The JPL researcher says his group chose to do all switching at the power source for each subsystem rather than on the wires that connect subsystems.

Three schemes. To achieve concurrent diagnosis, the JPL team employs conventional 32-bit binary numbers for all computer words. Three different error-detection schemes are used. Arithmetic operands fed into the machine are 28 bits long and are multiplied by 15 as they are entered. Thus, all numbers being processed are multiples of 15. The multiplication adds four bits to the 28-bit word for a total of 32. The result of every operation is also a multiple of 15; a checking unit divides every such result by 15. If the remainder isn't 0, an error is signaled. The number 15 in binary form is 1111, and the choice of this particular number is related to the STAR computer's execution of arithmetic operations in four-bit bytes.

The computer's instructions are also 32 bits long, and comprise a 12-bit operation code and a 20-bit address. The 12 bits in the operation code are divided into four-bit bytes, each of which consists of two 1 bits and two 0 bits. If any byte is detected containing one or three 1 bits during the interpretation of an instruction, an error is signaled.

Addresses are specified by four 4-bit bytes, that are encoded by a multiplication process similar, but not identical, to that used for arithmetic operands, adding another four bits for a total of 20.

Avizienis maintains that the multiple-of-15 code will detect 14 out of every 15 errors that can occur. The probability of the 15th error occurring, he says, is very small and can be tolerated. Thus, there is no need for a special diagnosis program, allowing the diagnosis function to be implemented in hardware.

All units in the STAR computer that have been built use low-power, diode - transistor - logic integrated circuits from Fairchild Semiconductor's Micrologic line.

Standby system. Once an error is detected, it is directed to a control and diagnosis unit, which then momentarily interrupts the computation and attempts to restart it from a given point. If the fault reoccurs a standby subsystem is ordered into service. If a fault is detected in one of the three control and diagnosis units that run constantly and simultaneously, the other two deactivate the faulty unit and a spare is put into service.

Avizienis says there might be one or two spare control and diagnosis units, depending on the duration and complexity of a spacecraft mission. He adds that each of these units has been designed as small as possible to compensate for the power drain caused by three running at the same time. The Fairchild IC's in the breadboard have typical power drains of less than 1 milliwatt per gate and less than 4 milliwatts per flip-flop.

The completed computer will employ a read-only braid memory to be supplied by MIT's Instrumentation Laboratory [Electronics, May 1, p. 88], and a braided read-write memory from General Precision's Librascope group, which has just been awarded a subcontract. Librascope's memory will have a nondestructive readout. These units, along with the control and diagnosis unit that is being designed by Stanford Research Institute, are the only subsystems of the STAR computer that aren't being built at JPL.

Industrial electronics

Touch-tone testing

A significant step toward automation of production processes will be taken this month by the Western Electric Co., manufacturing arm of the Bell System, at its Merrimack Valley works in North Andover, Mass. An on-line production information system—one of the first random-access computer-monitored process systems in the U.S.—will be put into operation in the crystal unit-fabrication shop.

Operators at 50 stations, equipped with frequency and resistance test sets, will have immediate access to a Honeywell H-21 process-control computer. Analog voltages representing crystal-resistance values, and digital signals for crystal frequencies will be fed into the computer through a multiplexer. The computer will then compare the readings with standards and generate reports on trouble spots.

"We hope to save about a half-million dollars a year in reduction of shrinkage," says William D. Watson, development engineer. A $5 million-a-year operation, the crystal shop usually has 40,000 units in production and test stages at one time. The plant makes transmission equipment for telephone and television trunklines. Quartz crystals are used by the thousands in this equipment.

Western Electric's long-range goals include closed-loop computer control of the crystal shop's frequency-adjusting facilities. The first step is the real-time production information system with on-line monitoring of the testing function.

Finger tip control. A total of 250 work positions, including the 50 test stations, will also be equipped with small input stations for entering manual data into the computer. These are part of the Gates VIII system developed by the Western Electric Engineering Research Center in Princeton, N.J. The term Gates stands for the initials of the men who developed it.

The input keyboards are modified touch-tone dialers similar to those on many new telephones. The stations will accept information directly from production workers on all their significant activities—including movement of product lots, quantities, and observed defects.

The system will permit identification of production problem areas, control of inventory, improved scheduling of jobs and facilities, determination of operator efficiencies, and reduction of supervisors' paper work.

"I am convinced," says Watson, "that an effective shop-information system must not flood supervisors with information, but let them see quickly those things on which they must take action. It will give us a handle on what is going on in quality as well as inventory, and will speed the feedback time, so we can do something faster about production and inventory problems."

Unpunched. The real-time system replaces a punched-card technique used in the last three years.

In the first phase, only the test data will flow directly to the H-21 computer. The Gates VIII manual data will be punched onto paper tape for subsequent batch analysis by the plant's central computer. Eventually, the paper tape will be replaced by a direct connection to the H-21 computer. There, the data on the tape will be checked for errors and then compiled with data from the automatic test sets. The total data stream will be recorded on magnetic tape to be used by the central computer for more detailed off-line analysis.

Button pusher. The fully automatic input stations for the real-time system will be situated where operators adjust the crystals, perform fine tuning, and do final testing. A station consists of a Hewlett-Packard voltmeter and frequency counter combined by Western Electric engineers into a frequency-resistance test set. After the operator pushes a button, the computer takes less than 2 milliseconds to communicate with the set. The operator codes in the crystal type. Then the signals representing frequency and resistance values are sent to the computer through the multiplexer, made by Astrodata Inc.

The 50 test sets time-share the

Dialing trouble. Western Electric is computerizing its testing of crystals. Information is entered through a touch-tone dial system.

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COMPUTER CONTROL DIVISION

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multiplexer and computer so that there is no noticeable wait for the operator after the button is pressed for a reading. It takes the system 5 milliseconds to perform the complete recording cycle. Meanwhile the computer has looked up the tables of standard values and average readings, which are updated daily.

Father of inertial navigation

On Feb. 8, 1953, an inertial guidance system automatically guided a converted B-29 bomber from Bedford, Mass., to Los Angeles without radio aids or star sightings.

The electromechanical system was designed and built by C. Stark Draper at MIT's Instrumentation Laboratory. The flight proved inertial systems were practical for long-range navigation and guidance. Since then, inertial-guidance systems have been used in most U.S. long-range missiles.

Regarded as the father of inertial guidance, Draper, now 65 and retired from the MIT faculty, still heads the lab. He has personally taken charge of developing a new generation of sensors for gimbaled inertial systems.

His goal: sensors that will keep inertial systems to a drift rate of only $10^{-5\circ}$ per hour, 100 times better than today's performance and with a lifetime of 100,000 hours, at least five times better than present systems. The sensors would be electronically self-adjusting.

Draper founded the lab shortly before World War II to develop gyroscopic gunsights for the Navy's antiaircraft guns. By war's end, the laboratory chalked up gyro-stabilized gun-bomb-rocket sights for fighter planes among its developments. After the war, Draper began applying his knowledge of gyroscopic stabilization and feedback control to inertial navigation and guidance, leading to that historic 1953 flight.

Avionics

In competition

NASA isn't taking any chances.

At the agency's Electronics Research Center in Cambridge, Mass., work is stepping up toward the development of strapdown inertial guidance technology. Meanwhile, right across the street at MIT's Instrumentation Laboratory, work is also stepping up on its development of gimbaled inertial guidance systems.

The two types of inertial systems—strapdown and gimbaled—are competing for use on the supersonic transport and future space vehicles, and NASA has decided to bet its money on both.

Research into strapdown systems includes a $500,000 contract with United Aircraft for the development of a modular-integrated circuit computer for such a system. And NASA is about to award a $300,000 contract for the design and construction of a standard strapdown system.

The inventor. MIT's work—a three-year, $7.9-million effort—is for the development of advanced gyroscopes and supersensitive solid state sensors for gimbaled systems. The project is under the direction of C. Stark Draper, the founder and director of the lab and the man who's credited with designing and building the first inertial navigation system.

Gimbaled systems—installed in the Apollo spacecraft and in Polaris, Minuteman, and other missiles—use a stabilized platform that isolates vehicle motion from the sensors and is initially aligned to inertial space—distant stars.

Strapdown systems are bolted directly to the body of the vehicle. As it moves, the gyros and accelerometers move with it. Thus, it must operate in a more severe environment and give measurements over a wide dynamic range. A newer technique, strapdown has been tested on Air Force experimental lifting-body vehicles and on a Lunar Orbiter flight. A strapdown system is the abort-guidance method on the Apollo landing module.

Most inertial-guidance specialists believe gimbaled systems offer greater accuracy and performance because the sensors operate in a protected environment, but that strapdown systems offer weight, cost, reliability, flexibility, and maintainability advantages for some applications.

Open-minded. "We're not hardnose about it, but there has been continuing work on gimbaled sensors and not enough on strapdown," says Richard J. Hayes, the NASA center's assistant director for guidance and control research.

In theoretical studies sponsored by the center, analytical-error modes of new plug-in, self-aligning gyros are being established to make tools for design trade-offs.

"There isn't a gyro house in the U.S. today that can handle the whole problem," says Hayes. "The trouble is that the gyro design is done by mechanical engineers, and the electronics people are called in afterwards to design a signal pickoff loop around it. We're asking companies to reassess their organizations and capabilities, and work toward integrated mechanical and electronic design of new gyros."

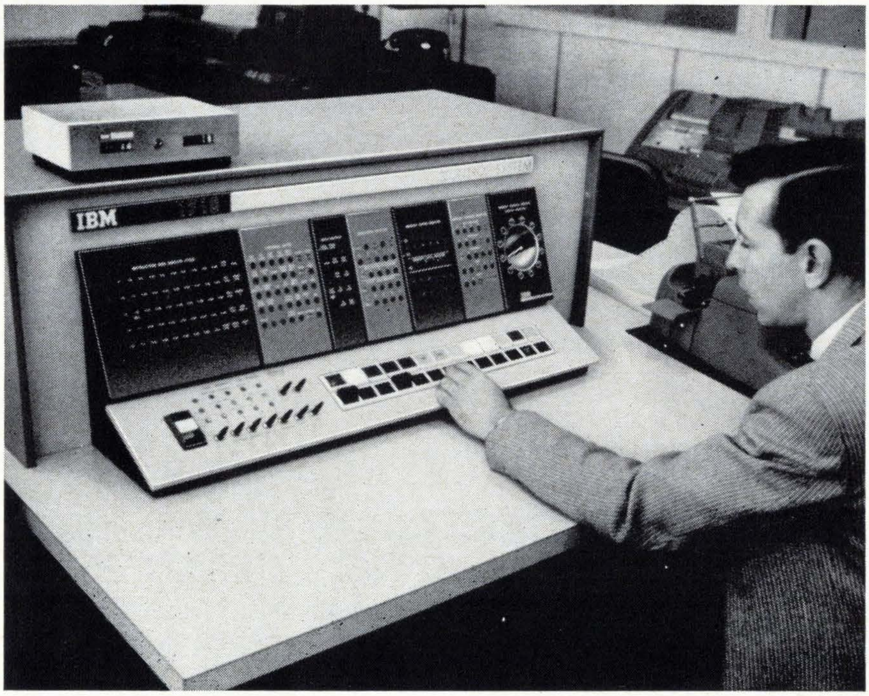
Meanwhile, the laboratory will test and evaluate new sensor principles, including the laser gyros developed by Honeywell and Sperry Rand. Laser gyros don't require warm-up time, are relatively inexpensive and simple, and also produce digital output for computers.

On course

American Airlines is pushing ahead with its in-flight testing of an inertial navigation system, undeterred by Pan American World Airways' decision to drop the inertial system developed by Sperry Gyroscope [Electronics, July 24, p. 38]. A prototype of Litton Industries' LTN-51 system was installed last month on an American Boeing 707 used for

SPEER COMPONENT COMMENTS

How to get a real reading on a resistor's true function... resistance.



That's right, we mean plain old electrical resistance.

The problem with this particular parameter it that it's just too basic. It doesn't have the exotic intrigue of such items as temperature coefficient, moisture resistance or load life. As a result, almost everyone takes it for granted—and naturally neglects to verify whether or not the resistance is actually being properly measured.

For example, if you don't realize the importance of using the proper test voltage, you can get all kinds of remarkable results.

The culprit in this case is the coefficient, not the component you're measuring. You can decrease the measured resistance of a carbon composition resistor by simply increasing the voltage applied... and vice versa.

Now with low value resistors below 100K improper applied voltage won't wreck your readings since the VC is comparatively insignificant. But if you're measuring resistors above 100,000 ohms this voltage coefficient can throw a real curve.

So what should your test voltage be? According to EIA Specifications RS-172, MIL-R-11, and MIL-R-39008, resistors above 100K must be tested at 80 to 100 volts.

Yet most commercial testing units used by receiving inspection departments and component evaluation laboratories apply, at most a mere 15 volts. So, unless compensation is made for this Voltage Coefficient, many lots of perfectly good resistors which are well within the parameters specified could be indicated as somewhat beyond the limit.

Needless to say, Speer tests and sorts all of its resistors at EIA/military voltages.

In addition, we've prepared an article that explores this entire subject in greater detail. This article has the appropriately basic title: "Resistance—How It Is Measured." If you'd like a copy, just mail the coupon.

Are you and your inductor supplier committing Typical Test Error #6?

If you've been purchasing any of the superb inductors manufactured by our Jeffers Electronics Division, we may well have warned you about this error already.

It consists of failing to obtain correlation between your supplier and your own incoming inspection, in cases where inductance tolerances of less than 5% are involved.

Ideally, this step should be completed before the actual manufacturing operation starts. Your supplier should measure and tag sample parts and then forward them to you for correlation.

There are seven other possible errors that you should also be aware of when you're using MIL-C-15305 testing procedures to measure inductance and Q. We've covered a number of these errors already. The others will be along shortly.

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military charter flights to Vietnam. Present plans call for the first of six production systems to be airborne starting in October.

No land marks. Eyeing new Pacific routes, American has an option to buy up to 25 of the systems, because the Pacific has few ground navigation aids.

There are still problems to be worked out in the system prototype, particularly with electrical connectors. The second test flight between Norton Air Force Base, Calif., and Anchorage, Alaska, was a washout. A wire came loose in a connector and the navigation system lost its memory.

Instrumentation

Burning up the track

Up until last year direct-writing event and graphic recorders puttputted along at about a few hundred hertz, while light-beam recorders pushed this speed up to a few kilohertz. Then last fall Honeywell broke the speed barrier with an oscillograph [Electronics, Nov. 14, 1966, p. 217] that pushed the state of the art to 1 megahertz —but at a price, $20,000. Now, a small company in Norwood, N.J., Alpine Geophysical Associates Inc., has developed a machine that promises to boost this speed at least two orders of magnitude and it'll cost only about $5,000 when it reaches the market within a year.

So far the Alpine recorder has attained speeds only equaling Honeywell's, but George Lehsten, the inventor and Alpine's chief engineer, says, "We haven't really opened it up; it'll eventually be able to record at up to several hundred megahertz."

Scratching the pen. The speed breakthrough, in both Honeywell's and Alpine's design, is achieved by eliminating the traditional moving pen, which has always been a drag on recorders.

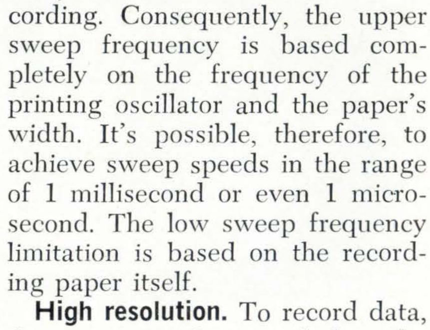
Honeywell's recorder uses a cathode-ray tube to display the image of a signal's waveform. The crt is connected, via fiber optics, to light-sensitive paper for recording the image. Alpine's machine, on the other hand, is much simpler. It uses the old-fashioned Lecher wire —the device that's used to measure wavelengths—to both measure a waveform and then literally burn the image onto a swift-moving roll of ordinary, inexpensive newsprint.

The Lecher wire is coupled to a very-high-frequency oscillator, which has a center frequency of 300 megahertz. The oscillator creates a voltage standing wave on the Lecher wire; then, when a signal from a sawtooth generator varies the oscillator's frequency by ±100 Mhz, the wave sweeps up and down the length of the wire much the way an electron beam sweeps across the face of a crt.

The only mechanical function in the machine is the device that feeds the paper through the loop of Lecher wire; its speed is electronically servoed to the rate of recording. Consequently, the upper sweep frequency is based completely on the frequency of the printing oscillator and the paper's width. It's possible, therefore, to achieve sweep speeds in the range of 1 millisecond or even 1 microsecond. The low sweep frequency limitation is based on the recording paper itself.

High resolution. To record data, the input signal is coupled to the oscillator with a processor modulator. Details on the modulator are proprietary; obviously, it's upon the design of this device that the entire instrument is based.

The modulator boosts the energy level of the voltage wave when data is present, causing an electric



Zip. High-speed graphic unit may record at 100 Mhz.

An oscilloscope picture in 10 seconds: any longer is a waste of time.

Polaroid Land films don't make you wait to see if your trace zigged when it should have zagged.

They let you know in ten seconds.

They give you an oscilloscope picture you can study, attach to a report, send as a test record with a product shipment, or file for future reference.

You have a choice of 5 films for oscilloscope recording.

The standard film has an A.S.A. equivalent rating of 3000. It comes in both roll film [Type 47] and pack film [Type 107]. They both give you 8 pictures 3¼ x 4¼ inches. This emulsion is also available in 4 x 5 sheets [Type 57].

For extremely high-speed recording, there's Polaroid PolaScope Land film [a roll film, Type 410]. It has an A.S.A. equivalent rating of 10,000.

It can take pictures of traces too fleeting for the human eye: such as a scintillation pulse with a rise time of less than 3 nanoseconds.

One thing all these films have in common is a sharp, high-contrast image that's easy to read. Because the films are so sensitive, you can use small camera apertures and low-intensity settings.

To put these films to work on your scope, you need a camera that will take a Polaroid Land Camera Back. Most oscilloscope camera manufacturers have one. For instance: Analab, Beattie-Coleman, BNK Associates, Fairchild, EG&G, General Atronics, Hewlett-Packard, and Tektronix.

You can get complete information by writing to Polaroid Corporation, Technical Sales Department, Cambridge, Massachusetts 02139, or by writing to one of the manufacturers mentioned above.

It will probably take a little longer than 10 seconds, but we promise the information won't be a waste of time.

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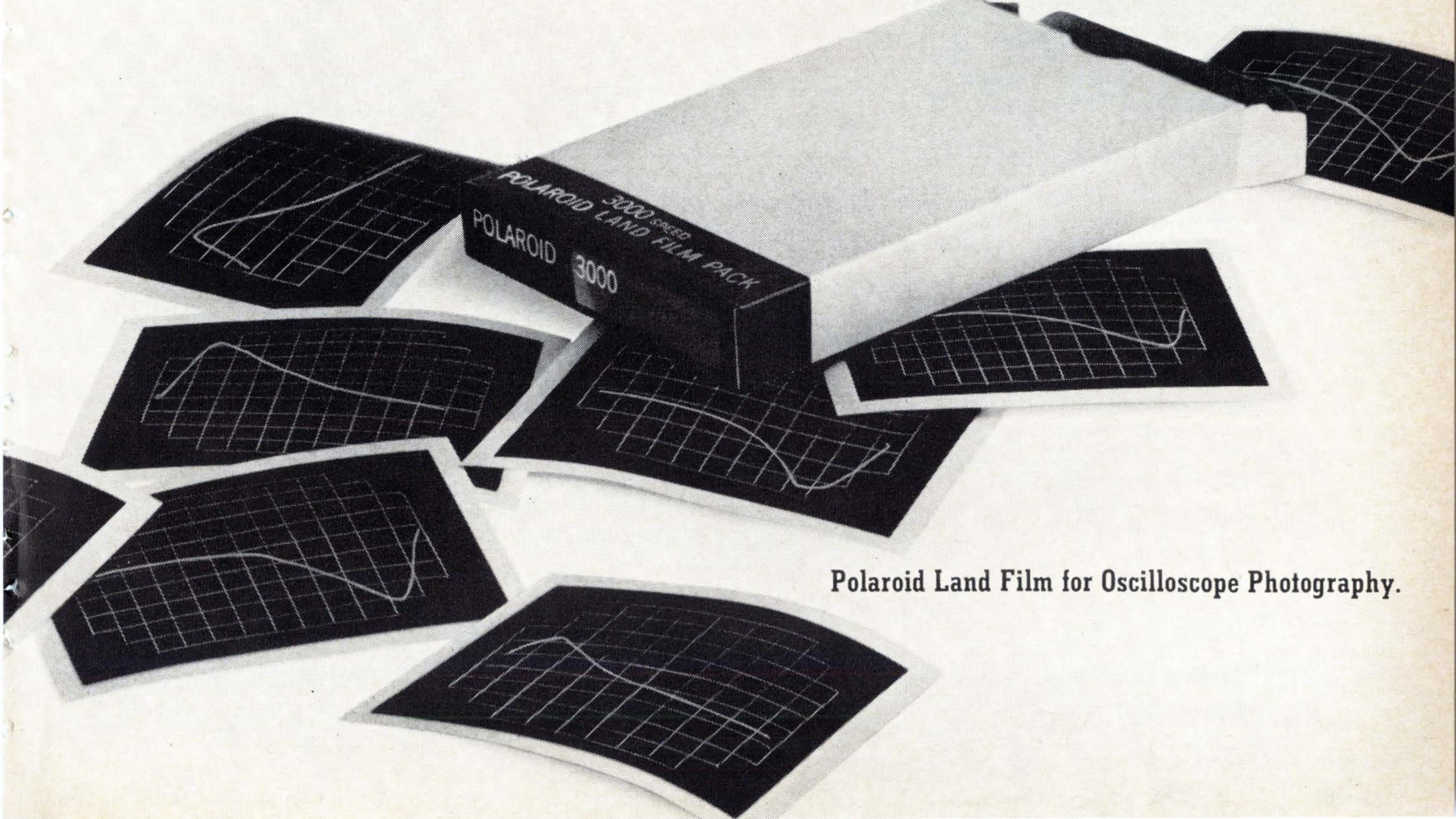


Polaroid Land Film for Oscilloscope Photography.

arc to jump between the Lecher wireloop and burning a mark no wider than 0.005 inch in the paper. With such small marks, resolution of the recorder is high, exceeding that of the best oscilloscopes.

Antilog, too. Aside from speed, the recorder has another advantage that's available only on the most sophisticated custom-designed units: it can perform both log and antilog sweeps. Since the sweep is entirely an electronic function, any sweep wave within reason can be employed at the flick of a switch. These changes can be made without any loss of recording continuity.

Oddly, Alpine isn't in the instrumentation business. It's basically an oceanographic firm that performs research and engineering. Inventor Lehsten explains that the machine was developed only because Alpine needed such a unit for its work on ocean-bottom measurings, and couldn't buy a suitable machine. Because it's not in the instrumentation business, Alpine is going outside to have it built for the commercial market; it's already conducted negotiations with several potential producers, but no firm decision on who will build it has yet been made.

Advanced technology

GaAs packs more power

If there's any lingering doubt about the power or efficiency of gallium arsenide (GaAs) microwave power sources, it should dissipate fast. The microwave applied research group at the Radio Corp. of America's Princeton, N.J., labs, has built Gunn-effect devices capable of pulse powers up to 150 watts at 1 to 2 gigahertz with the highest Gunn-effect efficiency yet, 19% to 25%—about four times better than previous achievements.

RCA's next step will be a parallel array of Gunn diodes designed to reach kilowatt outputs. Such an array may eventually find its way into an airborne transponder RCA is developing.

Meanwhile, researchers at Cornell University in Ithaca, N.Y., have squeezed 370-watt, 8-Ghz pulses out of GaAs wafers operated in the limited space charge accumulation mode (LSA). This is the highest power ever achieved with LSA. Cornell researchers are investigating the mode for the Air Force, which would use it in radar.

Making waves. At the Bell Telephone Laboratories in Murray Hill, N.J., John Copeland is expected to achieve continuous-wave LSA generation of 0.7 to 1.0 watt at 150 Ghz by autumn. In earlier work, he achieved tens of milliwatts of c-w power at 50 to 80 Ghz—and detected output at 150 Ghz. Copeland is now beefing up his instrumentation for millimeter-wave frequencies. He is also improving the heat-sinking capabilities of his crystal mount to boost output power.

Bell Labs is enthusiastic about LSA because it would enable the telephone companies to use the very broad bandwidths available at millimeter-wave frequencies. And solid state LSA devices could be far more reliable than tube oscillator.

The beauty of RCA's Gunn-effect achievement lies not only in high efficiency, but also in its repeatability. Industry sources say the company has found a doping profile for the semiconductor material that results in Gunn diodes with about 20% efficiency and that its epitaxial process control is close enough to assure repeating the profile time after time. RCA is patenting the profile.

Cornell's work is repeatable, too. Proof lies in the fact that the university's L.F. Eastman and G.C. Dalman, are forming a firm, Cayuga Associates, to market LSA-power sources for radar experimentation. The firm's first product will be unveiled in October, and will probably be capable of 350-watt, 8 Ghz pulses about 100 nanoseconds long.

Won't make waves. Although RCA's Gunn-effect work has proven successful, LSA work has had problems in materials and plumbing.

"Mounting these things (LSA

sources) and making them oscillate is a black art," says Martin Steel of the microwave research labs.

Ironically, it's the quality that makes RCA's GaAs good for Gunn oscillation that may be causing what Steel calls the company's "limited success" with LSA. Unlike LSA, which requires uniform doping throughout the GaAs crystal, the Gunn effect profits by graded variations in doping concentration along one dimension of the crystal. Using the very same crystal with which RCA first achieved 20% Gunn-effect efficiency, Steel's group got only weak, inefficient, 3% LSA output in K_u band at about 15 to 18 Ghz.

Government

The ups and downs

An economy-minded but defense-conscious Congress is playing seesaw with the defense and space budgets. While the House lopped $516.6 million from the $5.1 billion sought by NASA for 1968, Congress approved a $70 billion defense appropriation—the largest in history and about the amount requested.

Unless unexpected restorations are made by the Senate, space spending for fiscal 1968 will be the lowest in five years. Hardest hit were "new start" programs. The Voyager program to send a craft to Mars was eliminated, as was the budget's "advance missions" item, which includes the mission study for the launch vehicle to be used after Saturn 5.

Two-year setback. Elimination of Voyager means there will be no lunar and planetary exploration programs beyond the launch of two Mariners now scheduled for 1969. NASA requested $71 million for Voyager in its plan to land an unmanned spacecraft on Mars in 1973. Even if funded at a later date, the earliest possible landing on Mars will be in 1975, the next time the planet is close enough.

The Senate, which had earlier tried to scuttle Voyager when authorization hearings were held, is not expected to appropriate money for the program. A request for $40.2 million for electronic systems was trimmed by $5.2 million.

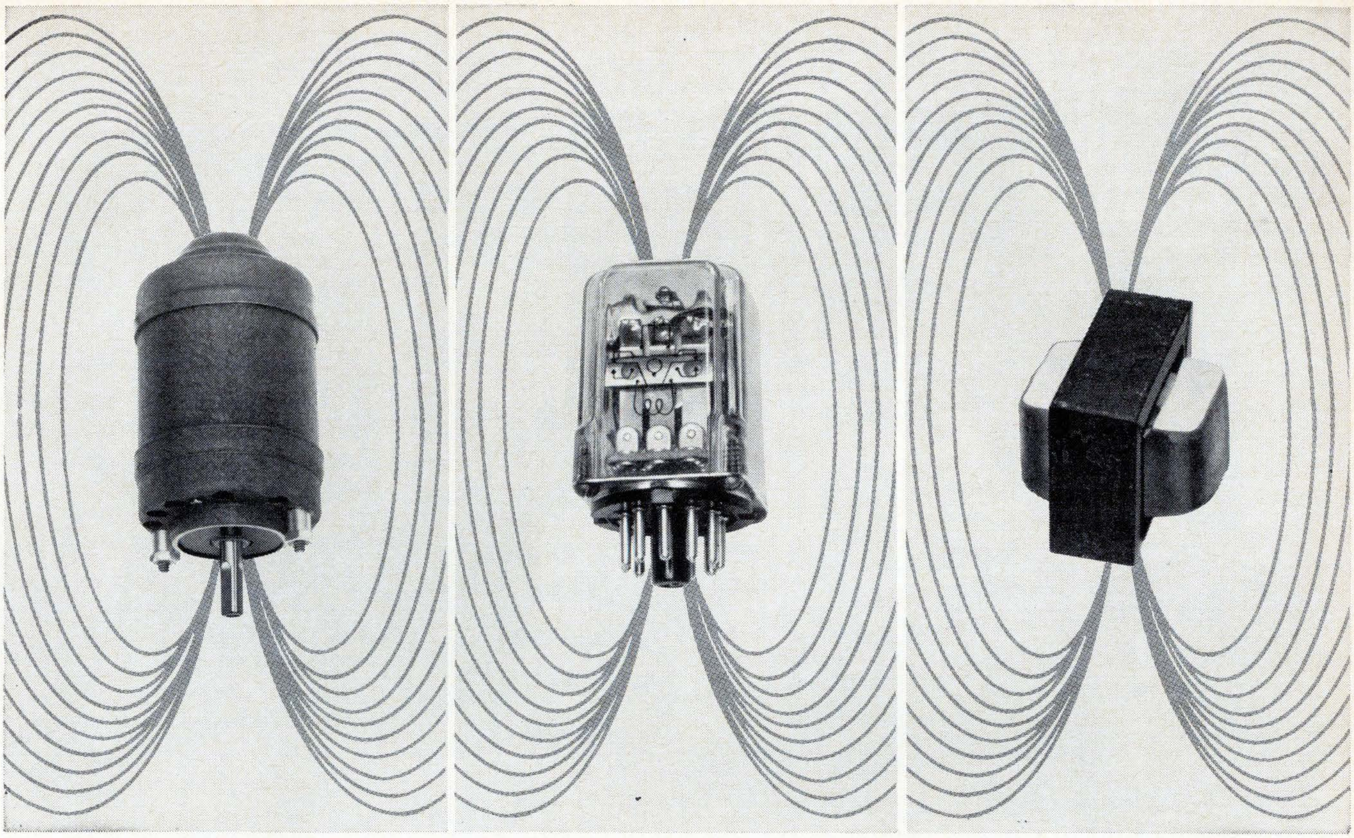
The defense budget does include some cuts. The bill limits the Navy to purchasing eight test models of the controversial F-111B aircraft instead of the 20 requested by the Administration. The reduced number will cost $147.9 million, roughly half the $287 million requested for the 20 planes. The cut reflects Congressional unhappiness with the plane, which has grown so heavy that some critics wonder if it will be able to be used on carriers. Grumman Aircraft builds the plane under subcontract from General Dynamics.

More for Nike. The spending bill includes $730 million for the Nike-X antiballistic missile system—increasing the amount available for the program to almost $1 billion. About half of this amount is reserved for initial production once the Administration gives a green light.

Congress authorized $47 million for the advanced manned strategic aircraft.

For the record

Narrow view. The National Science Foundation, recognizing that Federal funds are more likely to be spent on guns and ghettos than stargazing, has chopped a $130-million package of six proposed radio and radar astronomy programs to a pair of projects costing $18 million. The most ambitious of the six—$52 million for an array of 36 dishes proposed by the National Radio Astronomy Observatory—has been returned for further study. Also deferred for study were bids by the Northeast Radio Observatory for a 42-foot fully steerable dish in a radome, and Caltech's steerable 330-foot dish. Projects that were recommended are Caltech's plan to add seven 130-foot dishes to its Owens Valley facility, and Cornell University's bid to improve the accuracy of the 1,000-foot spherical dish in Arecibo, Puerto Rico.



Now, Get 6 Volts Noise Immunity For Your Digital Control System With New MHTL Integrated Circuits!

You'll get the "right" signal every time in your numerical control, supervisory control and computer peripheral equipment with the new Motorola-developed high threshold integrated circuit logic series. Called MHTL, it's the first family of integrated circuits to offer a noise margin of 6 volts (typ) and a 15 volt (±1V) operating voltage. And, it's priced, packaged, and specified for application in equipment designed for use in high noise industrial environments.

MHTL combines high noise immunity with a voltage swing of 13 volts, broad operating temperature range, large fan-out and a 35 mW power dissipation rating. In short, it offers you discrete circuit characteristics PLUS the price, size, and reliability advantages of integrated circuitry.

Here are some of the MHTL specifications:

CHARACTERISTICS	MHTL
Operating Voltage	15 ± 1 Volts
Noise Immunity	6 Volts (typ)
Fan-out (Gate)	10 (min)
Clock Rate (Flip-Flop)	4 MHz (typ)
Operating Temperature Range	−30°C to +75°C

Offered in the 14-pin dual in-line plastic Unibloc* package, the circuit functions and prices for the MHTL family are as follows:

TYPE	DESCRIPTION	PRICE (1,000 UP)
MC660P	Dual 4-Input Gate	$3.50
MC661P	Dual 4-Input Gate (Passive Pull-Up)	$3.50
MC663P	Dual J-K Flip-Flop	$6.10
MC664P	Master Slave R-S Flip-Flop	$4.05

Other functions planned for the immediate future include a Dual 4-Input Line Driver, Triple Input Interface, Quad Output Interface, Dual Monostable Multivibrator, and Quad 2-Input Gate.

To find out how easily your designs can conquer high-noise-environments with MHTL, write for our data sheets. We'll also send you our latest application note on how MHTL solves your noise problems. For circuits you can try right now — call your nearby franchised Motorola Semiconductor distributor. He has high-noise-immunity MHTL in stock!

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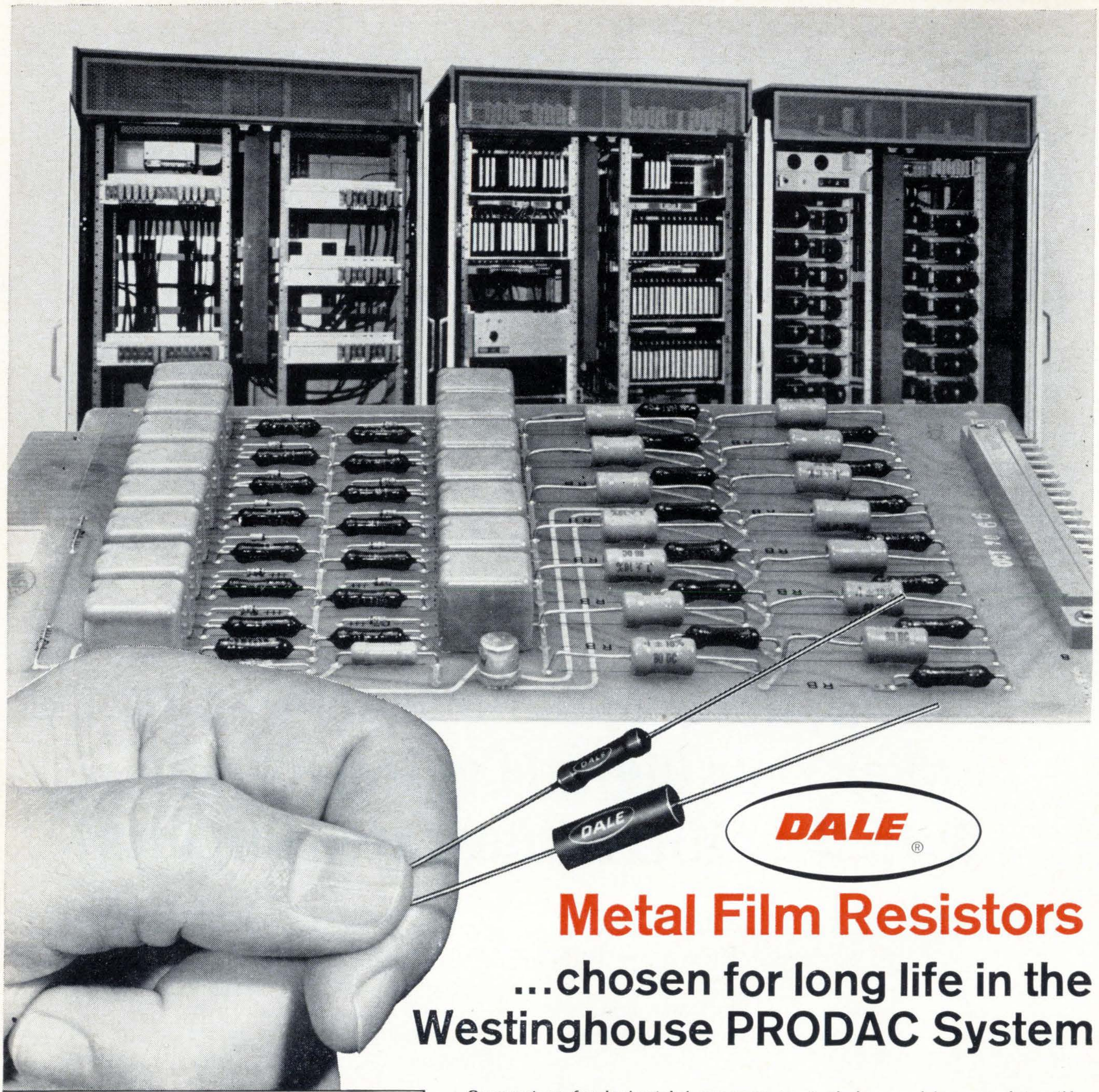
Circle 51 on reader service card



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DALE TYPE	MIL. TYPE	125°C RATING (Char. C & E)	70° C RATING (Char. D)	RESISTANCE RANGE (Ohms)
MF50	RN-50	1/20 w	1/10 w	30.1 to 80.6K
MF-1/10	RN-55	1/10 w	1/8 w	30.1 to 301K
MF-1/8	RN-60	1/8 w	1/4 w	10 to 1MΩ
MF-1/4	RN-65	1/4 w	1/2 w	10 to 1 MΩ
MFS-1/2	RN-70	1/2 w	3/4 w	10 to 1.5 MΩ
MF-1	RN-75	1 w	–	25 to 2.6 MΩ
MF-2	RN-80	–	2 w†	100 to 10 MΩ

*Also available in conformal coated (MFF) styles. †Char. B.
Tolerance: ±1%, ±.5%, ±.25%, ±.10% standard.
Characteristics D, C, or E apply depending on T.C. required.

Computers for industrial process control demand long resistor life. To insure this, Dale Metal Film resistors are used extensively in the versatile Westinghouse PRODAC System. Value analysis dictated the choice—with the long life characteristics of metal film winning over the lower price of carbon and carbon composition types. Dale verifies this reliability with long-term load life tests (see below). Delivery is reliable, too. Expanded production facilities can put quantities up to 50,000 in your plant in 2 weeks (1% tolerance units). We'll prove it—call 402-564-3131 today.

NEW METAL FILM LOAD LIFE DATA

Dale MF resistors have undergone 16,320,000 hours of load life testing without a failure (100% rated power, 70°C; failure defined as $\Delta R > 1\%$). Based on these tests, the MF resistor has a proven failure rate of .004% per 1,000 hours (60% confidence at 50% power, 70°C ambient). Write Dale for complete test data.

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Washington Newsletter

September 4, 1967

IBM will make Corsair deadlier . . .

Avionics in the latest Corsair 2 aircraft—the Air Force A-7D and the Navy A-7E—will be integrated by IBM. Built by Ling-Temco-Vought, the new planes will differ from the Navy's A-7A primarily in avionics.

Although the new craft won't have complete all-weather and night attack capability, the improved avionics—an inertial platform, doppler navigation, a highly sophisticated radar, and IBM's 4 Pi computer—will enable it to hit large targets in zero visibility and within 50 feet of visible targets when flying at 5,000 feet. This is twice the accuracy of the A-7A's.

The IBM-integrated system will cost about $700,000 compared to the $500,000 for the A-7A avionics. The older system isn't integrated, although it has a Univac 1818 central computer. And, it doesn't include an inertial navigation system.

The new system will include an improved Texas Instruments radar for target-acquisition, navigation, terrain-following, and other functions. Kaiser Electronics will build the heads-up display and General Precision will supply the inertial platform and doppler.

Deliveries of the new Corsair models will begin in late 1968. The Pentagon is anxious to get the new series operational; one reason is that **the Grumman-built A-6A intruder, the only all-weather attack plane in the U.S. inventory, is extremely difficult to maintain because of its complex electronics.**

. . . and Sperry feels the bite on Ilaas

Selection of IBM for the improved A-7 avionics system is another blow to Sperry Gyroscope, which has been trying hard to get its Integrated Light Attack Avionics System (Ilaas) on an aircraft and into production. Ilaas development originally was ordered by the Navy with the A-7's in mind, but has been stumbling badly because the military services refused to buy it, citing its high cost. But a Navy avionics official says: "As far as I'm concerned the Ilaas is alive and an on-going program."

Without a program the size of the A-7D and A-7E models, it is doubtful that Ilaas can be carried on beyond prototype. The Navy and Air Force haven't said how many Corsair 2's will be built, but estimates run about 800 for the Navy and about 600 for the Air Force. This is in addition to the 400 earlier A-7 models now flying or already on order.

Post office delays industry briefing

Because of a lack of qualified technical personnel, the Post Office has been forced to delay a symposium to brief industry on its mechanization needs until Nov. 3. Nearing the end of his first year in office, Leo S. Packer, assistant postmaster general who heads the Bureau of Research and Engineering, has learned the hard way that Government agencies do not move as fast as private business. **One of industry's biggest legitimate beefs in dealing with the Post Office, Packer has found, is the difficulty involved in finding technically oriented personnel to pass on proposals.**

Air traffic plan may not take off

Lack of both enthusiasm and money is expected to result in the rejection of an Air Transport Association proposal that the Government finance a five-year program to expand and improve the nation's air traffic control system. The industry group asked that $100 million be appropriated in fiscal 1968 to launch the program, which calls for terminal radar at every airport with scheduled airline service.

The FAA is cool to the proposal because it could mean changing the agency's basic philosophy: airport improvements based on flight operations. The agency has always maintained that the busiest airports—regardless of whether they're used by airlines—should get priority in improved equipment. The second problem is funding. The FAA, along with other agencies, has been ordered to hold down spending.

NAACP seeks more white-collar jobs

Indications are that the electronics industry, among others, may come under renewed pressure to step up the hiring and training of Negroes. Applying the pressure will be the National Association for the Advancement of Colored People, which is expected to use a report from the President's Commission on Equal Employment Opportunity as ammunition.

The report, to be released late in the fall, is expected to show that electronics is lagging behind other industries in employing Negroes in white-collar positions. Included in the Government's white-collar category are sales, clerical, technical, and administrative jobs.

A commission spokesman says the report will be used by the Government to "encourage" industry to review hiring and in-house training practices. But the NAACP may go farther. NAACP counsel J.F. Pohlhaus says that if persuasion fails, court action may be taken.

150-computer deal may be yule gift

Having reaped a storm of protests with its first decision, the Air Force is in no hurry to reaward the contract for 150 computers for housekeeping at its bases. **The new winner won't be named before December.** The contract, for the biggest computer order ever, originally went to IBM for model 360-30/40's at a price of $114 million, but at the insistence of losers Honeywell, Burroughs, and RCA, the General Accounting Office ordered new negotiations with all four companies [Electronics, July 24, p. 25]. **Will IBM lose the deal? That's hard to figure; one thing that could be in the cards, though, is a lower price. Honeywell claims it can supply the machines at almost half IBM's bid.**

Shrike replacement ready for flight

Only nine months after contracts were awarded [Electronics, Dec. 26, 1966, p. 36], and sooner than many expected, the Standard ARM (anti-radiation missile) will go through its first shakedown in the next two weeks. The missile, to replace the Air Force and Navy Shrike, will be tested on an A-6 Intruder all-weather attack aircraft. **The final element, the TIAS (target identification and acquisition system) guidance unit, built by IBM, is now being installed.** It uses IBM's 4 Pi airborne digital computer. General Dynamics Pomona division is prime contractor.

Antimortar missile? Army mum on bid

The Army, currently in a crash program to develop a radar that can speedily locate enemy mortars firing from any direction, has received an unsolicited proposal from the Marquardt Corp. that goes even farther. **The proposed system would detect and destroy an incoming mortar shell before it hits.** Although some Army R&D officials have discounted such a system, the Army promptly classified the Marquardt proposal. The office of the Chief of Army R&D acknowledged receiving the proposal, but would give no details. Such an antimortar missile system would have to have an extremely quick reaction time.

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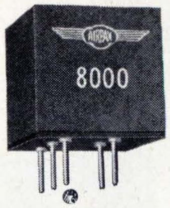


Booze is the only answer at my house, but they frown down at the office when I suggest there is more than one way to solve problems. They should have my mother-in-law — they'd stick to booze, not electronics.

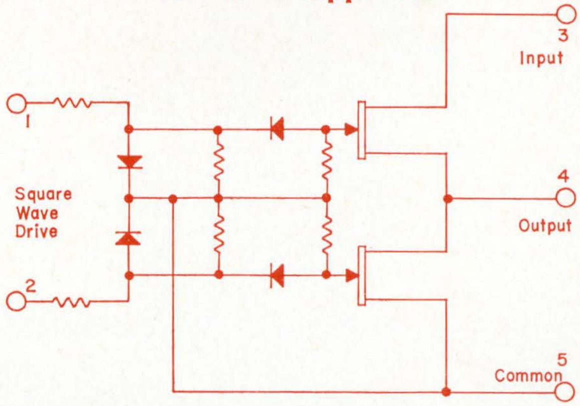
It turns out that an FET chopper is a distinct improvement over photo-choppers, what with 6 volts being enough drive instead of a couple hundred. Now the photo-chopper was better than the transistor choppers, because it looked like a resistor instead of a diode. So there ain't any voltage drops that have to cancel out. Mostly they don't. (Cancel, that is.)

As matters stand on noise and offset — and we sell choppers for only one purpose, which is to allow D.C. amplifiers with very little offset — the best of FET choppers are only two to three orders of magnitude worse than the best of mechanical choppers. Which is real progress. Last week it was three to four orders — before we invented this model 8000 FET chopper. The offset available is below 10 microvolts at 10,000 ohms, and would be lower if there weren't such wierd alloys inside the FET that have to come out eventually to copper.

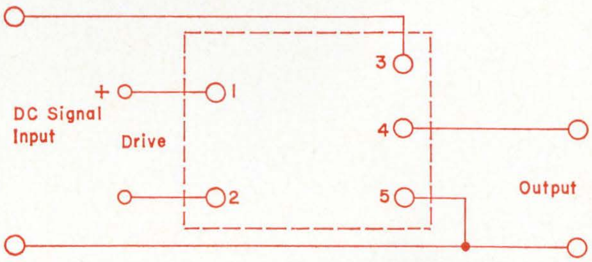
So today's best mechanical choppers reach down below some 50 nanovolts, the FET chopper gets to about 5 microvolts. That's two orders of magnitude and crowding. Good thing we make solid-state choppers too.

Speaking only of offset, and anyway, what else is speakable about a chopper? I suppose you could say Mechanical Choppers << FET Choppers < Photo Choppers < Transistor Choppers.

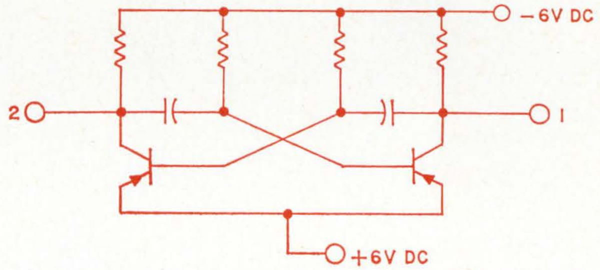
A FET Chopper . . .



in a modulator circuit . . .



with an inverter to drive it . . .



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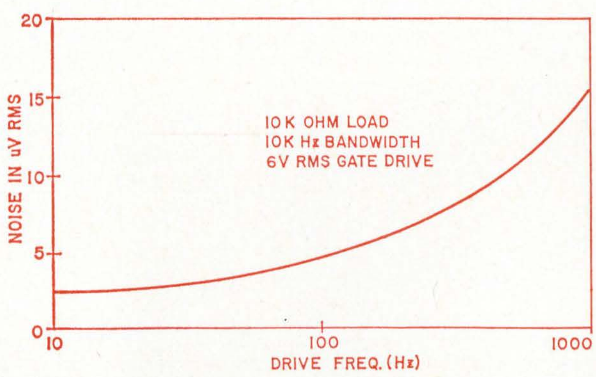

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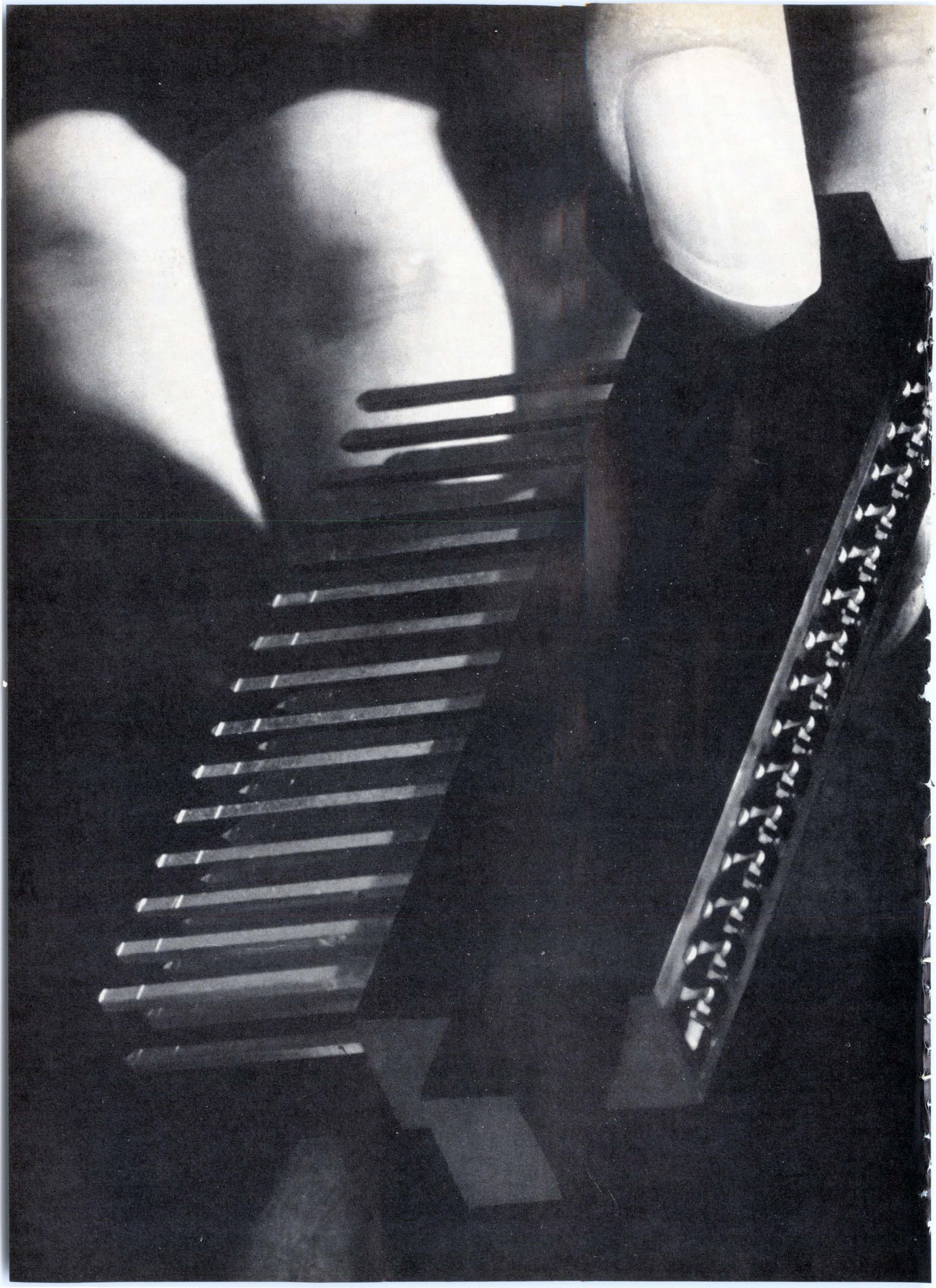
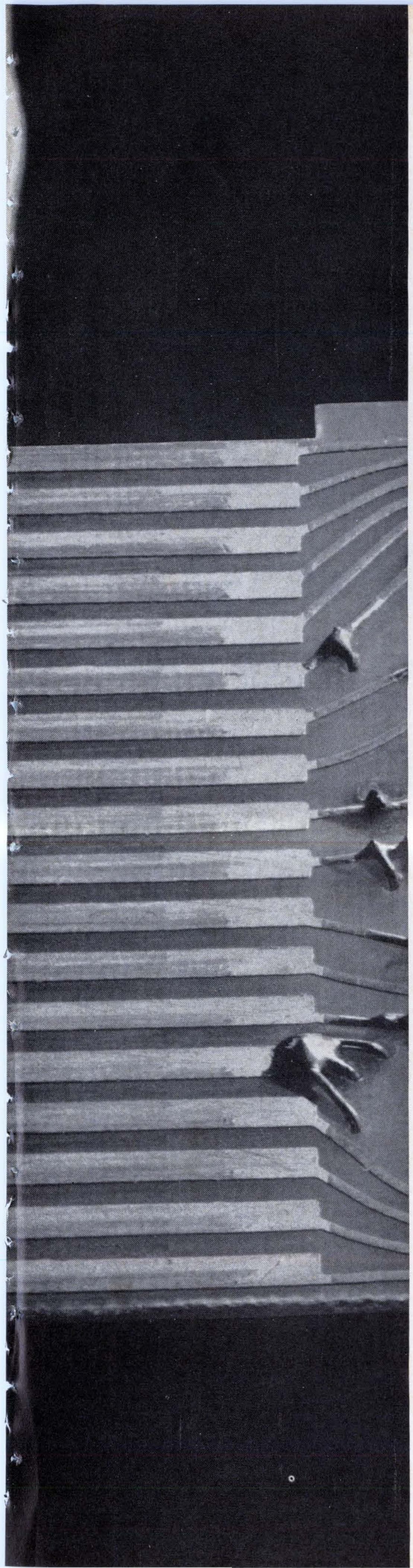
Circle 55 on reader service card





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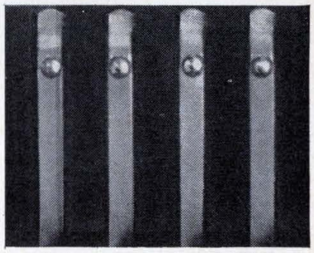

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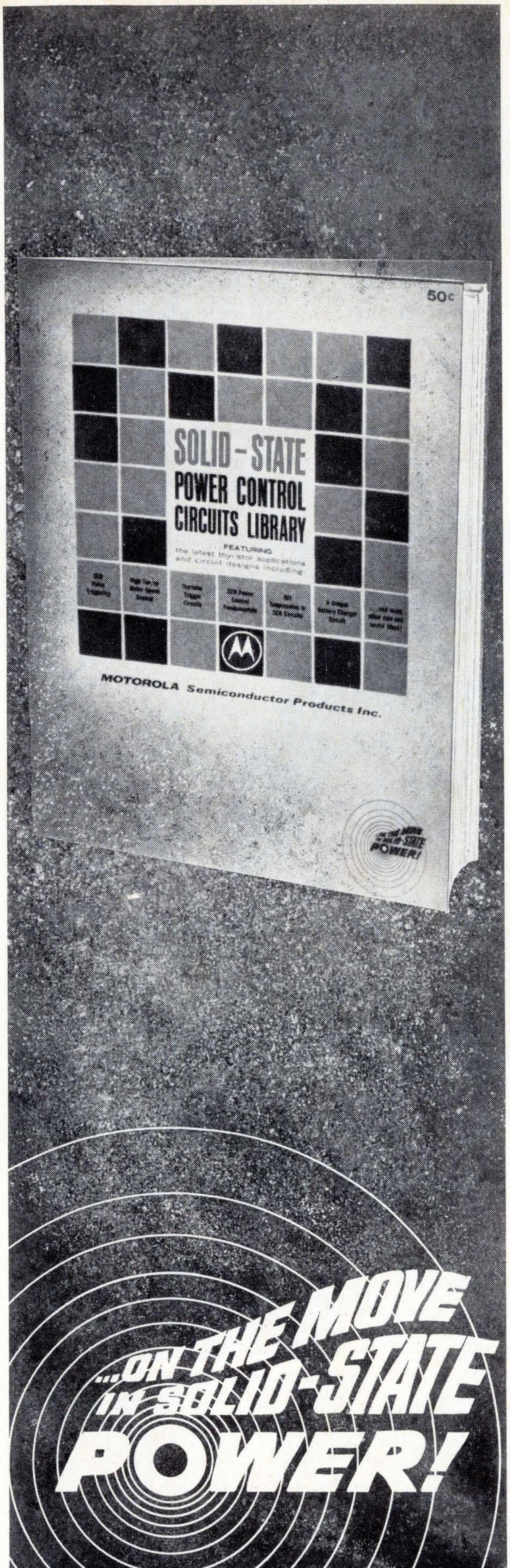

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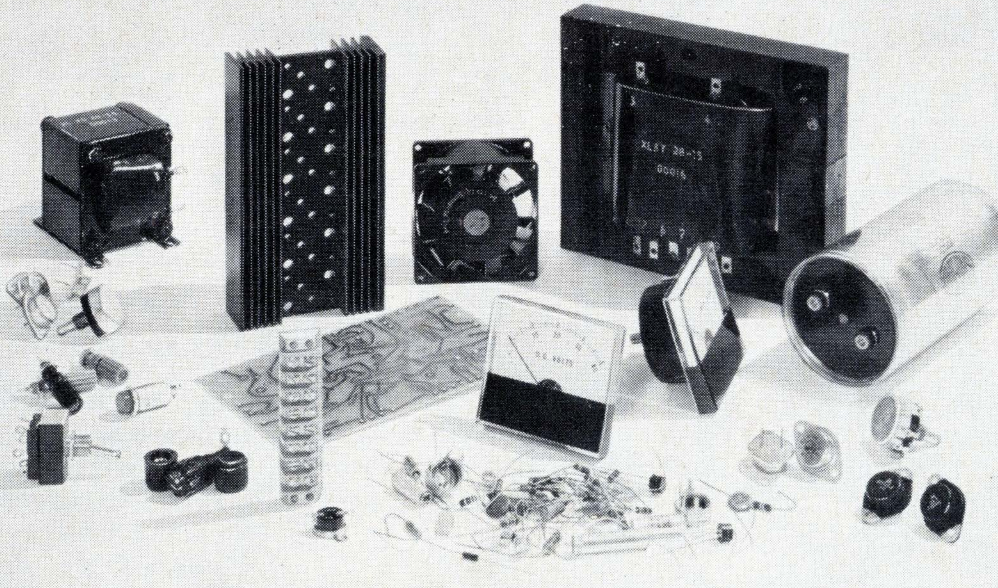

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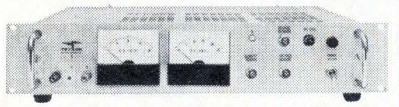

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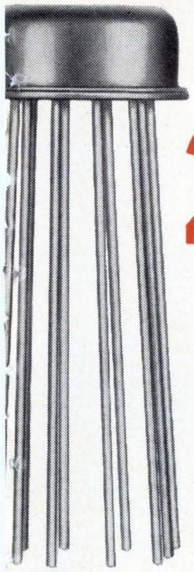

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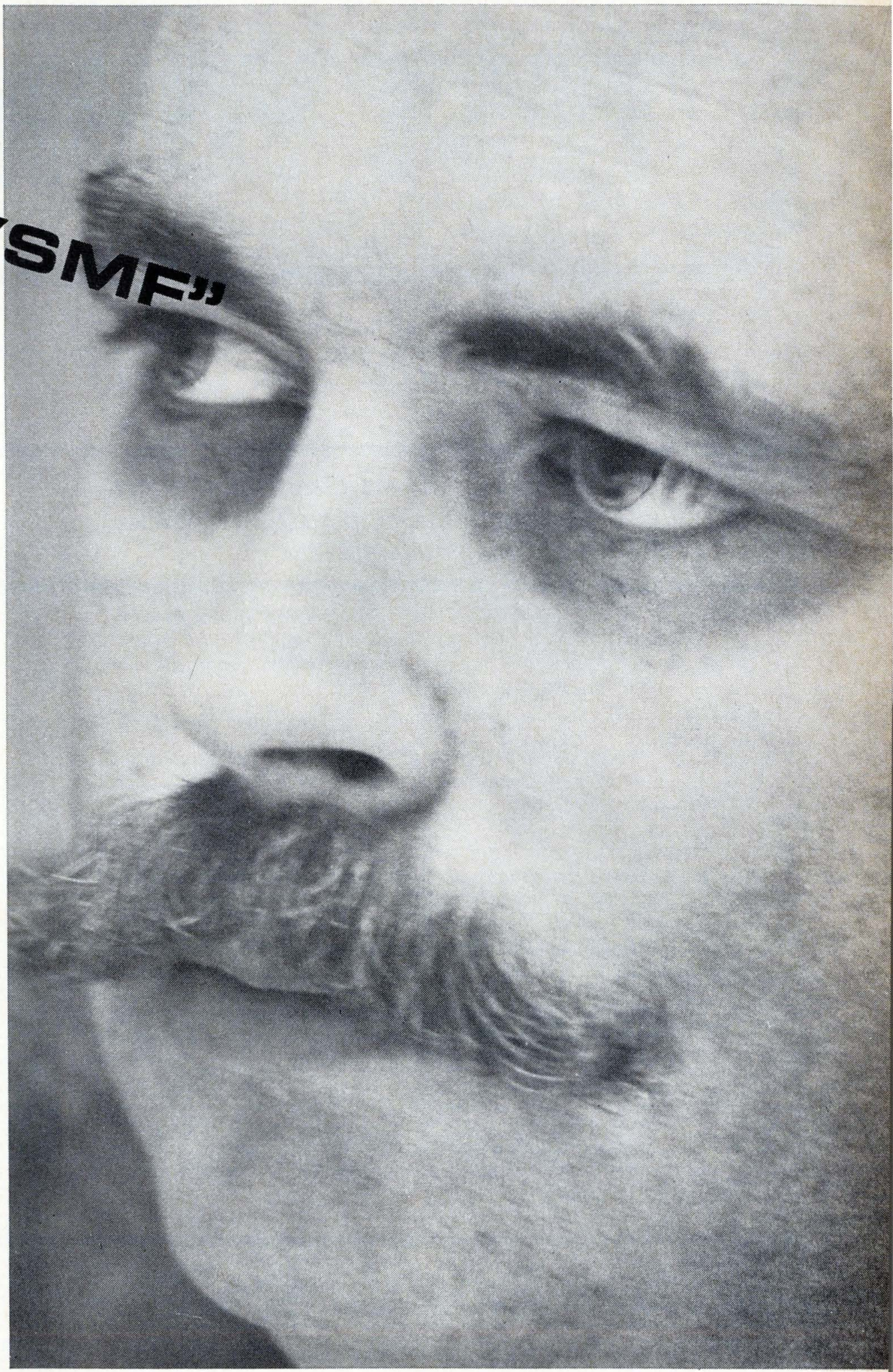

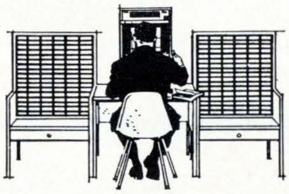

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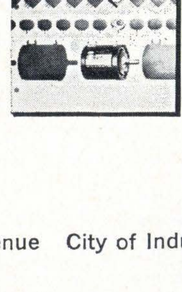

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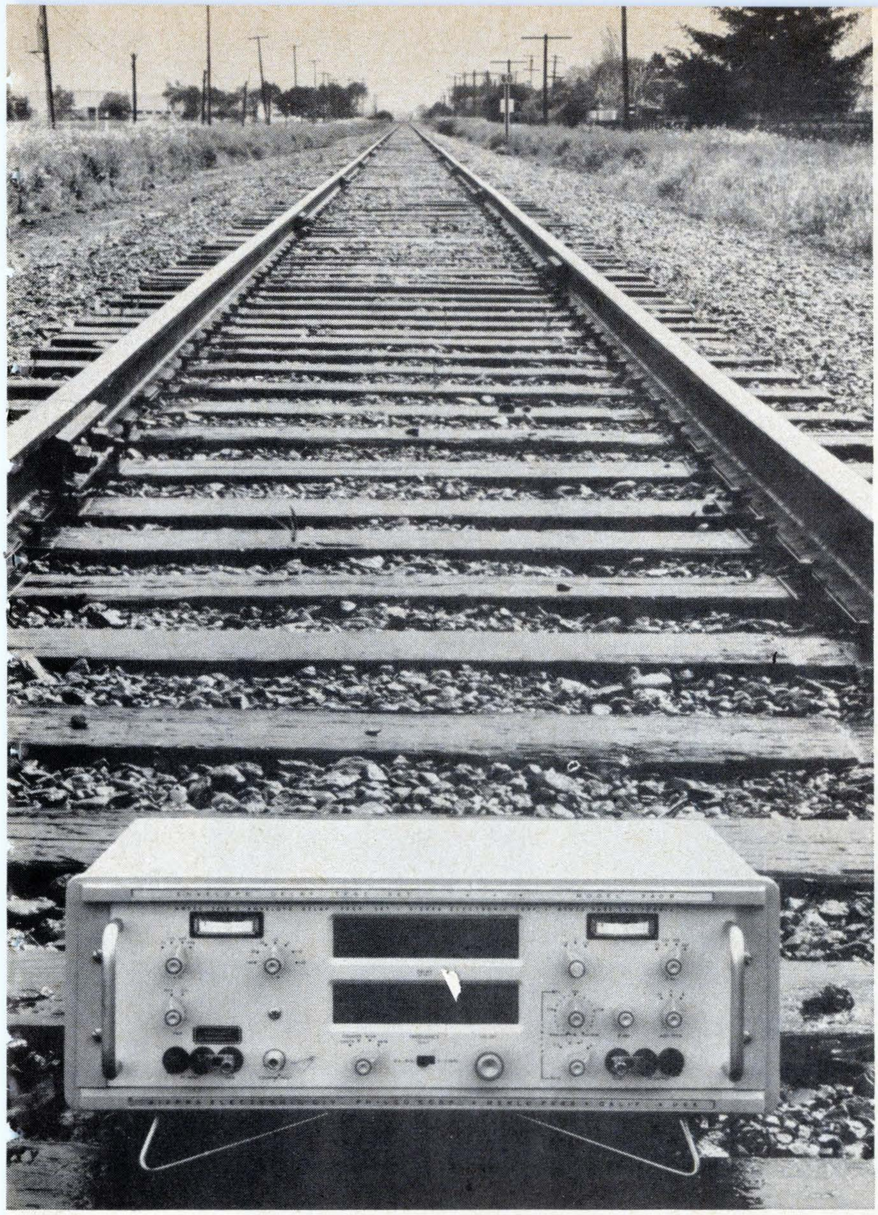

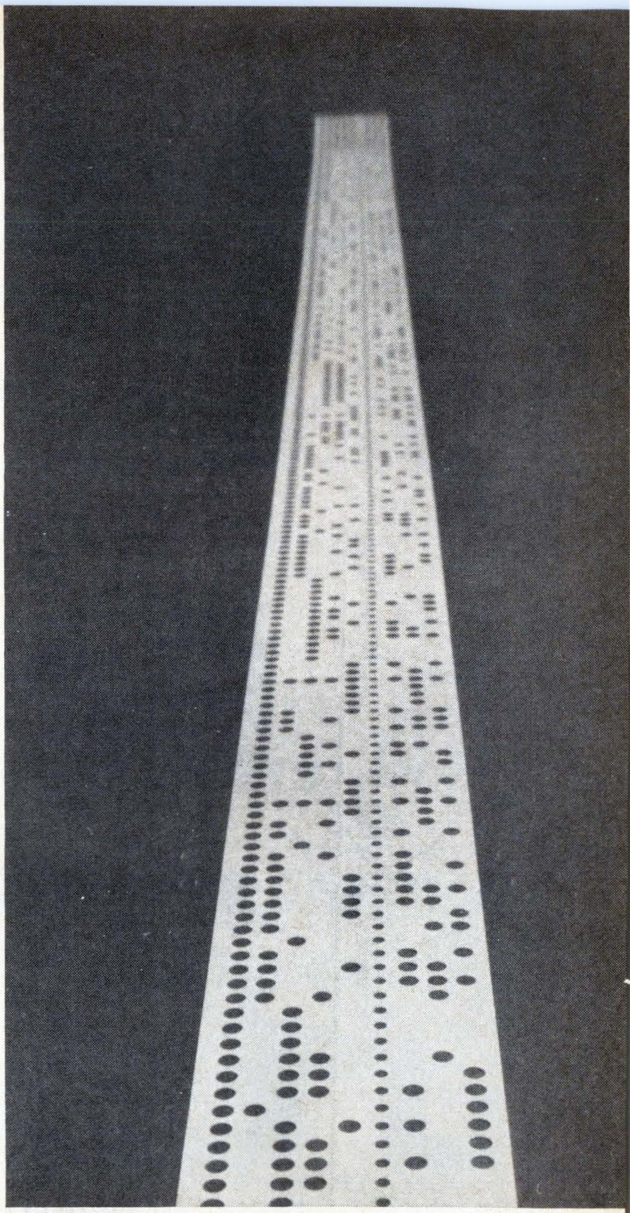

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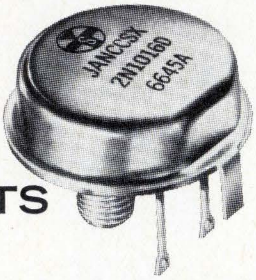

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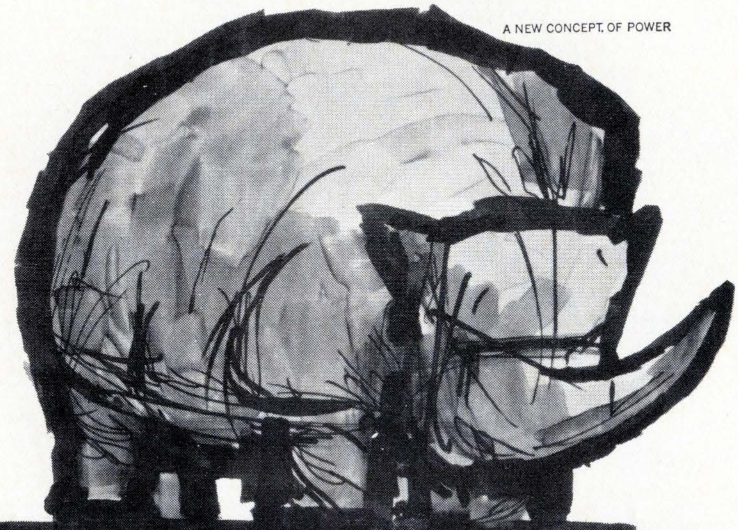

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Breakdown Voltage, Collector to Emitter, BV_{CEO} (SUS)	*I_C=100mA, I_B=0	30 A-60 B-100 C-150 D-200 E-250		30 A-60 B-100 C-150 D-200 E-250		Volts Volts Volts Volts Volts Volts
Collector Cutoff Current, I_{CEX}	V_{CE}=rated voltage V_{BE}=1.5V, T_C=150°C		20		20	mA
Emitter Cutoff Current I_{EBO}	V_{EB}=25V, I_C=0, T_C=150°C		20		20	mA
D.C. Forward Current Gain, h_{FE}	*I_C=2 Amps, V_{CE}=4V *I_C=5 Amps, V_{CE}=4V	10		10		
Saturation Resistance, r_{CE} (sat)	*I_C=2 Amps, I_B=300mA.	0.3 Typical	0.75			Ohms
	*I_C=5 Amps, I_B=750mA			0.2 Typical	0.5	Ohms
Base to Emitter Voltage, V_{BE}	*I_C=2 Amps V_{CE}=4V	1.5 Typical	2.5			Volts
	*I_C=5 Amps, V_{CE}=4V			1.7 Typical	3.5	Volts

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September 4, 1967 | **Highlights of this issue**

Technical Articles

Computer-aided design, part 11: Shortcuts to IC's and p-c boards page 70

The physical design of electronic circuits need not be the haphazard process it once was. Both integrated and printed circuits benefit from the computer's aid in their layout and interconnection. Three important computer programs ease the designer's task.

