Electronics®

Redundancy that uses low power: page 66

Programs for computer-aided design: page 74

Electronics in the Federal budget: page 131

February 6, 1967
$1.00
A McGraw-Hill Publication

Below: Two-tube color-tv camera separates color with a filter, page 99

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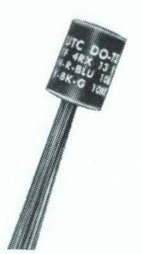
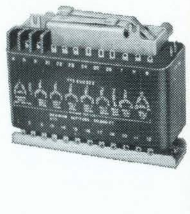
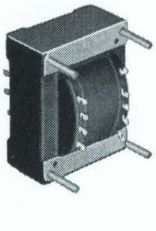


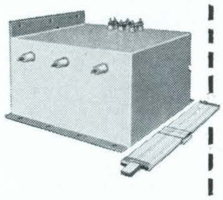
MIL-T-27B ultraminiature Scott connected power transformer, 5/16 Dia. x 13/32" H., 1/10 Oz. Primary 28 V. 400 ∽ with taps @ 50% & 86.6%. Two units provide 28 V two phase from three phase source.



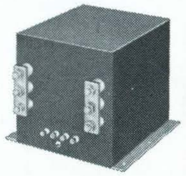
Molded Power Transformer 3 Phase. Input 200V, 380-420 cps. Electrostatic Shield, 8 output windings. 26 terminals. MIL-T-27B, Grade 2 Class S. Max. Alt. 50K Ft. Size 6 x 2½ x 5", 8 lbs.



Commercial type molded power transformer. Primary 115/230 V., 50/420 cycles to 680 VCT.-.015 A., 6.3 VCT.-1.2 A., 6.3 V.-.6A. Size: 2½ x 3 x 2⅞", weight: 1.6 lbs.



Three phase high voltage power transformer. Primary jumper hardware for easy conversion from delta to wye inputs. Made to MIL-T-27B specifications. Primary: 440 V 60 cycles delta or wye 3 phase input. Secondary: 2100 V line to line or 1215 V line to line @ 242 ma.



High current filament transformer. Primary 140/156 V., 47/63 cycles to 1.8 V.-1070 A. Current limiting through separate primary reactor, MIL-T-27B; 10 x 10 x 11½", 150 lbs.

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Circle 900 on reader service card

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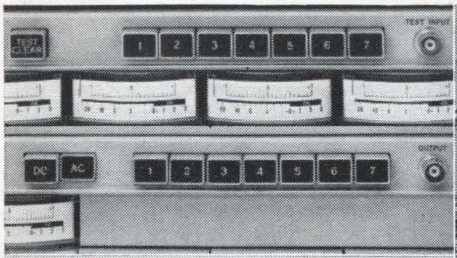
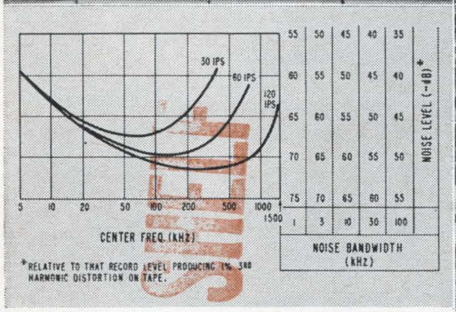
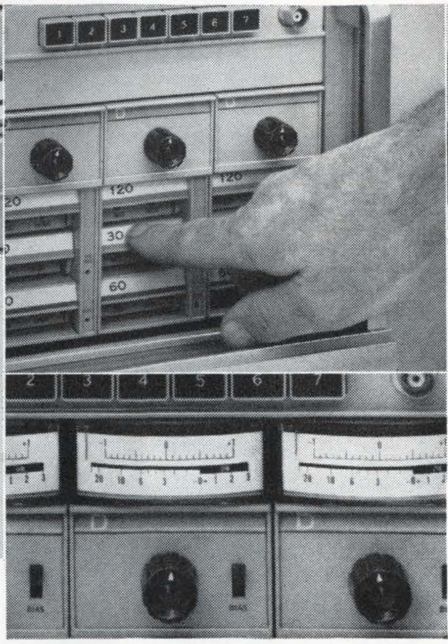




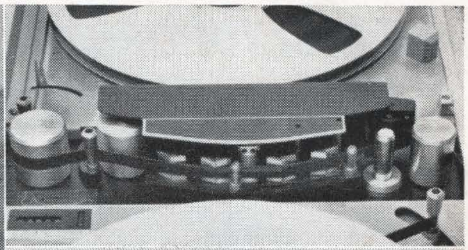
Typical noise levels for various noise bandwidths. A unique preamp/magnetic head combination delivers highest S/N ratio, > 30dB for full 1.5 MHz bandwidth.

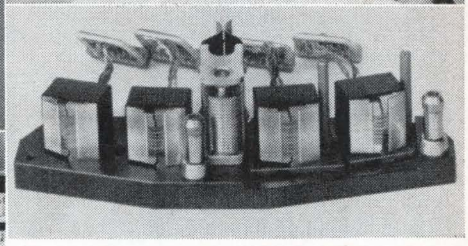
Unique push-bar reproduce equalizers assure positive contact.



Individual meters for record modules give continuous display of signal or bias levels: bias and calibration adjustments, as well as test points, are readily accessible.

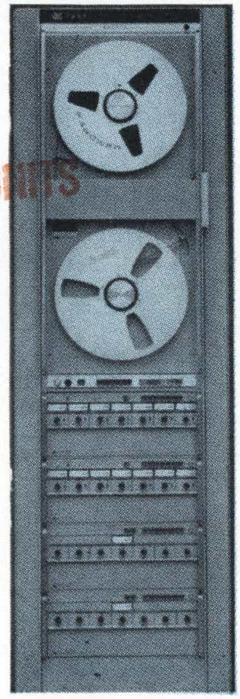
Fast threading, simple maintenance, exceptional motional stability with a simple open-loop tape drive.





Both record and reproduce heads are pre-aligned on a single precision baseplate that mates directly to the transport casting—virtually eliminating the need for adjustment. Assemblies are easily replaced in the field.

Convenience and performance with a new tape system from HP



The new HP 3950 Tape System offers 7 or 14 tracks and tape speeds of 3¾ ips to 120 ips, with both direct (400 Hz to 1.5 MHz) and FM (DC to 20 KHz) modules interchangeable channel to channel. Wideband (400 KHz) FM optional.

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For additional information contact your local HP field engineer, or write Hewlett-Packard, Palo Alto, California 94304, Tel: (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

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H12A

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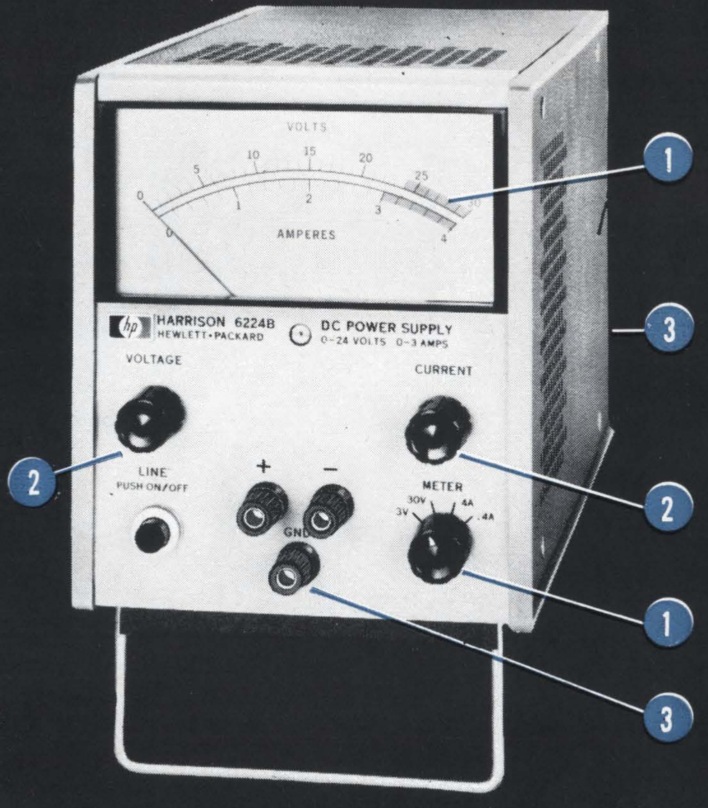

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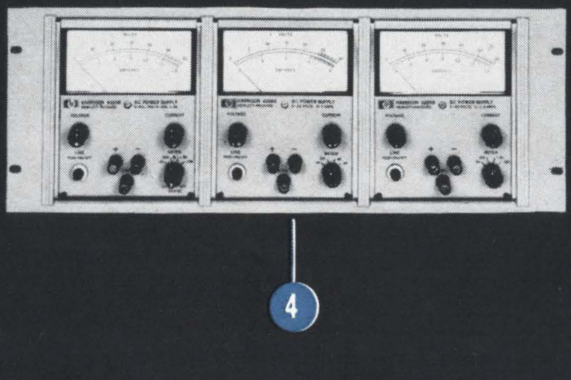
4. Compact ⅓ Rack Width **hp** Module
Convenient for Bench and Rack Use



Electronics

February 6, 1967
Volume 40, Number 3

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Probing the News

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Electronics Abroad

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I. Design

II. Applications

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Readers Comment

Time language

To the Editor:

The milliday concept is the greatest idea of all time [Nov. 14, 1966, p. 43]. It is a written presentation of time that can be read and understood by all nations. If millidays are put on a Greenwich mean-time basis, we have created a truly international time language.

Clarence Laber
Hewlett-Packard Co.
Loveland, Colo.

Bold position

To the Editor:

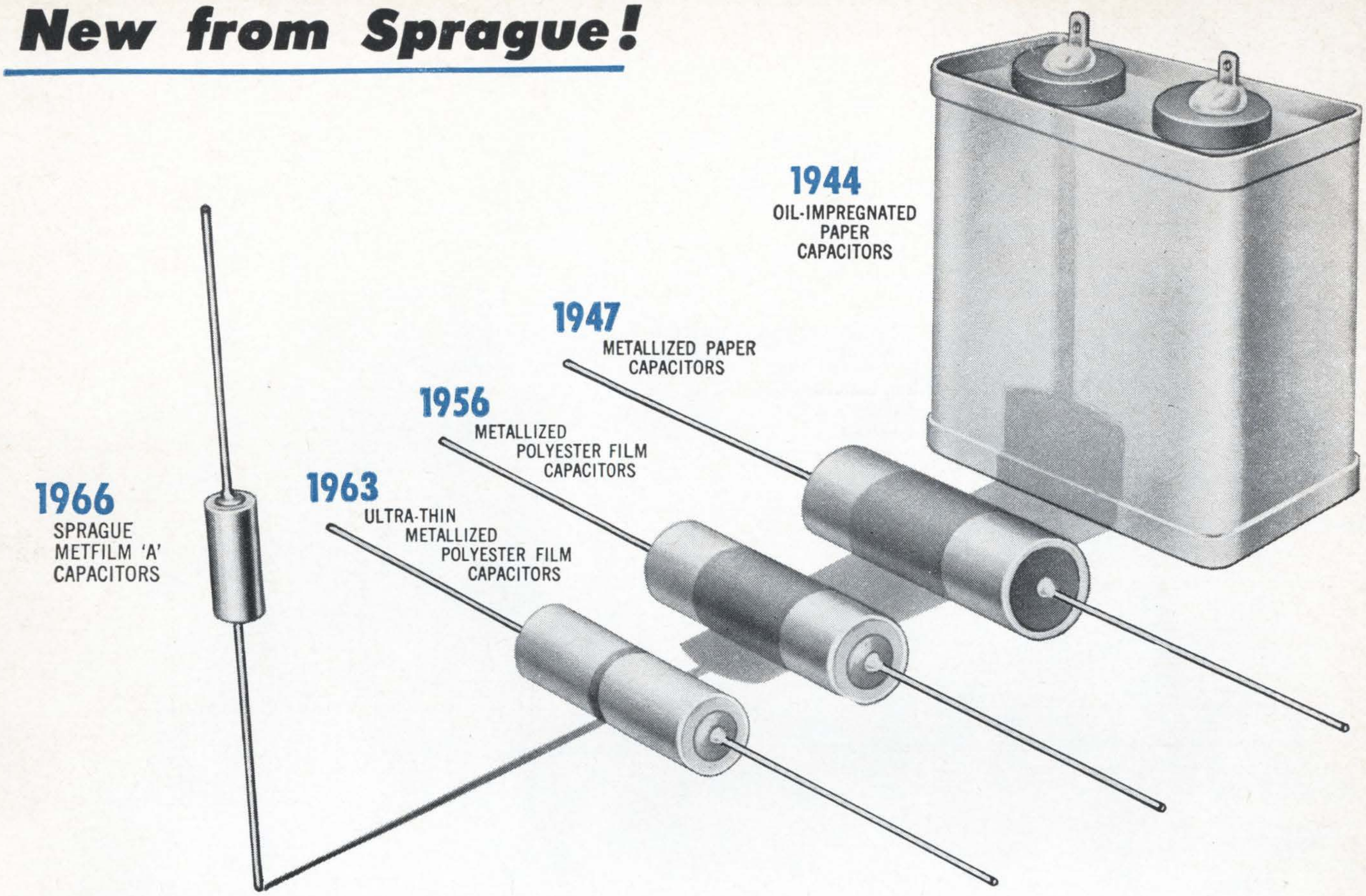
In the article "The BOLD librarian" [Oct. 17, 1966, p. 40], I question the statement that relates to the failure of librarians seeking to aid engineers.

One wonders why there is such a great demand for professional librarians, as illustrated by the special "Librarian Openings" section appearing monthly in the New York Times. If ". . . despite our best intentions we are often a source of irritation to engineers. . ." I am quite sure that industry, government and the universities would not be investing vast sums of money in libraries and library personnel if all they were getting in return was irritation.

You also imply that the object of the BOLD system is to replace the librarian with a machine. In truth, information retrieval systems are almost always designed to assist the librarian and to enable him to exercise greater control over and better dissemination of information. Many librarians are in the forefront of the move to mechanize library operations to provide library users with information by the most rapid and efficient means.

The article neglects to mention that each document in the BOLD system will probably have to be analyzed first by someone who will assign key words from a thesaurus of terms prepared in advance and who will also probably prepare an abstract. Librarians have been analyzing, indexing and abstracting documents for decades and there is a good possibility that in any machine system it will be a pro-

New from Sprague!



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dramatically smaller in size, yet more reliable than military-grade capacitors of the past!

Just a few years ago, the only 10 μF capacitor considered dependable enough for military applications was Type CP70 (to JAN-C-25), and was a block-busting 3¾″ wide x 1¾″ thick x 4″ high. Today, you can get a military-quality 10 μF tubular capacitor measuring only ½″ in diameter x 1¼″ long. And it's more reliable than any capacitor of the past!

Sprague Type 680P Metfilm 'A' Metallized Capacitors meet all environmental requirements of MIL-C-18312, yet they occupy only one-third the volume of conventional metallized film capacitors of equivalent capacitance and voltage rating. Employing a new thin organic film dielectric system, Type 680P capacitors use a dual film totalling only 0.00008″ thick, as compared to conventional polyester-film capacitors with a single film measuring 0.00015″.

*Trademark

Another distinct advantage of the Metfilm 'A' dielectric system is minimum degradation of electrical properties during life.

Hermetically sealed in corrosion-resistant metal cases, capacitor sections are effectively of non-inductive construction, resulting in capacitors with performance characteristics superior to those of comparably-sized capacitors.

Type 680P Metfilm 'A' Capacitors are available with capacitance values to 10 μF in both 50 and 100 volt ratings.

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For complete technical data, write for Engineering Bulletin 2650 to Technical Literature Service, Sprague Electric Company, 35 Marshall St., North Adams, Mass. 01247.

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- select from five modules
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B 1217-C High Performance at Minimum Cost
- 2.5 Hz to 1.2 MHz
- <10 ns rise time
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C 1398-A Fast Rise and Fall Times
- 2.5 Hz to 1.2 MHz
- < 5-ns rise/fall times
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E 1397-A Linear Amplifier with 1.2-Ampere Output
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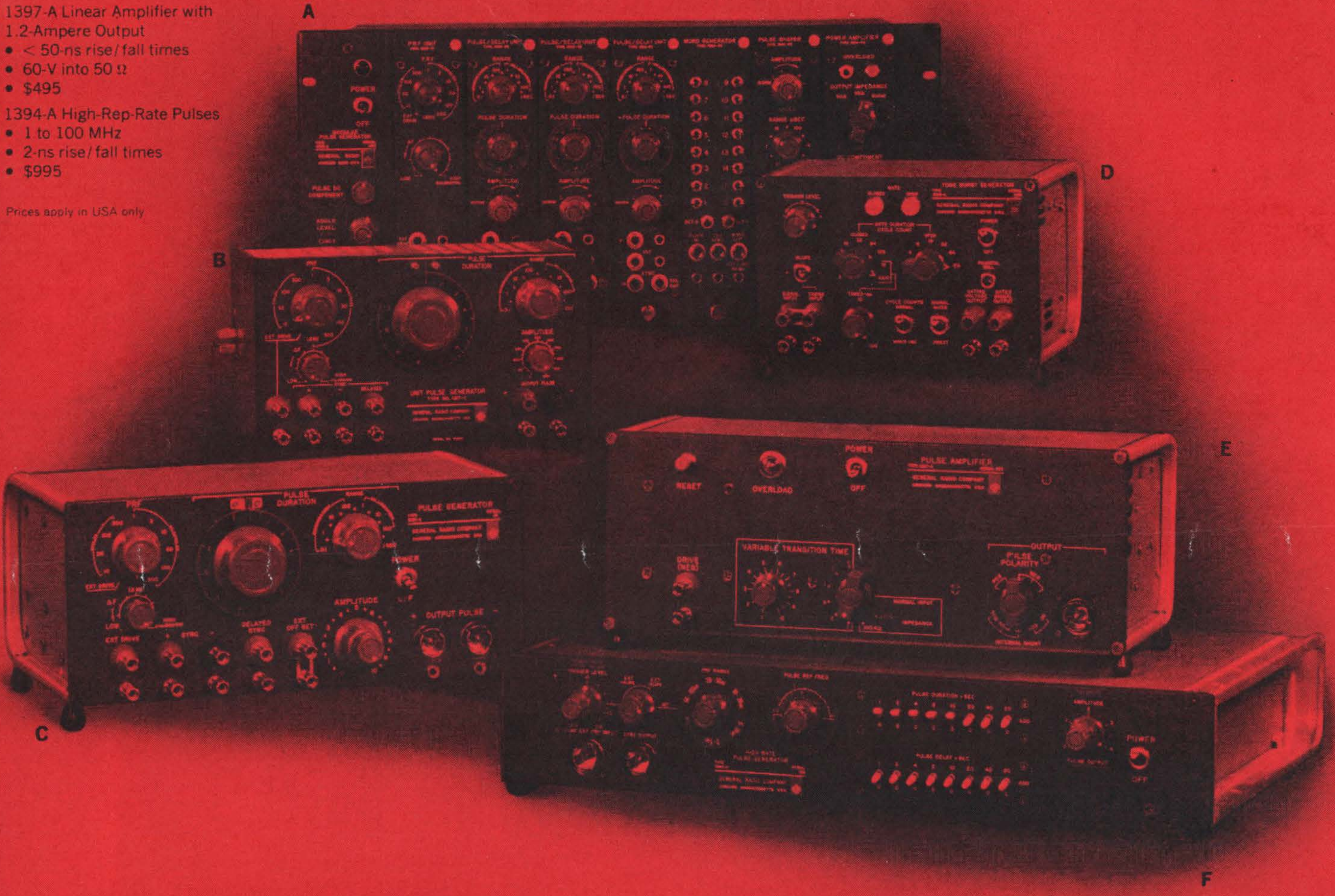

Pulses Galore!

In the market for a good pulse generator? Look into these instruments, with repetition rates as low as 2.5 Hz or as high as 100 MHz, rise and fall times from 2 ns to 10 ms, amplitudes as high as 1.2 A (p-to-p), and the best performance-to-price ratio you can find. If you want the special features of a custom-built pulse generator, our 1395 is the instrument for you. With its five different modules and capacity to handle up to seven modules in thousands of combinations, this instrument can generate just about any pulse or pulse train you can conceive.

For assistance in your hunt for a pulse, write General Radio Company, 22 Baker Avenue, W. Concord, Massachusetts 01781; telephone (617) 369-4400; TWX 710 347-1051.

GENERAL RADIO

Circle 6 on reader service card

fessional librarian who prepares the input.

It is my opinion that the technical librarian is not tottering down the road to obsolescence, to be replaced by a bibliographic computer. Instead, the computerized information system will serve as a tool in the hands of the librarian and will enable him to provide engineers and others with information even more efficiently than he has in the past.

H.B. Landau
Library supervisor
Bell Telephone Laboratories
Naperville, Ill.

Reliable or unreliable IC's

To the Editor:

It was with great interest that I read the article regarding the reliability of integrated circuits [Dec. 26, 1966, p. 56]. At the present time we are pursuing integrated circuits on a parallel effort with discrete component circuits for a new development program exclusively because of anticipated high reliability and low cost. In this application, size reduction associated with integrated circuits is not an overriding factor. Therefore, the accuracy of our cost and reliability predictions becomes very meaningful in the selection of a final design. For this reason I was particularly concerned with the quoted statement from a Defense Department spokesman that IC's may result in equipment that is less reliable than its equivalent built with discrete solid state components.

Soon after I completed reading your article, I received an article from another magazine which stated "The high reliability of microelectronics has prompted the Defense Department to urge their use in the broadest possible scale." The article goes on to state that all research and development projects already underway are to be reexamined in order to substitute microelectronic devices wherever appropriate.

It would appear that, if these two articles are accurately reported, there are technical opinions and policies emanating from DOD which are 180° opposed to each other. The only hope for the poor project engineer in the face of these conflicts is that some resolution can be made before any policies related to microelectronics are put into effect.

Warren G. Reiner
Morris Plains, N.J.

▪ The Department of Defense statement urging the extended use of microelectronics was first reported in Electronics in the Oct. 17, 1966 issue, on page 68. It was issued because integrated electronics promise high reliability—theoretically. As the Electronics article in the Dec. 26 issue pointed out, however, what actually happens is sometimes different. The inherent high reliability of integrated electronics can be lost in at least three ways: 1) if the IC's are poorly made; 2) if the IC's are used improperly; and 3) if the IC's are interconnected improperly. The apparent contradiction reader Reiner worries about is not a contradiction at all. It is proof that DOD engineers have adopted a realistic attitude about the reliability of equipment with integrated electronics. They know reliability will not come automatically.

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People

The resignation of **Norman F. Parker** as chief of North American Aviation Inc.'s Autonetics division—after less than a year in that job—hit the company and the aerospace industry by surprise. Parker, a 44-year-old Ph.D in engineering, is moving to the Bendix Corp. as vice president for operations.

Norman F. Parker

Moving into the post he vacated is S.F. Eystone, Autonetics' number two man. The passing of the reins to Eystone would indicate that no radical change is expected at the division, which has recently recovered from some sharp drops in business. The latest major business boost for Autonetics was receipt of the Mark 2 order, the integrated avionics for the F-111.

"Two-step procurement is the worst thing that ever happened in this business," says **Col. Spencer S. Hunn,** the newly appointed deputy for tactical systems at the Air Force Electronic Systems Division, Hanscom Field, Mass.

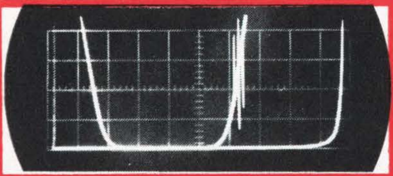
Col. S.S. Hunn

Quiet-spoken Hunn is bucking the tide when he fights the two-step system, in which bidders submit technical proposals, and then the acceptable bidders are asked to quote prices. "You never get a chance to correct the specifications," says Hunn, who favors the fixed price, negotiated contract. "I've never seen a contract yet without spec problems," Hunn adds.

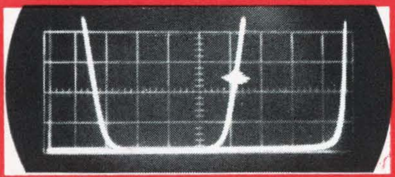
Rather fight than . . . He is willing to battle the rigidities of procurement edicts because he believes that, in development of command and control systems, the engineers should have the final word.

In his new post, Hunn is manag-

ULTRA-NARROW MARKERS—100 Hz



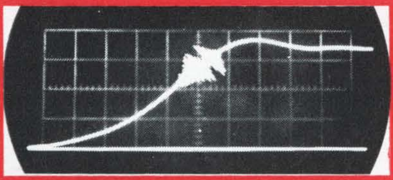
E. Location of birdy marker is difficult to determine on vertical.



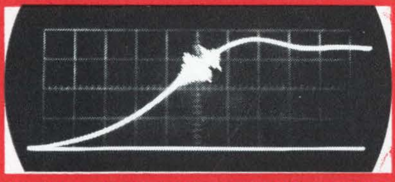
F. Tilted marker permits precise frequency determination.

Harmonic (1 MHz) and variable (200 Hz-20 MHz) frequency markers may be deviated from 10 kHz to as narrow as 100 Hz for precise frequency determination. Unique time-sharing circuit allows any combination of markers to be displayed simultaneously without interference. Marker tilt control provides precise readings even on steepest part of skirt.

ULTRA-STABLE



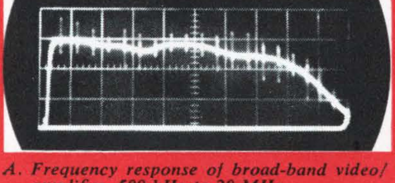
C. Same crystal filter as in (B) above, with 1/10 the sweep width (100 Hz/Div.).



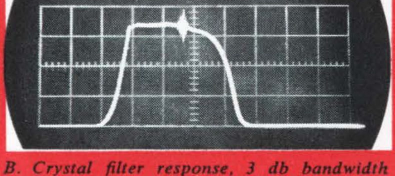
D. Five minutes later, no significant drift; birdy marker is 100 Hz wide.

New solid-state power supplies for the 1001 provide exceptional frequency stability of 100 Hz for short term operation (1 min.), and 5 kHz over long term (1 hour). Calibrating and adjusting are minimized, test results more dependable.

ULTRA-WIDE SWEEP RATIO



A. Frequency response of broad-band video/amplifier, 500 kHz to 20 MHz.



B. Crystal filter response, 3 db bandwidth is 2.8 kHz wide at 10.7 MHz center frequency.

The 1001 sweeps frequency in three ranges from below 200 Hz up to the full range of 20 MHz—that's a ratio of 100,000 to 1 overall—plus CW and modulated CW! This one instrument serves for narrow and broadband applications in RF, IF, and video frequencies.

PLUS

- VARIABLE SWEEP RATE FROM .01 TO 60 Hz
- MANUAL OR EXTERNAL SWEEPING FOR XY PLOT
- 1 VRMS OUTPUT WITH 103 db ATTENUATION

THE

1001

SWEEP/SIGNAL GENERATOR

200 Hz-20 MHz

SPECIFICATIONS

CENTER FREQUENCY	200 Hz - 20 MHz
SWEPT RANGE	200 Hz - 20 MHz
SWEEP WIDTH	
Narrow Range	200 Hz - 200 kHz
Intermediate Range	1 kHz - 2 MHz
Wide Range	10 kHz - 20 MHz
SWEEP RATE	
Variable	0.01 - 60 Hz
Line-Lock	50/60 Hz
OUTPUT	1 VRMS into 50 ohms
STABILITY	
Short Term (1 min.)	100 Hz
Long Term (1 hour)	5 kHz
HARMONIC MARKER	1 MHz
VARIABLE MARKER, RANGE	100 kHz - 20 MHz
VARIABLE MARKER, WIDTH:	
Narrow	100 Hz
Intermediate	1 kHz
Wide	10 kHz

APPLICATION DATA FILE DESCRIBING USE OF TELONIC SWEEP GENERATORS IN RESEARCH, PRODUCTION AND Q.C. APPLICATIONS AVAILABLE ON REQUEST.

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Representatives in all major cities in the U.S. and foreign countries. Factory offices located at Maidenhead, England and Frankfurt, Germany

Circle 9 on reader service card

People

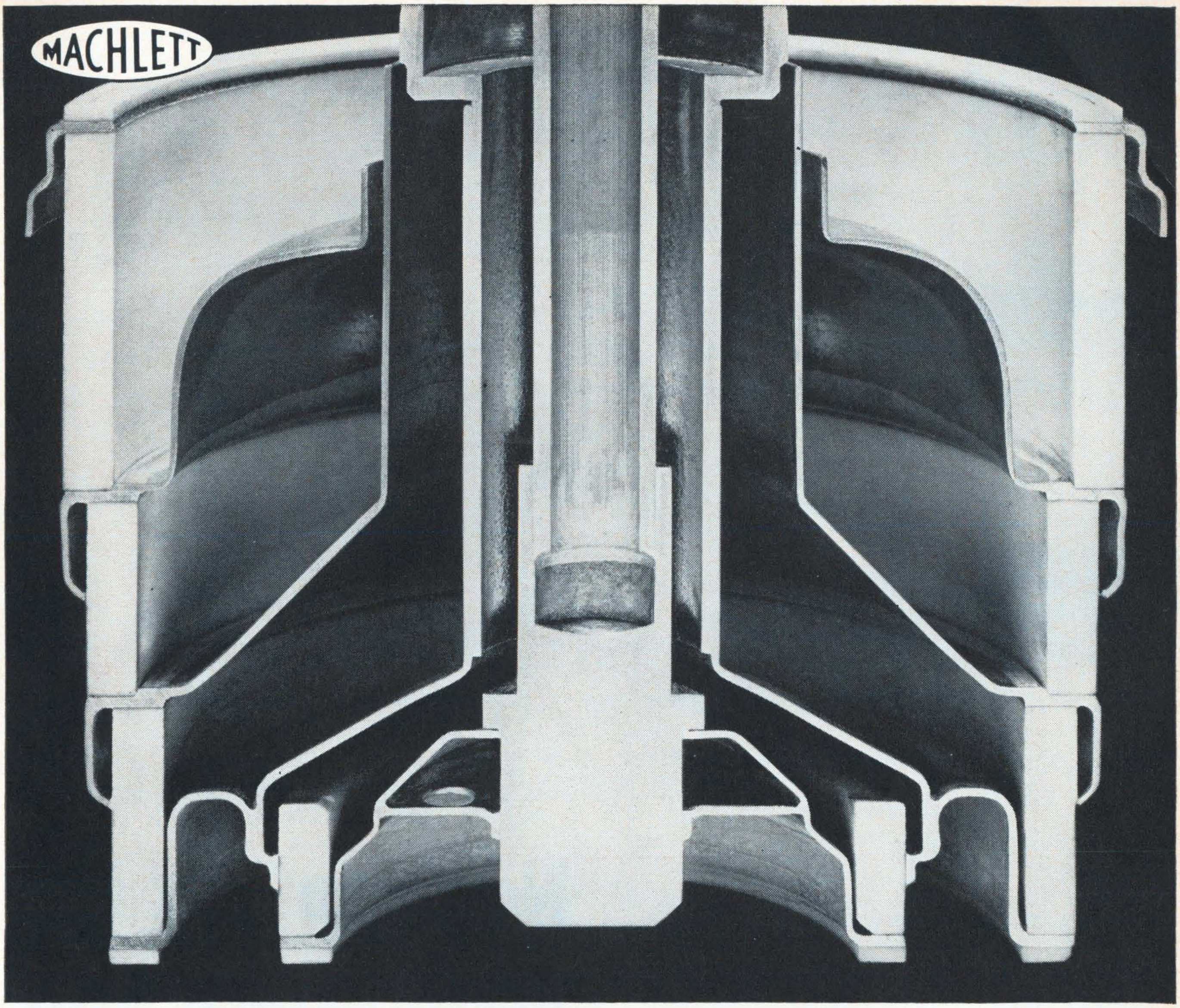
ing the $500 million program to build a modern tactical air control system. The Hanscom Field program, called 407L, may eventually involve a $1 billion procurement of such gear as air transportable radar and communications systems and data processors. Jeep-mounted communications equipment developed under the 407L program is already being used for direct air support in South Vietnam.

Last fall an article by **Joseph A. Parini** of Lear-Siegler Inc. described the Divic (digital variable-increment computer). The computer, for special-purpose navigation, offered the speed of a digital differential analyzer without sacrificing the flexibility of a general-purpose computer [Electronics, Sept. 5, 1966, p. 105].


Joseph A. Parini

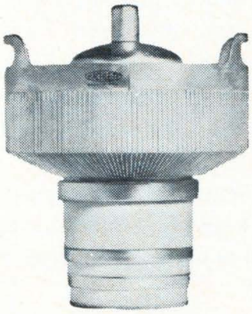
Lear-Siegler hasn't stopped there. The company is so confident that it has a valid approach to solving navigation problems that it has transformed Parini's computer department into a full-fledged division, with Parini in charge. The 35-year-old engineer has already doubled his staff, and the number is growing. The division is responsible not only for refining the design of Divic and for developing advanced versions, but also for designing digital receivers and total avionics systems.

New functions. The basic Divic design is being reprogramed under Parini's direction for new functions. Among the applications foreseen for it is navigation in the vertical plane, which will assist in takeoffs and landings and in maintaining vertical separation between aircraft essential in avoiding midair collisions. The advanced Divic design will easily handle these problems, says Parini, although it will have to be capable of more complex operations, such as matrix multiplications, than the present model.

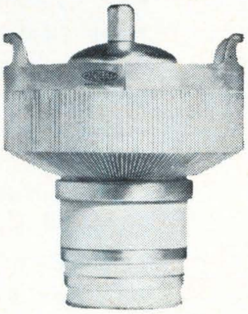


Continuous cone electrode geometry: designed into all these tetrodes only by Machlett

ML-8170/
4CX5000A



ML-8171/
4CX10000D



ML-8281/
4CX15000A

The result: uniform internal r.f. energy distribution and high performance stability.

Write for complete details:
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Springdale (Stamford), Conn. 06879.

Engineers' resumes invited

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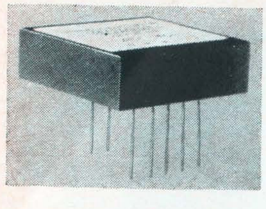
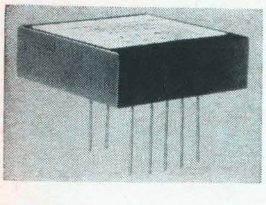
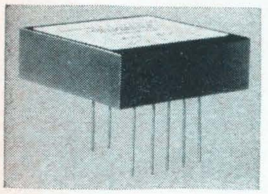
A SUBSIDIARY OF RAYTHEON COMPANY



Think Costs, too!



Think Hybrid...



Think Amperex...

Now you can get performance with

The plain facts are that Amperex can design and manufacture—to your specifications—the hybrid integrated circuit you need, and can do it faster, better and more economically than any other source known to us.

Why? Because Amperex special production line methods and Amperex thin-film/LID circuit technology are way ahead of the field. After all, who would have more skill in substrate processing and in microminiature circuitry than a leading producer of high-performance transistors? And who would be better able to apply LID semiconductor assembly techniques than the company who invented the LID?

Our batch-processed, large-volume runs of hybrid IC devices made with Amperex LIDS (off-the-shelf items and custom-produced items for special systems requirements) offer high performance at low cost, plus a third big bonus—small size.

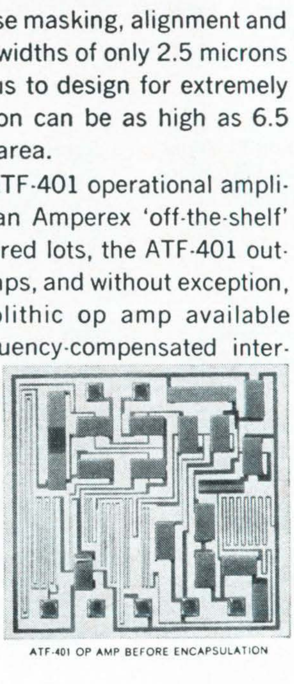
Amperex hybrids offer resistance values from 50 ohms to 300 kilohms with stabilities better than 1% over 2000 hours at 250°C; capacitance values from 10 pico-

economy as well as size and Amperex hybrid integrated circuits.

farads to 2 microfarads. Precise masking, alignment and exposure produce circuit line widths of only 2.5 microns (100 microinches), allowing us to design for extremely small circuit areas. Dissipation can be as high as 6.5 watts per square inch of film area.

The extremely successful ATF-401 operational amplifier is a typical example of an Amperex 'off-the-shelf' hybrid IC. At $29.00, in hundred lots, the ATF-401 outperforms many discrete op amps, and without exception, it outperforms every monolithic op amp available today. Since it is fully frequency-compensated internally, it requires no external circuitry which would increase its effective size.

Other examples, of even greater interest to today's markets can be taken from among this list of Amperex custom-designed hybrid IC's: Low-noise DC Amplifiers • Special Digital Interface Circuits • Signal Conditioners • Solid-State Commutating Switches • RF and IF Amplifiers and Limiters • Power Supply Regulators • Audio Amplifiers, Modulators and Demodulators.


ATF-401 OP AMP BEFORE ENCAPSULATION

The plain facts, then, lead to only one practical conclusion: If your product has reached the stage where you must begin thinking in terms of microcircuitry, it's not enough to think size and performance only . . . think costs, too! . . . think hybrid . . . think Amperex!

Ask Amperex about custom hybrid IC's for your linear applications, for impedance matching, logic transformation, current and voltage drive, low-noise amplification and any other application you can think of.

Write: Amperex Electronic Corporation, Semiconductor and Receiving Tube Division, Department 371, Slatersville, Rhode Island, 02876.

Amperex®

TOMORROW'S THINKING IN TODAY'S PRODUCTS

Circle 13 on reader service card

Meetings

Winter Convention on Aerospace & Electronic Systems, IEEE; International Hotel, Los Angeles, **Feb. 7-9.**

Electronic Packaging Conference, Society of Automotive Engineers; Roosevelt Hotel, New York, **Feb. 14-16.**

Conference on the Theory, Technique and Applications of Electron Probe Microanalyzers, Institute of Physics; London, **Feb. 15-16.**

International Solid State Circuits Conference, IEEE; University of Pennsylvania, Sheraton Hotel, Philadelphia, **Feb. 15-17.**

Airborne Photo-Optical Instrumentation Seminar, Society of Photo-Optical Instrumentation Engineers; Ramada Inn, Cocoa Beach, Fla., **Feb. 20-21.**

National Air Meeting on Collision Avoidance, Institute of Navigation; Dayton, Ohio, **Feb. 23-24.**

National Electric Automobile Symposium, Santa Clara Valley Engineers' Council; San Jose State College, San Jose, Calif., Feb. 24-25.