Taking the puzzle out of p-c design page 72

A computer program that views a printed circuit as a three-dimensional map (cover) speeds its efficient design. The program, developed under Atomic Energy Commission auspices, takes component descriptions and hand-drawn circuit schematics as its inputs and delivers complete specifications for wiring paths and component positioning.

Drawing board for IC's page 83

One problem in automatic IC design was that the designer had to give complete instructions to the computer, then sit back and wait for the results. They were sometimes far off base, forcing him to start from scratch. Now the designer and computer work as a team with continuous dialogue. As the design progresses, the designer views step-by-step results on a crt, making changes at will with a light pen.

Generating IC masks automatically page 88

Ideally, the engineer would like to describe a circuit to a computer and have it provide an output from which the art work for IC masks can be made. A program by IBM is doing just this on an experimental basis.

Paramatrix puts digital computer in analog picture page 99

Graphs and photographs can be scanned electronically by a new machine, the Paramatrix, which can manipulate the image (enlarge it, shrink it, rotate it, or slide it) and digitize it for further manipulation or display. The Paramatrix can do this quickly and inexpensively because it links the input and output by digitally controlled analog circuits.

Coming September 18

- **IC's in a dimension checker**
- **Thermal management techniques**
- **A new braid memory**

Computer-aided design: part 11
Short cuts to IC's and p-c boards

Three computer programs ease the designer's load by speeding and simplifying the building process

By Joseph Mittleman
Senior associate editor

Because high performance systems are increasing in complexity at an alarming rate, designers are under pressure to create faster and more compact circuits. But to make such designs economically, engineers have been forced to turn to computers to manipulate the many possible configurations needed to produce a usable circuit. Only computers can do the extraordinary computation required in the building of integrated circuits that can handle nanosecond switching speeds, and optimize component placing and wiring patterns—the kinds of problems that crop up in designing complex data-processing and analog systems.

In handling nanosecond speeds, lead lengths must be minimized to reduce pulse delay, eliminate crosstalk caused by these fast rise times, and reduce capacitance that could prevent circuits from operating properly.

Reducing pulse delay can be accomplished with new IC's having more components on a single chip. Thus, lead lengths are reduced. But cramming components on a chip tends to reduce yield and boost production costs. In addition, the chip may include high speed transistor elements that require finer resolution geometries in the IC mask design, thus complicating diffusion. To overcome this, better processing techniques are needed.

In large systems, each printed-circuit board contains many chips. Optimizing component placing and wiring patterns can be particularly troublesome. If each chip has a minium of 40 leads, getting the leads to the p-c assembly's output is difficult. Thus, it becomes necessary to reduce the output wires. This is achieved by better placement of components, possibly interconnected IC's, and better wiring schemes.

These problems are best solved by a computer. A major part of the IC and p-c board fabrication problem is the time gap between defining the circuit or layout and building it. The most difficult and time-consuming efforts in making integrated circuits are the design and manufacture of the masks from which the IC's are built. In printed-circuit boards, the difficulty lies in arranging and rearranging the layout and connections until a final set of drawings are prepared.

Programs help

The more complex the system, the greater the time and effort involved. It can reach the point where manual design becomes unwieldy and sometimes impossible to perform. The result: manufacturing costs skyrocket. Before the computer's aid could be enlisted to solve the problems, programs had to be devised to describe the conditions to the machine. Three such programs are now available. One automatically lays out a p-c board for a particular circuit based on its description and a listing of component shapes and sizes; another automatically designs an IC with optimum component placement given the circuit's components and how they are connected; the third automatically designs the fabrication masks from which the IC's are built once informed of component placement.

The three programs are:

- Accel (automatic circuit card etching layout), developed by the Sandia Corp., Albuquerque, N.M. [see p. 72].
- Cadic (computer-aided design of integrated circuits), developed at the United Aircraft Corp.'s Norden division, Norwalk, Conn. [see p. 83].
- Lager (layout generating routine), developed at the International Business Machines Corp.'s

Thomas J. Watson Research Center, Yorktown Heights, N.Y. [see p. 88].

An engineer who lays out p-c boards usually starts his design by selecting the components needed for the circuit and physically placing them on a board. He must be sure all conducting paths will fit between the components, which pairs of points should be connected, and, indeed, if two points can be connected at all. This last problem is solved by Lee's algorithm, but, unfortunately, this guide does not account for component spacing.

With Accel, the design task is simplified greatly. All the designer need do is tell the computer what components are in the circuit and how they are connected; the machine does the rest.

The technique simulates a topographic layout that represents component connector-pin locations by peaks, and the areas between the pins by combinations of slopes, plains, and valleys. In essence, the computer considers the circuit board as a large sheet of rubber. Terminals and nodes are fixed peaks, and the leads of the interconnected components are assumed to be elastic.

By stretching or depressing a point on the simulated rubber sheet, the designer is able to create a distorted terrain of hills and valleys, through which conductor paths are formed much as a mountain stream follows a natural raise. The advantage of the technique is that it can be altered mathematically to accommodate any set of laws—real or imaginary. For example, where real hills are up from a reference and valleys are down, with this technique a hill can be transformed into a valley simply by pushing it down on the sheet instead of pulling it up. In this way, new paths are created between peaks that may produce better board layouts.

Play as you go

When designing an integrated circuit, the engineer must be fully aware of component tolerance, shape, and size limitations. He must understand manufacturing processes, including thin-film, metal-oxide and isolation techniques. And, he must be able to prepare careful and detailed drawings that indicate an IC's structure.

Furthermore, if he uses a computer in a batch-processing mode, he is confronted with delays. For example, he specifies his input data on punch cards, waits until the cards are prepared, and waits again for a machine available for a run. He cannot visualize the result until the output data is plotted. Therefore, any errors—in the form of unused space, for example—are not immediately apparent. Plotting requires an additional set of data cards and is often further delayed by waiting for an available machine. If any changes are desired, a new card must be made and the run started from scratch.

A technique that enables the engineer to specify input, that enables the machine to provide an initial circuit, and allows the engineer to make visual changes easily and instantaneously as he goes along is preferred. All this is provided by a new system that applies the Cadic program.

Cadic enables a designer to completely lay out an integrated circuit in minutes. To apply the program the designer uses a symbolic language, a cathode-ray tube, and a light pen. A circuit description, in the form of punched cards based on a schematic, is fed into the computer as input.

The machine determines, for every component, size and shape of the mask pattern, and supplies an initial layout with all components presented in true size and shape. The components are arranged in the same relative positions as on the schematic from which the input is taken. During the run of the program, instructions appear on the crt that indicate what the designer must do. For example, the screen may say select move part. The designer then points to the part with a light pen to move it as instructed. The program reduces both cost and time in producing a complete IC layout and relieves the designer from routine calculation and drafting.

Automatic artwork

Before an integrated circuit can be manufactured, masks must be prepared. The masks are an exact replica of the IC and are used to make the semiconductor device. Designing masks is a costly and time-consuming process. The engineer must design a mask for all manufacturing processes that may be required for a component. For example, if a transistor is made by diffusion process, and a capacitor on the chip is made by a metal-oxide technique, different masks must be prepared. In addition, not all parts of the chip will have equal spacing between the conductor paths. Any changes in the design usually requires a new mask, which is costly.

Lager comprises a three-part technique that automatically generates the artwork for such masks. A language to permit the designer to describe the patterns and structures required in the individual masks, a computer procedure for translating the language into commands, and the automatic equipment that acts upon the commands to generate the final masks.

The language is a convenient shorthand and symbolic way of describing the patterns a designer wishes to generate with a minimum likelihood of error. It defines individual structures and groups of structures on the mask and assigns a symbolic name to each group. This system is analogous to that found in programing where the variables are defined with mnemonic names. The programer manipulates these names and leaves it to the computer to relate them to the actual items of data.

Any structure or groups of structures are defined with the language by means of substructures. For example, if the designer defines a structure that will generate the base of a transistor, this is then used as part of a set of structures that define the transistor. The transistor structures can then be used to define a still larger structure, a logic decision gate, for example.

Taking the puzzle out of p-c design

Simulated by a computer program, a contour map of the circuit helps complete a layout of a printed-circuit board in minutes

By Clifford J. Fisk, David L. Caskey and Leslie E. West
Sandia Corp., Albuquerque, N.M.

Laying out a printed-circuit board to perform a specific function can be likened to fitting together a jigsaw puzzle. In both, the challenge is basically the same—selecting the parts that mesh by trial and error. But unlike the jigsaw puzzle, which has only one solution, a p-c board can have several. And the designer of a p-c board, of course, has the advantage over the puzzle solver in that he's the one who determines the type, size, shape, and number of components that make up his particular puzzle.

To help the designer fit his pieces together, a computer approach has been successfully developed that combines a scheme for component placement with one for conductor-path routing to automatically produce a p-c board layout. The component phase, called force placement, is based on a set of simulated interacting forces. Conductor-path routing is achieved with a minimum path-length algorithm and a newly developed topographic-simulation technique. Called Accel, for automated circuit card etching layout, the method was developed at the Sandia Corp., Albuquerque, N.M., and the Thomas-Bede Foundation, Los Altos, Calif., under the auspices of the Atomic Energy Commission.

Makeup of the puzzle

Basically, a printed-circuit board is a thin, insulating board on which an assembly of electronic and electromechanical components are mounted. On the board's surface are several isolated copper conductive paths, each path attached to a component lead (the point of connection serves as the equipotential of the component). The junction of two or more paths is called a node. At one end of the board is either a connector or a set of printed contacts for electrical connection to the outside.

The paths are isolated to prevent shorting the circuitry. On two-sided p-c boards, where two surfaces are available, conductive paths may follow the same route on opposite sides. Isolation in this case is achieved by the board's thickness.

The effectiveness of using the computer to take the puzzle out of design can best be measured in time. Where the conventional trial-and-error route takes as long as weeks, computer-aided design drastically shortens this to minutes. Fabricating the assembly starts with the circuit specifications that the designer generates and culminates in the physical construction of the board. This process includes:

- Converting the engineer's design into acceptable computer input data.
- Editing this data for validity.
- Retaining information on all components considered standard for the system.
- Handling nonstandard data that is entered at the time the board is constructed.
- Determining the location of the components on the layout after the data is accepted as valid.
- Positioning all the components and making the necessary electrical connections with routing paths that connect all common electrical nodal points.
- Generating, with the aid of the computer, a schematic of the input circuit, a parts-ordering list, an assembly drawing, a hole drilling list, and a mask required to etch the circuit board. Computer programs for all of the output information are independent subroutines written in Fortran 2 for the IBM 7090 series so that various plotters can be used for output. At Sandia, the current routines were written for the Stromberg Carlson Corp.'s SC4020 cathode-ray tube plotter. With this system, Sandia engineers can design up to 47 circuit boards per computer run.

The maximum size board that this system can handle is 90 square inches, with the standard 0.025-inch grid. Other size grids can be specified. Although conductors can be placed on one or both sides the board—or laminated if required—components can be placed on only one surface. The system can accommodate up to 500 components and 300 nodes per board, and each component may have a maximum of four lead connections.

Input to the computer

The beauty of this approach is its simplicity. The designer checkerboards the schematic so that each element, crossover, corner, and connecting line is contained in separate squares. Each element in the circuit is assigned x-y coordinates. The x-y coordinates for resistor R_1, in the example of a checkerboard circuit at the right, would be B1, and its part number is 855794. Although they would be acceptable, neither a predefined grid nor a machine-drawn schematic is required.

To eliminate the puzzle of which element or component to choose, every element in the circuit has a symbol assigned to it from a predefined glossary stored in the computer's memory. The symbols take into account the components parameters, physical orientation in the circuit, and stock part number. Thus the designer merely feeds the symbol number and x-y coordinates into the computer, which then analyzes the characteristics and location to determine a node component list.

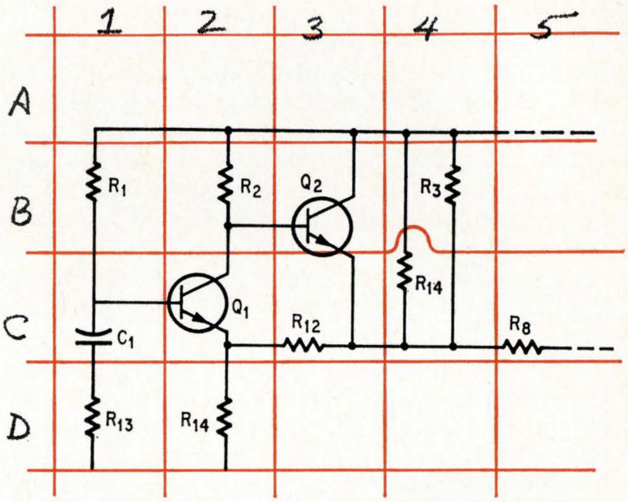
Upwards of 100 symbols are included in the glossary, and additional entries can be included by allocating the required storage.

An assembly can be designed with components that aren't included in the parts table: the computer will do it for him. All the designer need do is feed into the machine data describing what is required and the board will be produced from it.

Layout of components

One of the system's features is the method that determines the locations of the components on the board. Because of the way in which the forces act on the components, the method is called force placement. Although based on an adaptive set of equations, this method doesn't guarantee optimum placement of components. The best introduction to force placement is an analogy based on the circuit on page 74.

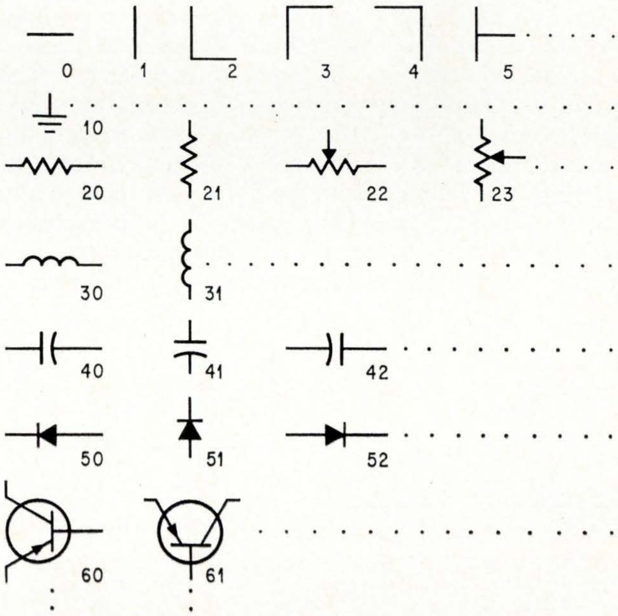
Imagine that each of the components has elastic leads that are stretched into tension until they contract to some arbitrarily shorter length. The components are placed in an open box whose bottom surface is the size and shape of the printed-circuit board, and whose sides prevent the components from spilling over the edge. Points P_1, P_2, P_3, and P_4 are stationary contacts that connect to the elastic leads of C_1, R_2, R_1, and R_3, respectively. Each component is confined so that it remains in contact with the bottom surface of the box. If the components are pinned arbitrarily to the bottom of the box, some or all of the elastic leads are strained in tension and each component is acted on by a set of forces. If the components are suddenly released from their pinned positions, each would accelerate according to the instantaneous force exerted on it. The components shift into



COMPONENT	DESCRIPTION	STOCK NUMBER
R_1	1/4 w, 5%	855794
R_2	1/4 w, 5%	855775
R_3	1/4 w, 5%	855784
:		
C_1	3.5μf, 50v TANTALUM	
:		
Q_1		873839

CONNECTOR BOARD IS STOCK NUMBER HHB5249/B5

Checkerboard. Keypunch operator arbitrarily sections off the schematic so that each square contains one component. Component positions are then fed to the computer together with part numbers. Nodal points, representing pin locations, are fixed throughout a computer run.



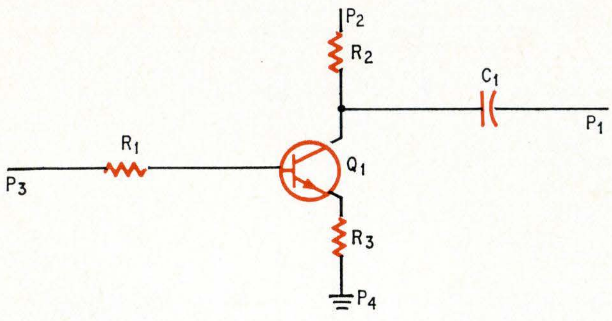
Symbol glossary. Components and wiring connections are assigned symbols from a table. A component may have several symbols to indicate different positions. By selecting the number corresponding to a particular element and its position, the designer can easily reconstruct the circuit as it appears in the schematic. Although there is a limit to the number of symbols, other elements can be described to the computer, which will then produce the layout. These additional descriptions can be stored in the computer's memory for future recall.

a cluster and stop moving only after the forces acting on each component are in opposing directions that cause a resultant of negligible magnitude. At this time, each elastic lead is either relaxed or stretched due to the static forces in the sytem. The motion of each of the bodies after release depends on the instantaneous force on the body, torque, and the first and second integral of linear and angular accelerations.

Fortunately, the computer is not limited to the physical laws of the real world. A new universe can be defined wherein bodies acted on by forces follow laws that the designer is free to dictate. For example, a component may experience a repulsive force due to another component before the two actually make contact. Components can even be allowed to pass through one another should this prove advantageous.

Basically, the defined universe is as follows: the domain is an area in the x-y plane bounded by a closed curve whose points coincide with the edge of the board. Two-dimensional components within the domain are free to move if they are acted on by vector quantities, called forces. Any component acted on by a resultant force is moved in the same direction with a magnitude proportional to the force. Thus, a component acted on by a net force must move, but a component with a zero force will not.

Components to be connected to a common conductive path are acted on by forces that cause them to move toward one another. The further apart these components are, the greater the attraction. To prevent the components from moving to positions in which their individual boundaries overlap, a force of repulsion is imposed. This causes closely located components to move further apart. The repulsive force between two components increases as they get closer. To keep components from being moved out of the domain completely, a force of repulsion is defined from the borders of the domain. Since actual connection points on a component can be located at other than the center point, a torque is generated by forces on these actual points.



Force analogy. Contact points P_1, P_2, P_3, and P_4 in this single-transistor circuit are fixed to components C_1, R_1, R_2, and R_3, shown in color, whose leads are assumed to be elastic. If the components are allowed to assume a position in which the net forces acting on each component are zero, the elements come to rest. The relative position of the components at this time becomes a possible board layout.

This torque then creates a force that rotates the component an amount proportional to the resultant torque. Thus, the four types of forces in this universe are attraction between components that connect to common conductive paths, repulsion between all components, repulsion between all components and the edges of the domain, and rotation from each connection point on a component to each common conductive point on others.

Force and moment on a particular component is the vector sum of the individual forces and moments contributed by each component and the borders. Force on a component, due to another component, is a function of both component size and the distance between components. The attractive forces and the repulsive forces reflect the shape of the components.

Forcing a move

At the start of the computation, the components are placed arbitrarily on the board. The forces acting on the first component are computed and summed vectorially. Then the component is moved in the direction of the force by an amount proportional to it, but not exceeding one-half the distance to any border. Next, the computation is performed for the second component, then the third, and so on. It is repeated until the last component has been moved. This completes one cycle. Successive iterative cycles are based on the positions of the preceding cycle.

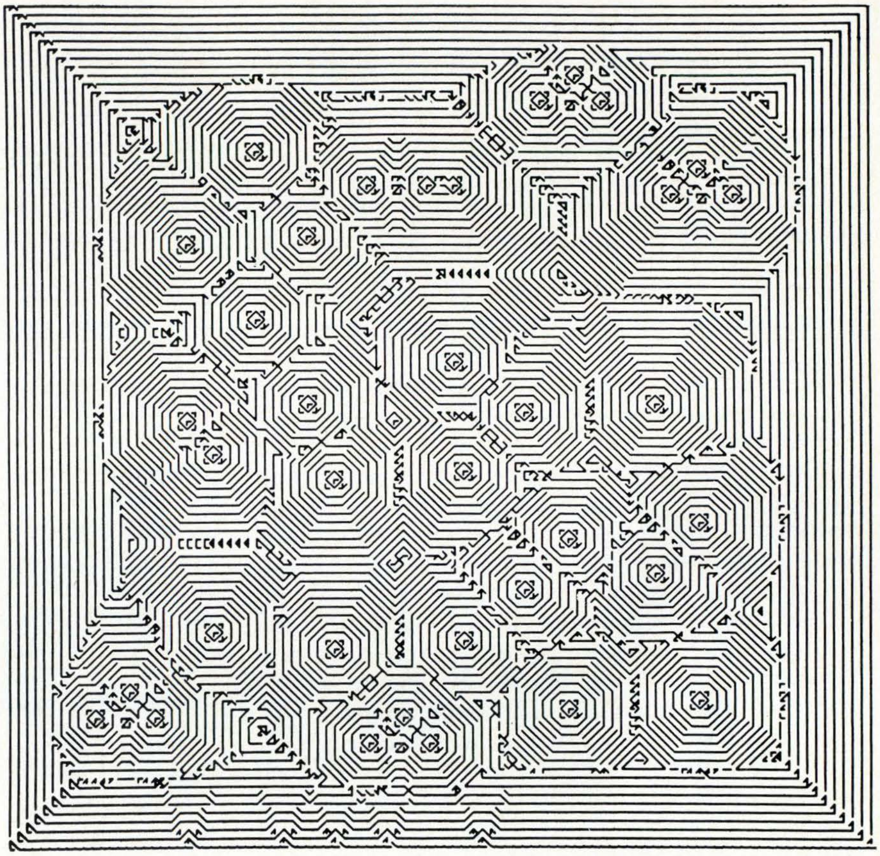
For a converging set of force equations, the components move less on each successive cycle until a point is reached where the average movement is less than some predefined amount. A solution has been found to the set of force equations that determine when the components no longer move significantly—the resultant force on each is zero.

During N-iterative cycles, a component occupies N discrete positions in the domain. If the coordinates of the components are connected sequentially with straight lines, these components are considered as having followed this path in the x-y plane.

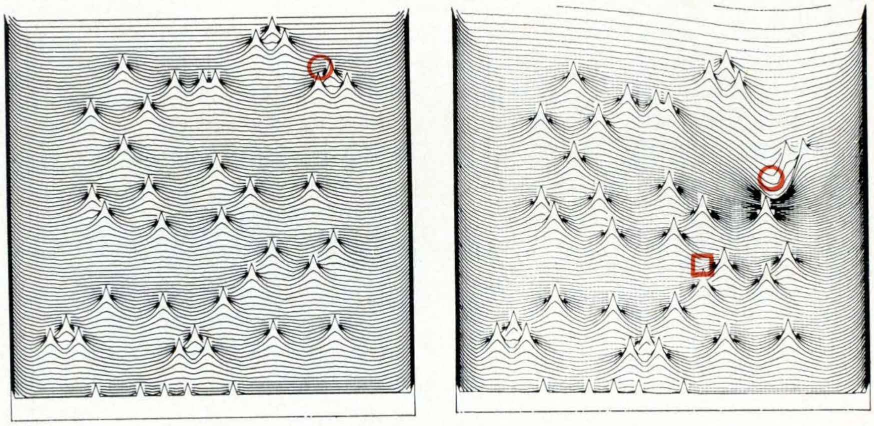
At the start of the placement process the attraction is undamped, while the repulsion is heavily damped. As the process progresses, the damping reverses—the repulsion increases and attraction decreases. This allows attracting components to quickly cluster, and the increased repulsion tends to eliminate overlap. When movement nears cutoff, each component is rotated to either a vertical or horizontal position on the board, depending on which orientation is the closer. Then the position of those components that overlap are readjusted to eliminate overlap. Next, the area that the components occupy is compared to the area of the board. If there is additional area available, the components are spread to give a more uniform placement.

The final set of coordinate points defines the component locations in the domain and on the face of the p-c board. Knowing the center points of the components and their lead coordinates with respect

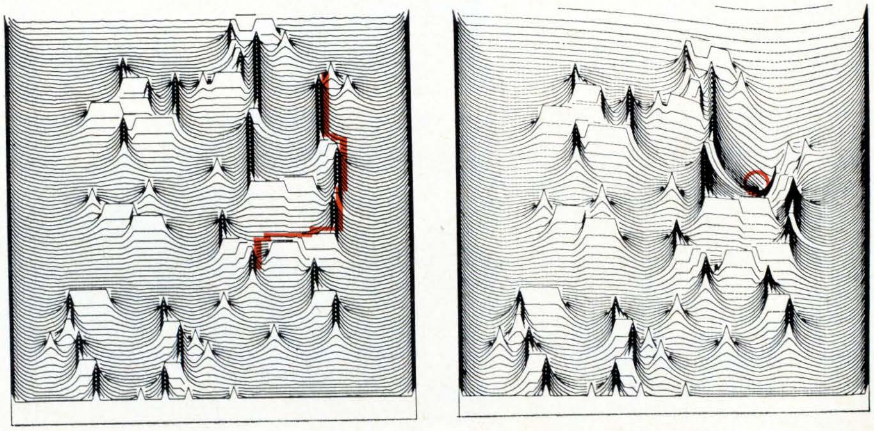
Topographic simulation



Contour map. Top view of initial layout of basin and peaks for a particular circuit at the start of the computer run. Peaks represent component conductor pins and the basins represent the possible conductor paths.



Pathfinder. To create a path from one peak to another, one is held fixed while the other is pulled down to form a target cone. With the cone formed, the computer scans the terrain for the nearest lowest altitude from the highest peak and a step is taken in that direction. At left, a circle in color is centered over peak about to be pulled down to form a target cone. At right, the peak is depressed and the surrounding area is scanned for a connecting path between the target and the peak pinpointed by square in color. Both views are from the side.



Sidestepping. Path shown in color indicates the connection between the two peaks. Sidestepping is caused by obstacles along the way. At right, target peak is again pulled down at a later stage of the process and the terrain examined for other connecting paths. Heavy black vertical lines and horizontal plateaus indicate several paths already completed.

to their centers, the positions of the leads are computed. This completes the information needed for the conductor-routing program.

Conductor-path routing

Conductor routing requires that the circuit provide all needed conductors, and that the paths of different nodes will not cross. Also, the distribution of paths should fully utilize the available space. This is especially important from a reliability standpoint, because crowded paths are easily shorted by metallic specks or by slight etching imperfections.

To date, no technique has been found that satisfies all requirements on every board. The result is a compromise whereby jumper wires replace printed paths that tend to cross. If too many jumper wires are required, another compromise is to subdivide the circuit onto several blocks. Although these compromises are electrically adequate, they are undesirable from a manufacturing standpoint.

A technique that minimizes the effects of these compromises is incorporated in the Accel system as a combination of a topographic-simulation method and a modified version of Lee's algorithm.[1]

In the earlier Accel attempts, an effort was made to improve the routing technique referred to as Lee's algorithm. This led to the introduction of still another compromise that attempts to make a connection with an L-shaped path, a path that can be made by only two perpendicular parts, and when this technique fails, resorting to an algorithm slightly modified from Lee's approach.

When the conducting path isn't completed by an L path, a number is affixed to each of the two connection points. One point is assigned the number 1, and the other, a large number like 100.

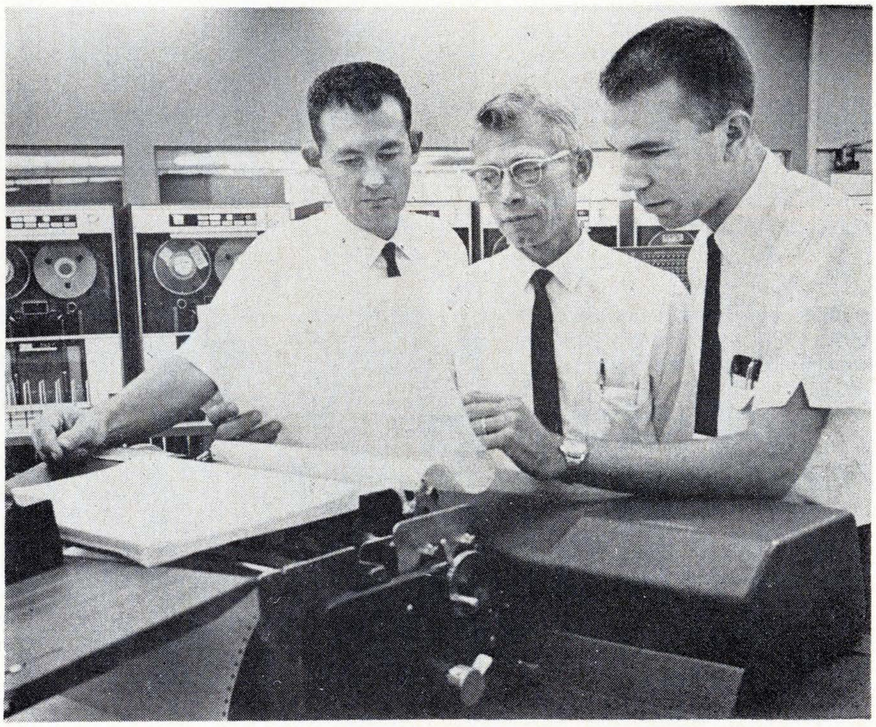
Starting from the point having the 1, the next step is to move outward to all adjacent orthogonal matrix spaces. After establishing that these spaces are empty, they are filled with the number 2. Advancing from all spaces containing a 2, the outward movement continues to adjacent spaces. If these are empty, they are filled with the number 3, and so on. At the same time, the procedure is reversed from point 100 in steps 99, 98, 97 . . . .

By scanning the entire board, the computer insert's 2's and 99's in the first scan, 3 and 98 in the second scan, and so on. The effect is to move numbers outward in count areas. When the two count areas intersect, a path is completed.

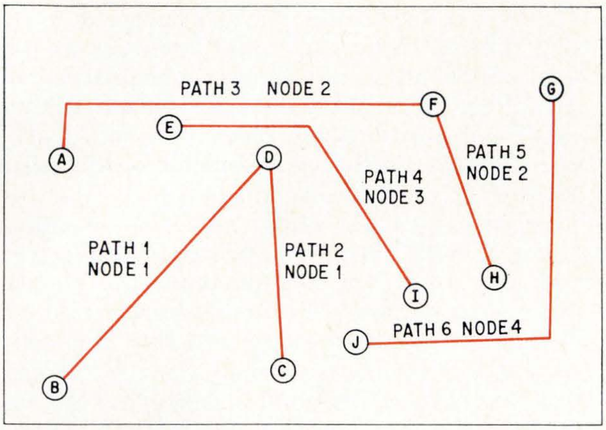
After the path is defined, it is filled with node numbers and the other spaces are cleared. The computer then proceeds to the next set of points to be connected. The routing matrix may contain coded elements that act as isolation to conductor paths. This allows for hole drilling areas, component heat sinks, irregular board perimeters, and all other objects that require conducting paths to bypass their locations.

Topographic approach

The method of topographic simulation was first developed and programed as an experiment separate from the Accel system. It is based on a scheme that represents the location of component-conductor pins by peaks and the areas between the peaks by combinations of slopes, plains, and valleys. By analyzing the terrain, the computer determines the trails that indicate conductor paths. It had been used to represent interrelated, steady-state forces,[2] such as the path of an electron in a vacuum tube. Applied to a computer, it becomes a scheme having self-modifying characteristics that produce a three-dimensional dynamic topography. In p-c board de-



Checking results. Author West holds program printout while co-authors Fisk (left) and Caskey study the results.



PATH NUMBER	PEAK TO PEAK		NODE NUMBER
1	B	D	1
2	D	C	1
3	A	F	2
4	E	I	3
5	F	H	2
6	G	J	4

Interconnection pattern. To indicate the possible path configuration, a drawing is prepared manually from the input data. Pin locations have been previously determined. Data representing these paths, nodes, and peaks are tabulated.

sign, this dynamic property is especially vital in representing the constantly changing conditions caused by the growth of circuit paths. Another feature of the simulation process is that any given point can be assumed as negative or downhill compared with other points at any given time.

In the computer, the topographic area is represented by a 100 by 100-element array (the grid size is limited only by the available core storage in the computer). The location of each element represents a corresponding location on the circuit board. Each element is a computer word and contains a number representing its altitude.

At first, only three features are on the contour map: shape or outline of the body, holes or other obstacles to conductor paths, and component and connector pin locations. Conductor paths, plated-through holes, and trouble spots that are established by the process are added to the topographic structure as they occur.

The process begins with all elements set at zero altitude. The data, representing locations of electrical contacts (component pins) and locations of physical obstacles, (such as holes in the board), are fed into the system. A peak is created in the grid at each location. By arbitrarily assigning a high altitude, say 1,000, surrounding elements are assigned lower altitudes, and the next ring of elements still a lower altitude. Then, to represent the edges of the circuit board, a ridge is created around the periphery of the grid. This ridge slopes inward from each of the four edges, forming a basin. The actual form of the peaks and the basin is variable, governed by control data substituted in:

$$A = \frac{K}{C \times D + 1} \qquad (1)$$

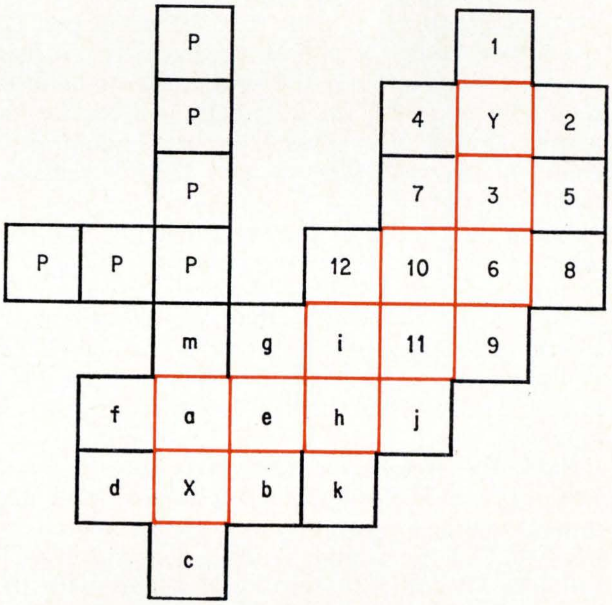
Although there are several ways in which the structure may be numerically developed, the one used most extensively is given by equation 1 where A is the altitude of any given element, C is a constant that controls the slope of the basin and peaks, D is the distance between the element and the nearest edge of the grid or between the element and the center location of the nearest peak, and K is the constant that determines the altitude.

Three variations of this form may be used. The first calculates the altitude that is caused by the basin and by each peak; whatever condition gives the greatest altitude is used as the value of that element. Another variation applies the cumulative effect of all peaks and the basin.

The third variation is the replacement of the constant, K, with a function. For example, if a peak represents a high-voltage contact on the board, K could represent voltage and thus cause low-voltage paths to avoid that area. Or, similarly, if a location in the circuit is particularly sensitive to the capacitance effects of conductive paths, the K (for peaks in that vicinity) could represent that sensitivity and thereby provide better dispersion of conductors.

After the basin and peaks have been formed, the process of establishing circuit paths begins. However, changes occur during the process.

Two conditions cause the topography to be modified. First, as the locations of circuit paths are



Step selection. With the X and Y squares representing the peaks between which a path is to be completed, the computer scans the area between them. Steps are chosen in the most downward direction from both X and Y. The squares surrounding the two peaks represent various lower altitudes. Steps can only be taken vertically or horizontally. They can neither be on or adjacent to steps of a different path nor retrace a previous step. The completed path is shown in color.

established, ridges are built along the paths. This, in effect, forms valleys between completed paths. The purpose is to help the computer route incompleted paths around or between completed ones. Second, when a path hits a trouble spot in the terrain, it is detoured in a zigzag. Such trouble spots may be caused by low areas surrounded by peaks, very narrow valleys caused by ridges of several completed paths, or V- or U-shaped bends in the completed path.

Up to this point, the topography is comparable to natural topography. The one remaining topographic characteristic has no natural counterpart.

To view this feature, imagine that the topography described thus far is built on a rubber sheet that is stretched on a frame. When a step is taken (a step representing an increment of a circuit path) from some location toward a target point, the latter is depressed, forming a cone with the ridges, peaks, and valleys on its inner surface. After the path is completed, the target location is released and the system is prepared to find the next path. Since an iterative step-sequencing system is used, all paths can be developed either simultaneously or individually.

Path-step selection

The system contains two basic features that work together to establish the location of circuit paths. One is the algorithm for step sequencing and evaluation; the other comprises the applications and variations of this algorithm in the several phases of the system.

A path step, as defined here, is an element in the 100×100 grid and represents a portion of a conductor path. If a path is to be developed between two peaks, it will be composed of at least as many steps as there are grid elements between them. Since paths are frequently routed, for example, around other peaks, the steps required to complete any path depends upon the obstacles between the two.

Input data is fed into the computer for preliminary analysis to determine between which pairs of peaks paths must be developed. When several peaks are interconnected, they are said to be on the same node. Specification data is then tabulated. In the sketch on page 77, the coordinate locations of the peaks, rather than the letter designations are used.

Since the process for developing steps is iterative, one step is taken from B toward D, then one from D toward B, then one from D to C, then C to D, A to F, F to A, and so forth down to G to J, and J to G. The next step cycle begins with the second step from B toward D, then D to B, and so forth. This process continues until the paths are completed, the uncompleted path ends are trapped, or a predetermined cycle limit is reached.

With this step-selection procedure, the computer examines the terrain's slope in the immediate vicinity of the element from which a step is to be taken, and chooses the direction that is most downhill. However, a step must not be on or adjacent to steps of a different node and cannot intersect itself. As a result, the most direct route may be unacceptable. Therefore, it is necessary to provide alternate choices of step direction. Because a step must be one of the four orthogonal elements of the existing location, it cannot move diagonally.

Suppose it is necessary to develop a path between X and Y in the diagram on page 77, where P, P, P . . . are steps of a different path. The computer seeks the first step from X by examining the altitudes of elements a, b, c, and d. If the step to element a is the most downhill, there is no reason that this element cannot be occupied. Thus location a is the first step from X. Similarly, from Y, the altitude of elements 1, 2, 3, and 4 are examined, and element 3 is chosen as the first step from Y. Then for the second step from X (now at a) elements m, e, and f are examined. Since the element at X was a previously occupied step, it cannot be included. If the greatest downward slope is toward m, the elements around it are examined. Because m is adjacent to the path P, this choice is rejected. Then if the second best slope is toward e and it is unrestricted, e is chosen as the second step from X. If e had been restricted, the third choice, f, would have been considered.

After the second step from X has been taken, the next step from Y is examined and taken. This process continues until the two ends meet, which in this case occurs at element 11. The entire sequence of steps is as follows: X to a; Y to 3; a to e: 3 to 6; e to h; 6 to 10; h to i; and 10 to 11.

In this example, neither path end is trapped. But if one end of a path progresses to a point where it cannot step in any direction, it is considered to be trapped and not allowed to move any farther. However, the other end is still active and seeks to connect with the trapped end. In the event both ends are trapped, nothing more is done with this conductor until a subsequent phase.

This stepping is controlled by a data array that keeps track of the most recent step location of each path end, as well as the point of origin (peak) of each. For definition, the most recent step of a path end is called the target of the other end; the peak toward which a path is moving is called the target peak; and the path end that is in the process of taking a step is referred to as the active end.

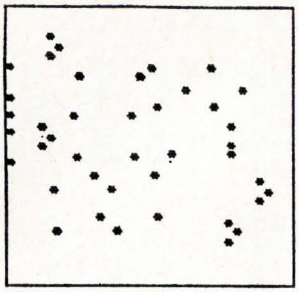
During the step-evaluation process, three characteristics of altitude are measured for each of the orthogonal elements at the active end: the instantaneous altitude, the portion of this that is due to the target peak, and the effect on altitude caused by the target being pulled down to form a cone. The first two are computed values produced from the following equations:

$$\text{Altitude due to target peak} = \frac{1{,}000}{C \times D + 1} \quad (2)$$

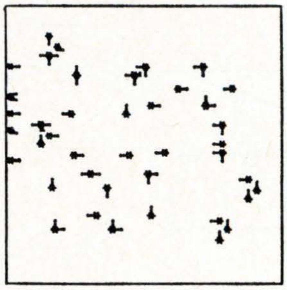
$$\text{Cone altitude change} = K \times (100 - D') \quad (3)$$

where

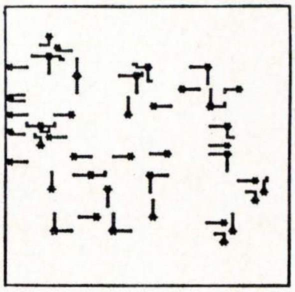
Path-interconnection pattern



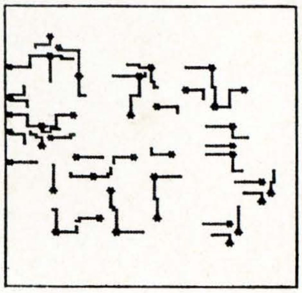
Frame 1



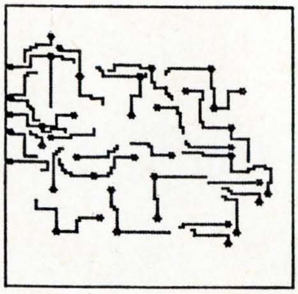
Frame 2



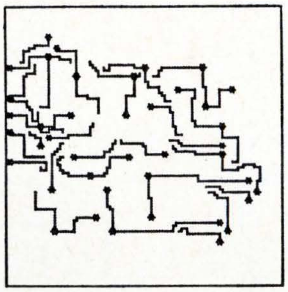
Frame 3



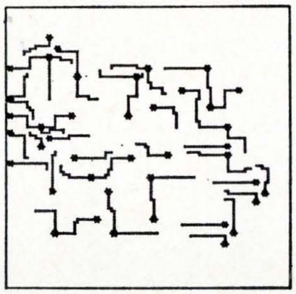
Frame 4



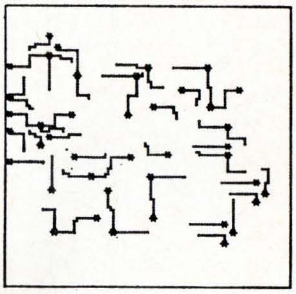
Frame 5



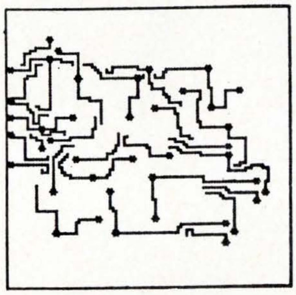
Frame 6



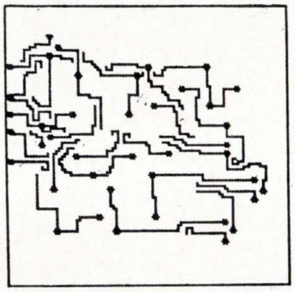
Frame 7



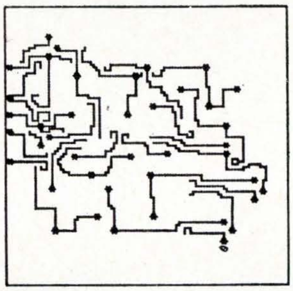
Frame 8



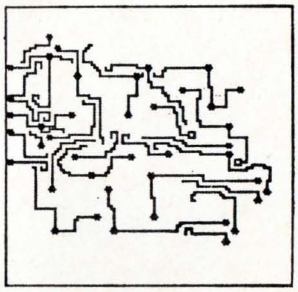
Frame 9



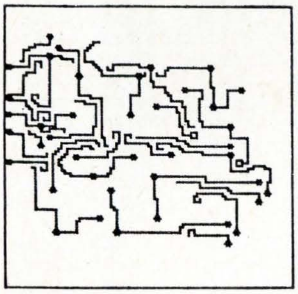
Frame 10



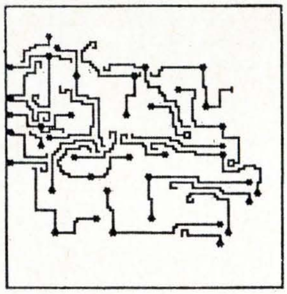
Frame 11



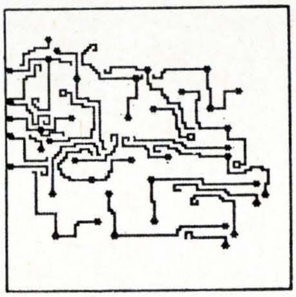
Frame 12



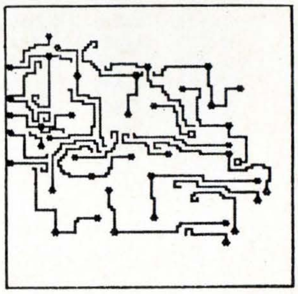
Frame 13



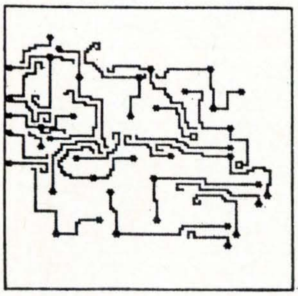
Frame 14



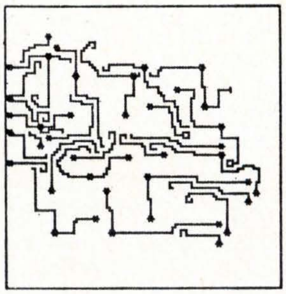
Frame 15



Frame 16



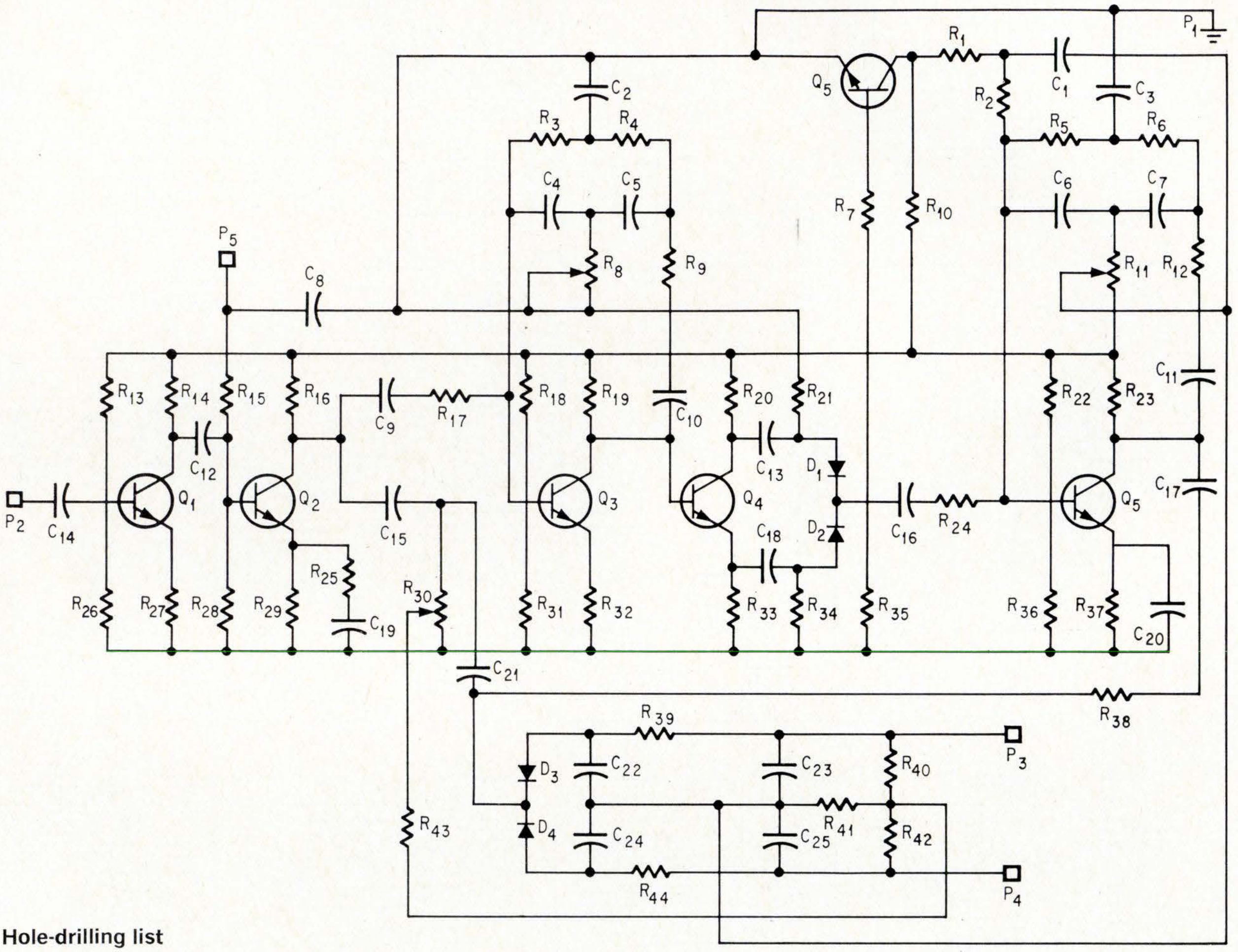
Frame 17



Frame 18

Stepping sequence. Pin locations, determined from the input data, are established in frame 1. As indicated in subsequent frames, paths between paired pins are allowed to step toward each other. While some paths are completed easily, others are not because paths cannot cross each other. At the end of the first computer run, the connected paths are stored in the memory and a second attempt is tried to complete the remaining unconnected paths. If this fails, a third attempt is made to connect incompleted paths on the back of the board. For those connections that are still incomplete, jumper wires are used.

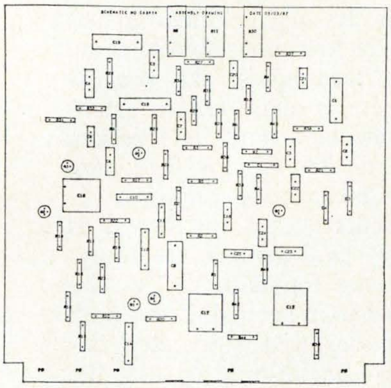
An f-m stereo multiplex adapter without transformers



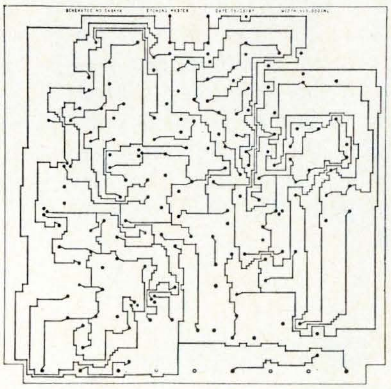
Hole-drilling list

SCHEMATIC NO CASKY4 HOLE DRILLING LIST DATE 05/03/67 PAGE 1

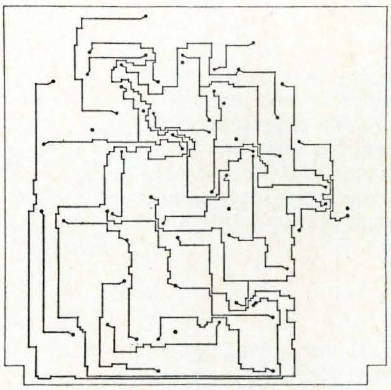
X	Y	DIAM	X	Y	DIAM	X	Y	DIAM	X	Y	DIAM	X	Y	DIAM
1.000	9.680	0.065	2.000	9.680	0.065	3.000	9.680	0.065	4.000	9.680	0.065	5.000	9.680	0.065
6.000	9.680	0.065	7.000	9.680	0.065	8.000	9.680	0.065	9.000	9.680	0.065	3.272	9.438	0.033
3.272	8.538	0.038	2.051	9.076	0.038	2.051	8.502	0.038	5.611	3.368	0.038	5.611	2.794	0.033
1.653	8.293	0.038	1.653	7.719	0.038	3.327	7.948	0.038	3.487	7.948	0.038	3.407	7.868	0.033
5.372	1.447	0.038	4.798	1.447	0.038	3.683	6.924	0.038	3.683	6.024	0.038	2.252	6.535	0.033
2.252	5.961	0.038	2.737	2.041	0.038	2.737	1.467	0.038	1.952	7.414	0.038	1.952	6.840	0.033
1.016	5.549	0.038	1.016	5.389	0.038	1.096	5.469	0.038	4.956	3.025	0.038	4.956	2.451	0.033
4.476	7.478	0.038	4.476	6.378	0.038	3.917	3.514	0.038	3.917	2.940	0.038	2.380	0.939	0.033
3.480	0.939	0.038	2.240	3.565	0.038	2.240	3.331	0.038	3.113	2.567	0.038	4.239	2.567	0.038
7.086	2.795	0.038	7.086	3.369	0.038	6.744	4.609	0.038	3.170	4.609	0.038	6.320	0.250	0.052
6.320	0.950	0.052	6.320	1.242	0.052	7.833	1.762	0.038	7.833	1.996	0.038	4.759	3.742	0.038
5.333	3.742	0.038	2.200	2.213	0.038	2.200	1.869	0.038	1.423	6.411	0.038	1.423	5.837	0.033
1.141	3.017	0.038	1.715	3.017	0.038	9.086	4.757	0.038	9.086	5.433	0.038	8.456	5.005	0.038
8.456	5.681	0.038	9.001	3.988	0.038	9.001	3.644	0.038	4.320	0.250	0.052	4.320	0.950	0.052
4.320	1.242	0.052	2.943	6.714	0.038	2.943	6.140	0.038	1.544	4.247	0.038	1.704	4.247	0.033
1.624	4.167	0.038	1.954	2.694	0.038	2.528	2.694	0.038	7.647	4.996	0.038	7.647	4.652	0.038
6.786	5.853	0.038	6.786	6.197	0.038	6.915	2.120	0.038	6.915	1.546	0.038	3.901	1.333	0.038
3.901	1.677	0.038	8.225	8.692	0.038	8.225	9.266	0.038	6.561	8.810	0.038	5.987	8.810	0.033
2.851	2.948	0.038	2.851	3.522	0.038	3.028	5.064	0.038	3.754	5.064	0.038	3.827	8.338	0.033
4.401	8.338	0.038	3.937	7.708	0.038	3.937	7.868	0.038	3.857	7.788	0.038	6.185	5.030	0.038
6.185	4.456	0.038	7.650	6.512	0.038	7.306	6.512	0.038	6.307	6.586	0.038	5.963	6.586	0.033
7.322	8.433	0.038	7.760	8.433	0.038	1.555	5.239	0.038	1.555	4.801	0.038	6.680	4.555	0.038
6.680	5.129	0.038	8.008	4.336	0.038	8.582	4.336	0.038	4.541	2.238	0.038	4.541	1.664	0.033
6.407	4.205	0.038	7.083	4.205	0.038	4.562	5.585	0.038	4.562	4.909	0.038	6.856	7.294	0.033
6.856	6.720	0.038	6.096	7.646	0.038	6.096	8.220	0.038	7.296	5.426	0.038	7.136	5.426	0.038
7.216	5.506	0.038	6.914	3.842	0.038	6.340	3.842	0.038	5.312	2.489	0.038	5.312	1.915	0.038
2.964	8.257	0.038	2.390	8.257	0.038	5.852	5.418	0.038	5.852	5.762	0.038	5.549	7.436	0.038
5.549	6.862	0.038	4.214	4.482	0.038	4.214	3.908	0.038	5.464	6.116	0.038	4.890	6.116	0.038
8.708	1.964	0.038	8.708	2.964	0.038	4.906	4.649	0.038	5.480	4.649	0.038	2.751	4.275	0.038
2.751	3.931	0.038	2.596	5.701	0.038	3.170	5.701	0.038	5.784	4.277	0.038	5.784	3.703	0.038
7.507	4.046	0.038	7.507	3.702	0.038	5.320	0.250	0.052	5.320	0.950	0.052	5.320	1.242	0.052
2.561	7.536	0.038	2.561	6.962	0.038	3.510	3.962	0.038	3.510	3.802	0.038	3.590	3.882	0.033
7.774	1.216	0.038	7.200	1.216	0.038	8.255	3.224	0.038	7.681	3.224	0.038	6.083	3.402	0.038
6.083	2.828	0.038	4.617	2.979	0.038	4.617	3.323	0.038	5.994	1.945	0.038	5.994	1.601	0.038
6.390	2.152	0.038	6.390	2.726	0.038	4.114	5.344	0.038	4.114	6.070	0.038	5.069	8.611	0.038
5.507	8.611	0.038												



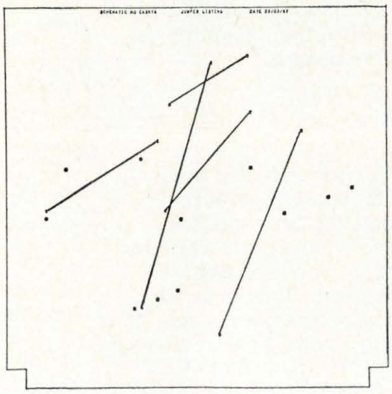
Component placement



Front of board



Back of board



Jumper wires for unconnected paths

C = a constant that defines the peak's shape;
D = the distance (grid elements) between the center of the peak and the element considered;
K = a constant that defines the depth of the cone;
D′ = the distance from the target to the element considered.

Then, for each of the orthogonal elements, an effective altitude is computed by subtracting the result of equation 2 from the instantaneous altitude, and the result of equation 3 from equation 2. The next step location is then the element that has the lowest effective altitude and does not violate any of the restrictions.

Multiphase operation

The over-all operation of the system is divided into four phases. Each phase, while employing the algorithm, follows a slightly different procedure for making connections. A control subroutine oversees the sequence of phases and is most subject to change. It is easily varied to try different procedures for making connections.

For the front of the board, phase 1 begins with a topography that includes only the border and the peaks at the land location. Here, steps are taken from both ends of a connection pair toward each other. A step from both ends constitutes one cycle of the stepping algorithm. The number of cycles in this phase, usually about 75, is specified by a data-control card. Although sloping ridges aren't present, there is an infinite barrier surrounding the progress of the paths. Consequently, no early warning of an impending obstruction is provided. Phase 1 terminates after the cycle limit is reached or when all the paths become trapped. Typically, about half the connections are made during this phase.

Phase 2 differs from phase 1 in one important aspect. The conductor paths completed in phase 1 are now provided with ridges, sloping downward and outward for 15 steps from each path end. Those connections not completed in the earlier phase are wiped out, and are attempted once again.

The final connections are now made on the front of the board. A special routine is used to determine whether the steps from the path ends are still progressing toward each other. If one end strays, its progress is halted and a land is placed at that point. Thus, when phase 2 terminates, after 100 cycles or less, a land is placed at the last position of each end of the incompleted path.

If a two-sided board is generated, the system attempts to complete the remaining paths between the new land locations on the second side. Completed path locations established for the front side are saved and the topography is set at zero before starting on the second side.

Back of board

To start on the back of the board, phase 1 is again employed to recalculate the topography, creating the peaks and border as before. However,

Lee's algorithm points the way

One of the major difficulties in laying out a printed-circuit board is determining whether a path exists between two points and if they can be connected. And, the larger the circuit, the more complex the problem. C.Y. Lee, of Bell Telephone Laboratories, Whippany, N.J., in a 1961 paper,[1] "An algorithm for path connections and its application," presented a technique that provides a solution.

Based on digital logic, the method enables a computer to solve efficiently the path-connection problem inherent in logic drawings and wiring diagrams. The algorithm is used to:

- Find a path between two points without using crossovers,
- Have the path avoid such obstacles as p-c board edges and circuit components,
- Determine the shortest path among several possible connections.

However, the algorithm has one drawback when used alone: it doesn't indicate the number of paths having a finite width that can be squeezed between two obstacles.

there are more lands or peaks than there were for the front of the board. The newly generated lands at the ends of incompleted paths, as well as the original lands, comprise the data for calculating peaks. These land positions must be avoided because the lands protrude through the circuit board.

After establishing the terrain for the back of the board, phase 1 is operated as before. Only those paths still not completed are attempted, and they step from new land locations.

Again, after phase 1 is completed, barriers are generated for newly completed paths, and incompleted paths are erased. Phase 2 is then tried, but only for 25 cycles. After phase 2, if there are still incompleted paths, phases 3 and 4 are tried.

Phase 3 and 4 differ from 1 and 2 in two ways: only one path is tried at a time, and steps are taken from only one end. Thus, these phases are executed once for each incompleted path. During phase 3, one end of the path stays at its land location while the other steps toward it. Up to 150 steps are taken to complete one path. If this doesn't succeed, phase 4 enters the picture.

This final phase is identical to the previous one except that the remaining incompleted paths are tried from the other end. Thus, if one end is trapped, the other end does the stepping. If there still are incompleted paths when phase 4 concludes, the program generates a tape for producing a picture of the board's paths before going on to the next circuit.

Topography and Lee's algorithm

The combination of topographic simulation and Lee's algorithm has been most successful. The main advantage of Lee's algorithm is that it finds a path if one exists. But, on the other hand, it crowds paths so that some subsequent paths cannot be developed even when logically possible. The major advantage of the topographic method is that it disperses paths. Its disadvantage is that it doesn't know when paths are impossible to form.