Numerical Control Society Conference, Statler Hilton Hotel, Detroit, **March 1-3.**

Particle Accelerator Conference—Accelerator Engineering and Technology, IEEE; Shoreham Hotel, Washington, **March 1-3.**

Symposium on the Effects of Radiation in Semiconductor Components, Faculte de Sciences of the University of Toulouse; Toulouse, France, **March 7-10.**

International Symposium on Residual Gases in Electron Tubes and Sorption-Desorption Phenomena in High Vacuum, Italian Society of Physics; Rome, **March 14-17.**

National Convention, Air Force Association; Hilton and St. Francis Hotels, San Francisco, **March 14-17.**

Temperature Measurements Society Conference and Exhibit, Temperature Measurements Society; Hawthorne Memorial Center, Los Angeles, **March 14-15.**

International Convention, IEEE; New York Hilton Hotel and Coliseum, **March 20-24.**

Symposium on Modern Optics, Polytechnic Institute of Brooklyn; Waldorf-Astoria Hotel, New York, **March 22-24.**

Photovoltaic Specialists Conference, IEEE; Sheraton Cape Colony Inn, Cocoa Beach, Fla., **March 28-30.**

Structures, Structural Dynamics & Materials Meetings, American Institute of Aeronautics and Astronautics; Palm Springs, Calif., **March 29-31.**

Symposium on Microwave Power, International Microwave Power Institute; Stanford University, Stanford, Calif., **March 29-31.***

Conference on the Transport Properties of Semiconductors, Solid State Physics Committee of Institute of Physics; Canterbury, Kent, England, **March 30-31.**

Business Aircraft Conference and Engineering Display, Society of Automotive Engineers; Broadview Hotel, Wichita, Kan., **April 5-7.**

International Electronic Components Show, FNIE; Porte de Versailes, Paris, **April 5-10.**

Call for papers

Meeting and Technical Display, American Institute of Aeronautics and Astronautics; Convention Center, Anaheim, Calif., Oct. 23-27. **Feb. 13** is deadline for submission of abstracts to Robert Langford, assistant director for guidance and control research, NASA Electronic Research Center, Cambridge, Mass. 02139

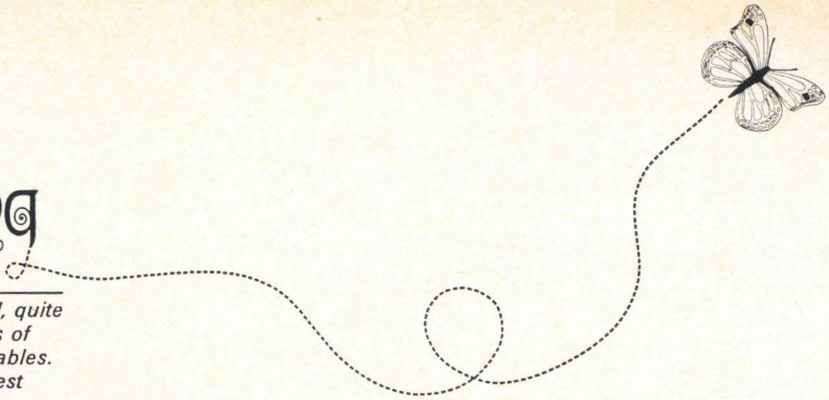
Symposium on Vacuum Science and Technology, New Mexico Section of the American Vaccuum Society; Holiday Inn, Albuquerque, N.M., April 19-21. **Feb. 15** is deadline for submission of abstracts to M.K. Laufer, Division 2411, Sandia Corp., P.O. Box 5800, Albuquerque, N.M., 87115.

Industry & General Applications Group Annual Meeting, IEEE; Pittsburgh, Oct. 2-5. **March 1** is deadline for papers to F.W. Gutzwiller, papers chairman, IEEE Power Semiconductor Committee, c/o General Electric Co., Auburn, N.Y. 13021.

*** Meeting preview on page 16**

The Connector Thing

A periodical periodical designed, quite frankly, to further the sales of Microdot Inc. connectors and cables. Published entirely in the interest of profit.



SSSSHHHHHHH

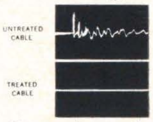
In order to inform you about (very quietly, please) our Mini-Noise coaxial cable, Microdot Inc. is extending a bribe to catch your interest. We are offering as a beautiful prize in this contest a little teeny weeny Sony television set so that you can watch Peyton Place in the office. We are doing this, quite frankly, to impress you with the fact that Microdot Inc. makes the best coaxial cable in the whole wide world, And you won't really know that for sure until you ask, will you? You see how evil we are.

This is the Sony TV you will win

Entering this contest is terribly simple. See this illustration? Many of you are probably too young to remember it, but this fine broth of a man used to decorate the cover of almost every telephone book in the country. As the symbol of Electricity, he also perches atop the American Telephone and Telegraph Building in New York City. All you have to do is hold back tears of memory while you write your own original caption for this illustration. Then send it to Microdot Inc., Great American Cable Contest, 220 Pasadena Avenue, South Pasadena, Calif. 91030. The best caption (judged by a panel of men over forty) will receive the television set. Everybody entering will receive (a) an 11 x 14 reproduction of the gentleman surrounded by his miles and miles of cable (b) a free 16-page, two-color catalog of Microdot Inc. miniature coaxial cable and cable assemblies, and (c) a lot of laughs.

This is the illustration you have to write the caption for

To enter this contest, you should have a smattering of knowledge about Microdot Inc.'s Mini-Noise cable. As a design engineer, you are probably often faced with the problem of performance degradation under increasingly severe environmental conditions. Also, you've probably found that the transmission of extremely small signals through coaxial cable is often made unintelligible by audio frequency noise generated in the cable through shock and vibration. No longer. Through a unique proprietary treatment, the noise voltage magnitude in Mini-Noise cable has been reduced by a factor of more than 100 to 1 in comparison to untreated cable.



Comparison of untreated cable and treated Mini-Noise cable

Some quick facts about two other Microdot Inc. cable products:

Miniaturized instrumentation means miniature coax cable (in most instances). By using a fine silver-plated copper covered steel wire, Microdot Inc. has been able to manufacture a miniature coax cable with an impedance of 50 ohms that—even with the addition of dielectric, outer shield and and protective jacket—does not exceed nominal OD of .080". Compare, please.

When you find it necessary to send two signals from a single source which must both terminate at a central point, use Microdot Inc. Twinaxial. No need to use two coax cables; therefore, greater flexibility at reduced cost.

One more point about Microdot Inc. cable products: if you've ordered them in the past, it will help you to know that we can now make more of them and make them faster. The reason is our recently completed new facility for cable products, which includes new braiders, new extruders—in short, new equipment and increased capacity for even faster deliveries.

There you have it. Be certain to enter the contest today (April 30, 1967 is your last day). Remember, just caption the illustration and send it to Microdot Inc., 220 Pasadena Avenue, South Pasadena, California 91030. We would hate for you to have to miss even one segment of Peyton Place.

Just because

MICRODOT INC.

Mini-Noise is a registered trademark of Microdot Inc.

Meeting preview

Microwaves make the big time

Formed only last September, the Microwave Power Institute will hold its first Conference on Microwave Power from March 29 to 31 at Stanford University in Palo Alto, Calif. The meeting will stress laboratory evaluations of microwave power as an industrial processing technique.

The institute itself is the outgrowth of a gathering last spring of about 100 engineers in Edmonton, Alberta. With the upcoming conference scheduled for the slightly more accessible San Francisco area, institute officials expect that the meeting will attract more than 500 persons.

Applications. Major topics of discussion will include case studies of current on-line microwave heating and processing systems; the design of microwave processing units; biological effects of microwave power, and chemical processing with microwave power.

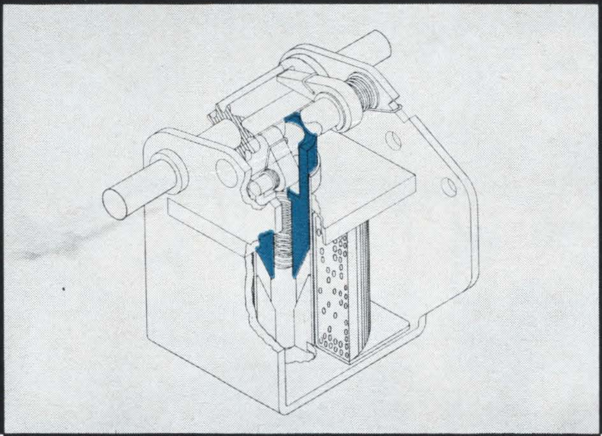
Norman H. Williams, a project engineer at the Eimac division of Varian Associates will present a paper on curing epoxy resin at 2,450 megahertz, one of the two principal microwave frequencies. Williams will describe a completed system that uses a klystron amplifier to produce 20 kilowatts at S band in curing plastic pipe reinforced with glass fiber.

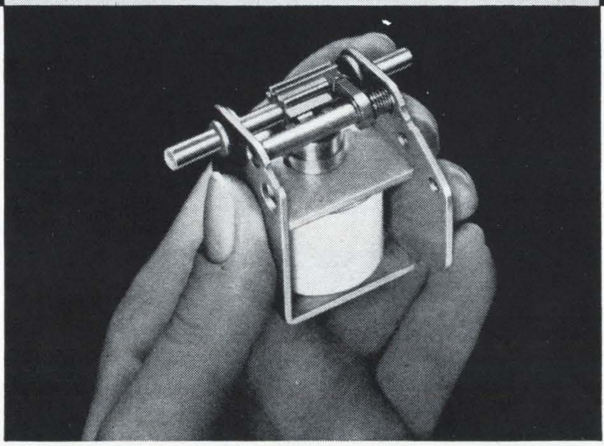
Heat vs. microwave. In the food processing field, M.W. Cronyn and R. Kavenoff of the chemistry department at Reed College, Portland, Ore., will deliver a paper comparing changes in the ultraviolet absorption characteristics of protein solutions subjected to conventional heat with similar changes induced by microwave radiation.

In a survey of European microwave techniques, H. Puschner, a German engineer, will concern himself specifically with applications in the lumber, chemical and mining industries.

A paper on the use of microwave absorption in high-temperature chemical processing will be presented by J.D. Ford and D.C.T. Pei, both from the University of Waterloo in Ontario.

Our new little stepping motor has two very interesting features:





1. A linear-motion armature
2. A price below ten dollars*

Rotary-type stepping motors work pretty well, but as we see it, they're unnecessarily complicated (and expensive).

Consider rotor overshoot compensation. We don't need any. The linear, solenoid-and-plunger design of our Roto-Netic® stepping motor obviates the problem.

When the solenoid is de-energized, the armature moves straight upwards, under positive spring pressure, and directly drives the actuator that turns the starwheel. Neat and simple as that.

The plunger configuration also eliminates the need to compensate for lateral shaft movement. Because the output shaft turns on its own axis, there is no axial thrust motion to worry about. (The output shaft, incidentally, is double-ended so that you have a built-in choice of either clockwise or counterclockwise rotation.)

Yet another advantage of our linear design is a relatively high torque output. The Model SC1 motor shown here will deliver a starting torque of 0.1 inch-pounds (1.6 inch-ounces). Pounds or ounces, that's good performance for a unit that is about the size of an ice cube and weighs a scant six ounces.

The SC1 provides a step increment of precisely 36°. The mathematically minded will immediately recognize that this works out to ten steps for one complete revolution. The motor should therefore be very attractive to those of you working with decade functions.

At present, we're stocking 12VDC and 115VAC models. We can and will produce other voltage ratings to your order. At any rated voltage, the motor is capable of 600 operations per minute.

We'll be glad to send you a descriptive spec sheet. Just ask us for Bulletin 701. If you're inclined to be daring, you can send us ten bucks for a sample unit and investigate further on your own lab bench. Either way, let us hear from you. Heinemann Electric Company, 2600 Brunswick Pike, Trenton, N.J. 08602.

*$9.00 to be exact, for OEMs, in quantities of 100 to 499.

HEINEMANN

3629

Price conscious about 2N3055's?

That's why the Bendix 2N3055 is one of the most widely used and best known power transistors in the business.

You don't pay a premium for Bendix quality. We offer sound and truly competitive pricing on the 2N3055—and on its entire related silicon mesa family as well. It's a direct result of our efficient, highly mechanized production of these types.

And to insure sound, rugged operation in your circuit, Bendix has SOAR (Safe Operating ARea) specified the 2N3055. SOAR protects you against second breakdown (see typical SOAR chart).

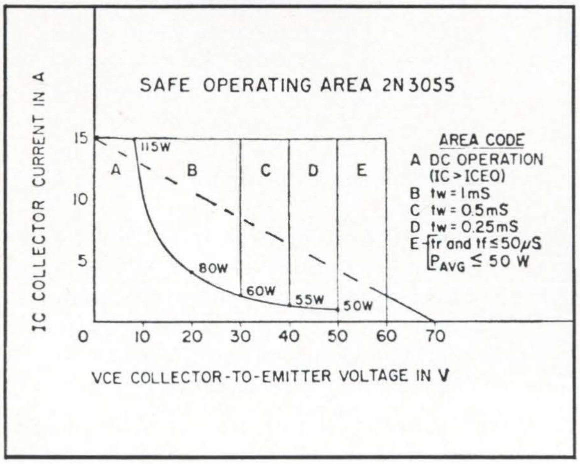
Need more flexibility? Consider the B170000 Series we've developed in conjunction with the 2N3055. These NPN power transistors are specified and grouped by application. Thus, you may select a device optimized for amplifying, regulating or switching use. This means you avoid paying for parameters not pertinent in your particular circuit. Selections are available on VCEO up to 100 volts, hFE at IC up to 5 amps and Pc up to 120 watts.

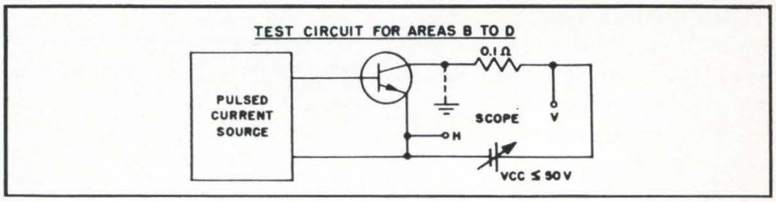
Looking for equally good values in higher current transistors? Look our way again. The Bendix 30-amp 2N3771 and 2N3772 merit your attention for power supply and power amplifier work.

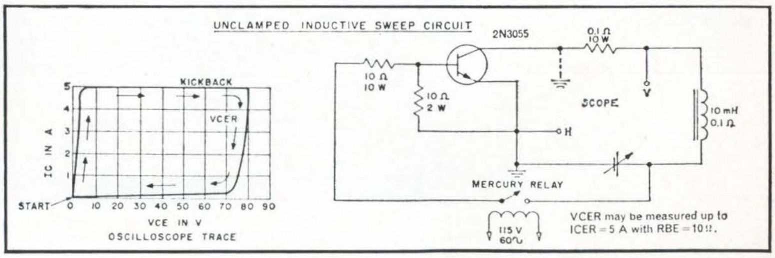
In fact, why not check into the complete line of Bendix power transistors? They'll help you hit a new high in performance and reliability. Call your Bendix distributor. Or write Bendix Semiconductor Division, Holmdel, N. J. 07733.

Atlanta—Grady Duckett Sales Co., (404) 451-3529; **Baltimore (Towson), Md.**—(301) 828-6877; **Chicago**—(312) 637-6929; **Dallas**—(214) 357-1972; **Detroit**—(313) 548-2120; **Greenwich, Conn.**—(203) 869-7797; **Holmdel, N. J.**—(201) 946-9400; **Los Angeles**—(213) 776-4100; **Minneapolis**—(612) 926-4633; **Los Altos, Calif.**—W. W. Posey Co., (415) 948-7771; **Seattle**—Ray Johnston Co., Inc. (206) LA 4-5170; **Syracuse, N. Y.**—(315) 474-7531; **Waltham, Mass.**—(617) 899-0770; **Export**—Cable: "Bendixint," 605 Third Avenue, New York, (212) 973-2121; **Ottawa, Ont.**—Computing Devices of Canada, P.O. Box 508—(613) TAlbot 8-2711.

Bendix knows you are!







Bendix Electronics

Now that you're going to buy an ac voltmeter, get hp's extra measure of

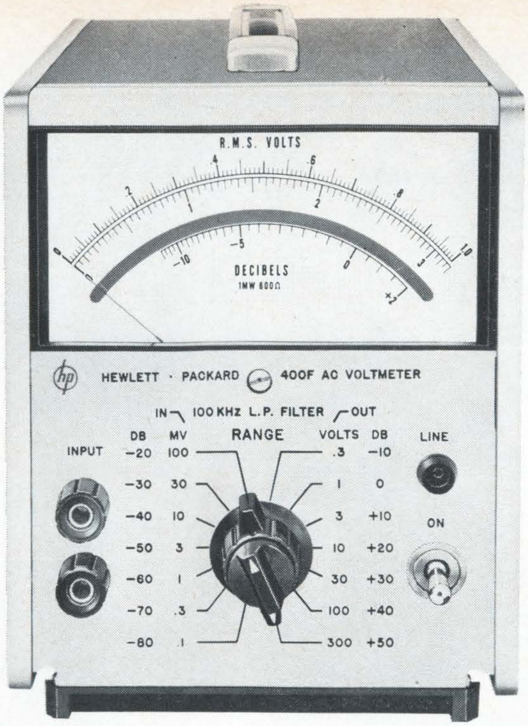
Performance

Sonar, acoustics, audio response, servo, communications measurements – or ac to dc conversion and amplification – these and many more are yours with a Hewlett-Packard 400-Series AC Voltmeter!

The 400-Series Voltmeters are wide bandwidth, average-responding, rms calibrated instruments. They are solid state, externally battery operable, equipped with the exclusive hp taut-band meter.

Each of the instruments in the 400-Series is outstanding in frequency, or sensitivity or dB range. The 400E/EL voltmeters, for example, have a broad frequency range of 10 Hz to 10 MHz. The 400F/FL meters have 100 μV full-scale sensitivity. They also have a low-pass filter to take out unwanted high frequencies for low-level audio measurements. The 400GL measures −100 to +60 dB for the greatest range available in a voltmeter.

How to choose the right ac voltmeter that exactly matches your requirements? Call your hp field engineer, he can show you the widest range of these instruments now available. Get that hp extra measure of performance in your ac voltage measurements!



hp Model 400E/EL for Broad-Frequency

Performance

The hp 400E/EL solid-state simple-to-operate ac voltmeters give a wider frequency coverage than any other comparable instrument! They cover a frequency range from 10 Hz to 10 MHz and have a constant 10 MΩ input impedance on all ranges.

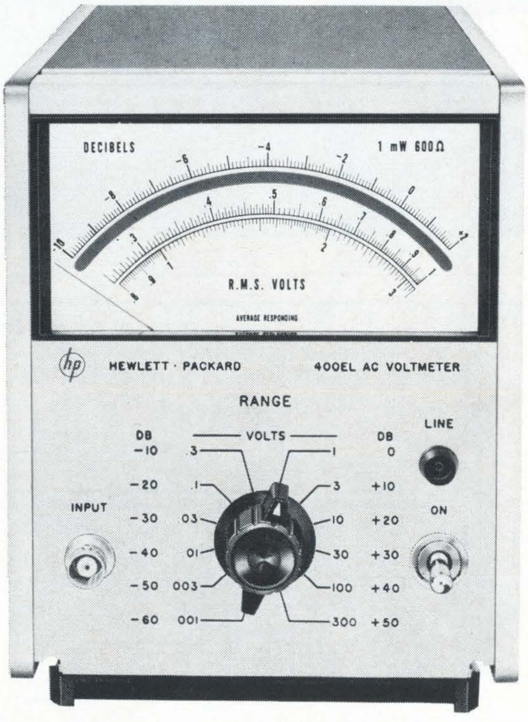
These voltmeters give exceptionally long-term stability. Calibration is not dependent on components subject to aging.

Either Model 400E or 400EL can be used as a wide-band ac voltmeter, high-gain ac amplifier or as an ac to dc converter.

The 400E has full scale accuracy of 1% on the linear voltage (upper) scale. Lower scale is log dB. The 400EL has 1% full scale accuracy on the linear dB (upper) scale. Lower scale is log volts.

Option 02, available on both 400E and 400EL, provides a front panel relative control for a variable 3 dB change in sensitivity on each calibrated range. This gives a convenient level, such as 0 dB, for relative voltage measurements. The control has a detented position to insure calibration accuracy.

AC-DC Converter:—The 400E/EL Voltmeters provide a linear dc output (1 Vdc for full scale meter deflection) proportional to meter deflection which can be used as a 10 Hz to 10 MHz ac to dc converter, with an accuracy of ±0.5%.



PERFOR

Pick the 400E or 400EL when you need broad frequency range performance. See table for comparative specifications.

hp Model 400F/FL for High Sensitivity

Performance

In addition to the 100 μV full-scale sensitivity, the 400F/FL AC Voltmeters contain a low-pass 100 kHz filter for controlling the bandwidth of noise—reduces the effects of unwanted high frequencies to give you more accurate low-level audio measurements.

You get fast response with these instruments—a reading in less than two seconds after turn-on—and <2 seconds overload recovery, too!

The 400F has 0.5% full scale accuracy on the linear voltage (upper) scale. Lower scale is log dB. The 400FL has 1% accuracy full scale on the linear 12 dB (upper) scale. Lower scale is log volts.

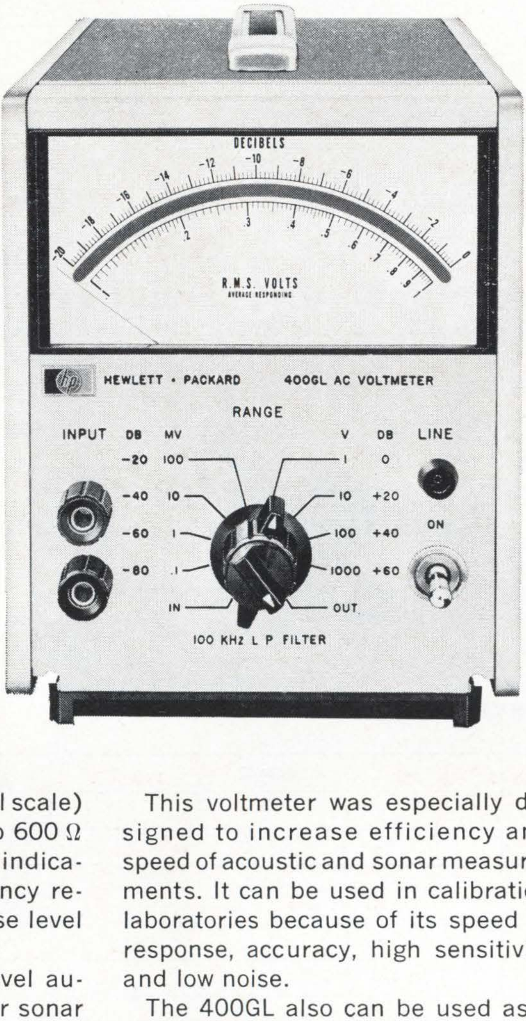
Amplifier:—Models 400F/FL are stable, low distortion, wideband ac amplifiers, with a maximum open circuit gain of 80 dB. AC output is 1V rms (full scale) open circuit, or 0.5 V rms into 600 Ω and is proportional to meter indication on voltage scale. Frequency response: 20 Hz to 4 MHz. Noise level <5 μV referred to input.

For general purpose low level audio, servo, communications or sonar measurements with low noise, choose the hp Model 400F or 400FL AC Voltmeter. Check the comparative specifications in the table.

hp Model 400GL for Broad dB Range

Performance

With the −100 to +60 dB measurements range (100 μV to 1000 V full scale), the hp Model 400GL AC Voltmeter is the instrument with the greatest dB range—20 dB linear log scale!



This voltmeter was especially designed to increase efficiency and speed of acoustic and sonar measurements. It can be used in calibration laboratories because of its speed of response, accuracy, high sensitivity and low noise.

The 400GL also can be used as a high-gain ac amplifier with 80 dB amplification.

When you need a ruggedly-built ±0.2 dB accurate voltmeter for broad-range dB measurements, hp Model 400GL is your best choice! See table for more specifications.

hp Model 11074A Probe

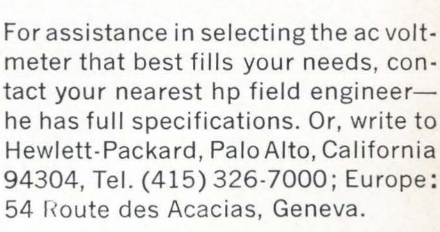
The hp Model 11074A Voltage Divider Probe (10:1 division ratio) provides constant 10 pF with 10 MΩ input impedance at the point of measurement. Probe and suitable adapter are usable with all the 400-Series AC Meters. Price: hp Model 11074A Probe, $45.00, plus adapter.

Pick Your

Performance

	400E/EL	400F/FL	400GL
Frequency Range	10 Hz to 10 MHz	20 Hz to 4 MHZ	20 Hz to 4 MHz
Sensitivity	1 mV-300 V	100 μV-300 V	100 μV-1000 V
db Range	−72 to +52	−92 to +52	−100 to +60
Low Pass Filter	No	100 kHz	100 kHz
AC-DC Converter	1 V at 1 mA	No	No
AC Amplifier	150 mV/50Ω	1 V/600Ω	1 V/600Ω
Price	400E: $285.00 400EL: $295.00	400F: $275.00 400FL: $285.00	400GL: $290.00

Option 01: Available on 400E and 400F, puts log scale uppermost for greater resolution in dB measurements. Other scale options available on request.



For assistance in selecting the ac voltmeter that best fills your needs, contact your nearest hp field engineer—he has full specifications. Or, write to Hewlett-Packard, Palo Alto, California 94304, Tel. (415) 326-7000; Europe: 54 Route des Acacias, Geneva.

HEWLETT hp PACKARD

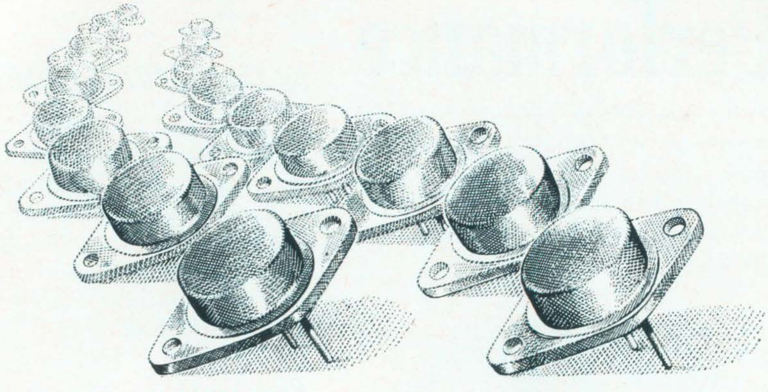
An extra measure of performance

Circle 21 on reader service card

097/7

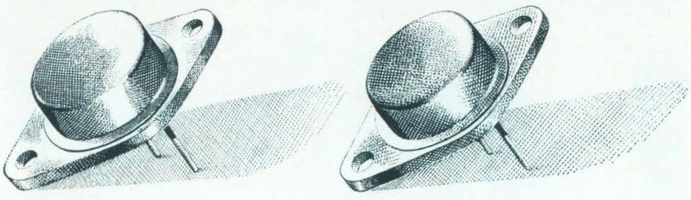
MANCE

Based on these industry favorites



2N3442 2N3773

RCA now introduces two new Hometaxial-Base power transistors



2N4347 2N4348

at attractive low prices

	2N4347	2N3442	2N4348	2N3773	Units
I_C (max)	5	10	10	16	A
P_T @ $T_C = 25°C$	100	117	120	150	W
h_{FE}	20-70 @ $I_C = 2A$	20-70 @ $I_C = 3A$	15-60 @ $I_C = 5A$	15-60 @ $I_C = 8A$	
V_{CEV} (sus)	140	160	140	160	V
$\Theta_{j\text{-}c}$	1.75	1.5	1.46	1.17	°C/W
Price	$1.80*	$2.75*	$2.75*	$4.75*	

**In quantities of 1,000 and up*

Available in production quantities, RCA's latest additions to its Hometaxial-Base family offer top-of-the-line performance at economy prices. Featuring high-power characteristics plus freedom from second breakdown, the new units are even less expensive in quantity than their popular prototypes.

RCA-2N4347 and 2N4348 are general-purpose silicon transistors ideal for power-switching circuits, series and shunt-regulator driver and output stages, dc-to-dc converters, inverters, and solenoid (hammer)/relay driver service.

For additional information and delivery on these and other RCA Hometaxial-Base transistors, see your RCA Representative. For technical data on specific types, write: RCA Commercial Engineering, Section IN2-1, Harrison, N. J. 07029.

CHECK YOUR RCA DISTRIBUTOR FOR HIS PRICE AND DELIVERY

RCA Electronic Components and Devices

RCA®

The Most Trusted Name in Electronics

Editorial

Nothing automatic about growth

Most electronics firms breathed a sigh of relief when the size of the Federal budget was described this month. In fact, examining the Government's fiscal 1968 spending plans closely [see pages 131 to 143], electronics executives have cause of be jubilant. Gargantuan chunks of money are being assigned to every area that means business for them: military, space, education and health. With this amount of Federal spending, the industry seems assured of a good year.

Although all the signs portend a healthy year for the industry, 1967 clearly has not started off well. Some electronics concerns are experiencing unexpected setbacks. Semiconductor makers such as Motorola, Texas Instruments and General Electric have had to cut back production. The computer department at GE is in serious trouble; its failure to deliver software has cost it orders, and these cancellations have moved down the supply line to hurt GE's suppliers. And the Sylvania division of General Telephone & Telegraph has even had to reduce its output of color television tubes, the one sure-fire prospect for explosive growth this year.

Each of these companies cites a specific though different reason for the temporary trouble, and each is sure the letdown is only temporary. Yet these specific problems—an inventory adjustment in semiconductor devices or an underestimation of the difficulty of writing software or a throttling of consumer demand by tight money—may hide the real causes of the trouble: failure to plan ahead, sloppy management, and a reluctance to move ahead technically.

Last year was such a good one for almost every company that some executives and engineers were lulled into a false feeling of security. Some reasoned that with Vietnam fighting on the rise, the space program calling for more electronics and less propulsion work, and the Great Society developing an appetite for medical and education electronics, an electronics company just couldn't miss. At the height of the boom last spring, for example, a few component producers said they would not accept any more orders until autumn because their books were full. Others put off the introduction of new products because the old ones were selling so well. And looking at the apparently insatiable demand for color tv sets and integrated electronics, an important executive of a television firm declared, "The last thing the industry needs now is a new development."

All this illustrates once again an old truism: the company that tries to stand still really slides backward. No matter how good sales are today, they won't stay good unless a company continues to develop new products and new markets and tries to apply technology, old or new, in new ways.

In 1963, electronics firms that had been doing exceptionally well earlier suddenly ran into serious difficulty when the Defense Department became cost conscious and military spending leveled off. By 1965, a lot of the concerns that had suffered the most during that dry spell tightened up their operations, turned lean, searched for new markets and pushed hard for new product development. Electronics firms, mostly young and heavily committed to military programs, learned what companies in more mature industries have known all along: that customer need has to be the driving stimulus behind product development and customer benefit the major goal.

But the boom of 1966 chased away the gloomy memories of slumping sales and shrinking military markets. The lessons learned were quickly forgotten. Along with bulging order books, a lot of fat was added to the once lean structure of electronics companies. Companies that had started to move quickly slowed their operations to a shuffle.

If 1967 is to be a good year, the industry will have to get serious again. The fundamental forces for great growth in electronics are there —a huge Federal budget, expanding civilian markets and growing consumer demands—but there is nothing automatic about it. Without hard work, creative engineering and good management, there won't be any growth.

Engineers who have learned to live with the flutter problem in hysteresis synchronous motors will find that living comes easier now. Especially in voice/data recording applications.

Indiana General's unique inverted stator design provides up to six times the rotor inertia of conventional designs. Flutter characteristics are so low as to be practically negligible.

And the price is not so high that it restricts the use of our inverted stator motor solely to recording devices. It is so economical to manufacture that it's priced competitively with induction type motors, making the Indiana General hysteresis motor economically practical for units like fans and blowers. And, the inverted stator design significantly reduces start-up input power-surge and combines very high operating efficiency with low slip characteristics.

Indiana General inverted stator motors are smaller and lighter than conventional synchronous motors and are available in a wide range of sizes, mountings, power ratings and torques. You can get full details by writing Mr. R. D. Wright, Manager of Sales, Indiana General Corporation, Electro-Mechanical Division, Oglesby, Illinois.

INDIANA GENERAL

New inverted hysteresis motor design drives the flutter out of recording equipment.

Electronics Newsletter

February 6, 1967

Pinch hurts makers of consumer gear

There are signs that semiconductor producers aren't the only electronics firms that were over-enthusiastic in forecasting late-1966 and early-1967 sales. In the past few weeks, such manufacturers of consumer electronic products as GE, Sylvania and National Video have announced layoffs and production cutbacks.

January sales of both color and black-and-white tv sets and tubes have been slower than anticipated. The drop in sales of black-and-white sets has been more precipitous than forecast, while the gain in color-set volume has been smaller than anticipated.

Sales of color sets in the first three weeks of 1967 came to 219,629, according to the Electronics Industries Association, up 45% from a year earlier; while sales of black-and-white sets dropped 39% to 180,061.

Despite the recent slowdown, **consumer electronics companies are still maintaining that 1967 will be a banner year.** Admiral, RCA, Zenith and Motorola say their sales so far in the first quarter are on target.

New time-sharing computer from GE

Another large time-sharing computer will be introduced within the next few months by the General Electric Co., whose computer department is beleaguered by software problems. The computer is understood to have a larger capacity than the current models in GE's 600 series and **will provide more security against possible "eavesdropping" by other users of the time-shared system.**

MIT is getting Beckman's giant hybrid computer

The world's largest hybrid computer, completed too late for one Apollo job [Electronics, Aug. 22, 1966, p. 38], is being shipped to the Massachusetts Institute of Technology. It will be operating in six weeks for verification of Apollo guidance and navigation computer programs. The computer, built by Beckman Instruments Inc., will be used by the MIT Instrumentation Laboratory under a lease-sale arrangement. The machine will double the capacity of the existing hybrid simulation facility, which also uses Beckman machines.

TI readies IC's for Polaroid camera

Texas Instruments is understood to be preparing a production line for the manufacture of integrated circuits for a shutter system on the Polaroid Land camera. This function—sensing light levels and adjusting the camera's aperture opening and shutter speed—is now handled by discrete components. The operation will start up within two months.

The AP sponsors design of photo transmission gear

The Associated Press is sponsoring the development of computer-operated photo-transmission equipment that employs pulse-code modulation techniques. The equipment, for sending and receiving news pictures, is being designed to overcome the existing incompatibility between U.S. and European picture-transmission gear and to improve the quality of the transmitted photos.

Laser record

A 5,000-joule laser, the most powerful pulsed system disclosed to date, has been delivered to the Army Ballistics Research Laboratory by the

American Optical Co., Southbridge, Mass. The active laser material is a neodymium-clad glass rod 1 yard long and 1½ inches in diameter. The previous record for a rod-type laser was 2,000 joules.

IC firms look to Maine to locate production plants

Maine is becoming the "in" place for semiconductor manufacturing. Behind the move to Maine is the fact that electronic components—especially IC's—are getting so small that shipping costs are insignificant. **The major consideration now is the labor supply.**

Across a continent, 3,500 miles from its engineering and management headquarters, Fairchild Semiconductor, a division of Fairchild Camera & Instrument, now employs 1,600 persons in South Portland, Maine. Until now, the plant there has handled only an assembly operation, but **Fairchild is preparing facilities for wafer fabrication and plans to increase employment to 2,000. The plant will become the division's principal center for production of IC's.**

Farther north, Sylvania Electric Products this summer will open a plant in Bangor exclusively for integrated-circuit work as an extension of its IC production line at Woburn, Mass. And in Lewiston, the Radio Corp. of America's production of consumer-type silicon transistors is being expanded to include memory planes.

Unique features draw 22 bidders on 407L program

Twenty-two electronics companies are competing for the integration assembly and checkout contract for the 407L tactical air control system. The bidding has attracted a large number of concerns because of two unusual features: **the contractor will not be excluded as a hardware supplier, nor will it be prevented from bidding** on subsystems.

Col. Spencer S. Hunn, deputy director for tactical systems at the Air Force Electronic Systems Division, Hanscom Field, Mass., has the overall responsibility for the $500 million program to develop radar, data processing and communications equipment that can be assembled into system packages for quick airlift. [For more on Col. Hunn, see page 8.]

Demler to head study of Air Force laboratories

Maj. Gen. M. C. Demler will soon be charged with reviewing and recommending changes in the Air Force research organization. Announcement of the appointment will come this month. Demler, commander of the research and technology division, will also serve as director of Air Force laboratories. **Possible changes under Demler include consolidation of various Air Force laboratories,** greater coordination with the labs of the other services, and new systems approaches to research and development.

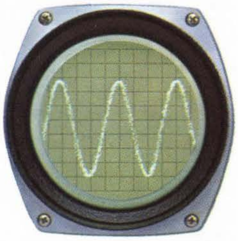
Bay Area Transit opts for d-c power

After months of appraisal, **the San Francisco Bay Area Rapid Transit District (BARTD) has decided to stick with direct current for propulsion.** The billion-dollar transit system found that while a-c induction motors provide some cost and weight advantages, they are unable as yet to provide the necessary torque and speed.

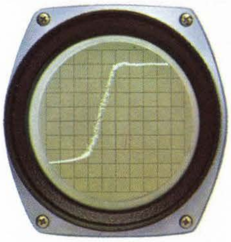
The prime objection to the use of d-c power had been substation cost: using mercury arc rectifiers, d-c power costs $100 a kilowatt, against $25 per kilovolt-ampere for a-c. With silicon-controlled rectifiers, however, the cost of d-c drops to about $40 per kva. BARTD feels a d-c chopper propulsion package will meet its requirements.

PUT THIS NEW WINDOW IN YOUR LAB —SEE OUT TO 12.4 GHz AND BEYOND

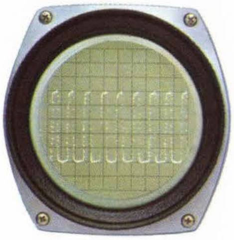
12.4 GHz bandwidth



28 psec rise time



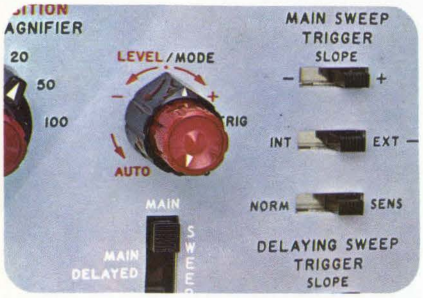
Delayed sweep



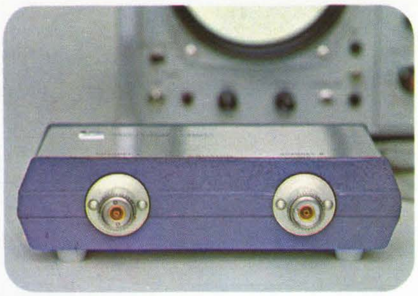
40 psec TDR

Hewlett-Packard has developed a radically advanced sampling system that lets you see through X band and make oscilloscope measurements never before possible. Turn the page and see how much easier high-frequency circuit analysis has suddenly become.

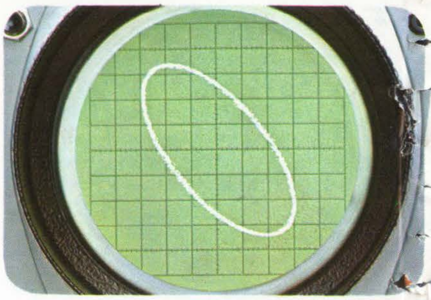
Automatic triggering for fast, easy trace set-up.



Remote sampler permits measurement at test point, eliminates lossy cables.



Accurate phase measurements: less than 10° phase shift between channels at 5 GHz.



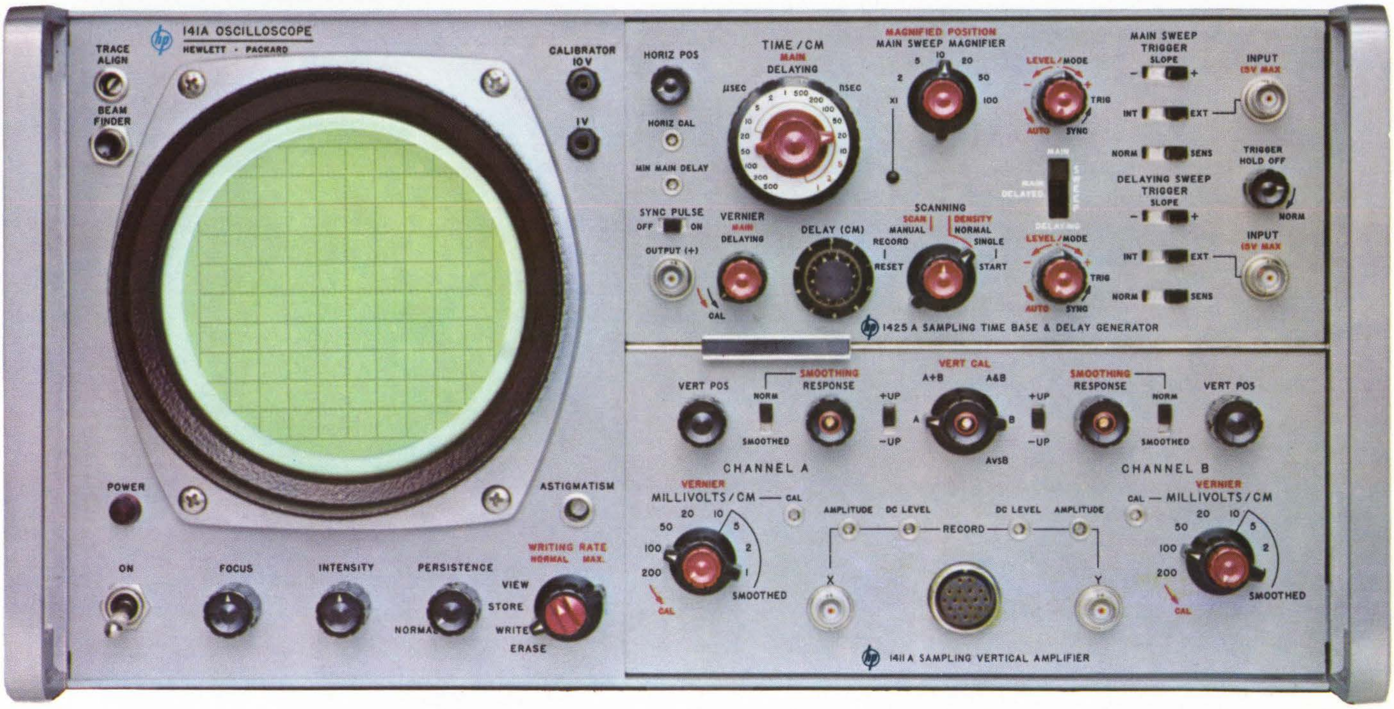
New hp Sampling Scope System enables you to

SIMPLIFY MICROWAVE DESIGN

- DC to 12.4 GHz at 1 mv/cm, dual channel
- 28 psec rise time
- Delayed sweep through full bandwidth for complex waveform examination
- Less than 20 psec jitter for clear displays
- TDR resolutions down to less than 1 cm
- Feed-through inputs for minimum signal disturbance

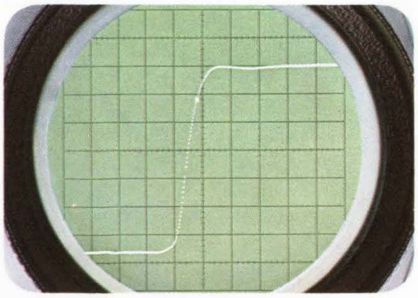
For the first time, you can see through X band, observe CW signals beyond 12.4 GHz, and see fast pulses with a 28 psec response capability. You can also use TDR measurements to resolve discontinuities down to less than 1 cm in the design of cables, coaxial components, connectors and strip lines. In addition, you can utilize delayed sweep to get displays of pulse segments that leave conventional sampling scopes blurred. Choose from these solid-state plug-ins to get the system that meets your particular requirements:

A **NEW 1425A TIME BASE & DELAY GENERATOR** is the first sampling plug-in with delayed sweep, which permits detailed examination of complex signals and pulse trains—even in the presence of high rate jitter. It has maximum sweep speeds of 10 psec/cm, triggering to 1 GHz, and delay times as long as 5 ms. It is also easy to use. Control nomenclature and layout are comparable to those of conventional high-frequency scopes. Automatic internal triggering puts a baseline on the screen in the absence of an input signal, gets a trace displayed sooner. When you want to set up a magnified trace, an intensified dot locates the expansion point for you. You also get push-button return to X1 magnification so that you can take a quick look at the unmagnified trace.

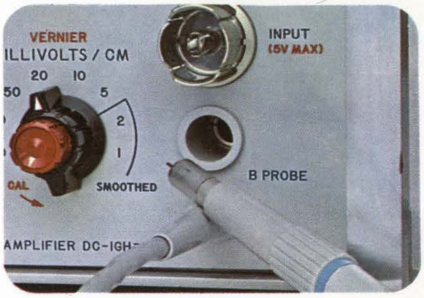


Optional variable persistence mainframe (141A) with trace storage capability.

Intensified dot simplifies magnification & setting delay times.



High-impedance probes **and** 50-ohm inputs with internal triggering—on one scope.



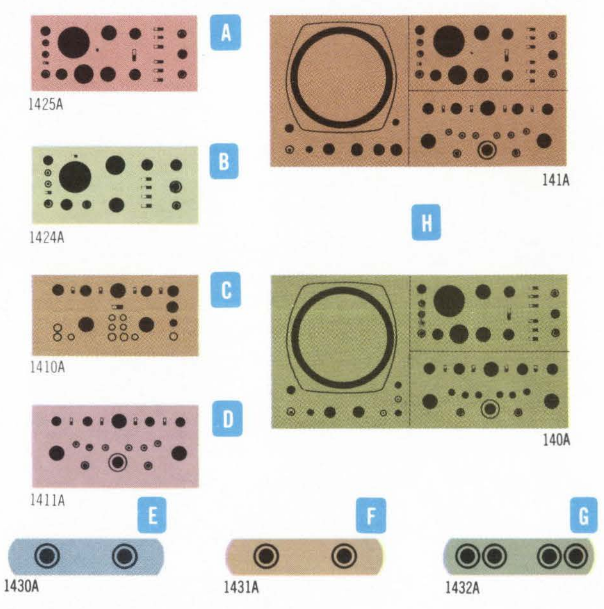
AND LOGIC CIRCUIT TESTING!

B **NEW 1424A SAMPLING TIME BASE** is similar to the 1425A (above) but does not have delayed sweep. It is easy to use and features triggering to 5 GHz, calibrated sweeps as fast as 10 psec/cm, low jitter and direct readout of sweeps, even when expanded. A calibrated marker position control permits accurate time interval measurements.

C **NEW DUAL CHANNEL 1410A SAMPLING VERTICAL AMPLIFIER** provides 1 mv/cm sensitivity at 1 GHz, and combines in a single instrument the convenience of high-impedance probes for circuit measurement **plus** 50-ohm inputs with delay lines for internal triggering—both with the full 1 GHz bandwidth. Both give less than 100 ps time difference between channels for accurate phase measurements in the A vs. B mode, and for precise dual trace time comparisons. Accessories include 10:1 and 100:1 Dividers, Isolator, Blocking Capacitor, 50-ohm Tee Connector and adapters.

D **NEW DUAL CHANNEL 1411A SAMPLING VERTICAL AMPLIFIER** plug-in provides dual-channel performance, front-panel recorder outputs, and A vs. B mode for X-Y scope presentations—plus the capability to function with any one of three remote samplers. Sensitivity ranges from 1 mv/cm to 200 mv/cm—with bandwidth up to 12.4 GHz.

Build your sampling scope with these plug-in units



NEW REMOTE SAMPLERS represent true state-of-the-art advances made possible by exceedingly fast switching diodes developed specifically by Hewlett-Packard for sampling applications. You can choose from three new samplers in order to optimize your system for best pulse response, flat bandwidth and low VSWR, or low-cost study of signals through 4 GHz:

E **28 ps risetime** with optimum pulse response for accurate measurements on fast-rise pulses, and sensitivity of 1 mv/cm, dual channel. Capable of resolving discontinuities as close as 1 cm apart when used with 1105A/1106A 20 ps pulse generator. Model 1430A.

F **12.4 GHz bandwidth.** This unit has an extremely flat bandwidth for CW measurements, 10 ps time difference between channels for accurate phase measurements, and a low VSWR of 1.4:1 from DC to 8 GHz (2:1 at 12.4 GHz). Model 1431A.

G **4 GHz with 90 ps risetime** at 1 mv/cm and feed-thru inputs permit accurate measurements of CW, fast pulses and TDR. Model 1432A.

H **VERSATILE hp 140A/141A MAINFRAMES** are general-purpose units whose frequency and sensitivity characteristics accommodate sampling plug-ins (as well as 13 other hp 1400 series plug-ins) so that you can cover virtually the entire spectrum of oscilloscope measurements. The 141A mainframe provides the additional benefits of variable persistence and storage capabilities.

COUNTDOWN AND PULSER. The 1104A/1106A Countdown Supply and Tunnel Diode Mount combination provides versatility to the new sampling system by extending triggering capabilities to 18 GHz. The unit counts down from 1 GHz to 18 GHz with an output of about 100 mv at 100 MHz. A 20 psec pulse, ideal for fast circuit testing on high resolution TDR, is provided by the 1105A/1106A Pulse Generator Supply and Tunnel Diode Mount combination.

HEWLETT hp PACKARD

An extra measure of performance

SPECIFICATIONS

1425A SAMPLING TIME BASE AND DELAY GENERATOR

Main Sweep:

Range: 13 ranges, 1 ns/cm to 10 μs/cm in a 1, 2, 5 sequence. Accuracy ±3%.

Magnifier: X1 to X100. Increases fastest calibrated sweep speed to 10 ps/cm. Push button returns magnifier to X1.

Magnified Position: 10-turn control with intensified marker that indicates sweep expansion point.

Triggering: (For both Main and Delaying Sweep) Internal triggering is available on the displayed signal with 1410A vertical amplifier.

Automatic: Baseline displayed in the absence of an input signal.

Pulses: At least 100 mv amplitude required (75 mv for internal triggering) of pulses 2 ns or wider for jitter < 30 ps.

CW: Signals from 200 Hz to 300 MHz require 50 mv for jitter < 10% of input signal period. (Usable to 1 GHz with increased jitter.)

Level Select:

Pulses: At least 50 mv amplitude required (100 mv for internal triggering) of pulses 2 ns or wider for jitter < 20 ps.

CW: Signals from 200 Hz to 1 GHz require 50 mv for jitter < 1.5% of input signal period + 10 ps. Jitter is < 50 ps for signals of 10 mv at 1 GHz. (For internal triggering, required signal increases to 400 mv at 1 GHz for jitter < 1.5% of input signal period + 10 ps.)

Slope: Positive or negative.

External Trigger Input: 50Ω, ac coupled (2.2μf) coupled; signal out of jack < 10 mv in sensitive and < 5 mv in normal.

Jitter: Less than 10 ps on 1 ns/cm range, and < 20 ps (or 0.005% of unexpanded sweep speed, whichever is larger) at 2 ns/cm and slower, with large amplitude signals having rise times of 1 ns or faster.

Delaying Sweep:

Range: 15 ranges, 10 ns/cm to 500 μs/cm in a 1, 2, 5 sequence. Accuracy ±3%.

Delay Time: Continuously variable from 50 ns to 5 ms.

Accuracy: ±3%, except ±5% on two slowest ranges. Linearity 0.5%. Time jitter is < 1 part in 20,000 or 20 ps, whichever is greater.

Sweep Functions: Main sweep, delaying sweep, main sweep delayed.

Scanning: Internal, manual, record and single scan operation.

Sync Pulse Output:

Amplitude: > 1.5v into 50Ω. **Rise Time:** Approx 1 ns. **Overshoot:** < 5%. **Width:** Approximately 1 μsec. **Relative Jitter:** < 10 ps. **Repetition Rate:** One pulse per sample.

Weight: Net 7 lbs. (3,2 kg). Shipping, 11 lbs. (5 kg).

Price: $1600.

1424A SAMPLING TIME BASE

Direct triggering to 5 GHz. Sweep ranges from 10 ps/cm to 500 μs/cm. Price: $1200. Available mid 1967.

1410A DUAL-CHANNEL VERTICAL AMPLIFIER

Rise Time: Less than 350 ps (Bandwidth, DC to 1 GHz).

Overshoot: Less than 5%.

Deflection factor (Sensitivity): 8 calibrated ranges from 1 mv/cm to 200 mv/cm; accuracy ±3%.

Operating Modes: Channel A only; B only; A & B; A & B added algebraically; A vs. B.

Isolation Between Channels: Greater than 40 dB to 1 GHz.

Input Impedance: Probes, 100K ohms shunted by 2 pf, nominal; GR type 874 inputs, 50 ohms ±2%.

Noise: Approx. 1 mv, 5 mv/cm to 200 mv/cm.

Dynamic Range: ±2 volts.

Drift: Less than 3 mv/hr. after warm-up.

Triggering: Internal or external when using 50-ohm inputs.

Internal triggering selectable from Channel A or B. External triggering necessary when using probes.

Time Difference Between Channels (for probes or 50-ohm inputs): Less than 100 ps.

Recorder Outputs: Front panel outputs provide 0.1 v/cm from a 500-ohm source.

Accessories provided: 10:1 dividers, blocking capacitors, adapters, isolators.

Weight: Net, 10 lbs. (4, 5 kg). Shipping, 15 lbs. (6, 8 kg).

Price: $1600.

1411A DUAL-CHANNEL SAMPLING VERTICAL AMPLIFIER (when used with 1430A, 1431A, or 1432A)

Deflection factor (Sensitivity), Operating Modes, Isolation Between Channels and Recorder Outputs same as 1410A.

Weight: Net, 10 lbs. (4, 5 kg). Shipping, 15 lbs. (6, 8 kg).

Price: $700.

1430A 28 psec SAMPLER (when used with 1411A)

Rise Time: 28 ps (DC to approx. 12.4 GHz).

Overshoot: Less than 5%.

Noise: Less than 8 mv, 5 mv/cm to 200 mv/cm.

Dynamic Range: ±1 volt.

Low Frequency Distortion: Less than ±3%.

Input Characteristics: 50-ohm feed-thru with Amphenol APC-7 precision 7 mm connectors on input and output. VSWR less than 3:1 at 12.4 GHz.

Time Difference Between Channels: Less than 5 ps.

Connecting Cable Length: 5 ft.

Weight: Net, 4 lbs. (1, 8 kg). Shipping, 9 lbs. (4, 1 kg).

Accessories Provided: Two type N adapters, two 50-ohm loads.

Price: $3,000.

1431A 12.4 GHz SAMPLER (when used with 1411A)

Bandwidth: DC to greater than 12.4 GHz (approx. 28 ps rise time).

VSWR: DC to 8 GHz, 1.4:1; 8 to 10 GHz, 1.6:1; 10 to 12.4 GHz, 2.0:1.

Noise: Less than 7 mv from 5 mv/cm to 200 mv/cm.

Dynamic Range: ±1 volt.

Low Frequency Distortion: Less than ±3%.

Input Characteristics: 50-ohm feed-thru with Amphenol APC-7 precision 7 mm connectors on input and output.

Phase Shift Between Channels: Less than 10° at 5 GHz, typically less than 2° at 1 GHz.

Connecting Cable Length: 5 ft.

Weight: Net, 4 lbs. (1, 8 kg). Shipping, 9 lbs. (4, 1 kg).

Accessories Provided: Two type N adapters, two 50-ohm loads.

Price: $3,000.

1432A 90 psec SAMPLER (when used with 1411A)

Rise Time: Less than 90 ps. Bandwidth, DC to 4 GHz.

Overshoot: Less than 5%.

Noise: Less than 3 mv from 5 mv/cm to 200 mv/cm.

Dynamic Range: ±1 volt.

Low Frequency Distortion: Less than ±3%.

Input Characteristics: 50-ohm feed-thru with GR type 874 connectors.

Time Difference Between Channels: Less than 25 psec.

Connecting Cable Length: 5 ft.

Weight: Net, 4 lbs. (1, 8 kg). Shipping, 9 lbs. (4, 1 kg).

Accessories Provided: Two 50-ohm loads.

Price: $1,000.

1104A/1106A 18 GHz TRIGGER COUNTDOWN

Input:

Frequency Range: 1 GHz to 18 GHz.

Sensitivity: Signals 100 mv or larger up to 12.4 GHz, produce less than 20 ps of jitter (200 mv required to 18 GHz).

Input: 50-ohm Amphenol APC-7 input connector.

Signal Appearing at Input Connector: Less than 250 mv step whose top is flat within 2% for 1 ns.

Output: Center Frequency, approximately 150 MHz; amplitude, typically 100 mv.

Weight:

1104A: Net, 2 lbs. (0, 9 kg). Shipping, 4 lbs. (1, 8 kg).

1106A: Net, 1 lb. (0, 5 kg). Shipping, 3 lbs. (1, 4 kg).

Price: 1104A, $200; 1106A, $550.

1105A/1106A 20 psec PULSE GENERATOR

Output:

Rise Time: 20 ps.

Overshoot: Less than 5%.

Droop: Less than 3% in first 100 ns.

Width: Approximately 3 μs.

Amplitude: Greater than +200 mv into 50 ohms.

Output Characteristics:

50 ohms ±2%, Amphenol APC-7 precision 7 mm connector.

Triggering Requirements:

Amplitude, ± 0.5 v peak; Rise Time, less than 20 ns (jitter less than 15 ps when triggered by 1 ns rise time sync pulse from 1424A or 1425A).

Width: Greater than 2 ns.

Input Impedance: 200 ohms, AC coupled through a 20 pf capacitor.

Repetition Rate: 0 to 100 kHz; free runs at 100 kHz.

Weight:

1105A: Net, 3 lbs. (1, 4 kg). Shipping, 8 lbs. (3, 6 kg).

1106A: Net, 1 lb. (0, 5 kg). Shipping, 3 lbs. (1, 4 kg).

Price: 1105A, $200; 1106A, $550.

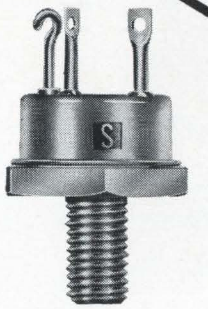
Mainframes include 140A with standard CRT ($595), and 141A with variable persistence and storage ($1275).

Solitron

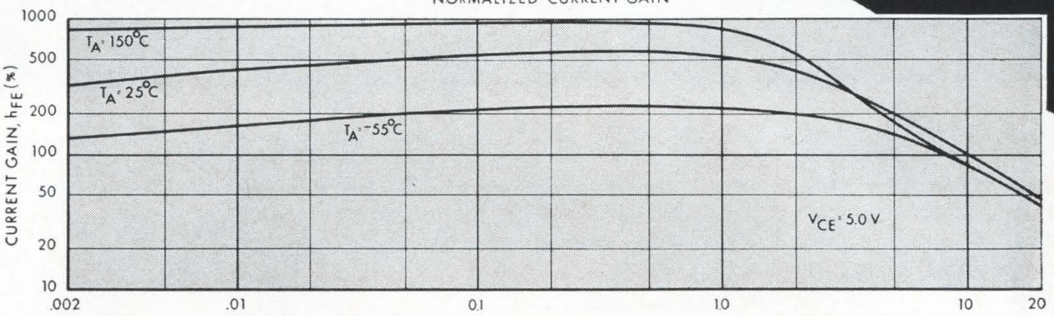
announces another

FIRST!

300v·275v·250v 225v·200v V_{CEO} (sus) in a 20 Amp. NPN Silicon Planar Power Transistor featuring 100 Watts at 100°C!



NORMALIZED CURRENT GAIN



Type Number	Pkg. Size	DESIGN LIMITS						PERFORMANCE SPECIFICATIONS					
		T_J	θ	P_T	BV_{CBO}	V_{CEO} (SUS)	BV_{EBO}	h_{FE}		V_{BE} (sat)	V_{CE} (sat)	I_{CBO}	f_T
		°C	°C/W	Watts @100°C Case	Volts	Volts	Volts	@I_C = 10 A V_{CE} = 5V		Volts @I_C = 10A I_B = 1.0A	Volts @I_C = 10A I_B = 1.0A	μA V_{CB} = 60V	mc
		Max.	Max.	Max.	Min.	Min.	Min.	Min.	Max.	Max.	Max.	Max.	Min.
SDT8801	TO-63	200	1	100	200	200	8	15	60	1.4	0.70	1.0	30
SDT8802	TO-63	200	1	100	225	225	8	15	60	1.4	0.70	1.0	30
SDT8803	TO-63	200	1	100	250	250	8	15	60	1.4	0.70	1.0	30
SDT8804	TO-63	200	1	100	275	275	8	15	60	1.4	0.70	1.0	30
SDT8805	TO-63	200	1	100	300	300	8	15	60	1.4	0.70	1.0	30

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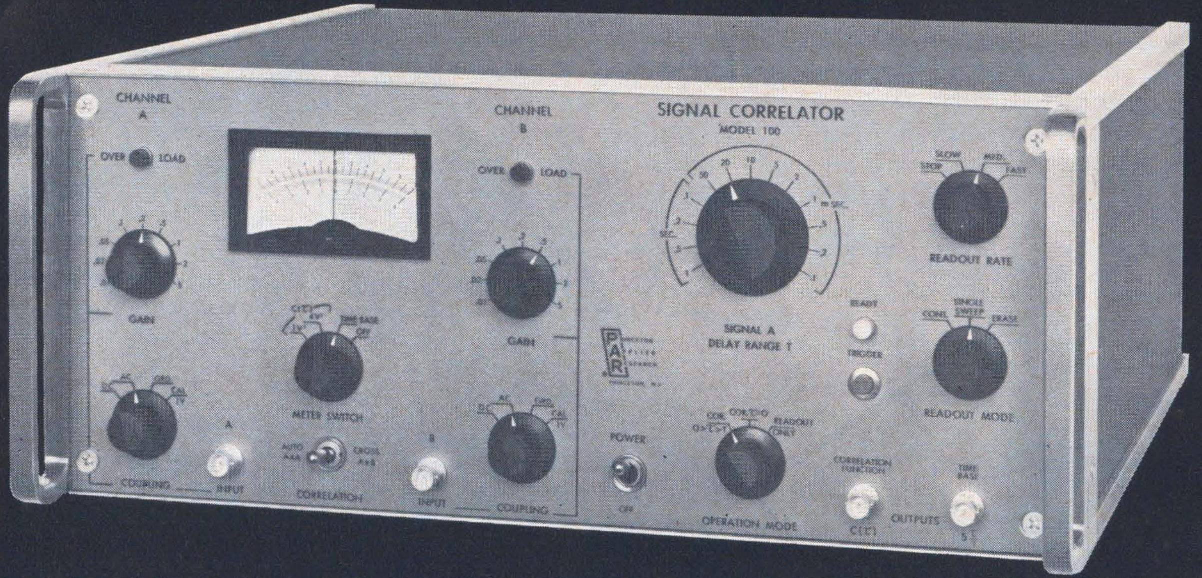

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Accuracy: Better than 1%.

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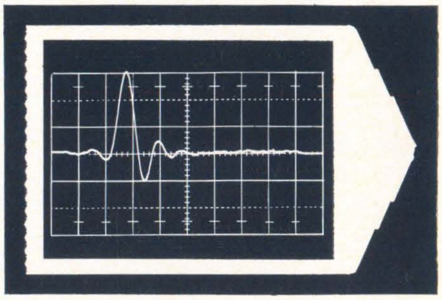


Typical Photograph of Crosscorrelation Function of Input and Output Signals of Complex Passive Network Driven by White Noise.

For more information call (609) 924-6835 or write Princeton Applied Research Corp., Dept. D, P.O. Box 565, Princeton, N. J. 08540.

PRINCETON APPLIED RESEARCH CORP.

Electronics Review

Volume 40
Number 3

Companies

Fred Bucy
Moves in . . .

Mark Shepherd
Pulls the strings

E. O. Vetter
Heads marketing

Cecil Dotson
. . . moves out

R. C. Dunlap
Takes Bucy's job

Shakeup at TI

Just three weeks after taking over the reins as president of Texas Instruments Incorporated, Mark Shepherd Jr. has moved with some swift and sudden organization changes.

With sagging sales, rumors of impending layoffs and confirmed reports of shorter work weeks hitting TI at the same time, outsiders asked if it was cause and effect.

Although officials at TI say the personnel shakeup and the slump in sales are unrelated, there's little doubt that one precipitated the other.

Friday, the 13th. Rumors of possible troubles at TI began on Friday afternoon, Jan. 13, when Semiconductor-Components (S-C) division employees (except for IC workers) were told that day shifts were being reduced one-half hour and night shifts 12 minutes starting Jan. 16 for a period of four weeks [Electronics, Jan. 23, p. 25].

The production cutback order was signed by Cecil P. Dotson, then vice president of the S-C division. He said in his order that since December the division had been faced with "a trend calling for longer delivery schedules on new orders and a slowdown in our S-C business level."

Ten days later, Dotson lost his job as head of the division to J. Fred Bucy, formerly manager of TI's Apparatus division. Dotson became head of "a new corporate staff activity."

At the same time Shepherd issued other orders:

- Moving R.C. Dunlap, vice president and manager of the Science Services division, into Bucy's former job.
- Upgrading Mark K. Smith, president of a subsidiary, Geophysical Service Inc., to fill Dunlap's vacancy.
- Placing E.O. Vetter, vice president, in charge of corporate marketing, control and central research.
- Moving the controls products group, formerly a part of the Apparatus division, into the S-C division.

Along with these top-level changes, there were other lower-echelon moves involving some key spots. One of these included replacement of the integrated circuit department's manager of manufacturing.

Record sales. On Jan. 20, TI put out a preliminary report indicating its 1966 sales were up 33% to a record $580.6 million. But in this statement it also said: "The rate of new orders entered recently has declined appreciably. These pressures have been felt especially by our S-C division."

And the rumors grew.

Some reports said TI's real troubles were on its germanium lines, with "the last big contract" petering out and layoffs inevitable unless new sales could be generated. Third-shift operations were reportedly suspended on four germanium lines, feeding the rumor mills.

Executives at TI hastened to dispel the gloomy reports.

Richard J. Hanschen, S-C division marketing manager, concedes there has been a slowdown in TI's semiconductor business since last December and that the rate parallels the drop in over-all consumer orders for durable goods—from a 40% growth rate to 15%.

But, insists Hanschen, "We saw all of this coming six months ago and were prepared for it. We are now forecasting that business growth will be back to normal by the second quarter. This is a temporary adjustment we are having to make."

There is no connection, says Hanschen, with sagging orders and

Shepherd's organizational moves.

The reason. A much deeper significance is claimed for the principal personnel shifts: to gear up for an anticipated evolution from integrated circuits to large scale arrays. TI calls these devices integrated equipment components, or IEC's.

As TI's planners see it, the industry is fast moving into an era where semiconductor makers, with such things as IEC's, will be moving higher up the total electronics market ladder, getting into subsystem and systems work. This calls for reorientation of marketing philosophy, says Hanschen, with the emphasis on applications of IEC's for customers.

The switch of Bucy from the Apparatus division—which has been in systems work—over to manager of the S-C operations makes sense, says Hanschen, when viewed in this light. Other organizational changes at top levels also coincide with this philosophy, it is said. Changes lower down are just "people reasons" in some cases, Hanschen adds.

What about the reports of serious sales troubles for TI's germanium lines?

Hanschen concedes there has been a general decrease in TI's germanium business for the past five years and the future outlook is for continued "steady decay." But, he says, TI's silicon devices and IC's have been absorbing the decrease registered in germanium sales.

TI expects to continue fairly heavy in germanium devices with sales on some devices "assured for the next 10 years," adds Hanschen. Other semiconductor firms, however, are swiftly dropping their germanium lines.

Recovery in sight. At this time TI is forecasting that the current slowdown will recover by the second quarter, says Hanschen. He believes the S-C division will be able to avoid a layoff of production workers. But it is possible that reduced work schedules ordered by Dotson could be stretched beyond the originally announced four-week period.

TI's S-C division is trapped by the high rate of annual growth that executives, stockholders and financial men have become accustomed to in semiconductor companies. Just before he was replaced, a harrassed Dotson commented, "We've had 20% rate of growth for so long that people consider a 10% growth rate as a recession and a 5% rate as a depression."

Clearly, new president Shepherd is trying to avoid a Texas-style depression.

Consumer electronics

Computer course

More and more companies are going back to school via the computer-aided education route. The International Business Machines Corp. and the General Electric Co. are already in the field. The Westinghouse Electric Corp. and the Philco-Ford Corp. have recently developed systems and the Radio Corp. of America plans to enter the classroom next month with instructional aids.

Philco-Ford will deliver a Philco 2000 computer, four Philco 102 data processors and 32 student consoles to the Philadelphia school district this spring. The computer will be able to communicate with data processors at each of four schools, though the processors, which will serve the student consoles, can be operated independently of the central computer.

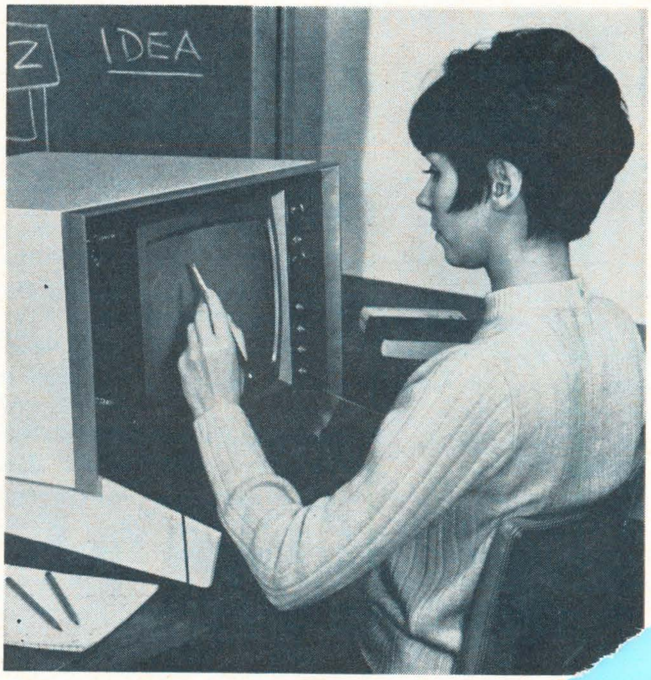
Dialogue. The student console looks like a tv set, with a keyboard added. The instructional program is presented to the student via the cathode-ray tube or the console speaker or both. He responds on the keyboard or with a light pen.

Westinghouse recently demonstrated two audio-visual aids for schools. The first is a one-man tv studio, which enables an instructor to present lessons live, as well as with films, slides, charts and other graphic materials. The second is an audio-visual recorder capable of handling video and as many as five audio tracks.

Industrial electronics

Type casting

It takes at least an hour and a half to set type for one page in a telephone book with an ordinary linecasting machine. With a new photographic typesetter, developed by



Student at console communicates with the central computer by using the keyboard or a light pen. The Philco-Ford unit, at right, permits pupils to proceed at their own learning pace and frees the teacher from routine classwork.

the Harris-Intertype Corp., the time has been cut to 30 seconds.

The typesetter, which has monolithic integrated circuits in its digital logic system, produces up to 1,000 type characters per second. The company spent 4½ years developing the system. Its cathode-ray tube—large enough to display a 9- by 11-inch page without enlargement—has a resolution of better than 500 lines per inch.

Tape job. The first step in producing a printed page with the system is to transfer the text from the typewritten page to magnetic tape and then into a computer, which automatically justifies lines.

The tape then feeds into the typesetter, which generates the characters on the face of a crt at high speed. The optical system photographs these characters on film, which is then automatically developed, fixed and dried. The final step is to make the plate that can be used with any conventional printing process.

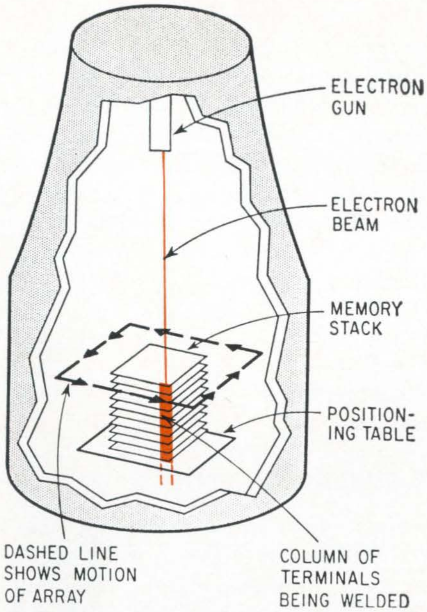
Revisions. Harris-Intertype said its system probably will be priced between $200,000 and $400,000, depending on the input and number of fonts stored. The first production unit will be delivered in June to a large printing company in the South. Because corrections, too, can be punched into tape, the system is particularly valuable in printing telephone books, catalogs and other frequently revised publications.

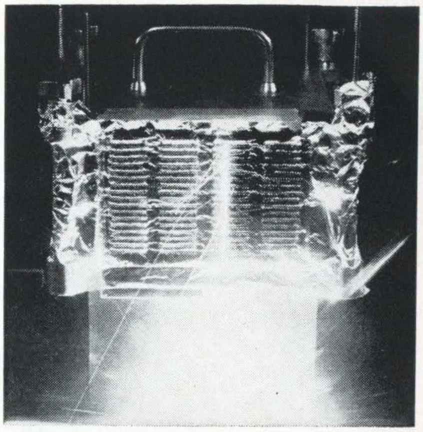
Two other companies have recently announced high-speed typesetters using crt's. The Radio Corp. of America is selling a German-made system, called Videocomp, which turns out 600 characters a second. And the Mergenthaler Linotype division of the Eltra Corp. will deliver its Linotron system to the Government Printing Office and the Air Force this year [Electronics, June 13, 1966, p. 255].

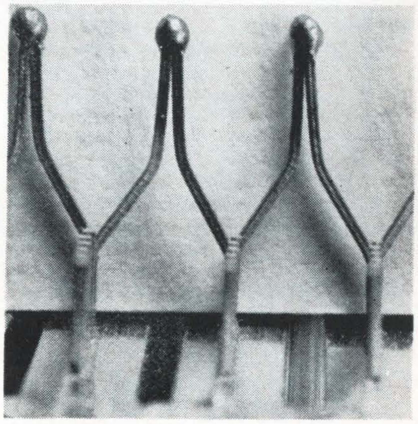
Manufacturing

Making the connection

Electron-beam techniques have found wide use in welding exotic metals and a few applications in assembling integrated circuits. Now there's another: welding the thousands of connections in ferrite-core memory stacks for System 360 computers. It's being done at International Business Machines Corp.'s Kingston, N.Y., plant.







Electron beam welds whole column of terminals on a stack of core planes for a computer memory. Details of the process are in the cutaway drawing of the electron beam welder. The photos at the right show the welding operation (top) and the final welded nuggets (bottom).

Aside from its obvious advantage—the speed with which the beam can be moved from one tiny weld spot to another—the technique provides an easy way for detecting occasional bad welds.

Conventional techniques for welding terminals of ferrite core planes involve resistance welding of one pair of terminals at a time. But in the new process, an electron beam fires through a column of terminals at one time, welding an entire line simultaneously and producing small look-alike nuggets of weld material at each terminal. Since the nuggets are nearly uniform, a quick visual inspection discloses any poor-quality connections.

Square dance. The welding process takes place in an electron-beam welding machine modified from the model W-2 built by the Hamilton Standard division of United Aircraft Corp., where electron beams are used to weld microcircuit module interconnections. The machine consists of an electron gun, a series of control grids and a vacuum chamber containing a positioning table. The table can move independently in either of two horizontal directions.

The memory stack to be welded is placed on the table, the chamber evacuated and the beam turned on. As the table moves, the beam strikes successive columns of terminals and welds them together in pairs. The memory, in effect, executes a do-si-do square dance movement inside the vacuum chamber, successively exposing all four sides of the array to the vertically directed electron beam, welding all columns on each side during a single pass through the process.

Square holes seek peg

A man whose profession is developing printing and chemical techniques for the graphic arts will soon be knocking on the doors of electronics manufacturers. John D. Eerde of New York, thinks they will be interested in a way he has developed of making very small, very precise holes.

Some companies, he hopes, will want to use the holes in the production of shadow masks in color-television picture tubes. Others may want to consider the metal around the holes as microminiature wiring patterns or thin-film deposition masks.

One of his samples is composed of holes only 20 microns square—about 0.0006 inch; a square-inch sheet contains 562,500 of them. The holes, he says, are exact squares surrounded by a nickel matrix, each segment of which is round in cross section.

Rounding corners. The idea of using the technique to make tv-tube shadow masks was hit upon by Eerde and Robert Fondiller, a New York teacher. Shadow masks have fairly widely spaced round holes. Eerde says he can round his holes by modifying the plating pattern, and claims that they would be more precise than the etched holes now used.

Another possible application of the process would be in the production of the fine-wire grid used to deflect beams in one-gun types of color-tv picture tubes.

With square holes, the matrix resembles a fine-wire screen, fused wherever the wires intersect. Such a mesh might interconnect many points simultaneously, or insulated orthogonal grids might form X-Y matrixes, such as the wiring of thin-film memories.

Fishtank. There is no practical limit to the size of the matrixes, Eerde says, and their geometry and resolution depend only on the master pattern used. The present resolution is 750 lines per inch, and Eerde expects to get 1,000 lines soon. In his experimental equipment, about the size of a small fish-tank, it takes about 25 minutes to generate matrixes of about 2 square inches; larger equipment would reduce the time.

Eerde won't describe the process except to say that it's a modified form of plating using what he calls an exchange technique. The matrixes are formed on a master pattern, or a replica of it, and then stripped from the master. To maintain resolution, the master is rotated with respect to the plating field.