In applying the two techniques, the process begins by first running Lee's algorithm to establish if there is a path available and its location. The topographic scheme is then employed to complete these paths, which takes a few minutes.

A topographic representation of the board is kept in one array, where land centers are represented by 0's and all paths found by —1's. The elements running outward from each side of a path are given decreasing altitudes; that is, the elements adjacent to the path have an altitude of —2, the next closest have an altitude of —3, and so forth to a maximum of —7. Then a topographic unblocking algorithm distorts the Lee path, pushing it toward the lower elevations. A final path is obtained when further movement is no longer possible. This path is added to the topographic array and the program is ready to begin the next path.

The sequence in which the connections are made is determined by the straight-line distance between each end of the path. The shortest connection is processed first.

References

1. C.Y. Lee, "An Algorithm for Path Connections and Its Application," Transactions I.R.E., PGEC-10, September 1961, p. 346.

2. V.K. Zworykin and G.A. Morton, "Television, the Electronics of Image Transmission in Color and Monochrome," 2nd ed., John Wiley and Sons, 1958, p. 108.

The authors

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Drawing board for IC's

With the aid of a light pen, a computer and the Cadic program, an engineer can speedily design his IC layout on a crt display

By Arnold Spitalny and Martin Goldberg
Norden Division, United Aircraft Corp., Norwalk, Conn.

For the engineer who wants to design his own integrated circuit, a major drawback is that the designing process is often time consuming and costly. A computer can offset this by reducing both development time and cost substantially. The machine helps the engineer develop better IC designs faster, automatically checks them for conformance with all process tolerances, and generates a complete set of fabrication masks. Furthermore, since design changes can be made directly in the machine before an IC is actually built, the computer assures that a new circuit will work properly the first time.

Two factors make this design task more difficult than laying out a conventional printed-circuit board —the components vary more widely in size and shape, and more exact tolerances are required. The computer helps the designer determine size and shape of all elements, allows for isolation moats and clearance tolerances, arranges the elements into a rectangle of minimum total area that fits in a flat pack or header with satisfactory form factor, locates terminals, and routes interconnections without metalization crossover, if possible.

On-line computer program

Although computer programs can be designed to assist in developing IC's using conventional batch-processing computer techniques, they suffer serious limitations. For example, cards must first be punched that describe not only the input data but also the program operations. These cards are then scheduled and must wait their turn on the computer. Since the output from such a run is usually numerical, this data must be converted on additional cards or tape and fed into a plotter to obtain a visual display. If a change is desired, it cannot be performed until the computer run is completed; should there be an error in the change card, the run must be repeated from the beginning. Many changes and runs are usually needed before a satisfactory design can be achieved.

A new graphical on-line system avoids these problems. Circuit-layout patterns are manipulated on a cathode-ray tube with a light pen and results in data that can be used to produce the mask artwork. Called Cadic, for computer-aided design of

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Light-pen operation. Martin Goldberg, author, points light pen at the left edge of a component while co-author Arnold Spitalny looks on.

Picturing an IC chip's layout — a visual approach to design

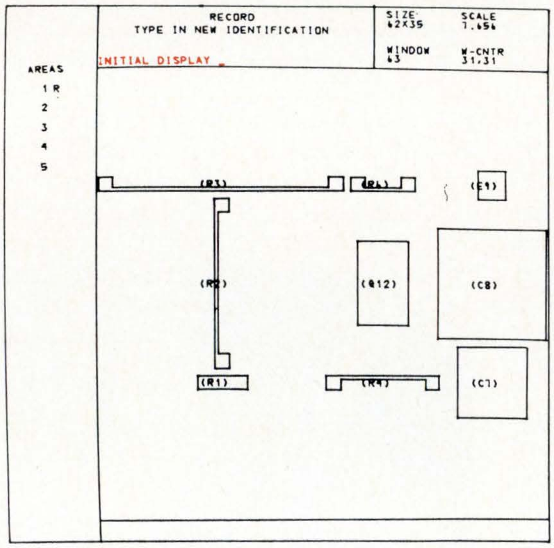
Designing an integrated circuit is vastly simplified, thanks to the Cadic system. With a clear picture of his circuit on a cathode-ray tube, the designer merely uses a light pen to manipulate the component parts to obtain an efficient circuit layout. These illustrations, reproduced from a crt, show some of the capabilities of Cadic when applied to a simple demonstration circuit.

An initial display is automatically developed from the computer input and appears on the crt. This or any subsequent display can be recorded by the computer and recalled at any later time during the design. The first step shows the initial display being recorded. The designer selected the RECORD mode by pressing the record key on the function keyboard. On top of the screen appears the information INITIAL DISPLAY, written in with the console typewriter to identify the data for reference.

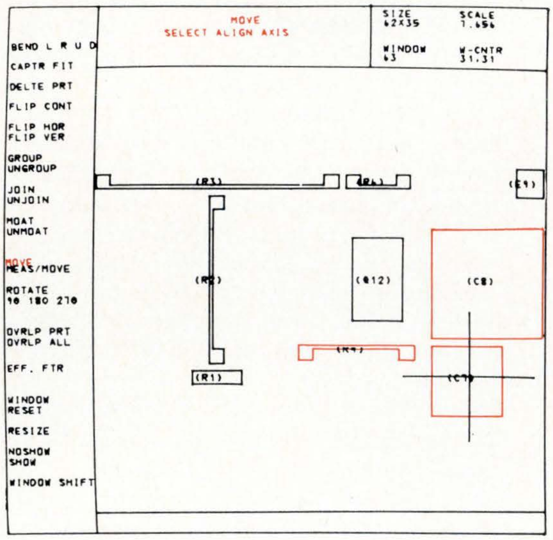
The list of numbers at left of the screen indicates the storage areas in which a particular display can be recorded. After each operation, various messages appear in the conversational-message area of the crt. Here, for example, the placement mode is selected and the computer asks the designer to choose a command. A particular command is selected by pointing the light pen at it—in this case, the MOVE command. Once set in this command, many component moves can be done without repeatedly pointing to MOVE.

Immediately after this command is selected, the computer changes the message to SELECT MOVE PART OR GROUP. The part or group of parts to be moved is selected by pointing with the light pen, whereupon a new request for instruction is made to designate a constraint which indicates where the part or group should be moved.

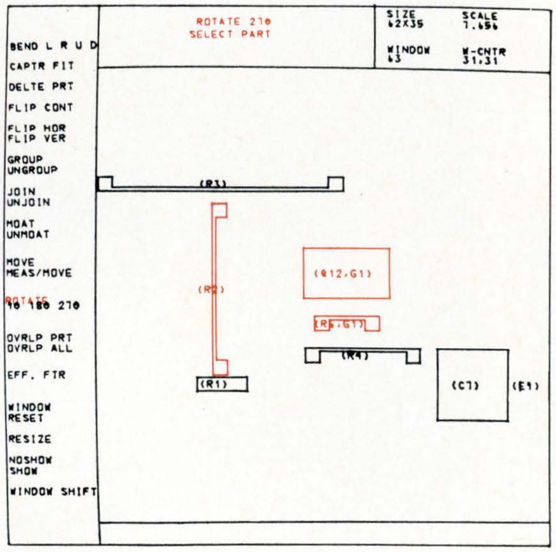
Several variations of this command are available, depending on the part edges designated as move



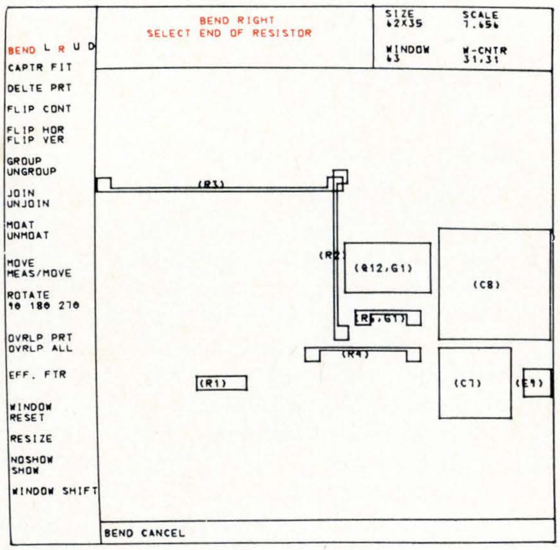
Step 1. Initial circuit layout.



Step 2. Selecting alignment axis.



Step 5. Additional rotation.



Step 6. Compressing parts.

and constraint edges. If the light pen is pointed at the left edge of two components, for example, the second is held fixed and the first moves to align its left edge with the left edge of the second component. Thus, R4, in the initial configuration, is moved slightly to the left, and the left edges of C7 and C8 are aligned. This alignment is accomplished simply by pointing with the light pen to the left edge of C7 (part to be moved) and then the left edge of C8 (constraint).

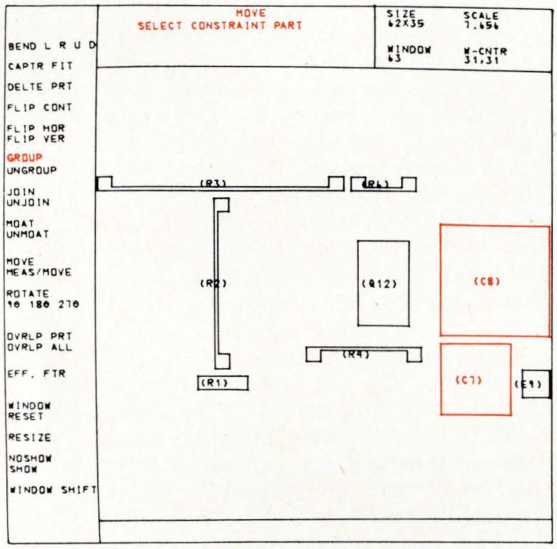
By pointing the light pen at the right edge of two components, a similar alignment takes place between them. Thus, the external pad, E9, is moved to the right to line up with the right edge of C8. Component E9 is then moved down and placed adjacent to the center of C7. To request a center-to-center move, labels are used instead of edges. An axis is then selected to indicate whether the center of the part moved should be shifted to the horizontal or vertical constraint axis.

To move one component next to another the light pen is pointed at different edges—here, the left edge of Q12 and the right edge of R2. Element Q12 is then moved left to be adjacent to R2 with a preselected separation automatically applied.

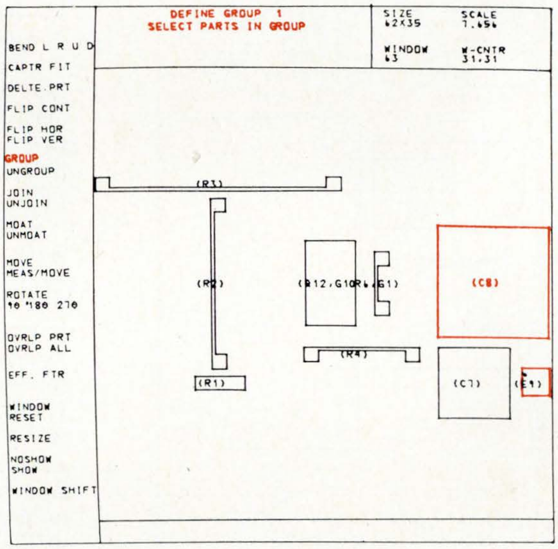
By selecting ROTATE from the menu, components are automatically turned when designated by the light pen. Thus, R6 is rotated 270° and moved down to align its center with the center of C8. Also, Q12 is moved adjacent to R6. The message area now indicates that the command GROUP is selected, a command that enables a designer to choose and group several components and manipulate them like a single part.

A group is defined by successively pointing the light pen at the parts desired. As each part in the group is selected, a group label is placed next to it. Group G1 consists of Q12 and R6.

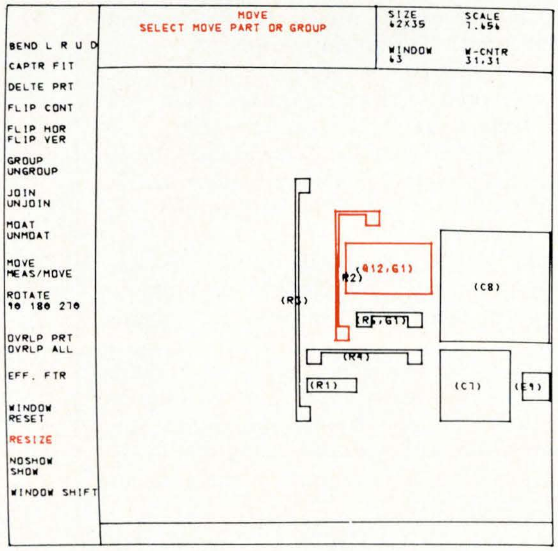
Additional moves are made to compress the parts into an even smaller area. For example, the message area indicates that the command BEND RIGHT is selected. This is achieved by pointing the light pen to the R next to the BEND menu item. As the result, R2 (end to be bent) is bent to the right



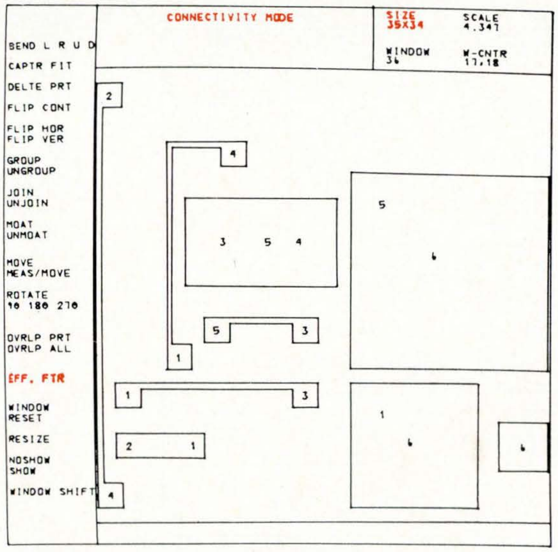
Step 3. Vertical alignment.



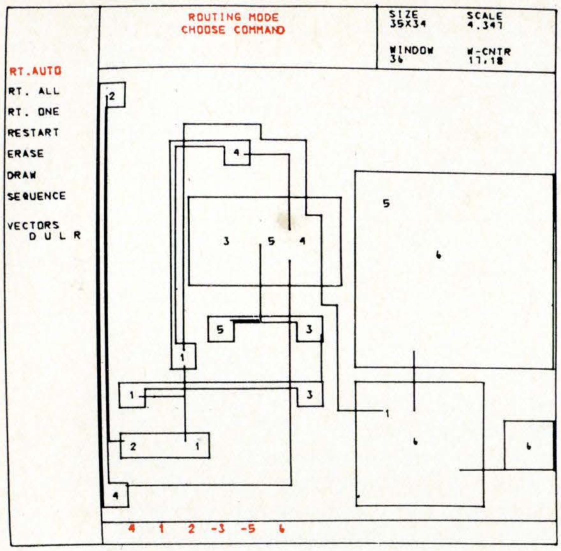
Step 4. Rotating and grouping.



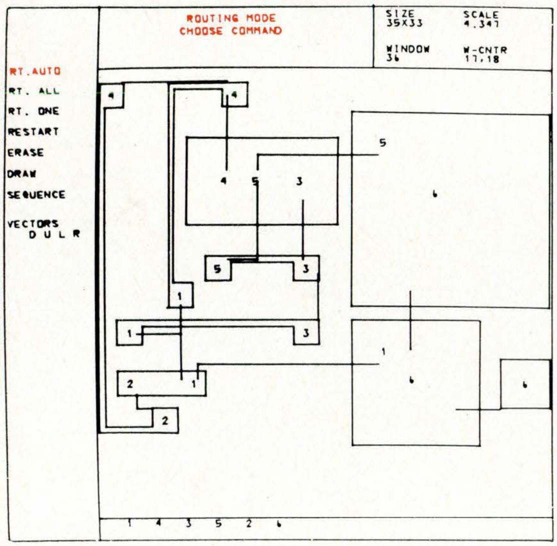
Step 7. Bending for compactness.



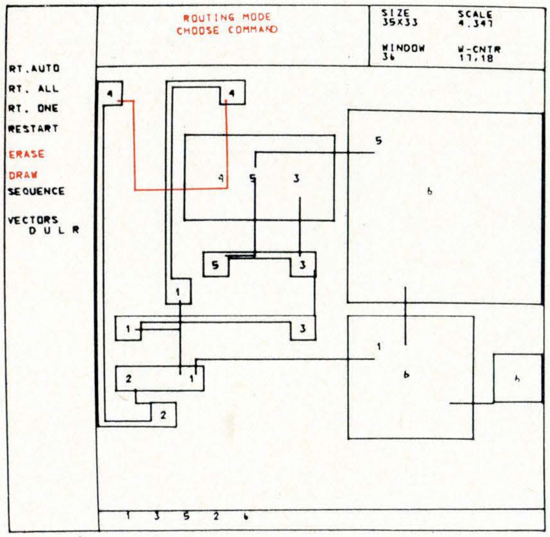
Step 8. Rescaling for smaller chip.



Step 9. Routing starts.



Step 10. Routing ends.



Step 11. Changing routing.

around Q12 (constraint). This is accomplished by pointing the pen at the top end of R2 and the top edge of Q12. Separation between the bent segment of R2 and the top edge of Q12 is automatically maintained. Another rotation and two moves complete the initial consolidation of chip area.

Since the parts as they now appear occupy considerably less area, it is desirable to readjust the boundaries (a rectangle enclosing all parts) to define a much smaller chip. The initial chip size is indicated as 62 by 35 mils, shown in the parameter area at the top right of the screen. Readjustment is achieved by pointing to the command RESIZE. This results in new boundaries. Rescaling is then made so the screen represents the full area of the chip now measuring 35 x 34 mils.

Chip-packing efficiency is measured at any time by selecting EFF. FTR in the menu. The ratio of total component area to total chip area is then computed and displayed in the message area.

To avoid unnecessary clutter on the screen, the designer eliminates the names of the components by pressing the names key on the panel. By pressing the nodes key, node numbers are displayed at the contact locations on each part. A node, or net, is a set of contacts that are to be electrically connected with interconnection metalization. Connectivity data is included on the input card, and can be displayed at any time during the layout to assist the designer in placing and orienting components.

Making connections. With node numbers on the screen, the route function key, calling for the routing mode, is pressed and a new list of commands appears in the menu area. The first command selected is RT. AUTO, which causes all the nets to be routed in descending order according to length. The computer determines length. The sequence of numbers, which appears at the bottom of the screen, indicates the order in which the nets were routed, reading from left to right. In this case, net 4 is routed first. Although contact geometry isn't shown, all the points on net 4 are indicated with a 4 on the layout display at the center of the corresponding contacts.

Blocked nets are indicated by a minus sign next to the net number in the sequence display. Here, nets 3 and 5 had blockages preventing the routing algorithm from connecting all their points. To move the blockages, the designer returns to the placement mode and applies the FLIP HOR and FLIP VER commands to reverse the contact position of R3 and Q12. R3 is also moved and bent to obtain a more compact chip. By reversing contact positions on R3 and Q12, the routing is simplified because nets 2, 3, and 4 are shortened.

Several other options are available to the designer to perform routing manipulations or eliminate blockages. Two of these are ERASE and DRAW commands. Here, the path for net 4 is erased and then drawn manually by the designer. In this case, there is no problem of blockages, but it is desired to change the path obtained by the algorithm. Instead of having the path proceed along the body of R2, it is preferred to have it cross at right angles to reduce capacitive pickup.

Erasing of net 4 is accomplished by selecting ERASE and then pointing anywhere on net 4.

Continued from page 83

integrated circuits, the system was developed for the Air Force by the United Aircraft Corp.'s Norden division.

Cadic is similar to the batch-processing techniques in one respect: both accept circuit definition from punched cards. But from there on, Cadic takes a different course. The input data is translated into size and shape of every component, recalled from the computer's memory and keyed by type designations. Additional component types may be added to the memory at any time. Resistor and capacitor dimensions are computerized from their values.

From this input, an initial layout is displayed on the crt. All components are presented in true outline size and shape, arranged for easy recognition in the same relative positions in which they appear on the schematic, and separated to avoid overlap.

While viewing the display, the designer can use a light pen to manipulate the components and make any desired changes instantly. The results are observed immediately on the screen. To assist the designer in making the layout more compact, the program provides messages on the screen that tell him what the computer is doing at all times and what information it needs.

Simple on-line commands are displayed for the design of interconnection routing. Included are many combinations of both automatic maze-solving programs and manual-routing techniques. The program has an automatic checking procedure to assure compliance with all design rules. It accommodates circuits of any size, and can adjust scale-screen size to enable the designer to look at the complete circuit or work on any desired portion.

The computer also stores and retrieves intermediate and final designs and generates display patterns for any or all desired mask designs.

Laying out an IC

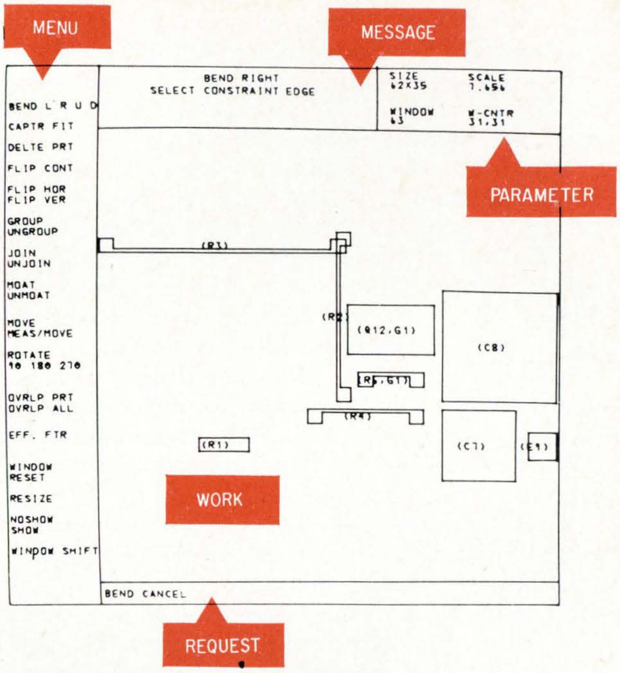
The crt display is divided into five screen areas, shown above, as follows: the work area containing the layout display, the conversational message area, the command area called the menu, the parameter display area, and the request area for both display of data and input of operator requests.

Data on the input cards describe the circuit schematic, specify component values or types and connectivity, and indicate the designer's approximation of part centers estimated from a rough grid sketched on a schematic.

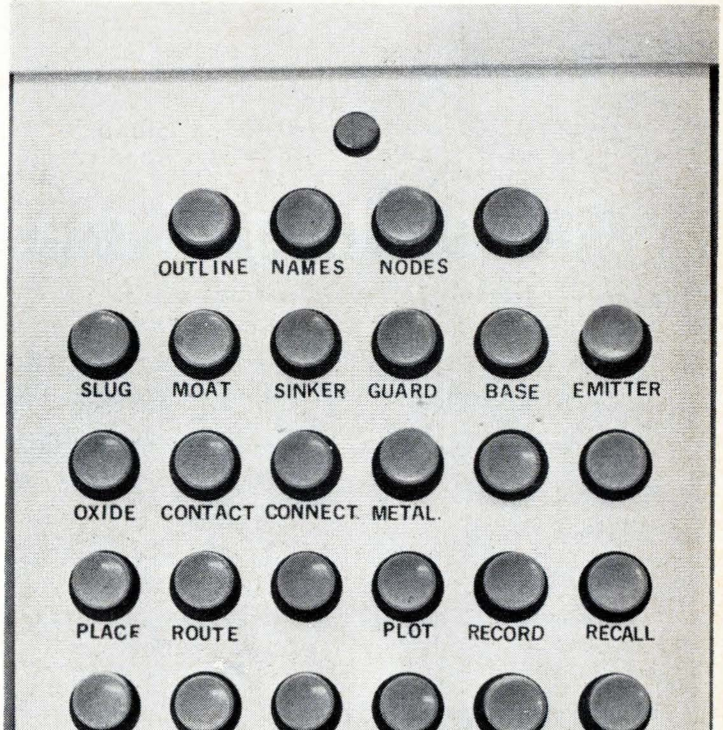
Based on this data, Cadic displays the initial layout. Overlapping of components is eliminated automatically by the computer, which also rotates the components to obtain preferred orientations for interconnection routing.

To avoid cluttering the display, the initial layout contains only element outlines and symbols. However, the designer can request the display of detailed mask geometries by pressing the keys.

A typical function keyboard, at the right, contains 32 keys, each of which calls for a discrete function to be performed. The first three rows of



Screen areas. Five basic sections of the screen used by the designer to develop an IC layout.



Function keyboard. Each of the 32 keys triggers a discrete function. Pressing the plot key, for example, causes a Calcomp plotter to draw the output.

keys, which are all press on-press off, are for display options. For example, pressing the emitter key causes the emitter diffusion mask to be displayed on the crt. Pushing the same key after the emitter mask is displayed removes the mask.

The fourth and fifth rows are mode-selection keys. For example, by pressing the place key, the designer selects the part-placement mode. By pressing the route key, he selects the interconnection-routing mode. The plot key calls for plots of the display on a Calcomp digital plotter. Record and recall keys are for recording a particular display on disk storage and recalling the display at a later time. Thus it isn't necessary for the designer to complete a design at one sitting at the console; he can always recall a partially completed layout and continue working where he left off.

Moat-build and metal-build keys tell the system to construct the isolation moats and metalization masks for the circuit, since these are not automatically determined at every stage of the layout design. The remaining keys request various system-check printouts, and the quit key ends a particular session at the console.

One of the methods of obtaining a hard-copy output from the Cadic system is with a Calcomp digital plotter, which provides a plot of several of the mask geometries superimposed. It is also possible to obtain separate plots of each mask geometry; however, the accuracy of these are not suitable for the photoreduction artwork required to make the circuit masks. These are used only to give the designer an indication of what the masks will look like. Suitable artwork can be obtained with equipment that uses light heads to expose film or sensitized glass plates. Presently, the Cadic system doesn't interface with direct mask-plotting equipment, but this will eventually be included.

The authors

Arnold Spitalny is chief of the engineering computer branch at United Aircraft Corp.'s Norden division. As a project engineer for the Cadic program, he developed the first experimental off-line system for generating IC layouts.

Martin Goldberg is a senior computer applications engineer at Norden. He investigates potential applications for graphic-computer techniques and is responsible for developing the on-line Cadic system.

Circuit design IV

Generating IC masks automatically

Now an engineer can describe a circuit to a computer and the machine provides the output to generate the artwork from which masks are produced

By Harlow Freitag

Thomas J. Watson Research Center, International Business Machines Corp., Yorktown, N. Y.

When it comes to fabricating integrated circuits, one of the most difficult—and expensive—steps is making the masks from which the IC's are manufactured. The more complex the circuit, the more complex the mask-making problem. It is now reaching the point where, in some cases, masks can't be produced without some aid from a computer.

With existing manual or batch-processing techniques, it can take as long as months to build an IC chip from the start of the design process. And the costs are often prohibitive, particularly when there are engineering changes or error corrections.

Generating conventional mask artwork can begin once the circuit and chip technology are determined. Then a layout of the chip is prepared, at which time problems of element placement and wiring must be solved. The layout enables the designer to prepare a detailed composite drawing for each mask, and the actual artwork is made by removing an opaque layer from selected areas of a double-layer plastic film. To achieve high quality, the original artwork is made on color overlays 200 to 500 times the final chip size. When the original artwork is found to be error free, it is reduced photographically to 10 or 20 times the final chip size. In turn, these are used in step-and-repeat photographic operations to produce master masks.

This process works well with chips having a small number of circuits, but becomes cumbersome with the advent of large-scale integration.

Prior to LSI, integrated-circuit chips were relatively simple and had broad applications. Chip fabrication, load bonding and packaging, and checkout were largely independent operations, with many chips manufactured and stockpiled by machine-design groups for off-the-shelf use. Changes in machine design were usually accomplished at the level of card or board wiring, rather than the chip level. For these chips, mask artwork was essentially an easy task.

A changing picture

But LSI changed this picture radically. The greater complexity of LSI chips tends to make them less universal. For example, an LSI chip containing 50 to 200 logic circuits will not have the general-purpose function of a chip that contains a single latch. It is expected that at the higher levels of integration a chip will be employed only in one machine type. Thus, while the number of chips may be reduced, the number of chip types—and, hence, the number of artwork sets—will increase.

In addition, the special-purpose nature of LSI chips makes stockpiling of completed chips unlikely. As a result, machine-design groups will not be able to use off-the-shelf chips for breadboarding and testing. Instead, these operations will have to wait for chip fabrication, which in turn must wait for mask fabrication.

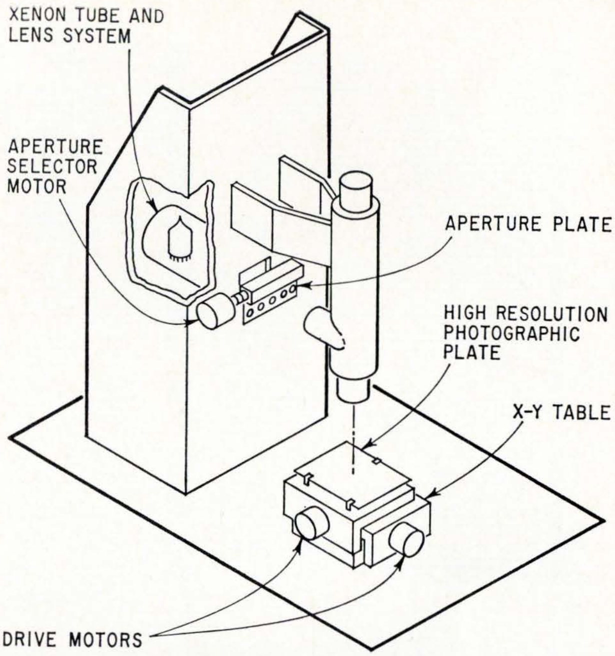
Finally, the complexity of LSI chips makes the artwork generation a tedious and error-prone process, with perhaps several iterations necessary before artwork can be obtained that is 100% accurate.

Because chip fabrication and artwork generation have become a part of the machine design-checkout cycle, it is necessary that the artwork be prepared rapidly.

Several approaches may be taken to reduce the time it takes to design and build an LSI chip (turnaround time). These include:

- Applying computer to simulate hardware for the elimination of bad layouts and errors before mask design starts.
- Applying the master-slice technique in which only the final masks are changed to modify the function performed by a chip. Thus, wafers can be stockpiled at an advanced state of fabrication.
- Automating the mask designs completely with a computer, or with computer-aided techniques.
- Generating the artwork and masks by simple and rapid automatic techniques.

The approach taken by the researchers at the International Business Machines Corp.'s Thomas J. Watson Research Center applies all of these features in three parts: a language that enables the designer to describe the patterns and structures required in the individual mask, a computer program that translates the language into commands, and the automatic equipment that accepts the commands and generates the masks.



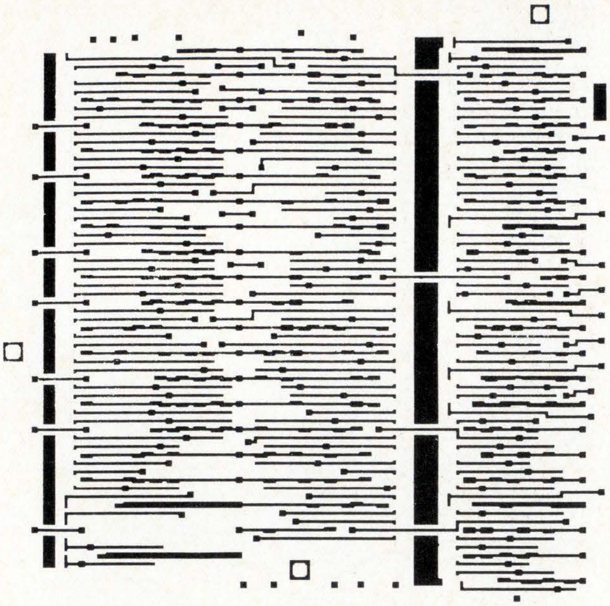
Light Table. Sensitized plate is exposed to light as the table moves in either x or y direction.

Understanding the language

The language is a convenient shorthand and symbolic way of describing the patterns a designer wishes to generate. Called Lager (for layout generating routine), it is analogous to Fortran. It accepts a higher-level description of mask geometries, automatically reduces this description to a list of line segments, and generates all the commands required to expose the segments.

The Lager language has a vocabulary of 12 words that defines five operations. The simplest operation accepts a series of point coordinates and connects them with a single line. If other commands are inserted in the series, they are executed in the order in which they occur. Additional operations select different apertures for exposure to accommodate different line widths and geometries, repeat patterns throughout a chip if desired, and provide macroinstruction (macro)—the most powerful command in the language. The macro capability defines and stores information under an arbitrary symbolic name. When that name is referred to later, it is regarded as equivalent to the stored information and becomes, in effect, a new command of the language. Included in the information that can be stored are single coordinates, parts of instructions, commands necessary to make a transistor, a logic circuit, or a group of logic circuits.

Macros may be nested, with one employed as part of a definition of another at a higher level. Unquestionably, it is the computer's macro-language capability that allows the designer to build specialized languages to suit his own needs. Simple macro



Generated artwork. Interconnection pattern for 122-element logic chip is generated 10 times oversize. Typical line width is 0.4 mil.

names replace whole series of commands.

Because computer language is complex, it is possible that errors may be buried within a set of input commands. To provide assistance, several error-checking routines have been built into the language. Here again the analogy with Fortran is appropriate. The routines detect errors in either incorrectly formed or incomplete instructions. However, the system does not determine whether a set of predefined instructions also represents the desired chip geometries. To aid in this latter check, the system plots for each mask all line segments that result from the input.

Another feature of the language permits any structure or group of structures to be represented three-dimensionally. Thus, when a designer requests a given pattern to be repeated at a particular part of a chip layout, the language automatically accounts for the multiplicity of masks required.

In addition, the language has a repeatability feature that permits a given pattern to be duplicated at a fixed interval around the layout. The pattern can be either along a row or column, or it can be a matrix.

Outlining the program

A rough sketch of the mask is first drawn from which the designer writes a set of statements needed to produce the layout. This may include previously prepared statements from other mask designs. The statements are punched on cards and fed into a computer.

A digital plot that represents the masks generated by the input statements is produced by the computer. The data is then plotted with a Calcomp plotter. If any errors are found in the output, the statements are corrected and a new plot is obtained. This correction procedure is repeated until the design is error-free. At this time, the designer may call on the computer to produce a magnetic tape containing the commands necessary to generate the mask set. Each statement or set of statements may refer to several masks simultaneously. For example, a transistor is made from several processes, each requiring a different mask. One macroinstruction can be used to select all the masks needed to represent the transistor.

One task of the computer is to remember on which mask layer the pattern is to be found and then sort the entire set of patterns mask by mask. Individual masks are then produced with the appropriate patterns.

Producing the masks

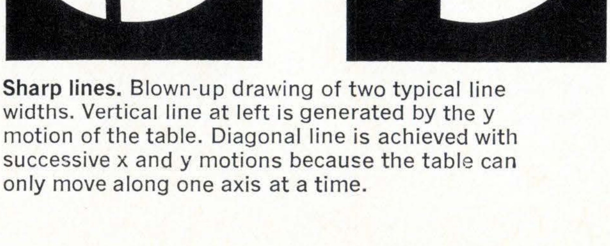
Mask generation is preformed with an automatic exposure device, called the Light Table. The unit contains three basic parts: a high-resolution photographic plate mounted on an x-y table, an aperture mechanism, and a light source.

The x-y table is made of two slides, mounted with one riding upon the other, but traveling on perpendicular axis, driven by a stepping-motor drive train. Each step of the motor results in a table motion of 0.5 mil. The field of table motion is 2.2 inches square, across which an absolute accuracy of ± 50 microinches and a short-term (measured in minutes or hours) repeatability of ± 20 microinches is achieved. Table speed is nominally 0.1 inch per second.

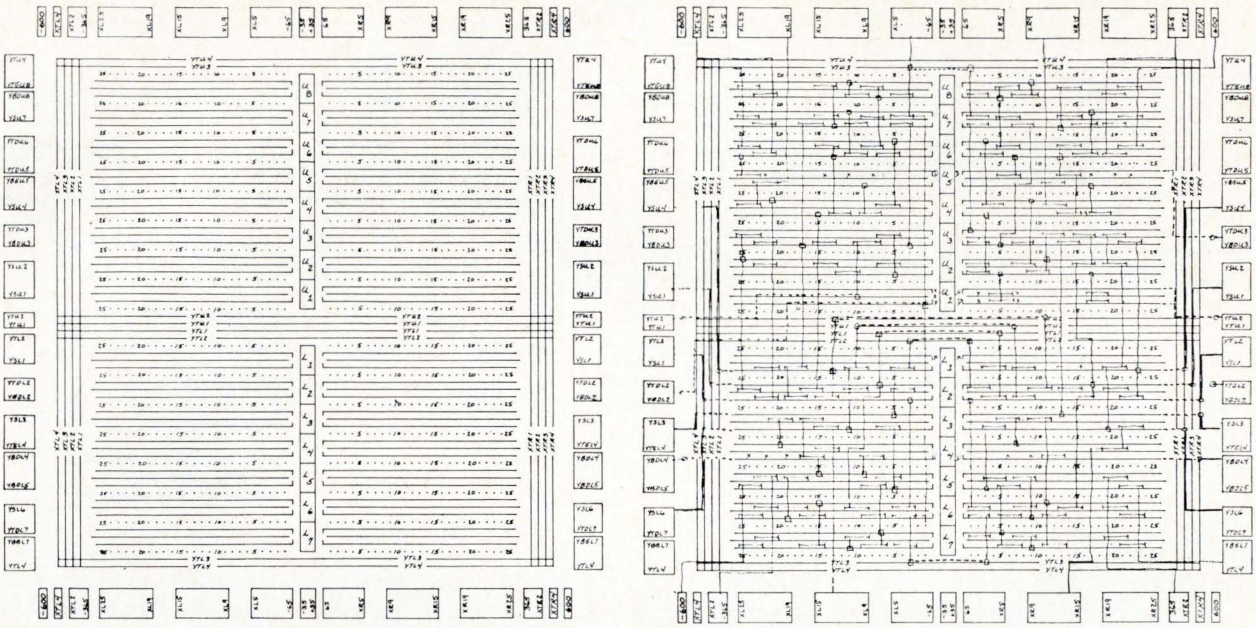
The aperture mechanism consists of a photographic plate, upon which the aperture images are formed, mounted on another slide assembly. By moving this slide, any one of several apertures may be selected.

System lighting is provided by a xenon flash tube, arranged to illuminate the selected aperture through a condenser-lens system. An image of the aperture, reduced in size by a factor of 10, is formed on the plate on the x-y table.

Associated with this equipment are two pieces of peripheral equipment: an incremental magnetic



Sharp lines. Blown-up drawing of two typical line widths. Vertical line at left is generated by the y motion of the table. Diagonal line is achieved with successive x and y motions because the table can only move along one axis at a time.



Mask layout. Both placement and wiring are layed out at left to indicate a final circuit scheme. Horizontal rows of dots indicate the vertical wiring positions; three solid lines between these rows indicate dual NOR circuits. By adding metal and diffused lines, the designer defines his final layout. Rectangles represent inputs to the circuit.

tape reader and appropriate control logic. The tape reader is the primary input to the system, with an incremental reading capability that minimizes the need for buffer memory. The control logic calls for the instructions read by the tape reader, interprets and executes them.

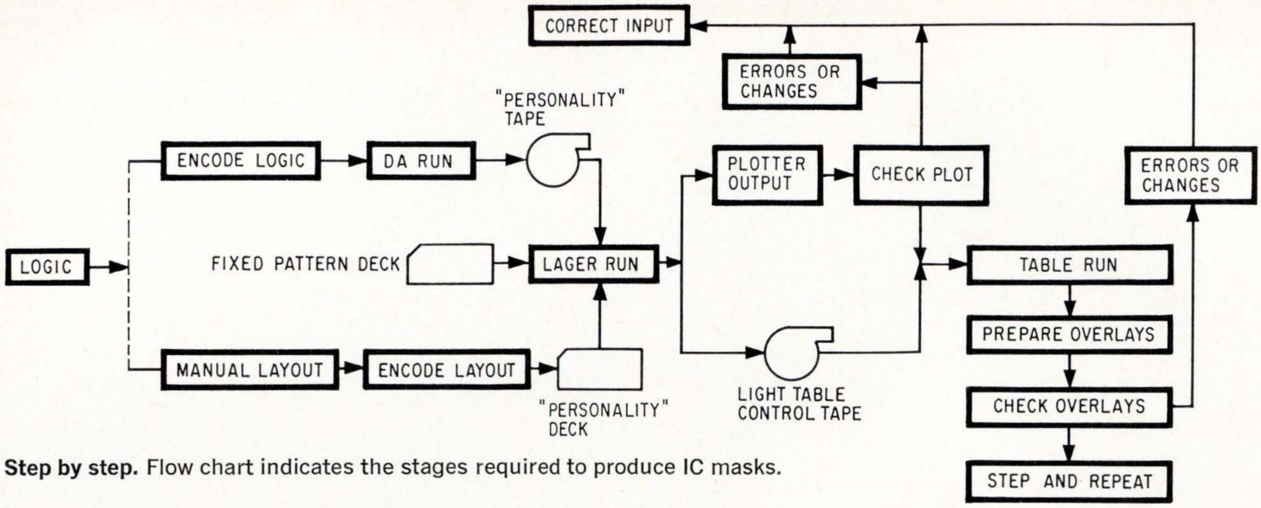
Stop and go

Operation of the light table is simple. A command—move or stop—is called for by the control logic. If the received command is to stop, no operation takes place and the logic waits for manual resetting. If the command is to move, it is decoded into axis selection, direction, distance, and flash instructions. Pulses are routed to the appropriate stepping motor to move the selected axis the desired distance. When motion is complete, the logic will, if the flash instruction is on, wait approximately 15 milliseconds, then fire the lamp and call for another instruction. If the flash is off, the logic calls for the next command without flashing the lamp.

Continuous lines are exposed by executing a series of move-flash instructions. Usually, in such cases, no overlap is provided between adjacent exposed areas; continuity of line is achieved by

Operation	Convential Regular[1]	Light Table-Lager		
		Adhoc	Regular[1]	Full Design Automation
Encode and keypunch logic				1.5
Run program				0.5[2]
Manual layout	32	50[3]	32	
Prepare mask drawings	80			
Encode and keypunch mask data		30	12	
Cut film artwork	120			
Run Lager program[4]		0.1	0.1	0.1
Light Table run		1	1	1
Prepare overlays	2	2	2	2
Reduce to single segment	2			
Step and repeat	4	4	4	4
Total	240	87.1	51.1	9.1
Artwork preparation time[5]	204	33.1	15.1	3.1

1. Assumes use of regular array approach described in text.
2. Estimated 7094 time for good replacement and wiring program.
3. Includes preparation of skeleton drawing.
4. Optional plot generation may require several hours off line.
5. From completion of layout to start of step and repeat all times are in hours and do not include queuing time.



Step by step. Flow chart indicates the stages required to produce IC masks.

scattering of light in the material's emulsion.

When circuit density is at a premium, it is desirable to place the components in a way that will most efficiently use the available area. To accomplish this, the designer uses an adhoc layout in which the devices and their interconnections are arranged to make maximum use of the available silicon area. In this approach, manual solutions to placement and wiring problems are usually required since the layout is irregular. As in the conventional method, final layout is a composite drawing. But by using Lager language, the implementation of these layouts is simplified.

First, macros are defined for repetitive circuit features; for example, transistors, diodes, contact holes, pads, and resistors. These may be pinpointed on the composite drawing by a single reference point. Only the center lines of line segments need be shown. It is usually only necessary to show those mask layers that are used for interconnections; the others can be accommodated by the macros. Furthermore, it isn't necessary to prepare detailed drawings of all masks in a set, as coding into the Lager language may be done directly from the skeleton composite drawing.

Designing the arrays

When circuit density is not quite as important, it is possible to place all allowable circuit and track positions into a regular structure. This leads to the regular-array method of using a Light Table-Lager system. In this method, because of the symmetry of circuit and wiring-channel location, it is possible to assign a mnemonic code to every significant coordinate in the chip; circuit locations, entry and exit points, wiring locations, and pad locations may all have simple names assigned to them. The macro structure of Lager allows these names to replace the coordinates they represent. In effect, this allows a separation to be made between what may be termed mask topology (relative placement of features) and mask geometry, which is the exact location of all structures on the mask. Input expressed as mnemonics for the coordinates is essentially an expression of the mask topology; the Lager language translates this into geometry.

Because placement and wiring are largely topological problems, it is possible to prepare a sketch that expresses the allowed topology of a given layout scheme.

Such a sketch may be used as a preliminary design upon which lines can be added to represent the diffusions and metalization patterns. Coding into statements for the Lager program may be done directly from this diagram, applying the macro names associated with the array. This method brings to the mask-artwork generation many of the advantages of the master-slice technique. These advantages are rapid turnaround time and stockpiling of partially completed wafers at an advanced level of fabrication.

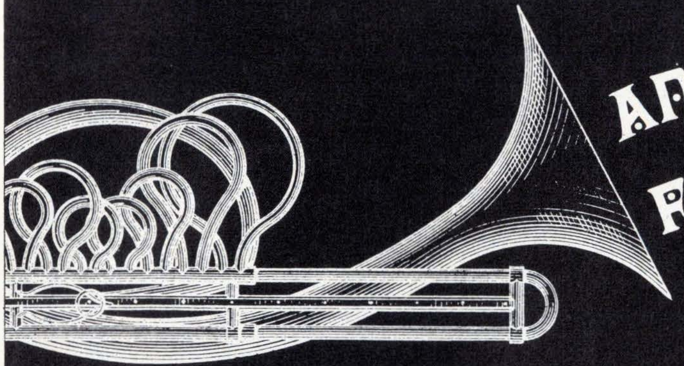
It is a simple matter to extrapolate to a third method of applying the Light Table-Lager system: the full design automation (DA) method. This technique would use macro instructions to fabricate the circuit structures. Topological problems of placement and wiring would be done by a design-automation program. The program is arranged to have its output recorded on a magnetic tape as Lager commands. This tape is then run as input to the Lager program together with a set of macro definitions.

The Light Table system, in addition to saving time is also more flexible. However, in the adhoc approach, this flexibility is limited by the need to conserve space on the chip.

When the regular-array method is used, the flexibility is even greater. Changes in array design may be easily accommodated, providing they do not alter the topological ground rules. Thus, wiring changes may be made at will and wiring may be added to any array design.

The author

Harlow Freitag manages design-automation research at the Thomas J. Watson Center. A mathematician, he is responsible for the development of advanced computer-aided design techniques.



AN OHM-PA-PA FROM PAPA OHM

TO MY LAW-ABIDING FRIENDS

Dear and

You five are the joy of my days these years! You have no idea how it makes me feel to know that you five - of all the ones who have tried - are following my law so faithfully.

With you, resistance is resistance, just as I saw it. No maybe's, excuses or big changes because of temperature, frequencies, time, etc.

I always felt someone would be able to make what you call "resistors" the way they should be.

So, to you for developing Vishay Resistors, and to

- Welwyn in Britain

- Rosenthal in W. Germany

- Sfernice in France

- Kyowa in Japan

for becoming licensees of Vishay, for continuing to try to make even better precision resistors and networks, and for distributing them in your part of the world, my eternal thanks.

Papa Ohm
Papa Ohm

P.S. Could you send me some literature? It will help me convince the doubters.

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Circuit design

Designer's casebook

Designer's casebook is a regular feature in Electronics. Readers are invited to submit novel circuit ideas, packaging schemes, or other unusual solutions to design problems. Descriptions should be short. We'll pay $50 for each item published.

Digital timing provides frequency-sensitive relay

By Rui Vilela Mendes

Laboratorio de Fisica e Engenharia Nucleares
Sacavem, Portugal

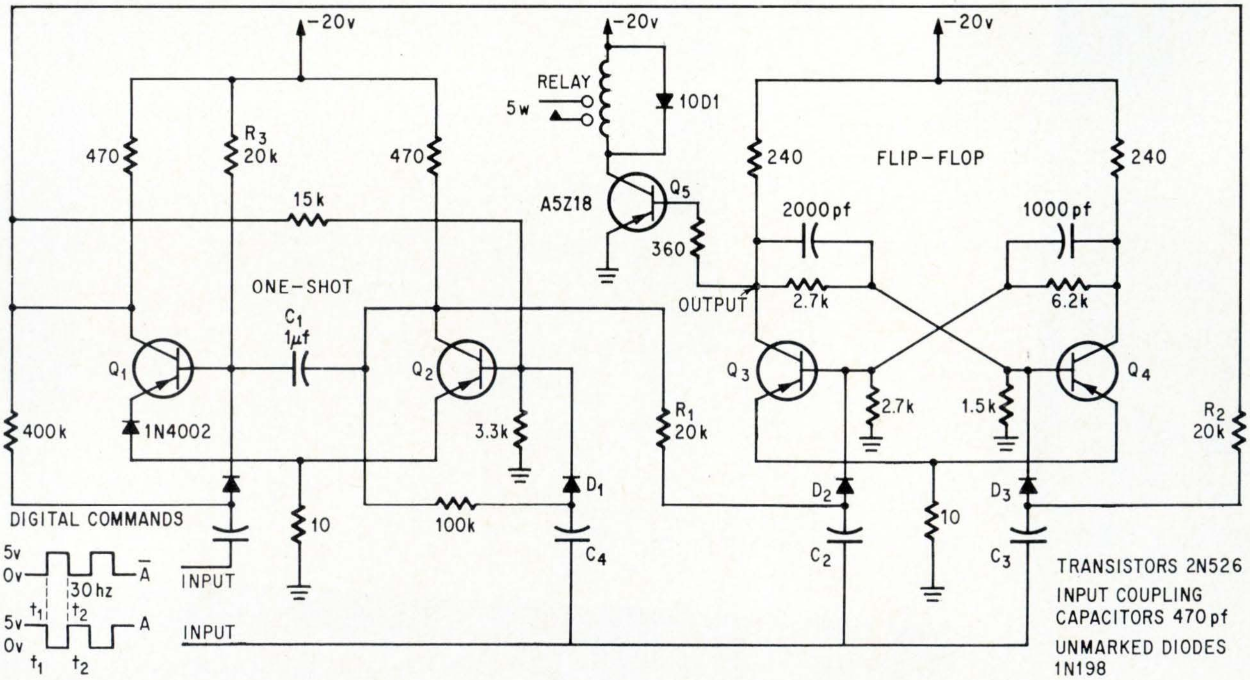
A digital decoder that fires a relay when commands exceed a given frequency can be built by timing the access to a flip-flop with a one-shot multivibrator. By comparing the duration of command pulses with the transition time of the one-shot, the circuit determines whether command frequencies are higher or lower than 30 hertz. Command pulses are steered to the relay side of the flip-flop, turning the relay on, whenever the command pulse's duration is shorter than the one-shot's transition time.

This system was designed to command contactors in a three-phase power inverter. The inverter supplies induction motors having a duty cycle of repeated high-torque start-ups and long operating periods at normal velocity. A 30-hertz digital command closes the relay and shorts some inverter voltage-dropping reactances to produce an output voltage proportional to the frequency. This system replaces the conventional frequency-proportional power supply.

The circuit's frequency precision of 1.5% also makes it attractive for digital decoding. Reducing the size of resistors R_1 and R_2 to shorten the time constants, R_1C_2 and R_2C_3, improves the precision.

When the one-shot is quiescent, transistor Q_1 is on, Q_2 is off, and timing capacitor C_1 is charged to −19 volts on the right side. The positive transition in $\overline{A}$ at time t_1 turns Q_1 off; the collector of Q_1 then travels to the negative supply causing Q_2 to turn on. With Q_2 on, the right side of C_1 is shorted to ground.

Since the charge on C_1 cannot change instantaneously, the voltage on the left side of C_1 rises to +20 volts. This positive charge is gradually decreased by the negative supply voltage through resistor R_3. When the voltage on the left side of capacitor C_1 reaches zero, transistor Q_1 turns on, Q_2 turns off, and the multivibrator returns to its



Operating sequence. Leading edge of $\overline{A}$ at t_1 triggers the one shot to start the timing. If the command pulse is short, Q_5 turns on and fires the relay.

quiescent state—Q_1 is on, Q_2 is off.

Although $\bar{A}$'s positive transition at t_1 triggers the one-shot, the negative step at t_1 in waveform A has no effect on the circuit. If command pulse duration is shorter than the one-shot's transition time, however, the relay fires at t_2 by the trailing edge of pulse $\bar{A}$. The trailing edge of $\bar{A}$ at t_2 does not affect the one-shot.

If the pulse duration is shorter than the one-shot's transition time, transistor Q_2 is conducting when the positive step in A occurs at t_2; the positive step turns off Q_3 through C_2 and D_2. With Q_3 off, the base of transistor Q_5 moves to the negative supply, turns on and actuates the relay by closing its contact.

The positive step in A at t_2 also turns off Q_2 through C_4 and D_1 to reset the one-shot. The cutoff of Q_2 does not prevent the positive step of the voltage that occurs at t_2 from turning off Q_3.

If a command pulse longer than the one-shot's transition time is now applied, the leading edge of pulse A at t_2 reaches the flip-flop after Q_2 is off and has back biased diode D_2. Hence, the positive step at t_2 is steered to the base of Q_4 and resets the flip-flop in the opposite direction by turning off Q_4. With Q_4 off, Q_3 turns on and grounds the base of Q_5 to open the relay.

The circuit requires both a command pulse and its complement to operate. With modification, the circuit can function without the complement of the command pulse. To accomplish this, D_1 is shorted and input A operates the circuit. In this case, the one-shot is initially triggered by the negative step in pulse A at t_1. However, the trailing edge of A at t_2 continues to operate the flip-flop and reset the one-shot.

Potentiometer turns flip-flop into an adjustable trigger

By David Schoon

Minneapolis

By placing a potentiometer at the input of a conventional flip-flop, a designer can construct a simple trigger circuit with adjustable hysteresis. The circuit is ideal for generating square pulses from sine waves or for providing a binary output from a transducer.

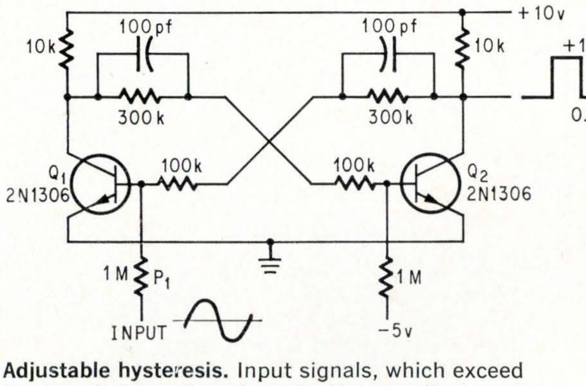
Potentiometer P_1 permits easy adjustment of the hysteresis; this feature is particularly useful where the desired hysteresis cannot be accurately ascertained until the trigger circuit has been installed in a piece of equipment. In one application, for example, a photocell produces a binary readout from punched paper tape; the cable between the photocell and the trigger circuit is unshielded so that a certain amount of 60-hertz hum is picked up. To prevent chatter in the trigger circuit as it changes state, a certain amount of hysteresis must be included. Since the amount of hysteresis needed varies with the background noise, the hysteresis setting differs for each application but may be quickly set by adjusting P_1.

When the circuit is generating square pulses from sine waves, potentiometer P_1 facilitates shifting of the triggering level to any desired point on the leading edge of the positive half-cycle of the sine.

Only two transistors, Q_1 and Q_2, are needed to generate a rectangular output pulse that travels approximately between ground potential and the supply voltage—an amplitude of nearly 10 volts in the circuit shown. A Schmitt trigger circuit, comparably biased, would require three transistors to produce a similar output pulse. In addition, the Schmitt circuit has a considerably more difficult hysteresis adjustment than the modified flip-flop.

However the circuit is somewhat less flexible than a Schmitt trigger in that it requires zero-level triggering signals and negative reset voltages with amplitudes equal to the input triggering level; these two constraints are satisfied when the input sine wave is centered about ground. The sine wave shown at the input of the circuit, for example, triggers output pulses during positive half cycles and resets the trigger circuit during negative half cycles.

When the input voltage is near ground, the



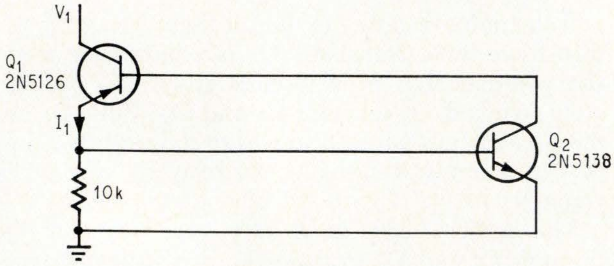
Adjustable hysteresis. Input signals, which exceed the threshold level set by potentiometer P_1, turn Q_1 on and Q_2 off, generating an output step.

circuit is in a stable state with either Q_1 or Q_2 saturated. As the input voltage rises above the preset threshold level (1 volt when P_1 is 100 kilohms), Q_1 turns on, Q_2 turns off and the output voltage rises to 10 volts. The circuit remains in this condition until the input voltage becomes sufficiently negative (—1 volt for P_1 at 100 kilohms) to pull Q_1 out of saturation. When Q_1 turns off, Q_2 turns on and drops the output voltage to 0.3 volt, completing the output pulse.

Transistor breakdown yields inexpensive thyristor trigger

By Robert B. Hood

Fairchild Semiconductor, Mountain View, Calif.



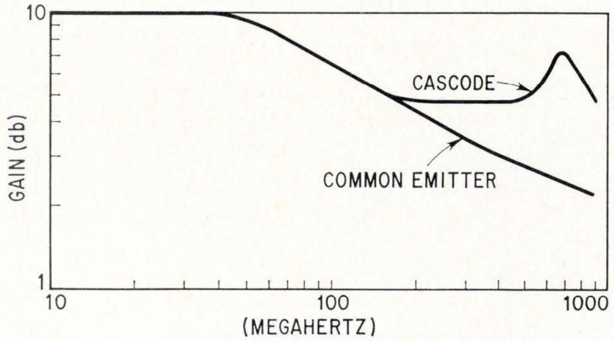
Triggering. Current I_1 flows in the direction indicated after the reverse-biased base-emitter junction of Q_1 breaks down.

An inexpensive trigger circuit utilizes the reverse breakdown characteristic of a transistor's emitter-base junction to accurately set the triggering level. The design, a simple combination of two transistors and a resistor, is particularly valuable as a thyristor gate-drive trigger in phase controls. The circuit offers good temperature stability, low saturation voltage, efficient energy transfer, and rapid switching.

As voltage V_1 is increased, the collector-base junction of transistor Q_1 becomes forward biased. This causes V_1, minus the collector-base forward drop, to appear across the reverse-biased base-emitter junction of Q_1. As V_1 is increased, a point is reached where the reverse-biased junction breaks down, and a current, I_1, flows (near 6 volts).

Transistor Q_2's base-emitter junction is then forward biased by I_1, and Q_2 begins to conduct. The collector current of Q_2 drives Q_1 into increased inverse conduction. The regenerative action thus initiated drives both transistors into saturation within less than 1 microsecond. The collector-emitter saturation voltage of Q_2 in series with the forward drop of Q_1's collector-base junction determines the new value of V_1.

In a typical thyristor gate drive, a capacitor charged to a predetermined level is discharged through a trigger element to the thyristor. If the trigger's energy transfer efficiency is high, lower-cost components can be used, and in some cases an amplifying state is not necessary. Also the efficiencies of most two-terminal triggers are limited by their high ON voltages. The low saturation voltage of the trigger results in increased efficiency.



Resonant peak. Unlike the single common-emitter stage, whose frequency response is fairly flat, the cascode amplifier has a resonant peak. A variable capacitor, C_1 controls peak position. When C_1 is increased, the resonance is shifted to a lower frequency and a higher amplitude. This circuit has an 18-db gain and a 550-Mhz bandwidth.

Emitter peaking pushes bandwidth to 500 Mhz

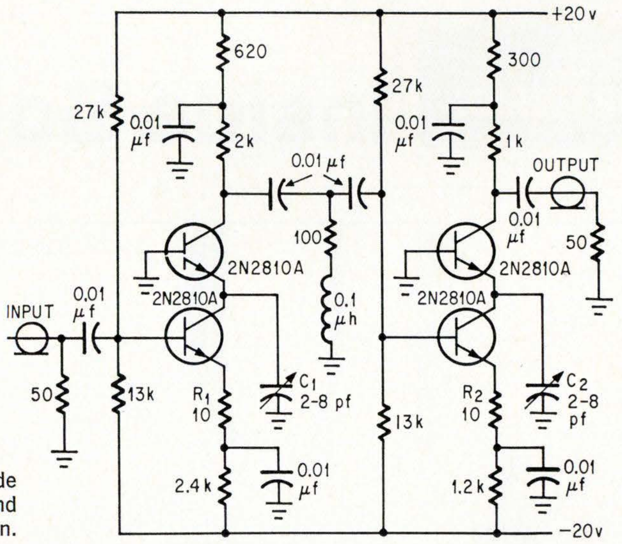
By H. T. McAleer

General Radio Co., Boston

Video amplifiers, operating at 500 megahertz, can be designed by adding variable capacitors to conventional cascode circuits.

A single common-emitter stage with 50-ohm input and output resistors has an initially flat response that falls off at the rate of about 6 decibels per octave at high frequencies. A cascode circuit, formed by adding a common-base transistor amplifier to the common emitter, also begins with a flat response, drops slightly at high frequencies, but reaches a peak before falling off rapidly.

The peaked response curve is due to an inductive component in the input impedance of the common-base stage. When this impedance is shunted by the output capacitance of the common-emitter amplifier, a resonant circuit is formed. Near the resonant frequency, more current enters the common-base stage than leaves the common emitter. This resonant rise in current compensates for the reduction in amplification of the common-emitter stage as the frequency increases.



Cascode circuit. Bandwidth of the two-stage cascode amplifier is adjusted by variable capacitor C_1 and C_2. Resistors R_1 and R_2 prevent oscillation.

Feedback loop stabilizes FET oscillator

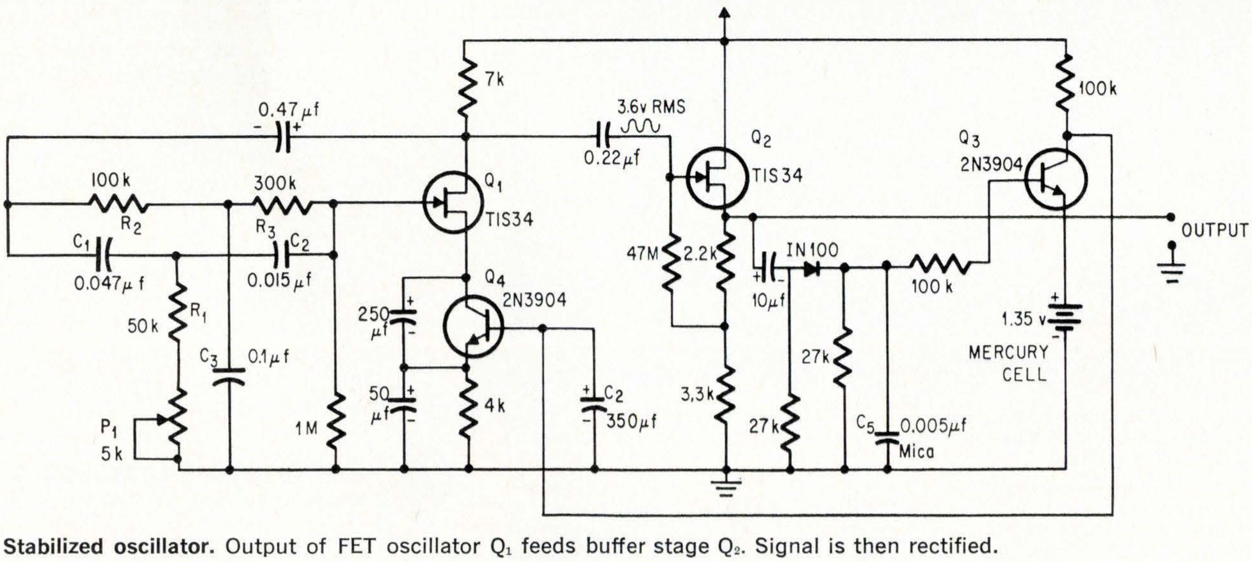
By Louis Mourlam Jr.

Institute for Atomic Research, Iowa State University, Ames, Iowa

Adding negative feedback to a field effect transistor oscillator is an effective way of getting good amplitude stability. The oscillator, which is applicable to frequencies in the low kilohertz range, consists of a FET connected to an unbalanced parallel-tee.

The 180° phase shift needed for oscillation is produced by the unbalanced tee network, formed by P_1, R_1, R_2, and R_3, and capacitors C_1, C_2, and C_3. Potentiometer P_1 allows for small variations in frequency about a center value. The low-frequency output of Q_1 is fed to buffer FET Q_2 and then rectified to charge integrating capacitor C_5. The voltage across C_5, proportional to the amplitude of the oscillations, is compared to a stable d-c reference voltage (1.35-v mercury cell) in the difference amplifier Q_3. Any resulting error signal is then applied to the base of transistor Q_4, varying the bias of Q_1 and compensating for the variation in amplitude.

The oscillator is stable to a few parts in 10^4, with virtually constant output amplitude. For the values shown, oscillation occurs at 33 hertz.

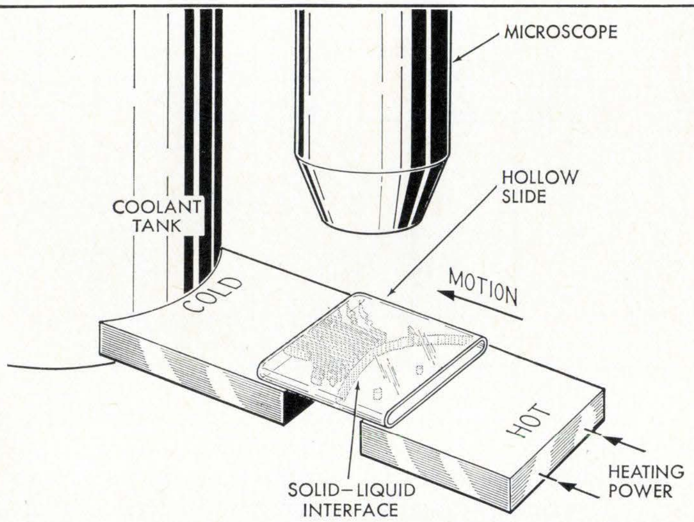


Stabilized oscillator. Output of FET oscillator Q_1 feeds buffer stage Q_2. Signal is then rectified.

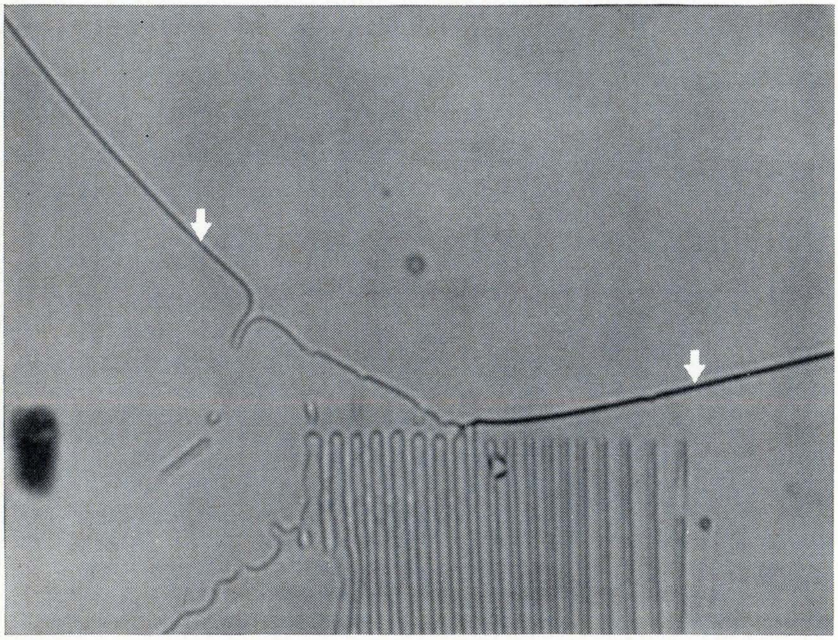
Report from

BELL LABORATORIES

Inside Solidifying Metals



Experimental setup in which photographs such as that below were taken. The glass slide or cell—containing a liquid which freezes like a metal—is placed between hot and cold blocks of brass. This produces a temperature difference along the slide. A solid-liquid interface then forms between the two blocks. By moving the slide toward the cold block at a constant rate, one can observe the steady growth of the crystal under the microscope.



Bell Laboratories' model (200x) permits physical simulation of a eutectic phase diagram for an alloy such as lead-tin. Diagram relates liquid proportions (horizontal scale) to temperature (vertical).

Two different liquids were put into a single slide . . . hexachloroethane on the left and carbon tetrabromide on the right. After a brief period, the liquids formed a graded mixture, from 100% of one at the left to 100% of the other at the right. The mixture was partially frozen, then photographed with the slide stationary. The solid-liquid interface (arrows) then showed the freezing point for every possible composition.

The "grid" under the solid-liquid interface is made up of alternate solid layers of the two chemicals (the eutectic region).

At Bell Telephone Laboratories, metallurgist Kenneth A. Jackson has devised transparent models of solidifying molten metals. With these models, we can now study what happens inside a metal as it freezes. This gives us a tool which promises to improve existing alloys and will perhaps help us find new and better ones.

The models are hollow microscope slides (diagram) containing such organic liquids as camphor or carbon tetrabromide. These compounds are among the few transparent substances whose molecules freeze without having to rotate into a specific orientation. Metal atoms act the same way, hence the similarity in freezing behavior.

Various modes of metal-crystal growth—planar, dendritic (tree-like branching) and cellular—have been studied in detail with this technique. Also, the solidification of alloys has been simulated (photo). To do this, liquids with freezing characteristics corresponding to those of two metals are mixed and cooled. With this procedure, Jackson and J. D. Hunt (now at the University of Oxford) observed, for the first time, the process by which the "equiaxed" zone forms in alloy castings. This is a zone of relatively small crystals, usually found in the center of an alloy casting. The new technique shows that the equiaxed zone results from "branches" melted from dendritic crystals. As the alloy cools, freezing begins at the outer surface, producing dendrites which project inward toward the hotter, liquid center. Branches, melted from these growing dendrites, are carried to the center of the casting to form the crystals of the equiaxed zone.

Until now, the only methods for studying metal freezing were laborious . . . cutting, polishing and etching, for instance. The new technique is not only simpler but also reveals hitherto unknown details of crystal growth.

Paramatrix puts digital computer in analog picture, and vice versa

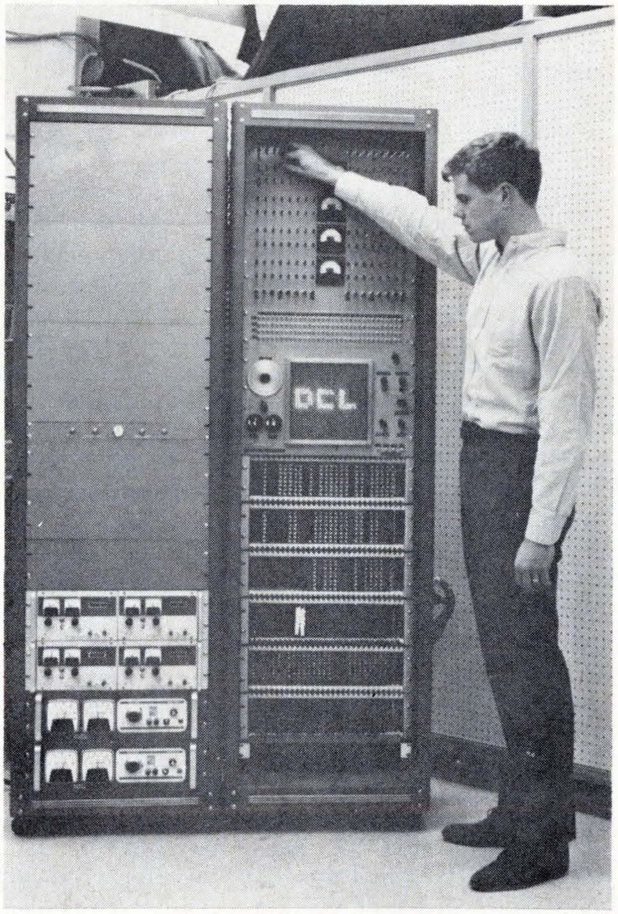
Prototype system uses digitally controlled analog circuits to handle preliminary transformation of graphic patterns cheaply and quickly

By W.J. Poppelbaum, Michael Faiman, and Edward Carr
Digital Computer Laboratory, University of Illinois, Urbana

A good interpreter can save a digital computer a lot of time in dealings with the analog world outside. With a foot in both worlds, digitally controlled analog circuits can do the job quickly and fluently. They can process and convert analog signals while the computer concentrates on its prime task—analyzing graphic patterns or making calculations. The hybrid circuits perform simple operations at great speed, and—with fewer components—they're cheaper than their digital equivalents.

Analog-digital gates and comparators are used in a prototype system designed to preprocess analog information—primarily graphs and pictures —while converting it into digital signals. The system, called the Paramatrix, can handle pictures of different sizes and orientations, reshaping them, displaying them on a grid, and transmitting them in digital form to the computer along a single wire. It does this under computer control but without using the time or memory the computer would need.

The Paramatrix can enlarge or shrink a picture, move it around, or rotate it. It can even make such corrections as filling in blurs or gaps. All this frees the computer to concentrate on analyzing what it sees in the picture. If the computer has to translate a line of handwritten letters or determine the content of a bubble-chamber photo, its job is eased if the picture is first juggled into a standard configuration.

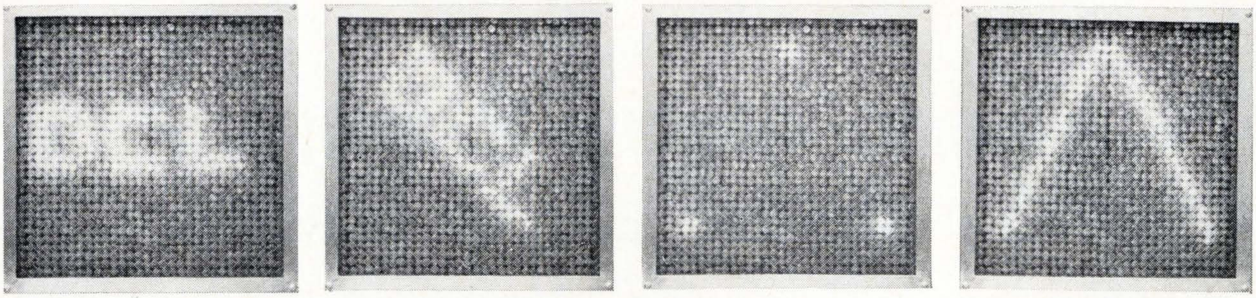


Prototype Paramatrix. Unit fits in half a rack, because it uses only about 50 printed circuit cards for its major functions, and another 68 cards for the display matrix flip-flops and drivers. The other half of the rack contains the input simulator. The second rack here contains power supplies shared by the Paramatrix with other projects in the laboratory.

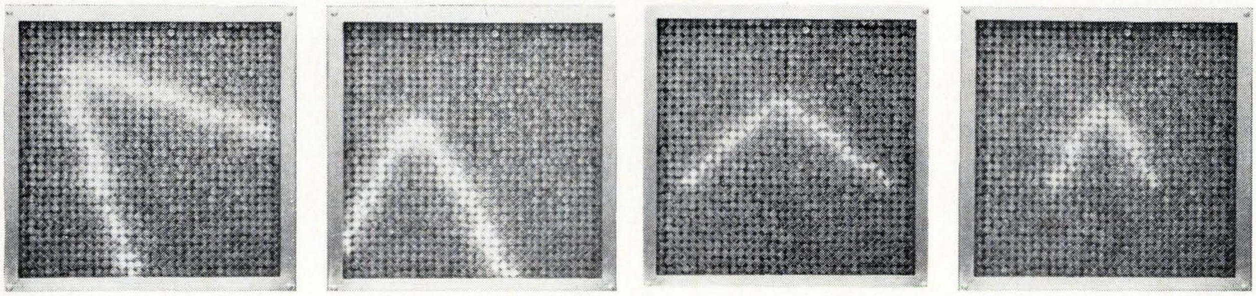
Interface

The Paramatrix is essentially an interface between the picture and the digital computer. Its operations are basically nonmathematical, although they can be conveniently expressed in mathematical

Paramatrix juggles images



Alphanumeric display. Normal and rotated positions are at left. Other photos show how Paramatrix can fill in large gaps in an input picture.



Translation, rotation, demagnification. These can be done in one or both coordinates.

form. Where a large digital computer would execute six multiplications and four additions—one at a time—and take 15, 20 or more microseconds to do it, the Paramatrix can perform the equivalent operation in 2 μsec.

Furthermore, the computer needs great blocks of memory and much programing effort to produce an accuracy far greater than the simple preliminary operations demand. The accuracy of the Paramatrix is a few percent, about the same as that of most devices that receive and transmit pictorial information. Such devices—optical sensors, electronic display tubes, and the human eye, for example—can easily tolerate small departures from perfect straightness or roundness.

The prototype Paramatrix hasn't yet been connected on-line to a computer, nor does it scan real graphic inputs. But it does demonstrate that graphical data can be processed by hybrid digital-analog circuitry, and its principles have already been successfully applied in an automatic drafting project called Artrix.

Connections between the Paramatrix and a computer would be few and simple. The system's output, a processed picture in digital form, can go into a computer along a single wire. The computer can issue the five parameters of translation, magnification, and rotation through a digital-to-analog converter, and can easily supply commands for simple corrections.

These are the basic connections, but others could be made to attain a higher degree of sophistication. The computer, for example, could specify four numbers that define a smaller-than-normal area of the input picture for processing.

An input simulator is attached to the prototype in place of a mechanism to scan real graphic inputs. This unit produces an arbitrarily modifiable set of signals resembling those a scanner would generate from a picture. A device to scan photographic slides is now being built to replace the simulator.

The Paramatrix is built from discrete components mounted on printed circuit boards, though it could easily have been built from integrated circuits. However, the University of Illinois has no IC facility of its own, and found it impractical to have custom-designed circuits built by an outside manufacturer at this development stage.

Fundamental scan

The fundamental scan in the system is the output scan; that is, the output picture is always scanned in the same way and the corresponding input scan is generated by means of the inverse coordinate transformation (translation, rotation, or enlargement). If the input scan were fundamental, some combination of transformations might create an output scan outside the permissible range. The inverse transformation is possible because the coordinate transformation between a pair of points in the input and the output scans is always on a one-to-one basis.

The decoded outputs of two digital counters are converted to analog voltages that increase step by step over a specified range. The variation in one of these voltages corresponds to a sweep from bottom to top of the output picture, and the other to a left-to-right sweep. Thus the Paramatrix scan covers its output display point by point and line by line in the same fashion as a raster scan on a cathode-ray tube, except that in the new system the lines are vertical. For each point on the output scan, the system locates the corresponding point on the input picture, taking into account the specified translation, magnification, and rotation. If the input point is a point of interest in the picture, as opposed to part of the background, the output point lights up and a signal is transmitted to the computer. In this way, the input picture is reproduced with the specified transformations on the output display.

The analog raster in the Paramatrix is an array of 32 by 32 points. The two analog voltages sweep this array in steps of 0.5 volts over a a total range of 16 volts. The operating range in the Paramatrix is 20 volts; the 2-volt margin at each end of the sweep permits out-of-range detection.

The circuits are accurate to within 0.3% over the analog range of —10 to +10 volts, and their frequency range is d-c to 1 megahertz square-wave. Raster size and resolution could be made greater with more refined circuits and wider ranges, but these values are adequate for the prototype.

The display—a 32-by-32 array of light bulbs driven by inexpensive flip-flops—serves as a visual monitor of the output and makes the Paramatrix a self-contained system. Other types of displays will probably be developed as the Paramatrix evolves; these might use cathode-ray tubes or electroluminescent panels, for example.

Analog process

Three operations are needed to transform a point on the input picture that has the rectangular coordinates (X, Y). First the coordinate origin is translated a units left or right and b units up or down; the X and Y scales are then multiplied by factors m and n, respectively; finally the point is rotated counter-clockwise about the new origin by an angle, θ.

All this gives the point output coordinates (x, y), which are related to the input coordinates (X, Y) by the equations:

$$x = m\,(X - a)\cos\theta + n\,(Y - b)\sin\theta$$

$$y = -m\,(X - a)\sin\theta + n\,(Y - b)\cos\theta$$

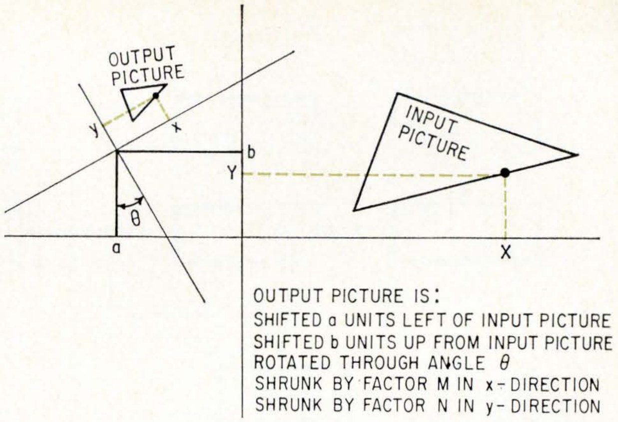
Parameters a, b, m, n, and θ can be specified by the computer or dialed on five potentiometers.

The Paramatrix actually uses the inverse transformation. It scans its output field in successive steps whose digital coordinates are (0,0), (0,1), (0,2), . . . (0,31), (1,0), (1,1), . . . (31,30), (31,31). Each pair of coordinates corresponds to a pair of analog voltages; coordinate 0 corresponds to —7.5 volts, 1 to —7 volts, 2 to —6.5 volts, and so on in half-volt steps up to +8 volts.

At each point in the output field, the system generates the inverse analog coordinates:

$$X = \frac{1}{m}\,(x\cos\theta - y\sin\theta) + a$$

$$Y = \frac{1}{n}\,(x\sin\theta + y\cos\theta) + b$$



Shifting output picture. Limits on horizontal and vertical movement are those of the scan; angle of rotation is unlimited. The size can be increased or decreased. The transformation equations are derived from the quantities in this diagram.

The input picture simulator specifies up to 128 points—four on each of 32 uniformly spaced abscissae—also in the form of analog voltages in the range —7.5 to +8 volts. At each step in the scan, the Paramatrix compares the coordinates with the four specified points. If they agree, a digital signal is sent to the computer and another signal lights the bulb in the corresponding position in the display.

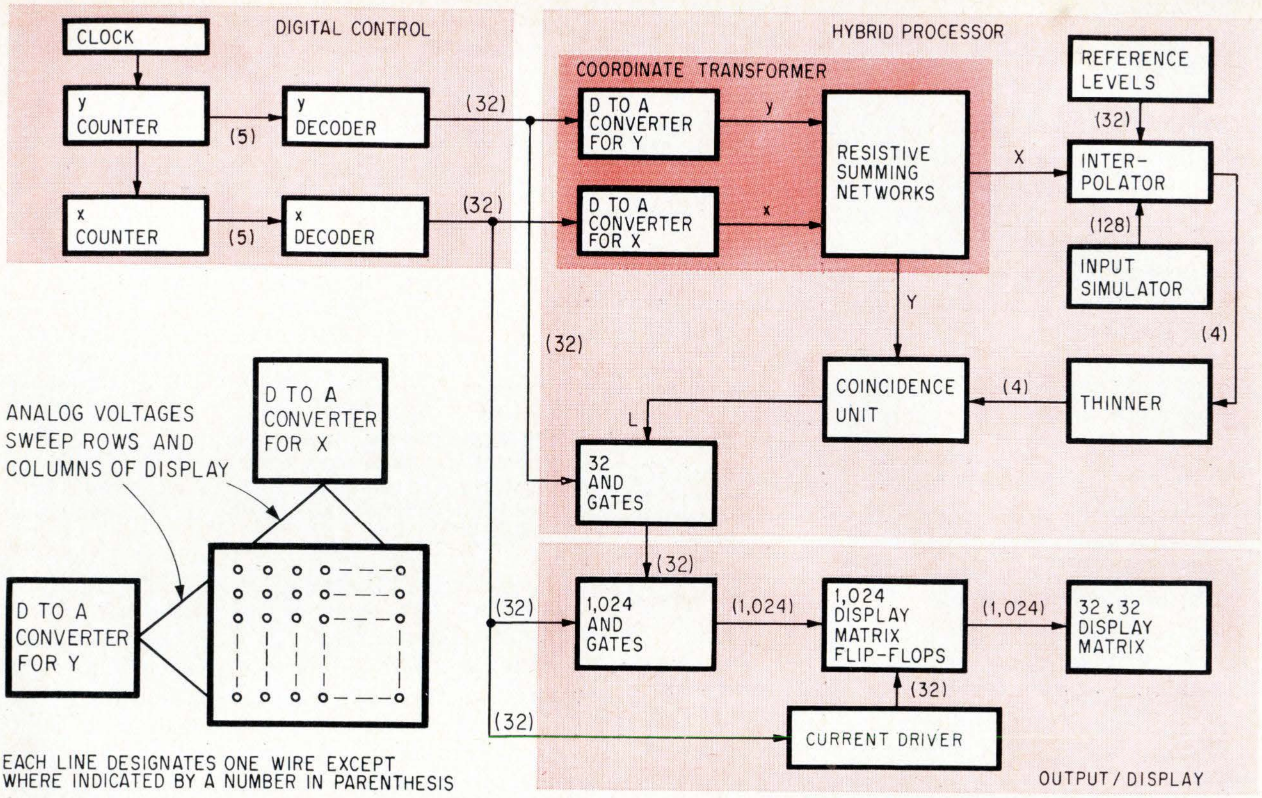
The major subsystems in the Paramatrix are a digital control, a hybrid processor, and an output/display unit as shown in the block diagram on the next page.

Coordinates are specified digitally at any given instant by the contents of the clock-driven y- and x-counters. The decoded outputs of these counters drive the coordinate transformer, which also has the parameters a, b, m, n, and θ as inputs. The transformer in turn generates the new X and Y coordinates that specify the corresponding point in the input scan.

Splitting the difference

For each X-coordinate generated by the transformer, the corresponding Y-coordinates are generated from the input picture (the input simulator in the Paramatrix prototype) and compared with the successive Y-coordinates from the transformer. The interpolator—a set of comparator circuits and summing networks—selects "best" values for the Y-coordinates in those cases when the X-coordinate doesn't exactly match one of the 32 reference levels. The technique followed is the simplest possible. If one of the transformed X-coordinates falls between two successive reference levels, a set of interpolated Y-coordinates is generated halfway between the specified Y-coordinates for comparison with the transformed Y-coordinates.

For example, the input simulator could specify (8,3), (8,7), (8,17), and (8,25) as the four input points for the coordinate X = 8, and (9,5), (9,8), (9,15), and (9,22) for X = 9. Suppose the transformed X-coordinate comes out to be 8½. The four input points corresponding to this coordinate



Three major parts. The Paramatrix sections are lightly tinted. The heavier tint indicates the coordinate transformer, which generates the input coordinates in response to an output scan by the digital control section.

are generated by the interpolator as (8½,4), (8½,7½), (8½,16), and (8½,23½); the new Y-coordinates are halfway between the specified values for X = 8 and X = 9.

The thinner compares the magnitudes of the four interpolated Y-coordinates. If two or more of these are essentially the same, the redundant voltages are suppressed and the thinner's outputs go to the coincidence units, where a comparison is made of the transformed Y-coordinate and the interpolated and thinned input Y-coordinate.

If the coincidence unit records an agreement between the transformed Y-coordinate and any one or more of the input Y-coordinates, it generates a signal (L in the block diagram) that gates the corresponding flip-flop in the display and, in an on-line system, notifies the computer.

The operation and speed of the Paramatrix are illustrated in the oscilloscope photographs on the opposite page. When these photos were made, the Paramatrix clock was running at 0.5 megahertz, processing one point every 2 μsec and one complete picture about every 2 milliseconds.

In the first two photos, the staircase waveform is the X-coordinate produced by the transformer viewed over one complete picture scan. The Y-coordinate scans the entire picture top to bottom in each step. Beneath the X-coordinate waveform is one of the four outputs of the interpolator, steady at −10 volts except during one step near the center when it rises to −5 volts to indicate equality between the X-coordinate and one of the reference levels. The first two photographs show the same thing except that the sensitivity of the comparator circuits in the interpolator has been decreased in the second photo so that the coincidence is registered over three adjacent steps.

The third and fourth photos show the Y-coordinate staircase waveform on an expanded time scale in the same situation. The lower trace in the third photo is the same as in the first photo. The fourth trace down is the output of the coincidence unit, and a signal that turns on the lamp is at the left.

Subsystem design

The clock has a frequency that is adjustable from 100 kilohertz to 1 Mhz and a mark-space ratio variable from 1 to 10. It has an additional output, inverted and delayed 0.6 μsec, to provide a strobe for the counters and decoders.

The counters are conventional and made of NOR circuits. The y-counter continuously goes from 0 to 31, generating a pulse on return to 0 that steps the x-counter, an identical circuit that operates at $\frac{1}{32}$ the speed.

The decoders are also of conventional design, being built of OR circuits. They decode the five outputs from the counters into 32 lines, only one of which can carry a signal at a time.

The transformer generates the input coordinates corresponding to the coordinates of the output point under examination as defined by the inverse transformation equations.

The inverse transform is done in three steps.

First the analog voltages associated with the 64 digital outputs of the decoders are generated in the digital-to-analog converters, which gate voltages from a resistor chain, as at the top of the next page. The diamond-shaped symbol represents a digitally controlled analog gate, or diamond gate; its output is the same as its input when its digital control signal is a 1.

If the resistors labeled R are all equal, and the two supply voltages are +8 and −8, the voltages at the points V_0 through V_{31} assume the values −7.5 to +8 volts in 0.5-volt increments. These are the analog voltages corresponding to the x and y coordinates. Thus, when the x decoder output signal to any one diamond gate is a 1, the x output of the converter is the analog voltage corresponding to a specific abscissa on the matrix. Similarly, the y output corresponds to ordinates.

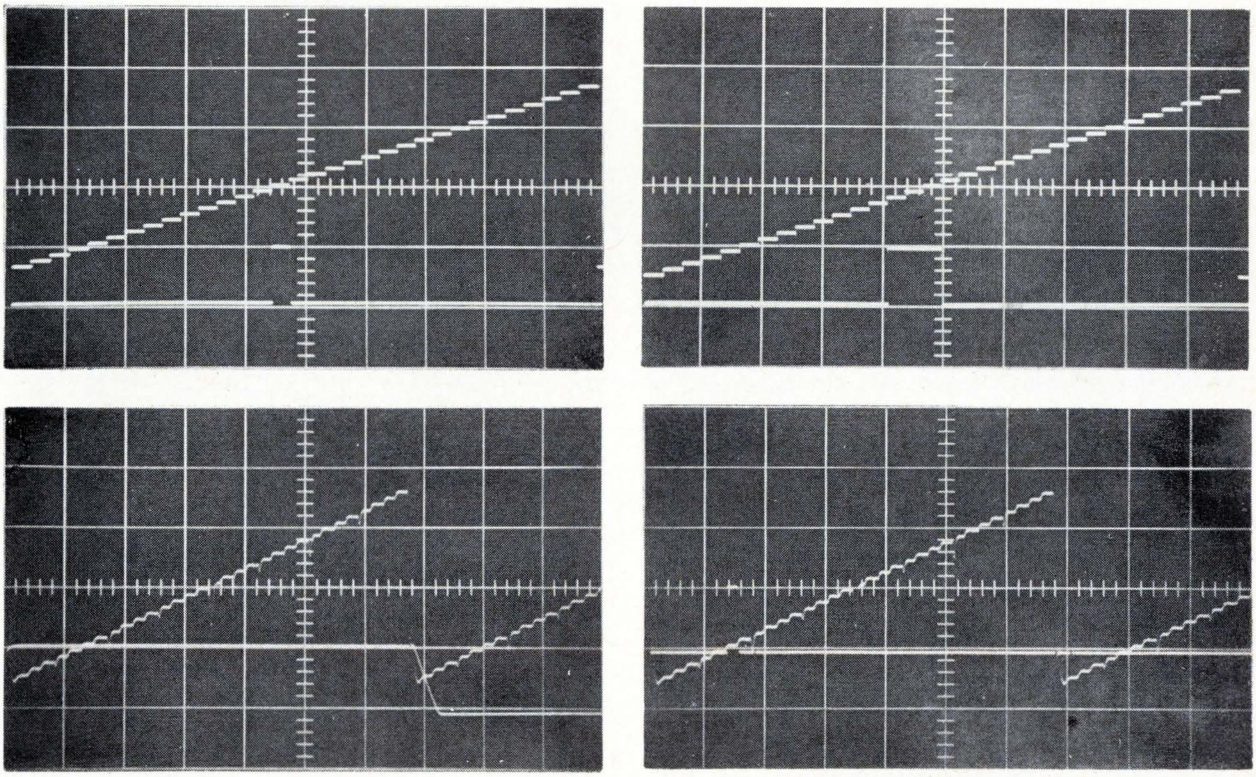
In the coordinate transformer, the outputs of a sine-cosine potentiometer replace +V and −V, and the output of the resistor chain becomes the desired rotational term for the inverse transformation. The sine-cosine potentiometer has four wipers 90° apart and capable of continuous rotation around a wire-wound resistance whose windings are proportional to the sine and cosine curves. The diamond gates that generate the two cosine terms are in the same order, but those that generate the two sine terms are reversed with respect to each other.

Thinning out equality

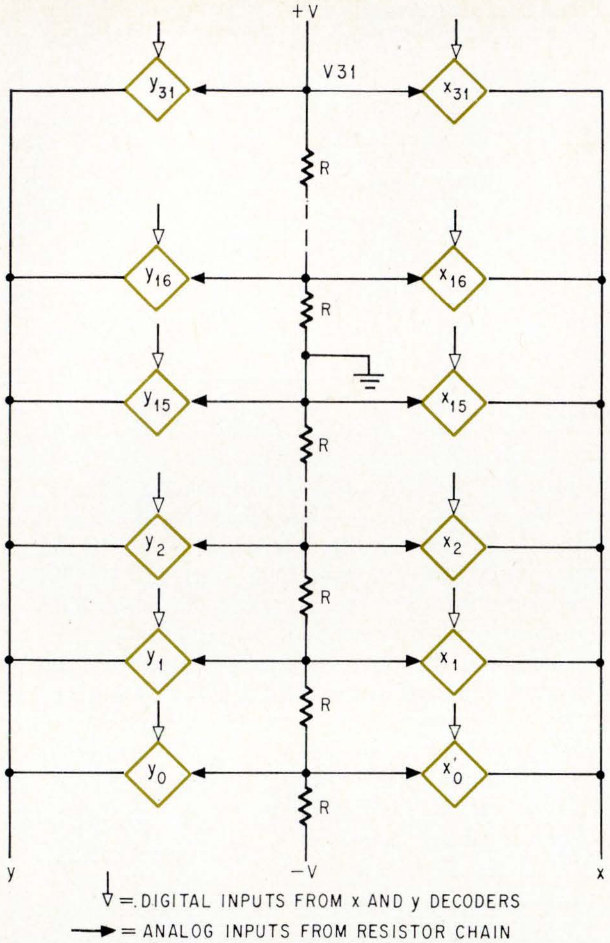
Comparator outputs			Thinner outputs			
F1=F2	F2=F3	F3=F4	F1	F2	F3	F4
NO	NO	NO	F1	F2	F3	F4
NO	NO	YES	F1	F2	F3	float
NO	YES	NO	F1	F2	float	F4
NO	YES	YES	F1	F2	float	float
YES	NO	NO	F1	float	F3	F4
YES	NO	YES	F1	float	F3	float
YES	YES	NO	F1	float	float	F4
YES	YES	YES	F1	float	float	float

The sine terms in the transformation equations have opposite signs, and the reversed order eliminates the need to subtract the analog signals.

The second step in transforming is to add the outputs of the resistor chains in pairs, in accordance with the parenthetical part of the inverse transformation equations, using the resistive summing network at the left in the diagram at the top of page 105. Because the current amplifiers on the inputs to the summing network act as buffers, the resistor network need provide only very small currents. These amplifiers can generate up to 10 milliamperes positive or negative current, and their output is within 50 millivolts of their input over the entire range of −10 to +10 volts. The



Speed of the Paramatrix. In the two upper oscilloscope traces, the staircase waveforms are of the X-coordinate output from the transformer, viewed over one complete picture scan of about 2 milliseconds. The lower traces in the upper photographs show one of the interpolator outputs, with a fine sensitivity setting in the photo at left and coarse sensitivity at right. The two lower photographs are of the Y-coordinate output on an expanded time scale; the entire staircase takes as much time as one step in the upper photos. The lower traces in the lower photograps show the interpolator output again (left) and the output of the coincidence unit. Note the pulse at left.



Digital-to-analog converter. Diamond gates (color) convert each of the x and y input coordinates from the digital decoder into an analog voltage.

variable summing resistors vary the coordinate voltage according to the terms 1/m and 1/n, and compensate for gain in the voltage amplifiers and for attenuation in the summing networks.

In the third step, the terms a and b in the equations are added. The terms cover vertical or horizontal movement of the picture and voltage swings compatible with the system. The resistive summing networks, at the right in the diagram at the top of the opposite page, add these terms, which are generated by two potentiometers.

The voltage amplifier has a high input impedance and supplies 10 ma over the entire output range. Its gain is 20, and this remains constant over the frequency range.

Four potentiometers for each of the 32 columns of the matrix set the voltage levels in the range −7.5 to +8 volts to specify the 128 points in the input simulator.

Matchup

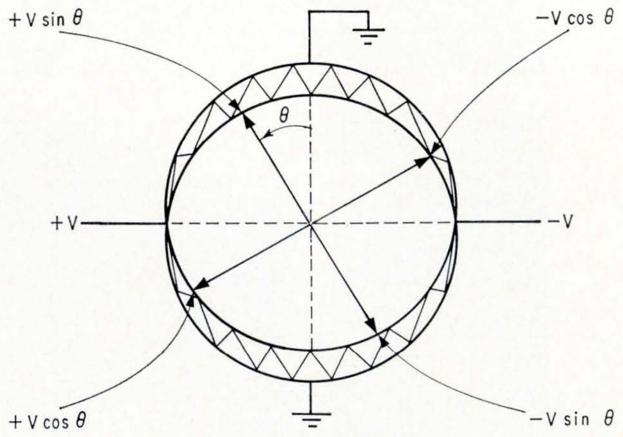
The input to the interpolator is the X-coordinate output of the coordinate transformer. It is compared with the 32 voltage reference levels, each corresponding to one column of the input picture. When the transformer signal equals a particular reference level, the corresponding comparator (one of the hexagonal blocks on page 106) puts out a 1 that opens the four associated diamond gates, thus transferring the four simulated input signals for that abscissa to the resistive summing network, and generating the four input Y-coordinates.

If the transformer signal falls between two reference levels, the two nearest comparators produce a 1; two sets of diamond gates open, and the summing network does the interpolating.

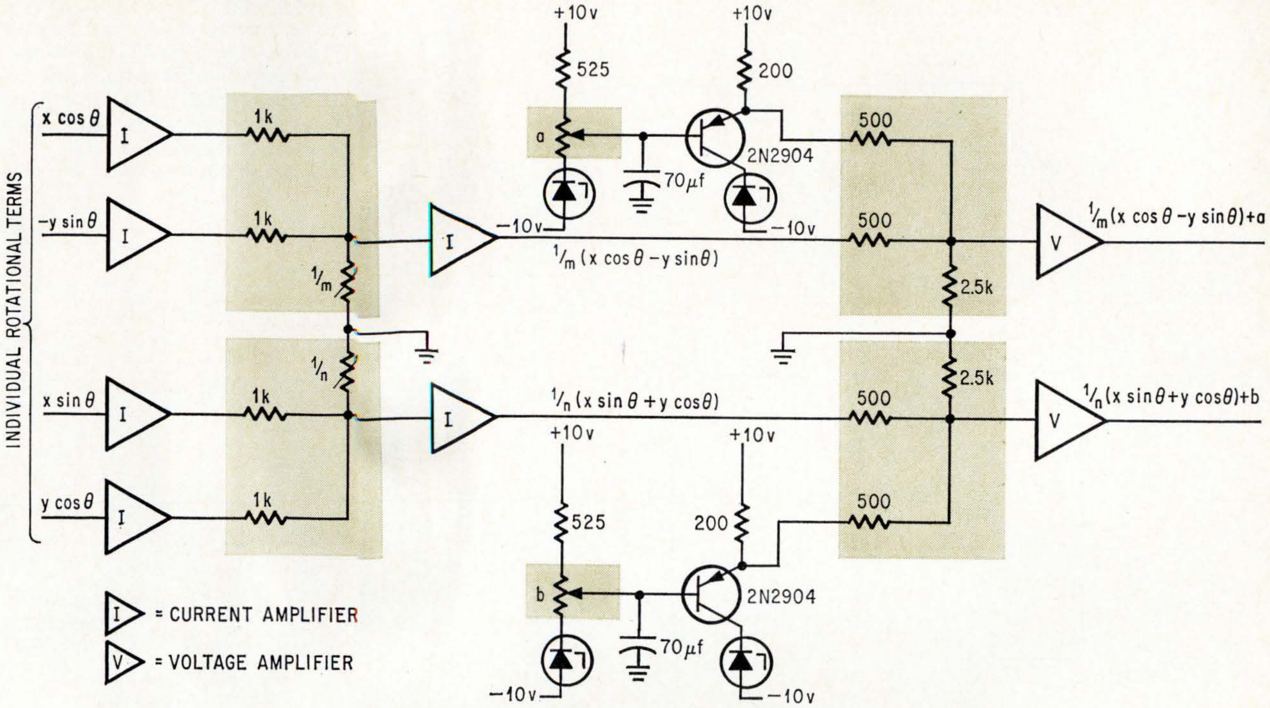
The comparator circuit's sensitivity may be varied between 0.2 volt and 2 volts, so that the transformer signal can be compared with as many as nine reference levels or with none. The adjustment permits the smoothing of jagged sections in an input picture. The comparator outputs gate four times their number of potentiometer voltages into the resistive summing network, which produces the average of each group. All four ordinates are produced simultaneously for each abscissa.

Thinning can occur only if the four interpolated Y-coordinates, labeled F_1, F_2, F_3, and F_4, increase in magnitude in that order. With this restricted ordering, the thinner needs only three analog comparators, not six, and the comparator output gating is simpler. These outputs are 1 if the inputs are equal within some established tolerance. The thinner's outputs appear at the common point of a resistive summing network, as shown at the top of page 107. If no two outputs are equal, the thinned outputs are the same as the inputs; where equality occurs, the smaller-numbered output carries the signal and the other floats electrically.

The table on page 103 shows the thinner's outputs for all possible equality combinations from the interpolator. Each output is actually the average of the various equal inputs; this is usually about the same as one of the equal inputs, but the sensi-



Rotation. A sine-cosine potentiometer connected to the power terminals of a network of diamond gates (color) enables the gates to generate analog signals that match the rotation angle of the potentiometer.



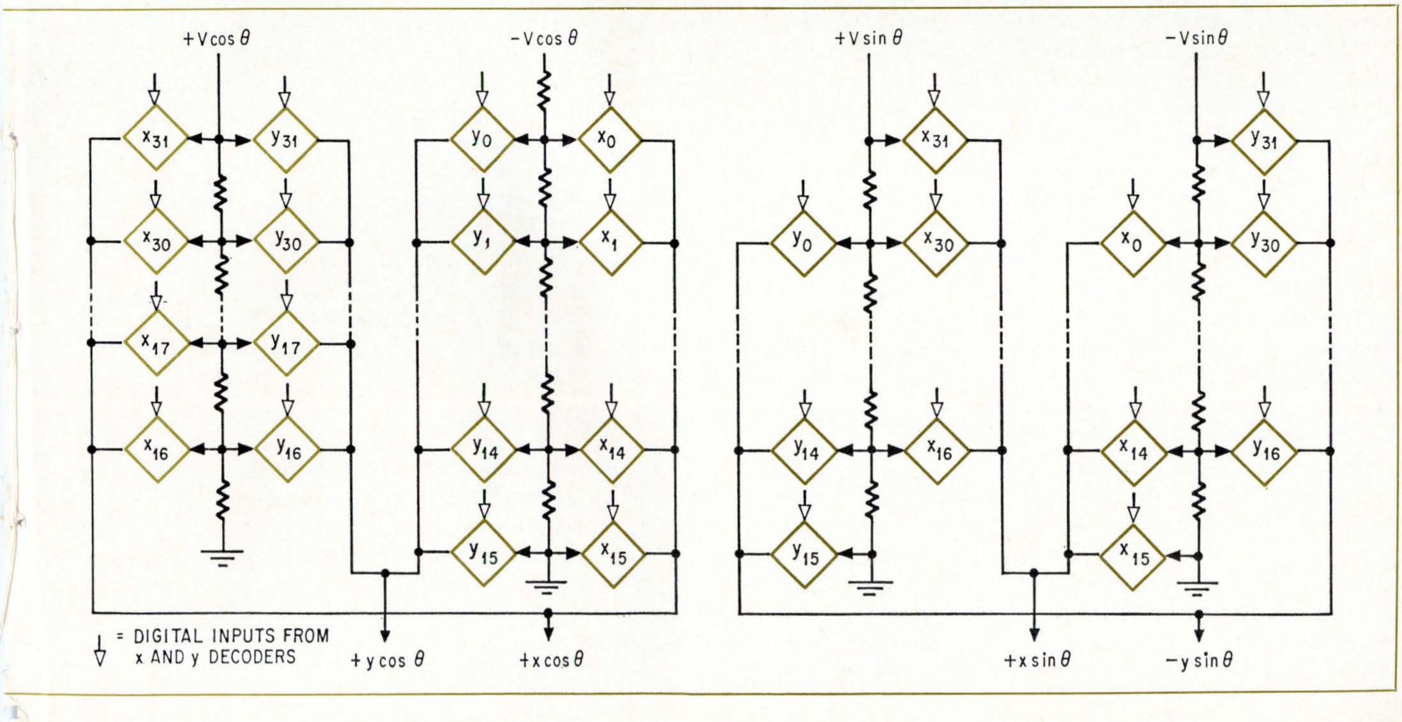
Adder. Resistive summing network (tinted at left) adds up the rotational terms and supplies the factors for magnifying or demagnifying the picture. Current amplifiers isolate the network from the preceding diamond-gate terminals. Translation terms are added by the second-stage summing network at right. Voltage amplifiers at the output boost the signal to sufficient strength for the interpolator and coincidence unit, and the potentiometer circuit provides the translation terms to the second-stage summing network.

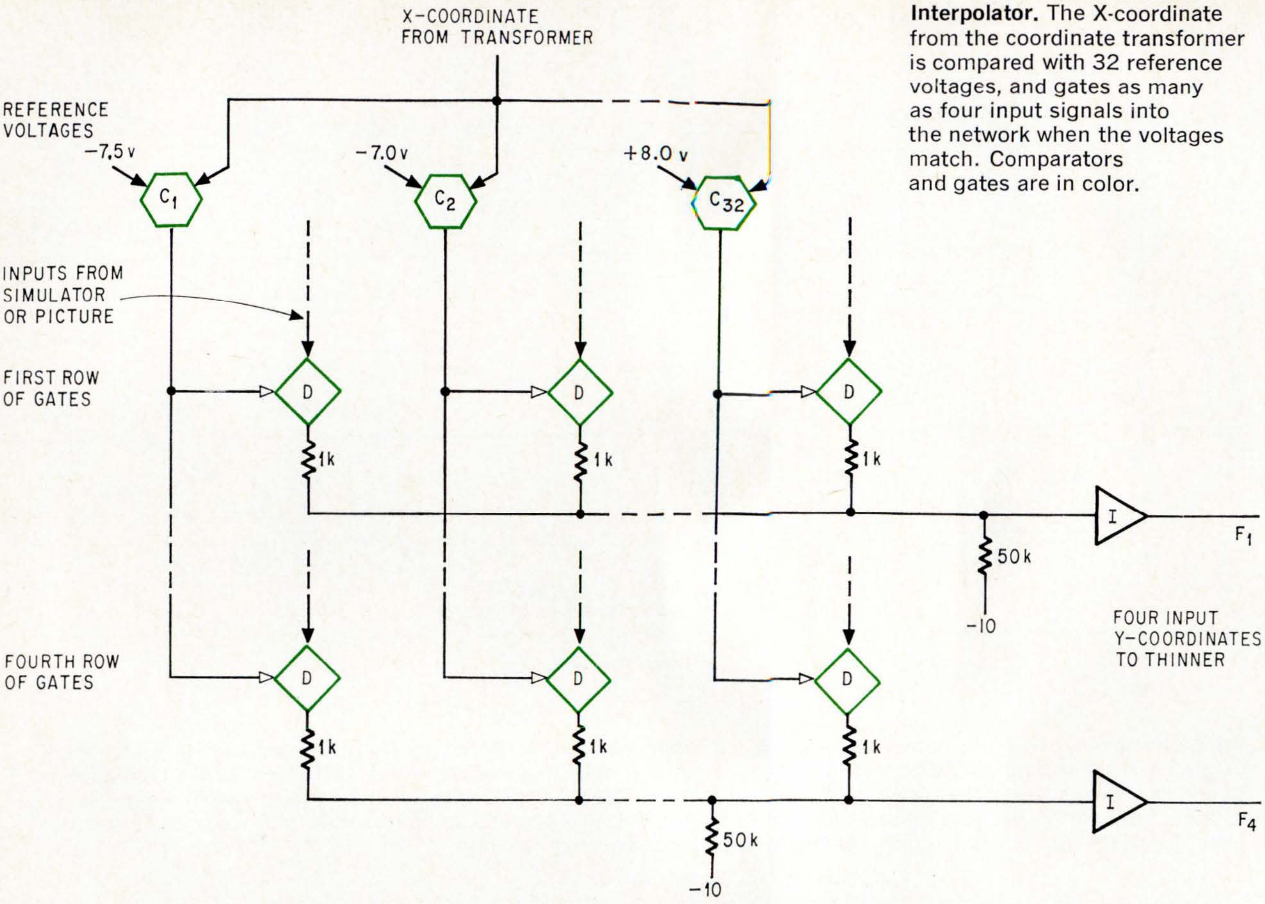
tivity setting may cause a small variation.

The inputs to the coincidence unit are the four outputs from the thinner and the Y-coordinate output of the transformer; the Y-coordinate is common to all the comparator circuits. The coincidence unit's comparators determine if any of the thinner outputs are equal to the transformed Y-coordinate. If one or more are equal, and if the Y-coordinate is within the limits of —7.5 to +8 volts as determined by the out-of-range indicator, the unit generates a signal to light a lamp.

Gates

Two types of diamond gates are used in the Paramatrix, both based on the principal of bypass gating. The type used everywhere in the system





Interpolator. The X-coordinate from the coordinate transformer is compared with 32 reference voltages, and gates as many as four input signals into the network when the voltages match. Comparators and gates are in color.

except the interpolator has a single digital control input. An AND circuit controls the bypass action in the other type, which gates the potentiometer voltages in the interpolator to shut off an unused input.

When the signal at A is at ground potential in the first type of diamond gate, bottom of page 107 in black, the potential at point B is 13 volts and the emitter-base junction of Q_1 is reverse biased. Under these conditions, point C is about 10.7 volts and a current of about 15 milliamperes flows through the bridge diodes. If current is flowing in the bridge, point D is about 0.7 volt—the drop across the diode—above V_{in}. If the diode drops and the d-c gain of Q_2 and Q_3 are matched, point D is also 0.7 volt above V_{out}. Thus V_{out} follows V_{in} with an accuracy of 11 millivolts per milliampere up to 9 ma of input-output current.

The diamond gate is turned off when point A goes to −5 volts; this reduces the voltage at point B to 8 volts and turns on Q_1. Now point C drops to about 8.7 volts, and this reverse biases the emitter-base junction of Q_2 and diverts the bridge current around the gate through Q_1.

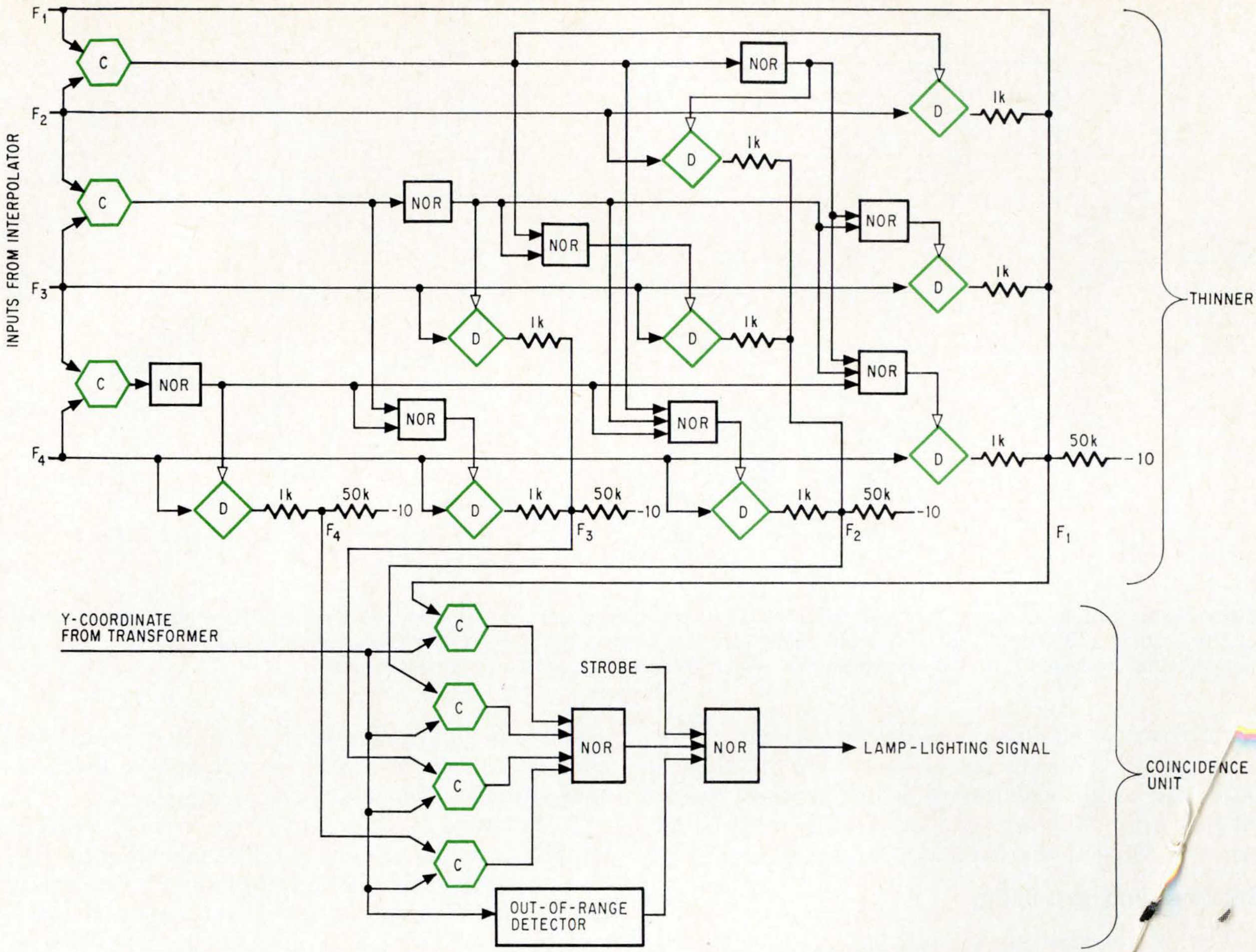
The second type of diamond gate is made from the first by adding the parts shown in color in the diagram. Both points A and A′ must be at ground to turn on the gate. If, for instance, point A is at ground and A′ is at −5 volts, point B will be at 13 volts and B′ at 8 volts. Q_2 is then on, and point C is approximately at +9 volts, which, as noted before, turns off the bridge circuit. The diodes in the emitters of Q_1 and Q_2 prevent damaging reverse currents.

The analog comparator is simply a difference amplifier. The sensitivity, varied from 0.2 to 2 volts, is controlled by the adjustment at S, which essentially is a variable voltage supply common to all comparators in a particular subsystem.

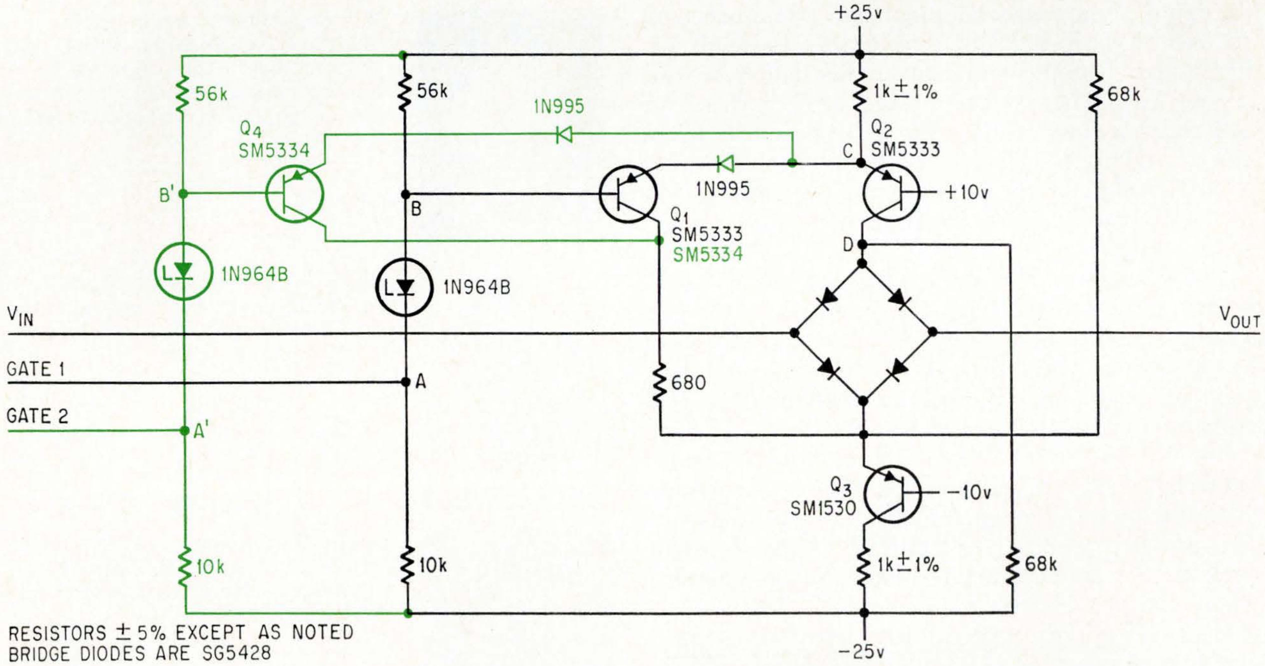
If both inputs are equal within the desired tolerance, transistors Q_1 and Q_2 are conducting equal amounts of currents, Q_3 is cut off, and Q_4 is conducting. The output is near ground—in this case, the binary 1 level. Now if the input to Q_1 rises substantially above that to Q_2, Q_1 conducts more heavily and its collector voltage decreases. Because the total amount of current is held constant by transistor Q_5, transistor Q_2 conducts less and its collector voltage increases. Point C follows the lower collector voltage; when it drops below 10 volts, Q_3 turns on, Q_4 turns off, and the output becomes negative, or a binary 0.

Driving circuits

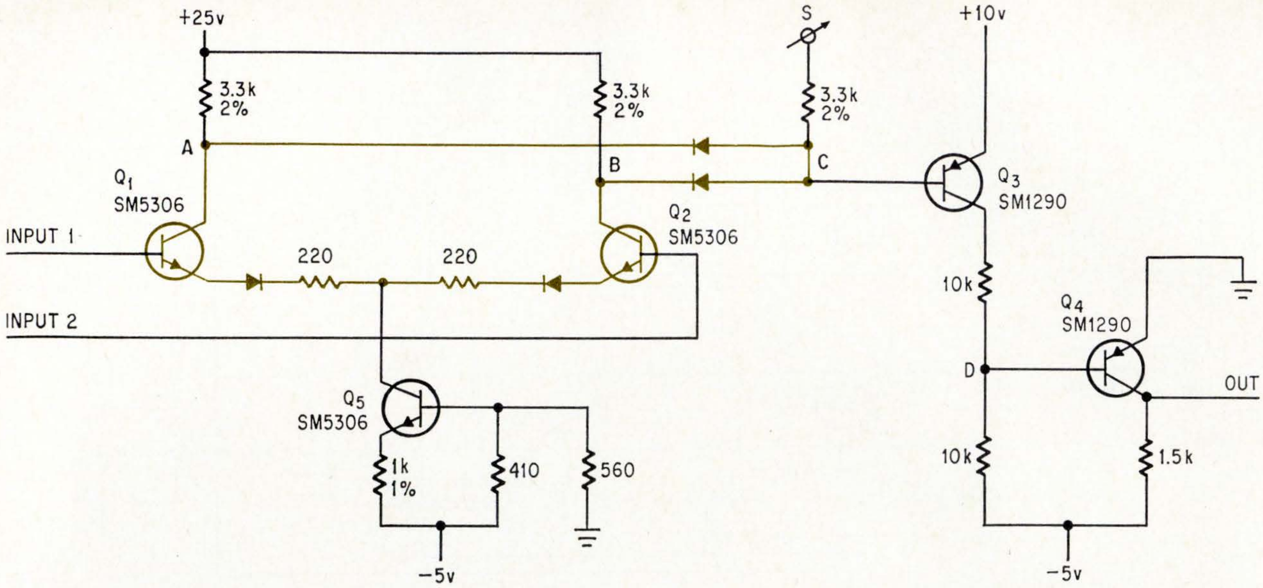
The flip-flop that drives the indicating lamps is a single-loop regenerative circuit containing two transistors and a lamp that go on and off together. The circuit therefore draws very little power when it is off. The flip-flop is turned on when the x-decoder output, the y-decoder output, and the signal from the coincidence unit all go below −3.6 volts at the same time. The flip-flop turns off when a cur-



Thinner. The four outputs of the interpolator (F_1 - F_4) are compared. If two outputs are nearly equal, the thinner eliminates one of them by closing a diamond gate. The coincidence unit compares the four or fewer outputs of the thinner with the Y-coordinate from the transformer, and a lamp in the display is turned on when the comparators detect a matchup.



Diamond gate. A simple diode bridge transmits an analog voltage unchanged when an input gating signal is a binary 1. When the gating signal is 0, the output floats regardless of what the analog input is. The more complex diamond gate (with circuitry in color) used in the interpolator needs two digital gating signals to transmit the analog voltage.



Comparator circuit. A binary 1 output appears when the two inputs are equal within a sensitivity margin determined by the setting at S. The circuit portion in color does the actual comparing. Point C follows the lower of the two collector voltages A and B, depending on which transistor is conducting more heavily.

rent driver circuit cuts off its emitter current.

One current driver circuit drives 32 flip-flops at once. An entire column of lamps is thus turned off just prior to being scanned, and then turned on one at a time if the coincidence unit so indicates.

Strobing and gap-filling

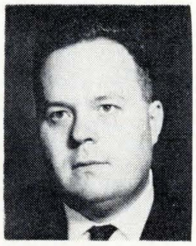
The 64 decoder output signals that drive the coordinate transformer also light the display bulbs. Obviously this lighting has to be inhibited until transients at the output of the coincidence unit have died away. The generation of analog voltages, transformation, blur thinning, and comparison with the input picture require about half a microsecond. To inhibit bulb-lighting during this interval, the Paramatrix timing circuitry is divided into two phases by another counting stage between the clock and the y-counter. During the first phase of a given clock period, the transformer, interpolator, and coincidence units are activated; in the second phase, the bulbs are lighted if the coincidence unit output so indicates.

The Paramatrix fills in gaps by the linear interpolation of the two voltages bordering the gap. The operator activates certain switches that indicate to the system where the gap exists. These switches connect a chain of 5K resistors between the two voltages bordering the gap—one resistor for each column of bulbs included in the gap—and also connect the junctions between resistors to the inputs of the diamond gates in the interpolator. The resistors produce a linearly related set of voltages that override the potentiometer voltages in the columns where the gap occurs.

Even if the output coordinates are in the specified voltage range, one or both of the input coordinates will be out of range for certain values of a, b, m, n, and θ. Since points of interest in the input aren't defined outside the specified range, a spurious signal could conceivably arise that could light a bulb in the output display corresponding to a nonexistent or meaningless point in the input.

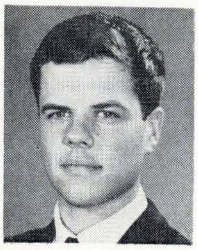
To prevent this, an out-of-range indicator checks the Y-coordinate on its way to the coincidence unit. The out-of-range indicator is a modified comparator whose digital output is a 0 if its analog input is less than —7.5 volts or more than +8 volts. A bulb-lighting signal can be produced only if the out-of-range output is 1.

The authors



W.J. Poppelbaum, a professor of electrical engineering at the University of Illinois, originated the Paramatrix idea and headed the design and construction work.

Michael Faiman is an assistant professor of electrical engineering. He did most of the design work on the Paramatrix.



Edward Carr, an engineering assistant in the Digital Computer Laboratory, assembled and debugged the Paramatrix prototype.

Leadership

We developed this new Operational Amplifier for its combination of high performance and low cost.

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- **Offset Voltage Drift: 10μV/°C**
- **Offset Voltage: 5 mV**
- **Offset Current Drift: 1.0 nA/°C**
- **Offset Current: 50 nA**
- **Power Supplies: ±15 V**
- **Power Dissipation: 90 mW**
- **Compensation:**
  40 db gain—none
  0 db gain—two components
- **Monolithic Integrated Circuit in TO-78 or dual inline package**
- **Common Mode Range: ±13 V**
- **Common Mode Rejection Ratio: 90 db**
- **Power Supply Rejection Ratio: 90 db**
- **Gain: 40,000**
- **Input Impedance: 200K Ω**
- **Output Swing (5K load): 24 VP-P**
- **Output Short Circuit Protected**
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  Operating 0°C to +100°C
  Storage −65°C to +150°C

Price:	1-99	100-99	1000	10,000
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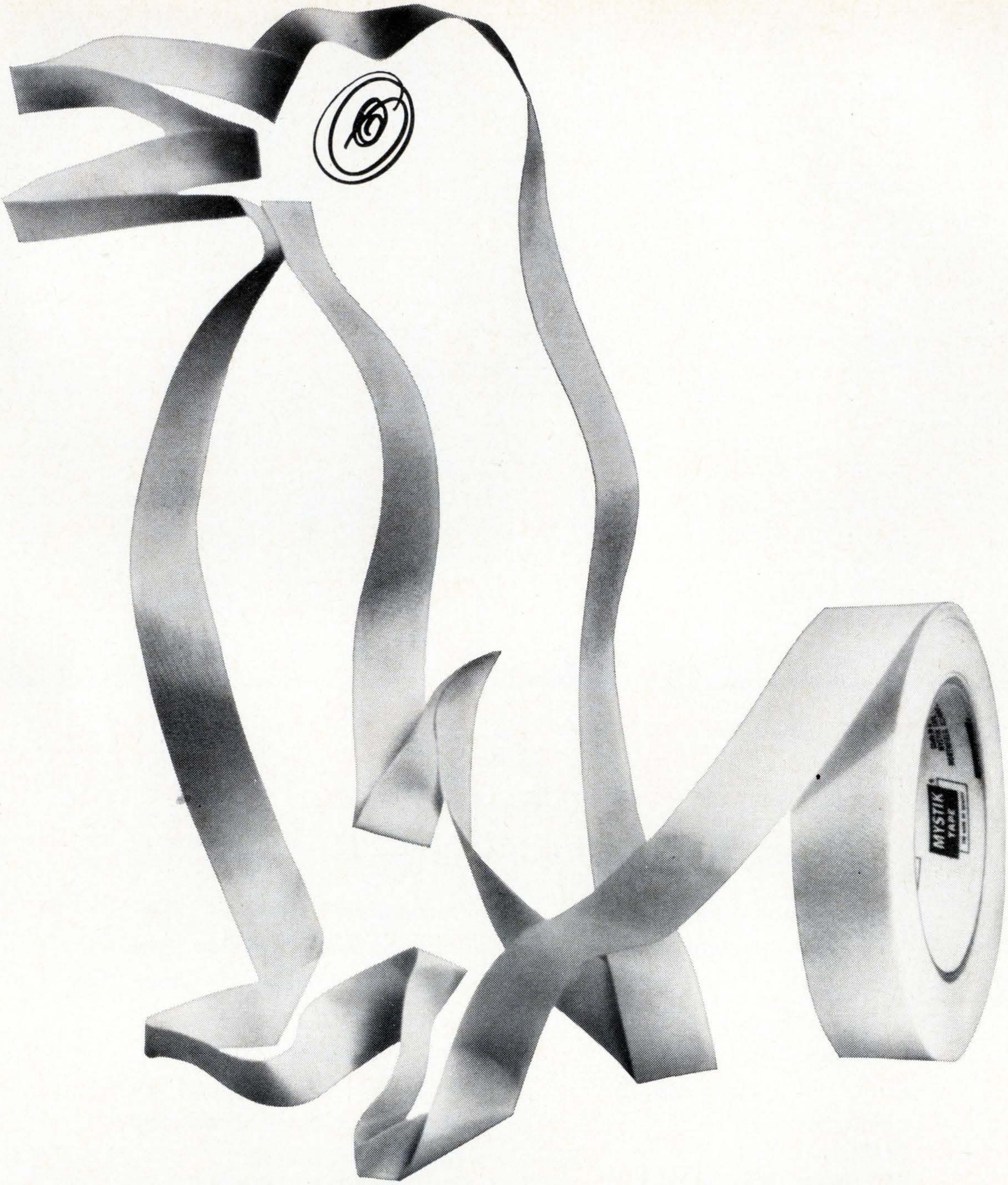

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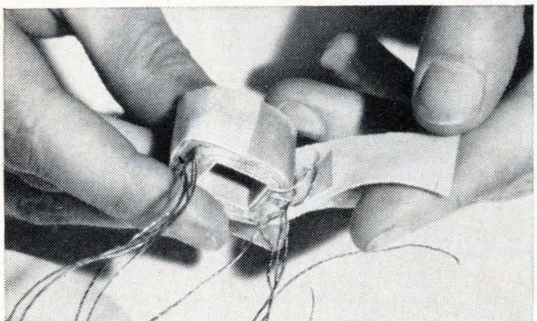

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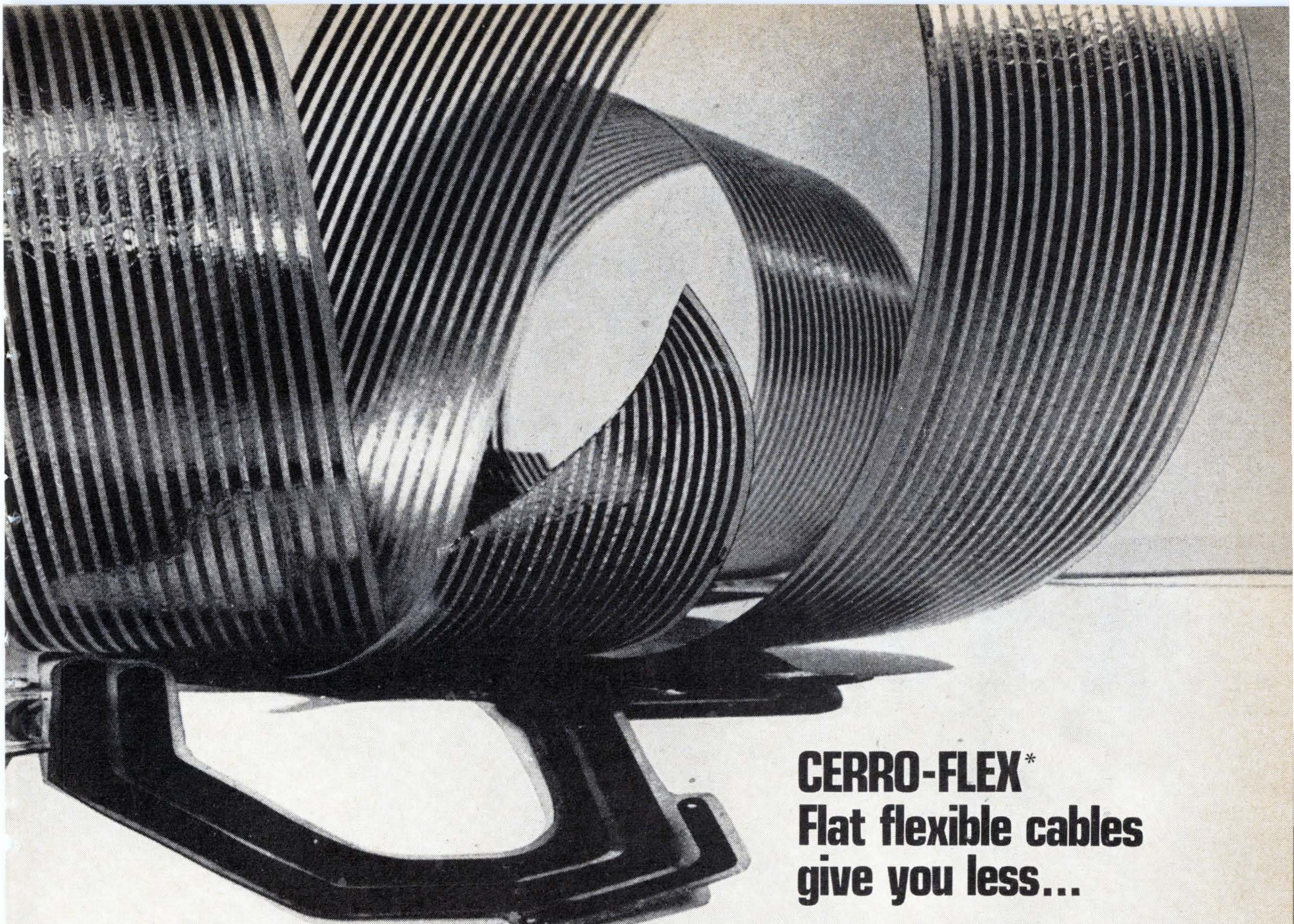

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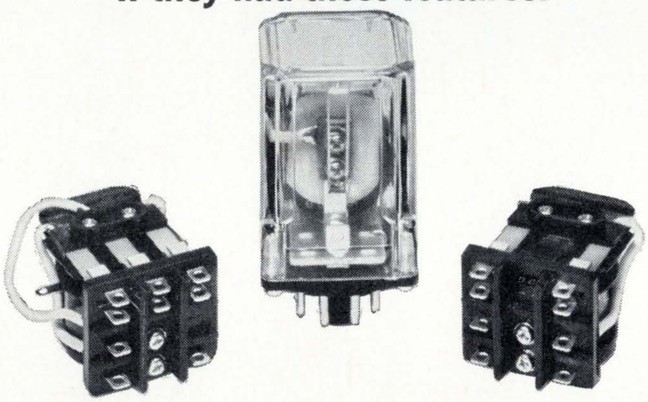
If they had these features.