Computers

A question of privacy

The chief architect of the first computer utility says the time has come to start thinking about protecting users' privacy in the time-shared services of the near future. "Don't wait until time-sharing systems are all built and vested interests have to fight against costly changes," warns Robert M. Fano, a professor of engineering at the Massachusetts Institute of Technology. Fano is the director of Project MAC (machine-aided cognition), the Government-funded computer research center at MIT and a facility that has already had some security problems with clever pranksters and even vandals [Electronics, Jan. 9, p. 25].

Fano draws a parallel between time-shared computers and the present telephone network. If engineers of the past had thought about it, he explains, they could have designed a telephone system that was wiretap-proof. Now, he says, such a project would be prohibitively expensive.

Certification. The professor believes that certification of a time-shared computer system should be required to protect the public and pinpoint accountability for that protection. "Someone besides the salesman who sells you the time-sharing service should certify the security of the system," he says. The question of who should do the inspection and certification is one of public policy, according to Fano.

Adds a colleague at MAC, Edward L. Glaser: "When time-sharing systems do become utilities, they should be inspected, licensed and audited as business auditors and bank examiners now audit the books of a bank."

"The centralization of information will not necessarily result in a loss of privacy," says Prof. Glaser, "as long as there is accountability for the proper use of that information."

An investigation touching on this problem is already under way. The Federal Communications Commission is studying the general question of when, if ever, an interstate time-shared computer service becomes a communications common carrier and is thus subject to Federal regulation.

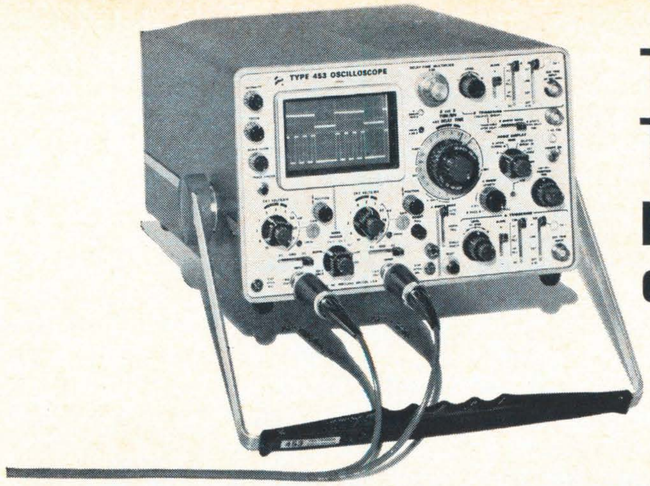
Within the next month or two, the FCC will make specific public proposals on the subject. Interested parties will have four to six months to reply; the agency will then decide whether to hold hearings.

Break-in. At MIT a rash of student invasions of the preliminary MAC time-sharing system has resulted in the installation of protective measures in the new Multics, for multiplexed information and computing service. This system, a prototype of the computer utility of the future, is being developed jointly by Project MAC, the Bell Telephone Laboratories and the General Electric Co. It uses a GE's 645 computer redesigned from the GE 635 specifically for Multics. Installations at Bell Labs' Murray Hill, N.J., facilities and at Cambridge, Mass., will be linked, and hundreds of scientists, engineers and students will have simultaneous access to the system after it begins operations sometime this fall.

The only weak spot in the Multics security system, says Fano, will be the telephone lines from remote terminals. These could be tapped to steal a password, for example. Therefore, certain parts of Multics will never be available to anyone linked to the system over ordinary telephone lines.

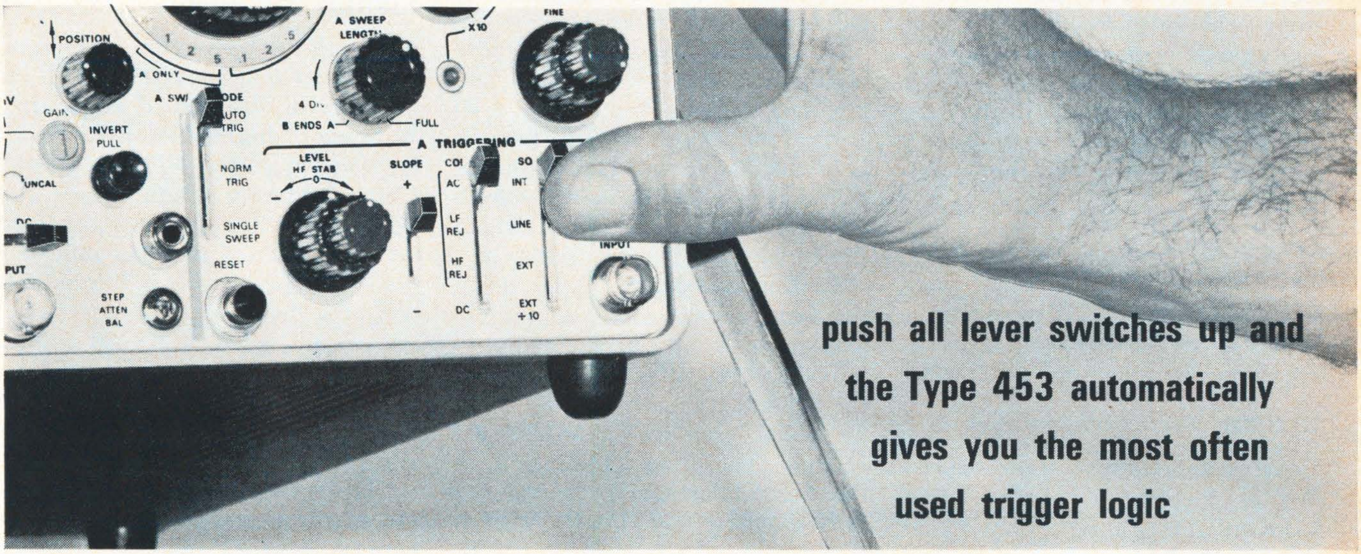
Building bulkheads. The basic approach to security, Fano says, will be partitioning; "bulkheads" will be erected to prevent any individual from searching around in the memory.

"You cannot rely on a single wall



Tektronix Type 453 portable oscilloscope

takes the guesswork out of triggering



The Type 453 provides the following features when all lever switches are up: automatic triggering that allows discrete trigger level selection with the presence of a signal and provides a bright base line at all sweep speeds when no signal is present; + slope triggering; AC coupling that gives positive triggering regardless of vertical positioning; and internal triggering that makes full use of the vertical amplifier gain and the compact internal delay line. The Type 453 will trigger to well above 50 MHz and a green light gives a positive indication of a triggered sweep.

The Type 453 is a portable instrument with rugged environmental capabilities plus the built-in high performance normally found only in multiple plug-in instruments.

The vertical amplifier provides dual trace, DC to 50 MHz bandwidth with 7 ns risetime from 20 mV/div to 10 V/div. (DC to 40 MHz, 8.75 ns T_r at 5 mV/div.) The two included Type P6010 miniature 10X probes maintain system bandwidth and risetime performance at the probe tip—DC-50 MHz, 7 ns—with an increase in deflection factors of 10X. You can also make 5 mV/div X-Y and 1 mV/div single trace measurements.

You can operate the delayed sweep with ease. Lever control to the right and HORIZ DISPLAY switch to A INTEN DURING B gives delayed sweep operation. Setting the B TIME/DIV and the DELAY-TIME MULTIPLIER to meet your requirements and switching to DELAYED SWEEP allows $\pm 1.5\%$ delay measurements to be made.

The Type 453 is a continuation of the Tektronix commitment to quality workmanship. Its design and layout make it easy to maintain and calibrate. Transistors plug in and are easily removed for out-of-circuit testing. An accurate time ($\pm 0.5\%$) and amplitude ($\pm 1\%$) calibrator permits quick field calibration.

The front panel protection cover carries all the accessories with the complete manual carried in the rain/dust cover. The Type C-30 Camera and a viewing hood that fits in the rain cover also are available.

Type 453 (complete with probes and accessories) . . .	\$1950.00
Type C-30 Camera	\$ 390.00
Collapsible Viewing Hood	\$ 7.50

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of security," Fano notes, "there has to be a sequence of hurdles." In the new system, for example, there will be no one inner sanctum which, once gained, will provide access to all information. Instead, there will be successive walls and partitions to be passed only under specified conditions. Segmented blocks of memory, multiprocessing techniques and multiprograming will allow the supervisory program to choose from a variety of access paths.

Fano believes that in the long run it will be more difficult to protect the system from mistakes than from deliberate invasions. To protect against error, it's again a matter of partitioning, he says. "If you accidentally find a hole in the program, you can go just so far before you are blocked by another partition."

Medical electronics

In time

Heart assist pumps—those experimental mechanical devices that help an ailing heart pump blood through the body—are only as good as their timing circuits. Most timing circuits are relatively complicated and require at least three body measurements to keep the pump synchronized with the heart's natural rhythm: blood pressure, electrocardiogram (EKG) and one other parameter. An engineer at NASA's Lewis Research Center has developed a circuit for a timer that works off a single measurement. The parameter being measured is the R-wave, which indicates the start of the heart's compression cycle.

A particularly attractive feature of the R-wave is that it's easy to detect. It's so effective, in fact, that a patient can move about in bed without worrying about generating noise that would disrupt the timing circuit. Other waves are generally distorted or washed out by a patient's sudden movement.

Hospital job. The circuit was developed for Cleveland's St. Vincent Charity Hospital by Vernon D. Gebben. The circuit controls a relay to switch a fluid amplifier, which subsequently drives a mechanical value.

The relay draws only 0.25 milliwatt from the circuit. The circuit consists of five basic building blocks: an amplifier, a filter, a Schmitt trigger, a pulse-width discriminator and a multivibrator.

First the EKG signals are detected and amplified; the four other blocks pick out the R-wave from the EKG signals, which contain many different frequencies.

To separate the R-wave from the EKG, the circuit relies on two criteria: the amplitude and pulse width. The filter screens out frequencies below 15 and above 60 hertz (the frequency of R-waves is about 50 hertz). The output of the filter now contains signals whose frequency resembles that of the R-wave.

Getting a signal. To pin down the signals further, the amplitude and pulse width must be determined. The amplitude is sensed in the Schmitt trigger, which is turned on whenever a preset level is exceeded. Therefore the output of the Schmitt trigger is a train of pulses whose amplitudes exceed the minimum required for an R-wave but now have varying pulse widths. The discriminator then responds to those pulses which are 12 milliseconds—the pulse width of an R-wave.

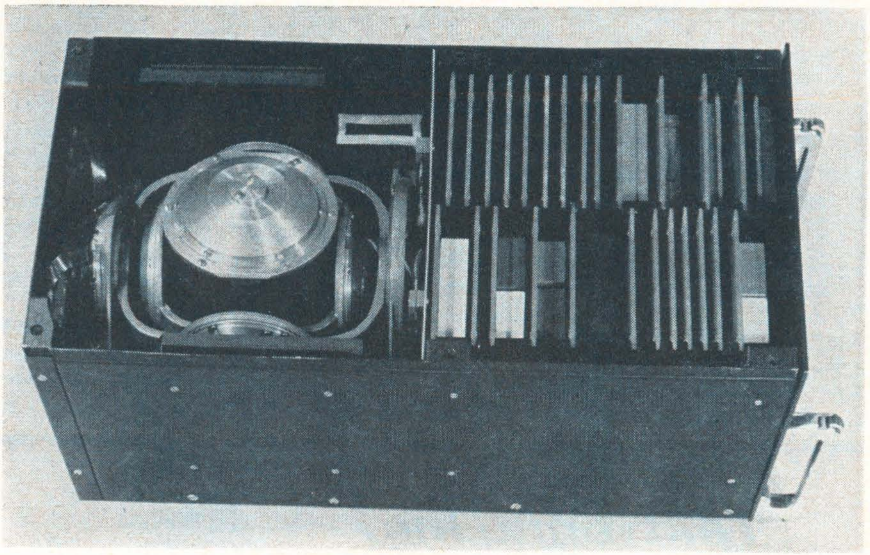
To power the relay, the pulses, which are now only those associated with R-waves, drive the monostable multivibrator; the device is triggered by each pulse and essentially is a circuit that holds preset output level from 200 to 500 milliseconds.

Avionics

Pointing the way

Although the Boeing Co. wanted an inertial navigation system with an accuracy of 20 nautical miles after 10 hours of flight, the AC Electronics division of the General Motors Corp. did better. The company developed a system with an accuracy of better than 1 nautical mile per hour, which is superior to any system now being used commercially. As a result, AC won a $100 million contract from Boeing, beating out Litton Industries Inc. and the Sperry Gyroscope Co., both veterans of the avionics business.

The system, called the Carousel IV, marks AC's debut in the commercial avionics market. Boeing's jumbo 747 jet transports will carry the system and AC says it will also sell it directly to the airlines. In-



Inertial navigator, built by AC Electronics will guide Boeing's giant jet transports with an accuracy of better than 1 nautical mile per hour.

24 DB gain / 120 DB dynamic range at 100 Mc

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If you have an unusual circuit design problem, TRW IGFET technology may solve your problem. Get your IGFET at local distributors or write TRW Transistor Plant, 14520 Aviation Boulevard, Lawndale, California 90260.

TRW designs and manufactures high performance transistors for the communications industry and specialized types for military and industrial applications.

TRW SEMICONDUCTORS

dividual systems will cost under $100,000.

Round and round. The stable platform, containing two gyros and two accelerometers, rotates around the unit's vertical axis. The company says that rotating the entire platform as a unit reduces errors.

An inner platform turret on which the azimuth gyro is mounted spins at one revolution per second. This corresponds to a rotation about the gyro's input axis. The gyro senses this motion and precesses to cause a second rotation around its output axis. This second rotation is converted into an electrical signal, amplified and used to drive a gimbal torque, which turns the entire platform in a direction opposite to the inner turret.

Mounting error. The result is that the turret and azimuth gyro remain fixed and accelerometer, misalignment and gyro drift errors appear as sinusoidal signals. These bias errors can be easily removed because the mean of the sinusoidal error signal is zero; since the error signal's frequency is precisely known, it can be attenuated. In a conventional system, a bias error cannot be separated from a heading error and its effect becomes more significant at higher altitudes.

Unlike other commercial avionic systems now being flown, AC's continually examines itself—without the aid of the pilot—to see whether it is performing correctly.

Advanced technology

Hologram camera

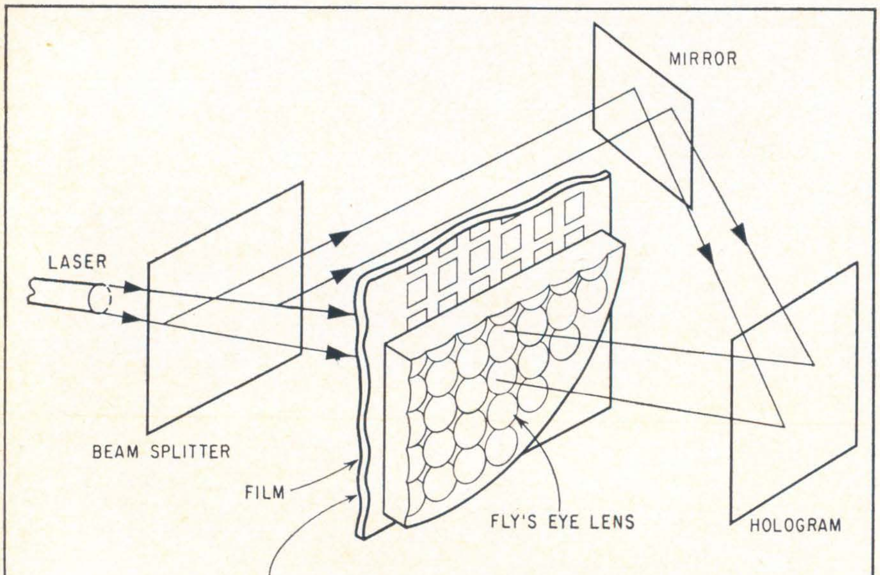
Remove a single-facet lens from a conventional camera, replace it with a multifacet fly's eye lens and you're about ready to shoot a roll of holograms.

The technique was developed by Robert V. Pole, a physicist at the International Business Machines Corp.'s research center in Yorktown Heights, N.Y. With it the subject image can be recorded in the field with ordinary light and without laboratory equipment.

Producing a hologram starts with the snapping of a picture through the fly's eye lens. The negative contains an array of tiny images—each taken at a slightly different angle. Next the negative is placed against another fly's eye lens and illuminated by a laser, using conventional beam-splitting techniques. The new negative produced from this step is the true hologram, which is illuminated to reconstruct a three-dimensional image.

Off the shelf. In the prototype system that Pole developed, he used an available fly's eye lens, one intended for projecting transistor diffusion masks on silicon wafers. Better holograms can be produced, Pole says, by increasing the density of the individual tiny lenses.

Pole is not the first to advance a technique for combining lensless and lens photography for producing 3-D images. Back in 1908, an optical physicist, Gabriel Lippman, proposed a similar system. But he was stymied by two problems: lens technology was too crude to develop a fly's eye device and he was unable to produce a coherent beam to reconstruct the image.



Space electronics

Death on the ground

Project Apollo may have been set back as much as a year by the flash fire that killed astronauts Virgil Grissom, Edward White and Roger Chaffee Jan. 27. A 12-man board investigating the accident may take weeks to pinpoint the cause.

The pure oxygen atmosphere of Apollo is certain to get a close look, although NASA officials say all electronics subsystems in the command module and all electrical connections servicing it passed demanding tests to function in 100% oxygen. No one at NASA will discuss either the possible delay in the lunar landing program or the cause of the fire—believed triggered by an electric spark—until its investigation is completed.

For the record

Shadow masks. Two improved shadow masks for color television tubes have been developed by the Buckbee Mears Co., the major shadow-mask manufacturer. They're still experimental and probably several years away from being incorporated into color tube production, according to the company.

One is designed to be shipped to tube makers already blackened, annealed and curved. Usually the masks are shipped as flat, raw stock that has just been etched. The tube makers must then prepare the masks before they fit them into the color tubes. The second type of mask is a lightweight design that incorporates its own frame and magnetic shield. The shield goes inside the tube and partially supports the mask, so that a much lighter mask frame is required.

Quick startup. A control introduced by the Ferro-Allied Engineering division of Ferro Corp. automatically turns electrical equipment back on once power is restored following an electric power failure. The Ferro Restart Unit provides a conducting path around the start button through which the equipment's starting solenoid is activated by the returning power. The start button itself need not be pushed.

As simple as the idea sounds, Ferro claims it's the first such gear on the market. Up to 11 loads can be tied into a single one of the electromechanical units. Depending on options such as timing devices for delaying restart, a model costs anywhere from $500 to $1,000.

Broad coverage. The fourth ESSA (Environmental Science Services Administration) weather satellite, built by the Radio Corp. of America, was orbited last month from the Western Test Range. The satellite carries two automatic television cameras to transmit continuous weather pictures of the earth to ground stations in 35 countries.

Good times. The Westinghouse Electric Corp. set sales and earnings records in 1966 despite labor troubles that held fourth-quarter earnings below last year's figure. The company also raised its quarterly dividend by 5 cents—to 40 cents a share. Earnings totaled $119,657,000, up 12% from 1965's record. The International Business Machines Corp. earned $526,130,192 in 1966, up $49,227,702 from the previous year. IBM will declare a 2½% stock dividend.

Teacher tape. The Rand Development Corp. is working on a high-speed, inexpensive tape duplicator for use in schools. Rand's objective is to produce a 2-by-4-inch cartridge that costs only 25 to 50 cents—compared with tapes now selling for $7 to $10. Lectures would be recorded on a master tape and stored in school libraries. The duplicator would produce up to six copies at a time in a couple of minutes.

Alert. An electronic warning system for plants, offices, banks and other institutions has been introduced by the Automatic Sprinkler Corp. of America. Called Vandalarm, the system consists basically of a sonic device and miniature digital computer that can be programed to pick up all types of intrusion sounds and at the same time disregard ordinary sounds.

Money talks. An IBM 360 computer and an audio response unit are taking the load off the bookkeeping staff at the American Bank and Trust Co. of Pennsylvania. The system—with a vocabulary of 63 words—can carry on eight telephone conversations at one time. The computer memory contains the account numbers and balances of 120,000 customers.

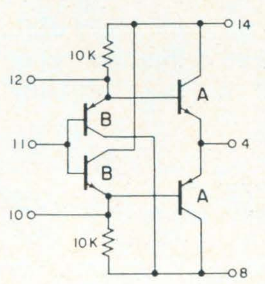
Prototype. The Philco-Ford Corp. has unveiled a prototype of the automatic digital message centers it is building for the Department of Defense. The system, known as the Autodin, contains six Philco 102 computers and peripheral equipment deployed in three operational rooms. Autodin stands for automatic digital network.

Award. The Navy Department has awarded the Sperry Rand Corp. a $16.9 million contract to continue development of the Polaris/Poseidon submarine navigation system.

Exclusive! THERMAL-PAIRING™... for the best behaved hybrids in the business

General Instrument announces: Thermal-pairing, a new thermal servo-control technique that establishes new standards of reliability, stability and circuit performance unachievable until now in integrated circuits.

Thermal-paired hybrid microcircuits work like this: If a critical component starts to heat up, the temperature rise is transferred through the common substrate to a control component which reacts to limit the heating. For example, the PC-260 is a high-efficiency hybrid linear amplifier using Thermal-pairing (see circuit diagram). Transistors A & B are selectively positioned on the substrate. If thermal imbalance occurs, the resultant temperature rise in the A transistors is transmitted through the substrate to the B transistors. These transistors, in turn, heat up and readjust the voltage levels to correct the imbalance. The Thermal-paired feedback loop thus eliminates the danger of thermal runaway. Balanced operation resulting in better power efficiency, excellent linearity, and low distortion is maintained with a minimum of circuit complexity.



FEATURES: PC-260

Typical Circuit Performance:
$V_{CC}=V_{EE}=12V$, $R_L=1K\Omega$, $T_A=25°C$

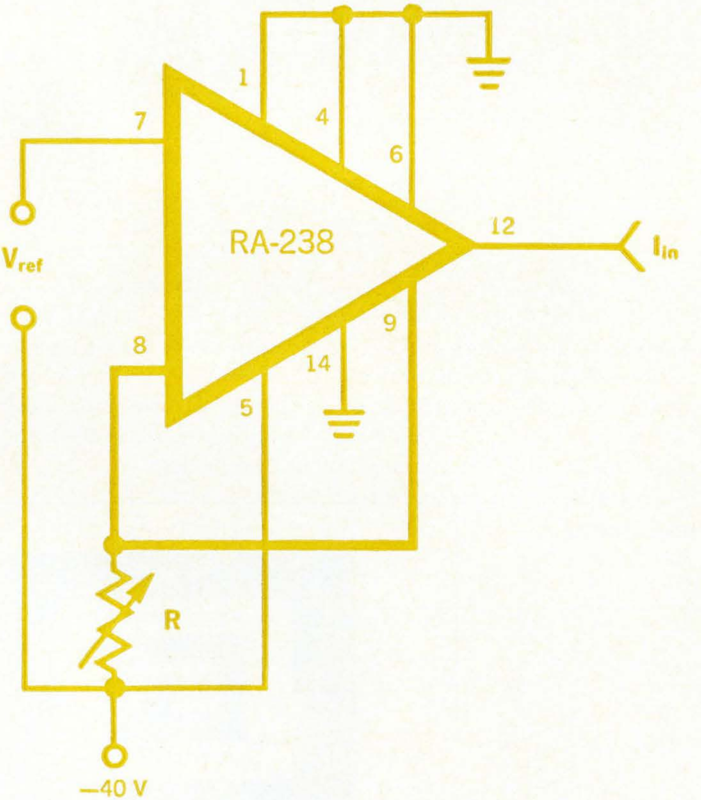
- Power Efficiency ($R_L=240\Omega$, $18V_{PP}$ Swing) 53%
- Bandwidth (3dB), $R_S=100\Omega$, $V_{IN}=1V_{PP}$ ...... DC to 40 MHz
- Input Resistance 1MΩ
- Output Impedance 12Ω
- Output Swing .... ±10V
- Total Harmonic Distortion V_{IN} (1-5 Vrms) 0.2%

The PC-260 is immediately available from your authorized General Instrument Distributor. Write for full information.

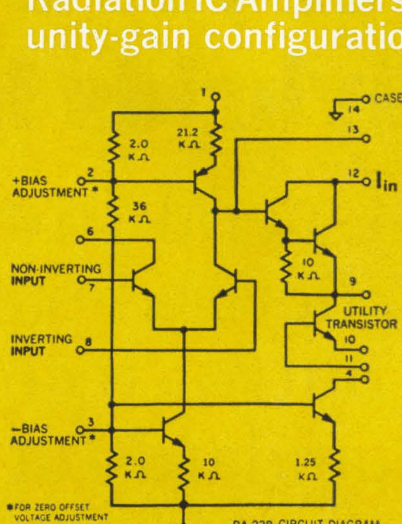
GENERAL INSTRUMENT

GENERAL INSTRUMENT CORPORATION • 600 WEST JOHN STREET, HICKSVILLE, L. I., NEW YORK

State of the design art



Design ultra-precision DC current sinks with Radiation IC Amplifiers in unity-gain configuration



RA-238 CIRCUIT DIAGRAM

Use of Radiation's RA-238 Operational Amplifier greatly simplifies design of DC current sinks, as illustrated at left. First, absolutely no external stabilization is required. And second, in a practical system, this stable dielectrically isolated amplifier contributes typically less than 0.04% error in the total sinking current.

Hence, accuracy depends on the external voltage reference source (V_{ref}) and the precision control resistor (R). Precise control is maintained over a 25:1 current range.

The following expression for sinking current applies:

$$I_{in} = \frac{V_{ref}\left[1 - \frac{1}{|A_{OL}|}\right]}{R}$$

Where A_{OL}=open loop gain.

Further, performance data of Radiation's RA-238 in this application indicates unusual design flexibility:

Current range $= \Delta I_{in} =$ 0.2 to 5.0mA
Voltage range $= \Delta V_{in} = +10$ to -30 V
Equivalent load presented: > 50 MΩ < 3pF

VISIT US AT THE IEEE SHOW . . . BOOTH 4G32, 4G34.

Circle 44 on reader service card

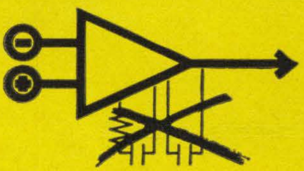
A new line of universal building blocks for integrated analog circuitry is now available to design engineers. Radiation Incorporated supplies three different types of IC operational amplifiers to serve your individual requirements: general-purpose, broadband, and high-gain amplifiers.

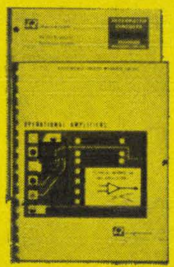
These amplifiers provide outstanding performance. Parasitics are eliminated, thanks to our unique dielectric isolation technique. Tighter tolerances and improved temperature coefficients are achieved through use of precision thin film resistors over the oxide.

Thus, Radiation's technology simplifies system designs which were hampered by limitations imposed by conventional integrated circuit fabrication techniques.

Only Radiation can provide production quantities of inherently stable IC operational amplifiers. These circuits are stocked for immediate shipment in TO-84 flat packages.

Write or phone for our data sheets which include *worst-case limits* as well as all information required by design engineers. We'll also be glad to send you a copy of our new manual entitled: Operational Amplifier Technical Information and Applications. For your copy, request publication number ROA-T01/A01 from our Melbourne, Florida office.





Radiation IC Operational Amplifiers*

Typical characteristics ($T_A = +25°C$)	GENERAL PURPOSE RA-238	BROADBAND RA-239	HIGH GAIN RA-240	UNIT
Phase margin	60	60	45	Degrees
Bandwidth (unity gain)	7	15	6	MHz
Slew rate	3.2	30	3.2	$V/\mu s$
Voltage gain	2,700	2,700	50,000	
Offset voltage	2.0	2.0	2.0	mV
Offset current	80	400	80	nA
Thermal drift	±5 ±1	±5 ±5	±5 ±1	$\mu V/°C$ nA/°C
Undistorted output swing	21	21	9 (11.6)†	V_{P-P}
Power dissipation	90	160	90	mW
Common mode rejection	100	100	100	dB
Power supply rejection	100	100	100	dB
Input bias current	0.4	1.0	0.4	μA

*Standard temperature range: −55°C to +125°C. $V^+ = +25V$; $V^- = -15V$.
†$V^+ = +20V$; $V^- = -20V$.

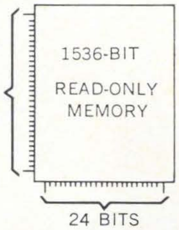
All Radiation integrated circuits are dielectrically isolated.

RADIATION
INCORPORATED
MICROELECTRONICS DIVISION

Sales offices: Suite 622, 650 North Sepulveda Blvd., El Segundo, Calif. (213) 772-6371—Suite 232, 600 Old Country Road, Garden City, N. Y. (516) 747-3730—Suite 201, 1725 Eye Street, N. W., Washington, D. C. (202) 337-4914—P.O. Box 37, Dept. E-OZ, Melbourne, Florida (305) 723-1511, ext. 554

State of the monolithic art

Significant advances are now possible in construction of data storage for read-only memories. The 64-word read-only memory, block diagram below, is a good example.



The circuit requires only 33 Radiation RM-34 "custom patterned" matrices, 11 RD-220 Hex Inverters, and four RD-234 Hex Interface Inverters. Assembly is simplified because the memory consists entirely of TO-84 packages.

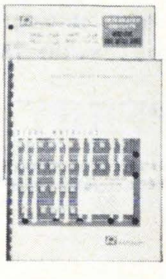
This design approach, using Radiation 6 x 8 Matrices, provides the most economical fully-monolithic integrated circuit memory.

Thus, simplified design, simplified packaging and reduced cost of read-only memories is assured through use of Radiation's unique monolithic diode matrices. Flexibility is achieved by Radiation's exclusive fusing technique for selection of data-storage patterns.

Further information will appear in our ELECTRONIC DESIGN advertisement of February 15.

Our entire line of matrices contain all active devices within a single chip. A fusible link in series with each diode permits unlimited matrix patterns to be formed. Matrices can be combined to produce an infinite variety of size configurations.

We'll be glad to send data sheets which include *worst-case limits*. Our design manual, Monolithic Diode Matrix Technical Information and Applications, RDM-T01/A01, is also available. Write or call our Melbourne, Florida office for your copy.



Circle 45 on reader service card

Washington Newsletter

February 6, 1967

Defense budget safe, but NASA's is due for cuts

While there isn't much doubt that the Defense Department will get everything slated for it in the fiscal 1968 budget, most observers expect rough going in Congress for the NASA request. **Some feel that President Johnson was passing the buck in approving $5.1 billion for the space agency, leaving any paring to Congress.**

NASA officials have told some contractors informally that they don't expect their budget to end up below $4.9 billion. A $200 million reduction to that level would chip away generally in all areas of the agency's funding without concentrating on any specific projects. However, cuts to the $4.6 billion level some Congressmen are calling for could seriously affect two new programs—Apollo applications and Voyager.

Although the Pentagon insists that the new budget won't require supplemental requests such as were needed in fiscal 1966 and 1967, the heavy aircraft losses the U.S. is sustaining in Vietnam may change the picture. One Congressional observer, a man who is often rough on the Administration's defense policies—and often right—**says that while the military budget seems to be a sincere attempt by Secretary McNamara to cover the cost of the war through fiscal 1968, the number of new aircraft proposed is on the short side.**

Funds for SST may be available in three months . . .

Although the supersonic transport and the Rover nuclear rocket—two programs of major interest to electronics companies—weren't included in the budget, chances are good that both will be approved later this spring. Money for the two may come from a $2.2 billion contingency fund. [For details on budget, see story pp. 131-143.]

It's likely the President will approve the start of the Rover program, which would be a new third stage for the Saturn V. If work begins in fiscal 1968, a test flight could be made by 1977 at a cost of at least $2 billion.

Although some Washington observers feel that failure to put the SST in the budget spells trouble for the Boeing Co., it now appears **that the President's strategy is to slip the SST funding into the budget once the appropriations process is well along in Congress.** Thus, in about three months it's expected that the White House will okay prototype construction and ask for $400 million in fiscal 1968. This delay will not slow the program, since Boeing is currently doing major redesign work.

. . . but big splurge in oceanology is a year off

While the President's budget calls for a tidy 15% boost in oceanology funds, a much sharper increase is in store for fiscal 1969. By that time, new Government policy groups will be directing what is to be a full-fledged national effort to exploit the seas. Oceanology spending in fiscal 1968 is slated to rise to $462.3 million from the $409.1 million of fiscal 1967, **but Federal oceanology planners are talking of a $100 million boost the following year.**

FAA will test new vhf antenna

A new type of circularly polarized, very-high-frequency aircraft antenna will be delivered to the Federal Aviation Agency in April. Built by the Kamen Nuclear division of the Kamen Aircraft Corp. under a $100,000 contract, the antenna will be mounted on a C-135 plane for tests over the Pacific, beginning in May, of communications via the Applications Technology Satellite.

The FAA says a circularly polarized vhf antenna built by Dorne & Margolin proved erratic in December tests with the ATS-1. The agency wants a gain 6 to 9 decibels higher than the 3 dbs provided by the best of the existing antennas.

A cockpit switch in the C-135 will allow selection of any of six possible beam positions for the Kamen antenna, which will be nearly flush-mounted around the plane's fuselage. The antenna can thus be directed to "look" only at the relay satellite; this will eliminate multipath problems caused by signals bouncing off the ocean.

EROS relies on other sources for funds

No money was requested in the 1968 budget for the Department of Interior's Earth Resources Observation Satellite (EROS), but project officials stick to their 1969 launch schedule. William Fischer, EROS manager, who earlier expected to seek money in the fiscal 1968 budget, **says no request was made as "other resources" are available to pay for at least part of the program, with the remainder to come from a request for supplementary funds later.**

Defense comsat system to evolve from test project

The Initial Defense Communications Satellite Program (IDCSP) has, until now, been strictly a research and development effort. It was to have been followed by an advanced system (ADCSP) designed from scratch as an operational network incorporating IDSCP technology. **However, the Defense Communications Agency has decided to gradually improve the trial system and allow the operational network to evolve out of these improvements.**

Eight more near-synchronous satellites were orbited successfully on Jan. 18, raising the total number of satellites in the IDCSP system to 15. Four more satellites, including one with an experimental electronically despun antenna, will be launched in May on a Titan-3C.

Fed into the design of advanced models will be data from the March 1968 launch of Britain's stationary military communications satellite—an Intelsat-2 type—and an IDCSP replenishment launch in the summer of 1968. The latter shot will orbit eight more satellites probably supplied by Philco-Ford Corp., builder of the original 100-pound birds. These improved satellites have yet to be contracted for, however.

NASA confirms shift in Voyager responsibilities

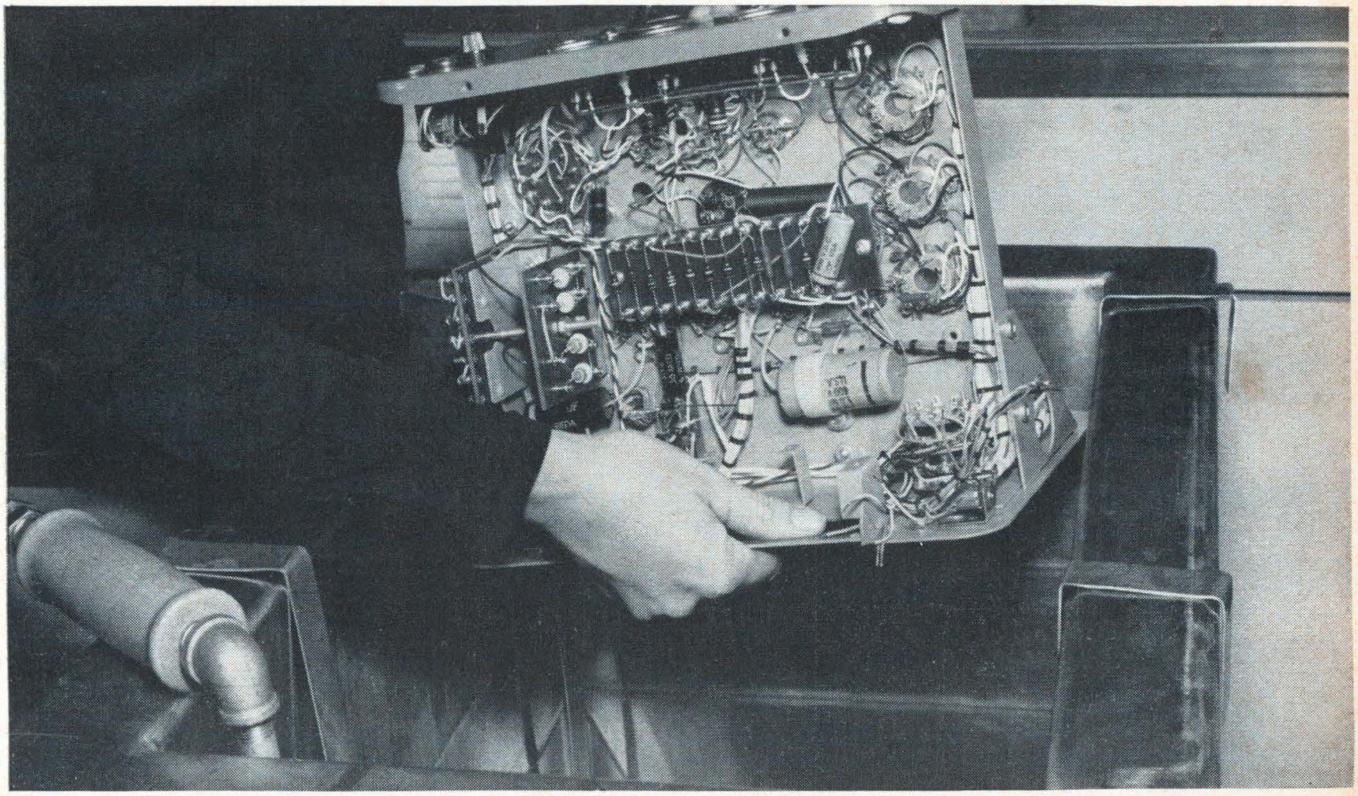
With the big Voyager program slated to roll, space agency officials now acknowledge that a shift in responsibilities for the $2 billion-plus project, is being made away from the Jet Propulsion Laboratory in Pasadena, Calif., to other NASA field centers—a move NASA quietly began making last fall [Electronics, Nov. 14, 1966, p. 25]. Langley Research Center, Hampton, Va., will take over development of the capsule, or planet lander, and the Marshall Space Flight Center in Huntsville, Ala., will assume responsibility for the mother spacecraft, or bus.

A request for bids to design the lander was mailed to 25 companies Jan. 1. Proposals are due March 1, after which the space agency will select two to four teams to do parallel initial design work, called Phase B.

Four teams have been formed to bid on the capsule. They are headed by the Hughes Aircraft Co., the McDonnell Co., the Martin Co. and the Grumman Aircraft Engineering Corp.

What cleans parts 20 times faster?