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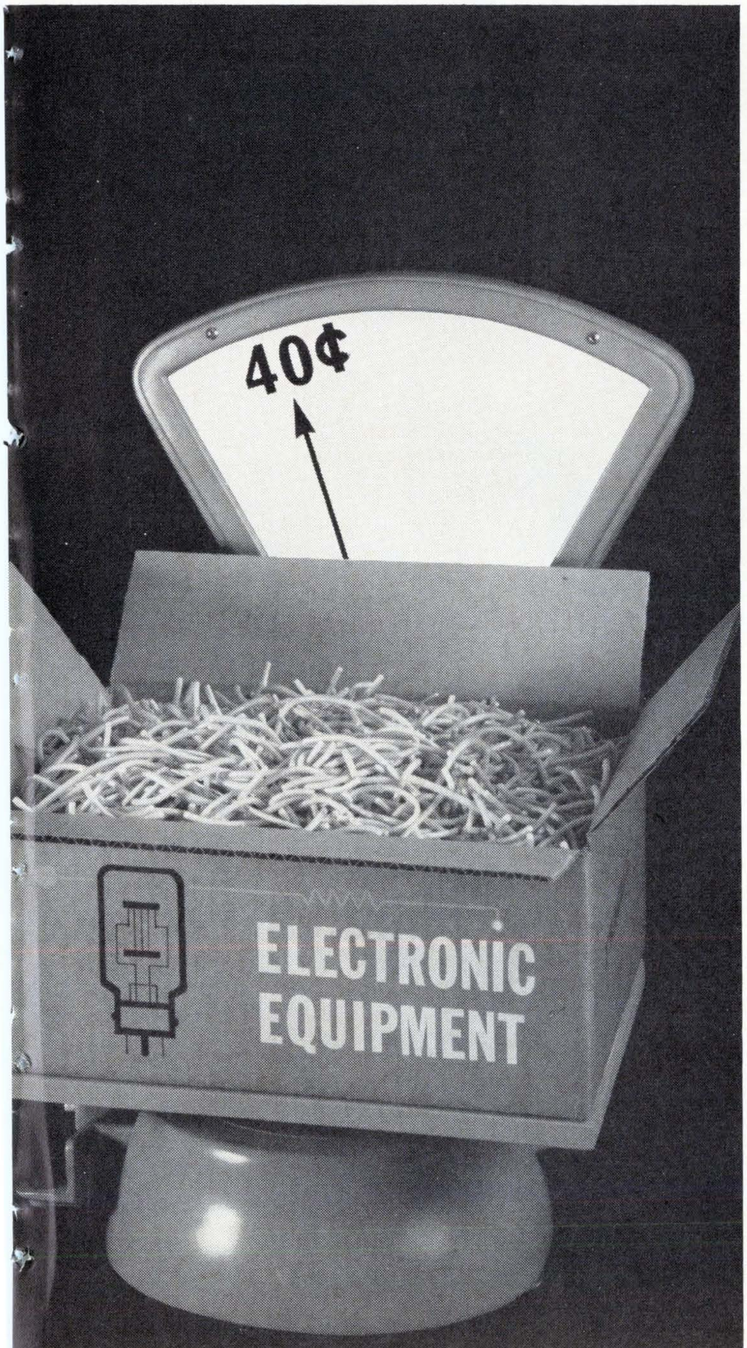

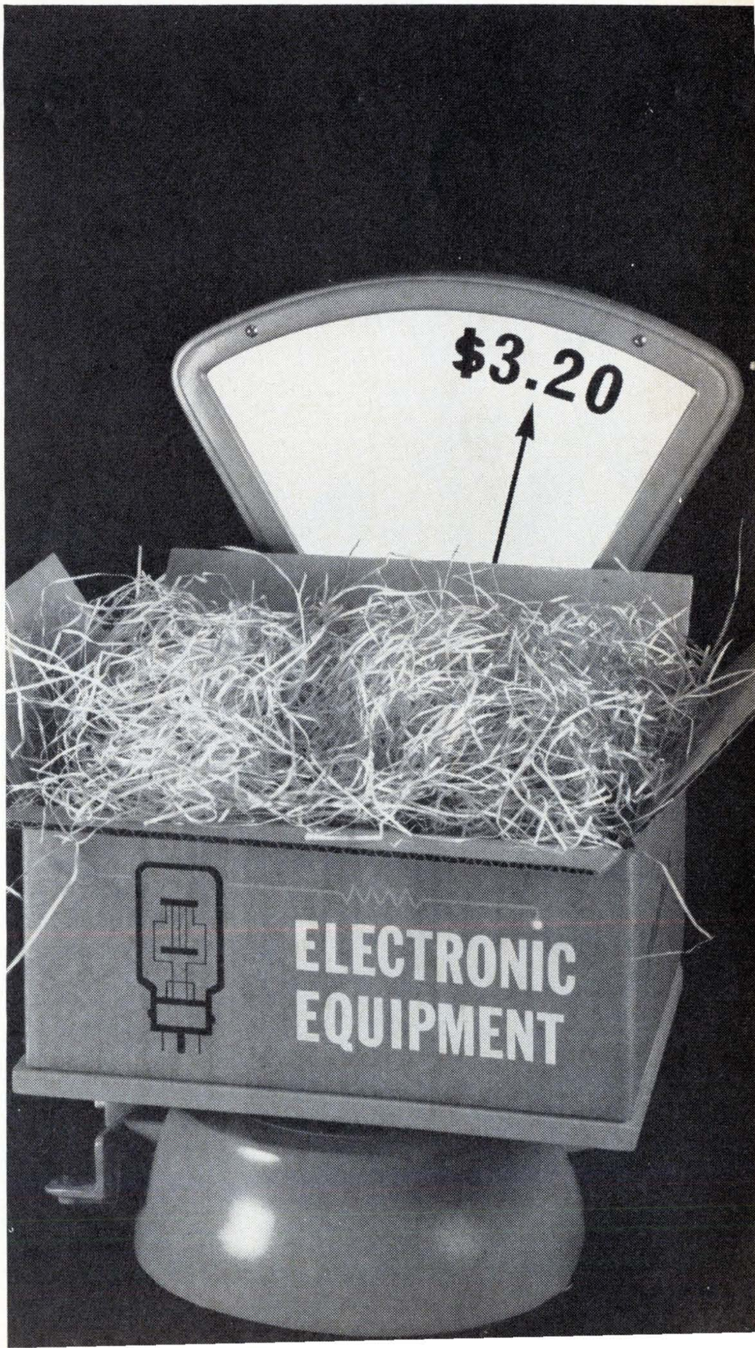

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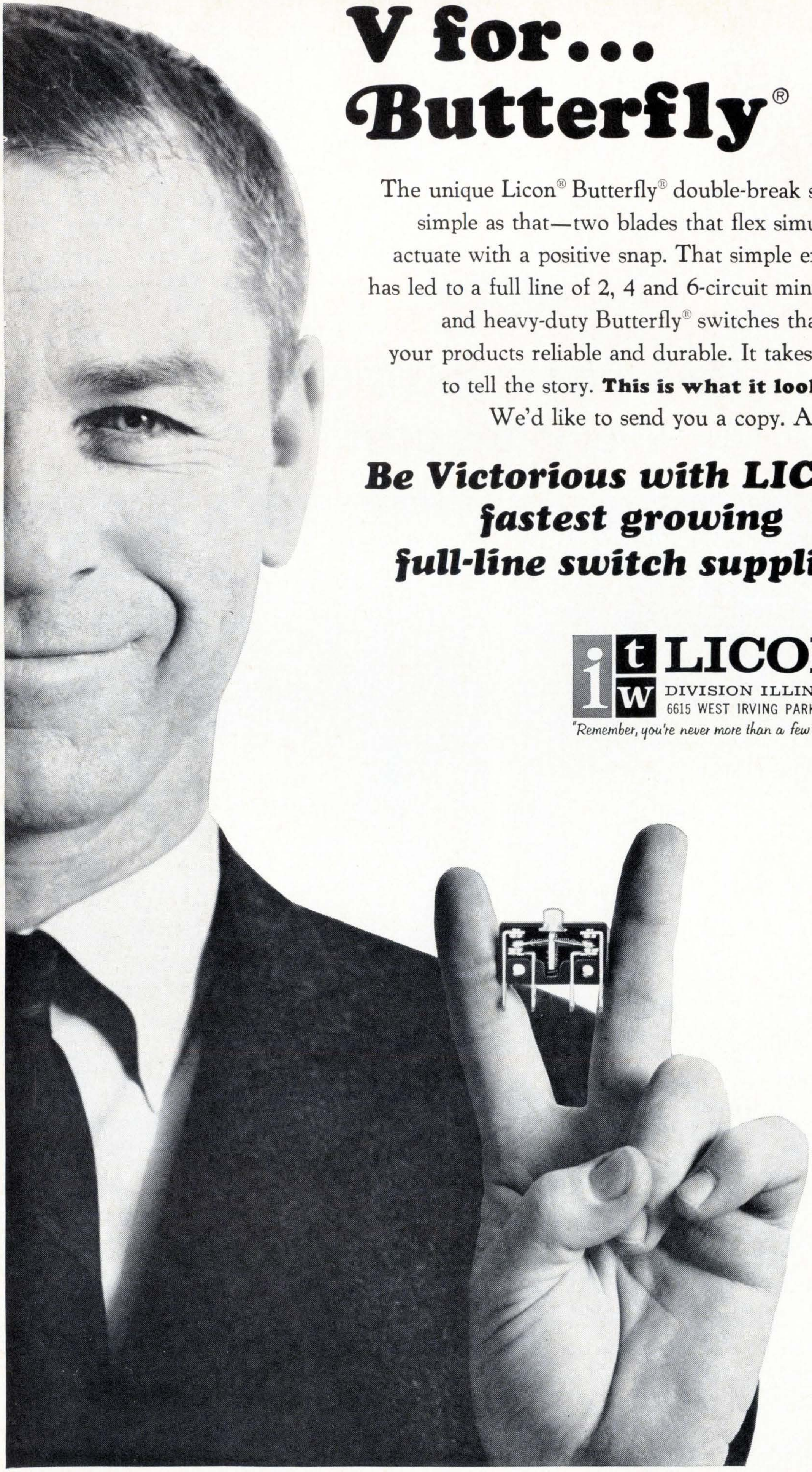

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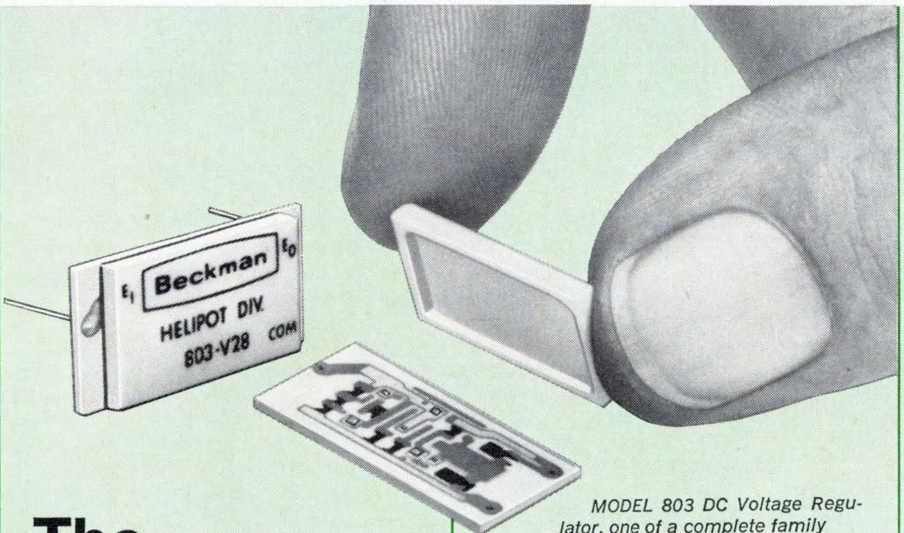

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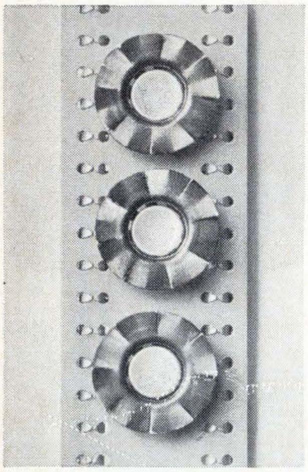

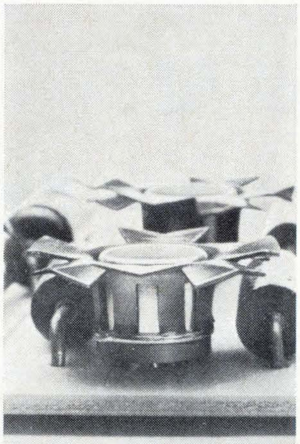

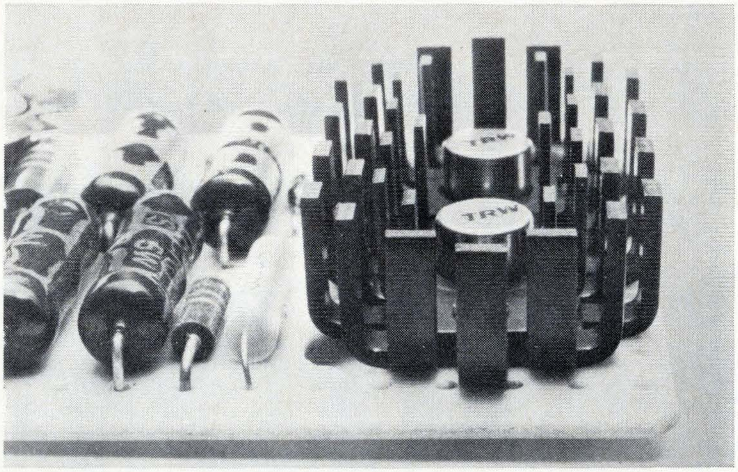

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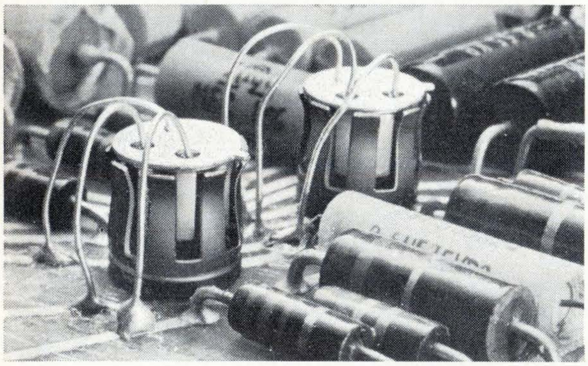

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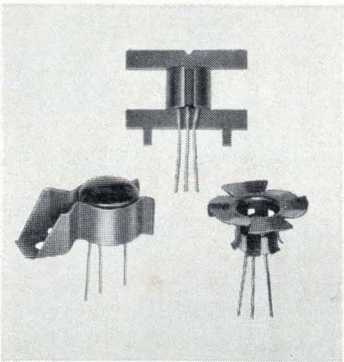

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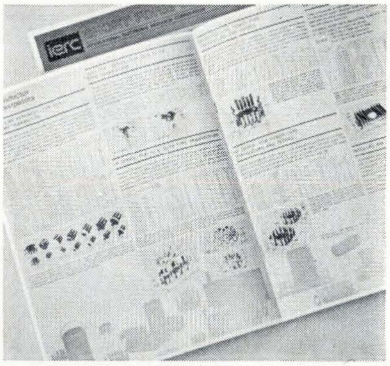

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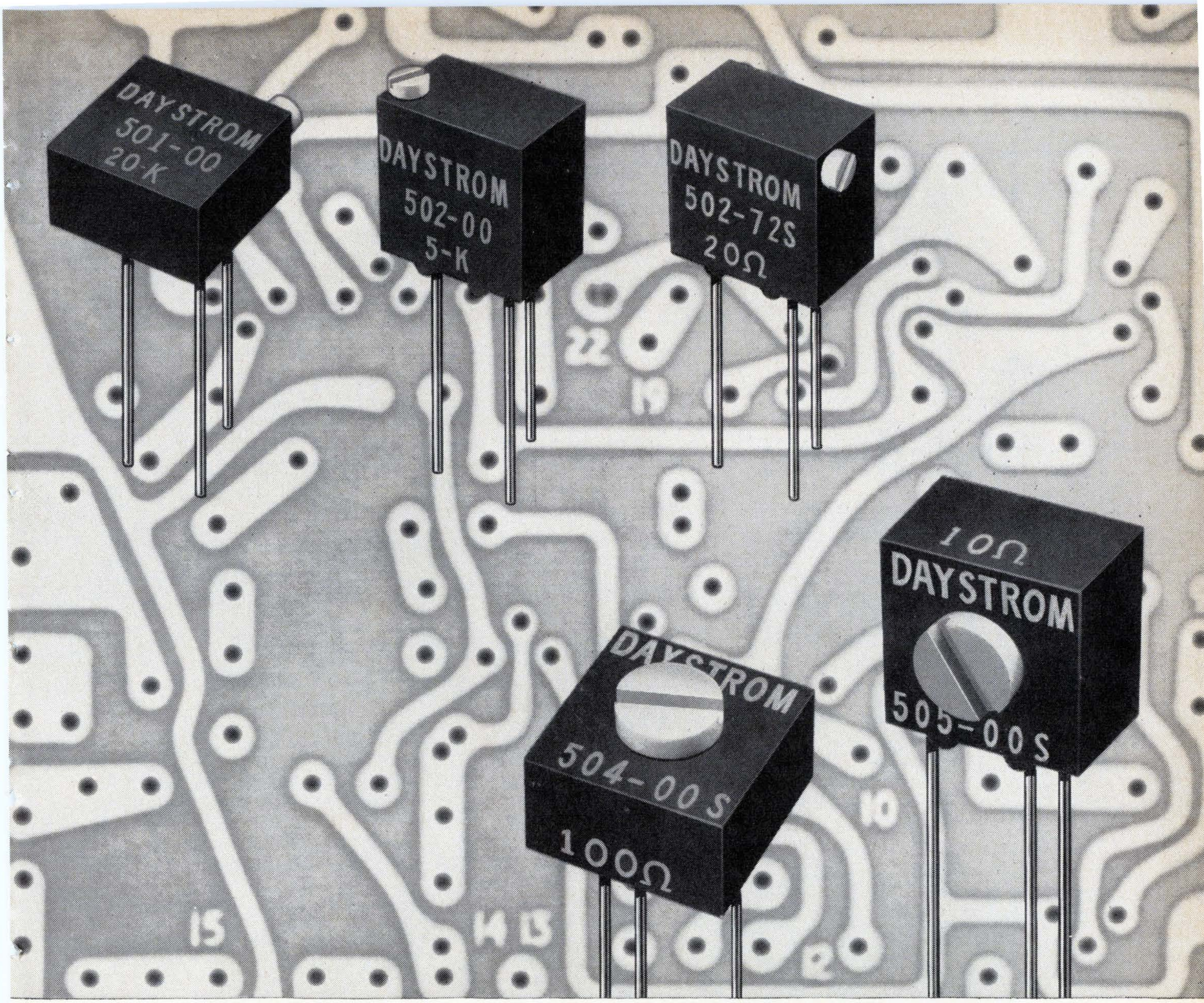
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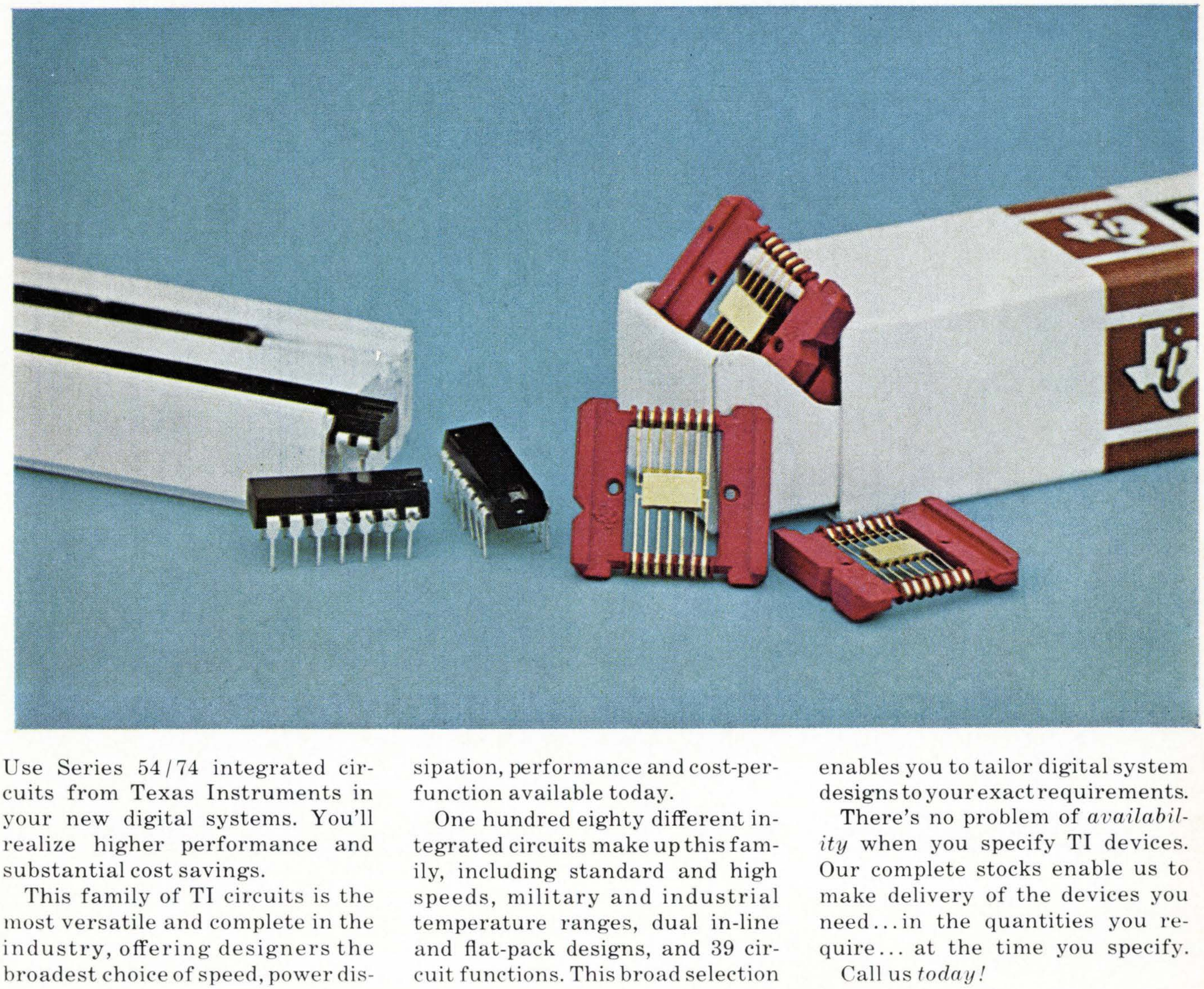

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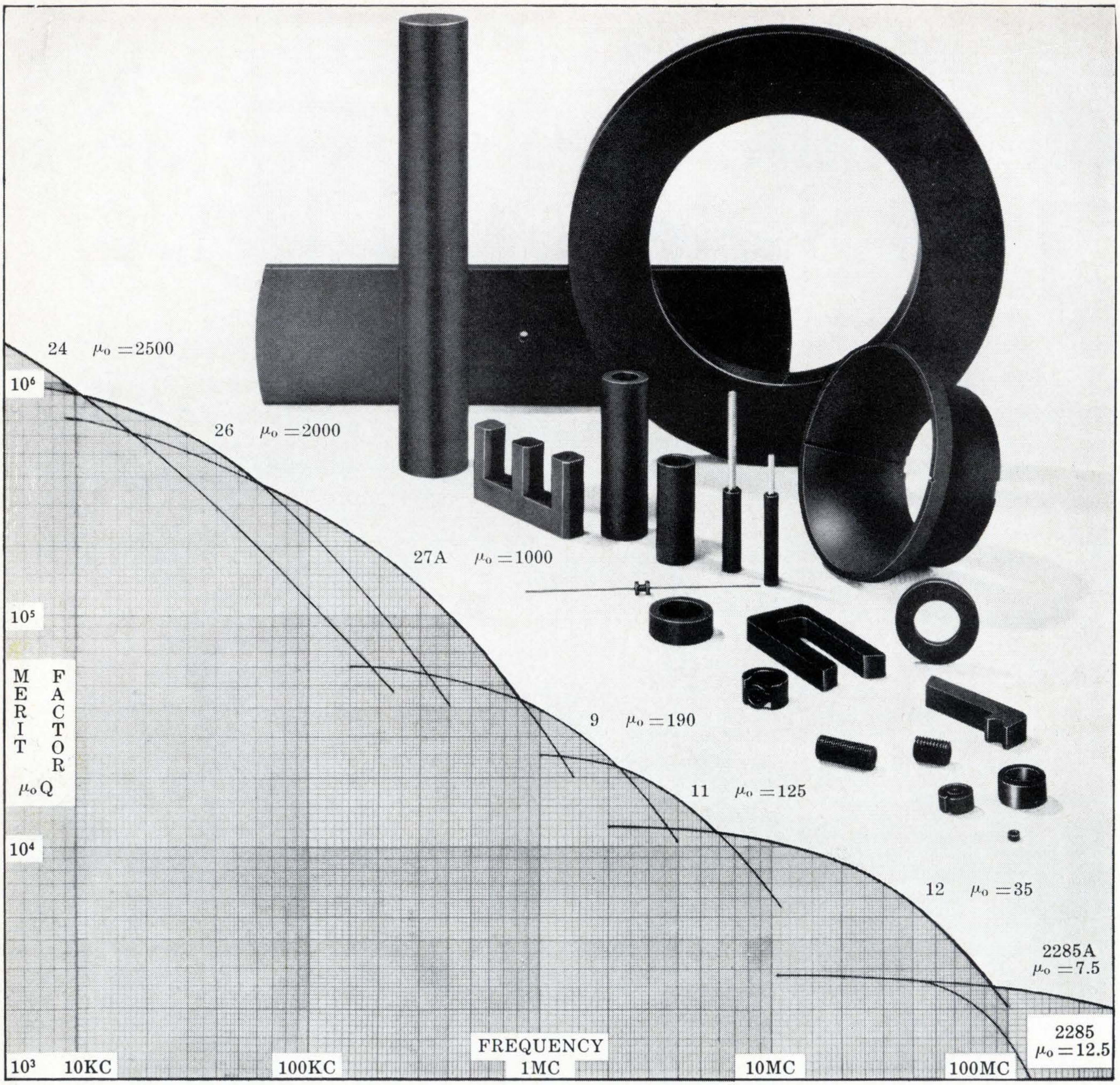

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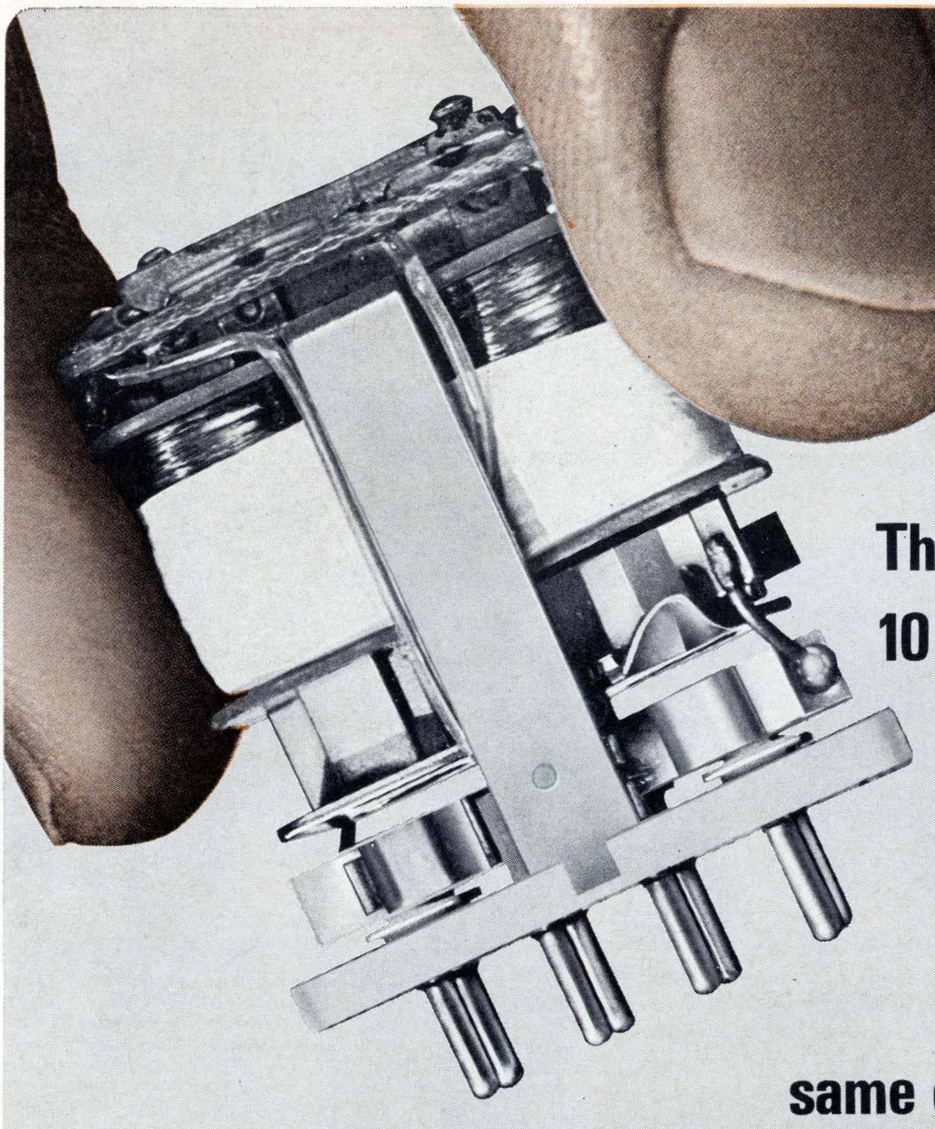

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SPECIFICATIONS

SIZES 1.300" h. x 1.075" l. x .515" w	PULL-IN POWER: Low as 80 mw.
WEIGHT: Approx. 1.0 oz.	LIFE: 100,000 operations, min.
CONTACT ARRANGEMENTS: SPDT and DPDT	TEMP. RANGE: −65°C to +125°C

FROM THE BABCOCK FAMILY OF CRYSTAL CAN RELAYS

TWICE SIZE
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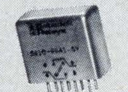
dc to 10 Amps.

FULL SIZE
DPDT
dc to 10 Amps.

HALF SIZE
SPDT & DPDT
dc to 2 Amps.



SIXTH SIZE
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dc to 1 Amp.

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TEKTRONIX Type 547 sweep-switching oscilloscope

The Tektronix Type 547 is a 50-MHz, 7-ns sweep-switching oscilloscope that offers dual-beam measurement capabilities with most repetitive signals. A complete selection of plug-ins permits you to change your oscilloscope performance to meet your changing needs.

The sweep-switching feature of the Tektronix Type 547 Oscilloscope and the vertical switching of the new Type 1A4 Four-Channel plug-in provide two independent dual-trace oscilloscope systems that time-share the same CRT. The identical sweep systems provide 2% calibration from 5 s/cm to 100 ns/cm, extending to 10 ns/cm ($\pm$ 5%) with the horizontal magnifier. The calibrated sweep delay range is from 100 ns to 50 s and sweep-switching provides alternate displays of the delayed and delaying sweeps.

With the Type 1A4 Four-Channel Plug-in, the Type 547 has a 7-ns risetime and DC-to-50 MHz bandwidth over its 10 mV/cm to 20 V/cm calibrated range. You can also select from 50-MHz dual-trace plug-ins, differential plug-ins with bandwidths to 50 MHz, sub-nanosecond sampling and TDR plug-ins, and four spectrum analyzer plug-ins covering the spectrum from 50 Hz to 10.5 GHz.

Type 547 Sweep-Switching Oscilloscope	$1875
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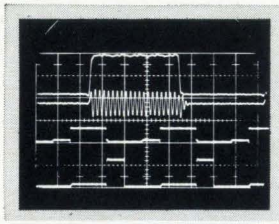
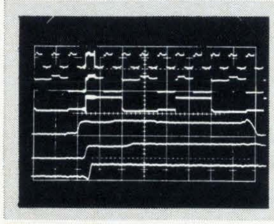


Four Signals–Two Sweeps

Using alternate vertical and horizontal display modes, Ch 1 and Ch 2 are locked to A Sweep (100 ns/cm) and Ch 3 and Ch 4 are locked to B Sweep (2 μs/cm). This provides dual-beam measurement capabilities with most repetitive signals.



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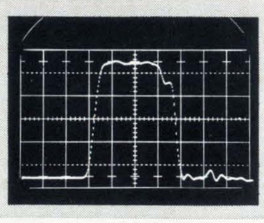

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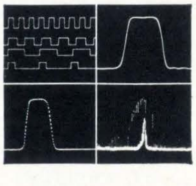

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Probing the News

Consumer electronics

Consumer electronics firms entertain the possibility of using more IC's

Aggressive development and sales tactics of semiconductor houses seem certain to make the home-entertainment field a volume market for devices, but set makers are typically closemouthed on their plans

By John D. Drummond

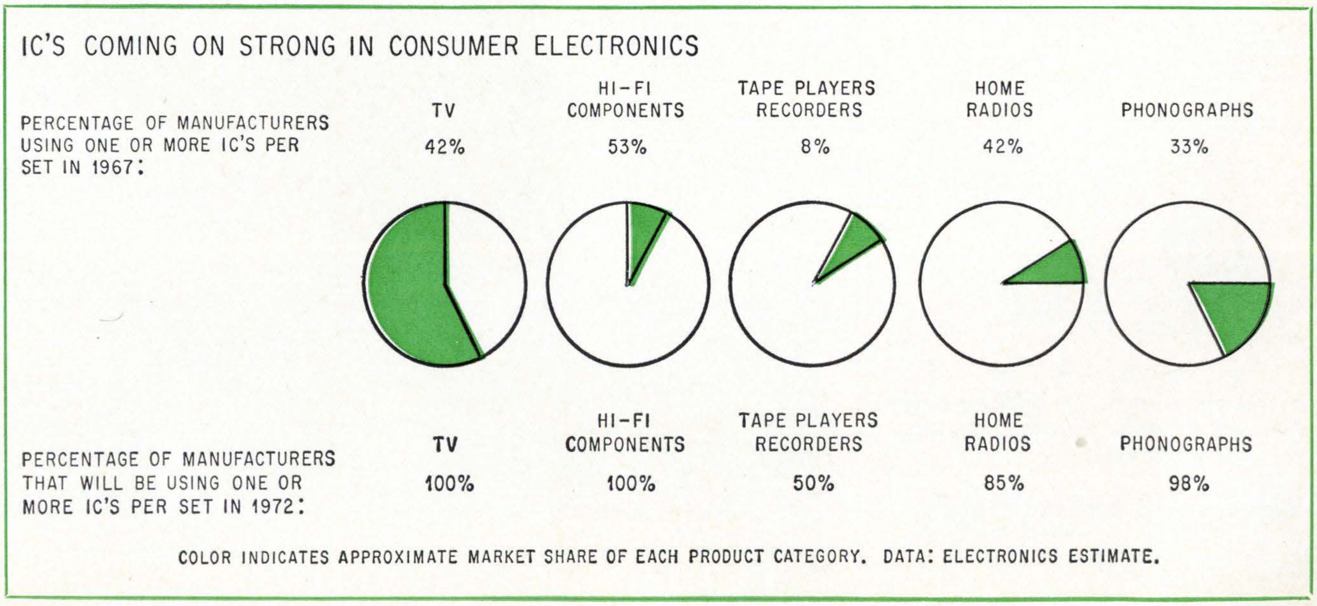
Consumer electronics editor

Manufacturers of television sets and other consumer electronics products are being forced to take a harder look at developments in the fast-moving field of linear integrated circuits. Zeroing in on potential volume markets, semiconductor houses have deliberately priced their latest generation devices low enough—in some cases, 50% less than previous offerings—to command attention from the price-conscious consumer market. What's more, the new breeds of assemblies are tailored to interface with tubes or discrete components. Some can be used as direct replacements for diodes, transistors, and associated circuitry.

So far, IC's have been used sparingly in the sound sections of home-entertainment goods, and many firms view the devices as little more than promotional ploys. However, vendors are clearly aiming at saturation of the general-purpose radio-frequency and audio-amplification market with integrated assemblies providing multifunctions on a single chip. Special-purpose IC's for automatic fine tuning and remote control are also cropping up. Farther down the road, IC makers are staking a claim on such areas as waveshaping control, signal processing, and video amplification.

In keeping with the supersecretive customs of the industry, most manufacturers are playing it close to the vest on revealing plans to use more IC's in home-entertainment products. But it is safe to conclude that producers' public disinterest in volume applications obscures feverish behind-the-scenes investigation. Now that the price barrier has been decisively breached and availability presents no problems, big orders are clearly in store.

Integrated circuitry is not going to make immediately spectacular inroads in the home-entertainment field. Evaluation of the new devices



COLOR INDICATES APPROXIMATE MARKET SHARE OF EACH PRODUCT CATEGORY. DATA: ELECTRONICS ESTIMATE.

... manufacturers say IC's must offer flexibility and superior performance ...

will take time. Moreover, redesigning equipment and converting production lines to make it can consume 12 to 24 months. But IC makers have vastly improved their foot-in-the-door position of a year ago and crossed over the threshold. By 1971, the demand for IC's from consumers outlets is expected to rise from an annual rate of only a couple of million to 200 million units.

Roll call. Leading the pack so far in the race for consumer business are the Radio Corp. of America and the General Electric Co. These two firms are closely followed by Motorola Inc., the Semiconductor division of the Fairchild Camera & Instrument Corp., and Texas Instruments Incorporated. New arrivals include the Philco-Ford Corp. and the Westinghouse Electric Corp.

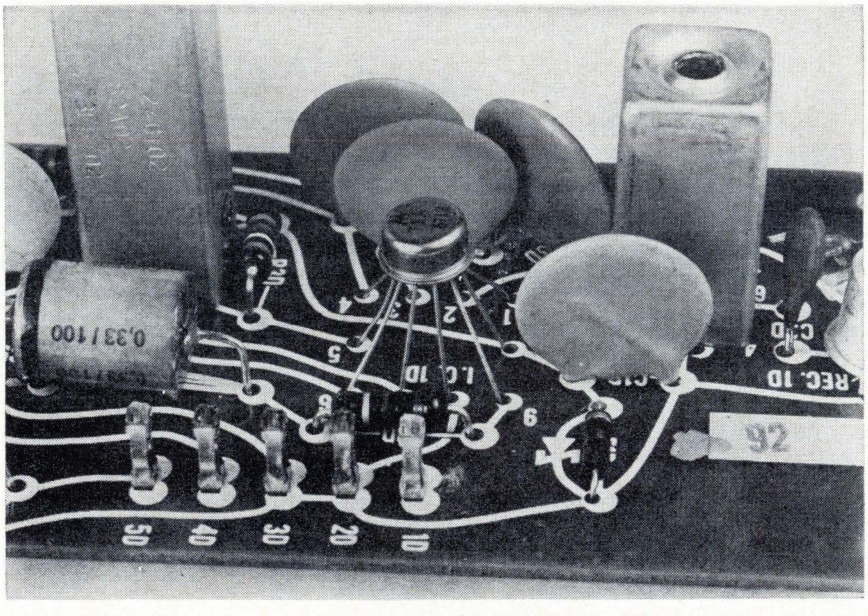
First off the mark with IC's in consumer goods was RCA which used home-made devices in the sound section of its 1966 black-and-white and color tv sets. Since then, other manufacturers have followed suit and incorporated IC's in a-m and f-m radios, phonographs, hi-fi components, stereo systems, and even kits. Ironically, however, IC's have achieved their greatest success in a comparatively minor segment of the business—f-m receivers, particularly stereo models. It was not until recent months that semiconductor houses were able to shoot for volume applications in the vast television field.

I. Price is paramount

For all the ferment, a number of consumer goods companies still approach IC's with the enthusiasm of a bridegroom at a shotgun wedding. But the marketing pressures are almost irresistible: once any firm in this brutally competitive field tries something new, competitors are forced to follow—or take a long, hard look at—the development.

Manufacturers are vocal in their insistence that IC's must afford design flexibility and superior performance. However, their principal preoccupation still appears to be price. An official at GE's Semiconductor Products department puts it this way: "The switchover to IC's and the extent of their use will be determined by economic factors, not performance. Manufacturers of consumer goods have settled upon fixed levels of performance at each level of pricing."

Interim insert. Fred Hayden, director of engineering at the Packard-Bell Electronics Corp.'s Home



Replacement part. Audio IC in Motorola color-tv set replaced 15 discrete components; chip incorporates 15 resistors, 12 transistors, and 12 diodes.

Products division, says, "I don't think any IC's now being marketed compare with discretes on a price basis. As far as we are concerned, unless they help trim costs, there's no great argument for using them since we don't have a space problem in our products." The company is using an IC in the i-f sound amplifier and limiter circuit in one tv set in the current model run.

"From a performance and reliability standpoint," says Hayden, "the set was a success." But he estimates the cost of using the device was at least 25% higher than would have been the case with discrete components. Hayden concedes that Packard-Bell was looking for a merchandising edge when it decided to go the IC route; he says the device will be out of next year's models.

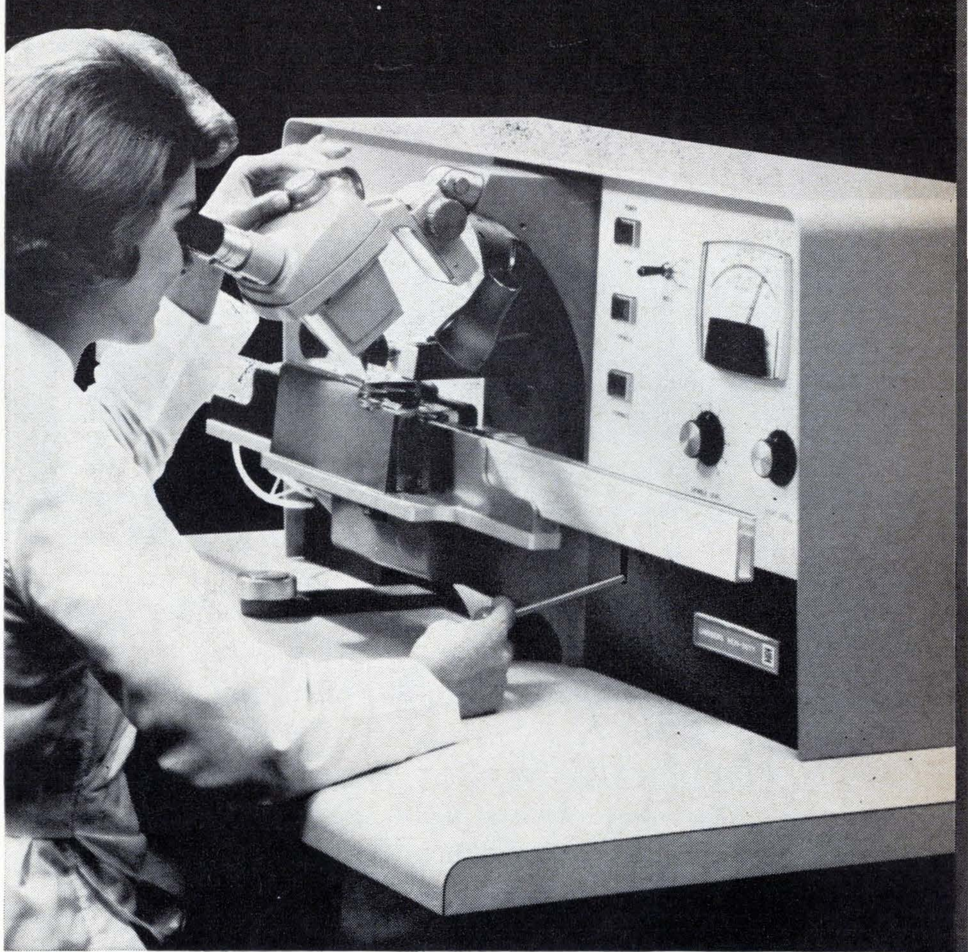
Satisfied customer. Motorola, which is using its own devices in the audio section of its 1968 color tv sets, is sold on IC's. The receivers, all solid state, cost about $40 more to produce than those with tubes. But, says Motorola, the IC's are one of the least expensive aspects of the new models.

Gene Blanchett, manager of operations at Motorola's Semiconductor Products division, says the company uses IC's in critical audio applications. "We find we get a clearer f-m sound under adverse signal conditions when we use IC's," he notes. The chip going into Motorola's color sets replaces 15 resistors, 12 transistors, and 12 diodes.

Daniel von Recklinghausen, director of engineering at H. H. Scott Inc., says, "IC's are not necessarily more expensive than discrete components. On the whole, the use of IC's does not boost the total cost of the manufactured product significantly if labor savings and other factors are taken into account."

For all the concern over costs, a surprising disparity exists in pricing practices, apparently because IC makers are willing to negotiate. A recent check revealed that some set manufacturers are paying as much as 25% to 50% more than competitors for equivalent devices. For example, a sound i-f amplifier has been offered to a quality radio house for $1 apiece, while others have gotten quotations of $1.50.

As high-volume, general-purpose



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... transistors are still new to most engineers ...

circuits like audio amplifiers are integrated, increasing attention will be paid to trickier special-purpose circuits. Video circuits in tv sets are a prime target according to Motorola's Blanchett. "We've been working in this area for quite a while," he says. "We're in a design phase now, trying to find a way to increase yields to an economical point. We have to set up lines, sample customers, get feedback, and just plain learn how to use IC's more cheaply."

II. Different by design

Other sections of tv sets high on the list for integration include wave-shaping and sync circuits. At the moment, applications of IC's in tv receivers are limited largely to audio circuits. Among the exceptions, however, are Philco-Ford which uses a chip as a video driver and RCA which is using IC's for automatic fine tuning and as a remote control amplifier. Both companies report that these circuits are performing at least as well as the discrete transistors they dislodged and RCA says that, in the case of the automatic fine tuning application, frequency control is better because of the device's inherently stable operation. Finally, Warwick Electronics Inc. reports using an IC for automatic frequency control in one of the black-and-white tv sets it builds for Sears, Roebuck & Co.

However, before the IC millenium is reached in consumer electronics, equipment manufacturers and semiconductor houses will have to give a little. Set makers must be induced to eschew circuitry packages left over from the days of vacuum tubes and IC vendors must be willing to be increasingly responsive to specific design requirements. There are those who doubt that such a love-feast is scheduled to start any time soon. For example, Fred Mergner, director of engineering at the Fisher Radio Corp., says, "The engineer's mind has to be conditioned before he'll begin to think about IC's. After all, he's just crossed the bridge from tube to transistor, and he hasn't recovered."

Pro and Kahn. Some interested

. . . Zenith was one of the first to use IC's in consumer goods . . .

parties profess to be worried that the use of off-the-shelf IC's will limit designers flexibility. "We are not using IC's at this time," says Morley Kahn, the director of marketing at the Marantz Co., a subsidiary of Superscope Inc. "Available devices cannot provide the high performance levels required in our sophisticated gear." Kahn's views are echoed by an audio engineer at an East Coast radio firm who complains that because of IC's encapsulated packages, circuit redesign is difficult. On the other hand, Fisher Radio's Mergner, Scott's von Recklinghausen, and E. C. Fiebich of the Heath Co. have been using IC's for a good while; they are unanimous in asserting that once the techniques are mastered, IC's afford the same design flexibility as discrete components.

III. Activity report

Publicly, a number of critics still contend that IC's performance characteristics are overrated. It is difficult to reconcile this mistrust with the consumer electronics industry's well-known price bent since the active elements which improve performance quality come cheap in IC's. Engineers designing entertainment products with discrete components still face limits on the number of diodes and transistors they can add to a circuit because of the costs involved. By way of example, however, a single RCA device that replaces 26 discrete components has 39 elements, 24 of which are active.

Morris Levy, vice president of engineering at the Emerson Radio & Phonograph Corp. says, "We've been experimenting with IC's for some time now and haven't detected any improvement in performance over discrete transistors." Levy cites this factor as the reason for the company's not having put devices in either its tv or radio lines. "Most people who are using IC's in a circuit here or there are doing so for marketing purposes," he concludes.

Traditionalist. The Zenith Radio Corp., one of the last, lonely outposts of hand-wired circuitry, agrees with Levy's analysis—at least as far as television is concerned. A spokesman says, "Our philosophy is to use something only when it will make a contribution to the unit itself. We will increase our use of IC's only when they prove worthwhile."

However, Zenith was one of the first to use IC's in consumer goods, having incorporated monolithic devices in its hearing aids as long ago as 1963. In addition, the company is using IC's in its top-of-the line f-m stereo tuners. This is the one application in which there is a consensus that IC's improve performance. The Zenith chips, fabricated by TI, replace five resistors, one transistor, and three condensers in the intermediate-frequency amplifier section.

Despite its sparing use of IC's, Zenith conducts intensive research programs in thin- and thick-film technology as well as in hybrid and monolithic devices. "We have an elaborate laboratory arrangement where it is possible to fabricate IC's, says a spokesman. "We don't have the facilities to mass produce the chips but we can make enough for test applications."

Viewing the situation from the opposite side of the fence, Motorola's Blanchett takes a more optimistic tack, believing it is only a matter of time before IC's completely replace all conventional solid-state devices in home-entertainment goods. "Right now, IC's are more economical in the front ends and audio sections of many top-of-the line hi-fi sets and radios," he says. "In general, the limitation of IC's is that they do not offer high enough voltage or power. The power problem will be easy enough to solve, but voltage will be difficult."

IV. Beautiful music

Integrated circuits have enjoyed perhaps their greatest success in the hi-fi components sector of the home-entertainment industry. Engineers are virtually unanimous in their praise. Scott's von Recklinghausen says, "As a result of using IC's in our f-m i-f amplifier circuits, we have greatly increased the performance of our receivers. The devices provide better gain stability with circuit changes, vastly improve capture ratio, and i-f alignment is a lot easier."

A typical IC i-f amplifier like Fairchild's μA 703E has three transistors and two diodes in an emitter-coupled bias arrangement. With high input signals, the circuit acts as a current limiter without saturation. Using an emitter-coupled pair also affords good isolation between input and output circuits so high gain can be achieved without resorting to neutralization.

At the moment, some top-of-the line f-m stereo receivers are using as many as seven IC's. It appears certain that all manufacturers of hi-fi components will be incorporating IC's in their receivers by 1969 at the latest.

To each his own. The downward trend in the price of off-the-shelf IC's for consumer applications results from manufacturers' design and production ingenuity as well as from rising sales volume [Electronics, July 10, p. 125]. In their zeal to develop circuits with wide appeal, semiconductor houses are staying in close touch with consumer electronics engineers, supplying them with samples of new devices before getting into mass production. They are getting feedback and the interplay is proving increasingly fruitful.

Some set makers who concede they would like to integrate a number of their pet circuits are still scared by the prospect of high development costs. Custom designs of moderate complexity can run into the tens of thousands of dollars—a level beyond the reach of many manufacturers.

B. A. Jacoby, an RCA marketing official, estimates that custom-designed, special-purpose IC's, having annual production runs of 1,000 units, will sell for from $10 to $25 apiece in 1971. This contrasts sharply with the $1.50 price tag expected for off-the-shelf devices produced at the rate of 100,000 units a year. Integrated circuits earmarked for general-purpose applications in consumer electronics markets, manufactured in volumes of 2 million or more units annually, will probably be priced as low as 50¢ each by 1971.

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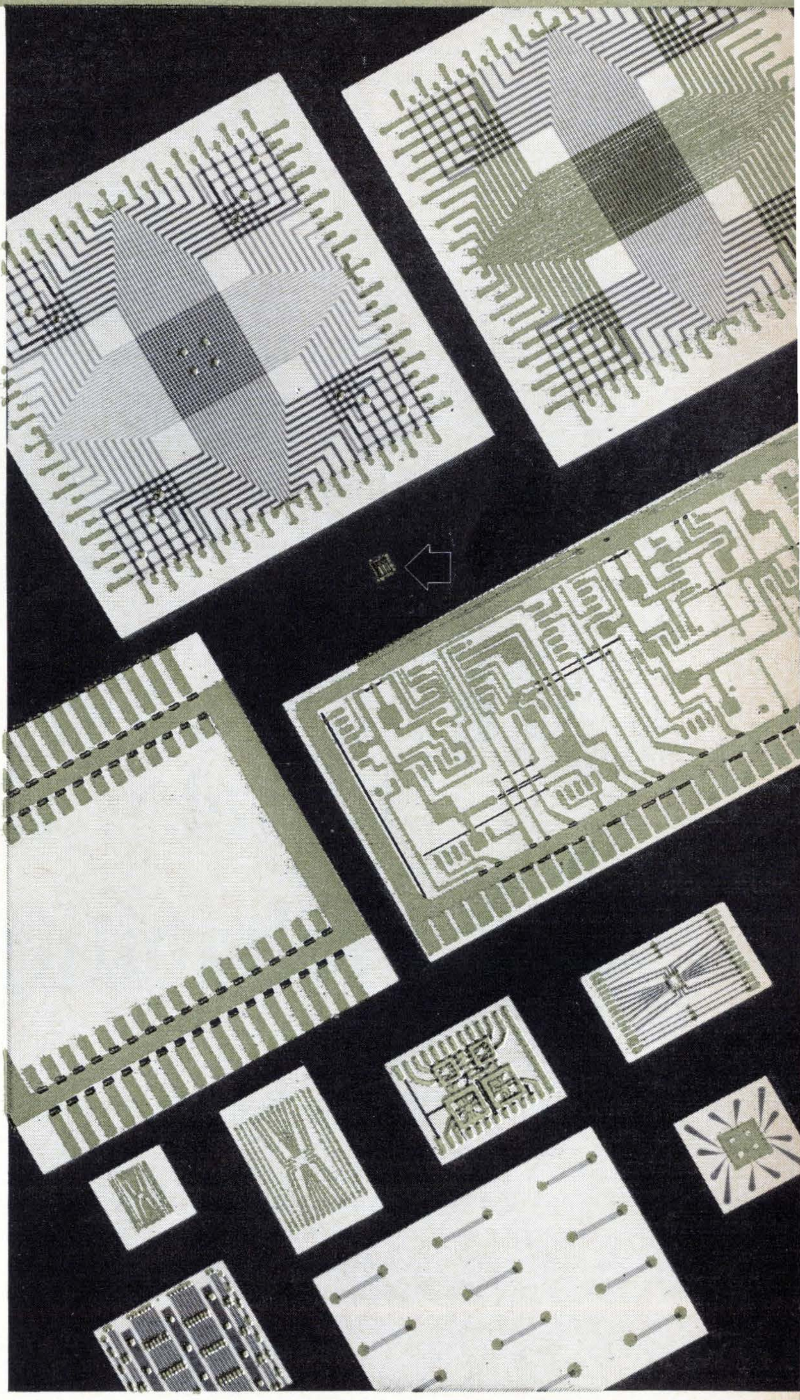

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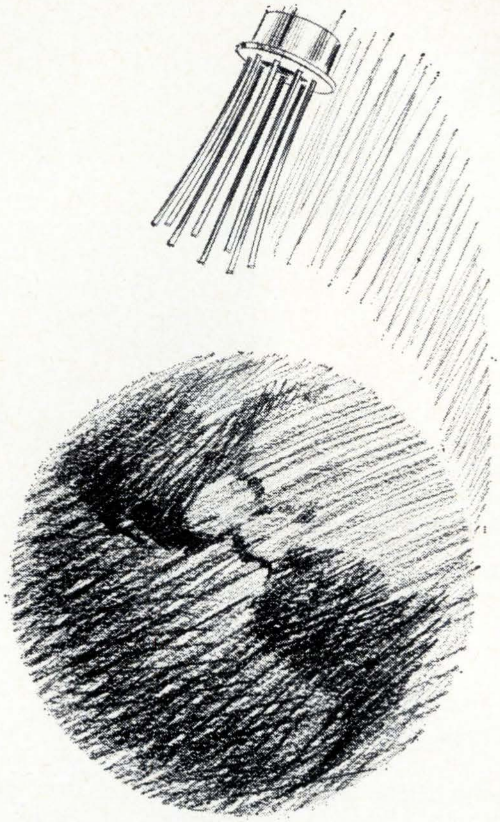

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Canada files claim on space sites

But its insistence on stationing a communications satellite system in synchronous equatorial orbit is producing friction with the U.S.

By William D. Hickman

Washington regional editor

A bitter test of national wills is shaping up between the U.S. and its northern neighbor as a result of Canada's top-priority effort to get a communications satellite of its own into operation by the early 1970's. The U.S. will do everything it can to discourage Canada from going it alone, according to a top Administration official.

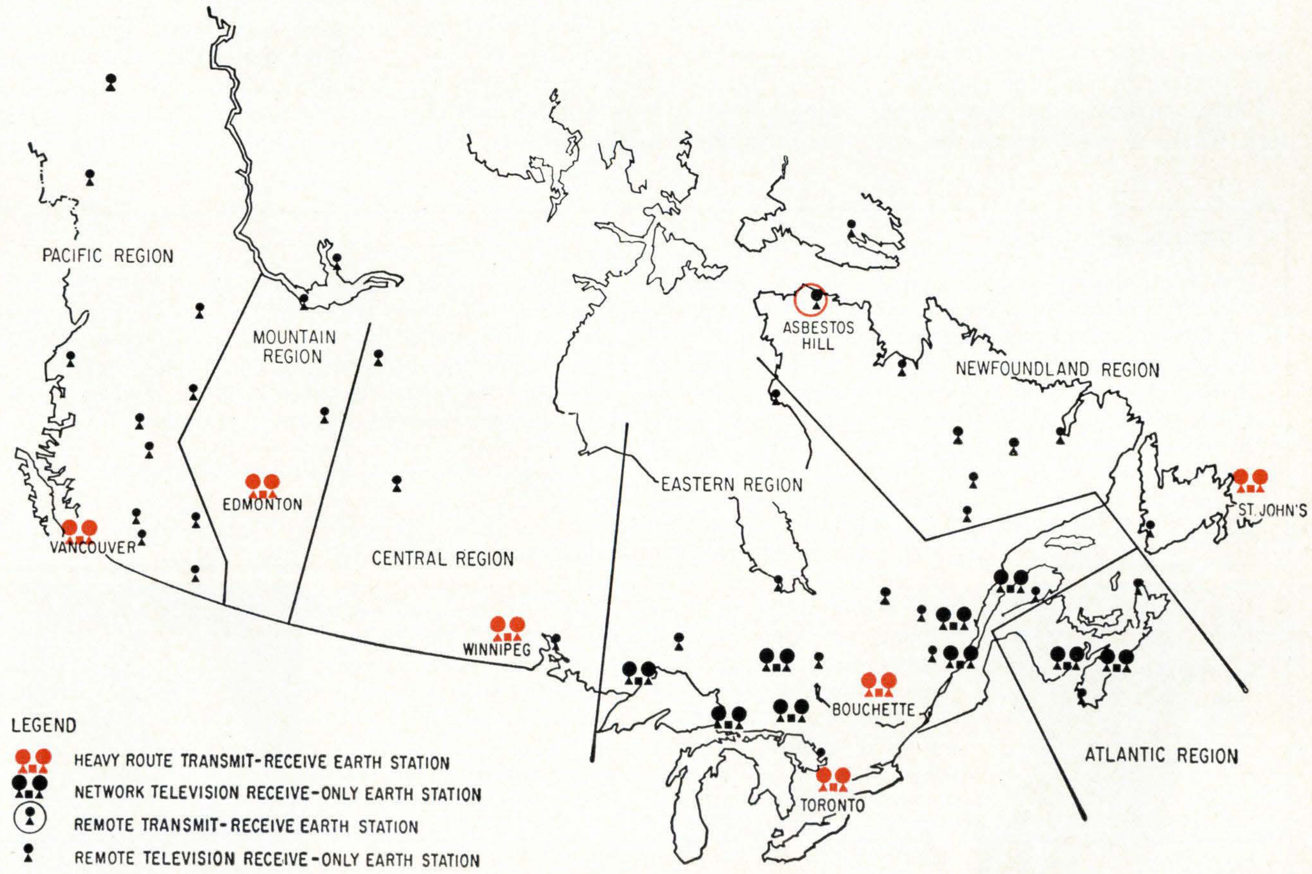
While fully aware that it will need a technical boost from the U.S. to achieve its goals, the Canadian government has recently given additional evidence of its determination to play a lone hand. This summer, it set up a special task force on satellites to plan and coordinate the development of an advanced system to distribute television signals and voice traffic. Estimated cost of the system: more than $80 million.

Grow power. Canadians are confident they can furnish most of the needed research and industrial capacity. Moreover, the government plans to award local companies any contracts to tailor U.S. designs to Canadian needs, hoping to increase the firms' capabilities. But when it comes time to buy space hardware, practicality will transcend nationality; bids will be thrown open to all. Canadian and U.S. companies are expected to share these dollars equally, with perhaps a small amount going to European concerns.

Canada will be totally dependent on the U.S. for launch services. Despite the penalty in foreign exchange, the Canadians feel that the planned frequency of their satellite launchings doesn't justify the construction of boosters locally.

I. Chapman reporting

In the wake of an offer by Canada's largest common carriers to underwrite a communications satel-



Checkerboard. Communications satellite system proposed by Canada's common carriers would have 54 ground stations.

. . . Canadians are in no mood to join forces with Intelsat or the U.S. . . .

lite program on their own [Electronics, June 26, p. 211], Ottawa named physicist John H. Chapman to head the special task force charged with overseeing system development. The author of last February's Chapman Report on Canada's space activities, he has since recruited a panel of top aides.

Chapman concedes that one of his biggest jobs will be to reconcile Canada's aims with those of the U.S. Along with other government people, he realizes that Canada can build the system only with U.S. assistance. And he insists that Canada should get this help because it has a greater need for communications satellites than any other country.

"It would be grossly unfair of the U.S. to deny Canada's attempt to establish a domestic system," says Chapman. But he's fearful this might happen. Further, Canadians are worried that the U.S. might usurp the equatorial orbit locations they are eyeing. Since the communications satellite frequency spread, set by international agreement, extends only from 4 to 6 gigahertz, spacecraft in proximity could interfere with one another.

Chapman holds that space territory where a satellite can be stationed is a natural resource "to be treated as prudently as the country's water." Thus, an important objective of his group is the gathering of data to arm Canada's diplomats when they sally forth to negotiate space rights.

II. South of the border

On Aug. 14, just 30 days after the Canadian government activated Chapman's task force, President Johnson formed a similar group in the U.S. [Electronics, Aug. 21, p. 26]. In doing so, he warned all 58 members of the International Telecommunications Satellite Consortium (Intelsat), including Canada, that failure to adhere to Intelsat's directives on the use of domestic or regional satellites would result in "communications anarchy."

An official at the White House's Office of Telecommunications Management reiterates that Canada and the entire world would be better served if all countries used the space facilities of Intelsat. He says the U.S. will not put any insurmountable stumbling blocks in Canada's way if it insists on developing a system. But, he indicates, there will be a good deal of foot-dragging in the process. The U.S. might even propose—albeit reluctantly—a plan for a regional North American system if Canada cannot be dissuaded.

No sale. Canadians are in no mood for a joint venture with either Intelsat or the U.S. While agreeing that it's necessary to coordinate such matters as satellite positioning, effective radiated power, radiation patterns, polarization, and frequency stability, Canadians want assurances that any operational freedom they give up will be "on terms that are good for Canada," as the Chapman group puts it.

Conceding that Canada has a greater need for a satellite communications system than other countries, the U.S. telecommunications official says that he is sure an agreement can be made to provide sky space. He sees little immediate danger of overcrowding in the equatorial satellite belt, but a possibly critical problem in 20 or 30 years.

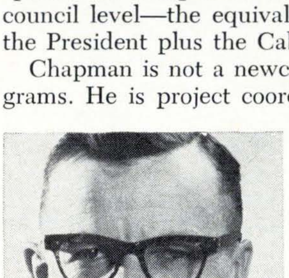
This spokesman is hopeful that the International Telecommunications Union will grant higher frequencies to communications satellites. He says there is a possibility of using the millimeter band—specifically, 16 to 18 Ghz for the down link and 35 Ghz for the up leg.

Above the battle. The Communications Satellite Corp. which holds a majority interest in Intelsat and plans a domestic satellite system

Coming and going

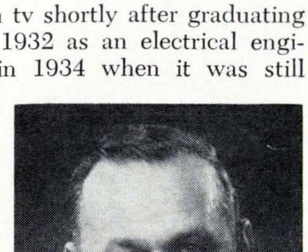
If Canada sets up a space agency—and it well might—the boss would probably be John H. Chapman. In July, Prime Minister Pearson appointed him to head the country's special task force on satellites, a group charged with putting Canada into the applications space race. Chapman's task force is operating at privy council level—the equivalent of the executive office of the President plus the Cabinet in the U.S.

Chapman is not a newcomer to Canadian space programs. He is project coordinator of the Canadian portion of the Alouette-Isis satellite project, and, until taking over the task force, was deputy chief superintendent of the Defense Research Board in charge of military telecommunications and radar programs. Chapman holds a doctorate in physics from McGill University in Montreal.



Alphonse Ouimet, sometimes called the father of Canadian television, will soon be retiring from his post as president of the Canadian Broadcasting Corp. He resigned last fall from the job he has held since 1953, but his actual departure will be deferred until legislation reorganizing the CBC is approved by Parliament—probably within a few months.

Ouimet began research in tv shortly after graduating from McGill University in 1932 as an electrical engineer. He joined the CBC in 1934 when it was still called the Canadian Radio Broadcasting Commission, and was the organization's chief engineer during the early years of tv's development. Ouimet is also credited with helping the Australians to develop a tv system of their own while working as a government consultant in that country in 1954.



for the U.S. has had little to say on Canada's plans beyond expressing support of President Johnson's statement. Anyway, Comsat says, the Canadians haven't notified it of their intentions in this area.

Comsat plans to begin domestic service by late 1969 [Electronics, July 24, p. 50]. Its program, subject to the approval of the Federal Communications Commission, includes two satellites, two terminals with two 85-foot dish antennas apiece, two terminals with 42-foot dishes, and 30 small receive-only facilities. The project is designed to serve the Western states, relaying eight tv channels and 6,200 voice or message circuits. Approval of the scheme is expected soon.

III. Spread thin

It's no good bewailing the passing of the pioneering spirit. Canada has to live with the fact that the exploitation of its rich mineral resources—a key to the nation's future prosperity—depends to a large extent on live television coverage of championship sports events. Mining companies report they are unable to recruit employees to work in areas that don't get live coverage of the Stanley Cup hockey and Gray Cup football classics. And establishing stable communities with families is all but impossible in areas without tv.

Providing nationwide tv is, however, but one of the reasons Canada is pushing hard for its own communications satellite system. With about 15% more land area than the continental U.S., Canada has only about 10% as many people. Although by no means undeveloped, the country's hinterlands lack the extensive microwave and land-line communications networks that blanket the U.S. In particular, because of prohibitive costs, the minerals-rich northern provinces lack direct lines to the well-served population centers along the St. Lawrence River and near the Great Lakes.

Prime Minister Pearson's administration has concluded that the only feasible and economic way to provide adequate telecommunications services to 20 million Canadians dispersed over nearly 4 million square miles of territory is to use satellite repeaters to relay telephone traffic and data trans-

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missions, as well as tv and radio signals, to local ground stations for rebroadcast.

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Alphonse Ouimet, president of the government-owned Canadian Broadcasting Corp., predicts that as many as 15 color-quality tv channels may eventually be needed to achieve coast-to-coast coverage. "We really have two networks at CBC," he says. The French-speaking minority of the population, about 6 million strong, has demanded and gotten completely separate programing and studio facilities.

To further complicate matters, Canada's vast breadth spans six time zones, and all programs except sports events have to be delayed and rebroadcast in each zone. And though French Canadians are concentrated in the eastern half of the country, every program must be rebroadcast in that language in four time zones.

Besides broadcasting in the two official languages, the CBC also beams programs to the Indians and Eskimos in the far north in their own tongues. Finally, the CBC, unlike U.S. networks, conducts regional operations serving specific areas of the country.

Natural enemies. Even the environment produces critical communications problems. Such phenomena as the northern lights, ionospheric storms, and a magnetic field that trails close to the moon's orbit from the sun are all factors in Canada's atmosphere that can affect terrestrial radio propagation.

Canada's policies are thus rooted more in necessity than in simple national pride. In space communications terms, Chapman says, the whole of the country is visible from only that part of the equatorial orbital plane lying between $\pm 20°$ of $95°$ west longitude. Because there are so few nonconflicting positions commanding Central and North America in that belt, Canada reasons it must stake its claims and secure them by physical occupancy as soon as possible.

IV. Technically speaking

So far as actual hardware, though, Chapman says: "Right now, what we want doesn't exist." However, the satellite system proposed this spring by the common carriers gives a good indication of the probable design that will be followed. The satellite would be a synchronous active repeater in a stationary orbit 22,300 miles above the equator. With 12 transponders, each capable of handling one color-quality tv channel or 1,200 one-way voice channels, the spacecraft would use uplink frequencies of 5.295 to 6.425 Ghz and transmit to ground stations at 3.7 to 4.2 Ghz. Effective radiated power would be 37 to 38 decibels above 1 watt. Solar cells for power would be backed by rechargeable storage batteries for use during periods of darkness or eclipse.

The common carriers recommend that Canada initially build three

Vast wasteland?

If an experimental scheme proves successful, the Canadian Broadcasting Corp. will provide television services to small, remote towns and mining camps in the far north. Yellowknife in the Northwest Territory, selected as the test site, has been getting four hours of programing a day since July via an Ampex Corp. 660 video tape recorder and a 5-watt transmitter. Programs are taped at the network outlet in Edmonton, Alberta, and flown to Yellowknife daily for rebroadcast. The local station, which cost about $20,000, has an effective broadcasting range of five miles.

Pending favorable reaction to the pilot program, the CBC plans to provide as many as 40 more communities with what it calls its "frontier package." Such an arrangement would fill part of the broadcast gap until communications satellites go into operation. Meanwhile, the 6,000 inhabitants of Yellowknife have apparently taken to the idea: by the time service began, local merchants had sold all their tv sets.

satellites. Two would be launched as soon as possible, one as a standby in case the other fails. The third would be ready for launching when needed. Useful life of the satellites is pegged at five years.

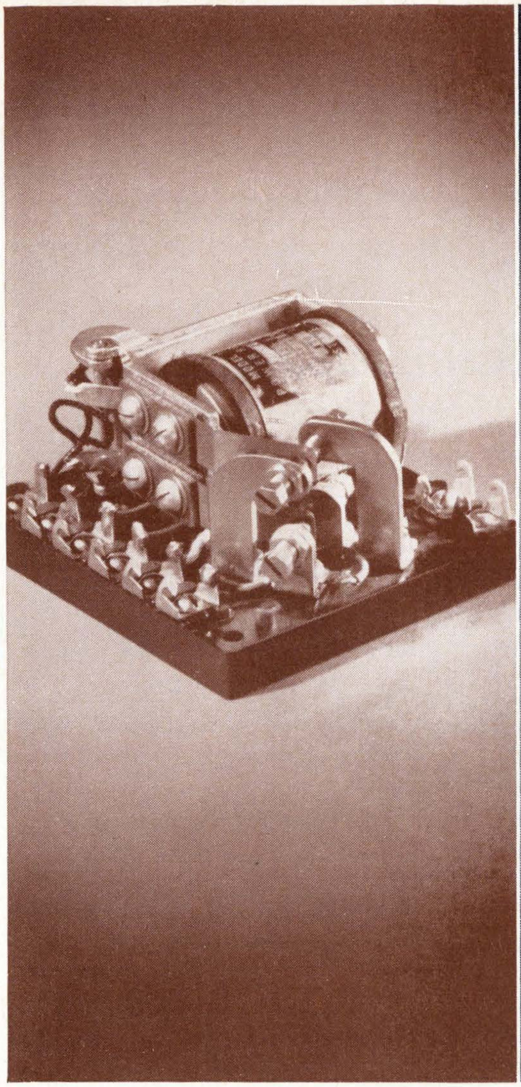
Nine transponders would be allocated for tv use. The CBC would get six of them, four for regional broadcasts and one each for English and French network transmissions. Canada's commercial tv would get a channel, and two would be used for educational purposes. The remaining three transponders would be devoted to message traffic, with one each allocated to the telephone system, the transportation companies, and remote telecommunications operations.

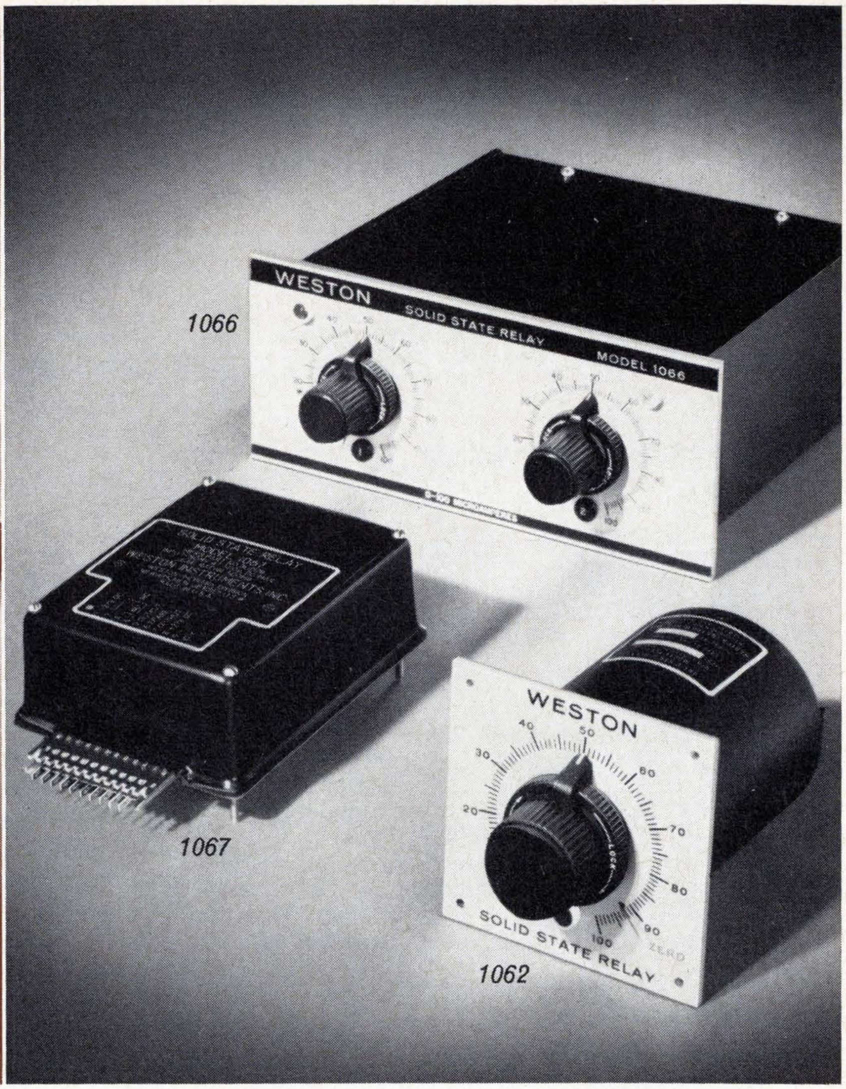
The carriers urge construction of 54 ground stations, 38 of them in Canada's far north country where telecommunications service is substandard or currently impossible. Operating costs, the carriers say, can be reduced by using 25-foot to 45-foot dish antennas with receivers equipped with parametric amplifiers that don't require cooling. Elimination of the need to perform tracking operations would also cut costs.

Openers. Canada's space ambitions are going to cost a lot, but the government appears more than willing to make the investment. Current annual spending on space projects comes to about $17 million, but Chapman is calling for outlays of as much as $70 million a year. Not all of this money would go for the communications satellite system, however.

Estimates of the system's cost run to $38 million for the 54 earth stations, proposed by the carriers, $17 million for three satellites, and $25.5 million for launching services.

Chapman calculates that Canada's optimum investment in space activities will total 0.1% of its gross national product—about in line with U.S. outlays for applications projects. However, Canada's spending wouldn't accelerate overnight. Government officials reason that it's unrealistic to expect stable growth rates of better than 35% a year because of Canada's relatively limited technical manpower. The $70 million rate of annual investment will probably be reached within four or five years.





Weston solid state relays make electromagnetic relays look like antiques

Now the "mechanics" has been taken out of adjustable relays and replaced with rugged, reliable solid-state circuitry. As a result, these three new Weston relays not only look modern, they offer solid-state performance, too . . . the kind that eliminates rejects and puts more money in your pocket.

Model 1062 is fully adjustable over its entire 320° scale, includes a trip indicator and zero adjustment on the front panel, and features a self-contained differential amplifier, power supply and SCR switching circuit. Model 1066 is a Dual Set Point Relay with a synchronizing circuit for time-sharing between channels. Either model can control a full amp at line voltage with ½% repeatability, 2% accuracy, and selectivity as low as 1 μa.

"Value engineered," low cost Model 1067 is designed for 28-volt dc operation and has a load rating of 500 ma at 50 watts ac. All three relays are dust-free, vibration-proof, and operate from 0° to 50°C.

Find out what solid-state technology has done for the relay. Get complete details from your Weston distributor today, or write: ***Weston Instruments, Inc., Weston-Newark Division, 614 Frelinghuysen Avenue, Newark, N.J. 07114,*** *a Schlumberger company.*

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IBM® Circuit Design and Packaging Topics

☐ General Radio relies on IBM reed switches

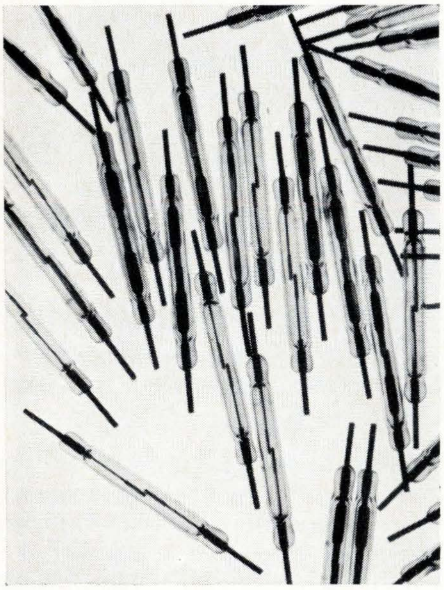
☐ Suppression circuits extend reed switch life

☐ General Radio relies on IBM reed switches

General Radio Company, West Concord, Mass., maker of test instruments, demands the best for their customers knowing that they can't tolerate equipment failure that will interrupt inspection or production routines.

That's why IBM reed switches go into General Radio's instruments.

General Radio uses reed switches in test instruments because they offer lower contact resistance than transistors, are smaller and more reliable than conventional relays.



General Radio confirms through its own vendor-component evaluation program that IBM reed switches show zero failures after 25 million operations.

GR's Service Department claims they can't afford anything less since tests prove that the IBM switch "just keeps on going."

As a result, General Radio relies on IBM reeds in nine varieties of instruments, including the GR 1680-A Automatic Capacitance Measuring Assembly, the 1770 Scanner Systems and four different models of Coherent Decade Frequency Synthesizers.

☐ Suppression circuits extend reed switch life

The miniature dry reed switch possesses characteristics which make it applicable to an extremely wide range of low power switching applications.

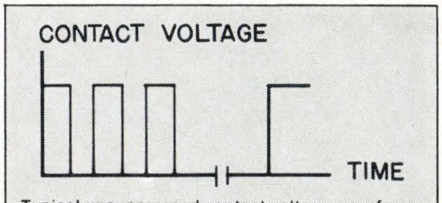
The reed offers rapid response, low actuate power, small size and a contaminant-free, adjustment-free contact arrangement. All of this provides the switching circuit designer with a highly adaptable device for modern, low-power, high density applications.

However, the construction of the miniature reed, with its small air gap and low-release spring force, makes it more susceptible to failure from contact degradation than any previous common contact switching device. Accordingly, special precautions must be taken when applying the miniature reed switch.

IBM conducts a continuing study to learn as much as possible about the reasons for contact degradation. Once we know why, we can take steps to prevent it—and, in some cases, prolong switch life by a factor of 10 or more.

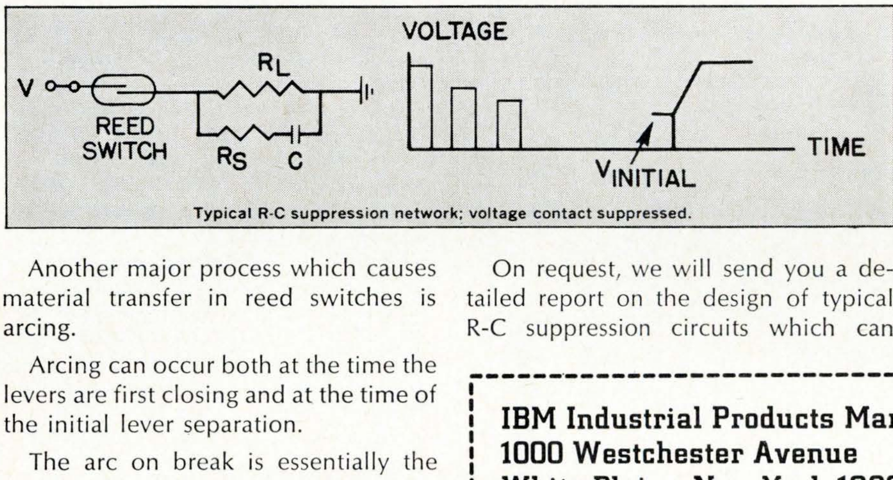
What causes a reed switch to fail after 20-million cycles in one application yet continue to function after several hundred million cycles in another?

Failure in the reed switch can be caused by material transfer which occurs each time the contact makes or breaks current. This material transfer, plus any magnetic particles caused by wear, form a mound in the contact area. The mound eventually causes failure by increasing the contact resistance or bridging the air gap.



Typical unsuppressed contact voltage waveform.

Bridge transfer occurs whenever two current-carrying conductors start to separate. The cross section of the contact point becomes increasingly smaller, giving rise to a constriction resistance that serves to heat the area. This heating effect first causes the metal to melt forming a bridge; then with further lever separation, to boil causing the bridge to rupture by vaporization.



Typical R-C suppression network; voltage contact suppressed.

Another major process which causes material transfer in reed switches is arcing.

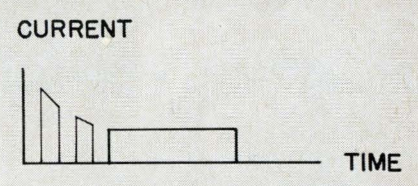
Arcing can occur both at the time the levers are first closing and at the time of the initial lever separation.

The arc on break is essentially the result of thermionic emission. It is caused by the heating of the levers, which in turn causes increasing constriction resistance at the time of lever separation.

The arc on make is caused solely by field emission and does not necessarily entail lever preheating. With open circuit voltages as low as 15 volts an arc can occur.

IBM studies to date indicate that major causes of contact degradation are a function of load conditions. It is a fallacy to rely exclusively on volt-ampere ratings in estimating contact life. For any particular load condition, contact life can be considerably extended through the use of suppressive techniques.

On request, we will send you a detailed report on the design of typical R-C suppression circuits which can maximize the life of your reed switches. Proper suppression techniques create new possibilities for circuit designers where speed, size and power are increasingly important.



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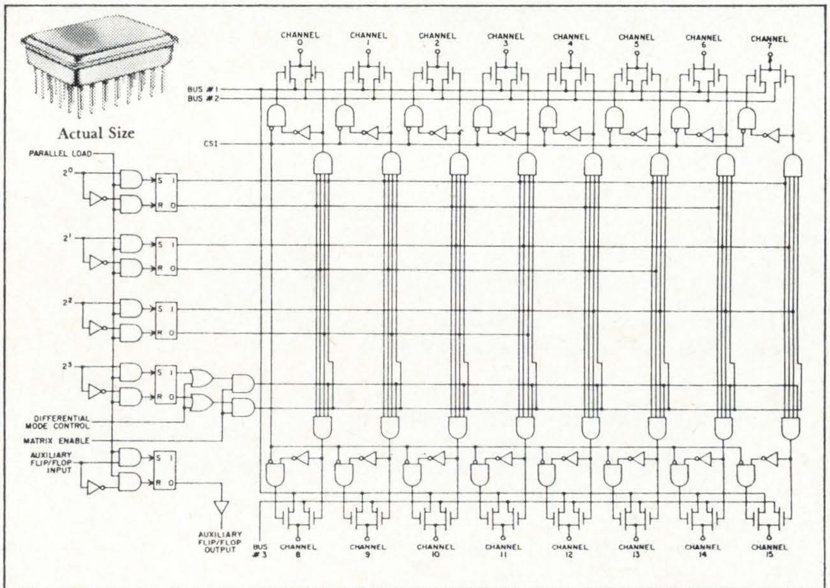

General Instrument's MEM 5015 is the newest complex integrated circuit available in the rapidly expanding line of MTOS firsts. It is a monolithic MTOS Large Scale Integrated Circuit containing 223 P-channel enhancement mode transistors on a chip 77 x 74 mils operating as a 16 channel randomly addressable multiplexer. The unit consists of four address holding flip-flops, a "four-in/sixteen-out" decoding matrix, 16 single-pole-double-throw switches, and some auxiliary logic for increased versatility. A Current Shunt Inhibit control line permits the selection of Current Mode or Voltage Mode multiplexing, while the Differential Control allows the switches to operate as eight ganged pairs. A Matrix Enable line allows multiple MEM 5015s to be connected to form larger multiplexing arrays.

The MEM 5015 is in a 40 lead hermetically sealed in-line package which can be soldered to a printed circuit board or used with a 40 pin socket. They're available off-the-shelf from your authorized General Instrument Distributor. In Europe, contact General Instrument Europe, Via Turati 28, Milano, Italy. Write for complete data.

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Data processing in 3-D

Holograms are made in crystal by a laser system that includes an air-suspended aluminum work table

Its most common manifestation seems to be three-dimensional pictures of toy trains and chess pieces, but the laser hologram can also help process side-looking radar data, predict the radiation pattern of phased-array radar antennas, analyze structural stress, and study seismic data.

A variation—Bragg-angle, or crystal, holography—is being investigated by the military [Electronics, Nov. 14, 1966, p. 52] and the National Aeronautics and Space Administration, and is now available to the public in a new data processing system from Carson Laboratories Inc.

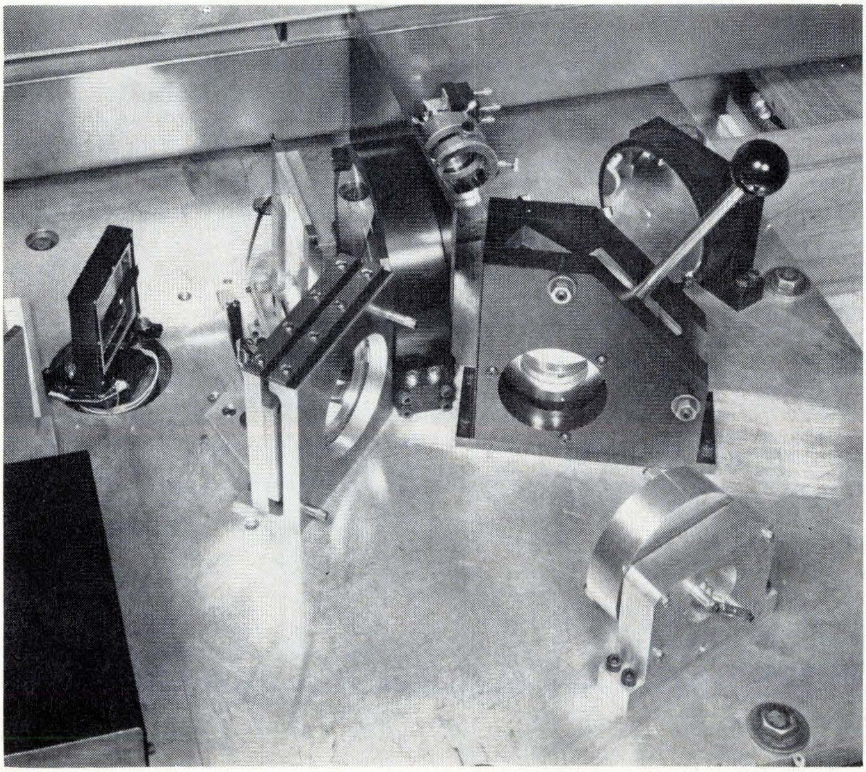
Two systems compete with Carson's. One, from Jodon Engineering Associates, is called a holographic camera and has a full set of equipment for making high-quality holograms on film or glass plates. A line of optical correlators from the Conductron Corp., a subsidiary of the McDonnell Douglas Corp., performs optical data processing. Carson's system does both and adds a crystal holographic capability to boot.

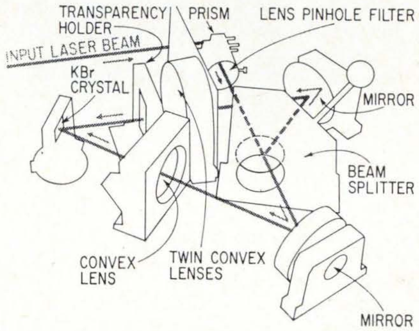
I. Multiple images

The Government is studying the use of Bragg-angle holography to store large amounts of data, such as engineering drawings or photos from planetary probes, in small volumes. But crystal holography's other features make it helpful in the research lab, and the Carson system makes the necessary equipment available in a single package.

Potassium bromide (KBR) stores data in the form of spots within its molecular lattice; the spots are bleached by laser light. A hologram consists of a thin layer of such spots. Since the angle of incidence of the light beams striking the KBR determines the depth at which the data is stored, multiple images can be stored by making slight changes in this angle between exposures.

Four advantages. Use of KBR rather than photographic plates has four advantages. First, no development is needed—one can even watch the hologram form within the crystal during exposure. Second, up to 50 holograms can be





Crystal set. Diagram shows how light travels among prototype components set up in photo at left to record analog data such as photos or drawings. After exposure, a joy stick is used to lift the beam splitter out of optical path. and the crystal can be viewed from the rear. In this early model, the stepping motor for the KBR crystal holder is below the table.

. . . one can watch the hologram form within the crystal during exposure . . .

stored within a single crystal by changing the angle at which the laser light strikes its face. Third, KBR has high optical resolution—at least 1,000 lines per millimeter. Finally, exposure to ultraviolet light erases stored data, leaving the crystal ready for reuse.

A good example of KBR holography would be the recording of bubble formation in viscous liquids. The crystal would be rotated through six minutes of arc as each new view is added. The hologram record wouldn't require development as would a photographic plate, and could be read out almost instantly by removing a beam splitter from the optical train by pulling on a joy stick, and rotating the crystal through the original angles. The result would be instant stop-action or moving photography in three dimensions, a valuable lab tool.

To simplify such recording, Carson supplies a KBR crystal mount with a stepping motor to move the crystal through its range of incidence angles, or to set it to a single one for stop-action viewing or single-shot holography.

Double exposure. KBR's high resolution makes it possible to find hot spots in components as tiny as integrated circuits. A hologram is taken with the IC inoperative and cool, and then with the IC working. This double exposure pinpoints hot areas by revealing their expansion; hot spots show up like measles.

In the event that the user's needs don't fit in with KBR, Carson supplies photographic-plate or film holders.

II. Optical correlation

The spatial filter is the key element in optical correlation and pattern recognition. To make a filter with the Carson system, the user first makes a transparency of the pattern to be identified, whether it's a waveform or a fingerprint, passes through it a collimated beam of laser light, and focuses it in the plane of a photographic plate. This gives a diffraction pattern of the original image—and a contact print of the diffraction pattern is a spatial filter.

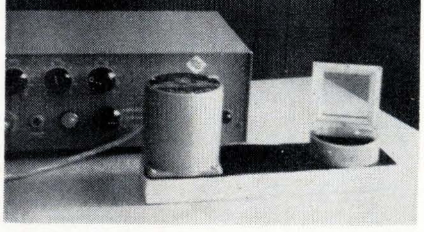
Spotting it. Optical correlation is performed by placing a transparency of raw data—a very noisy radar signal, for example—in a collimated laser beam. The beam then passes through a convex lens that focuses it in the plane of the spatial filter. Another convex lens beyond the filter forms the light into a "recognition" pattern in still another plane. Bright spots in this plane indicate a match—the waveform the user was looking for is contained in the raw data; blurs indicate a mismatch.

This sort of pattern recognition is one of the simplest forms of optical correlation possible with the new system, but enough optical accessories are included to accommodate most other arrangements.

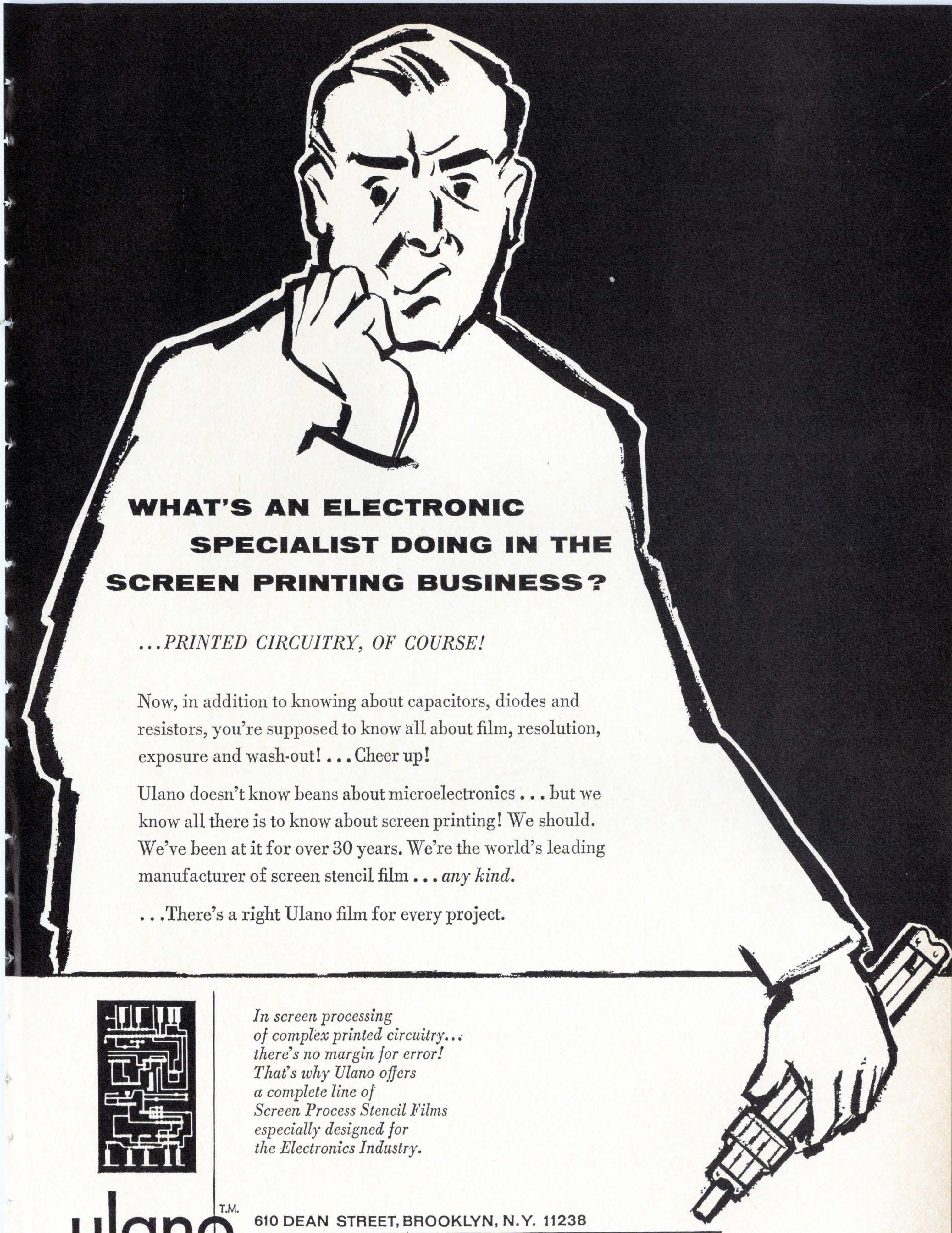
III. Stable table

Carson's system includes an air-suspended stable table, necessary because holograms must be made in a vibration-free environment. This table is as unconventional in a commercial product as is the KBR. Usual engineering practice would call for a granite slab on a foundation possibly going down to bedrock. In Carson's design, a lightweight metal table rests on air sacks inflated to about 5 pounds per square inch. These damp all vibrations and completely block any above 2 hertz.

The combination work surface and optical bench is a reinforced aluminum plate. It was chosen over granite because it can be



Playing the angles. Crystal at right is rotated by stepping motor whose controller is at the rear. Six arc minutes of rotation change incidence angle of laser beam enough to separate holograms.



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drilled and tapped easily—optical components such as mirrors and beam splitters can be bolted down and will stay put—and because the metal's high thermal conductivity makes it a stable surface. Thermal shock is dissipated rapidly and produces only momentary warpage, and this reduces the need for temperature control in the holographic lab.

The system's $11,500 price includes two KBR crystals as standard equipment, as well as the necessary rotating crystal mount and the stable table. Also covered are a red-emitting, 15-milliwatt helium-neon laser, two sets of fixed-angle and adjustable mirrors, a beam splitter, a selection of achromatic lenses with several focal lengths, a Polaroid film holder to record the results of optical correlation, holders for glass and film holographic plates, and holders for the transparencies needed in optical data processing.

Extras. For customers who want to make color holograms, or who need more light power, Carson offers a 100-mw argon-ion laser. Its emissions span the visual range, and for users who need power extending toward the ultraviolet, the same laser tube can be filled with krypton.

The argon-ion laser is one of a line of such systems just introduced by Carson. Not only is its plasma tube usable with various gases, but it's also warranted for 1,000 hours. Built of a ceramic material, it will outlast quartz plasma tubes by a wide margin, according to Carson.

A motorized film transport is available for users who want fast sequential input of optical correlation transparencies. And for those who want to record the results in style, Carson offers a 35-millimeter camera frame to replace the Polaroid film holder. Finally, for users who require the utmost accuracy in rotation of the KBR crystal, a servo-like control panel is offered with three separate vernier adjustments.

Delivery is within 90 days.

Carson Laboratories Inc., 375 Lake Ave., Bristol, Conn. 06011 **[338]**

RESOLVER/SYNCHRO DIGITAL CONVERSION

A very short course for engineers who are concerned with converting resolver or synchro data to digits and vice versa.

Engineers working in digital computer input/output interface systems for tactical airborne equipment, aircraft and space vehicle simulation, antenna positioning or programming, and similar systems are increasingly involved in solving the digital/analog interface problem for resolver and synchro data. Accomplishing this task becomes quite simple by taking advantage of North Atlantic's family of high accuracy resolver/synchro converters. Through the use of solid-state switching and precision transformer techniques, these converters provide single-speed accuracy and resolution from 10 to 17 bits, along with solid-state reliability and calibration-free operation.

Resolver/Synchro-To-Digital Conversion At 2000°/sec.

One typical North Atlantic resolver/synchro interface is shown in Figure 1. It continuously converts 400Hz resolver and synchro angular data to digits at angular velocities up to 2000°/sec. This device

Figure 1. Model 545 Automatic Angle Position Indicator converts resolver and synchro angles to digital form.

utilizes micro-circuits and all solid-state plug-in cards in conjunction with precision trigonometric transformer elements (no motors, gears, or relays), and operates at all line-to-line voltages from 9 to 115 volts. It can be supplied in a wide range of configurations for specific system requirements. For example, signal frequency bands of 50Hz to 1600Hz or 50Hz to 4.8K Hz, BCD digital outputs, .001° resolution with 10 arc second accuracy and multi-speed inputs. The unit illustrated has an accuracy of .01°, and offers added submodes of operation; they are Command (single update and hold), and Free-Run (repetitive update and hold) for observation of changing or noisy data. Prices start at $5900.00.

Digital-To-Resolver/Synchro Conversion

North Atlantic's all solid-state digital-to-resolver/synchro converters (Figure 2) accept digital input data at computer speeds in either binary angle or binary sine/cosine form and convert to either resolver or synchro data. Their high accuracy and resolution (up to 17 bits) and freedom from switching transients meets an important requirement in space-mission simulation and antenna positioning systems for smooth servo performance at low rates of data change. All models are usually supplied with input storage registers.

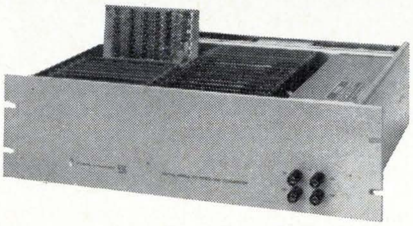

Figure 2. Series 536 Digital-To-Resolver Converters translate binary digital angle to four-wire resolver data.

Depending on the combination of features specified, prices are in the $4500. to $6000. range.

Modular D-R/S Converters For High-Density Systems

The plug-in converters pictured in Figure 3 were developed by North Atlantic specifically for airborne systems and for aircraft simulation systems requiring high-density multi-channel operation. The modules illustrated provide 11-bit digital-to-synchro conversion and are capable of driving up to four torque receivers. As with other North Atlantic resolver/synchro interfaces, conversion is achieved through solid-state switching and trigonometric transformers, so there are none of the stability or calibration problems associated with conventional resistor-chain/amplifier type converters. Prices, in production quantities, run about $1100. per set. In prototype quantities about $1500. a set.

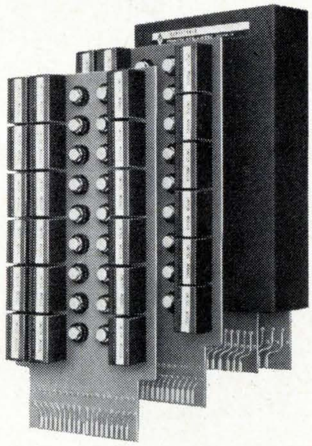

Figure 3. Series 537 D/S Converter Modules can drive multiple torque receivers from 11-bit digital data.

If you would like to take advantage of North Atlantic's state-of-art experience in resolver/synchro computer interface, we would be pleased to show you how these converters can meet your particular requirements. Or if you prefer, we will arrange a comprehensive technical seminar for your project group, without cost, in your own plant. Simply write: North Atlantic Industries, Inc., 200 Terminal Drive, Plainview, N.Y. 11803. TWX 510-221-1879. / Phone 516-681-8600.

PRECISION AC INSTRUMENTATION FOR TEST, MEASUREMENT AND DATA CONVERSION

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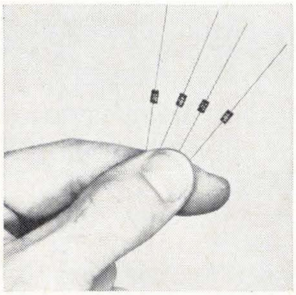
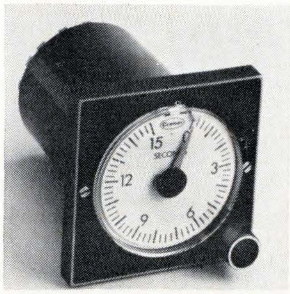
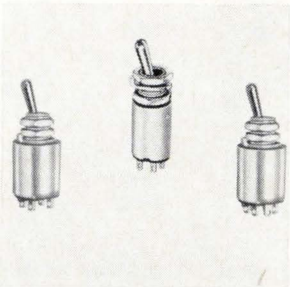
New Components Review



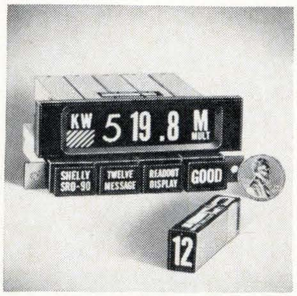
Subminiature ceramic tubular capacitors series CT07 are rated at 50 v d-c over a temperature range of −55° to +125° C. Capacitance values are from 10 to 10,000 pf in tolerances of +10% and +20%. The capacitors exceed the requirements of MIL-C-11015. They measure 0.165 x 0.095 in. Gulton Industries Inc., 212 Durham Ave., Metuchen, N.J. [341]



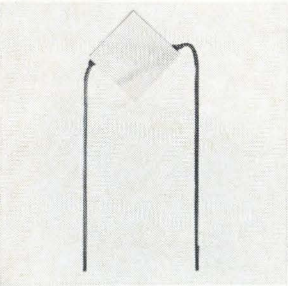
A plug-in industrial reset timer provides instant interchangeability for circuit testing and maintenance. Model 400 has time ranges from 6 sec to 96 hours, accuracy within 0.25%, and 2 load and 2 instantaneous switches. Applications include control of machine tools, induction heating equipment, and conveyor controls. Cramer Division, Conrac Corp., Old Saybrook, Conn. [342]



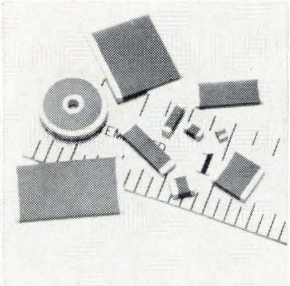
Rfi-shielded toggle switches attenuate conduction and radiation in the 0.14-to 200-Mhz range. They are suitable for radiation-free airborne electronic equipment conforming to MIL-I-26600. Series TR2100, 2150, and 3100 have an operating torque of 20 in.-oz max. Prices start at $7.56. Control Switch Division, Controls Co. of America, 1420 Delmar Dr., Folcroft, Pa. [343]



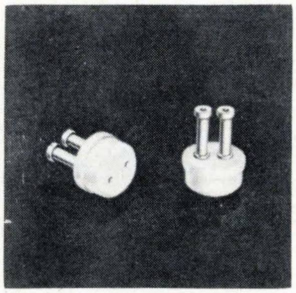
Ultraminiature rear projection readout SR-90 has 12-message capability. It reads out symbols, characters, or up to 4-line messages 0.1 in. high. Front dimensions are 0.650 x 0.460 in. Lamp replacement is accomplished from the front panel, by removing the readout from the housing assembly. Shelly Associates Inc., 111 Eucalyptus Dr., El Segundo, Calif. 90246. [344]



Thermoelectric module 3954-1 spot cools small components and controls temperatures of biological specimens. It is permanently mounted between 2 aluminum plates for mechanical strength and uniform cold junction temperatures. Units measure 4 sq cm with a heat-pumping capacity of 30.6 BTU/hr. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. [345]



Ceramic chip capacitors are moisture resistant and contamination free in small rectangular, large rectangular, square, and monolithic disk feed-through configurations. Type K-1200 series, available in 51 models, ranges from 10 pf to 1.5 μf. They operate from −55° to 125°C. D-c working voltages are 50, 100, and 200. Monolithic Dielectrics Inc., Box 647, Burbank, Calif. [346]



Two-pin, feed-through terminal FT-MC-300 features tubular lugs mounted in a single Teflon bushing suited for multiconnection applications in compact assemblies. Component leads come up from beneath the chassis, through holes in the lugs, and are then soldered in place. Circuit wiring can be attached to the outer lugs. Sealectro Corp., 225 Hoyt St., Mamaroneck, N.Y. 10543. [347]

Circular connectors type ESM are bayonet locking, subminiature, and have a high contact density (0.080 in. center-to-center). They come in a 37-contact version in a No. 12 shell, and a 92-contact type in a No. 18 shell. Contacts are rated at 5 amps. They accept 22-, 24- or 26-gauge wire and are accessible from the rear of the connector. Elco Corp., Willow Grove, Pa. 19090. [348]

New components

Diode chips for automatic tuning

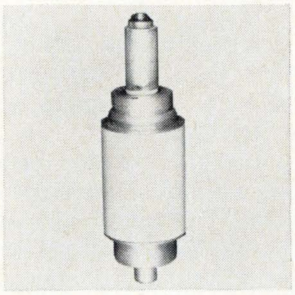
Variable-capacitance units are available for use in hybrid integrated circuits

Totally electronic tuning systems are replacing everything from the fine-tuning controls in television sets to the ganged capacitors in a-m radios. The heart of these systems is a voltage-variable capacitor diode—a device whose capacitance is a function of applied voltage.

The availability of these diodes in chip form gives designers of hybrid integrated circuits the ability to design a complete IC to perform tuning tasks.

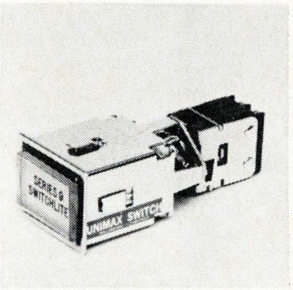
Fallout. The series VVCC diodes were originally developed for a large electronics firm by MSI Electronics Inc., but the order was cancelled and MSI is marketing the chips themselves.

The diodes are available in capacitance ranges from 3 to 18 picofarads, with a tuning ratio of 2:1. Each chip measures 0.020 by 0.020 by 0.008 inch, and the junction contact varies from 0.002 to 0.011 inch in diameter depending upon the capacitance value. The chips can dissipate up to 300 milliwatts; the operating junction temperature is rated at 150°C, although

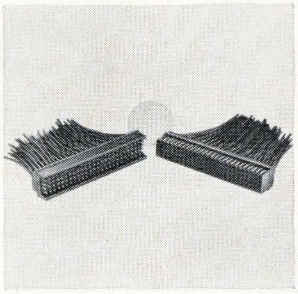


Variable capacitor CAQA-200 utilizes ceramic and copper materials with a vacuum dielectric. It handles 50 amps rms at 16 Mhz. Temperature rating is 120°C. Capacitance range is 10 to 200 pf. Over-all length is 3.75 in., diameter 1.31 in. The CAQA-200 makes possible the design of compact transmitter tank circuits. Jennings Division, ITT Corp., Box 1278, San Jose, Calif. [349]

A 40-pole, double-throw relay package has 2-amp, 28 v d-c resistive contacts. The SR package eases replacement of individual switching units, eliminating the need to replace the complete unit. The sealed relays operate in a −65° to +125°C range, withstand 50 g shock for 11 msec, 20 g vibration from 10 to 2,000 hz. Branson Corp., Vanderhoof Ave., Denville, N.J. [350]

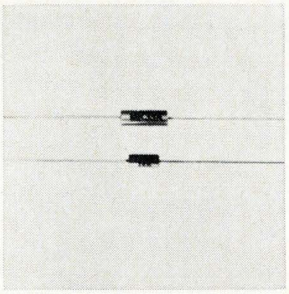


Illuminated pushbutton controls designated LPB series 9 consist of 4-lamp units that meet MIL-S-22885 requirements. Features include two-step (push-pull) relamping, and factory-installed internal lamp bussing. The LPB's are available with 2-, 3-or 4-pole momentary or alternate action switching. Unimax Switch Division, Maxson Electronics Corp., Wallingford, Conn. [351]

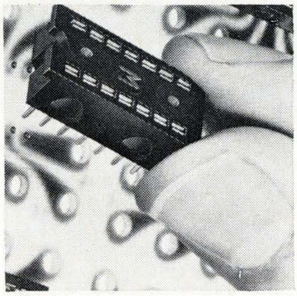


Miniature phenolic connectors offer from 4 to 104 circuits in multiples of 4. They have aligning ribs to assure positive polarity. The connectors are UL recognized to 250 v a-c at 5 amps average per contact. They can be used by manufacturers of computers, communications equipment, and consumer-type equipment. Molex Products Co., 5224 Katrine Ave., Downers Grove, Ill. 60515. [352]

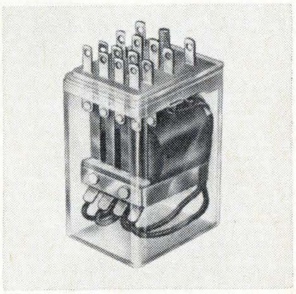
Ten-turn wirewound pot model 3253 PixiePot is ⅞ x ¾ in. and weighs ½ oz. Resistance tolerance is ±5% over 100 ohms to 100 kilohms. Linearity is ±0.25% and resolution is typically 0.222. Units are rated at 2w at 25°C. Price is $5.95 in lots of 1 to 24; less than $4 in production quantities. Duncan Electronics Inc., 2865 Fairview Rd., Costa Mesa, Calif. [353]



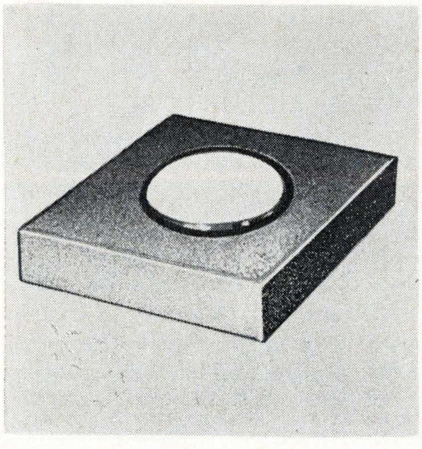
Molded metal film resistors conforming to MIL-R-10509E come in 2 types. The MR-31 and MR-39 have wattage ratings of 0.1 and 0.125 respectively. Units have a ceramic core on which a metal film is deposited. End caps make contact with the resistive film. Tinned copper leads are resistance welded to the end caps. Mepco Inc., Columbia Road, Morristown, N.J. [354]



Dual in-line IC sockets series M-1000 have universal mounting capabilities. They can be p-c-board mounted with standard 0.100 x 0.300 pin spacing and have snap-in features for mounting into punched aluminum panels to ⅛ in. thick. Prices range from 15 cents each in large production quantities. Methode Manufacturing Corp., 1700 Hicks Rd., Rolling Meadows, Ill. [355]



Magnetic latching relay type RR is offered in voltages ranging from 24 to 220 v a-c, and 12 to 110 v d-c. Standard design incorporates 4PDT contacts in fine silver, silver-cadmium oxide, gold nickel, silver palladium (60/40), and silver palladium (30/70). Mechanical life is 100 million operations. Schrack Electrical Sales Corp., 1140 Broadway, New York 10001. [356]



Contact. White dot on diode chip is junction contact.

the chip will withstand temperatures of up to 400°C for short periods.

Junctions are processed to resist adverse ambient conditions with an exclusive MSI silicon thermal oxide protection technique. The diodes have a 30-volt breakdown rating with a leakage current of 0.1 microamps measured at 20 volts reverse bias, and have a Q factor in excess of 200 at 50 megahertz.

Prices range from $4.50 to $16.50, depending upon capacitance, and delivery is from stock.

MSI Electronics Inc., 34-32 57th St., Woodside, N.Y. **[357]**

New materials

Dichlorethane's in — and dirt's out

Solvents for cleaning circuit boards remove dirt, leave part numbers

In a comment that might have been written for a Tide ad, the Union Carbide Corp. says that its

. . . for tough cleaning jobs, another mix . . .

new solvent for cleaning printed-circuit boards provides gentle, controlled cleansing and a lifting, floating action that will get dirt out of even the smallest crevices in a p-c board assembly.

The solvent was concocted because customers had complained that straight trichlorotrifluorethane—the standard 113-type solvent—didn't always do a good job. Sometimes it left contaminants on the board. Sometimes it dissolved printed identification numbers on components while leaving quality control markings, scribbled with grease pencil, on the boards.

Ink is safe. To the basic 113, the company added dichlorethane and called it 113 DCE. The additive allows the solvent to remove pencil markings, but not the standard component marking inks, and to do a more thorough job of removing soil. It also controls the cleaning action of the fluorocarbon base material, making it less harsh, the company adds.

Union Carbide also has another new type, 113 MCP, consisting of the basic 113 plus methylene chloride and cyclopentane. This is equivalent to Mr. Clean. Intended for tougher cleaning jobs, it will root out polymerized solder fluxes, greases, oils, and waxes—and those grease-pencil scrawls—but it still won't harm most component marking inks.

Samples ready. Type 113 DCE is exclusive with Union Carbide; 113 MCP is similar to a solvent made by the du Pont Co. Union Carbide is making samples available for test and evaluation. Sales in bulk—from 5 gallons to a tank car—will be made after Oct. 1. The company hasn't set prices for bulk quantities.

Both new solvents are aziotropes, which means they have constant boiling points and can be reclaimed, when full of dirt, by the usual distillation equipment. They don't require inhibitors or stabilizers and can be used in dip or ultrasonic baths, spray cleaners, vapor degreasers, and similar washing equipment.

Union Carbide Corp. Chemicals and Plastics, 270 Park Ave., New York 10017 **[358]**

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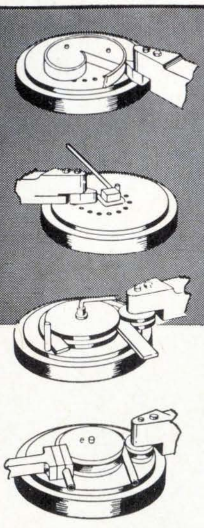
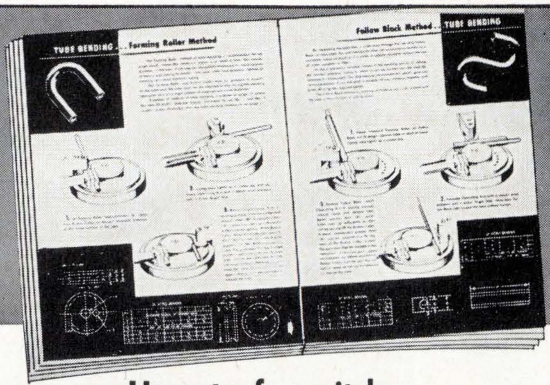
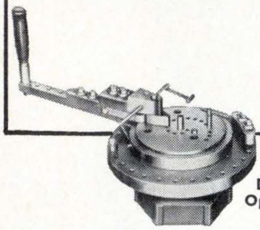






Ceramic magnet is 25% smaller

Improved resistance to demagnetization reduces size of focusing magnets

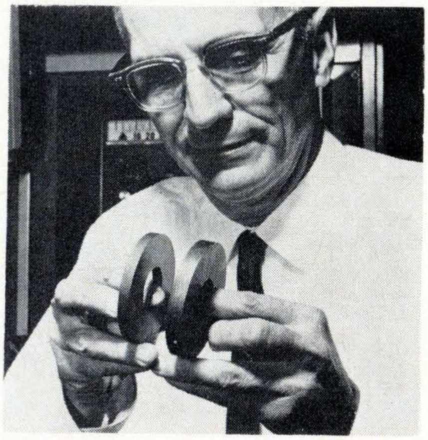
Traveling-wave tubes and motors can be made smaller if designers switch from the Indiana General Corp.'s Index 6-A ceramic magnet material to the new Indox 7. Focusing magnets in TWT's, or motor magnets, will give the same performance in 25% less volume.

Indox 7 was developed for applications requiring good flux output during or after exposure to severe demagnetizing influences. In motors, magnets must fight the armatures during stalls or starts, and in tubes must resist the like poles of neighboring magnets. Only high-priced cobalt-platinum does this better than Indox 7, says James R. Ireland, research and engineering vice president of Indiana General.

The specification that counts is B_rH_x (residual induction times the intrinsic magnetization curve's H coordinate at 0.8 B_r). Index 6-A has a value of about 9.5 million, while Indox 7 has 12.7 million.

Production of ring-shaped magnets has started, and facilities to produce arc-shaped magnets will soon be ready.

Indiana General Corp., Magnet Division, Valparaiso, Ind. **[359]**



New ring. Slim magnet in the left hand is as strong as the fat ring.

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- Tolerance to ±1% available

Product information is available from TRW Capacitor Division, TRW INC., Box 1000, Ogallala, Nebraska. Phone (308) 284-3611. TWX: 910-620-0321.

*DuPont's trademark for polyester film.

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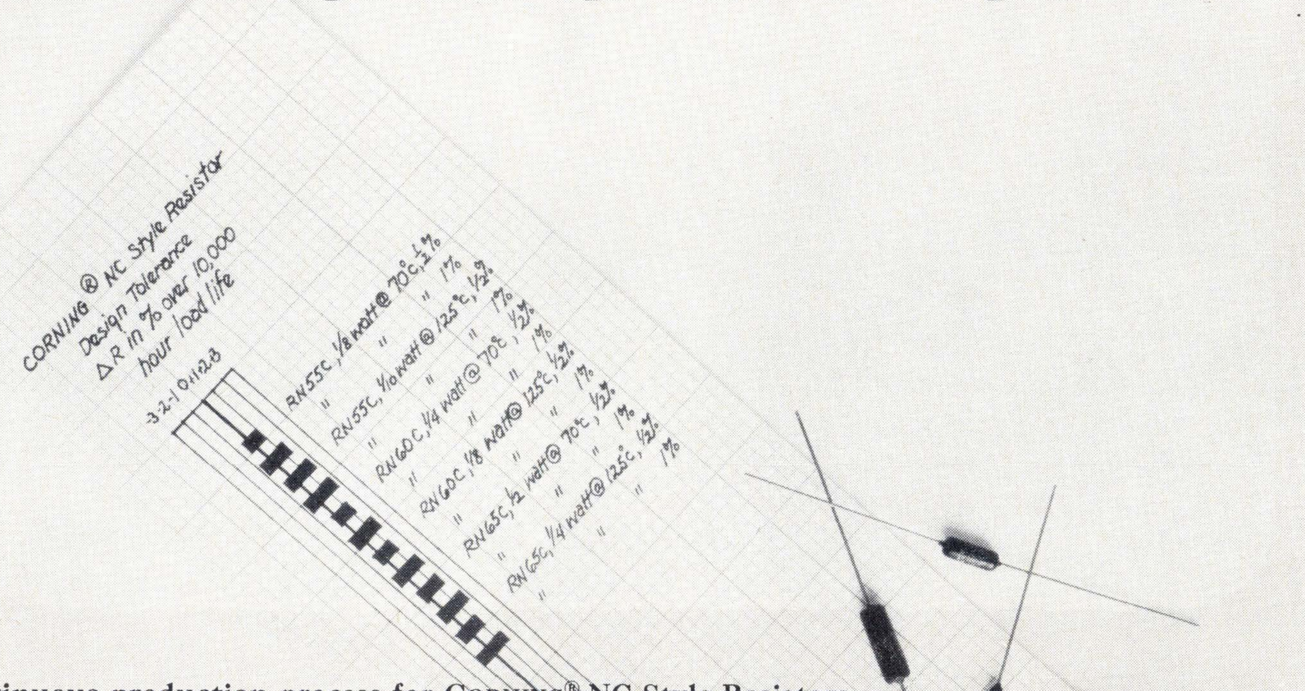

The continuous production process for CORNING® NC Style Resistors gives you total uniformity to these specs:

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Precise data is yours for the asking from your Corning distributor, or by writing to: Corning Glass Works, 3913 Electronics Drive, Raleigh, N. C. 27602.

CORNING
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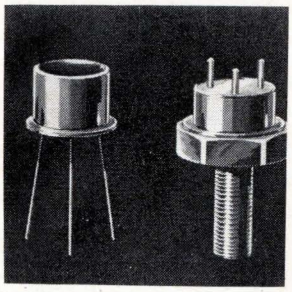
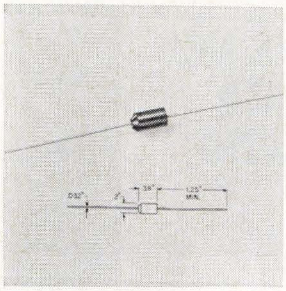
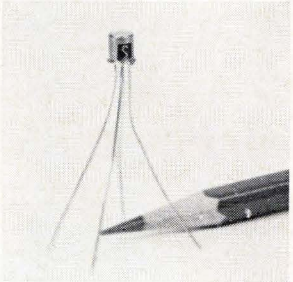


Silicon npn transistors A200/A201/A202 serve as class C r-f amplifiers. Power output is 1w, 7 w, and 12 w; gain is 10 db, 6 db, and 6 db, respectively. The inherently fail-safe units are intended for use in 12 v, battery-operated 175 Mhz mobile communication systems. Semiconductor and Receiving Tube Division, Amperex Electronic Corp., Slatersville, R.I. 02876. [436]

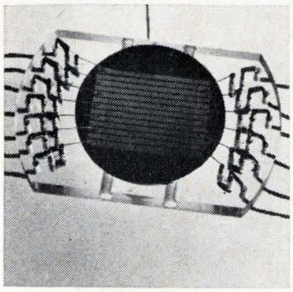


Axial-lead silicon rectifiers rated at 2 amps have a surge rating of 200 amps. Piv ratings range from 50 to 1,200. The devices are 0.2 in. in diameter and 0.38 in. long with a transfer molded, void-free body. They replace 7/16-in. stud units and eliminate heat sinks. Price of a typical unit—the MIBO (200v)—is 64 cents each. Electronic Devices Inc., 21 Gray Oaks Avenue, Yonkers, N.Y. [437]

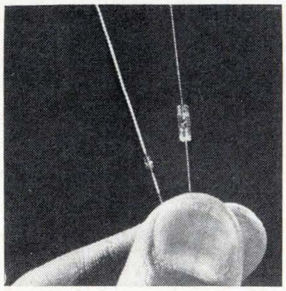
Engineers experimenting with semiconductors can cut prototyping costs by 75% with a designers' kit of plastic-encapsulated components. Pnp and npn switching and amplifier transistors, FET's, unijunction transistors, scr's, silicon power transistors and an IC operational amplifier are included. Price is $24.50. Texas Instruments Inc., 13500 N. Central Expressway, Dallas. [438]



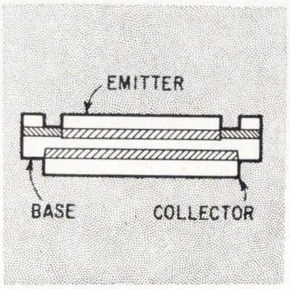
Silicon planar npn Darlington transistors 2N2723-4-5 are 2 transistor chips mounted in either a 3- or 4-lead TO-18 package. Characteristics include h_{FE} within 10%, V_{BE} matched within 30 mv, and temperature tracking within 100 μv/°C. Applications are constant-current supplies and voltage comparators. Solitron Devices Inc., 1177 Blue Heron Blvd., Riviera Beach, Fla. [439]



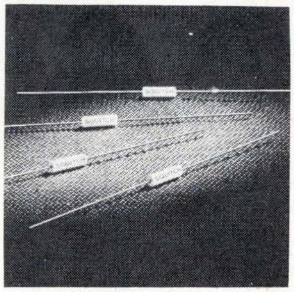
Gold-striped semiconductor detector 5441 on an n-type silicon disk is used for studying the structure of a beam of charged particles. It may be used in a beta spectrometer for the simultaneous measurement of electrons with slightly different energies. Resistivity is greater than 10,000 ohm-cm. Energy resolution is less than 35 kev. AB Atomenergi, Studsvik, Nykoping, Sweden. [440]



Mini-Mono, whiskerless glass diodes 1N5315 and 1N5316 are less than 1/9th of the standard subminiature DO-7 glass package. Minimum breakdown voltage at 10 μa is 100 v. Forward voltage drop at 10 ma is 0.650 and 0.690 v minimum for the 5315 and 5316. Reverse current at 50 v is 50 na. Continental Device Corp., 12515 Chadron Ave., Hawthorne, Calif. 90250. [441]



Utilizing the ADE (alloy diffused epitaxial) construction process, the MP2200A-2400A germanium transistors are suited for core driving, power conversion, and high-voltage switching where high power handling capability (80 to 120 v minimum at 8 amps) is needed. Prices range from $2.25 to $2.60. Motorola Semiconductor Products Inc., P.O. Box 995, Phoenix, Ariz. 85001. [442]



A radiation-hard squib firing switch withstands nondestructive testing. Called Squitches, the 2-terminal devices are made of Ovonic amorphous semi-conductor materials encapsulated in standard DO-7 glass envelopes. Blocking resistance is over 1 megohm in the off-condition, switching speed, less than 1 nsec. Energy Conversion Devices Inc., 1675 W. Maple Rd. Troy, Mich. 48084. [443]

New semiconductors

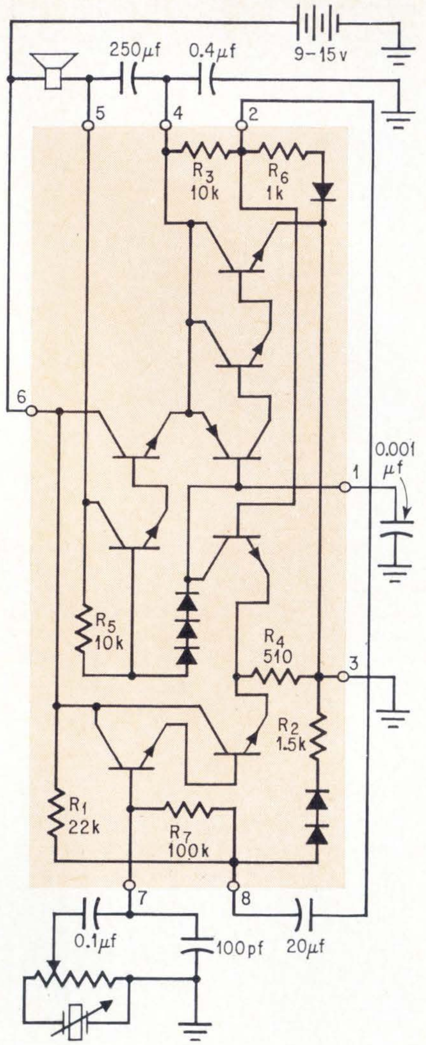
IC line is based on feedback

Phonograph makers were sounded out before Westinghouse designed its first low-cost consumer IC, an audio amplifier

Latest to join the ranks of semiconductor suppliers introducing integrated circuits for consumer application is the Westinghouse Electric Corp.'s Molecular Electronics division. The company's deliberateness was caused in part by a market-research effort that sent a team of engineers into consumer plants to ask manufacturers of entertainment equipment what they planned in the way of new products and how IC's could help.

The answers resulted in Westinghouse changing circuit designs considerably to satisfy performance requirements. One product was the audio amplifier; the research team brought back the word that the makers of phonographs had specific demands: mainly, they wanted a circuit that required a low-voltage power supply and had a high-input impedance because the signal it would handle was likely to come from a ceramic pickup, which has a high impedance. At least 1 watt would be required to drive a typical speaker of 4 to 16 ohms impedance.