Consolidated Electrodynamics says: FREON® Solvents and a Baron-Blakeslee degreaser



Consolidated Electrodynamics' Transducer Division in Monrovia, Calif., cleans with FREON TMC solvent in a Baron-Blakeslee Model M degreaser. FREON TMC is a patented azeotrope of FREON TF and methylene chloride . . . another tailored solvent from Du Pont. All kinds of components—from transistors to terminal boards, from subassemblies to complete chassis—are cleaned faster, better, at lower cost than ever before. For example, hand-cleaning one part used to take more than an hour. With FREON it takes just three minutes!

Besides requiring high labor costs, hand cleaning failed to do the job completely. Hidden corners and crevices went untouched. Solvent residues remained after drying. Brushes damaged delicate components. But FREON is a selective solvent—it cleans entire assemblies without harming commonly used components. And FREON has low surface tension to penetrate the smallest pores . . . high density to float away even microscopic particles. It dries quickly, leaving no residue.

Because FREON can be used over and over again, it helped cut CEC's solvent costs in half. And because FREON is nonflammable and relatively nontoxic, no special exhaust systems are needed.

FREON solvents are used for cleaning in many of CEC's divisions. Chances are FREON can give you faster, better, less costly cleaning, too. For more information, write Du Pont Co., Room 4902, Wilmington, Delaware 19898. (In Europe, write: Du Pont de Nemours International S.A., FREON Products Div., 81 Route de l'Aire, 1211 Geneva 24, Switzerland.)

DU PONT REG. U.S. PAT. OFF. Better Things for Better Living . . . *through Chemistry*

DU PONT FREON Fluorocarbon SOLVENTS

Circle 49 on reader service card

The only two void-free monolithic that guarantee on-time delivery.

You don't even have to *order* marbles. You can get all you want at your local five and ten. Or in your son's top drawer.

Diodes are another story.

You could lose your marbles waiting for delivery from some sources. But with Unitrode, on-time delivery is guaranteed (less than 1% late to date!).

So is our quality control. (We've had less than .06% rejections since we've been in business!).

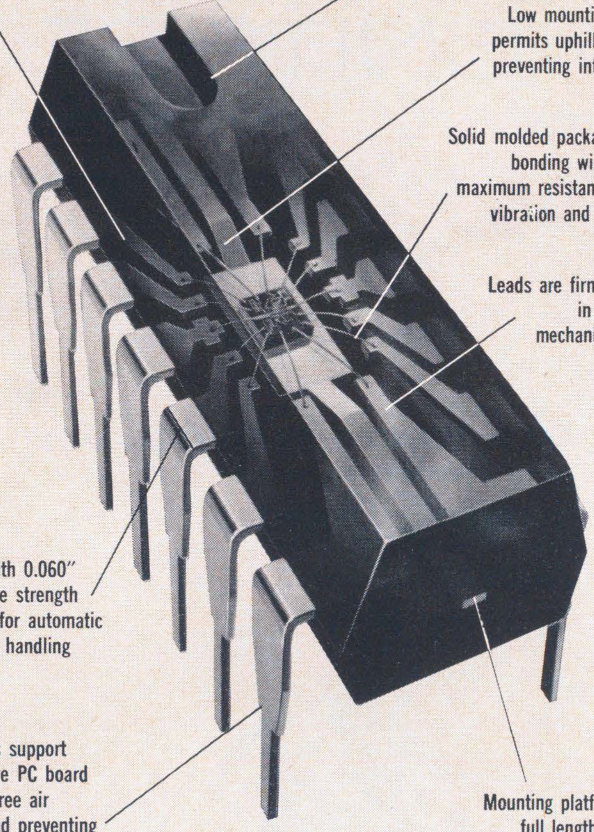
Which isn't easy when you consider how void-free monolithic fused-in-glass structures like *our* diodes have to be made.

First, two terminal pins of the same diameter have to be metallurgically bonded directly to silicon. That solid state bond is stronger than the silicon itself, so the silicon will break before the bond does. The entire unit is fused in hard glass at over 800°C. It's voidless, so all contaminants are excluded.

But to us, all the difficulty is worth it. Because that's why you can hold a Unitrode diode in liquid nitrogen, or subject it to 300°C.

That's why a Unitrode diode can handle as much

Tougher-than-military of TI molded packages



Recently-completed reliability tests by Texas Instruments have proved the ruggedness and durability of TI's molded economy package for integrated circuits.

These tests confirmed both TI's advanced package design, and the merits of the special molding compound. This material is characterized by such features as: strong adherence to metal leads, high resistance to heat, good thermal dissipation, and a temperature coefficient of expansion near that of metal leads.

The molded package passed all tests! Many of the tests summarized below involved stressing far in excess of military requirements.

Package hermeticity tests

Moisture resistance. Three consecutive 10-day tests per MIL-STD-750A, Method 1021 (preconditioning omitted).

Thermal shock. Temperatures of 0°C and +100°C with transfer times of less than 10 seconds (per MIL-STD-750, Method 1056). Test was followed by two consecutive moisture resistance tests per MIL-STD-202C, Method 106B for 15 days total.

Temperature cycling from −55°C to +150°C with five-minute transfer time. Test was followed by two moisture resistance tests as described in the thermal shock test above.

Moisture resistance per MIL-STD-750A, Method 1021, under steady state operation. (Units preconditioned with two 90-degree bends.)

Physical endurance tests

Mechanical shock. Five blows in each of four planes at four levels ranging to 5500 G.

Constant acceleration in four planes for one minute dwell time each plane. Maximum acceleration was 100,000 G.

Vibration. Variable frequency (100 to 2000 cps) in three planes for four minutes per sweep. Maximum intensity was 60 G.

Severe hermeticity tests

Detergent bomb tests. Units were stored in a 4% solution of detergent and water at 110 psi. Three four-hour, and one 24-hour test.

Salt atmosphere test per MIL-STD-750A, Method 1041 for two 24-hour periods.

Solderability test per MIL-STD-202C, Method 208A. Solder was 60% tin, 40% lead (per MIL-QQ-571). Flux was type W (per MIL-F-14561).

Long-term temperature variation. Six one-week cycles. Each cycle included 24 hours

testing proves reliability for integrated circuits

at +25°C, 72 hours at –55°C, and 72 hours at +125°C.

36-page reliability report

Complete information on these tests is detailed in a new "Plastic Package Reliability Report." For your copy, circle 31 on Reader Service card.

Both DTL and TTL

A broad selection of circuits are offered in molded economy packages with availability to meet your immediate production needs. Included are popular digital circuits from both the 930 DTL and Series 74 TTL families (listed at right). Because of their high performance and low cost, Series 74 TTL circuits are usually first choice in the newer system designs — yet these devices may be designed into earlier equipments which employ 930 DTL circuits.

For Data Sheets on Series 15830 DTL circuits, circle 32 on Reader Service card.

For Data Sheets on Series 74 TTL circuits, circle 33 on the Reader Service card.

New complex-function circuits provide further economies

Five recent additions to TI's Series 74 TTL family make possible important new economies. Over-all system savings in excess of 50% can often be realized, since more functions per package reduces cost per circuit function and also permits sizeable reductions in inventory, handling and assembly costs.

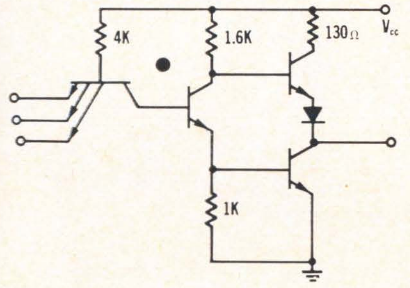
Two of the new circuits are offered in a new 16-pin version of the molded package. Except for being 100 mils longer, the 16-pin package is identical to the one with 14-pins.

As with all Series 74 devices, the five new complex-function circuits can be used to upgrade 930 DTL designs now in production.

Low cost plus ease of handling

Both Series 15830 and Series 74 circuits are priced competitively. In addition, the TI molded package permits automatic testing, handling, and insertion. Since assembly costs are a significant part of the total for any equipment, you realize big savings by specifying TI.

For price and availability information, contact your nearest TI sales office or authorized distributor. Or, write directly to Texas Instruments Incorporated, P. O. Box 5012, Dallas, Texas 75222.



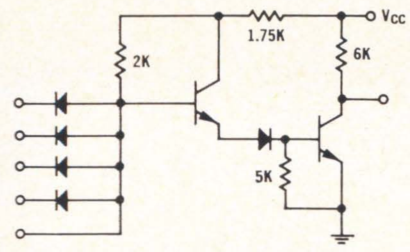
Series 74 TTL

Device Number	Circuit Function
SN7400N	Quad 2-input NAND gate
SN7410N	Triple 3-input NAND gate
SN7420N	Dual 4-input NAND gate
SN7430N	8-input NAND gate
SN7440N	Dual 4-input NAND "power" gate
*SN7441N	BCD-to-decimal decoder/driver
SN7450N	Dual EXCLUSIVE-OR gate with expander inputs
SN7451N	Dual EXCLUSIVE-OR gate
SN7453N	Quad 2-input AND/OR/INVERT gate with expander inputs
SN7454N	Quad 2-input AND/OR/INVERT gate
SN7460N	Dual 4-input expander
SN7470N	Single-phase J-K flip-flop
SN7472N	Master/slave flip-flop
SN7473N	Dual master/slave flip-flop
SN7474N	Dual "D" type flip-flop
SN7480N	Gated full adder
*SN7482N	Dual adder
*SN7483N	Quad adder
SN7490N	BCD decade counter
SN7491N	8-bit shift register
*SN7492N	Divide-by-12 counter
*SN7493N	Four bit binary counter

*New device

TYPICAL CHARACTERISTICS

Parameter	Basic Gate	Flip-flop
Propagation delay	13 nsec	40 nsec
Power dissipation	10 mW	60 mW
Fan-out	10	10
D-c noise margin	1 V	1 V
Supply voltage	4.75 to 5.25 V	4.75 to 5.25 V
Temperature range	0° to +70°C	0° to +70°C



930 DTL

(TI Series 15830)

Device Number	Circuit Function
SN15830N	Dual 4-input expandable NAND gate
SN15831N	J-K/R-S flip-flop
SN15832N	Dual 4-input expandable buffer
SN15833N	Dual 4-input expander
SN15844N	Dual 4-input expandable NAND "power" gate
SN15845N	High performance J-K/R-S flip-flop
SN15846N	Quad 2-input NAND gate
SN15848N	Fast-rise-time J-K/R-S flip-flop
SN15850N	A-C flip-flop
SN15851N	"one-shot" monostable multivibrator
SN15862N	Triple 3-input NAND gate

TYPICAL CHARACTERISTICS

Parameter	Basic Gate	Flip-flop
Propagation delay	25 nsec	50 nsec
Power dissipation	5 mW	20 mW
Fan-out	8	7
D-c noise margin	750 mV	750 mV
Supply voltage	4.5 to 5.5 V	4.5 to 5.5 V
Temperature range	0° to 75°C	0° to 75°C

TEXAS INSTRUMENTS
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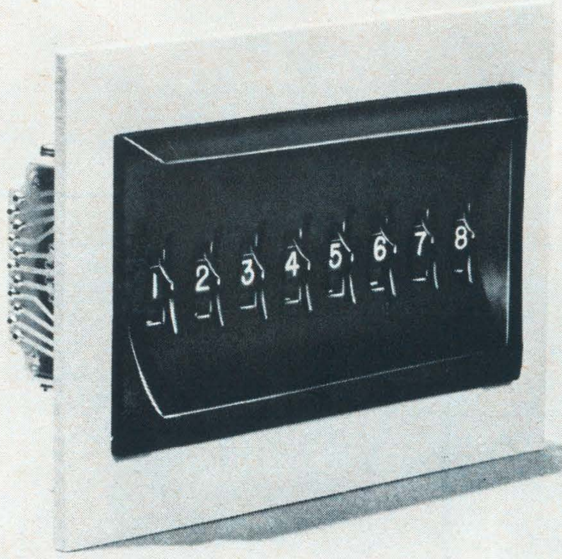

C•D•I

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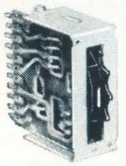

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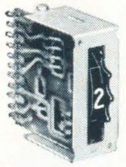

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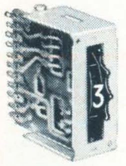

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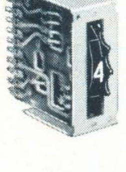

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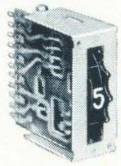

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RESISTANCE	50 ohms to 10K

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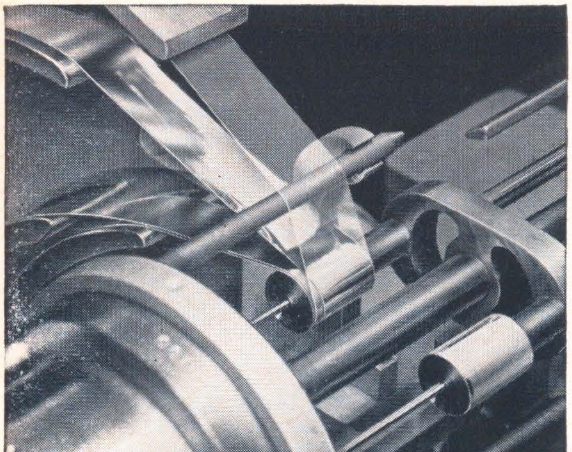

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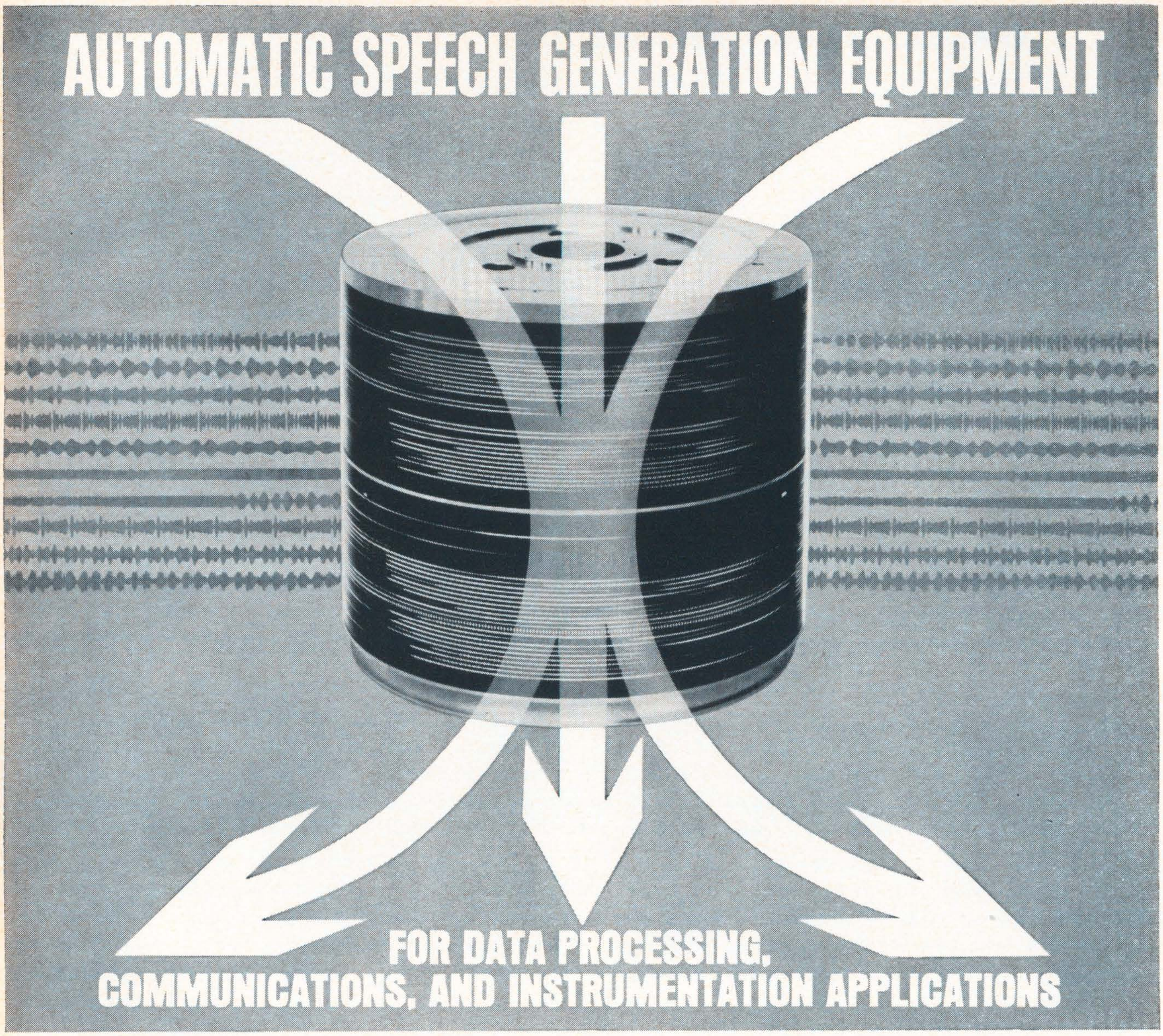

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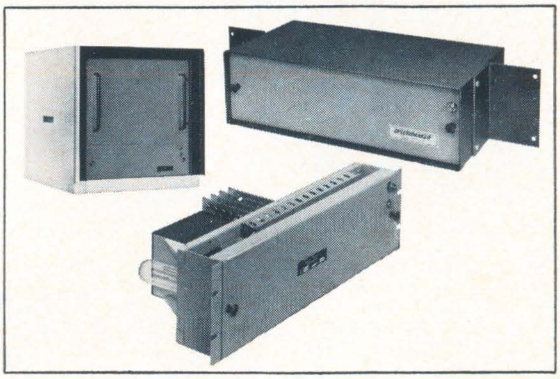

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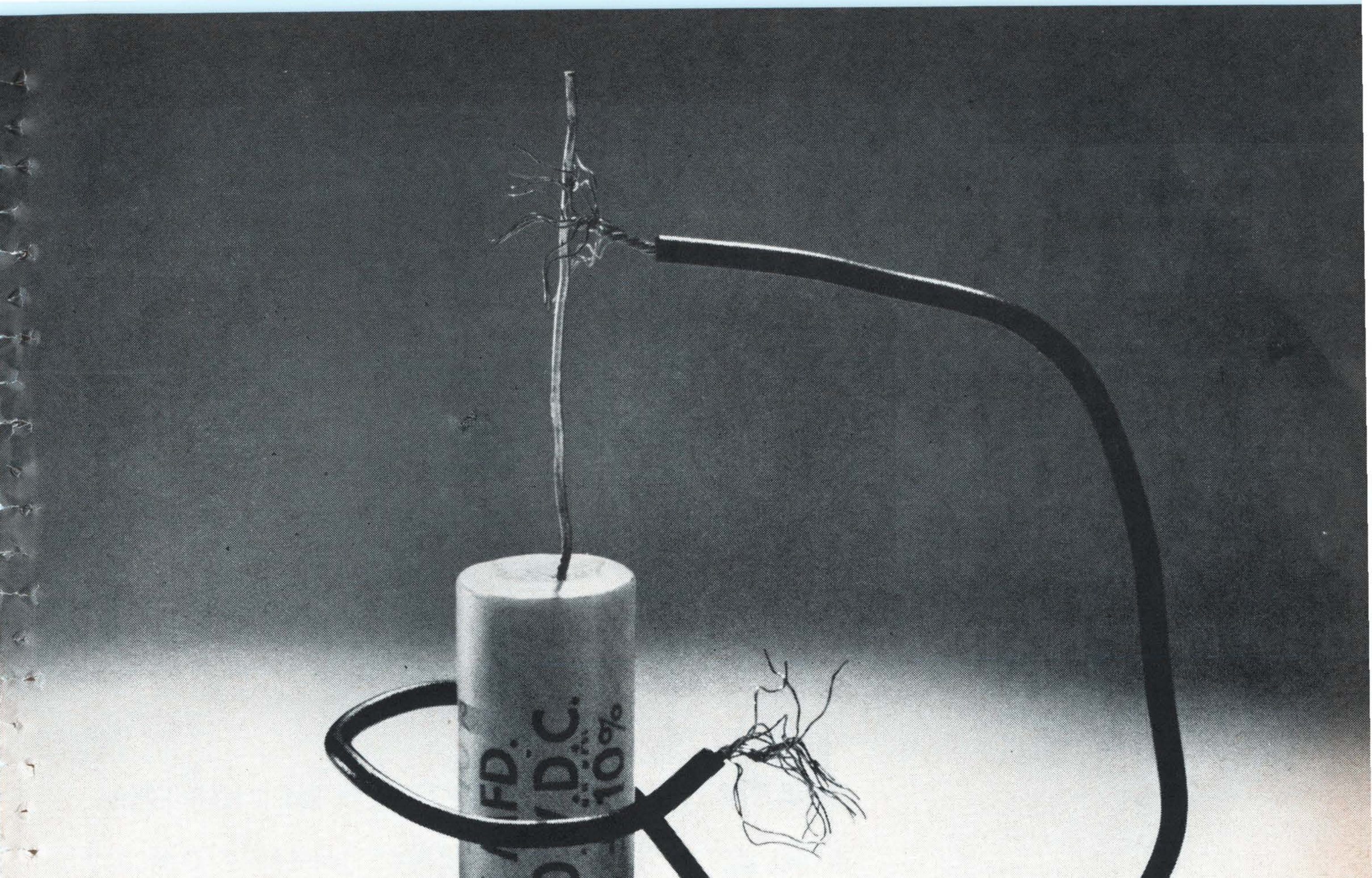

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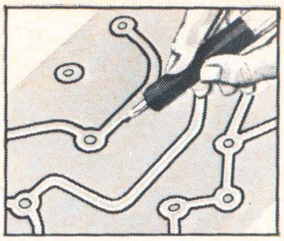

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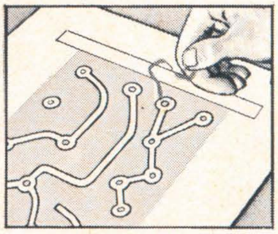

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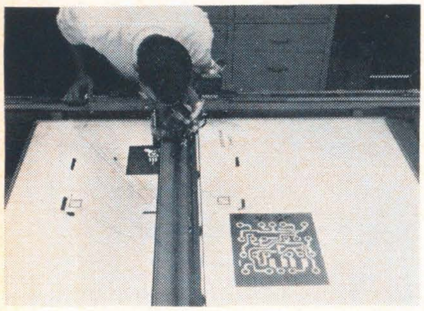

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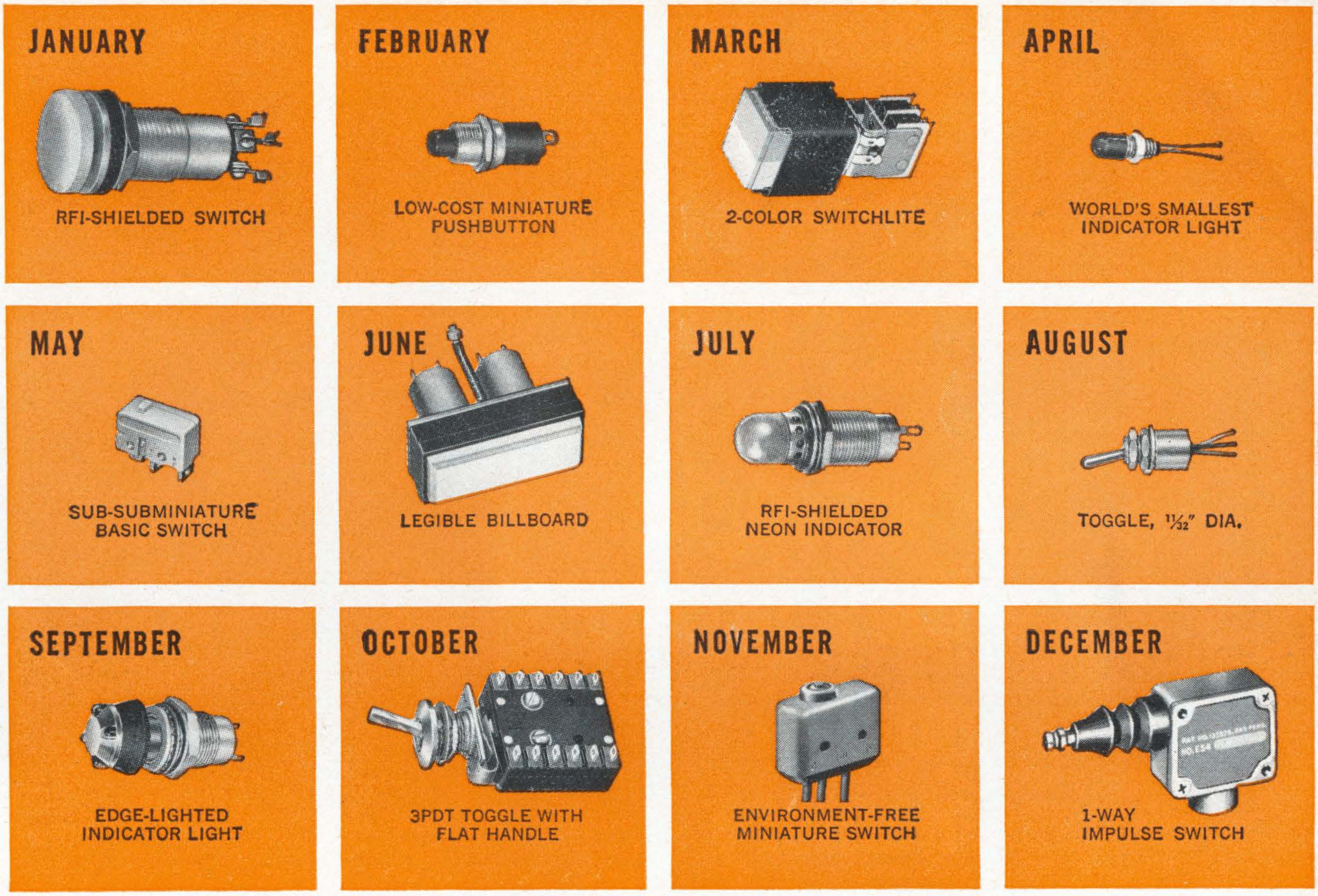

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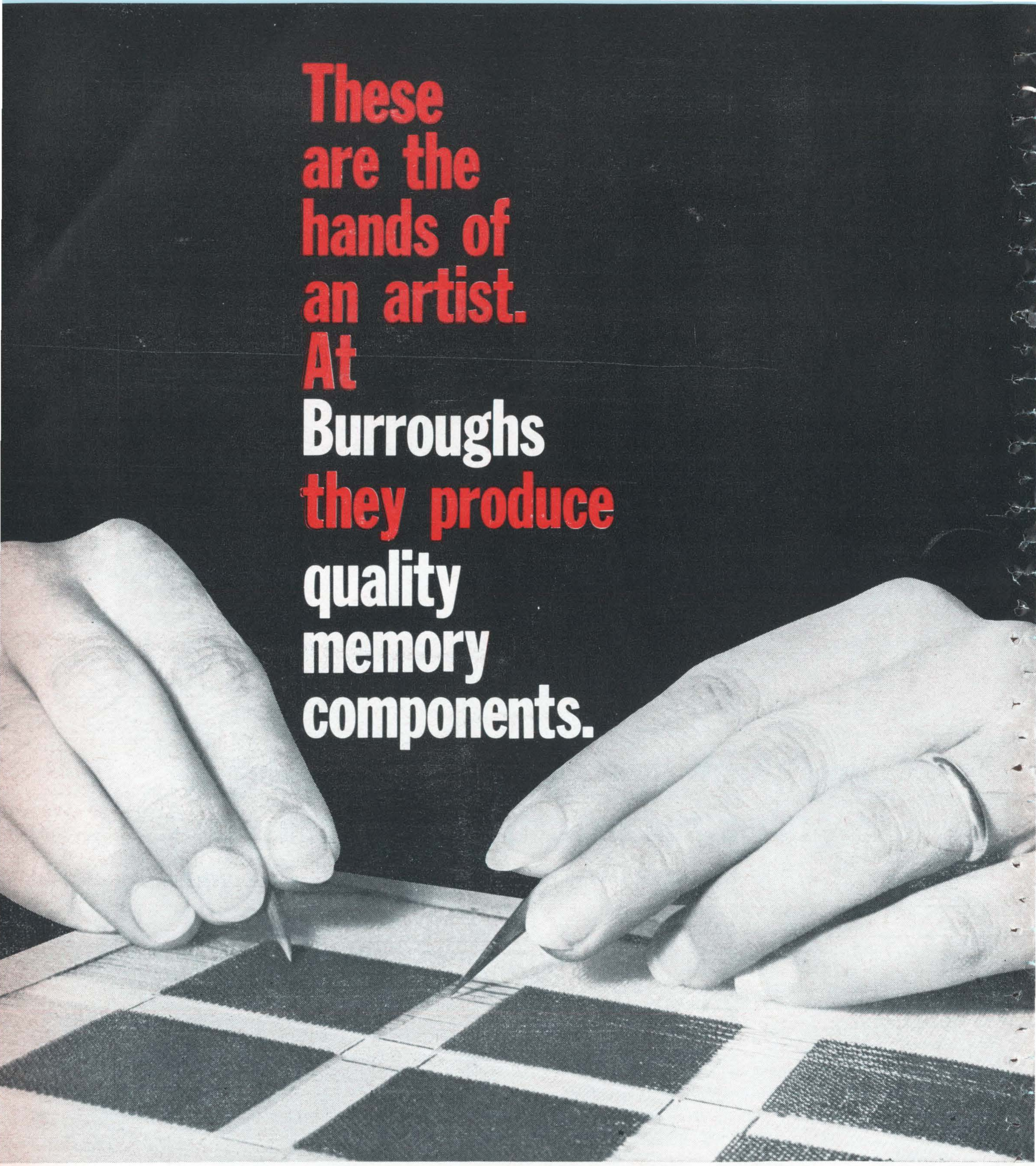

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February 6, 1967 | **Highlights of this issue**

Technical Articles

Micropower redundant circuits correct errors automatically
page 66

Redundancy is one way to get the high reliability that many applications demand. But designers of digital circuits often find that redundancy comes at a price they cannot afford to pay—an excessive consumption of power. The authors have devised a method to operate digital integrated circuits which are available commercially at power levels of a few microwatts instead of milliwatts. They use pulsed, or gated, power mode and connect redundant elements by appropriate capacitors.

Computer-aided design: part 6, Comparing the "Big Two" programs
page 74

Anyone interested in computer-aided design sooner or later runs into two programs that have received the widest publicity: NET-1 and ECAP. The former demands complex device models and then produces relatively accurate results. ECAP is extremely flexible. Now a third program blends some of the best features of each.

Memory on a chip: a step toward large-scale integration
page 92

As the jobs that a computer has to do become more varied, the programing becomes terribly complex and expensive. One way to reduce the software needed is to use read-only memories that carry the instruction for a specific task. Until recently, read-only memories tended to be more expensive than the software so they were used sparingly. But with the advent of large-scale integration—putting hundreds of electronic components on a tiny chip of silicon—the read-only memory becomes economic and looks like a promising tool in computer design.

Japanese technology: Computers and color are the big forces in tv broadcasting
page 99

Most Westerners see only one side of the Japanese consumer electronics industry—the transistor radios, television sets and recorders they sell. But the Japanese are putting forth a great technical effort to create new telecasting gear. On the cover is a picture taken through a stripe filter that allows one tube to do the job of two in a color-television camera.

Coming February 20

- **Special report on large-scale integration**
  - **The impact on system design**
  - **Discretionary wiring or the master slice**
  - **Using silicon-on-sapphire (SOS)**
  - **Using metal oxide semiconductors (MOS)**
  - **The users' view**
- **Shifting phases digitally**
- **Computers that run the North American Defense system**

Micropower redundant circuits correct errors automatically

Pulsed power and deceptively simple capacitive coupling between digital integrated circuits provide what systems designers crave—high reliability without a power penalty

By Robert E. McMahon and Nathaniel Childs

Lincoln Laboratory*, Massachusetts Institute of Technology, Lexington

Redundancy is one way to get the high reliability that spacecraft electronic systems demand. But digital circuit designers often find that redundancy comes at a price they can't afford to pay—an excessive consumption of power. Furthermore, previous redundant circuit designs have generally proved to be rather complex.

By using a pulsed, or gated, power mode[1], and interconnecting redundant elements by appropriate capacitors, commercial digital integrated circuits can operate reliably at a few microwatts, although their usual operating power level is several milliwatts. What's more, the capacitor interconnection scheme provides immediate automatic error correction by a reliable majority charge technique.

The pulsed power technique requires that the supply voltage be gated to the digital elements only during the clock interval. Relatively high-speed elements are used—in this case they are GME 134D2 elements, made by the Microelectronics division of the Philco-Ford Corp. at Santa Clara, Calif. This element is composed of a pair of two-input NAND-NOR gates. When cross-coupled [facing page] the gates form a set-reset flip-flop. For these devices, typical clock rates are less than 1 microsecond.

To store the state of the digital elements between clock intervals and to reestablish their states during the next clock interval, capacitors are used as temporary storage elements. Associated gate circuits, operating with the capacitors, first provide a charging period during the active on-time of the circuit and then a holding period when the power is off—just before the reestablishment of the circuit state at the next active period.

Transistor Q_1 is turned on by the first set pulse [see timing waveforms], and transistor Q_2 is turned off during the active period allowed by power gate Q_5. Capacitors C_1 and C_2 are charged according to the voltages at the collectors to which they are respectively connected, since both gate transistors Q_3 and Q_4 are on during the gated power interval.

At the end of the power gate clock pulse, the voltage is removed from the flip-flop, returning the capacitor gates to an off condition. At this point, the state of the flip-flop is represented by the charge on capacitors C_1 and C_2 and no additional power is required during the off period. The amount of charge lost during the off period is proportional to the leakage current of gate transistors Q_3 and Q_4.

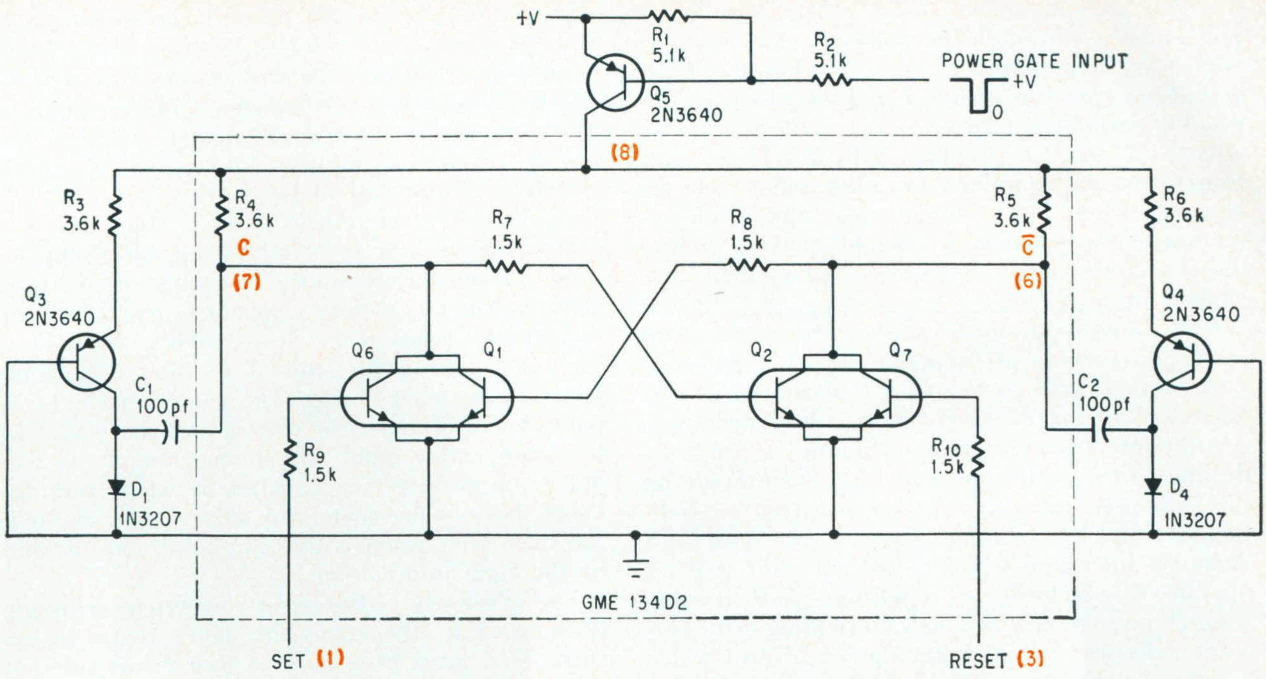
At the next application of power to the circuit through Q_5, the remaining charge on capacitors C_1 and C_2 triggers the flip-flop through its collector connections and reestablishes the flip-flop state.

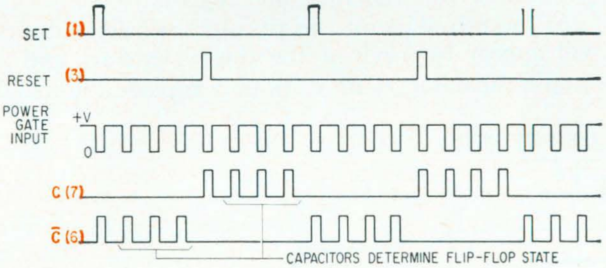
*Operated with support from the U.S. Air Force

The authors

Robert E. McMahon is a staff member at Lincoln Laboratory, where he has been active in magnetic core research, computer development and space instrumentation. He graduated from Georgia Institute of Technology and is a member of Tau Beta Pi, Eta Kappa Nu and Phi Kappa Phi.

Nathaniel Childs joined the staff of Lincoln Laboratory in 1964 after graduation from Yale, where he received his engineering degree. He is involved in r-f circuit, digital circuit and system design, and in implementation of computer-aided design. Childs is a member of the Yale Engineering Society.





Reduction in power from milliwatts to microwatts is achieved by gated or pulsed power operation of commercially available digital integrated circuit. Stored charge on capacitors C_1 and C_2 represents state of flip-flop, obviating need for power during off interval.

Even with capacitors as small as 100 picofarads, the allowable ratio of off-to-on time intervals will be several orders of magnitude, thereby reducing the required circuit power to very low values. The GME digital elements operate reliably in the gated power mode at a few microwatts, although their usual level is 30 milliwatts.

Error correction

With the first requirement for redundancy—low power—satisfied, it is possible to consider interconnecting methods that provide error correction. The schematic on page 68 shows the first three stages of a typical redundant register with capacitor coupling between transistor collectors for error correction.

The GME 134R register element is a synchronous clock-gated flip-flop with a synchronous set and reset. Data at pin 2 (information input) can be entered during a one to zero transition at pin 1 (clock input). The data bit at pin 2 must be present a minimum of 70 nanoseconds before and 29 nsec after the transition at pin 1 is 50% completed.

Since the main flip-flop collector terminals of the element are available at pins 5 and 6, the capacitors in the pulse power mode of operation effectively determine the state of the flip-flop (depending on the capacitor charge conditions) during the time that pin 1 is at a high level. New information may be applied during this time, but it will be clocked into the element during the transition of the clock input.

Assume that capacitors C_1 through C_6 have stored some prior state of the flip-flop stages in the manner just described. Now, reapplication of power to the flip-flops through their respective power gates will cause a redistribution of capacitor charges so that the three circuits will assume the state dictated by the majority capacitor charge. Capacitors C_7 through C_{12} provide the coupling to achieve charge redistribution.

In the diagram, the set and reset connections to flip-flop 3 have been deliberately interchanged. Thus, when flip-flops 1 and 2 are in the correct one state (for example, C sides high), flip-flop 3 indicates incorrect data (C side low). Under these conditions, capacitors C_2, C_4 and C_5 have a charge equal to the product of the capacitance and the difference between the on and off collector voltages. Capacitors C_1, C_3 and C_6 have charges that depend on the difference in saturation voltages of the flip-flop and gate transistors.

At the next clock period, when power is reapplied and the capacitor gates turn on, the various capacitor charges are applied to the flip-flop collectors and redistributed according to the majority charge conditions that exist.

Several factors operate to insure proper error correction. The saturation voltage of the gate transistors helps overcome the threshold voltage of the flip-flops so that very low levels of majority charge will initiate turn-on. The different transient response of the flip-flops to opposite charge polarity conditions and the resulting reinforcement of the flip-flop switching process are in a direction that aids the correction process. With unselected gate transistors and coupling capacitor values chosen equal to those of the storage capacitors, error correction continues even if long off periods reduce the remaining capacitor charges to less than 20% of their initial value.

Under investigation are the effects on the error correction process of capacitor dielectric polarization, storage time in the gate transistors and the influence of capacitor delay on charge distribution.

Although this correction technique is primarily designed for systems operating at a fixed repetition rate, adequate margins exist for changes in repetition rate over a wide range. For example, GME 134R elements in a three-level redundant shift register operate satisfactorily at repetition rates ranging from 20 milliseconds to 2 μsec, providing error correction despite voltage variations of 2.5 to 6 volts.

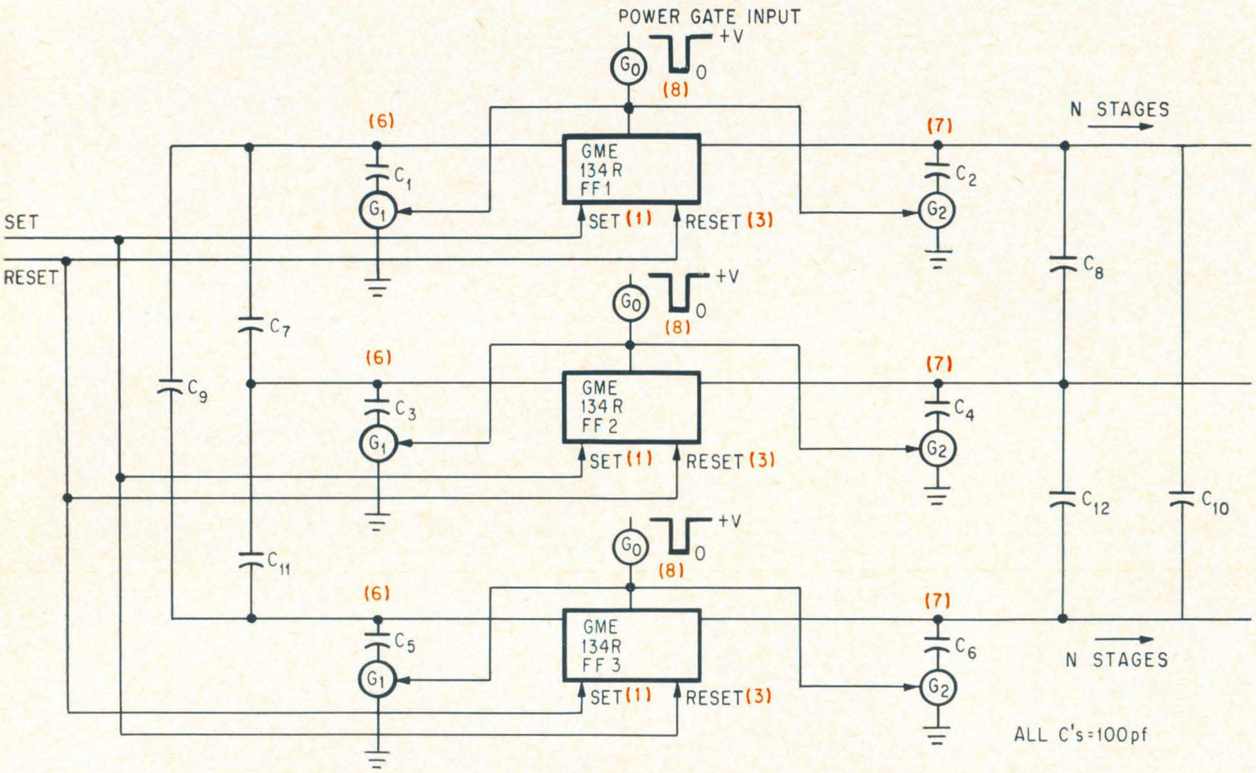
Reliable register

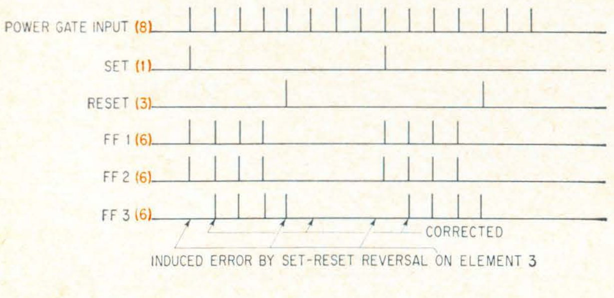
In a register of n stages, on page 69, the gated power is applied for 10 μsec to the voltage supply terminal (pin 8). The shift clock is applied in a high state to allow a time interval in which the storage capacitors reestablish the flip-flop in its prior state and to permit errors existing in any of the stages to be corrected. For the example demonstrated by the timing waveforms, the prior information of a typical stage is assumed to be a one.

As the shift clock returns to a low level, information (assumed here to be a one) appearing on the input line is clocked into the first stage. At the next clock pulse, the storage capacitors restablish the correct state (one) in the element while the clock is high. Also during this interval, the first stage compares its capacitor charge with the other stages in parallel with it and error correction takes place. In the example, the input data at the time of the second clock pulse is a zero. After the stage reestablishes its prior one state, any errors are corrected; the stage then assumes the zero condition dictated by the input information.

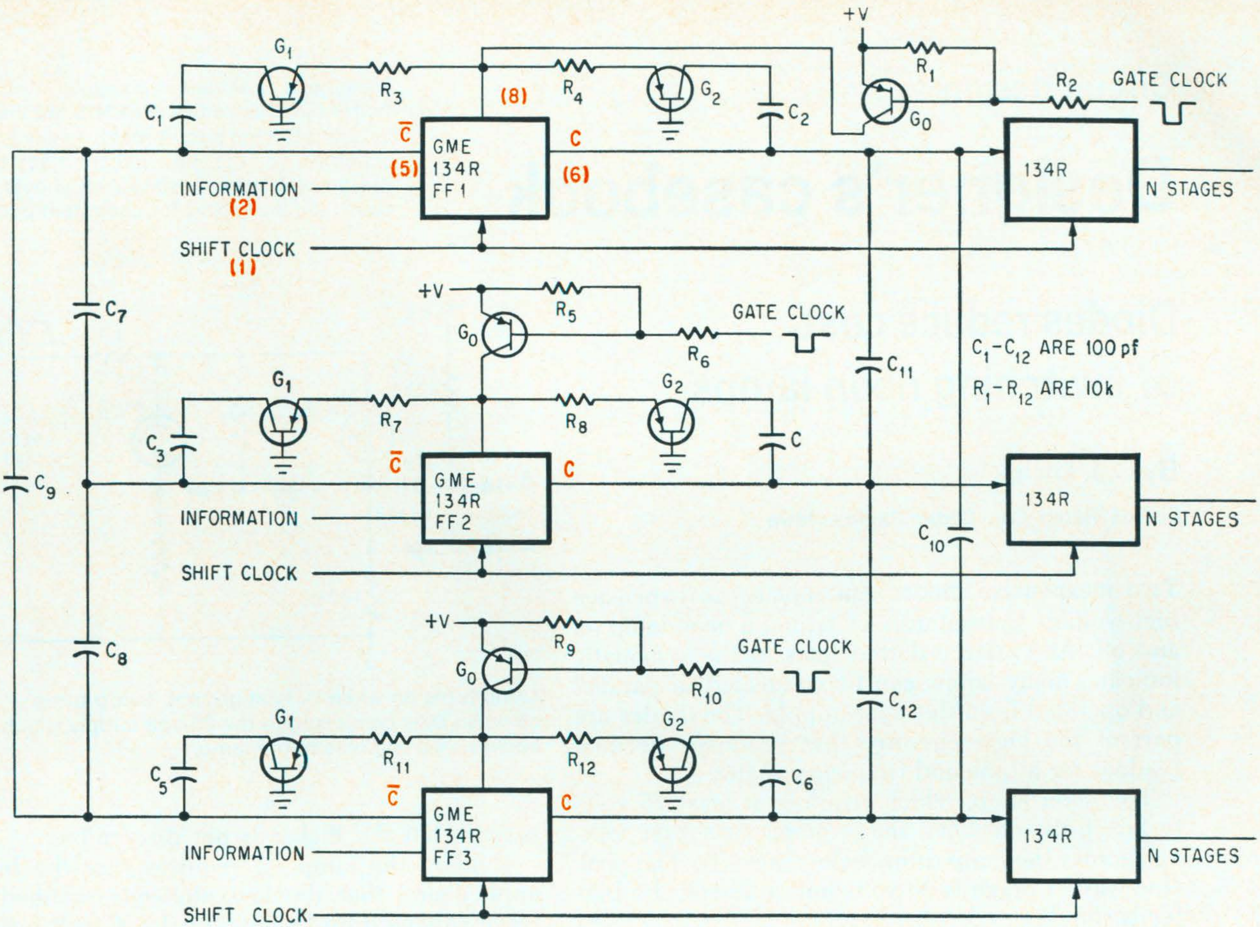
The advantage of this error correction technique is quite clear: the correction takes place within each stage prior to a shift so that errors are not propagated through the shift register.

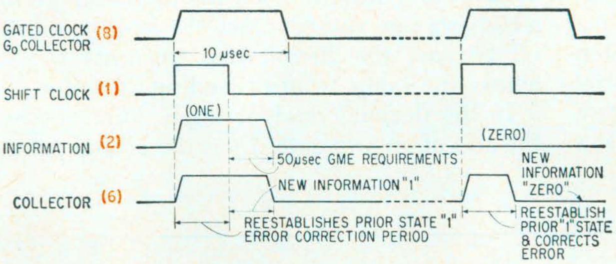
At the nth stage of the register, correct outputs will appear for each of the three elements and a simple capacitor OR network may replace the usual





Deliberate error, introduced in register by interchanging set and reset leads of flip-flop 3, is corrected automatically by majority charge redistribution through coupling capacitors C_7 through C_{12}.





Triply-redundant shift register of n stages, incorporating power-saving pulsed power mode and error correction, operates reliably despite power supply variations and large changes in repetition rate.

majority gate. If further redundant processing is desired, no OR network is necessary.

No chance for noise

Practical tests on small systems using the redundant error correction design indicate that operation is reliable even under adverse conditions—including worst-case component values, ±30% variations in power supply voltage and clock timing variations. The noise immunity of the pulse-powered mode of operation is inherently high because noise is only effective during the clock period. In addition, since the commercial integrated circuits have relatively low impedances and must be driven rather hard, errors induced by system noise are not likely to compete successfully with the proper input signal. Coupled with these advantages, the error correction features of the system reduce the probability of error to an extremely low level.

For applications at very low repetition rates, the need for large capacitors can be avoided by employing an idling clock that operates at a multiple of the main clock frequency. The reduction in power to micropower levels balances any disadvantage resulting from operating above the basic low repetition rate.

For very severe environments, like radiation, where sufficient margins cannot be conveniently obtained by a choice of capacitor values and maximum leakage specifications, an adaptive mode of operation can be used with little additional complexity. In such cases, the idling clock period can be controlled by sensing the leakage of a typical gate transistor in the circuit. Any degradation in leakage that might influence the reliability of the restoring capacitors can be offset by an increase in clock rate by means of a feedback circuit.

Reference

1. R.H. Baker et al, "Pulse powered circuits", Technical Report TR 65-1, Center for Space Research, MIT.

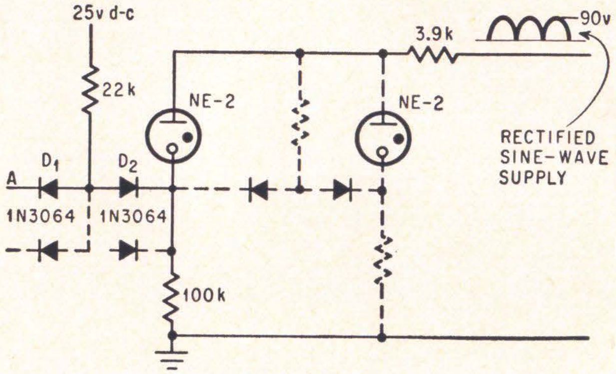
Circuit design

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.

Diodes reduce cost of switching neon lamps

By C.J. Ulrick
Collins Radio Co., Cedar Rapids, Iowa



Lamp turns on when D_1 is at ground. Lamp turns off when D_1 is connected to the 25-volt supply which applies a 20-volt bias to the lamp.

Two inexpensive diodes can replace an expensive high-voltage transistor in switching a neon lamp on and off. And, as the dotted lines in the schematic indicate, many lamps can be connected in parallel and operated from the same supply. The diodes are part of the logic circuitry that produces decimal readout for a time and frequency meter.

The neon lamp, which requires at least 75 volts to fire, turns off when the rectified sine-wave voltage across the lamp drops below 50 volts. The peak sine-wave voltage is 90 volts and a 25-volt d-c bias feeds the diodes.

To hold the lamp off, point A is directly connected to the 25-volt supply which establishes a 20-volt bias on the lamp's lower electrode. When point A is switched to ground, by some external control action, the lamp turns on. While lighted, the lamp actually turns on and off 120 times a second, but the flicker is not discernible.

Holding the lamp off requires that the bias be applied and that the instantaneous rectified sine-wave voltage drop below 50 volts. Cutoff occurs in 1/120th of a second when the high-voltage input is a 60-hertz line votage. Once the lamp is off, it stays off because the 20-volt bias prevents the voltage across the lamp from exceeding 70 volts.

In the decimal readout application, diode D_1 is the arm of an AND gate, D_2 is the arm of an OR gate.

Fast pulse generator is temperature stable

By Louis St. Marie
Consultant
Glendale, Ariz.

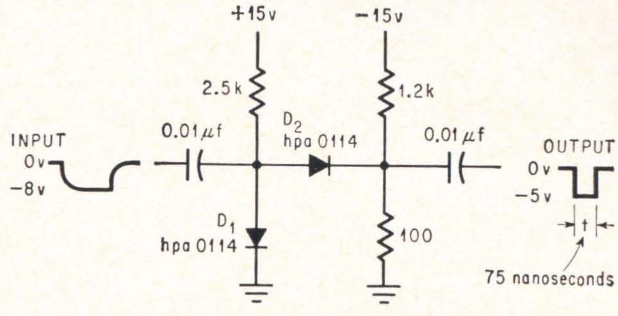
Nanosecond rise time pulses which maintain constant width over the temperature range of —55° to +80° Centigrade are formed by a step recovery diode circuit. Most pulse circuits incorporating step recovery diodes are considerably affected by extreme temperature ranges because the storage times (which determine the diode's switching characteristics) vary by 60% to 70%. In this circuit the pulse width is fixed by the difference in storage times of two diodes, which varies very little; therefore the circuit remains stable with temperature while retaining the speed advantage of step recovery diodes.

Such diodes have been optimized for a finite controlled storage of charge and a very abrupt transition to cutoff from reverse conduction of stored charges during junction depletion. Thus, during the cutoff process, the conductivity as a function of time closely approximates a step function. The diode's storage time (the time interval between application of reversing current and production of the corresponding step) may be varied from 1 to 1000 nanoseconds by changing the forward bias current.

In the circuit, diodes D_1 and D_2 (both identical step recovery diodes) are forward biased with D_2

biased slightly more. Since D_1 is more lightly biased than D_2, it cuts off first, and the output drops to -5 volts. However, D_2 continues to conduct for 75 nanoseconds due to its slightly longer storage time created by the greater bias current. When D_2 cuts off 75 nanoseconds later, the output jumps up to zero volts and the square pulse is completed.

Since both diodes start to turn off at the same time, the width of the output pulse represents the additional time which D_2 conducts after D_1 has cut off. As temperature affects the storage times of both diodes equally, the difference in storage times (and hence the pulse width) remains virtually constant over extreme changes in temperature.



An input pulse reverse biases diode D_1, producing a negative step; diode D_2 continues to conduct for the duration of the pulse and then cuts off.

Stable amplitude regulator for wide temperature range

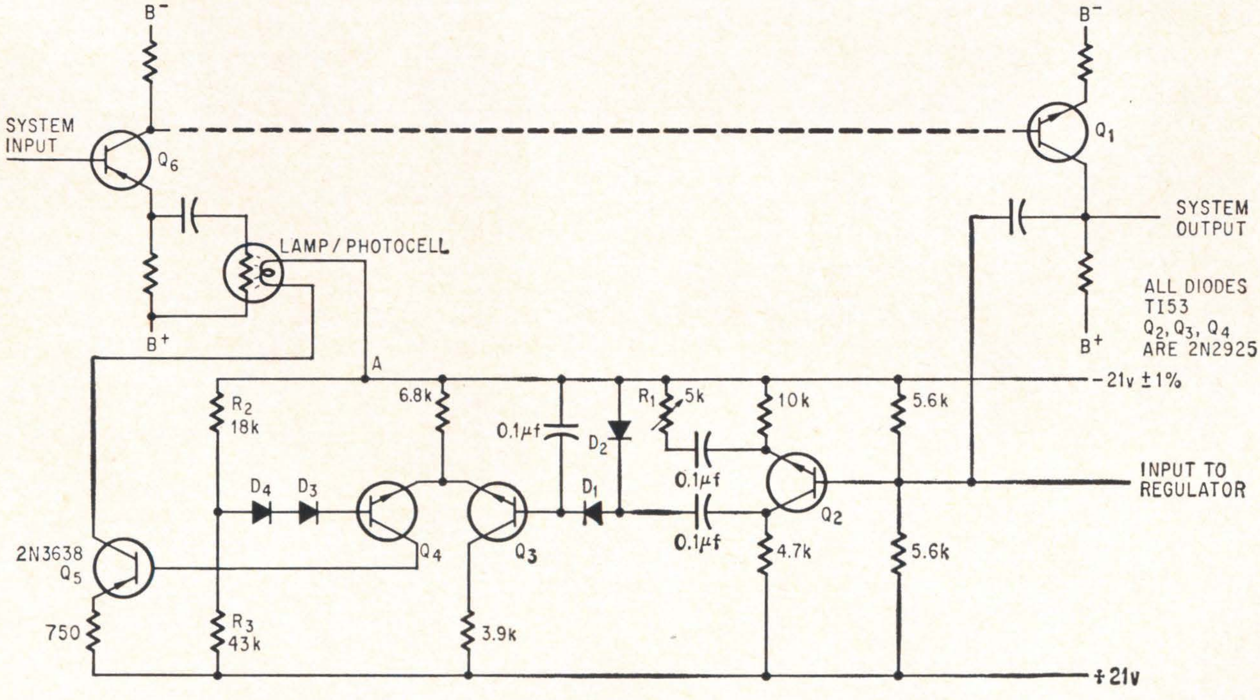
By Anthony E. Lofting

Lynch Communication Systems Inc.
San Francisco

Temperature instability afflicts most circuits available for regulating a-c voltages in telecommunications equipment. The problem is severe when the "stiffness" or ratio of input signal change to output signal change is great—for example 100 to 1.

However, the circuit illustrated will restore to an amplitude level change of only ±0.1 decibel an input signal that is fluctuating by ±10 db. Regulation is maintained over a temperature range of $-10°$ to 60°C, although the circuit is built of unselected semiconductor devices and requires tolerances of only 5% for the resistors and 1% for the power supply.

This circuit amplifies before rectification. In the schematic, Q_1 represents the output stage of the amplifier being regulated and Q_6 is its input. The a-c amplifier, transistor Q_2, is easily controlled. With the two diodes, D_1 and D_2, arranged as a voltage doubler, the signal is next converted to



Low level signals at Q_1, the last stage of an a-c amplifier, are compared with a reference voltage.

d-c. The derived voltage is compared with a reference voltage that is sensed by resistors R_2 and R_3; voltage comparator, Q_3 and Q_4, is a conventional amplifier configuration well known for its temperature stability.

To compensate for the temperature effects of the rectifier diodes, two more diodes—D_3 and D_4 —are placed in series with the reference voltage lead from point A to the base of Q_6. When Q_3 and Q_4 are operating properly, they draw like amounts of current, making the base currents of Q_3 and Q_4 and the diode currents similar.

Transistor Q_5 drives a lamp, whose intensity varies the resistance of a photocell or thermistor. When current through the collector of Q_5 varies, the intensity of the lamp changes and hence the resistance of the photocell. The change in resistance controls the gain of the amplifier being regulated, and the output level of the regulator can be adjusted by potentiometer R_1.

Converter cuts start-up power, offers good regulation

By Robert M. Glorioso

University of Connecticut, Storrs

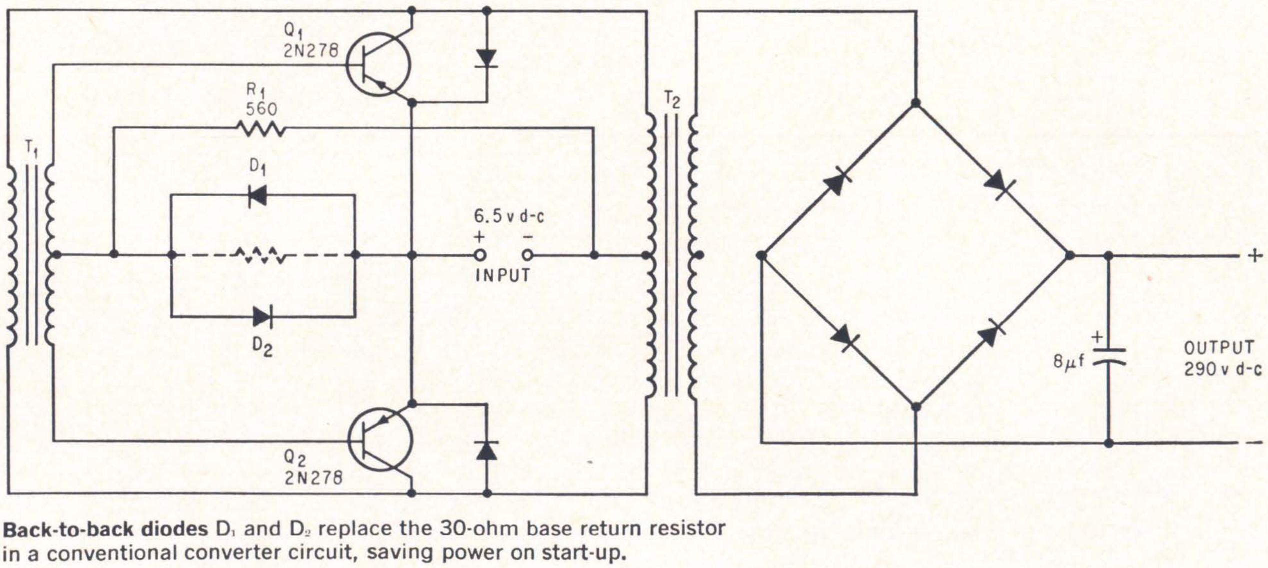
Two diodes and a feedback network added to a conventional d-c to d-c converter reduce start-up power consumption and improve voltage regulation.

The first modification replaces the small resistor (in this case, 30 ohms) in the base return path of the converter circuit shown below with back-to-back diodes D_1 and D_2. Formerly, the resistor, kept small to assure an adequate base current during converter operation, was a source of excessive power consumption on start-up because of the large currents needed to develop a starting voltage for the switching transistors, Q_1 and Q_2.

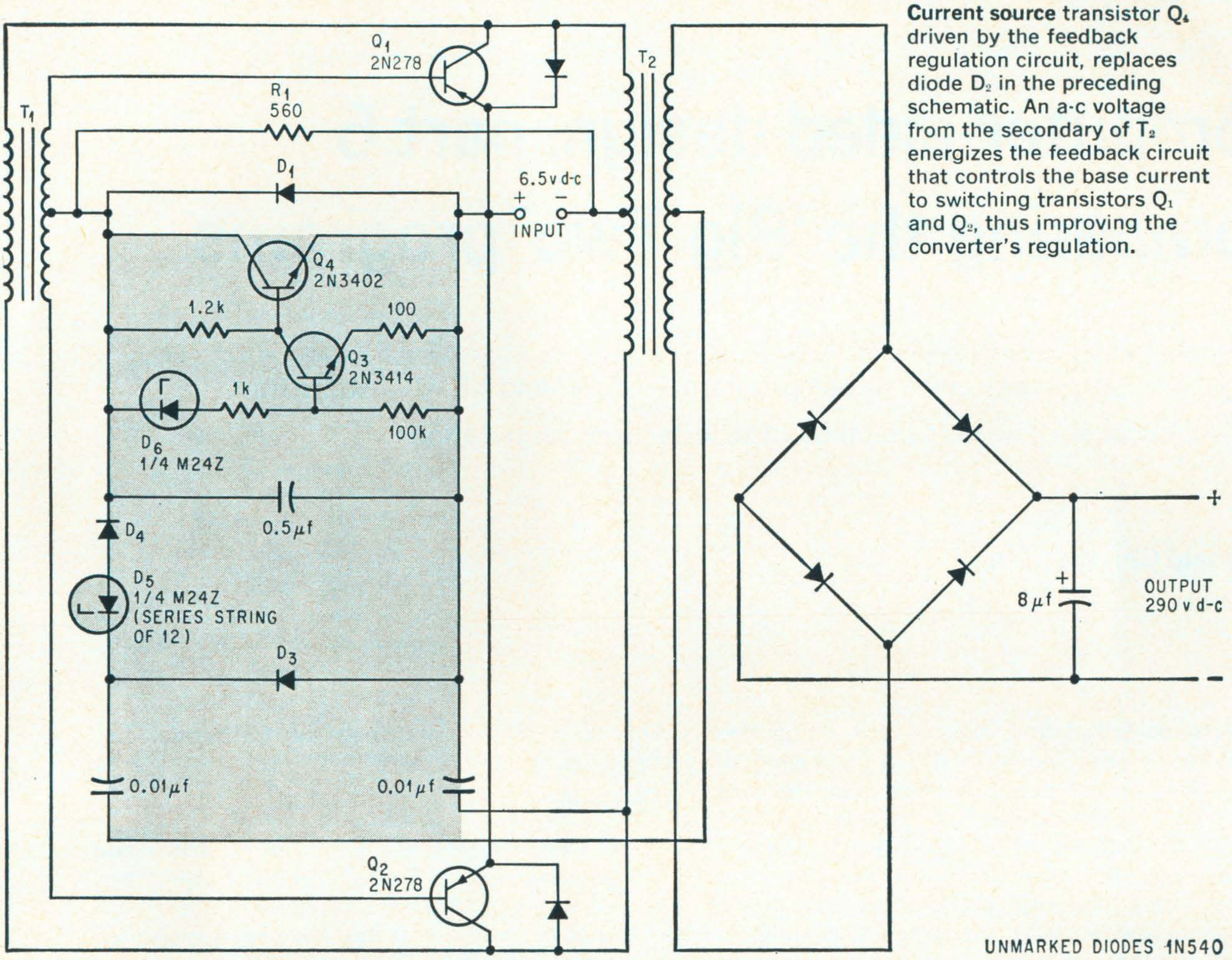
The second modification improves the converter's voltage regulation by controlling the base current of switching transistors Q_1 and Q_2 with a feedback circuit. Feedback substantially improves the regulation of the converter's output voltage in applications where the input supply is poorly regulated. For example, if a standard 6.5 to 290-volt converter is powered by a 6-volt automotive electrical system, then the supply voltage may vary from 5.8 to 7.2 volts; thus, the converter's output voltage may vary from 259 to 321 volts, since the voltage regulation of the unmodified converter can be no better than that of its supply. Such poor regulation would make the converter unsatisfactory as a source of B+ voltage for portable communication or test equipment.

To start the converter, silicon diode D_1 is forward biased by the input voltage. With D_1 conducting, a 0.7-volt potential is placed across the base-emitter junctions of Q_1 and Q_2 via the secondary winding of T_1. Since Q_1 and Q_2 are germanium transistors that require only 0.4 volt to forward bias their base-emitter diodes, when one of them turns on, the converter's oscillations begin.

During the first half cycle, one transistor conducts through the primaries of switching trans-



Back-to-back diodes D_1 and D_2 replace the 30-ohm base return resistor in a conventional converter circuit, saving power on start-up.



Current source transistor Q_4 driven by the feedback regulation circuit, replaces diode D_2 in the preceding schematic. An a-c voltage from the secondary of T_2 energizes the feedback circuit that controls the base current to switching transistors Q_1 and Q_2, thus improving the converter's regulation.

former T_1 and step-up transformer T_2 until the core of T_1 saturates. At saturation, the current decreases, generating a voltage in T_1 that turns on the other transistor; this transistor conducts in the opposite direction and generates the second half cycle of voltage. Both half cycles are stepped up by transformer T_2 and rectified by the bridge to produce the desired d-c output of 290 volts.

Once the converter is oscillating, the center tap in the secondary of transformer T_1 becomes positive, back biasing D_1 and forward biasing D_2. Diode D_2 then provides a low resistance base return path to assure an adequate base current during operation of the converter. Although R_1, the start-up bias resistor, continues to conduct, its power consumption is less than 20% of power absorbed by the usual 100-ohm bias resistor.

The d-c to d-c converter shown above incorporates a voltage regulation feedback circuit. The circuit regulates the converter's output voltage by replacing diode D_2 in the preceding schematic with current source transistor Q_4. A feedback voltage derived from the secondary of power transformer T_2 controls the base current of the switching transistors via Q_3 and current source Q_4.

The feedback voltage is derived from the a-c voltage at the center-tap of T_2's secondary by rectifying the voltage with diodes D_3 and D_4 and then dropping the high voltage across zener diodes D_5 and D_6, reducing it to a value appropriate to drive transistor Q_3. Start-up diode D_1 protects Q_4 from the effects of ringing during switching.

Feedback regulates the output voltage as follows: Any change in either input or load that increases the output voltage will increase the base current in Q_3. In turn, the current flow through Q_4 and the switching transistors decreases, causing the output voltage to drop. Similarly, any change in the circuit that decreases the output voltage decreases the base current in Q_3. Thus, the current through Q_4 and the switching transistors increases, causing the output voltage to rise.

The circuit was designed for an input of 6.5 volts ±0.5 volt and a switching frequency of 1.2 kilohertz.

Test circuit performance data

Input		Output		
Voltage	Current	Voltage	Current	Efficiency
6 v	5.5 amp.	290 v	98 ma	86%
7 v	5.8 amp.	292 v	98.5 ma	70.7%

Computer-aided design: part 6
Comparing the 'Big Two' programs

Two general-purpose circuit analysis programs—ECAP and NET-1—share the spotlight because of broad capabilities and widespread application

By Donald Christiansen
Senior editor

Designers contemplating the use of computers want to know: How much faster is a good general-purpose program for circuit analysis than the man armed with a soldering iron?

Allan F. Malmberg, who helped develop such a program, says that an experienced computer user can start with a schematic, number its nodes, punch the input cards and have the program running in the time it takes an engineer to solder the parts together and begin to measure circuit response. In general, Malmberg claims, the man who uses the computer will get more valuable information from the calculated response than will a competent engineer from an operating circuit. [Malmberg describes one of the two major CAD programs in an article which starts on page 76.]

Many designers already sold on CAD will develop their own computer programs to solve circuit problems. Often it seems faster and simpler to design from scratch than to adapt an existing program. Yet in the long run there are disadvantages to the do-it-yourself approach. For one thing the homegrown program is likely to be poorly documented. Even the man who developed the program may have to redevelop it unless he uses it regularly. The specially designed program is also limited in scope; how it can be modified to broaden its application is not always clearly defined.

Chiefly as a result of the limitations of the smaller, special-purpose programs, computer manufacturers and users developed the large, general-purpose programs. Two of the best known are the electronic circuit analysis program, ECAP, circulated by the International Business Machines Corp. and the network analysis program, NET-1, developed under the auspices of the United States Atomic Energy Commission at the Los Alamos Scientific Laboratory of the University of California, Los Alamos, N.M.

Availability

ECAP stemmed from the joint efforts of IBM and the Norden division of United Aircraft Corp; it was released in June, 1965 as a program for use with the IBM 1620 computer. It has since been expanded to the IBM 7090, 7040, 7044 and 7094 and System 360 computers. Written in machine language, NET-1 was developed for the Maniac II computer. Since its completion in October, 1962, it has been translated into versions for the IBM 7040, 7044, 7090 and 7094. It is in use at over 90 installations in the U.S., Canada, England, Germany and Sweden.

The guiding principles in developing powerful general-purpose programs are simplicity and applicability to a broad range of circuit problems. For example, an ideal program would be usable by an engineer who has no comprehensive background in mathematical analysis methods or computer programing. Furthermore, the program should handle d-c, a-c and transient analysis and be able to solve nonlinear problems as well. The simplicity requirement is critical if the program is to become accessible to the average electrical engineer and not be restricted to the expert in circuit analysis. With NET-1, notes Malmberg, the user need not know even the basic rudiments of computer programing; he doesn't have to know how to solve systems of simultaneous nonlinear differential equations or whether the circuit equations are stable.

The engineer, Malmberg says, may have a circuit schematic that he doesn't even begin to comprehend and still NET-1 will perform a correct analysis. The results of the analysis may help the engineer understand the circuit; NET-1 may even respond with informative remarks along the way.

Restrictions

While in principle both NET-1 and ECAP can simulate any circuit containing lumped parameter circuit elements, in practice there are two important restrictions. First, the circuit under study can contain only circuit elements for which the two programs in their present forms can provide models. Second, the circuit cannot be so large that it exceeds the available memory capacity of the computer.

Both ECAP and NET-1 can simulate fixed resistors, capacitors, inductors and mutual inductive couplings, as well as fixed voltage sources. In addition, ECAP can simulate fixed current sources, dependent currents and time-varying current and voltage sources, while NET-1 can handle five classes of time-dependent sources.

The major difference between the two programs lies in the way that active devices are modeled and in the accuracy of analysis. With NET-1, each transistor is described by 36 parameters; each diode, by 13. The NET-1 program calls for a transistor or diode by number; thus a library of stored device parameters is needed, otherwise the necessary parameters for a new device must be determined and fed to the program. ECAP, on the other hand, permits the use of any device model that can be devised from the elements in the program. Thus, if it will provide the required accuracy, a very simple model can be used.

ECAP in its present form cannot perform nonlinear d-c analysis, and NET-1 falls short in its ability to handle a-c analysis. NET-1 also permits writing a transient solution on a reel of magnetic tape. The tape can be used as the input to other programs which can plot or print the transient solution in a variety of forms. Normally, ECAP outputs—such as print, punch or plot—are built directly into the program. However, Herbert Wall, author of the article on ECAP beginning on page 82, reports it is feasible to expand ECAP so it would possess similar capabilities.

One virtue of general-purpose programs like ECAP and NET-1 is the ability to make studies that are impractical or impossible in real-life circuits. With NET-1, for instance, it is possible to change junction capacitance, semiconductor bulk resistance or leakage currents in a transistor or diode and then evaluate the effect of the change on the circuit. One can even evaluate transistors and integrated circuits that have not yet been built, or optimize circuits involving components that are very costly or hard to obtain. Furthermore, studies of destructive transient phenomena can be made without damage to expensive devices. And, Malmberg points out, since there is no interaction of measuring instruments with the circuit a source of error encountered in breadboard testing is avoided.

Improvements

Shortcomings of both ECAP and NET-1 have been widely publicized [Electronics, Sept. 19, 1966, p. 120]. Besides the restrictions on the size of circuits that can be analyzed, there are limitations in handling nonlinear circuits and in achieving accurate device models, particularly with ECAP.

Advanced workers in CAD circumvent some of these problems by writing subroutines or by combining the best features of ECAP and NET-1. Norden uses ECAP for a-c analysis, NET-1 for transient analysis, and its own nonlinear extensions of ECAP for nonlinear work. The Raytheon Co.'s Wayland, Mass. Scientific Computer facility is using a Raytheon-developed program that combines ECAP and NET-1 in one package. [Lawrence Dersh describes this program, called Raycap, in the article beginning on page 89.]

Multiple choice: ECAP, NET-1 or both

The fraternity of CAD proponents is close knit. Programs are swapped and secrets are shared—sometimes informally. The result is a reluctance to knock the next fellow's program. Yet the pride of Allan Malmberg and that of Herb Wall, authors of the articles on NET-1 and ECAP, respectively, is evident. Malmberg points out that in just a few months the number of users of NET-1 has jumped from 60 to 90. Wall claims "greatest versatility and widespread use" for ECAP. Almost casually, Malmberg mentions that ECAP is weak in nonlinear capabilities while Wall counters with a comment on NET's inability to handle a-c analysis.

Notwithstanding, both men are strong proponents of CAD. Wall was a cofounder of Cadar (committee for computer aided design and analysis realization) which recently was given a two-year trial term by the IEEE under its Technical and Scientific Activities Committee. A systems engineer at IBM's Waltham, Mass. operation, Wall spent several years as a project leader in developing ECAP on the IBM 1620. Malmberg, a CAD expert at the Los Alamos Scientific Laboratory, Los Alamos, N.M., is currently involved in refining the NET program. The result will be a second-generation program, NET-2.

NET-2 will perform variational studies. One, the Monte Carlo technique, is well known to circuit analysts. It determines the distribution in a circuit response which results from known component and parameter variations. NET-2 will also provide an "extrema search" in which particular circuit responses or characteristics will be minimized or maximized by varying component and parameter values over a specified range. NET-2 will also perform a-c steady state calculations and provide an ideal switch for use in transient analysis.

Larry Dersh, author of the article on Raytheon's program, chose the best of both ECAP and NET-1 to develop Raycap. Dersh, now developing design automation techniques for circuits and systems at Raytheon's Wayland, Mass. laboratory, was previously a computer systems specialist with ITT's Data and Information Systems division.

Circuit design II

NET-1 gets an 'A' for accuracy

Program demands complex device models but provides speed plus accuracy and is able to perform nonlinear analysis

By Allan F. Malmberg

Los Alamos Scientific Laboratory, Los Alamos, N.M.

Though he may know next to nothing about computer programing and less about advanced circuit analysis, the circuit designer can use the NET-1 network analysis program to evaluate electronic circuits and gain insight into their operation.