Westinghouse's amplifier WC334, built to specifications suggested by the inquiring engineers, is rated at 1¾ watts, requires 9 to 15 volts,



Push-pull. Output stage delivers more than a watt to speaker.

and has an input impedance of 400 kilohms. It is intended for phonographs, and its low-voltage rating makes it usable in battery sets.

Building resistance. Hardest part of fabricating the WC334 was building in the high impedance. To do it, Westinghouse designers chose a signal path whose configuration was a Darlington amplifier connected to the emitter follower. The gain of the Darlington multiplied the 510-ohm emitter-resistor to produce a signal whose input impedance was several-hundred kilohms.

Instead of using large-value resistors to increase the impedance of the bias networks, the company turned to positive feedback or bootstrapping. The feedback signal is obtained at the output from the resistive divider formed by R_3 and R_6 in the schematic, and applied to the 100-kilohm resistor, R_7, feeding the bias to the input.

As the bootstrap signal raises and lowers the voltage on R_7 with fluctuations of the applied signal, the current drain through R_7 decreases, making that resistor appear larger. The effect is enough to multiply R_7 tenfold, so the bias impedance looks as if it were a megohm to the signal. This prevents shunting the signal to ground.

Output. The output circuitry is direct drive push-pull, which is capable of good performance without the use of an output transformer.

Because the push-pull stages are self-centering across a wide range of power-supply voltages—from less than 9 to more than 15 volts—the same circuits can be used in phonographs with different power-supply voltages. And it can continue to operate satisfactorily after the batteries have started to run down.

Westinghouse hopes to make its new amplifier competitive by pricing the circuit between $1 and $2 in large quantities.

Molecular Electronics division, Westinghouse Electric Corp., Elkridge, Md. **[444]**

New semiconductors

For stereo, two circuits in one

Isolation of 50 db separates channels in IC preamplifier

You don't get two for the price of one when you buy the new dual preamplifier for consumer stereo applications made by Motorola Semiconductor Products Inc., but you do get the first integrated circuit dual preamplifier on the market. It is priced competitively with single preamplifiers now available.

The two preamplifiers on a single monolithic chip are in a dual in-line plastic package designated MC1302P. In addition to saving space because the two preamps are in one package, the device provides isolation that is "quite good for stereo," says Clay Tatom, Motorola's linear-product planner for ic's. Channel separation is 50 decibels at 1 kilohertz, and 45 db at 10 khz. This is better than the 25-db sep-

. . . frequency response goes back to flat . . .

aration offered by stereo cartridges.

Clips crosstalk. Signal isolation is not necessarily obtained when two separate preamps are used. The signals can be coupled through the power supply, introducing crosstalk that can kill the stereo effect. Motorola not only eliminates the crosstalk problem, but does it on one chip, avoiding the need for isolation components in the outside circuitry.

The MC1302P is designed primarily for use in low-level audio signal processing, such as built-in responses for the Recording Industry Association of America's (RIAA), and the National Association of Broadcasters' (NAB) playback equalization curves for disk and tape recorders.

The output signal from a microphone in a recording studio is flat with frequency, but as the signal is recorded, the intensity of low frequencies is decreased, and that of high frequencies is amplified. To produce a flat response when the disk or tape is played back, the low frequencies must be amplified and the high frequencies must be attenuated.

Going flat. The dual preamp is employed in one type of circuit to give a flat response in RIAA applications, and in another type of circuit to produce a flat response in NAB applications. Typical gain using the MC1302P in the RIAA curve is 40 db, with 30 db for the NAB curve. Maximum distortion with an output of 1 volt rms is 0.8% for the RIAA characteristic, and 0.3% for the NAB characteristic.

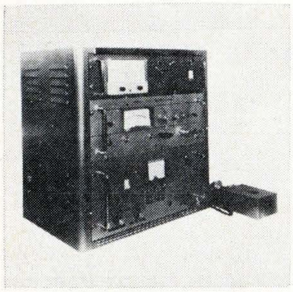
Selling for $4.20 in quantities of 100 or more, and $3.50 in lots of 1,000, the cost of the MC1302P compares favorably with the $2 price for single preamps. And these single devices are not designed specifically for stereo applications.

Specifications

Supply voltage	+8 vd-c and —8 vd-c
Differential input signal	+ or — 2.0 v
Output short circuit duration	continuous
Power dissipation	400 mw at 25°C
Operating temperature	0 to 75°C

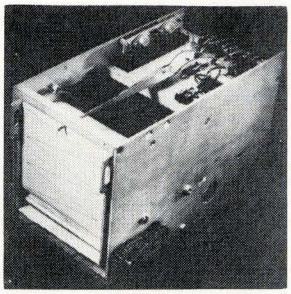
Motorola Semiconductor Products Inc., Box 955, Phoenix, Ariz. 85001 **[445]**

New Instruments Review

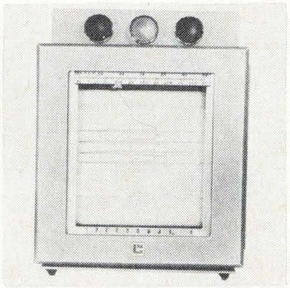


Magnetic stabilizer model MS-10 fully charges and stabilizes metallic alloy magnets up to ¼ lb with a stabilization accuracy within 2%. It is capable of up to 1,000 charging cycles per hour. It is available in 115-v or 230-v models with single pushbutton or foot pedal operation. Instrumentation Division, Thomas & Skinner Inc., 1120 E. 23d St., Indianapolis, 46207. [361]

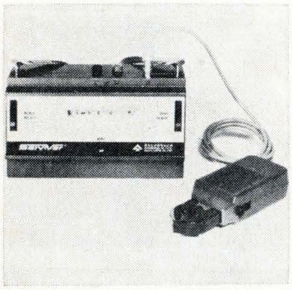
Amateur and Citizens Band radio operators can measure noise, resonant frequency, and operating impedance of whip antennas, dipoles, beams, and quads using an antenna noise bridge and a receiver that tunes the range of interest. Operating range is 0.5 to 150 MHz, from 0 to 100 ohms. Price is $24.95. Omega-t Systems Inc. 516 W. Belt Line Rd., Richardson, Texas. [362]



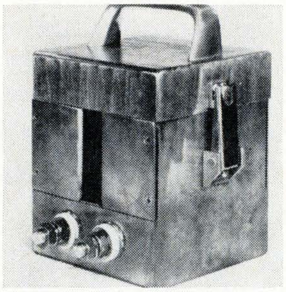
A single-channel analog recorder has 100-mm channel width. Single, dual, or multiple speeds in the range from 1 mm/sec to 100 mm/sec can be supplied. Amplifiers and power supplies are available for sensitivities from 1 mv/cm to 50 v/cm. Frequencies up to 125 hz can be recorded. Mechanics For Electronics Inc., 152 Sixth St., Cambridge, Mass. 02142. [363]



A dual-range Speedomax recorder measures molten-metal temperatures with the Temtip expandable immersion thermocouple, as well as carbon equivalent (or other analyses) with the Tectip thermal-analysis detector. This offers a savings for foundries and meltshops over the 2 recorders normally required. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia. [364]

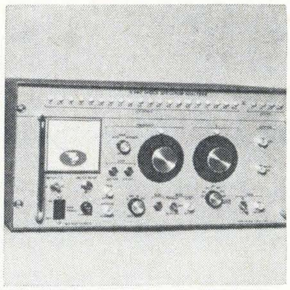


ServiVar is a battery-operated instrument that measures a-c voltage from 25 to 600 v at frequencies from 25 to 500 hz; a-c current, from 0.2 to 100 amps at 60 hz; and resistance, from 50 to 100,000 ohms. A snap-around probe allows readings in hard-to-reach locations. It accommodates wire up to 0.5 in. Bacharach Instrument Co., 200 N. Braddock Ave., Pittsburgh, Pa. [365]



An injection-current probe can be clamped around d-c, 60 hz or 400 hz power lines carrying up to 300 amps, without altering their transfer characteristics. Designated GIP7418, it is also capable of injecting 1 amp from 100 hz to 100 khz into a circuit using an audio amplifier as the source. Genistron Division, Genisco Technology Corp., 18435 Susana Rd., Compton, Calif. [366]

The Micro/marker is a crystal controlled, time-mark generator. The battery-powered unit provides a harmonic output of approximately 1 v peak-to-peak with an output impedance of 50 ohms. Stability is better than ±0.01% from 0° to+60°C. The unit is packaged in a 1¼ x 1¼ x 4⅞ in. aluminum case. Price is $59.50. Accutronics Inc., 12 South Island, Batavia, Ill. [367]



Fully automatic shock spectrum analyzer model N980 is designed for lab or field use. Accuracy is ±3% (any model), and frequency response is ±0.5 db. The unit spans 1 to 10,000 hz. Frequency intervals are selected by pushbutton in ⅙-octave increments or by vernier control. Dynamic range is 60 db. MB Electronics Inc., 781 Whalley Ave., New Haven, Conn. 06508. [368]

New instruments

Plug-ins make voltmeter a triple threat

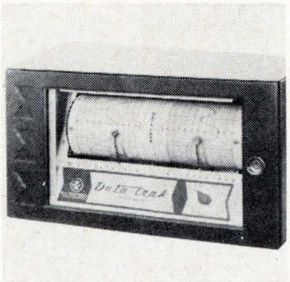
Developers see a $20 million market for differential voltmeter that also measures ratios and frequencies

By year's end, Wavetek will be selling a differential voltmeter that can measure alternating- and direct-current voltages, d-c ratios, and frequencies from 5 hertz to 100 megahertz.

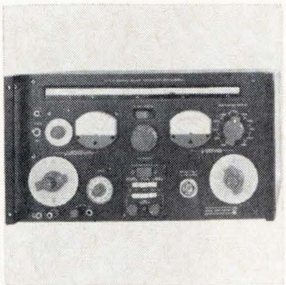
"This covers about 80% of all measurements made in the electronics industry," says a company spokesman. "We'll be offering all this capability in one small package for less than $2,000. If a customer wanted to buy just a 100-Mhz counter, he couldn't get one for less than $3,000."

Flexible. Wavetek entered the differential voltmeter field a year ago with a unit that had two special features—a company-developed "transfermatic switch" that coupled the digit dials to cut down on knob twisting, and a nonsaturating null amplifier to speed the selection of null sensitivity. Now, the company has followed this up with a basic meter package incorporating similar features but designed to operate with a variety of plug-in units.

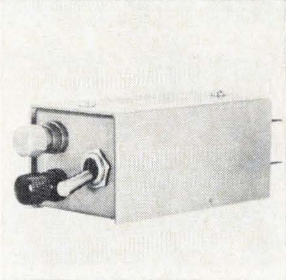
The model 210's meter has a five-hole, six-digit transfermatic switch (the last hole or disk has two digits for greater accuracy), an edge-reading taut band meter, Kelvin-



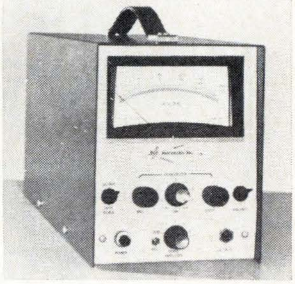
Data-Trak 5110-2P is an electrostatic curve follower with 2 curve-sensing probes which track the individual x and y coordinate data plotted on a Mylar chart. A precision pot is servocoupled to each probe to translate graphical data to equivalent electrical outputs. The unit is suited to any process requiring 2 synchronized and programed signals. Research Inc., Box 6164, Minneapolis. [369]



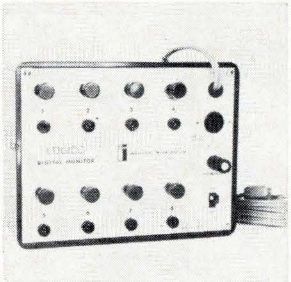
Standard-signal generator type 1003 covers 67 khz to 80 Mhz, with calibrated output of 0.1 μv to 6 v behind 50 ohms. Total warm-up drift is typically 150 ppm in 3 hours, and drift after the warm-up period is typically 1 ppm per 10 minutes. Price, including the automatic control package and crystal calibrator is $2,995. General Radio Co., West Concord, Mass. 01781. [370]



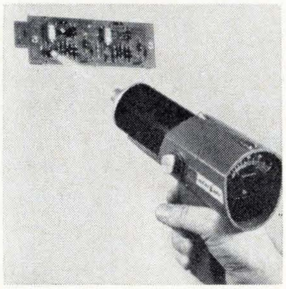
A plug-in thermocouple reference junction converts millivolt recorders to thermocouple recorders. The JR393 measures any temperature with any thermocouple. Over the 55° to 90°F range, its accuracy is ±½°F. Temperature range is −15° to +200°F. Consolidated Ohmic Devices Division, Consolidated Airborne Systems Inc., 115 Old Country Rd., Carle Place, N.Y. [371]



Portable strain gauge and transducer indicator model 1-115SI is an input conditioning module with integral power supply, amplifier, and meter readout. It accepts inputs from 1, 2, and 4 active arm bridges using input wiring up to 8 wires, plus shield. Accuracy is ±0.5% full scale in 4 ranges to 20 mv. Price is $475. B&F Instruments Inc., Cornwells Heights, Pa. 19020. [372]



By providing a simultaneous visual indication of the logic states of up to 18 digital or binary circuits, the Logico digital monitor gives the engineer a picture of the operation of discrete or integrated systems. It can be left in the circuit while bread-boarding, and is useful for servicing. Price is $59.50. Industrial Inventions Inc., RD2 463 US1, Monmouth Junction, N.J. [373]



Heat-Spy model HS-8 handles selective noncontact temperature measurement of small components. The exact target area is defined by a light beam which enables the operator to aim at objects 0.1 to 0.4 in. in diameter. The instrument is available in 4 models covering 60° to 1,000°F. Its accuracy is ±2%. William Wahl Corp., 1001 Colorado Ave., Santa Monica, Calif. [374]

Analog peak sense and hold modules measure the amplitude of transients, obtain a peak noise voltage level, and measure the peak of a complex waveform. Operation up to 10 Mhz and accuracies as high as 0.01% full scale are provided by models 5138/5139 and 5146/5147. Prices are $360 and $400, respectively. Optical Electronics Inc., Box 11140, Tucson, Ariz. 85706. [375]

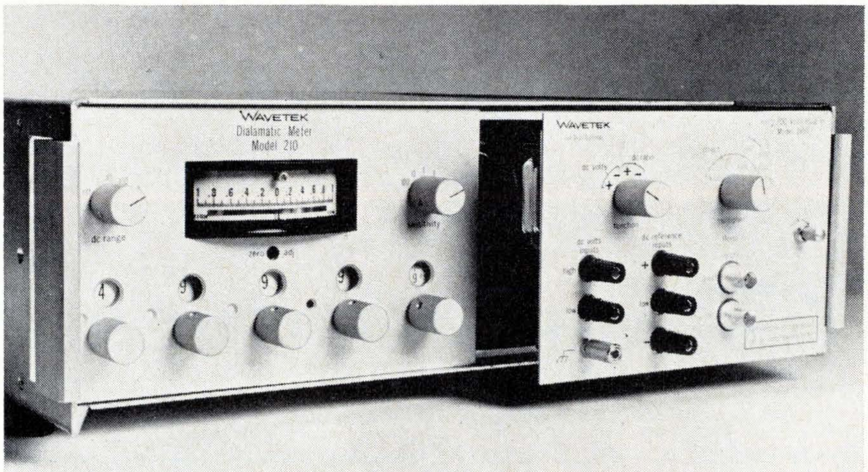
The Miniduser measures 0.5 x 1 in. and is available in pressure ranges from 0-500 to 0-10,000 psia and psig. Used primarily for airborne telemetry and control, it monitors air, fuel, and other media compatible with its NiSpanC sensing element. Over-all accuracy is ±1.75%. Servonic Instruments, subsidiary of Gulton Industries Inc., 1644 Whittier Ave., Costa Mesa, Calif. [376]

Varley divider, null amplifier, power supply, and interface connections. The basic unit is a d-c differential voltmeter with ratio and infinite impedance to 1,000 volts. The plug-ins are:

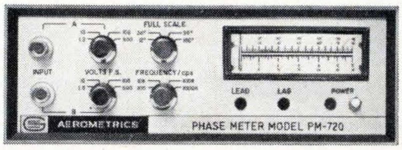
- Model 2101, for d-c voltage and d-c ratio.
- 2102, d-c voltage, d-c ratio, and a-c voltage.
- 2103, d-c voltage, d-c ratio, and frequency measurement from 5 hz to 100 Mhz.

Shipments of these units will start within about 90 days.

The model 211, to be introduced later this year, will have an a-c converter built into the main frame,



Gang switch. Coupled dials reduce time spent in knob twisting.



which measures 17 by 16 inches and is 5½ inches high. With the 2103 plug-in, it will measure a-c and d-c voltage, d-c ratio, and frequency.

Upcoming. Plug-ins slated for introduction next year will handle resistance, current, and phase measurement, and will make the unit a precision power supply. In the latter application, the user will simply dial the d-c voltage on the transfermatic switch.

"We see a market potential of $20 to $30 million," says William Zongker, Wavetek's marketing manager. "We expect to pick up more of the differential voltmeter and frequency market, and will also be chipping away at the digital voltmeter and counter markets."

The transfermatic switch, on which Wavetek has a patent pending, couples each meter switch or knob to the one on its left. Thus, by turning one knob, the user can advance all the decades—for instance, from 4.999 to 5.000.

Circuitry. The new 210 meter has an extra digit for greater accuracy, improved circuitry throughout to provide higher resolution and accuracy, and a 1,000-volt reference power supply. About 25% of the main frame circuitry is integrated, and IC's make up about 90% of the frequency-counting circuitry, which Wavetek calls a hertz meter.

The IC's are a major reason for the low cost. "Design is 50% of the trick, especially with the hertz meter," says Jerry Foster, chief engineer. "If it weren't for IC's, it wouldn't be economically feasible to build the 100-Mhz input circuit."

In the hertz meter, a specially developed frequency-to-voltage converter provides accuracy to 0.001% of range; the readout is said to limit this to ±0.005%. "We have developed a one-shot multivibrator whose precision pulse width is not dependent on temperature-sensitive timing components, but is tied to the reference crystal," Foster says.

The hertz meters will take any input from 250 millivolts to 600 volts without adjustment. Special trigger circuitry automatically adjusts to the correct level for automatic triggering; there's no need for slope and level adjustments.

Specifications

Model 210 with 2101 plug-in

Input	0 to 1,000 v d-c in four ranges: 1, 10, 100, and 1,000 v full scale
D-c input impedance	Infinite at null in 1 v and 10 v ranges, 10 megohms at 100 and 1,000 v
Common-mode rejection	With 1 kilohm unbalance in either side of input: 130 db at 1 v d-c to 52 db at 400 hz and 1,000 v
Resolution	1 ppm of range
D-c accuracy	± (0.005% of reading + 0.005% of range + 5 μv)
Ratio linearity	± 0.0025% of reading, + 0.00025% of range
Null ranges	Full-scale sensitivity is ± .01%, ± .1%, ± 1%, ± 10%, and 100% of selected voltage range
Reference stability	± 0.0005% p/p per hour; ± 0.0025% p/p per year
Recorder output	± 300 mv at full scale, 10-kilohm impedance
Environmental	As specified at 25°C ± 5°C; for 0°C to 50°C, derate by a factor of 3
Power	115 or 230 v, 50 to 400 hz, less than 25 w
Price	Model 210 main frame, $845; 2101 blank plug-in, $30; 2102, $250; 2103, $495

Wavetek, 8159 Engineer Road, San Diego, Calif. **[377]**

New instruments

Multimeter designer outdoes himself

With the help of IC's, the cost of a four-digit model is cut below $1,000

When Phillip D. Wasserman joined Darcy Industries a year ago as director of instrument development, Darcy asked him to design a better digital voltmeter than Cubic Corp.'s model 271. The 271 was designed by Wasserman when he worked for Cubic. Although Cubic no longer makes the 271, thousands of them are still in use.

Darcy had bought out Cubic's industrial voltmeter line when Cubic decided to emphasize military products. The fruit of Wasserman's efforts, the DM-440 digital multimeter, was introduced at the Western Electronics Show and Convention. It is Darcy's first completely new instrument.

The instrument is a pushbutton,

fully integrating device. It can measure d-c from 1 microvolt per digit—thanks to a built-in preamplifier—to 1,000 volts full scale. An accuracy of one digit is held for 90 days, without recalibration, at temperatures of 15 to 35°C. Liberal use of integrated circuits—about 75 of them—plus molded-plastic panels cut the cost to about $975, and the size to a half rack, 5¼ by 8½ by 19 inches.

According to Wasserman, the DM-440's closest competitor is the Fairchild 7000 multimeter; it measures d-c to 100 microvolts per digit, but needs an external preamplifier to reach the DM-440's level and costs about $1,150. Darcy's is not the lowest-priced multimeter, however. Non-linear Systems Inc. has a $695, three-digit model.

Stores displays, too. Bipolar transistors drive the display tubes. The instrument can show 10 readings a second, with no intermediate figures between readings, and also store displays. The display has four full digits, plus an overrange digit, polarity, range, and units.

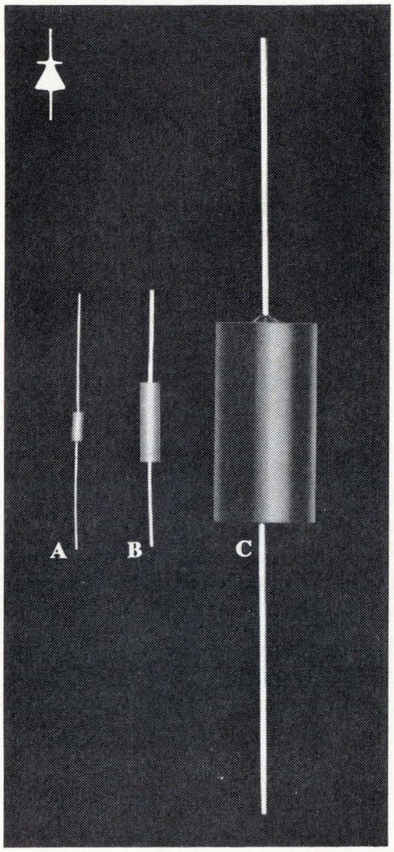
Wasserman claims the DM-440 is the only fully guarded half-rack multimeter. With a three-wire input, he got common-mode rejection of 120 decibels at 60 hz with a 1-kilohm imbalance at either input lead. Leakage capacitance past the guard is less than a picofarad.

"This instrument can measure voltages that are not isolated to earth ground," Wasserman asserts. "It behaves as though it were run by batteries instead of the a-c source."

Specifications

D-c range	±0.001 to ±1,000 v in ranges of ±10, ±100 and ±1,000 with 20% overrange
Ranging	Automatic, manual, and remote
Accuracy	±0.01% of reading, ±1 digit
Linearity	Within 1 digit at all readings
Input impedance	10,000 megohms
Common-mode rejection	Infinite at d-c
Normal-mode rejection	Infinite at 60 hz and integral harmonics
Input isolation from earth ground	1,000 v d-c or peak a-c
Operating temperature	0° to 55°C
Power	115 or 230 v rms, 47-63 hz (47-440 hz optional)

Darcy Industries, 1723 Cloverfield Blvd., Santa Monica, Calif. 90404 **[378]**



Frequencies a la carte

Options convert 20-Mhz counter to a 200-Mhz unit, and to a meter-timer

The counter-timer that marks the entry of Beckman Instruments Inc. into the integrated circuit counter field is not an instrument but a whole series of them, each distinguished by a different set of input and function modules. Yet the series is still basically one piece of equipment; the user selects two modules according to his need, and should that need change he can buy a new module without junking the whole counter.

The flexibility of the 6300 series, built by Beckman's Electronic Instruments division, is more important than the achievement of a new industry high for direct counting —200 megahertz.

Neal W. Vinson, chief of the division's laboratory instruments group, isolated four components that, with a display, are common to counters: a power supply, a frequency standard, an accumulator, and some sort of gating control and recycling logic. The rest of the circuitry, he reasoned, was likely to change with the different requirements, which, in turn, would vary with what was being measured (input) and how it was to be measured (function).

Pick one A and one B. The user decides whether he wants six, seven, or eight digits of display; he can even take a ninth digit, for an extra decade of accumulation, at the sacrifice of the legend glow tube. Then he builds his own counter by selecting from four input modules and three function modules; as with a Chinese dinner, he chooses one from each list. Beckman says it will soon add seven more modules to the initial group.

The input modules, in order of increasing price, are: a single-channel unit counting to 20 Mhz; a double-channel unit, with the same frequency range; a single-channel unit going to 200 Mhz; and a double-channel unit with one of the channels accepting 200 Mhz.

The function modules are a simple accumulator, a frequency meter, and a frequency meter and timer.

Direct drive. Even though two of the input modules count at 200 Mhz, the main-frame accumulator will accept only 20 Mhz. Higher frequencies are divided by 10 before entering this unit's binary-coded-decimal storage logic. Beckman displays the direct count by using four flip-flops in the input module's divided-by-10 logic to drive the last significant digit directly. Thus, for example, an input of 175.682 Mhz would be passed to the universal unit's accumulator as 17.568 Mhz. The four flip-flops (for the 1-2-4-8 BCD code) would then read out 0010 to drive the last 2 on the display.

Wave uneven. One common difficulty in using a counter is determining when the Schmitt trigger is firing. The Schmitt transforms the input sinusoid into an orderly train of pulses to the signal gate. But if the square waves are not symmetrical, the count will be in error. By trial and error, the operator must normally attenuate the input signal.

In the 6300, one IC package in the input module integrates the signal from the amplifier and pulses two tiny light bulbs on the front panel. If one bulb is getting more pulses because the wave is not symmetrical, that bulb appears to glow brighter. To assure symmetry the operator turns the attenuator until the bulbs are equally bright.

The main frame costs $1,000 to $1,275, depending on the choice of six, seven, eight, or nine digits. The prices of the plug-in modules range from $150 for the accumulator input module to $800 for the 200-Mhz, dual-channel unit.

Specifications

Display time	0.1 to 10 sec, variable or held indefinitely; 30 μs recycle
Accuracy	± 1 count, $\pm$ oscillator stability
Frequency standard	1 Mhz
Oscillator stability	3 parts in 10^7 per week
Output signals	6, 7, or 8 digits of 1-2-4-8 BCD; 1 = +4 v, 0 = 0.5 v
Power	115/230 v a-c $\pm 10\%$; 50 to 400 hz, 30 w

Beckman Instruments Inc., Instruments division, 2200 Wright Ave., Richmond, Calif. [379]

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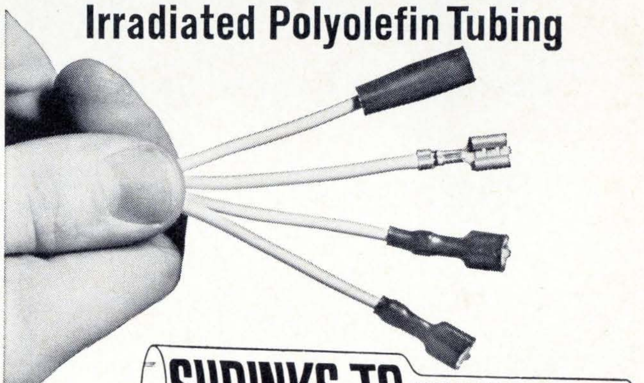

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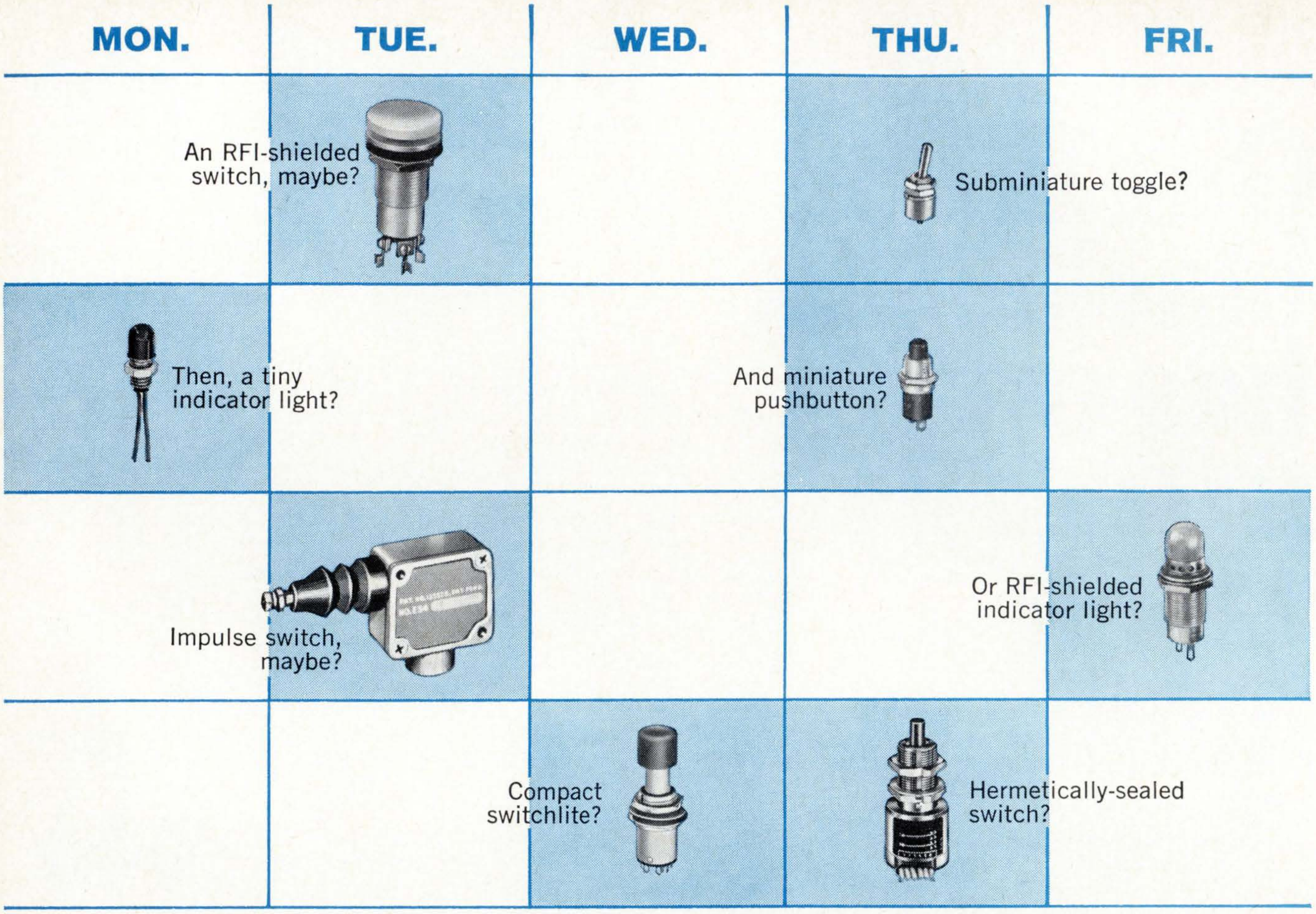

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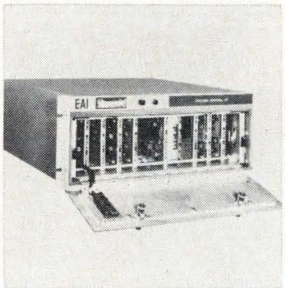
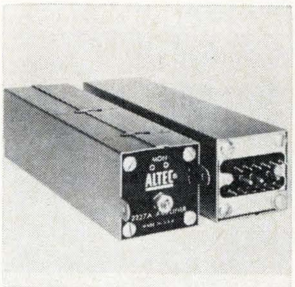
New Subassemblies Review

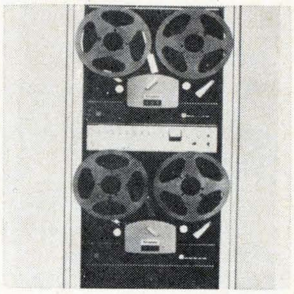
A universal dual-output power supply named Unitwin-164 meets MIL-E-5272 and related specs. It provides 2 voltage outputs adjustable between 0 and 25 v at 0.750-amp capacity for each section. Regulation is better than ±0.005% or 1 mv for line and load. Output impedance is 0.0032 ohm or less to 1 khz. Power/Mate Corp., 163 Clay St., Hackensack, N.J. 07601. [381]



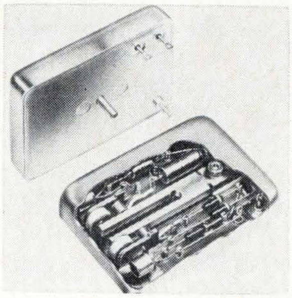
Series 10 analog data processor provides space for up to 10 plug-in operational modules. Module selection includes 3 dual voltage-to-current converters, 3 dual current-to-voltage converters, a low-level widebandwidth differential amplifier, and a dual amplifier resistor network. Prices are from $3,000 to $5,000. Electronic Associates Inc., West Long Branch, N.J. [382]



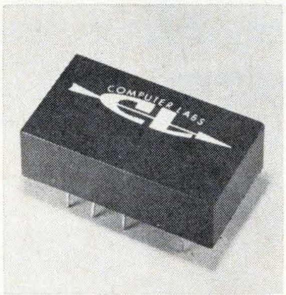
Amplifier model 2227A is a 15-pin device for voice frequency repeater systems. The low-frequency response may be adjusted for a flat characteristic or a roll-off at 200 hz. The unit has an input-output impedance of 600/1,200 ohms and operates on either 48 to 52 or 24 to 26 v d-c. Altec Lansing Division, LTV Ling Altec Inc., 1515 S. Manchester Ave., Anaheim, Calif. [383]



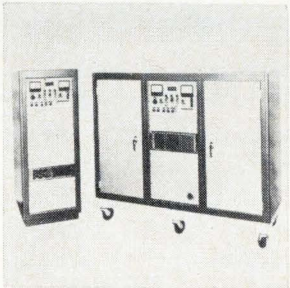
Multichannel recorder-reproducer model 248 is for communications in air traffic control, fire and police service, and other specialized uses in government and industry. It is expandable as logging needs increase and is equipped with 4,800 ft of tape on 10½-in. diameter reels and allows 24 hours of recording time at 0.653 ips with each transport. Dictaphone Corp., Rye, N.Y. [384]



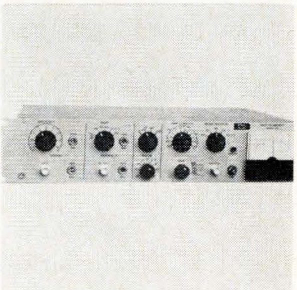
Tuning-fork oscillator LCG-2 is offered in discrete frequencies from 400 to 8,000 hz. Accuracy is 0.050% at 25°C. Output voltage at nominal d-c input is 6 v peak-to-peak 50% clipped sinewave into 6,000 ohms through an external d-c blocking capacitor. D-c input voltage is 12 v at 3.33 ma. Price is under $32. Philamon Laboratories Inc., 90 Hopper St., Westbury, N.Y. 11590. [385]



Operational amplifier OA-125 is stable at closed-loop gains of unity or greater, and provides a gain-bandwidth product of 125 Mhz. It is suited for linear applications as well as those involving nonlinear elements in the feedback loop, such as threshold circuits. Price is $135. Computer Labs Division, Strandberg Engineering Laboratories Inc., 1109 Valley Park Dr., Greensboro, N.C. [386]



Laser power supplies for use with pulsed ruby and glass lasers range from 2.5 to 30 kw output. They are suited to high repetition operation in both the normal and Q-switched modes. All systems have solid state components including 20 amp, 7200 v piv single-phase, full-wave h-v rectifier. Prices from $4,600. Spacerays Inc., Northwest Industrial Park, Burlington, Mass. [387]



A phase-sensitive detection system recovers signals 51 db below ambient white noise in a 1-khz bandwidth. Model 120 lock-in amplifier operates as an amplifier-detector-filter combination with an equivalent over-all noise bandwidth of 0.0083 hz. Minimum full-scale sensitivity is 100 μv. Price is $765. Princeton Applied Research Corp., P.O. Box 565, Princeton, N.J. [388]

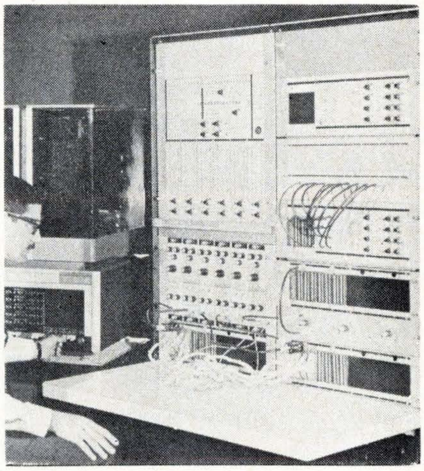
New systems

Computer analyzes memory performance

Digital testing system is programed by a general-purpose computer that can be used by itself for design work

About $100,000 will be the tab for Digital Equipment Corp.'s (DEC) programed memory analyzer, the PMA-8. But the company is making the price palatable with attractive sweeteners that have whetted sales of process control computers.

Purchasers will get a software package that permits a selection of memory test routines and parameter variations with plain language inputs. They will get hardware to interface a computer with the process controlled—in this case, the circuitry that stimulates the memory and checks its re-



Lab assistant. Computer at left can exercise newly designed memories.

. . . tables are turned over to the computer . . .

sponses. And they will get a general-purpose computer, Digital Equipment's PDP-8.

When the production test department isn't using the analyzer, the engineering department can experiment with new memories or try an old one in a new digital system. In any remaining free time, the PDP-8 alone can perform other chores in the plant or lab.

Loaded memory. For analysis, the PDP-8's memory is loaded with test parameter reference tables and instructions for a variety of routines. The operator types into the computer the name of the test he wants, and any special instructions or parameter values not in the stored tables. However in most cases he can use punched tapes, supplied with the PMA-8, which program the standard tests for computer memories.

Analyses performed include go-no-go production testing, maximum-minimum parameter searches, distribution plot analysis, switching current measurements, core-peaking and difference testing, and schmoo plotting—a performance curve obtained from two variables [Electronics, July 25, 1966, p. 127]. Performance evaluations can be isolated down to a single core in the memory. For example, in go-no-go testing, the analyzer makes a test pass through the memory and decides if the cores are good or bad. Then results are tabulated in terms of error locations indicating both the address and reason for error.

Test circuitry, contained in a single cabinet, includes modular current drivers, switching systems, variable-width strobes, sense amplifiers, and discriminator subsystems. These are set up, timed and calibrated through the computer, which also tests the analyzer.

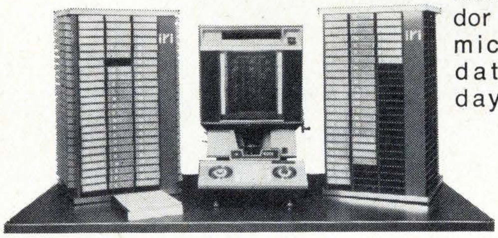
As the test is made, the results are printed out on a teletypewriter, or on a plotter that is an optional accessory. As he watches the results, the operator can vary the parameters, weigh the effect, and return to the original routine by entering instructions through the keyboard.

Adaptable, too. Digital Equipment says its software and hard-

Design engineer Bob Alden searched for nearly an hour to find he didn't have the information he needed.

iri could have told him that in less than 5 minutes.

But chances are 10-1 IRI has it...and it's up-to-date, too! IRI—Information Retrieval Incorporated—is a vendor catalog file on microfilm. Because we make no charge to vendors, and microfilm everything they have in print, IRI has more than 600,000 pages of vendor data including application notes, reliability tests, price lists and names of distributors and reps. What's more, the IRI Vendor Catalog File on microfilm is up-dated every 60 days!



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In addition, the IRI system is tailored to your needs by adding the vendors you want – at no extra cost. We start with a basic file of the most wanted information. Up-date it regularly, and then—to top it off—"personalize" the file by adding the complete vendor information you request. Small wonder IRI enables you to eliminate your hard copy central catalog file. It also reduces storage area by 98%, cuts redundancies in design efforts and increases sources and use of standard items.

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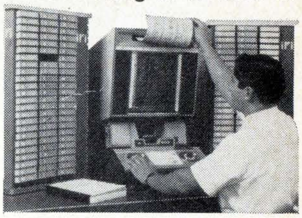

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. . . replace the tapes, not the test gear . . .

ware is sufficient to test memories ranging from simple coincident-current models to those with multi-sense and multi-inhibit operation. However, if memories get more sophisticated, the system won't have to be replaced. Since it is based on a general-purpose computer, it can be updated by expanding the program instructions and by adding additional test-circuitry modules to the test frame. In fact, the company wouldn't be surprised if some users modified the system to test digital equipment other than memories.

DEC has been using the analyzer to test memories for its computer lines. A larger system, based on a PDP-7 computer, tests the company's logic circuitry.

The PMA-8 will be offered this fall, and the company expects to fill orders in 60 to 90 days. The decision to sell the memory analyzer has been in the works since last spring, when the market for computer-based instrumentation systems suddenly began opening up [Electronics, April 17, 1967, p. 161].

Digital Equipment Corp., 146 Main Street, Maynard, Mass. 01754 **[389]**

New subassemblies

Everyman's x-y recorder

Extra features adapt it to bench or rack, lab or factory use

Like true Texans, the engineers at Texas Instruments Incorporated conducted a roundup before they sat down to design the company's first x-y recorder.

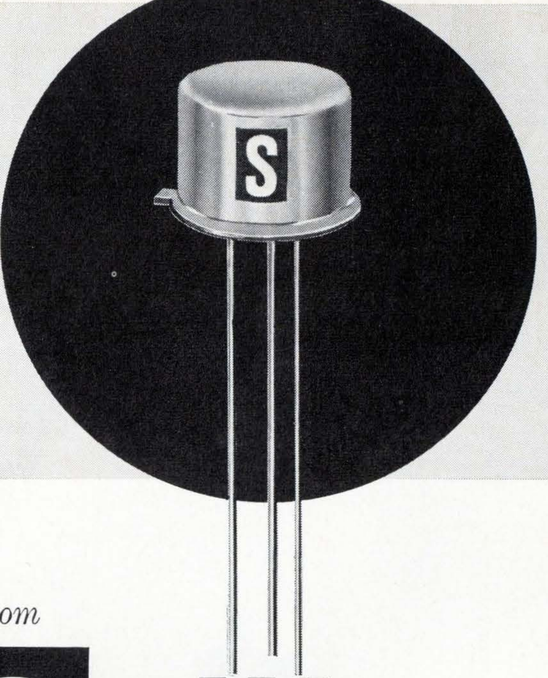
For the first time, says TI, the best features of other recorders have been corralled in a single instrument, the "function/riter." It can be employed in applications ranging from laboratory research to

160V

pnp silicon chopper transistors

from

Solitron



Solitron, now in full production of small signal transistors, has a complete line of PNP Silicon Choppers with voltage capabilities up to 160 Volts. Identified as the SSS 1001-4 Series, these devices are available in the TO-5 package. They offer high reliability, low saturation voltages and can be purchased as pairs with offset voltages matched to 100 μV @ $T_A = 25°C$. A few of their many circuit applications include modulators, servos, telemetry and multiplexing.

Type Number TO-5	Power Dissipation $T_A = 25°C$ (mW)	Rated Breakdown Voltages			I_{ECX}			*I_p!		**$V_{CE(sat)}$		C_{obo}	
		$V_{(BR)CBO}$ (Volts)	$V_{(BR)CEO}$ (Volts)	$V_{(BR)EBO}$ (Volts)	Max (na)	V_{BC} (Volts)	V_{EC} (Volts)	Max (na)	V_{BC} (Volts)	Max (mV)	I_B (μa)	Max (pf)	V_{CB} (Volts)
2N 1920	250	—40	—18	—40	—2.5	10	—15	—1.5	10	3.0	—500	14	—6
2N 1921	250	—50	—50	—50	—10	10	—30	—2.0	10	4.0	—750	14	—6
2N 3345	250	—50	—50	—50	—	—	—	—	—	3.0	—1000	25	—0
2N 3346	250	—50	—50	—50	—	—	—	—	—	1.5	—1000	25	0
2N 1922	250	—80	—80	—80	—10	10	—50	—2.0	10	4.0	—750	14	—6
SSS 1001	400	—100	—100	—100	—10	10	—60	—3.0	10	2.0	—750	30	—6
SSS 1002	400	—120	—120	—120	—10	10	—70	—3.0	10	2.0	—750	30	—6
SSS 1003	400	—140	—140	—140	—10	10	—80	—3.0	10	2.0	—750	30	—6
SSS 1004	400	—160	—160	—160	—10	10	—90	—3.0	10	2.0	—750	30	—6

*Emitter Offset Current **Emitter Offset Voltage

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... even the inkwell is a plug-in item ...

industrial process control.

Key features include high accuracy, guarded input, remote pen lift, and time-axis control. Plug-in modules handle single-range input signals, multirange signals, and time sweeps. Either the x or y axis can be geared to time.

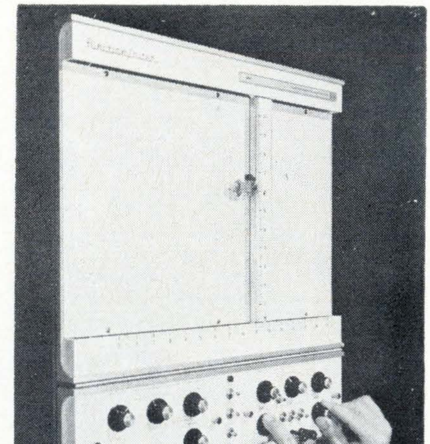
Protection. To improve precision, infinite-resolution slide-wires are used instead of helical-wound resistance elements in the pen-positioning circuitry. Signal input leads are not grounded, but a guard shield insures accurate recording of signals with a-c and d-c common-mode interference. To increase transverse interference rejection, a low-pass input filter can be added.

The recorder can be used on a bench or mounted horizontally or vertically in a rack. When the instrument is on a bench, the chart can be tilted 45 or 90 degrees. The pen is fed ink from disposable cartridges, and the chart paper is held on the platen by vacuum.

Specifications

Accuracy	
Time base ± 2%	± 0.2% full scale or 5 μv, whichever is greater
Linearity	
Time base ± 1%	± 0.1% full scale
Repeatability	0.1% full scale
Slewing speed	20 ips min. both axes at 60 hz 16 ips min. both axes at 50 hz
Power requirements	120 or 240 v, ± 10% at 50 or 60 hz 90 w, 120 va max.
Price	$1,600
Delivery	90 days

Texas Instruments Incorporated, 3609 Buffalo Speedway, Houston. **[390]**



Facing up. Chart table can be tilted 90° for easier viewing.

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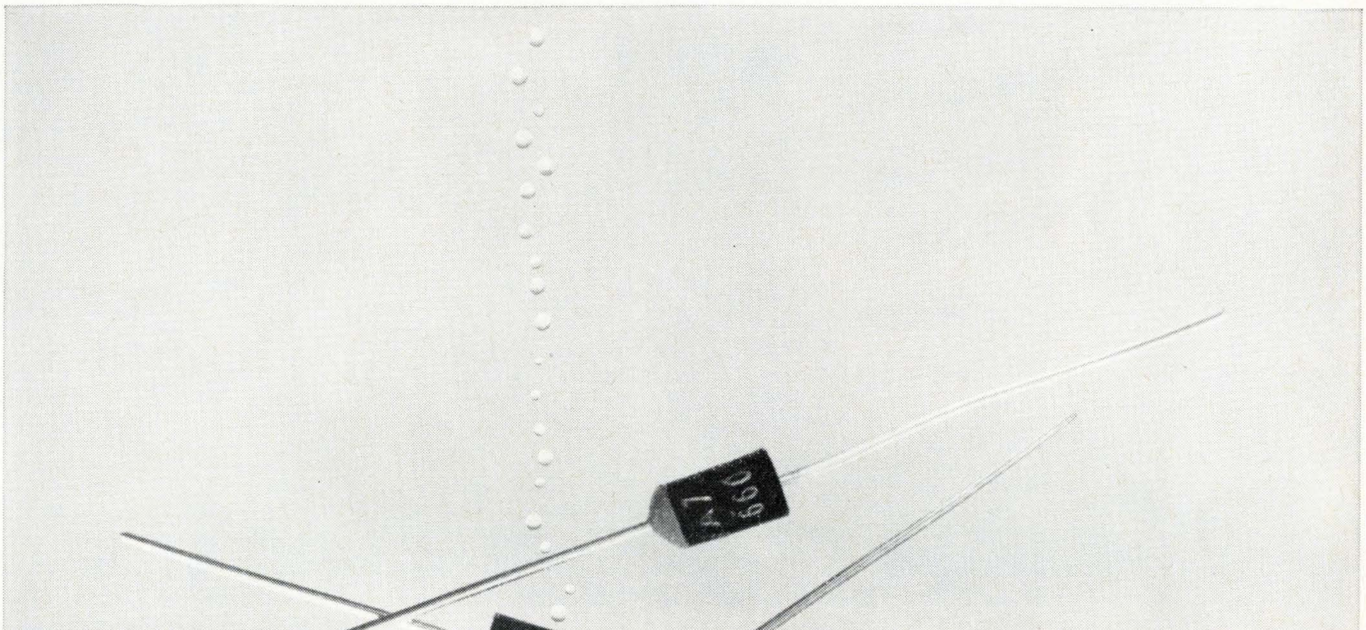
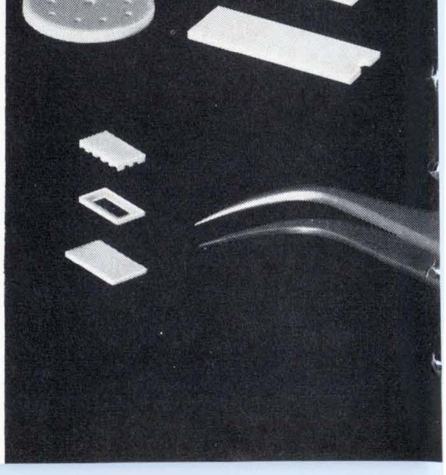


Circle 173 on reader service card

consider Coors ceramics

If you are working with a single chip or with complex circuit networks, Coors micro-ceramic modules offer you high reliability packaging. In the example above, the design engineer utilized base, frame, and lid modules to form a universal stacked package that can grow to fit any circuit density required. Each module is approximately 5/16″ wide, 11/16″ long and .050″ high—indexed for high speed assembly. Because of the unique properties of Coors Ceramics, modules can be joined by epoxy, glass, low temperature solder, or high temperature brazes. Thin film or thick film technique can be used. The high mechanical strength, high surface resistivity and high thermal conductivity of Coors Ceramics combine to make the package reliable under widely varying operating conditions. Precision tolerances can be held even on complex designs. Whether your requirements call for thousands a week, or millions a week, Coors has complete facilities to offer you on-time delivery of alumina or beryllia packaging modules. Faced with a packaging decision? Get on-the-spot answers. Dial Coors — 303/279-6565, Ext. 361. For complete design criteria, write for Coors Alumina and Beryllia Properties Handbook No. 952.



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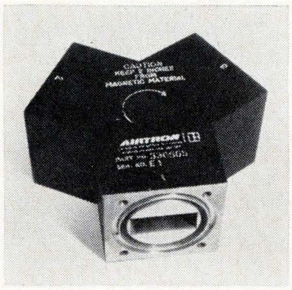
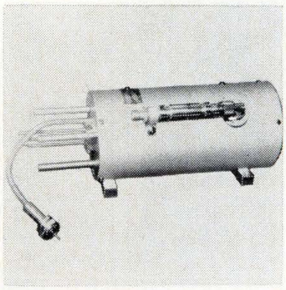
Circle 174 on reader service card

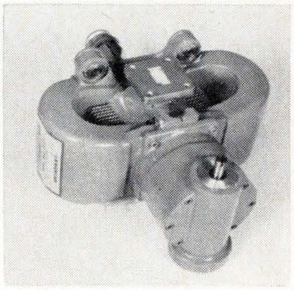
New Microwave Review



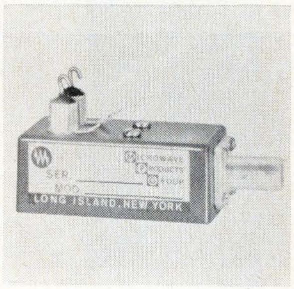
Designed to operate in X band in WR-12 waveguide, model 336505 is a 3-port junction circulator with a peak power of 300 kw and an average power of 300 w. Suitable as a circulator, isolator, or duplexer, it offers insertion loss of 0.3 db, isolation of 20 db, and vswr of 1.20. Price is about $350. Airtron Division, Litton Industries, 200 E. Hanover Ave., Morris Plains, N.J. [401]



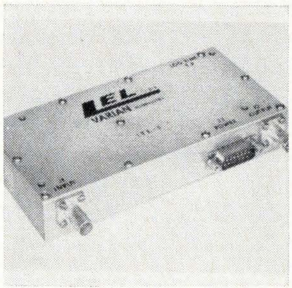
Class C pulse-cavity oscillator 11005 is a 2.5-kw unit that is tuned manually and covers 410 to 460 Mhz. Applications include drone control circuitry and a h-f test source. The unit is rated at 35% efficiency and has a duty cycle of 0.00015. Maximum input vswr is 2:1. Dimensions are 11 9/16 x 3½ in. Microwave Cavity Laboratories Inc., 10 N. Beach Ave., LaGrange, Ill. [402]



Tunable coaxial magnetron SFD-325, for airborne and ground-based radar systems, has a frequency range of 16 to 17 Ghz, and peak output power of 75 kw. Compatibility of the tube with modulators delivering widely varied pulse shapes is assured by the low pushing factor (60 khz/amp). Duty factor is 0.001. S-F-D Laboratories Inc., 800 Rahway Ave., Union, N.J. [403]

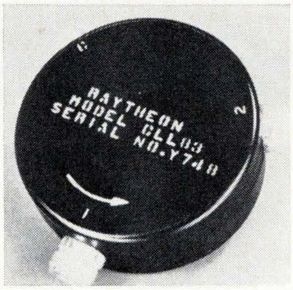


Fundamental voltage-tuned oscillator model ETS3152 has a tuning range of 1.2 to 1.8 Ghz. Linearity is within ±1% over 75% of the range. The devices, 1 x 1 x 2¼ in. provide a power output of 50 mw c-w. Noise is —70db, and harmonics approximately —15 db, Microwave Products Division, Consolidated Airborne Systems Inc., 115 Old Country Rd., Carle Place, N.Y. [404]

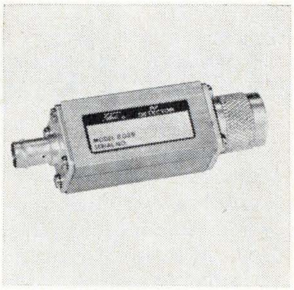


Logarithmic amplifier ITL-5, for microwave receivers, provides a log video output with a 70-db input dynamic range. Video output is proportional, within ±2 db, to the log of the input from —60 to +10 dbm. The unit is available at 30- or 60-Mhz center frequency, 4- or 8-Mhz bandwidth. It operates in a 50-ohm i-f system. Price is $325. LEL Division, Varian Associates, Akron St., Copiague, N.Y. [405]

Coaxial bandpass filter model BK-51FN, covering 2.2 to 2.3 Ghz, is useful in telemetry receivers and down-converters. It offers high rejection-band characteristics—50 db at 2.04 and 2.46 Ghz—with 80 db image rejection. Insertion loss is 0.5 db, and vswr is 1.5 max. Price is $275. The unit is available from stock. Microlab/FXR, 10 Microlab Rd., Livingston, N.J. 07039. [406]



Coaxial L-band circulator model CLL-83 operates at 1.2 to 1.4 Ghz. It has a maximum vswr of 1.20, maximum insertion loss of 0.3 db, and minimum isolation of 20 db. The unit has a Y package configuration. It can also be supplied with 1 port terminated for isolator uses. The circulator is 3⅛ in. in diameter, 1 5/32 in. thick. Raytheon Co., 130 Second Ave., Waltham, Mass. [407]



R-f voltage detector model 8029 has a vswr rating specified at less than 1.2:1, with typical values of 1.05:1. It is designed for c-w and swept applications, as well as general purpose usage, covering 10 khz to 3 Ghz. Square-law sensitivity is typically 0.3 mv/μw; flatness, ±0.5 db. Input impedance is 50 ohms. Price is $95. Telonic Instruments Inc., 60 N. First Ave., Beech Grove, Ind. [408]

New microwave

Harmonic mixer trims receiver

With a single oscillator covering a 40-Ghz range, plug-ins aren't needed and weight drops to 18 pounds

Engineers going into the field to make electromagnetic compatibility tests can now carry their notebooks in one hand and a microwave receiver in the other. Less batteries, Scientific-Atlanta Inc.'s series 1710 receiver weighs only 18 pounds and is the size of a portable typewriter. It is, the company says, the smallest wide-range receiver ever offered.

Despite its size, the 1710 can do the work of several narrowband receivers, or of a large one containing plug-in oscillators for different bands. Solid state design and a crystal-harmonic mixer with a range of 40 gigahertz were used to trim down the circuitry.

Display. Oscilloscope is provided to facilitate tuning.

. . . l-o tuned above or below . . .

At frequencies between 940 Mhz and 2.5 Ghz, a local oscillator directly feeds the mixer, which is built around Schottky-barrier diodes. Crystal harmonics are used from 2.5 to 40 Ghz. The frequency range can be lowered to 20 Mhz with an optional low-frequency converter.

The output of the i-f amplifier is also detected by a crystal detector and the resulting audio signal is applied to the vertical amplifier of a monitor oscilloscope.

Automatic frequency control is used on both upper and lower sidebands, so if the receiver is tuned past the desired frequency, it can still be locked in with the upper sideband. An yttrium-iron garnet preselector is available for the 1-to-12.4-Ghz range. Since the preselector is electronically tuned and can be swept electronically, this option allows more rapid surveillance and detection of unknown signals in this portion of the spectrum.

The receiver is a natural for antenna pattern tests, as well as for electromagnetic compatibility tests, according to P.T. Spence, a project engineer at Scientific-Atlanta. It has ample sensitivity for field or lab measurement of radio-frequency power density.

Spence has measured the minimum detectable signal at —100 dbm at 10 Ghz, and at —118.5 dbm at 2 Ghz. The narrowband (0.1 Mhz) sensitivity of the 45-Mhz intermediate-frequency strip is even greater—only —124.5 dbm.

The dynamic range of 40 db can be extended to 60 db. Other options are signal-level compensation, a precision i-f attenuater, and a battery inverter for field use. A battery pack designed especially for the receiver will soon be available.

Specifications

Frequency range	940 Mhz to 40 Ghz
Dynamic range	40 db
Noise figure	4 db over-all
I-f sensitivity	—124.5 dbm
I-f bandwidth	0.1, 0.5, or 5 Mhz
Minimum detectable signal	—93 dbm at 11 Ghz —100 dbm at 8 Ghz —118.5 dbm at 2 Ghz
Size	6.6 x 8.3 x 11 in.
Weight	18 lbs.
Price	$5,800 without options

Scientific-Atlanta, Inc., Box 13654, Atlanta, Ga. **[409]**

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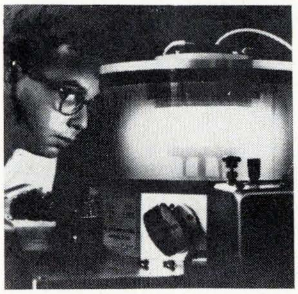
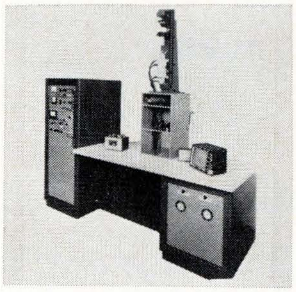
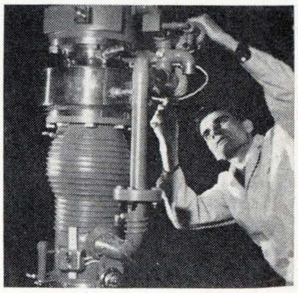


Thin-film sputtering modules for existing vacuum systems are designed for operation at vacuums of 10^{-6} to 10^{-8} torr. They provide film deposition rates of up to 1,100 angstroms/minute. Heart of the V4-8500 module is a d-c diode and r-f sputtering assembly that can be operated in d-c only, r-f only, or d-c r-f combined. Materials Research Corp., Orangeburg, N.Y. [421]

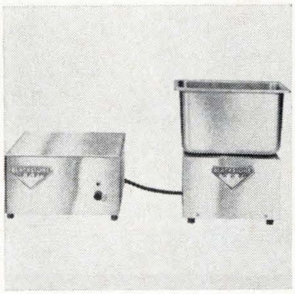
Ultrasonic die bonder DU-6 attaches dice to devices ranging from large stud packages to small headers or flatpacks. Ultrasonic energy is supplied by a 10-watt 40-khz generator. The dice are picked up by vacuum and a slide with the heater column holding the work is moved rapidly into place for bonding. Axion Corp., 6 Commerce Park, Danbury, Conn. [422]



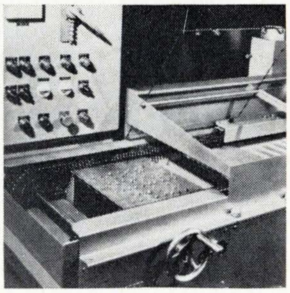
Resistor trimming is performed by an automatic laser system suitable to production use. Safety to the operator or persons in close proximity is assured by light-tight seals and safety interlocks. The system has been tested for 100,000 discharges and operates continuously at rates up to 1 pps. Prices start at $17,500. Spacerays Inc., Northwest Industrial Park, Burlington, Mass. [423]



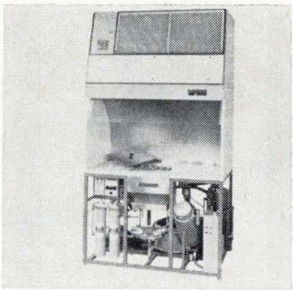
Vacuum pumping module 3352 pumps about 900 liters per sec. This allows more rapid production operations in vacuum metalizing, IC deposition, high temperature furnaces, and space simulation equipment. The module measures 35½ x 21½ x 27 in. It uses a 6-in. diffusion pump. Price is about $2,000. National Research Corp., 160 Charlemont St., Newton, Mass. 02161. [424]



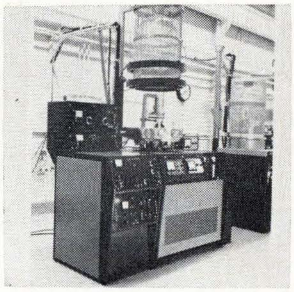
Ultrasonic cleaners for p-c boards and components come in tank capacities of ½ and 1 gallon. Each cleaner consists of the tank (detachable for cleaning); the transducer assembly, which induces cavitation in the tank; and the generator, which powers the transducer. The tank is for use with water-base detergents. Blackstone Ultrasonics Inc., 25 Barrett St., Sheffield, Pa. [425]



Integrated wavesolder system 364 has an adjustable conveyor, eliminating the need for board carrier or pallet. A p-c board from 2 to 15 in. is slipped into the conveyor and firmly held as it passes the fluxing, flux-drying, preheating, and soldering stations. The system is suited for white room use. Electro-Mechanical Division, Electrovert Inc., 86 Hartford Ave., Mt. Vernon, N.Y. [426]



A cleaning station called Micro-Cleaner helps reduce rejects of ICs. It provides 5 hot, cascading rinses and a final rinse of hot, ultrapure water in a totally clean environment. The recirculating, repurifying system includes a built-in still, demineralizer, organic removal bed, 0.1-micron particle filter, and storage sump. Barnstead Still & Sterilizer Co., 2 Lanesville Ter., Boston. [427]



Designated the Plasma Vac AST1 300, a reactive sputtering system features 2 parallel-mounted water-cooled disk electrodes. The target electrode and discharge suppressor are in the upper position and the substrate-table electrode in the lower. An r-f supported plasma discharge is used to ionize the gas. Consolidated Vacuum Corp., 1775 Mt. Read Blvd., Rochester, N.Y. [428]

New production equipment

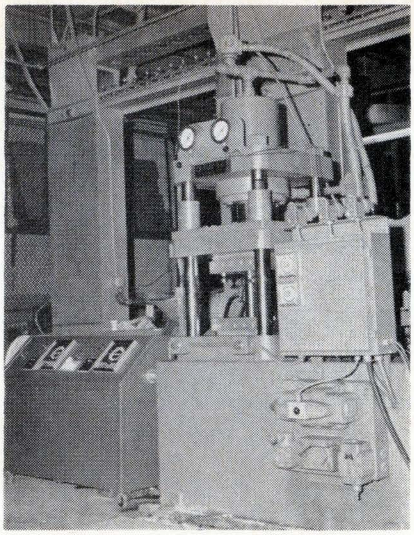
Faster, safer packaging for semiconductors

Liquid molding process is reported to cut packaging cost in half while reducing damage from pressure and heat

Epoxy's popularity as a packaging material for semiconductor devices and other components will wane if a new encapsulating system lives up to test results compiled by Cryplex Industries Inc. The company says its resin can be molded around components four times as fast as epoxy, and for half the cost. Molding temperatures and pressures are lower, so fewer components are damaged, Cryplex also claims.

The International Telephone & Telegraph Corp. is being licensed to use the process, according to a company spokesman. The company wants its customers to pay royalties, in addition to paying $8,000 to $25,000 for the machines and 60 cents a pound for the resin. The resin was recently developed under the direction of John A. Lowry, Cryplex vice president, who was a research specialist at Rohm & Haas for 22 years.

No preheating. The formulation of the plastic has not been disclosed, but it is a thermosetting liquid that can be used at viscosities as low as 100 centipoise and molding temperatures as low



Press. Resin is cured in the mold.

as 170°F. The resin does not have to be preheated or preplasticized. Nor is a post-cure needed after molding, the company says. The storage life of the resin is reported to be six months and its work life, after catalysts are added, is four to 15 days—another economy.

Molding and curing time in the press ranges from about 15 seconds, when small components such as diodes are being encapsulated, up to two minutes for large components. In one test, Cryplex's complete molding cycle time was 30 to 40 seconds while transfer molding of epoxy took 168 seconds. However, the company said it needed 100 seconds to clean and lubricate the epoxy mold.

Safety in numbers. Significantly higher component yields are claimed. As evidence of how safe the process is, the company says, it successfully encapsulated hybrid circuits that could not be transfer-molded.

In another test, five batches of high-voltage rectifiers—200 in all—were given one-hour pressure-cooker tests after half were encapsulated in the new resin and half were transfer molded with epoxy powder. The reported yields per batch ranged from 15% to 47% for epoxy and 68% to 92% for Cryplex. One of the Cryplex-encapsulated components was said to show no damage after 1,200 hours storage at 150°C and thermal cycling from —55 to 125°C.

Cryplex Industries Inc., 2800 College Point Causeway, Flushing, N.Y [429]

New Books

Hard core

Basic Theory of Waveguide Junctions and Introductory Microwave Network Analysis
D.M. Kerns and R.W. Beatty
Pergamon Press Ltd., 150 pages, $5.50

Not intended for casual reading, this volume is essentially a textbook covering two areas—basic theory of waveguide junctions, written by D.M. Kerns, and introductory microwave network analyses by R.W. Beatty. And, as expected from authors connected with the National Bureau of Standards laboratory in Boulder, Colo., the book is heavily slanted toward measurements.

The network-analysis discussions, organized so they can be digested in small doses, center on the scattering matrix representation of microwave circuits and components. Scattering coefficients are given for power terms, reflection coefficients, efficiency, attenuation, mismatch losses, and phase shifts. Two-port, three-port, and four-port networks are taken up in detail. Although practical components are discussed as waveguide elements, the basic matrixes are, of course, equally applicable to strip-transmission line and coaxial representations.

Beatty supplies a helpful touch by collecting the scattering matrixes in one comprehensive table for each type of network—phase shifters, isolators, and the like. This table is particularly useful in cascading two ports.

Three applications are touched upon in the entire book, but only lightly. It's unfortunate that Beatty didn't draw more on his experiences at NBS for unusual examples of the techniques he describes.

Majority rules

Threshold Logic
P.M. Lewis and C.L. Coates
John Wiley & Sons, 483 pp., $15.00

Experiments have shown that threshold logic—also called majority, or voting, logic because the gate's output is determined by the state of the majority of its inputs—cuts by two thirds the number of gates in conventional logic schemes. However, threshold logic has not been used to any great extent in digital computers because of the lack of adequate design techniques and a need for tighter-tolerance circuits.

Two previously published books share the same title as this one—the first by M.L. Dertouzos, M.I.T. Press, 1965, and the other by S.T. Hu, University of California Press, 1965. While the latest is the most comprehensive and can be recommended for reference use, it still is not a complete treatise. And most designers would probably like a more compact treatment of the major aspects of threshold logic.

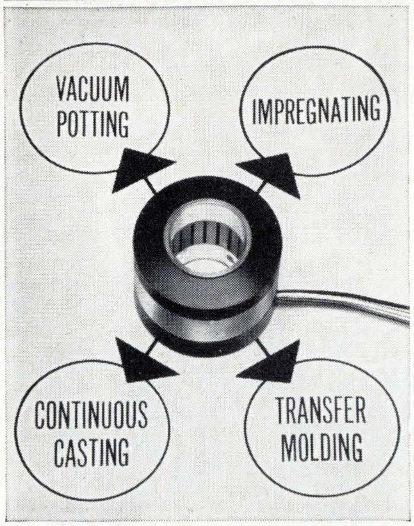
The first three chapters cover in detail the properties of threshold functions and abstract models of the gates used in this technique. Because the authors have done well in selecting, presenting, and referencing their material, they do succeed in giving the reader a feel for the subject. But Karnaugh maps and switching cubes, which would help, are omitted; they deserve coverage.

Definitions are clearly proposed and the proofs are usually easy to follow. Many examples allow the reader to follow the text without studying the proofs in detail. The notation, however, is at times cumbersome and could easily have been streamlined.

Many well-chosen examples are included to illustrate the methods. Some pertinent references are given in the bibliography, which covers work through 1965, but much has been done recently on using integrated circuits as threshold gates. In IC form, threshold gates are compatible with conventional IC gate structures and even competitive with them.

The authors devote several chapters to the use of the "function tree" to synthesize single threshold gates and threshold-gate networks with prescribed tolerance bounds—a method that they originated several years ago. The major advantage of the procedure is that the designer controls tolerance requirements as he proceeds through the design.

Other synthesis techniques, also described, rely on three-input majority gates, easily built with a variety of components, and special networks for synthesizing symmetric functions, which are important in digital systems. One drawback in this procedure is that the networks of three-input majority gates usually contain many levels. Complementing these gates with others, such as AND's or OR's can simplify the problem. Synthesis methods based on duality, linear programing, and sequential techniques developed from pattern-recognition problems are also considered. Missing, however, are dis-



cussions of the applicability of each procedure and computational aids for both hand and computer calculations.

Donald R. Haring
MIT Electronic Systems Laboratory
Cambridge, Mass.

Not cricket

Low Noise Electronics
W.P. Jolly
American Elsevier Publishing Corp., 149 pp., $5.00

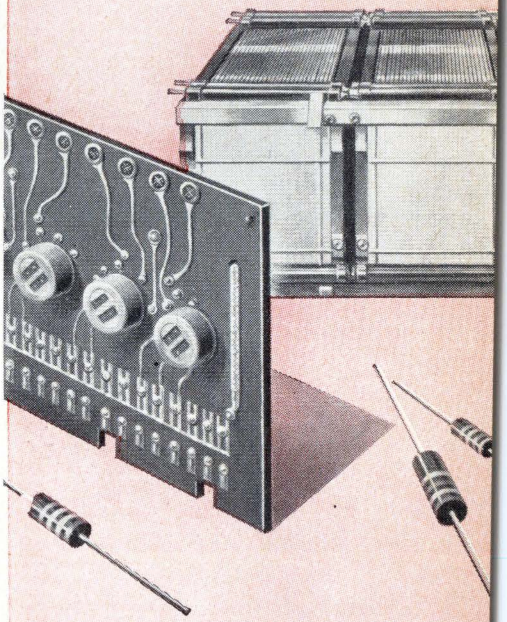
Of late, many books have been published with the same idea—to make complex physical phenomena understandable to the engineer who completed his formal education long ago. To be successful with this sort of thing is not easy. It requires a detailed, intuitive-level explanation of a group of topics that are carefully selected. It cannot lean on mathematics or references for support; if it does, it defeats its own primary purpose. On these counts, this volume is, like most of the others, only moderately successful.

The portion devoted to maser systems is well done. Jolly describes pumping, refrigeration, and system noise. Unfortunately, in most of the other broad-brush descriptions, the references carry the weight of supplying details that are omitted in the text.

At that, the book is not particularly rich in references. The ones that are given were presumably carefully chosen, but they cannot be substituted for an actual description in the text. Some books like this turn out to be little more than annotated bibliographies; Jolly's book is not one of these, but in some cases it comes perilously close.

Even on the simplified level that is attempted, many parts of the book must be studied to be understood. This would hardly be fair criticism for a textbook, but if study is necessary, it would be better to find a book that offers a greater return for the time invested. The difficulty here may be related to the book's size and scope.

In 149 pages, the book covers the evolution of modern quantum theory, energy band structures, p-n junctions, Gunn effect, electron-



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New Books

phonon and electron-photon interactions, Compton and Mossbauer effects, stimulated emission, masers and lasers, parametric systems, electron-beam amplifiers, microwave ferrites, injection lasers, and atmospheric absorption of radiation. He also mentions low-temperature amplifier operation, ferroelectric amplifiers, laser applications, and radio telescopes, and provides an index to all these subjects.

In his preface, author Jolly, a professor at the Royal Naval College in Greenwich, England, compares his book to the lightweight cricket bat that a child might use to get the feel of the game before moving up to the real thing. But once he gets the feel of it, he'd better switch to a heavy bat or he'll never belt one very far.

Recently published

Integrated and Active Network Analysis and Synthesis, Paul M. Chirlian, Prentice-Hall Inc., 427 pp., $10.50

Primarily a text, the book details the latest techniques for handling circuit problems in integrated and active circuits. Background information is provided on physical behavior of semiconductors and methods for fabricating IC's.

Electronic Counting Circuits, J.B. Dance, American Elsevier Publishing Co., 390 pp., $16.75

Descriptions of all types of electronic counting circuits are given with many designs that include actual component values. No previous knowledge of pulse techniques is needed.

Quantum Electronics, Amnon Yariv, John Wiley and Sons Inc., 478 pp., $14.95

Written at a first-year graduate level, the volume concentrates on the interaction of optical radiation and atomic structures and the devices that use such interactions. Laser amplifiers, oscillators, noise in masers, and other related topics are discussed.

Computer Programming and Computer Systems, Anthony Hassitt, Academic Press, 374 pp., $10.95

An intermediate-level text for the programer, the book offers an introduction to machine language programing, monitor systems, computer hardware, and advanced programing. A knowledge of Fortran or Algol is necessary to fully utilize the information presented.

Wave Phenomena, Dudley H. Towne, Addison-Wesley Publishing Co., 482 pp., $12.50

The author presents a unified treatment of transverse waves on a string and acoustic and electromagnetic waves. Discussions of the wave equation, wave propagation, boundary value problems, and normal modes in various physical contexts are used to provide an introduction to the mathematical techniques of quantum mechanics.

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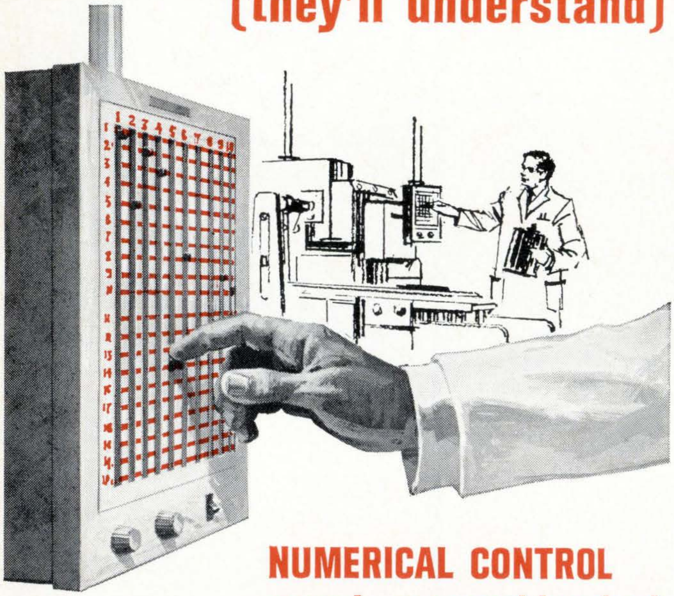

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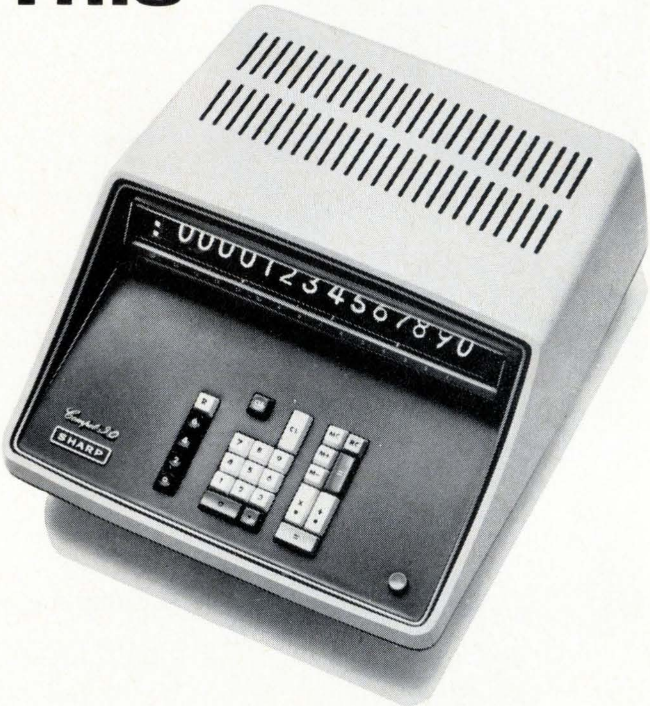

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A blow at vidicons

A self-scanned solid state image sensor
P.K. Weimer, G. Sadasiv, J.E. Meyer, L. Meray-Horvath, and W.S. Pike
RCA Laboratories
Princeton, N.J.

New scanning circuits for an array of thin-film photosensitive elements may soon make it possible to build a solid state television camera as a single integrated device.

RCA's self-scanned image sensor consists of a photosensitive array with 32,400 elements and two 180-stage shift register scan generators with associated video coupling transistors. Integration of all components was accomplished with thin-film techniques. Each element in the photo-sensitive array uses a photoconductor that is a mixture of cadmium sulfide and cadmium selenide for high gain. Center-to-center spacing is 2 mils. The scan generator uses 540 cadmium selenide thin-film transistors deposited on a glass substrate. The entire array is scanned at the conventional rate (63.5 microseconds) so that the picture can be displayed on a commercial tv receiver.

The sensor array is scanned with a method similar to that used in a vidicon. There, an electron beam acts like a commutator, contacting each picture element once during the scanning period. In the solid state device, the beam is replaced by switches attached to each photosensitive element. The switches are normally off, but when activated by pulses from a scan generator they connect the individual photoconductive elements across the video load. Although diode switches are used in this sensor, insulated gate transistors are also suitable. An appropriate scan generator might be a parallel-output shift register, as used in this camera, decoder switching circuits, or a tapped delay line.

The solid state camera's fast horizontal scan generator produces a positive pulse that travels across the array in 53.5 μsec (line time for commercial tv). This pulse turns the diodes on sequentially, discharging the photoconductors. Simultaneously, a slow vertical scan generator activates the video coupling transistor for the row being scanned.

Experimental image sensor arrays with more than 100,000 elements have been constructed, but they're still too expensive to compete even with the costly vidicon. Ultimately, integrated image sensors will need about 1 million individual components.

Although signal uniformity from element to element in the present array was good, most of the transmitted pictures were marked by vertical and horizontal streaks caused by disconnected lines and shorts in the sensor. This was due to imperfections in the fabrication of the monolithic array. Also, with the equipment used, image sensitivity was only about 1/10th that of the conventional camera's sensitivity.

The camera, however, was easy to use and reliable. The sensor array was operated for more than 6,000 hours with negligible changes in dark or light. The 180-stage scan generator was operated for 10,000 hours at 85°C without failures developing in any of the 100 stages under test.

Presented at Wescon, San Francisco, Aug. 22-25.

. . . and another

100-by-128-element solid state imaging system
R.A. Anders, D.E. Callahan, W.F. List, D.H. McCann, M.E. Wing
Westinghouse Defense & Space Center
Baltimore

Another scheme to replace the conventional television camera uses a 3-inch cube solid state imaging system in which silicon phototransistors are the sensors. Development units capable of 100-line resolution at 60 frames per second have been demonstrated, and resolutions of greater than 200 lines at the same scanning rate are predicted by 1970.

A monolithic silicon mosaic, consisting of 12,800 phototransistors

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in a 100-by-128-element array, measures 0.5 by 0.5 inch. The phototransistors are sequentially scanned by rows and columns at rates up to 60 frames per second. Patterns can be easily recognized by this element-by-element scanning without external digital-to-analog conversion.

There are 100 horizontal common-collector strips, each containing 128 base-emitter junctions. The emitters are joined vertically by metalization. Thus, external connections in both the x and y directions provide access to any image element. The charge stored in each element's collector-base junction corresponds to the total light falling on the junction during one complete scan cycle.

To read the mosaic, a voltage is applied to each collector strip in turn, while the 128 emitters are sequentially connected to an output operational amplifier through field effect transistor switches. The output during the sampling time is proportional to the total light that has fallen on the sensor during the entire 1/60th-second frame time.

Presented at Wescon, San Francisco, Aug. 22-25.

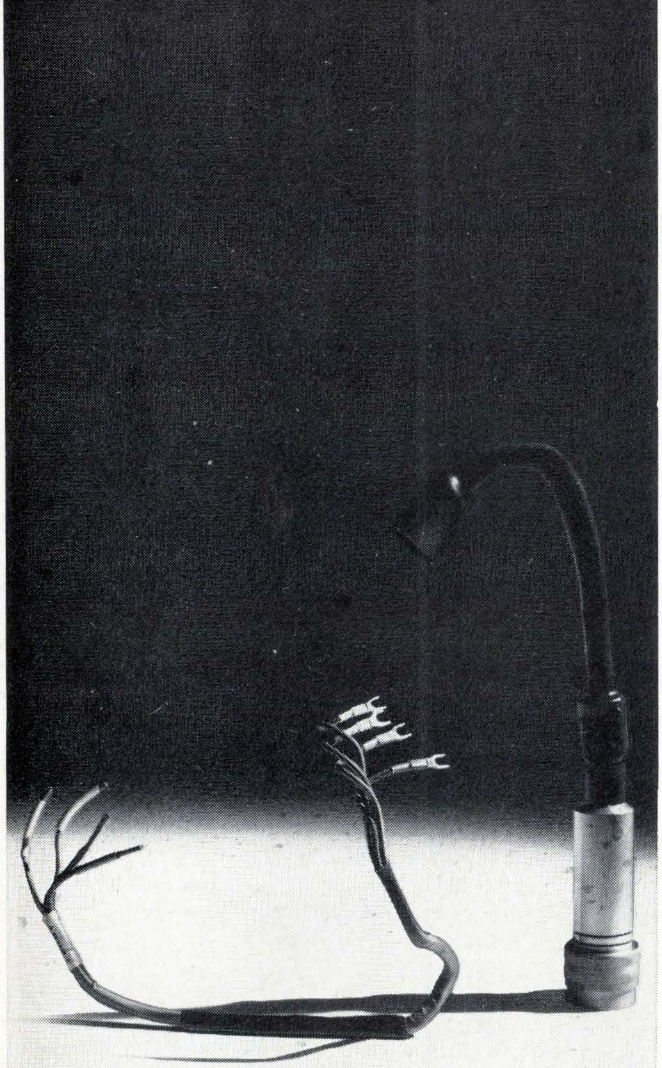
Light sandwich

A solid-state image converter
R.D. Stewart and E.L. Littebrant
General Electric Co.
Syracuse, N.Y.

Light-emitting diodes, though easy to make and use, are limited to a single wavelength infrared output. To transform this output to a variety of visible wavelengths, researchers at the General Electric Co. have developed an electroluminescent image converter based on an old principle but having a high quantum gain.

The electroluminescent-photoconductor (EL-PC) light amplifier, a device first introduced in the late 1950's, is built in four layers. On top is a glass substrate through which infrared radiation passes. The radiation strikes a cadmium selenide photoconductive layer. A dielectric layer separates the cadmium selenide from the final layer

These two heat-shrinkables are hungry for tough mil-spec insulation problems.



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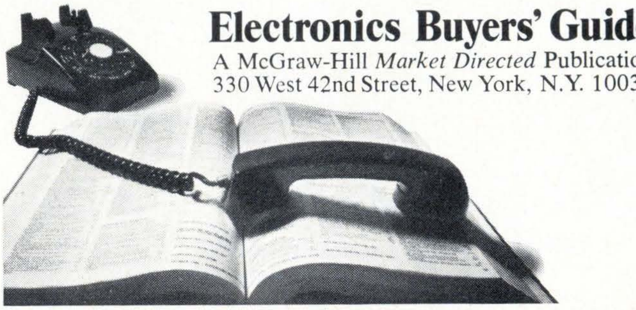

—the EL zinc-sulphide phosphor. The electroluminescent and photoconductive layers are connected in series across the alternating-current supply and behave as a voltage divider. Thus, small changes in selenide conductivity with incident light cause variations in voltage across the EL layer, and, because the phosphor emission is highly sensitive to voltage, light amplification is achieved.

In addition to its resistance, however, the PC has a small fixed capacitive reactance that, if excessive, can mask changes in the PC cell's resistance and thus limit the EL cell's contrast.

For maximum sensitivity, therefore, a PC cell structure with a small capacitance must be used. In one structure having the necessary low capacitance, circular evaporated-gold terminals rest on a common electrode with windows to allow the light to strike the photoconductor. This scheme yields high optical efficiency, since none of the radiation is lost in absorption or reflection. The measured capacitance of the structure is less than 0.1 picofarad, about 0.1% that of the EL layer.

When the common electrode has been deposited on the glass substrate, cadmium selenide doped with copper and chlorine is sprayed over the surface to form the photoconductive layer. The plate is then fired in an inert atmosphere and the gold electrodes are deposited by evaporation through a metal mask.

An opaque dielectric film is applied to the photoconductor and indium pellets are placed directly over the gold terminals below, completing the series EL-PC circuit. The layers are then assembled with heat and pressure and encapsulated by covering the phosphor with a glass sheet and fusing it to the bottom substrate. The entire cell is about 10 or 12 mils thick. Electrical connections are made to the common electrode and to a transparent electrode deposited on the EL layer.

Presented at Wescon, San Francisco, Aug. 22-25.

New Literature

I-f amplifiers. RHG Electronics Laboratory Inc., 94 Milbar Blvd., Farmingdale, N.Y. 11735, has available bulletin IFA-103 covering its line of solid state i-f amplifiers.
Circle **446** on reader service card.

Memory core press. Computer Test Corp., Three Computer Dr., Cherry Hill, N.J. 08034, offers a brochure on the model 1104 multistation press that was designed for the production of memory cores. **[447]**

Digital computing system. Electronic Associates Inc., West Long Branch, N.J., has released a brochure discussing the technical specifications of 640 digital computing system. **[448]**

Production-line measurement. James G. Biddle Co., Plymouth Meeting, Pa. An eight-page brochure introduces the Mentor series of precision-measurement instrumentation for production-line use. **[449]**

Time-delay relays. Airborne Accessories Corp., 1414 Chestnut Ave., Hillside, N.J. 07205. Information on a line of solid state time-delay relays for industrial use is furnished in bulletin PS-15. **[450]**

Voltage reference standards. Instrulab Inc., 1205 Lamar St., Dayton, Ohio. Two data sheets are available describing the 600 series (a-c to d-c) and 700 series voltage reference standards. **[451]**

Reed relays. Wheelock Signals Inc., 273 Branchport Ave., Long Branch, N.J. 07740, has released a short-form catalog covering 160 of its complete family of reed relays. **[452]**

Glass delay lines. Corning Glass Works, Raleigh, N.C. 27602. Glass delay lines that store one horizontal sweep line of video information for 63 μsec are described in a four-page bulletin. **[453]**

Digital magnetic tape. Memorex Corp., 1180 Shulman Ave., Santa Clara, Calif., has published a monograph entitled "Evaluating Performance of Digital Magnetic Tape." **[454]**

Solid state switches. American Electronic Laboratories Inc., P.O. Box 552, Lansdale, Pa. 19446. Bulletin 30-10 covers the physical dimensions, electrical characteristics, and capabilities of a line of solid state switches. **[455]**

Shielded programing system. AMP Inc., Harrisburg, Pa. 17105, has published catalog 612-7 illustrating and describing a low-capacitance shielded patch-cord programing system. **[456]**

Portable recorder. Brush Instruments division, Clevite Corp., 37th and Per-

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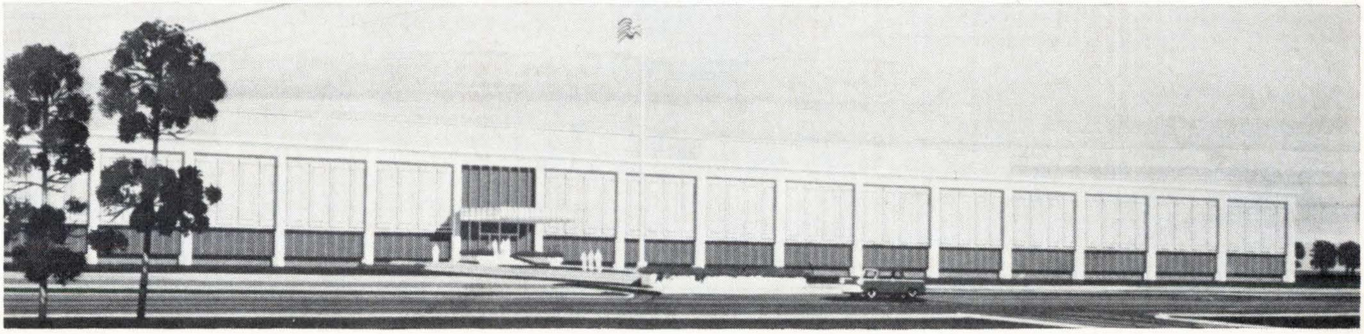
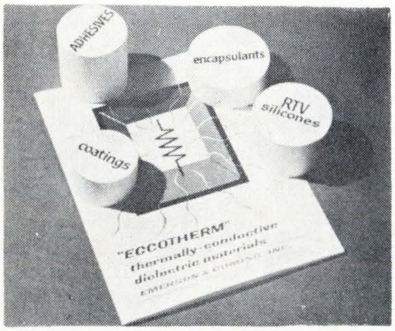
Fort Worth Division

Of primary interest in the Fort Worth Division's current $37 million facility expansion program is the new $8 million Engineering and Office Building, encompassing 581,400 square feet and covering 12 acres.





New Literature

kins, Cleveland 44114. Bulletin 942-1 covers the Mark 220, a portable, two-channel recorder with four pushbutton chart speeds. **[457]**

General-purpose relay. Sigma Instruments Inc., 170 Pearl St., Braintree, Mass. 02185, offers a catalog bulletin on the series 11, a low-cost, 1-oz, general-purpose relay. **[458]**

Impulse counters. Landis & Gyr Inc., 45 W. 45th St., New York 10036. Bulletin 167 is an impulse counter selector chart that gives outline specifications for a wide range of models. **[459]**

H-f antenna systems. Delta Electronics Inc., 4026 Wheeler Ave., Alexandria, Va., 22304, has released an eight-page, short-form catalog describing h-f antenna systems. **[460]**

Solid state products. Philco-Ford Corp., Microelectronics division, 2920 San Ysidro Way, Santa Clara, Calif. 95051, has published a product reference guide listing its bipolar linear and digital IC's, MOS IC's, epoxy transistors, and MOS FET's. **[461]**

Low-noise preamplifier. Hamner Electronics Co., P.O. Box 531, Princeton, N.J. 08540, has issued a technical bulletin on the NB-20 low-noise preamplifier for high-resolution gamma spectrometry. **[462]**

Tone signaling equipment. Trepac Corp. of America, 30 W. Hamilton Ave., Englewood, N.J. A brochure is available on the Datatone model T/R-800 miniature, transistorized, a-m tone transmitters and receivers. **[463]**

Ceramic-to-metal seals. Eimac division of Varian Associates, 301 Industrial Way, San Carlos, Calif. 94070. A 14-page document outlines the company's research and manufacturing capability in a wide variety of ceramic-to-metal structures. **[464]**

Microwave products. Electro Magnetic Radiation Laboratory, P.O. Box 1054, West Acton, Mass. 01780. A two-page mailing piece discusses the company's facilities in the field of high-power microwave components and subsystems. **[465]**

Magnetic tape systems. Scientific Data Systems, 1649 17th St., Santa Monica, Calif. 90404. Three data sheets contain descriptions and specifications of magnetic tape units used with Sigma computers. **[466]**

Time-delay relays. G.C. Wilson & Co., Box 5437, Huntington, W. Va. An eight-page brochure provides a selection chart, wiring diagrams, outline drawings, and applications of time-delay relays. **[467]**

Military systems. Maxson Electronics Corp., Great River, N.Y. 11739. A 20-page brochure shows the facilities of the company's military systems and equipment research and engineering unit. **[468]**

Communications. Barker & Williamson Inc., Bristol, Pa., has announced an eight-page catalog detailing its instruments and components for communications. **[469]**

Photoelectric keyboard. Invac Corp., 26 Fox Road, Waltham, Mass. 02154. A two-page data sheet describes the series PK-200 photoelectric keyboard's format and function flexibility. **[470]**

Variable-speed drive. Reliance Electric Co., 24701 Euclid Ave., Cleveland 44117, offers bulletin D-2522-1 covering performance characteristics of the ComPak variable-speed drive. **[471]**

Display communications buffer. Sanders Associates Inc., 95 Canal St., Nashua, N.H., has available a six-page brochure describing elements of a total system that interfaces its 720 data display with IBM 360. **[472]**

Laboratory stop clocks. A.W. Haydon Co., 232 N. Elm St., Waterbury, Conn. 06720. Bulletin C1702 gives complete information on laboratory stop clocks suitable for bench use or panel-mounting. **[473]**

Videotape duplication. Ampex Corp., 2201 Lunt Ave., Elk Grove Village, Ill. Brochure V66-280 describes the capabilities of the company's new videotape duplicating center. **[474]**

Crystal catalog. Texas Crystals division, Whitehall Electronics Corp., 1000 Crystal Dr., Fort Myers, Fla. A 12-page catalog details the frequency-control crystals being manufactured by the company. **[475]**

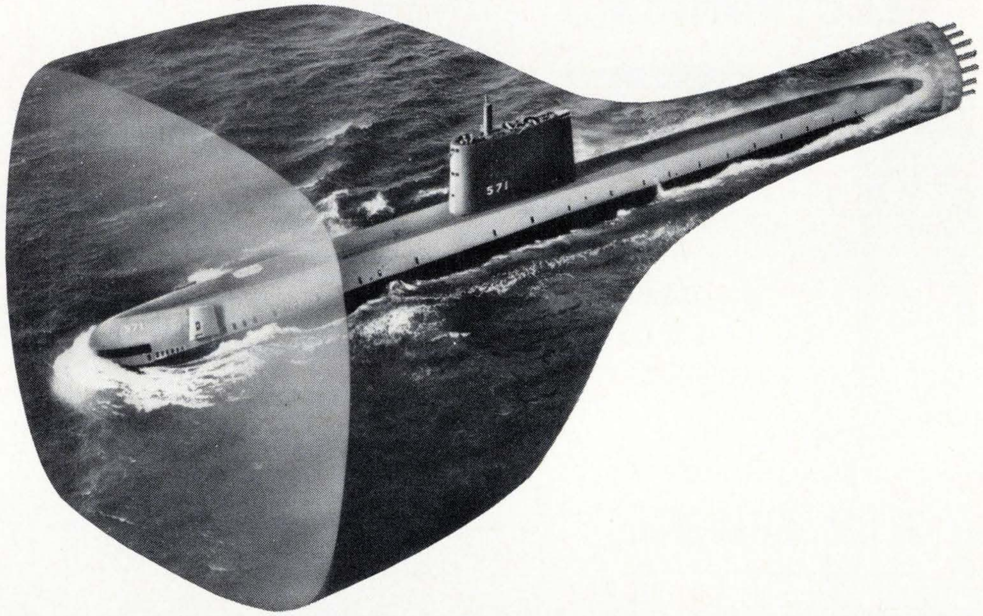
Spectrum analyzers. Federal Scientific Corp., 615 W. 131st St., New York 10027. A 12-page booklet describes the operating principles of the Ubiquitous spectrum analyzers, which produce high-resolution spectra for frequency bands as wide as 10,000 hz in real time. **[476]**

Shaft encoders. Librascope Group, General Precision Equipment Corp., 808 Western Ave., Glendale, Calif., offers a comprehensive brochure on shaft encoders, a line of devices for translating shaft rotation into digital form. **[477]**

Filter glossary. Electro-Mechanical Research Inc., P.O. Box 130, Van Nuys, Calif. 91408, has available a six-page glossary of terms most commonly used in describing filters and their characteristics. **[478]**

Digital interpolator. Boston Digital Corp., Ashland, Mass. A 16-page catalog describes the IM/10 digital interpolator. **[479]**

New Task Force for a Large Task:



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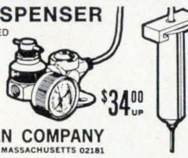

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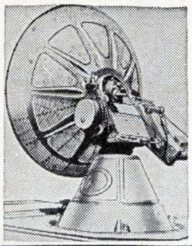

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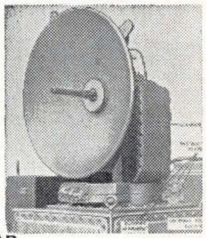

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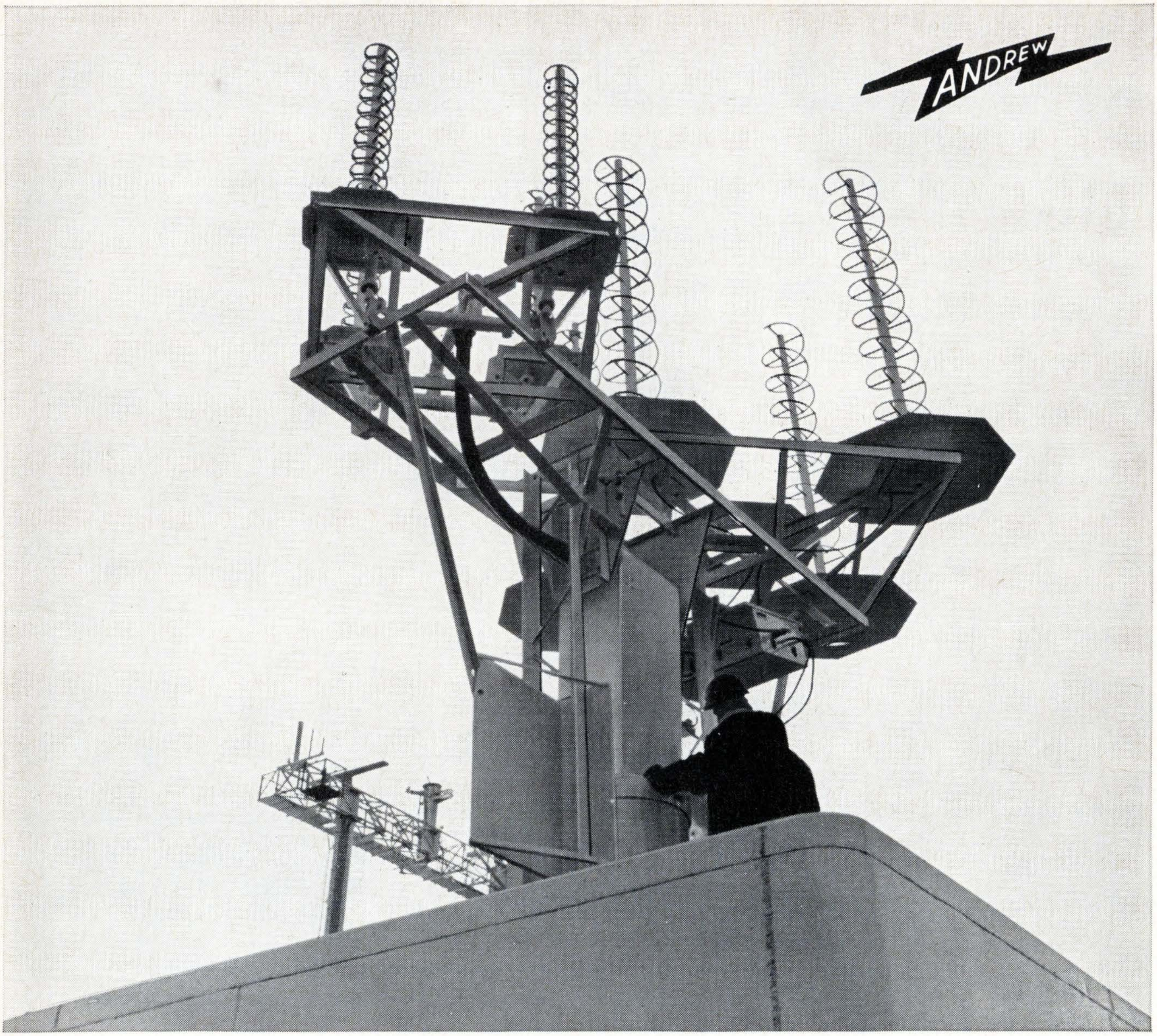

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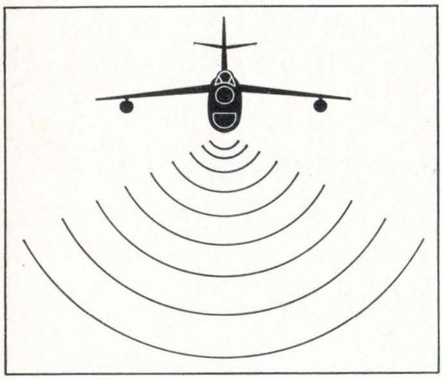

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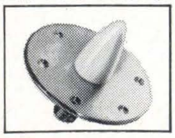

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Newsletter from Abroad

September 4, 1967

Hayakawa may test TI on IC patents

The long-standing hassle over integrated circuits between Texas Instruments and Japanese electronics interests may come to a head this fall. **Although the TI-Japan patent snarl remains as entangled as ever, the Hayakawa Electric Co. is poised to export desk calculators with IC control circuits to the U.S.**

The company will decide when to leap after it gets the results of a mid-September meeting between U.S. and Japanese trade officials. Japan's tiff with TI [Electronics, Nov. 28, 1966, p. 193] will be on the agenda, but there's little chance of a solution. **Unless it looks like TI can get a court order to have the calculators seized, Hayakawa may take the gamble.** Legal action by TI would also involve the Mitsubishi Electric Corp., which supplies the IC packages for the calculator.

Hayakawa's sortie into the U.S. market with an IC product apparently will have the blessing of the powerful Ministry of International Trade and Industry. MITI last spring warned Japanese producers not to export IC hardware until licenses had been arranged with Fairchild Camera & Instrument, which holds the basic U.S. patents on the planar process. With the exception of Matsushita Electronics and Sony, Japan's major IC producers have acquired rights to Fairchild's patents. **But TI, which also owns basic IC patents, has been holding off on licenses because its bid to set up a wholly owned subsidiary has been turned down by MITI.**

Hayakawa executives insist they're looking for a desk calculator market in the U.S. rather than a run-in with TI. The company is geared for mass production of its calculator and needs the large American market as an outlet. **But TI can hardly let Hayakawa's move go unchallenged. Other Japanese firms are itching to export IC products and figure to follow Hayakawa once it establishes a beachhead.**

Europe to kick off tv playback sales

CBS Laboratories' European partners in the development of Electronic Video Recording [see page 25] will probably be first to market the visual playback devices. CIBA of Switzerland and the Imperial Chemical Industries Ltd. of Britain plan to exploit the educational television market through "canned" programing.

CBS Labs' president, Peter Goldmark, expects CIBA to have the units on the market by 1968—perhaps several months before CBS starts sales in the U.S. CIBA, a chemicals and pharmaceuticals giant, will aim at the medical-school market. Imperial plans to sell or lease units directly to British schools.

The film used in the process, which stores video signals for playback to the antenna terminals of house sets, is made by a jointly owned subsidiary of CIBA and Imperial—Ilford Ltd. Another British firm, Thorn Electrical Industries Ltd. will manufacture the playback devices.

De la Rue pioneers time-sharing in U.K.

Britain's two native large-computer makers have been left at their marks by General Electric as far as time-shared data processing services go.

With multiaccess centers still very much in the planning stage at both English Electric Computers and International Computers & Tabulators, GE-controlled De la Rue Bull Machines last week launched Britain's first time-shared computer service open to all comers.

De la Rue will start with about 20 subscribers, linked by post-office lines to a GE 265 computer. The computer can handle up to 40 users simultaneously, but De la Rue expects it will need between 100 and 200 subscribers to keep the computer fully employed. Charges for the time-shared service won't be firmed until De la Rue picks up some experience; at the outset the rate will probably run around $600 a month for between 10 and 30 hours of connection time to the computer.

If the scheme catches on, De la Rue will follow up with a second GE 265 system. **The company apparently hopes to pin down a big share of the U.K. market for time-shared computer services before English Electric and ICT make their moves.**

European trio eyes air traffic control software market

Makers of air-traffic control equipment now face formidable competition in software systems. Three of Western Europe's strongest electronics firms—Britain's Plessey Radar Ltd., Germany's AEG-Telefunken, and France's CSF-Compagnie Generale de Telegraphie sans Fil—have pooled their air control programing know-how in a Brussels-based subsidiary, called Eurosystem.

Eurosystem is sighting in on Eurocontrol's software business. Eurocontrol, the seven-nation organization that controls the upper air space over most of Western Europe, almost certainly will turn to the new company for software systems needed for its experimental facility in Bretigny, France. Eurosystem's parent companies supplied the air-control simulation equipment for the Bretigny center.

If Eurosystem pockets the software order, it would then have the inside track for the operational centers Eurocontrol will build. **Eventually, the company hopes it can pick up about $1 million yearly in software business from Eurocontrol and national air-control agencies.**

Canadian pullout may still HARP

Canada's new emphasis on communications satellites in its space program [see story p. 131] may mean the end of a joint project with the U.S. aimed at drastically slashing the cost of getting small payloads into orbit.

As it reworked its space budget to match the accent on communications, the Canadian government last month earmarked nothing more for the high-altitude research program (HARP) that has been running for five years at McGill University in Montreal. **Goal of the program was to cut launching costs to as low as $100 a pound by shooting payloads out of big guns.** Using a U.S. Scout booster, launching costs run upwards of $2,500 per pound.

With Canada a dropout, HARP has been shifted to the University of Vermont. **But unless the U.S. steps up its financial backing, the program appears doomed. Of the $7.5 million spent thus far on the project, slightly more than half was funded by Canada.**

Addenda

Hitachi Ltd. and the Tokyo Shibaura Electric Co. are switching to yttrium oxide-cadmium sulphide red phosphors for color-tv picture tubes. Matsushita Electronics touched off the scramble to get brighter tubes onto the Japanese market early this year [Electronics, Feb. 20, p. 295] . . . The Royal Air Force and the U.S. Air Force have teamed for a joint study of long-range propagation of radio signals. The two air arms expect to have a large transmitter and aerial array operating within two or three years on a low-lying peninsula near Orfordness on the east coast of England.

The Complex Few

If you compare a present day system to one designed several years ago, you will discover that the predominant difference is quantitative: the new system contains fewer components at every level. That means that a simple gating function, which used to require a dozen or so components, has been replaced by a single monolithic circuit. A circuit board containing a dozen integrated circuits replaces enough hardware to require a separate chassis in older systems. And a single chassis in a new system does the work of a whole rackful of older equipment. Assuming the basic overall function of the system hasn't changed, it follows that each of the new system elements is more complex than those of the old, since it must perform more of the total workload. And because it is more complex, it must perform to higher standards of reliability. These points are best illustrated by example.

THE SIMPLIFIED SYSTEM: In a recent redesign effort, the circuitry of an events-per-unit-time meter was updated by using the most recent FET's and integrated circuits available. The results were startling. Even though the instrument was only two years old and used integrated circuits, the updated circuitry reduced the total can count from 241 to 84, or by nearly two-thirds. This was achieved without altering any of the functions of the unit, and with some improvements in its performance specifications. The updated meter also required less power to operate: 2.48W as against 7.47W required by its predecessor. Clearly the change would have been more dramatic if the meter had been, say, five years old and made with discrete components only. It is also easy to see that these reductions in can count and savings in materials could be multiplied by extending the redesign to all elements instead of confining it to the frequency meter.

TOTAL INTEGRATION: There are two reasons for this dramatic reduction in componentry. The first is that integrated circuits are themselves becoming more complex. The counter portion of the meter, for example, previously used 30 J-K flip-flops. In the updated version 4 J-K flip-flops were used along with 5 integrated counter circuits(CμL9958), for a total of 9 integrated circuits instead of thirty. A second reason is that linear integrated circuits and FET's offer an opportunity to integrate some functions which previously were of necessity discrete. For example, a saving of 14 components was effected in the input circuitry, by substituting 1 FET, 1 linear integrated circuit and 6 resistors for 5 transistors, 13 resistors, 2 capacitors and 2 diodes. This substitution also improved the performance characteristics of the circuit.

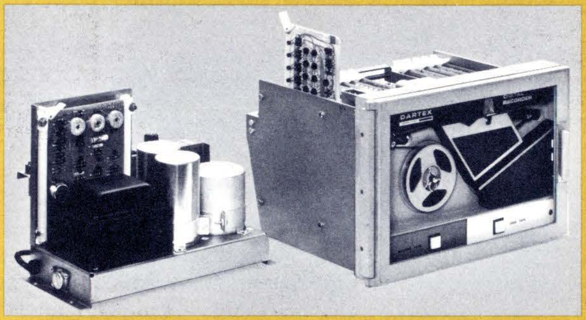
Thus, the designer of today's systems has at his disposal a wider selection of building blocks than ever before. He can choose to stick with discrete components, to integrate parts of the system, or to undertake the total system integration task. The trend is to total integration. This is not to say that the instrument designed two years ago is ready for the junk heap. Electrically, from a performance point of view, it could serve for some time to come. But in a competitive marketplace the customer will demand the equipment that does the best job at the lowest cost. The manufacturer who can reduce his component count by two-thirds while improving performance and reliability will surely have an advantage difficult to ignore.

TO SUM UP: Linear integrated circuits offer the designer an opportunity to integrate a larger percentage of the total system circuitry. New digital circuits offer the opportunity to substitute single elements for several older IC's of lesser complexity. If this trend continues unarrested, heaven forbid, it will soon be possible in theory to design a system with zero elements of infinite complexity.

Integrated Tape Transport

Modern computers are getting bigger and faster, requiring bigger and faster peripheral equipment. At the same time, however, another breed of computers has emerged over the past several years: small and medium sized desk computers, designed for engineers, accountants and small business or scientific organizations that cannot afford large scale equipment. Until recently such small computers used cards or paper tape for storage of data and programs. When data had to be transferred from the small computer to a larger one, inevitably it had to be translated to a faster medium such as magnetic tape. Recently magnetic tape units have appeared on the market, capable of recording data at the slow, asynchronous, single character mode of paper tape, then reproducing them at the fast, block mode suitable to large computers. And vice versa.

Dartex Division of Tally Corporation, Santa Ana, California, has introduced one of the smallest and most sophisticated tape units of this type. The Dartex 1020 digital magnetic tape unit can asynchronously record and reproduce eight-bit parallel characters at any rate up to 120 characters per second. It can also record or reproduce characters at a continuous rate of 1600 characters per second. The unit is only 8″ x 16″ x 9¾″ and fits easily into a console or standard rack, and has such impressive standard features as automatic tape loading. It uses 3″ reels of ¼″ tape for recording, with each reel capable of storing 140,000 characters.



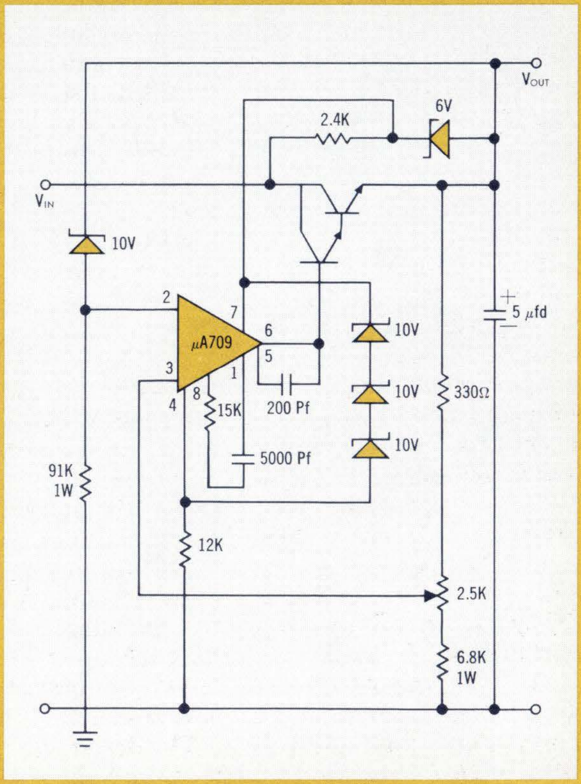
The tape handling properties of this unit are characterized by precise tape motion control and gentle handling to reduce tape wear. The electronic circuitry consists of 12 two-sided printed circuit cards, and is implemented with silicon solid-state devices — primarily Fairchild RTL 900, 914 and 923 integrated circuits. This compact electronic package furnishes all the necessary control signals for the read and write circuits, for data format control, and for the electromechanical elements.

The Dartex 1020 is particularly useful in applications where data is received sporadically and recorded for later evaluation by a fast processing system. It can be used as a buffer between digital data collecting systems and a central processor, in process control systems, communication systems, or small accounting and business machines.

Since the unit was designed with integrated circuits from the start, direct comparisons with discrete models cannot be made. It is possible to estimate, however, that without integrated circuits the unit would have required three times the number of connector joints used, would clearly not have been as compact, and would have, in all probability, cost considerably more to manufacture.

NEW USES FOR INTEGRATED CIRCUITS

High Voltage Series Analog Regulator For Power Supplies. In a power supply regulator which uses an operational amplifier as the comparator, the unregulated input voltage must not exceed the maximum specified device supply voltage. The circuit shown in the diagram illustrates one way to get around this limitation. A Fairchild μA709 linear integrated circuit is used as the comparator and is connected in a bootstrap circuit (numerals 1-8 show the actual lead connections). Normally the μA709 is capable of 28V swings at its maximum bias of 30V. But in the bootstrap configuration it allows control swings of 70V, without losing any of its regulation properties. In this type of circuit, therefore, the μA709 can be used for power supplies with an output voltage of 200V or more.



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Electronics Abroad

Volume 40
Number 18

Israel

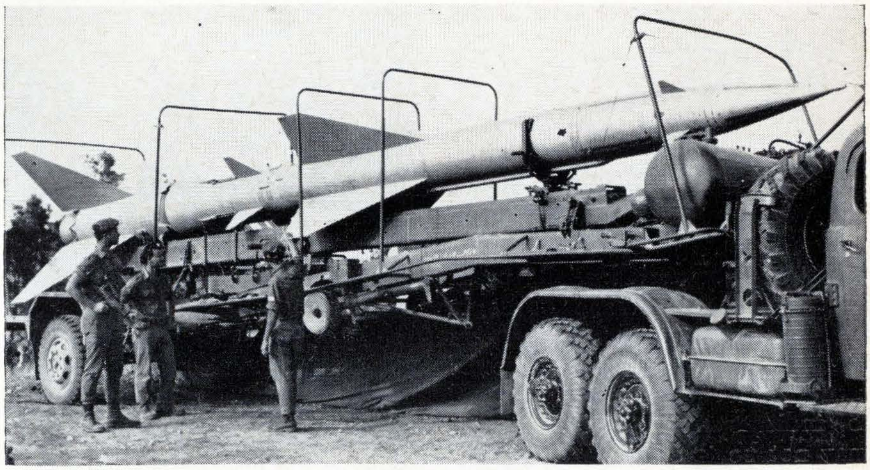
Peeking at prizes

After spreading the word that some of the Russian-made military hardware captured from the Arabs is "priceless" because details of its construction and operation are unknown in the West, the Israelis wrapped the equipment in a blanket of security and started looking for trade offers. A quick peek under that blanket by an Electronics editor shows that Soviet military electronics is built for ruggedness but not for sophistication. There are no integrated circuits in the field radio equipment, and only the newest models have transistors.

But perhaps the most important Soviet weapons taken by the Israelis are an advanced SA-2 ground-to-air missile being used against U.S. planes in Vietnam, a radar-controlled 57-millimeter antiaircraft gun that has been particularly effective against our craft there, an electronically guided antitank rocket, and an infrared guidance system for tanks.

By the book. It looks as if the arsenal supplied by the Soviets was too sophisticated for the Arabs. The SA-2 missile launching sites captured intact by the Israelis had complete kits of spares, maintenance tools, and even handbooks. One Israeli official said that although Arab troops could cope with routine maintenance, they failed completely when up against anything not covered in the handbooks. "They lacked affinity with modern technology," he said.

Of all the Soviet weapons taken by the Israelis, the one drawing the most attention is the improved version of the SA-2 ground-to-air missile. Western intelligence people reportedly had some idea of what the original version would do and how it worked. But until a dozen or so were captured from the Egyptians, along with three launching sites, little was known in the West about improved models.

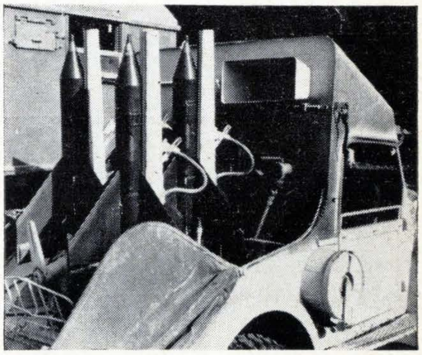


Unveiled. Of all the Russian-made equipment captured by Israel, this new model of the SA-2 ground-to-air missile arouses most interest.

The radar-guided SA-2 has a solid-fuel first stage that drops off four seconds after launch, and a liquid-fuel second stage that accelerates to a speed of Mach 3.5 and can climb to 55,000 feet. The warhead carries 300 pounds of explosives.

Ack ack. The radar-controlled 57-mm antiaircraft gun fires up to 60 rounds per minute. Its effective range is 2,200 yards and its maximum range is 5,500 yards. Each battery of four guns has a common fire-control system whose radar picks up potential targets at a range of 50 miles. At about 25 miles, the system locks onto one target and tracks it to within firing range. An analog computer and a five-man crew develop the aiming and pointing orders for the gun. To back up the radar for close-in targets, an optical tracking system is mounted atop the computer.

The desert war pitted antiquated Western-built Israeli tanks against some similar gear, but also against the latest tanks in the Soviet arsenal and a Russian antitank missile called the "Shmell." The Israelis, though, hit so hard and so fast that their Arab adversaries hardly used their Shmells.



Tank buster. The "Shmell" antitank missile has 2,500-yard range.

The Russian-made rocket can smack tanks up to 2,500 yards away. It is steered remotely under the visual control of an operator who guides it with a joystick. The launching gear can take up to four rockets, but is small enough to mount on a jeep.

Along with the rockets themselves, the Russians supplied Link-like trainers to sharpen the skills of Arab Shmell gunners. A dot representing a moving target moves across an oscilloscope screen, and the trainee tries to "hit" it with a second dot.

The Israelis also captured a Russian-made surface search radar, the Snar-2. The set is operated by nine men and can pick up targets as far away as 20 miles, depending on the target size.

West Germany

Pointing the way

The automation of rail traffic control, long touted as a way to optimum operating efficiency and a panacea for railroads' profit squeeze, has gotten a boost in recent German trials. The tests tend to confirm the promise of complete computer control and to indicate that implementation may not be too far off.

Officials of West Germany's federal railroad system say the trials showed that maximum train movement through stations can be accomplished by computer as a first step toward complete traffic control. Also, because nearly all the main rail routes in Germany are electrified, computers could control electrical energy distribution from power plants and transformers, which produce energy at different costs at different times.

At the heart of the tryout system was a Siemens 303 digital process-control machine installed at Siemens' Brunswick computer center. In an on-line operation, the computer furnished instructions for switching rolling stock at the Seelze yards, 45 miles away, which handle 4,500 cars a day. At the same time, the computer determined the routing for freight and passenger trains through the Uelzen station, 111 miles away on the busy Hanover-Hamburg stretch. Finally, it helped ease freight-handling at Kassel-Bettenhausen 138 miles away.

Braking point. At Seelze, information on freight cars—cargo, destination, identification number, weight, and braking capacity—was reported to the computer via teletypewriter. The computer then produced a tape instructing the switchman in the control tower on the routing of incoming trains, the reassignment of cars to other trains, the number of cars to put in each train, and the speeds and braking procedures to be followed. The computer further determined the status of each makeup track via signals from axle counters installed between the rails. The counters also told the computer if cars had been misdirected. In future systems, the computer would control track switches and car couplings.

Orders. Computer 45 miles away tells switchman how to assemble trains.

The computer indicated to the switchman at Uelzen the tracks to switch for the best train movement through the station.

Complete automation won't come until the early or mid-1970's at the earliest, in the estimation of officials of the Federal Railroad Central Authority in Frankfurt.

Great Britain

A step closer

The designer's ideal computer would combine the speed of an analog machine with the reliability and ease of control of a digital. Size is the major hurdle; despite the advent of integrated circuits, it takes a massive amount of hardware to get a true analog computer or its half-brother, the incremental computer, to carry out a complex series of computations.

In established types of incremental computer, such as the digital differential analyzer (DDA) and the operational-digital machine, each computation has to be set up individually by interconnection of the processing elements, generally through a patch board.

Phased. To get around this bottleneck, Brian Gaines and P.L. Joyce of Britain's Standard Telecommunication Laboratories, an ITT subsidiary, have designed and built an incremental phase computer with all interconnections controlled by auxiliary digital logic; the machine can be programed in the same way as a conventional digital machine. Gaines says it can be thought of as a conventional digital computer with the parallel binary arithmetic unit replaced by a complete DDA computer. Also, he notes, the advantage of programing makes for a considerably simplified DDA section.

The incremental digital processor uses unidirectional synchronous binary counters as storage registers. Each counter has 16 bits and a single input line through which it increments when the line is on. The arrangement permits the establishment of pseudo-analog computing loops, so that complex operations—division and square-rooting, for example—are performed with the same speed as simpler operations such as addition and data transfer. With the ease of programing, complex computations can be performed as a sequence of elementary operations.

Gaines and Joyce say they've tested their phase computer in aircraft-navigation, surveillance-radar, target-tracking, and biochemical-analysis applications, and report potential size and cost advantages.

The machine, designed and built in-house, is large and bulky because STL wanted to see what it could do. But it will be sold as a single-function computer rather than a large, comprehensive one. For example, STL is cooperating with SRT of Sweden in a project to apply the first production model to the job of azimuth-sweep generation in a digital plan-position-indicator radar for air traffic control. SRT will make the ppi, building in IC's on phase-computing principles.

Japan

What's cooking?

Two apparently unrelated elements—the search for new luxuries by well-heeled status seekers, and the expiration of Raytheon's Japanese patents on anode strapping in magnetrons—have convinced the Japanese electronics industry that the time has come to push electronic ovens as home appliances.

While last year's production came to only about 4,000 units, the figure this year might reach 10,000 and the total next year could be twice that. The market? Optimists say the same people who are buying color television sets (600,000 to 700,000 in Japan this year) and air conditioners (300,000 this spring and summer) will buy the ovens. In fact, the top producer, Matsushita Electric Industrial Co., plans to demonstrate its electronic ranges to customers who have already bought its other major appliances.

Price cuts. The patent expiration means the end of a license fee to Raytheon ranging from 2% to 5%. That fee wasn't an important cost factor in itself, but it did tend to dampen enthusiasm for all-out marketing campaigns. Now, the bullish production and sales outlook will bring a price cut by Matsushita and the number two producer, Hayakawa Electric Co., around the end of the year.

The price of the bottom-of-the-line unit, designed for home use and rated at an output of 500 to 600 watts, will be reduced from $550 to $415. Other electronic ovens range in price all the way up to $3,000 for 2,000-watt units.

Besides Matsushita and Hayakawa, others champing at the bit are Toshiba (Tokyo Shibaura Electric Co.), Hitachi Ltd., Mitsubishi Electric Corp., Sanyo Electric Co., and Japan Radio Co.

Matsushita is pinning most of its hopes on two small units. It rates the smaller at 500 watts output by working backwards from its power drain of 12 amps, which the company feels is the maximum possible in Japanese homes without installing special wiring. Using the same magnetron is a 700-watt unit.

Hayakawa's entry is a 600-watt model priced the same as Matsushita's 500-watter. The company is mounting a big home-use campaign to start after the price reduction.

Magnetron makers. About 80% of the magnetrons have been produced by New Japan Radio Co., a joint venture of Raytheon and Japan Radio. New Japan also exports some small magnetrons to the U.S. for Raytheon's use. Others in the business are Kobe Industries Corp., which exports some magnetrons for Litton, and Toshiba, which mainly supplies its own demand.

But this summer, Hitachi, with much fanfare, entered the cooker magnetron business with three models having ceramic seals rather than the usual glass seals. Two rated at 800 watts are air cooled; the third, at 1,400 watts, is water cooled. Matsushita, operating jointly with Philips of the Netherlands, has built a new plant and will go into the cooker magnetron business when it has developed a new product and completed life tests. Nippon Electric Co., a leading manufacturer of other types of microwave tubes, is also expected to start manufacturing cooker magnetrons.

International

Discordant Symphonie

France and West Germany a few months ago dubbed the communications satellite they plan to jointly develop "Symphonie." That was intended to convey a harmonious meshing of the two nations' independent projects. So far, though, Europe's first concert in space communications sounds a bit flat.

The governments agreed, when they signed their late April accord, to give each country's aerospace industry a precise half of the business [Electronics, May 15, p. 234]. They didn't quote a price, but estimates range from $32 million to $50 million for two operational payloads. They agreed, as well, to pick the prime contractor from industry. That was good news to the French, who, unlike West Germany, have already orbited satellites. Until Symphonie, however, prime contractor for the satellites has been the national space agency, Centre National d'Etudes Spatiales.

Satellite in a poke. Industry leaders are concerned, nevertheless, because they still don't know what they'll be asked to build—despite the hurry-up nature of the project. Originally scheduled for delivery in August, bid specifications now aren't expected to be ready until September or October. A CNES official blames summer vacations for the wait.

What worries industry still more

Get ready, get set. . . . Production-line tempo picks up as Matsushita, Japan's biggest producer of electronic ovens, prepares for sales push.

is what form a special government-level steering committee will want the bids to take. The question seriously jeopardizes the consortium formation because the committee may first order bids from all-French and all-German groups for the satellite's electronics. Then, industry insiders say, the steering group would select the two best groups, split each down the middle, and make one combining the two best of the four halves.

Because the number of candidates is fewer, the problem is less severe for the satellite structure makers. Only three are currently reported interested: Nord-Aviation and Engins Matra of France, and Boelkow of West Germany. However, consortium building is difficult there, too, because some hopeful participants expect the steering group to name two prime contractors, one for the electronics and one for the structure.

Nothing splashy. All the manufacturers want to start forming their consortiums quickly to assure launching in less than three years. Few are concerned about the technology the governments will require. Though most of the details are still unknown, one executive says: "There's nothing spectacular about it. It will just be a music and broadcast satellite with only a 50-megahertz bandwidth." The two nations agreed that the satellite will weigh 400 pounds and be capable of handling a thousand channels.

Despite the unknowns, one of two likely French consortiums is already lined up. Its members are Compagnie Générale de Télégraphie Sans Fil (CSF), Société Anonyme de Télécommunications (SAT), and Nord Aviation. If the steering group should accept binational bids, then those companies plan to join West Germany's Siemens AG, Telefunken, and Boelkow.

An assortment of additional companies, some well versed in communication satellites through Intelsat contracts, are talking of forming a second consortium, but want to see the steering committee's ground rules first. Among them are Compagnie Française Thomson Houston-Hotchkiss Brandt, ITT's Laboratoire Central de Télécommunications, Electronique Marcel Dassault, Société d'Electronique et d'Automatisme (SEA), Engins Matra, and Entwicklungsring Nord (Erno), a joint venture of two North German aircraft makers.

France

Shrug—in living color

Despite the hoopla of a 10-day sales drive focused on the arrival of color television in France, early indications are that the French are as enthusiastic about buying color sets as they are about drinking milk. The start of the drive coincided with the opening last Saturday of the annual International Radio and Television Salon in Paris.

Why the apathy? Start with price. Color sets at the show cost around a thousand dollars each—four times the price of the cheapest black-and-white models. And there's little choice. Just about each manufacturer offers a single table model with a 24-inch screen. Then there's the dual standard in French tv. One of the two black-and-white channels uses an 819-line standard, the other uses 625 lines. Color will be available only on the second (625-line) channel beginning Oct. 1 for 12 hours weekly. Thus, to equip a set to pick up both channels plus color adds up to higher price.

Gaul is divided. That's not all. According to critics of the government, only about half the country will be able to pick up the second channel clearly if at all, because relay equipment hasn't yet been installed all over France.

And one final complaint: Frenchmen still using old tv sets, bought before the second channel existed, can't receive it. That wasn't so bad up to now because it was a secondary channel. But when color broadcasts start, the second channel will carry major shows because those are the ones that the Office de Radiodiffusion-Télévision Française, the broadcast network, will want to deliver in color.

Austria

Tv in waltz time

While 50 million Frenchmen ignore color tv, 7 million Austrians—921,000 of them set owners—are going to have to wait until 1970 for it. The delay from the original target date of this fall stems from politics, technology, and money.

The government-owned Austrian Broadcasting Company (ABC) until recently was run by political appointees more attuned to Viennese intrigue than to their fee-paying viewers. But that has been changed to more commercial-minded management that wants to make sure the 15-year conversion to color (costing $600 million) will be financially feasible. Technically, the big problem is the transmission obstacle presented by the Alps.

The financial barrier comes in two sizes: the $2-a-month subscription fee and the price of sets. ABC wants at least a million subscribers before starting color, but anticipation of the switch has caused sales this year to drop 25%. And color sets range in cost from $921 for a Philips, $999 for a Kuba (West German subsidiary of GE), to $1,069 for a Bang & Olufsen from Denmark.

Soviet Union

Hard-to-get software

What's happened to Russia's fastest computer, the two-year-old BESM-6? So far only two machines are operating at civilian establishments: the Meteorology Center and the Computing Center of the Academy of Sciences, both in Moscow.

The delay, say informed Soviet specialists, is due to a lack of software that has delayed the machine's acceptance by the State Committee for Science and Technology, which has authority to order factory production.

Spread. Preparation of software is decentralized. Work is being done in Moscow at the Computing

Center, the Institute of Mathematics, and the Economics-Statistics Institute. Scientists are also working at the Institute of Cybernetics in Kiev and the Computer Center in Akademgorodok near Novosibirsk.

The Russians say the BESM-6 will be time-shared [Electronics, June 12, p. 244]; the software is expected to be developed early next year. But time-sharing will be further off because of a lack of adequate terminal facilities.

As far as the hardware is concerned, here's what goes into the BESM-6:

- A central processor with 16 registers and 300-nanosecond access time.
- Core storage consisting of eight blocks of 4,000 words each with each word containing 50 bits.
- Four magnetic drums, each with 120 tracks and three blocks of read-write heads. Each drum rotates at 3,000 rpm.
- Eight magnetic tape drives. Tape quality, according to a knowledgeable Russian, is "still not high enough."
- Two 700-cards-a-minute readers and two card punchers.
- One paper punch and a punch-paper reader.
- Two printers, each rated at 600 lines a minute. A set of 96 characters is on a cylinder opposite paper at each print position. Hammers behind the paper press it against the cylinder.
- A teletype input-output keyboard and printer.

The computer, which has no cathode-ray tubes, is considered a medium-scale machine by U.S. standards.

Around the world

Canada. The government has named a career diplomat as head of the Canadian Broadcasting Corporation. Jules Leger, currently ambassador to France, will succeed the retiring Alphonse Ouimet, who is credited with the technical development of the network [see story on p. 131].

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