NET-1 has already been applied to problems ranging from device studies through circuit and system analyses. It has been used in the design, evaluation and reliability analysis of pulse circuits, regulated power supplies, logarithmic amplifiers and megampere switching circuits. The program has also been used to study noise problems in magnetic core memories, to design particle accelerators and to study the effects of radiation on circuitry.

NET-1 calculates the voltages and currents at every point in the circuit as functions of time. It can advise the user of the switching times of transistors and diodes. It checks for violation of maximum ratings on transistors and diodes, and calculates power supply current drains and total circuit dissipation. It also tries combinations of power-supply failures and advises the user of the stresses the circuit would see in such situations.

Describing the circuit

An electronic circuit is uniquely defined by specifying the kinds of circuit elements, their values and the way they are interconnected. This specification is nothing more than the complete wiring diagram of the circuit. With this information, NET-1 produces the d-c steady state and transient response of all voltages and currents in the circuit. The circuit response is printed as a series of tabular listings and can be displayed graphically using auxiliary programs.

A circuit is described to NET-1 in three simple steps:

- All circuit elements on a schematic diagram are given identification labels such as R4, T3, D13, L6 and V7.
- The nodes are numbered sequentially, starting with 0 for the ground node. Voltage sources referred to ground do not receive node numbers since they already are named by the voltage source —for example, V7.
- The circuit description list is then written, using a standard format for each element. This format includes the element identification, its connection points, and its value.

Additional information may be added to the circuit description list for control of the calculation. The list is then punched on cards; the card deck is the input to the NET-1 program.

If the circuit contains no transistors or diodes, any self-consistent set of electrical units can be used. However, because NET-1 assumes certain units internally when transistors and diodes are present, this set of units is recommended: nanoseconds, volts, milliamperes, milliwatts, kilohms, picofarads, and microhenrys.

Specifying the elements

Passive circuit elements such as resistors, capacitors and inductors are written in the circuit description list as follows:

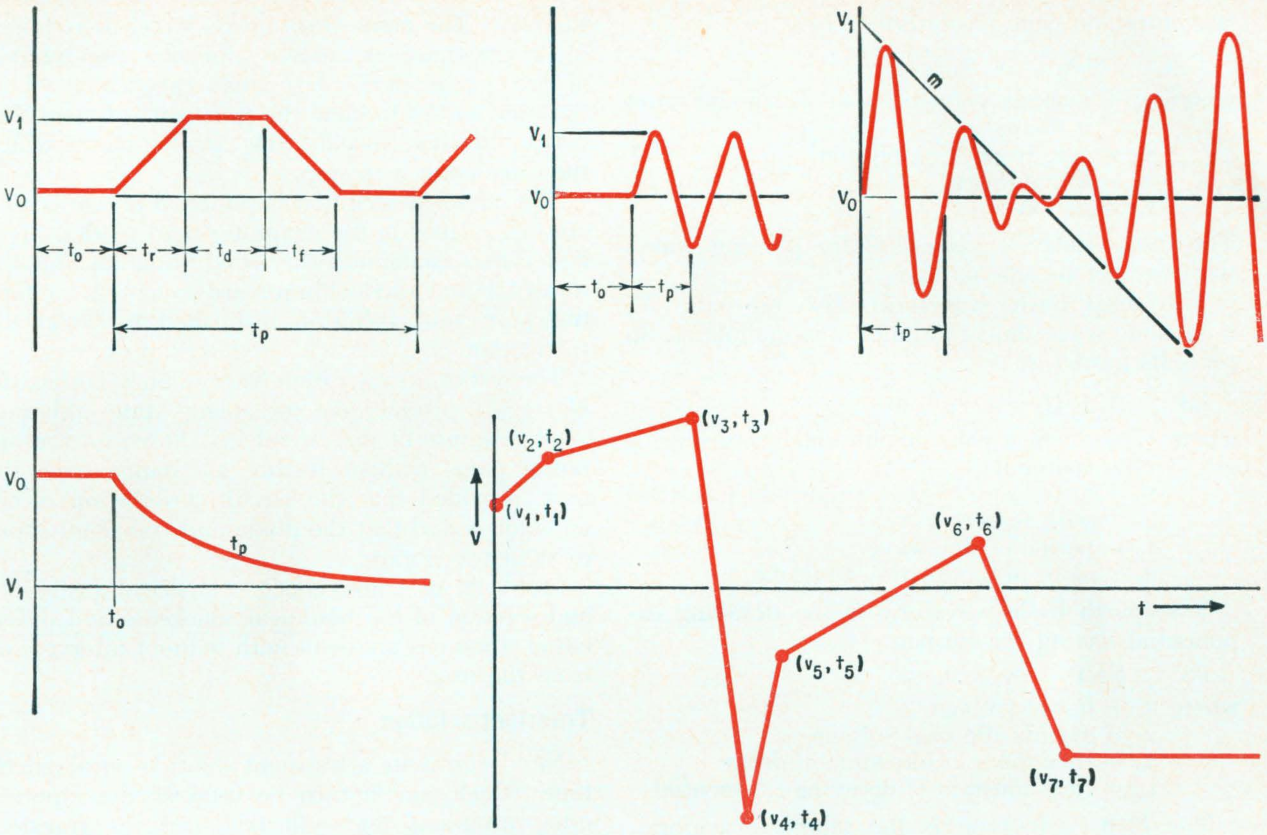
R6	7	V3	47
C2	8	0	100
L3	1	5	25

The first item in each line is the element identification, the second and third are the two connection points and the fourth is the value.

For transistors and diodes, one must specify the connection points in a particular order, since these devices don't have interchangeable terminals. For the diode, the anode is specified first, while the order of specification for the transistor is emitter, base and collector. Instead of giving a value for the transistor and diode, the device type number is specified. The formats for these devices are:

D5	7	V13		1N914
T3	0	3	6	2N1308

Transistor and diode models are quite complex. The diode model is controlled by 13 parameter values for each diode in the circuit, while the transistor model requires 36 parameters for each transistor. These parameter values are stored in a magnetic tape library arranged by device type number. Thus the specification of the type number for a particular device causes NET-1 to automatically



The NET-1 program can handle any of five classes of time-dependent voltage sources, as follows: a trapezoidal pulse, a sine wave, a sine wave that is linearly amplitude modulated, a decaying exponential wave, and a tabular waveform. The parameters that are called out are those needed to specify each pulse. In fourth waveform, m is the slope of the modulation envelope; in last waveform, t_p is the time constant.

enter the proper parameter values for that device and its equivalent circuit into the calculation.

Voltage sources may be either fixed or time-dependent. For fixed voltage sources, the identification and value of the source are given:

V3 +20

There are five classes of time-dependent voltage sources. The format includes the identification (of the form P1), the class of waveforms and voltage and time parameters that describe the waveform dimensions.

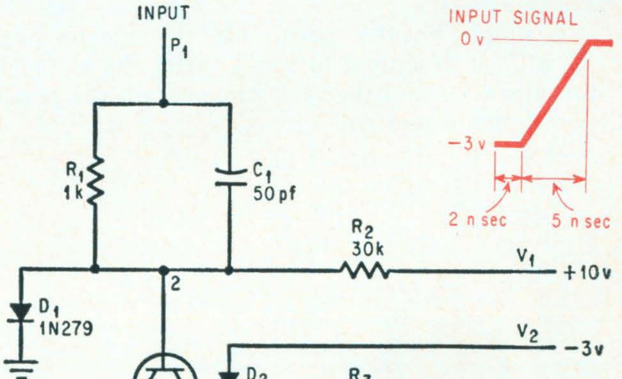
A basic waveform is a trapezoidal pulse, shown above. Each source of this class is described by the source identification, the word PULSE, and from two to seven numerical values that define the amplitude and time parameters of the particular pulse:

P3 PULSE v_o v_1 t_o t_r t_d t_f t_p

where v_o = the initial value of the pulse
v_1 = the peak value of the pulse
t_o = the time before initiation of the pulse
t_r = the rise time from the initial to the peak value
t_d = the duration of the pulse's peak value
t_f = the fall time from peak to initial value
t_p = the time between successive repetitions of the pulse

By allowing certain of these values to become zero, it is possible to produce triangles, sawtooths, square waves, and other variations of the basic waveform. Furthermore, only the first two parameters need be specified—the description may be terminated anywhere after the initial and peak voltages have been specified. All omitted rise or fall times are automatically set equal to zero; omitted durations and periods are set equal to infinity.

The second basic waveform is the sinusoidal



Inverter circuit serves as an example for d-c and transient analysis by NET-1.

waveform, on page 77, described by:

P21 SIN v_o v_1 t_o t_p

where v_o = average voltage about which sine wave is oscillating
v_1 = zero to peak amplitude
t_o = initial delay
t_p = period

The initial delay, t_0, is useful for phasing waves with respect to one another.

The third basic waveform, also on page 77, is a sine wave linearly amplitude-modulated in time. Its format is:

P3 AMSIN v_o v_1 t_p m

where v_o = average value about which waveform is centered
v_1 = initial zero to peak amplitude, measured with respect to v_o
t_p = period of sine wave
m = slope of modulation envelope

The fourth basic waveform is the decaying exponential having the format:

P3 EXP v_o v_1 t_o t_p

where v_o = initial voltage
v_1 = asymptotic final voltage
t_o = time delay before start of decay
t_p = time constant of decaying exponential

The fifth basic type is the tabular waveform. This waveform is completely arbitrary in shape and consists of pairs of time and voltage coordinates connected by straight line segments for purposes of interpolation during computation. The waveform is nonrepetitive.

A circuit can include any combination of these basic waveforms. They may appear in series with other circuit elements or they may be referred to ground. In any given circuit there can be as many as 63 different time-dependent voltage sources with unique waveshapes. A given source may be introduced in several different isolated portions of the same circuits.

An example

A simple inverter circuit like the one on page 77 will be described to NET-1. After the elements are identified and the nodes numbered, the circuit description is written:

```
*INVERTER CIRCUIT
R1    P1    2    1.
R2     2   V1    30.
R3    V3    3    1.
R4     3    1    .1
C1     2   P1    50.
D1     2    0    1N914
D2    V2    3    1N914
T1     0    2    3    2N964
V1   +10
V2    -3
P1    PULSE     -3    0    2    5
RESOLUTION     2
INTERRUPT     12
END
```

The list contains two standard entries: the title at the beginning to identify the circuit and END at the close. The RESOLUTION entry, which is required for every transient analysis, specifies the interval of circuit time, in this case 2 nanoseconds, at which the user wishes to view the transient solution. The INTERRUPT entry specifies the circuit time at which the calculation is to stop.

The circuit description is punched on cards that are then placed in the computer card reader. Magnetic tapes containing the NET-1 program and the transistor and diode library are mounted on tape transports and a button is pushed to begin the calculation.

The rest of the operation is completely automatic. NET-1 will produce the d-c steady state and transient response of the circuit, as shown on the opposite page, without further assistance from the user, provided that the circuit description is not ambiguous and that the diode and transistor types exist in the library.

Problems of convergence, numerical instability and solution of the nonlinear algebraic and differential equations are dealt with without intervention from the user.

Transient solution

NET-1 can write a transient solution on magnetic tape, which can in turn be used as the input to other programs that will read out the transient solution. One such program is the Solution Output Plotter (SOP) used at Los Alamos Laboratory on the Maniac II computer.

SOP will print and plot not only the voltages and currents in the circuit, but all algebraic functions of these variables and of time. In addition, it can perform integrations of one function with respect to another and can calculate nth differences and their functions.

An example of instructions to the SOP program is:

Print VN32, inductor currents, P3 and diode currents every 10
Plot P16 and VN12
Plot F5 versus P3
F5 = (VN12 − VN34)/IET3

In this example, SOP will print the voltage at node 32, all inductor currents, the value of voltage source P3 and all diode currents every 10 nanoseconds. Then a plot of P16 and the voltage at node 12 versus time will be displayed simultaneously. Finally, a plot of function F5 versus the value of voltage source P3 will be displayed, where F5 is defined as the difference between the voltages at nodes 12 and 34 divided by the emitter current in transistor T3. SOP automatically scales and labels the displays, which are available either on an on-line cathode-ray tube or on microfilm from the Stromberg-Carlson 4020 plotter.

Steady state series

Often it is desirable to vary the value of the voltage sources in a steady-state calculation and thus generate a series of steady-state solutions, one for each set of voltage sources. NET-1 has this capa-

STEADY STATE SOLUTION

```
NODE   VOLTAGES
                   1              2              3
       -1.2044-01  -4.6224-01  -1.2044-01

SOURCE              VALUE          CURRENT
   V  1          1.0000+01       3.4874-01
   V  2         -3.0000+00      -2.9227-06
   V  3         -2.0000+01      -1.9880+01
   P  1         -3.0000+00      -2.5378+00
TOTAL POWER DISSIPATED= 4.08692+02
TRANSISTOR    MODE                  IE              IB              IC
   1          SATURATED          2.20686+01    -2.18902+00    -1.98796+01
DIODE         CONDUCTION            I
   1          OFF               -2.23201-06
   2          OFF               -2.92273-06
```

TRANSIENT SOLUTION

```
V1        1.0000+01
V2       -3.0000+00
V3       -2.0000+01

TIME  0.00000+00      CYCLE 0

           P1
       -3.0000+00

                        1           2           3
                 -1.2044-01  -4.6224-01  -1.2044-01

           IE          IB          IC
T1      2.2069+01  -2.1890+00  -1.9880+01
D1     -2.2320-06
D2     -2.9227-06


TIME  2.00000+00      CYCLE   10

           P1
       -3.0000+00

                        1           2           3
                 -1.2044-01  -4.6224-01  -1.2044-01

           IE          IB          IC
T1      2.2069+01  -2.1890+00  -1.9880+01
D1     -2.2320-06
D2     -2.9227-06


D1    SWITCHED FROM        OFF          TO          ON

TIME  4.00000+00      CYCLE   20

           P1
       -1.8000+00

                        1           2           3
                 -8.1836-02   8.0708-02  -8.1836-02

           IE          IB          IC
T1     -2.3571+00   2.2300+01  -1.9943+01
D1      8.7792-02
D2     -2.4470-02


T1    SWITCHED FROM     SATURATED     TO        ACTIVE

T1    SWITCHED FROM      ACTIVE       TO         OFF

TIME  6.00000+00      CYCLE   30

           P1
       -6.0000-01

                        1           2           3
                 -8.4160-01   3.3296-01  -8.4160-01

           IE          IB          IC
T1     -8.1517-01   1.6369+01  -1.5554+01
D1      3.5849-01
D2      3.4939+00


D2    SWITCHED FROM        OFF          TO          ON

TIME  8.00000+00      CYCLE   40

           P1
        0.0000+00

                        1           2           3
                 -3.7207+00   5.3946-01  -3.7207+00

           IE          IB          IC
T1     -1.4922-02   1.0319-01  -8.8263-02
D1      1.9851-01
D2      1.5553+01


TIME  1.00000+01      CYCLE   50

           P1
        0.0000+00

                        1           2           3
                 -3.7579+00   5.3014-01  -3.7579+00

           IE          IB          IC
T1     -2.1860-02   7.4983-02  -5.3123-02
D1     -9.1665-02
D2      1.5955+01


TIME  1.20000+01      CYCLE   60

           P1
        0.0000+00

                        1           2           3
                 -3.7757+00   5.2297-01  -3.7757+00

           IE          IB          IC
T1     -1.8840-02   5.7148-02  -3.8308-02
D1     -6.2991-02
D2      1.6046+01


INTERRUPT ANALYSIS AT TIME = 1.20000+01  CYCLE   60

END OF CALCULATION
```

bility through the use of STATE solutions. In many classes of circuits, multiple steady-state analysis may be just as satisfactory as the more time-consuming transient analysis. Typical formats for STATE entries are:

```
STATE 1
  V7      8.9
STATE 2
  V3     -12
  P8      +6
```

Any source not mentioned in the STATE entry is treated in the corresponding analysis according to its original circuit description entry.

If one wants to explore the static contour of the hysteresis loop in a Schmitt trigger circuit, for example, STATE calculations can be used. In this case, the input voltage is increased from its minimum value to its maximum value, using small increments in voltage in the vicinity of the "flip" region. Then the input voltage is reduced to its minimum value in suitable increments. In this way, one side of the hysteresis loop is investigated while the input voltage is increasing, and the other side is studied as the input voltage decreases.

The transient analysis can be interrupted at a predetermined value of circuit time. This feature, along with the initial condition entry, allows ideal switches to be simulated in circuits that don't contain any transistors or diodes. Suppose a switch is to be closed at a circuit time of 100 microseconds. With the switch open, the circuit configuration is analyzed. At the specified interruption time of 100 microseconds, the values of all the capacitor voltages and inductor currents are printed. An initial

Modeling for the NET-1 program

A sophisticated user of NET-1 may have to forego use of library devices, substituting alternate values for some parameters. This may be necessary for worst case studies, radiation damage studies or for checking the sensitivity of a circuit to changes in certain device parameters. A knowledge of how the NET models are developed is useful in making the device modifications.

Transistor and diode models for the NET-1 program are composed of three parts: The equivalent circuit, a set of controlling equations which determine the values of the equivalent circuit elements, and a set of device parameters which represent the coefficients in the controlling equations. The controlling equations determine the nonlinear behavior of the device by assigning values to the nonlinear equivalent circuit element while the calculation is in progress. The device parameters are the only means by which the same model can represent different devices.

The equivalent circuit for the diode is shown on the opposite page. The forward current conduction as well as part of the reverse leakage current is represented by the equation

$$I = I_s\left(e^{\frac{qv}{MkT}} - 1\right)$$

where v is the function voltage, q is the electronic charge, k is the Boltzmann constant, and T is the absolute junction temperature. The quantity M is a constant which accounts for the departure from the ideal diode characteristic in the forward conduction region. I_s is the diode saturation current.

The junction capacitance is composed of two components: the transition capacitance C_t and the diffusion capacitance C_d:

$$C_t = \frac{R}{(V_z - v)^N}$$

$$C_d = \frac{q\,(I + I_s)}{2\pi\, MkTF}$$

The transition capacitance is a function of the junction voltage. R is a proportionality constant, N is a constant depending upon the impurity gradient in the device, and V_z is the junction contact potential. The diffusion capacitance is present only in forward-conducting diodes and accounts for storage effects. It is a function of the forward current I. The constant F is a proportionality constant which is closely associated with the cutoff frequency of the diode. R_b is the semiconductor bulk resistance and R_e is the ohmic junction leakage resistance. These values are constant during the calculation.

The diode model behavior is specified by 13 parameters, of which eight represent coefficients in the above equations, two represent the constant resistance values, and three represent device maximum ratings. The diode model exhibits normal cutoff and forward conduction behavior. Storage effects are included and it is both a small- and large-signal model. Avalanche breakdown of the junction and conductivity modulation of R_b are not included.

The equivalent circuit of the transistor, bottom, right, is a modification of the Ebers-Moll model. R_{ee}, R_{bb} and R_{cc} are the emitter bulk resistance, base spreading resistance, and collector bulk resistance, respectively. R_e and R_c are the emitter-base and collector-base ohmic leakage resistances, respectively. These five resistance values are constant during the calculation. The respective emitter-base and collector-base junction voltages are v_1 and v_2.

The two current generators, I_1 and I_2, are functions of two other quantities, I_{ef} and I_{cf}

$$I_1 = I_{ef} - \alpha_i I_{cf}$$
$$I_2 = I_{cf} - \alpha_n I_{ef}$$

$$I_{ef} = \frac{I_{es}}{1 - \alpha_n\,\alpha_i}\left(e^{qv_1/M_e kT} - 1\right)$$

$$I_{cf} = \frac{I_{cs}}{1 - \alpha_n\,\alpha_i}\left(e^{qv_2/M_c kT} - 1\right)$$

where α_n and α_i are the normal and inverted common base current gains. These current gains may be empirical functions of the junction voltages (and consequently empirical functions of the junction currents). In practice, beta normal and beta invert are actually specified and the α quantities are calculated from them. Each beta condition entry specifies the voltages and currents for the capacitors and inductors (identical to their values at interrupt time). NET-1, in calculating the response for the circuit with the switch closed, bypasses the d-c steady-state solution and uses the values specified by the initial condition entry as the initial conditions for the new transient analysis. Initial conditions cannot be specified for circuits containing diodes and transistors because there is no provision in NET-1 for specifying the initial voltages across the device junction capacitances other than by calculating the d-c steady-state solution.

In d-c coupled bistable circuits, it's possible, in the absence of noise, that the circuit can be in both of its states simultaneously. An example would be a flip-flop in which the two transistors are both conducting at the same time. NET-1 may therefore produce a steady-state solution with this valid but physically unrealistic condition. Consequently, NET-1 must be told which transistors in a d-c coupled bistable circuit are initially cut off. This is done by tagging the entry for such transistors with the word OFF, as in the example:

```
T1    9    13    67    2N501    OFF
```

Should NET-1 determine that a transistor cannot physically exist in the circuit in the cutoff mode, it will print a message to that effect. The OFF tag is utilized only in producing a steady-state solution; it is ignored during the transient solution.

The OFF tag applies to all STATE calculations unless it is superseded in a specific STATE entry. Also, other transistors not tagged in the original circuit

---

is represented by a third degree polynomial in junction voltage

$$\beta_n = a_0 + a_1 v_1 + a_2 v_1^2 + a_3 v_1^3$$
$$\beta_i = b_0 + b_1 v_2 + b_2 v_2^2 + b_3 v_2^3$$

The transistor model contains transition and diffusion capacitances for each junction

$$C_{te} = \frac{R_1}{(V_{ze} - v_1)^{N_e}}$$

$$C_{tc} = \frac{R_2}{(V_{zc} - v_2)^{N_c}}$$

$$C_{de} = \frac{q\left(I_{ef} + \dfrac{I_{cs}}{1 - \alpha_n \alpha_i}\right)}{2\pi M_e kTF_n}$$

$$C_{dc} = \frac{q\left(I_{cf} + \dfrac{I_{cs}}{1 - \alpha_n \alpha_i}\right)}{2\pi M_c kTF_i}$$

The transistor model behavior is specified by 36 parameters, of which 26 represent coefficients in the equations above, five represent the values of the constant resistances, and five represent device maximum ratings.

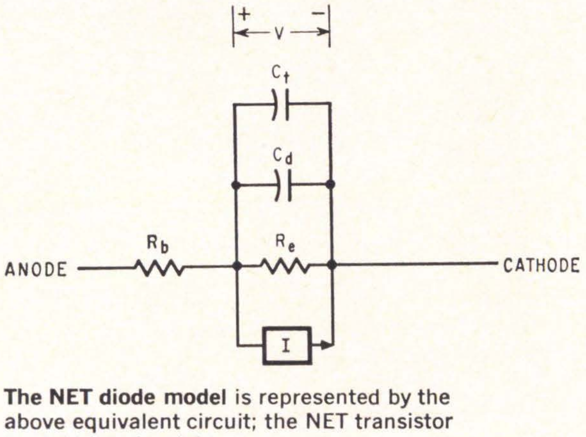
The transistor model is capable of both large and small signal operation in all four regions: cutoff, active normal, active inverted, and saturation. Storage effects and cutoff currents are included. Avalanche breakdown and the base narrowing effect on current gain and base spreading resistance are not included.

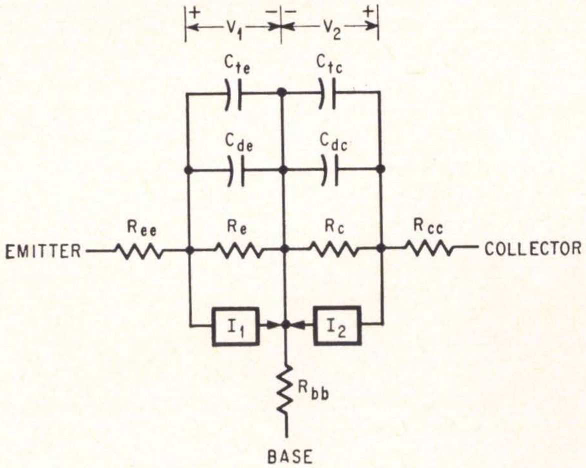
Normally the parameter values for a given device are obtained automatically from the transistor and diode library. In this case all devices of the same type have identical values for a particular parameter. The user has the option, however, of changing any parameter value for any specific component in his circuit, independently of other devices which may have the same type number. This is done by specifying a parameter substitution as part of the circuit description and is illustrated by this example:

```
PARAMETER
T12      T3
T7
T29
RBB          .02
     ICS           .0015
D7
     M             1.65
T3
     TEMP  40
```

This specifies that, for transistors, T12, T3, T7 and T29, the base spreading resistance, R_{bb}, is changed to .02 kilohms and the collector saturation current, I_{cs}, is changed to .0015 milliamperes. For the diode D7 the constant M is changed to 1.65. Finally, a junction temperature of 40 degrees centigrade is specified for transistor T3 (in addition to the other changes already requested).

Thus the user is able to change the model behavior drastically by allowing certain parameters to approach zero or infinity.





The NET diode model is represented by the above equivalent circuit; the NET transistor model is at the right.

description entry can be held OFF in a specific STATE entry.

```
STATE 1
     T1    NOT OFF
     T3    OFF
```

In those instances in the analysis of digital circuitry where several identical circuit segments appear connected at one or more common points —a circuit driving several identical loading circuits, for example—only one of the identical circuit segments need be given node numbers and entered as part of the circuit description. Each transistor, diode and passive element entry for that segment is then tagged with a number in parentheses to indicate how many parallel elements that particular element represents in the actual circuit, such as:

```
R12   3   4   27        (5)
```

For some applications, the user will require knowledge of the mathematical models NET-1 uses for the transistor and diode, as described in "Modeling for the NET-1 program," page 80.

NET-1 versus NET-2

Some features not possessed by NET-1 are being incorporated in a second-generation program, NET-2 The latter program, for example, will include models for many different kinds of devices; NET-1 is limited to only two, one for the transistor and one for the diode. NET-1's library lookup feature enables it to enter parameters into the calculation for any device that can be described by one of the models, but NET-2 goes a step further. Besides the parameter library, it has a library of models that can be entered into the calculation. Furthermore, this model library can be changed and added to at any time.

Bibliography

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B.O. Allen, D.R. Blazek and C.H. Purdue, "Computer-Aided Circuit Reliability Analysis," Proceedings of 11th National Symposium on Reliability and Quality Control, 1965, pp. 21-33.

Circuit design III

Flexibility is ECAP's forte

The IBM program features ease of modification and adaptability and has won wide acceptance among designers in a scant two years

By Herbert M. Wall

International Business Machines Corp., Waltham, Mass.

In the two years since it was introduced by the International Business Machines Corp., ECAP (electronic circuit analysis program) has become the most popular general-purpose program for CAD. Like NET-1, it is easy to use because it requires no great knowledge of computer programing. However, the most attractive feature of ECAP and the major reason for its broad acceptance is the facility with which it can be modified, making it a dynamic and continually practical tool for the designer. A variety of active device models can be used with ECAP, while parameter modifications can be made quickly and sensitivity and worst-case calculations are possible.

User language

The user of ECAP need only be familiar with its language to describe the circuit to be analyzed. The program will generate nodal equations automatically.

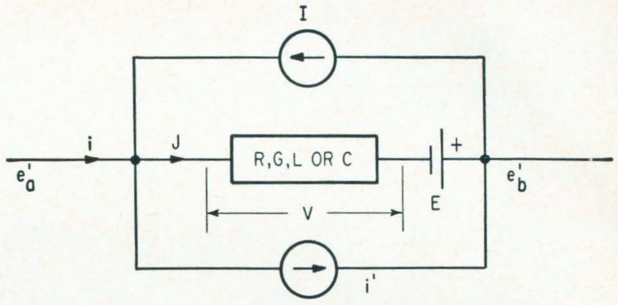
Input data cards feed the program information on how circuit elements are connected, types of elements and their values (including fixed and variable current and voltage sources), tolerances, current gains, inductive mutual coupling, transient initial conditions and dynamic changes in device models. Five different types of data cards are used: branch data (B), gain (T), mutual coupling (M), switching (S) and driving function (E or I).

The basic building block of ECAP is the standard circuit branch on the opposite page. It consists of a non-zero element; R, G, C or L. In addition, it can have a voltage source E in series with the element and/or a current source I in parallel. If a dependent current source i′ exists, it is also in parallel with the element.

In the ECAP branch, these symbols are used: i, branch currents; I, independent current source; i′, dependent current source; J, element current ($J = i + I$); e, branch voltage ($e = e'_a - e'_b$);

E = independent voltage source; and V, element voltage ($V = e + E$).

E is positive if the direction of current flow is assumed to be out of the positive terminal of the source, and I is positive if its direction and that assumed for branch current flow are the same.



Standard circuit branch is the basic building block of ECAP. It comprises an impedance, a fixed voltage source, and an independent and dependent current source.

D-c analysis

The d-c equivalent circuit is described with branch data cards (B cards) and gain description data cards (T cards).

A d-c equivalent circuit of a single-state common emitter amplifier with node and branch assignments and direction of current flow assumed is displayed on page 84.

Branch 4, as an example, is described as between nodes 1 and 3 with current flow assumed from node 1 to node 3. It contains a resistor whose value is 350 ohms with no tolerance provided. In series with the resistor is a constant voltage source of 0.5 volts. The input card describing this branch is:

B4 N(1, 3), R = 350, E = −0.5

A ± 5% resistor would be identified using the percentage tolerance

R = 350 (.05)

or the minimum and maximum value

R = 350 (332.5, 367.5)

Branches 4 and 6 represent the equivalent circuit of the transistor. The independent current flows in the base of the transistor, represented by branch 4, while the amplified current flows in the collector-emitter leg of the modeled transistor, represented by branch 6. The gain is indicated with the T card:

T1 B(4, 6), BETA = 50

Tolerances can be assigned to any of the input parameter values, permitting determination of worst-case and standard deviation for the established node voltages.

Parameter values can be modified easily as single value changes or as a sequence of values.

```
MODIFY
B2      R = 1000
B1      E = 19   (10)   21
EXECUTE
```

The resistance in branch 5 is thus changed to 1,000 ohms while the power supply in branch 1 is modified from 19 to 21 volts in 10 equal increments. Eleven solutions are calculated with output provided for each new value of E in branch 1. Output is provided by specifying PRINT together with any or all of the output block indicators shown in the table on page 86.

A-c analysis

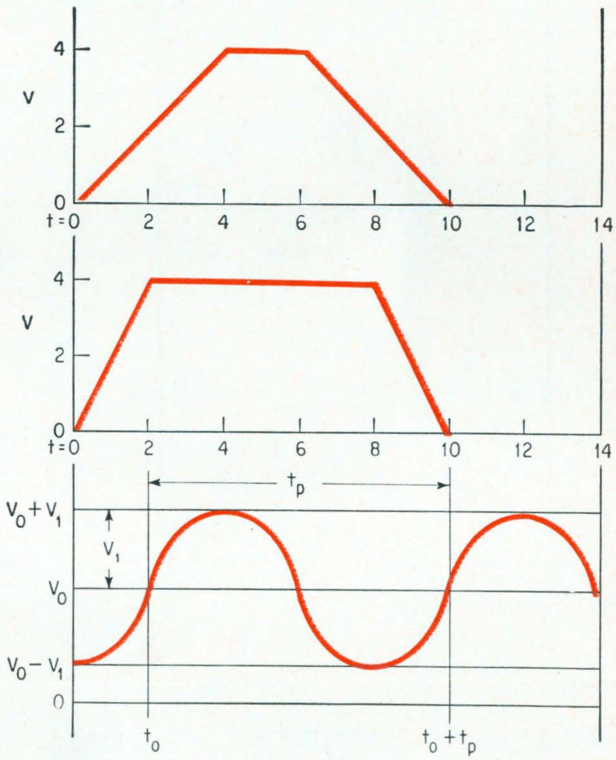
In addition to resistance and conductance the B card permits specification of capacitance and inductance (C and L). The voltage and current source format assumes a sinusoidal waveform. Therefore, each is specified in terms of amplitude and phase angle. Voltage and current outputs are also given by magnitude and phase. Real power is output when specified.

In the nominal solution, an arbitrary value of frequency may be assumed. Any input parameter can be modified either as a single value change or a sequence of values as in the d-c case. This includes frequency where responses are obtainable for linear as well as logarithmic variations.

FREQUENCY = 10 (10) 10000

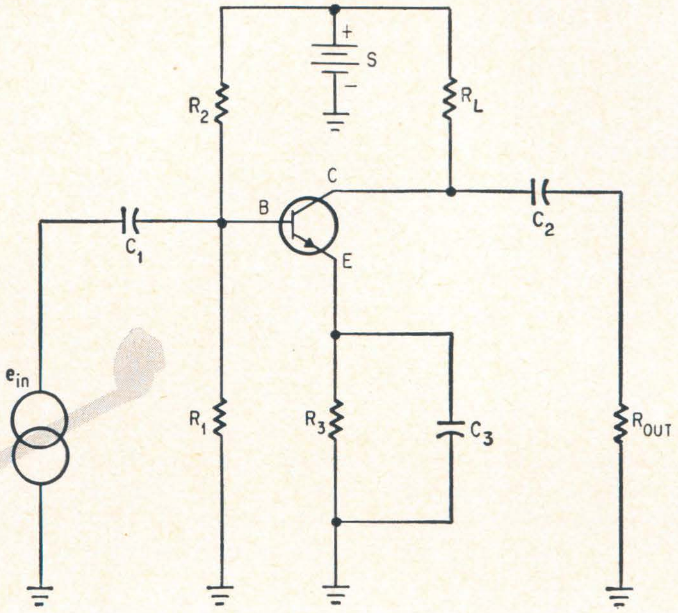
Output is calculated for a decade response from 10 hertz up to and including 10 kilohertz.

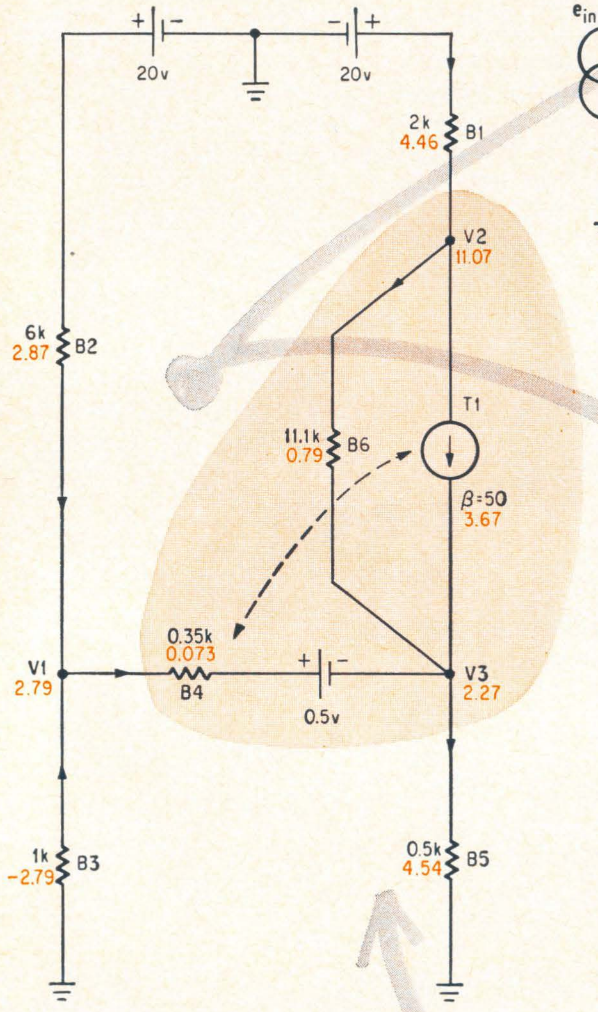
This output can be used directly or to modify ECAP to calculate voltage and current gains and



ECAP provides three classes of time-dependent sources. The first is the arbitrary input which, in the example here, would be specified E2 (2) 0, 2, 4, 4, 2, 0. The second is a periodic waveform; the example is E3 P (2) 0, 4, 4, 4, 4. In both cases, the number in parentheses represents the number of time steps between values. The third waveform is a sine wave which would be specified X_{nn} SIN (t_p), V_1, V_o, t_o. X would be replaced by E or I, and nn by the node or branch number.

D-c analysis





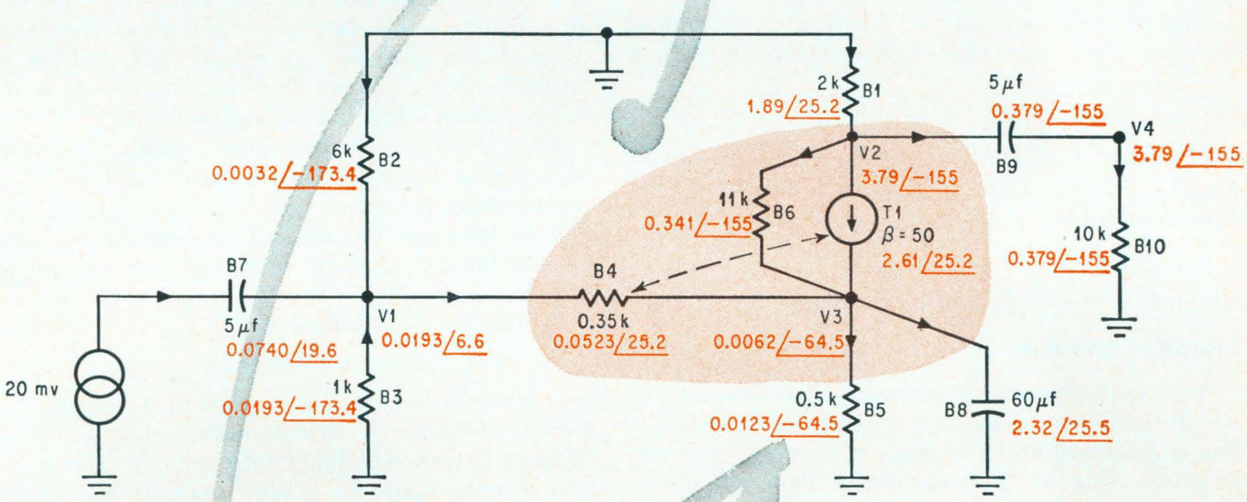

```
C    SINGLE-STAGE COMMON EMITTER AMPLIFIER
C    IBM 1620              DATE
C
C
C
     DC ANALYSIS
C
C
B1 N(0,2),R=2000,E=20
B2 N(0,1),R=6000,E=20
B3 N(0,1),R=1000
B4 N(1,3),R=350,E=-0 5
B5 N(3,0),R=500
B6 N(2,3),R=11.1E3
T1 B(4,6),BETA=50
   PRINT, VOLTAGES  CURRENTS
   EXECUTE
```

```
NODE VOLTAGES

NODES               VOLTAGES

 1- 3       .27942194E+01      .11072690E+02      .22685271E+01

ELEMENT CURRENTS

BRANCHES            CURRENTS

 1- 4       .44636550E-02      .28676300E-02      -.27942194E-02      .73406569E-04
 5- 6       .45370542E-02      .44634962E-02
```

A-c analysis

A-c analysis is shown on this page and d-c steady state analysis on the opposite page for common-emitter amplifier circuit. In both cases the schematic is first converted to an equivalent circuit (d-c and a-c, respectively), then the branches and nodes are numbered and component values written (in black). Next, the computer input is written (center, right, on both pages). Finally, the computer solution is printed out and the node voltages and branch currents transferred to the equivalent circuits. In the a-c case, phase angles are included.

```
C       SINGLE-STAGE COMMON EMITTER AMPLIFIER
C       IBM 1620               DATE
C
C
C
        AC ANALYSIS
C
C
B1      N(0,2),R=2000
B2      N(0,1),R=6000
B3      N(0,1),R=1000
B4      N(1,3),R=350
B5      N(3,0),R=500
B6      N(2,3),R=11.1E3
B7      N(0,1),C=5E-6,E=20E-3
B8      N(3,0),C=60E-6
B9      N(2,4),C=5E-6
B10     N(4,0),R=10E3
T1      B(4,6),BETA=50
        FREQUENCY = 1000
        PRINT, VOLTAGES, CURRENTS
        EXECUTE
```




```
FREQ =    .10000000E+04


     NODES            NODE VOLTAGES


MAG    1- 4    .19337409E-01    .37870215E+01    .61657815E-02    .37870023E+01
PHA            .65892438E+01   -.15483173E+03   -.64497744E+02   -.15464935E+03

   BRANCHES           ELEMENT CURRENTS


MAG    1- 4    .18935108E-02    .32229013E-05    .19337409E-04    .52267719E-04
PHA            .25168117E+02   -.17341060E+03   -.17341060E+03    .25182487E+02


MAG    5- 8    .12331562E-04    .22722098E-02    .74000958E-04    .23244448E-02
PHA           -.64497744E+02    .25198653E+02    .19604204E+02    .25502250E+02


MAG    9-10    .37870438E-03    .37870023E-03
PHA           -.15464989E+03   -.15464935E+03
```

Output block indicators

Indicator	Output available DC	AC	Transient
NV (node voltage)	X	X	X
Voltage	X	X	X
CA (element current)	X	X	X
Current	X	X	X
CV (element voltage)	X	X	A
BV (branch voltage)	X	X	A
BA (branch current)	X	X	A
BP (real power)	X	X	A
Sensitivities	X		
Worst case	X		
Standard deviation	X		

X—All ECAP versions
A—System 360 version only

provide programs for plotting the responses.

T cards in a-c allow real gain, as opposed to complex gain, to be represented. A phase shifting characteristic can be provided by using an auxiliary RC circuit in the transistor model.

The M card provides a description of mutual coupling that may exist between inductors in a circuit.

M1 B(5, 7), L = 3.75

This means that inductors are located in branches 5 and 7 and the value of mutual inductance, L, is calculated from

$$L = K\sqrt{L_1 L_2}$$

where K is the coefficient of coupling.

Transient analysis

A piece-wise nonlinear modeling technique, in which nonlinear devices are represented by straight line segments, forms the basis of transient analysis in ECAP. This method allows for dynamic modification of model parameters as a function of the behavior of the circuit.

The switch or S card designates a particular branch as a monitor. For example, in the voltage regulator equivalent circuit on the opposite page, switch 1 uses branch 8, whose function is to provide a reference voltage for regulation and also detect when a change of state is required.

While the 2-μf capacitor (B5) is being charged, the transistor Q is conducting, the diode G is blocking and the reference voltage exceeds the voltage at V3. When the voltage at V3 exceeds 12 volts, the switch S1 detects a change in the direction of current flow in B5. The program automatically determines the time of the change by sensing a null current in B5, records the time, calculates required output, changes parameters from normal to switched values, recalculates the output and then proceeds with the analysis. The reference voltage then becomes 11.7 volts and the capacitor discharges through the diode in B2. When the current in B1 again changes direction, it causes S1 to switch back to the normal parameter values. The responses at nodes 1 and 3 are shown in the plot.

The switching capability of the program can also be used to generate periodic waveforms such as square waves and ramps, and to model nonlinear devices such as resistors. Other commands which can be executed include time step (integration interval), output interval (number of time steps between outputs), finish time (end of response required), initial conditions (if any) and arbitrary and periodic driving functions.

Both initial conditions and steady-state (equilibrium) solutions can be printed out in the transient program. A check is made on residual current magnitude, which indicates the accuracy of the solution. An excessive residual current causes a message to be printed. The user controls the value of maximum residual current and can specify how close to the null condition switch time is determined.

Topological matrixes

A good analysis program properly "hooks the circuit elements together." Data that describes how the elements are connected is usually expressed as a matrix or as lists generated from the input cards. ECAP, like most programs, is based on an implicit matrix, but we shall assume that it is developed from a topological matrix.[1]

The branch-node incidence matrix, A, with branches as the rows of the matrix and nodes as the columns, describes how the branches are connected between the nodes. The matrix is listed by assuming a current direction into or out of a node.

If branch 5 is described as

B5 N(3, 2), R = 1000

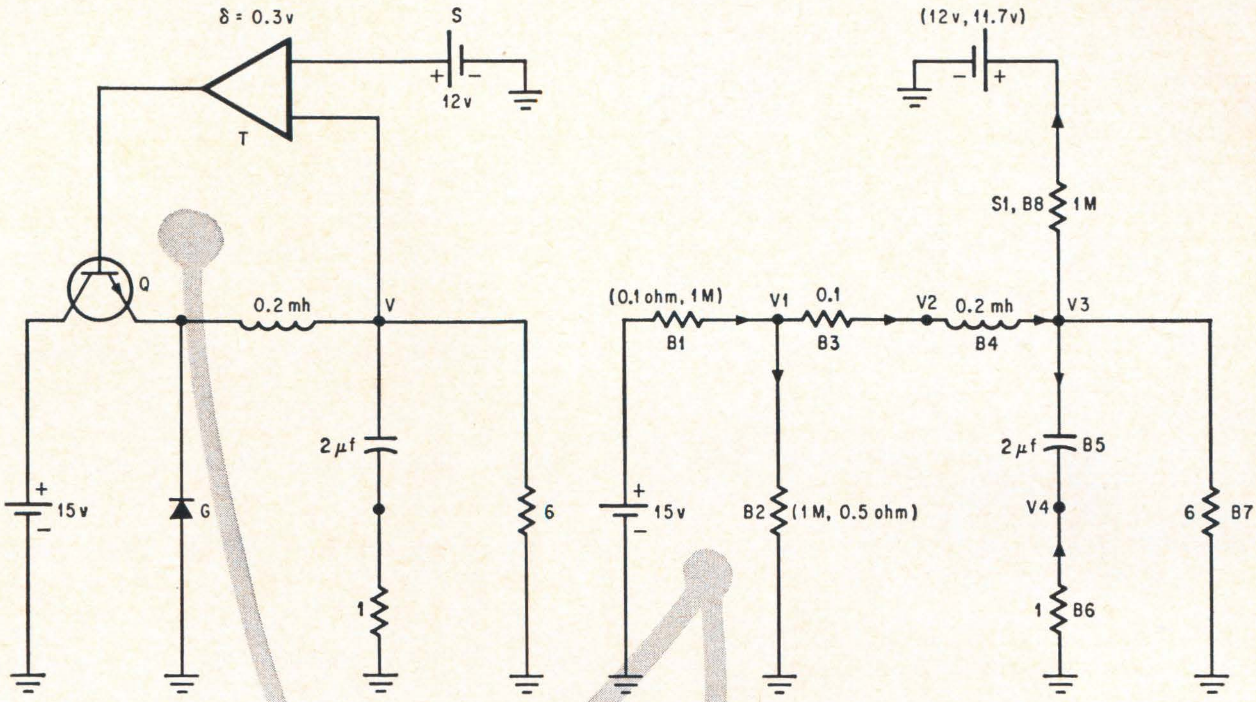
row 5 would have a +1 in column 3 because the current flows out of node 3, and a —1 in column 2 because the current flows into node 2. When the branch data cards have been entered, the matrix has just two listings in each branch row. All other entries in row 5 would be zero because these branches are not connected to these nodes. When the node voltages are known, the algebraic signs are also known because these are determined from the node voltage differences. The voltage differences indicate the direction of current because current flows from the higher node potential. Once the vector of node voltage e′ is established together with its corresponding topological matrix A [Electronics, Jan. 9, 1967, p. 88] a relationship for the branch voltage vector e is determined as a matrix form of Kirchhoff's voltage law.

$$e = A\,e' \tag{1}$$

Thus, to observe how branches impinge on a

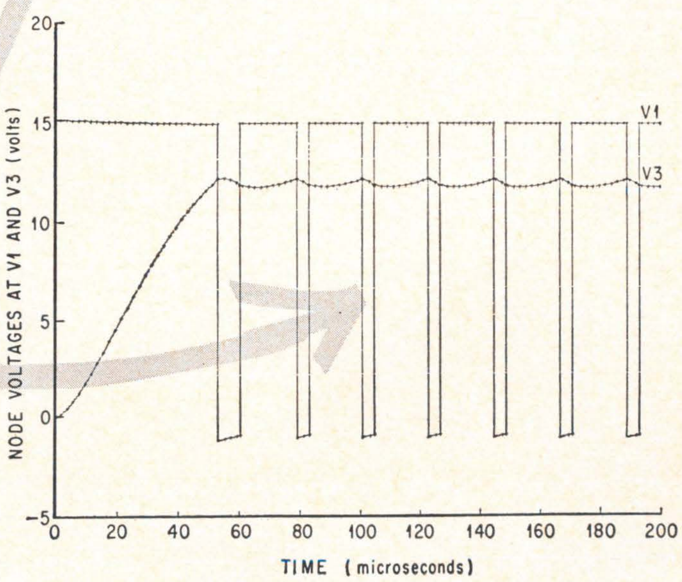
Voltage regulator schematic is transformed to its equivalent circuit for transient analysis. V is the voltage being regulated and δ is the trigger amplifier hysteresis voltage. Table shows alternate values of parameters (dependent upon status of circuit) representing diode, transistor and trigger amplifier. Circuit model is switched to match circuit condition by switch S1. The voltages at nodes 1 and 3 can be printed out or plotted, as here.

Transient analysis



ELECTRON DEVICE	V ≤ S STATE	V ≤ S EQUIVALENT CIRCUIT	V > S − δ STATE	V > S − δ EQUIVALENT CIRCUIT
TRANSISTOR Q	SATURATED	C — 0.1 — E	CUTOFF	C — 1M — E
DIODE G	NONCONDUCTING	E — 1M — ground	CONDUCTING	E — 0.5 — ground
TRIGGER AMPLIFIER T	OFF	V → J — S1 1M — + S 12v − ground; SWITCH S1 IS OFF (J ≤ 0)	ON	V → J — S1 1M — + S−δ 11.7v − ground; SWITCH S1 IS ON (J > 0)

```
C        VOLTAGE REGULATOR
C        IBM 1620              DATE
C
C
C
         TRANSIENT ANALYSIS
C
C
B1       N(0,1),R=(0.1,1E6),E=15
B2       N(0,1),R=(1E6,0.5)
B3       N(1,2),R=0.1
B4       N(2,3),L=0.2E-3
B5       N(3,4),C=2E-6
B6       N(0,4),R=1
B7       N(0,3),R=6
B8       N(3,0),R=1E6,E=(-12,-11.7)
S1       B=8,(1,2,8),OFF
         TIME STEP = 1E-6
         OUTPUT INTERVAL = 25
         FINISH TIME = 75E-6
         PRINT, VOLTAGES
         EXECUTE
```



Forty-watt amplifier on three integrated circuit chips was designed with the aid of a computer by Norden division of United Aircraft Corp., Norwalk, Conn.

particular node the operator looks down the columns of the A matrix and notes the +1, —1 or 0 entries. Matrix A^t, the transpose of the A matrix, is helpful in establishing the current form of Kirchhoff's law. Here the rows are node reference and the columns represent branches. Thus, the branch current vector is expressed as

$$A^t_i = 0 \tag{2}$$

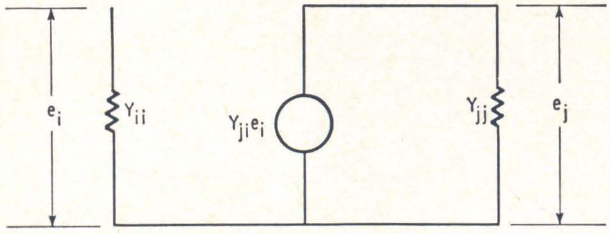
a form of Kirchhoff's current law. The element information is expressed as admittances (real for d-c and complex for a-c analysis). Branch element values are self-admittances and are entered in a matrix that relates branch references to themselves. Gains are transformed into transconductances and are related to the appropriate dependent and independent branches, as in the equivalent circuit below in which:

$$\begin{vmatrix} Y_{ii} & Y_{ij} \\ Y_{ji} & Y_{jj} \end{vmatrix} \begin{vmatrix} e_i \\ e_j \end{vmatrix} = \begin{vmatrix} i_i \\ i_j \end{vmatrix}$$

$$Y_{ii}e_i + Y_{ij}e_j = i_i \tag{3}$$

$$Y_{ji}e_i + Y_{jj}e_j = i_j \tag{4}$$

where $Y_{ji} = \dfrac{\beta}{Y_{ii}}$ and $Y_{ij} = 0$



Element information, including gain factors, is represented to ECAP by this admittance equivalent circuit.

Transposing

$$Y_{ji}\,e_i = \beta_{ii} \tag{5}$$

The matrix relationships that represent Ohm's law as nodal equations are given by

$$J = YV \tag{6}$$

where J = current vector
Y = admittance matrix
and V = voltage vector

Substituting the expressions given on pages 82 and 83 for J and V and rearranging terms yields

$$Ye = i + I = YE \tag{7}$$

Each term in equation 7 is then premultiplied by A^t and equation 2 is imposed, producing

$$A^t\,Ye = A^t i + A^t\,(I - YE) \tag{8}$$

Applying Kirchhoff's voltage law, equation 1, yields

$$A^tYAe' = A^t\,(I - YE) \tag{9}$$

The node voltage vector, e', is found by inverting A^tYA (nodal-admittance matrix)

$$e' = (A^tYA)^{-1}\,A^t\,(I - YE) \tag{10}$$

where $(A^tYA)^{-1}$ is the nodal-impedance matrix and $A^t\,(I—YE)$ is the source current vector.

Role of partial derivatives

Partial derivatives are valuable for examining tolerances and for worst-case analysis. Formulas for finding partial derivatives from node voltages are available.

Two techniques are employed in worst-case studies. In the IBM 1620 version of ECAP, a contributional or moment method is used; in other versions of ECAP, the Mandex method is applied. Both are based on the signs of the partials and element tolerances and are most appropriate for small excursions of tolerance. A check determines if a change in the sign of the partial has occurred between the nominal and extreme solutions.

The standard deviation calculation is based on the calculations of the partials and the tolerances (taken as the $\pm\,3\sigma$ values). Correlation between elements is taken to be zero. The variance, σ^2, of the node voltage is calculated as the sum of the products of the square of the partial times the variance of the element squared.

$$\sigma^2\,(e_j) = \sum_{i=1,n} \left(\frac{\partial e_j}{\partial P_i}\right)^2 \sigma^2\,(P_i) \tag{11}$$

The standard deviation is the square root of the variance.

Numerical integration

In the transient analysis program a set of integro-differential equations describes the circuit. This is solved in ECAP by an implicit numerical integration technique and the operator must set up difference equations and perform a repetitive solution. A capacitor is modeled as a resistor and voltage source in series and an inductor is represented by a resistor and current source in parallel.

The solution depends on the initial conditions. Conditions determined for the first solution (at the end of the first time step) are applied as the state or initial conditions for the subsequent solution.

The piece-wise nonlinear switching facility enhances the utility of the transient analysis method.

Extensions

Many users have modified ECAP to meet their particular requirements.[2] Several are using the IBM 2250 graphic input/output (crt) display unit in conjunction with ECAP. Others incorporate incremental plotters. ECAP has been used to calculate voltage and current gains, and topological information derived from ECAP has aided automatic circuit layout. One effort, described in the following article, incorporates the best of ECAP with the technique of NET-1, including the employment of stored models.

References

1. F.H. Branin Jr., "Computer-aided design: part 4, Analyzing circuits by the numbers," Electronics, Jan. 9, 1967, p. 88.
2. H.M. Wall, "ECAP-1966," 1966 NEREM Convention Record, pp. 84-85.

Circuit design IV

A profitable marriage

The best features of both NET-1 and ECAP are combined in a new program while many limitations are overcome

By Lawrence Dersh

The Raytheon Co., Wayland Scientific Computer facility, Wayland, Mass.

Although the NET-1 and ECAP programs have gained widespread approval, both suffer from shortcomings. These are circumvented in a new program called Raycap (the Raytheon Co.'s circuit analysis program) that unites the two in one package. The result is a program with the best features of the "big two" programs.

Raycap is written in FORTRAN IV. The basic ECAP subroutines are the starting point in the program's development and the ECAP language remains part of the Raycap language.

Users of Raycap can draw upon the library of semiconductor data available to those who employ NET-1 because the transistor and diode parameters used for nonlinear analysis are identical to those of NET-1.

Language

Because ECAP is a subset of Raycap, only the language that is unique to Raycap is shown here.

The basic transistor and diode specification cards are called Q and D cards respectively. The format is:

Col 1-5	Col 7 = 72	
QNN	(B, C, E), TYPE, N,	ON
	P,	OFF
DNN	(A, K), TYPE	

where NN = circuit serial number
B = base, C = collector, E = emitter node number
TYPE = transistor or diode serial number
ON = d-c state exists
OFF = no d-c state
N = npn transistor
P = pnp transistor

The N and P format permits quick specification of complementary transistor types.

A = anode
R = cathode

The result of using the cards in the input data is:

- The semiconductor model is automatically generated
- For d-c, a nonlinear analysis is performed
- For a-c, the source values in the branch cards are first assumed to be d-c, producing an initial nominal d-c solution, including the device operating point. Then the desired sinusoidal source values

Semiconductor d-c modify statements

Diodes
RBD Bulk resistance
RCO Ohmic leakage resistance
TEMP Temperature °C

Transistors
RBB Base spreading resistance
RCO Collector-base leakage resistance
REO Emitter-base leakage resistance
RCC Collector bulk resistance
REE Emitter bulk resistance
BN Normal current gain
BI Inverse current gain
TEMP Temperature °C

are inserted in the same branch cards via the MODIFY option. As a result a small signal analysis is performed, centered about the operating point produced by the initial solution.

The quantitative value of junction capacitance computed by Raycap is based upon the nominal d-c operating point, as follows:

- For the transient analysis, a nominal d-c steady-state solution is performed. The d-c values are automatically used as initial conditions for the time-varying solution. The semiconductor junction capacitances are computed as a function of time and voltage.
- The PARAMETER specifications shown in the table are used for substituting semiconductor data and junction temperature for a given type of device. Without them, the nominal library values of the transistor or diode parameters are used automatically.

There are two ways to specify semiconductor modifications for d-c (PARAMETER data may also be used in any MODIFY data group). The format for semiconductor modifications that are independent of the PARAMETER command and data is shown in the table of MODIFY statements. For a-c and transient analysis the PARAMETER specifications enable the user to perform semiconductor modifications for all transistors and diode characteristics except resistance.

Solution accuracy

The 1 ERROR = .xx command performs the following function if either a Q or D card is used:

- It specifies the allowable error for d-c convergence. If the solution doesn't converge within this error, a message to that effect will be printed out, together with the actual error. If this happens the d-c solution will be executed anyway. If no ERROR command is specified a value of .001 will be assumed.

Together with all the regular ECAP outputs, additional printouts of transistor and diode voltages, currents, power dissipated and stress levels are produced. Whenever a semiconductor rating is exceeded, messages so stating are automatically generated. The stress level is automatically assumed to be 50% of the specified power rating unless the following specification is used:

UU = .XX
XX = .XX

where UU and XX are the stress level commands designating a diode or a transistor, respectively. Or the following command may be used

PARAMETER
Q1
POWER = XX

If the above options are omitted, the library ratings are automatically inserted.

Parameter data specifications

Diodes

D-c parameters

RB Bulk resistance
RC Ohmic leakage resistance
IS Saturation current
TE Temperature °C

A-c parameters

NO Grading constant, e.g. 0.5 for alloyed, 0.33 for grown junctions
VZ Contact potential
CM Measured junction capacitance at specified reverse voltage V_t
VT Reverse voltage for C_m
If C_m and V_t are not available directly, then the respective proportionality constants for PN junctions must be supplied
FO Cutoff frequency of the junction
VR Reverse voltage rating
IF Forward current rating
PO Power rating
MO Dimensionless constant unique for a typical diode

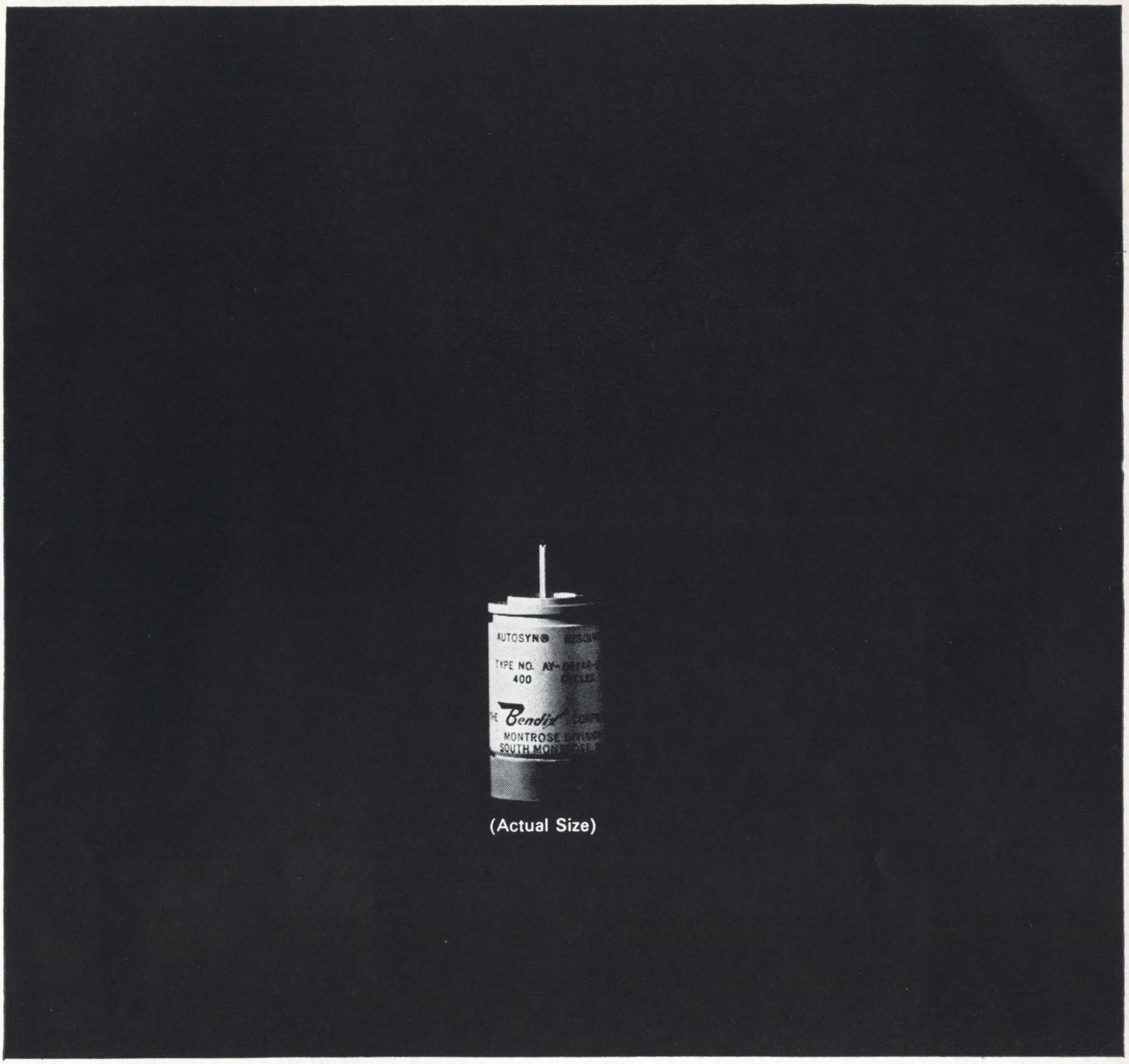
Transistors

D-c parameters

RBB Base spreading resistance
REE Emitter bulk resistance
RCC Collector bulk resistance
REO Emitter-base leakage resistance
RCO Collector-base leakage resistance
IES Emitter-base junction reverse saturation current (leakage) with collector open
ICS Collector-base junction reverse saturation current (leakage) with emitter open
BNO Normal current gain
BIO Inverse current gain

A-c parameters

NEO Emitter-base grading constant
NCO Collector-base grading constant
VZE Emitter-base contact potential
VZC Collector-base contact potential
CME The measured emitter-base transition capacitance when the emitter-base junction is at V_{te} volts
VTE Respective voltage for measured C_{me}
CMC The measured collector-base transition capacitance at V_{tc}, volts
VTC Respective value for measured C_{mc}
If C_{mc}, C_{me}, V_{tc} and V_{te} are not available directly, then the respective junction proportionality constants must be calculated for the particular device
FNO Cutoff frequency of the transistor in the active normal region
FIO Cutoff frequency of the transistor in the active inverse region
VBE Maximum base-emitter rating
VCB Maximum collector-base rating
VCE Maximum collector-emitter rating
ICO Maximum collector current rating
POW Maximum power rating



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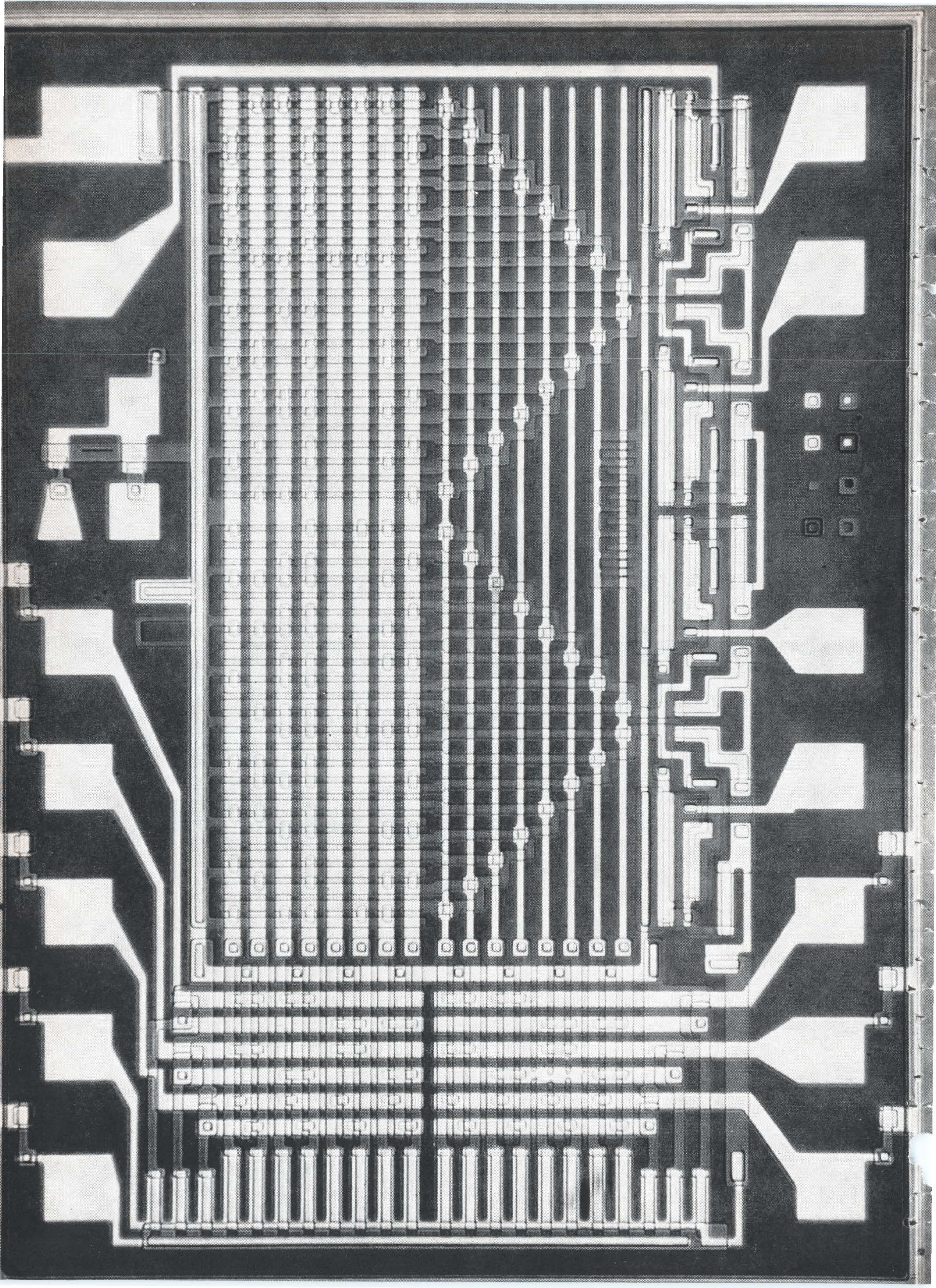


Memory on a chip: a step toward large-scale integration

Already in production, a read-only memory made of MOS transistors on a single chip of silicon is fast, inexpensive and easily stores any combination of 256 bits in less than 1/200th square inch

By Lee Boysel

Fairchild Semiconductor Division, Fairchild Camera & Instrument Corp., Mountain View, Calif.

Read-only memories, increasingly used to control instruction execution in general-purpose computers, have many potential applications in displays, controls and telemetry systems. However, the lack of suitable batch-fabrication methods has limited the size of high-speed, all-semiconductor types such as diode arrays because their cost per bit rises sharply with size.

Now, a read-only memory on a monolithic chip measuring 60 by 80 mils is in production at the Fairchild Camera & Instrument Corp.'s Semiconductor division. A density of 256 bits on this chip has been achieved through the use of metal oxide semiconductor technology. Active MOS devices serve as both the memory elements and as logic elements for address decoding. The memory's access time of 1 microsecond is longer than that of some other forms of memory, but is more than adequate for most applications.

Previous attempts to fabricate monolithic memory arrays from bipolar devices have met with only limited success because bipolar memory cells exhibit parasitic capacitance and must therefore be isolated from one another. To provide this isolation, together with word-decoding logic and output buffers, requires a complex succession of processing steps that appear to restrict the potential for reducing memory size and cost.

Magnetic memory systems, whether they be electromechanical drums and disks or all-magnetic thin films, wires or ferrite cores, cannot be batch-fabricated. Decoders and buffers require technologies different from that of the storage element. And the electromechanical forms are very slow.

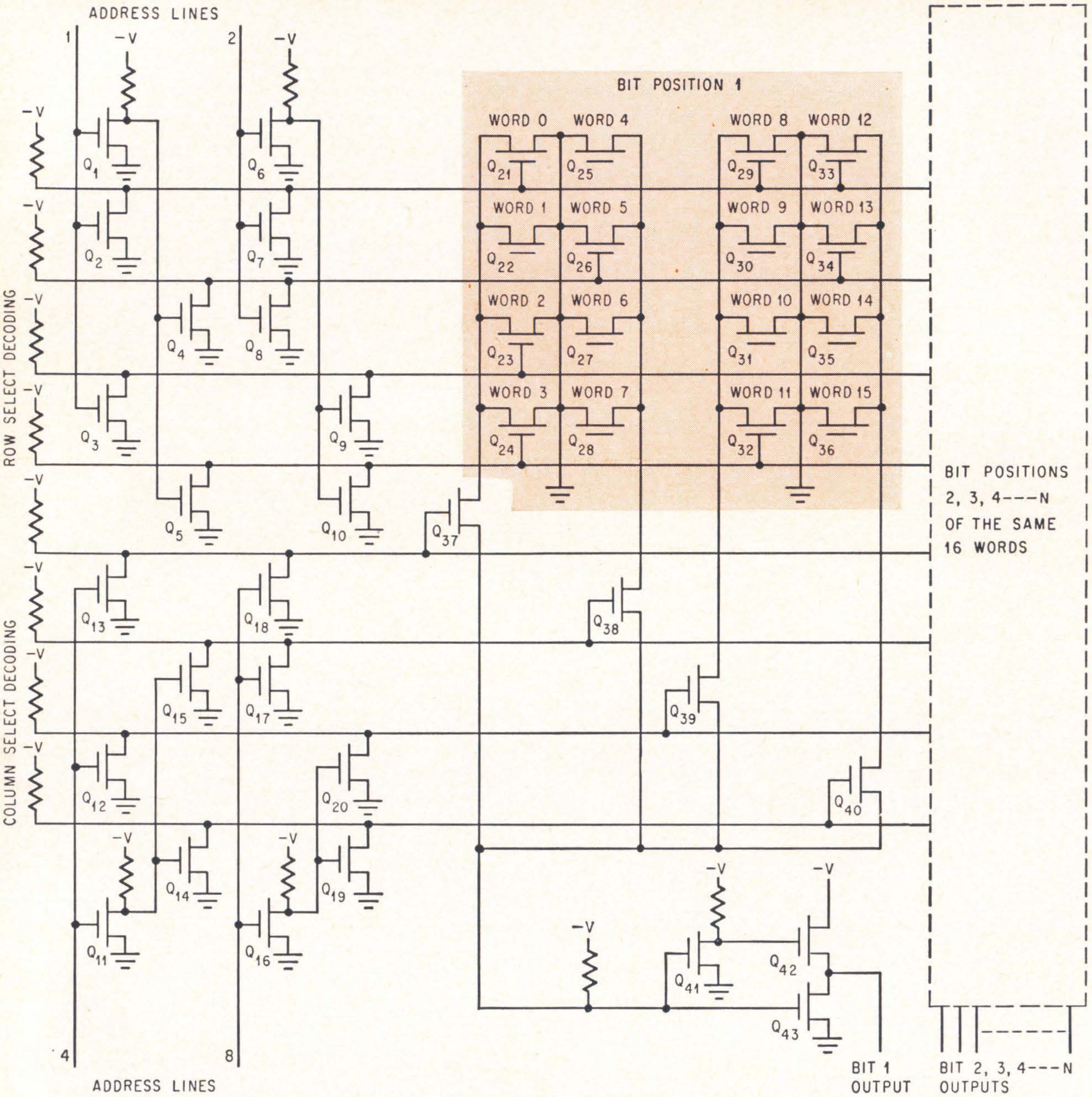
A memory built exclusively with active MOS devices has none of these disadvantages. The entire storage matrix, with address decoders and output buffers, can be formed simultaneously on a monolithic substrate using standard MOS techniques. Isolation isn't necessary, and component density can therefore be greatly increased. This, in turn, yields improved reliability and economy by permitting the packaging of complete functional entities together. External connections for internal purposes are not necessary. For instance, a 1,024-bit memory containing 256 four-bit words requires only 14 leads: eight binary input lines for the address, four output lines for the data and one lead each for supply voltage and ground reference.

Switching with MOS

The basic circuit depends on the application of a MOS transistor as a switch. The memory matrix stores a binary 1 wherever a channel can be established between a source and a drain; the oxide layer is made thin enough at these points to open the channel with an electrical signal. Where a binary 0 is to be stored, the oxide insulating meterial is left sufficiently thick so that the channel cannot be opened. The address decoder is made of MOS NOR gates that select only one word and gate all bits of that word to the output buffer. Load resistors are made of MOS transistors having their sources short-circuited to their gates. [See "Logic functions in MOS," p. 96.]

In the most straightforward design, a one-dimensional decoder selects a single word line. This line gates as many MOS transistors as there are bits in

One chip, greatly enlarged in this photo, stores 64 four-bit words with 1-microsecond access time.



A bit position of a 16-word memory, with the output buffer for that position and the address decoder for all 16 words. Storage elements of the memory array are tinted.

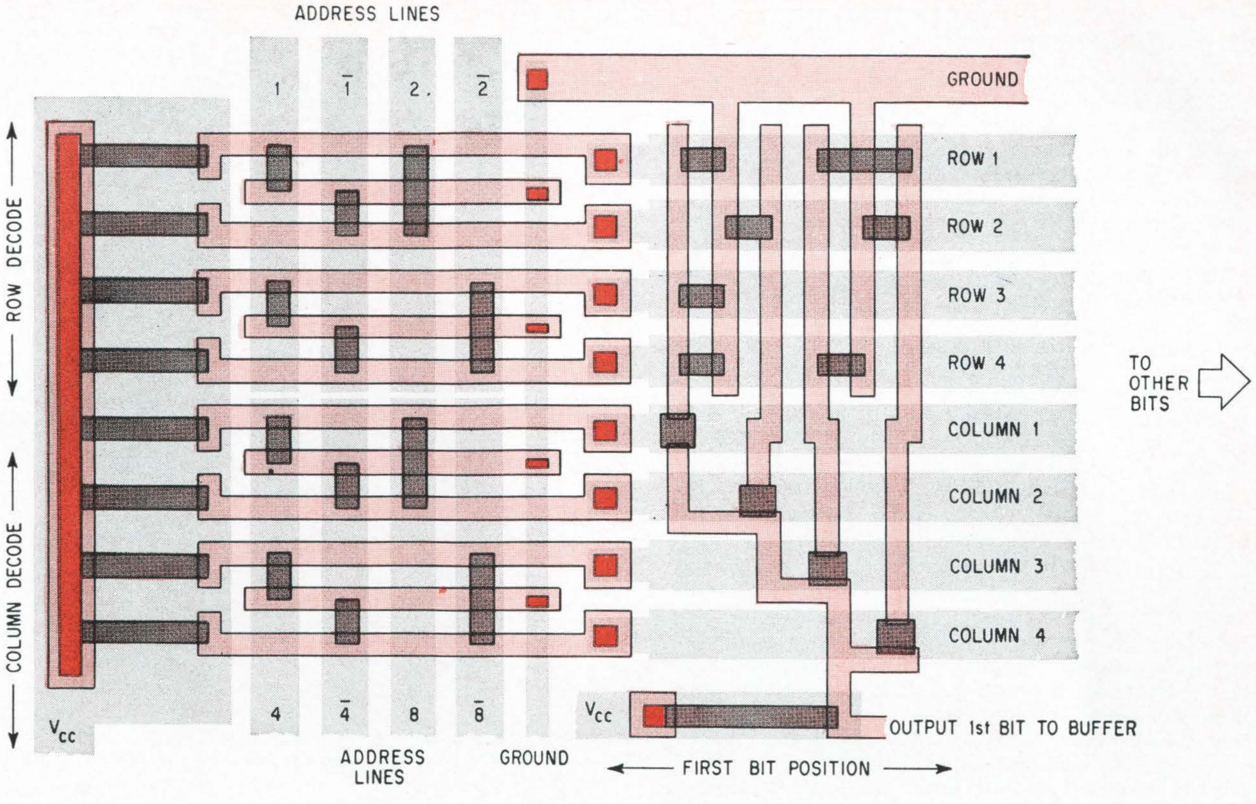
a single word in the memory. The opened gates pass current from the source to the drain, and the voltage drop across the load resistor produces a pulse through the buffer for each bit.

Each bit line in this straightforward design is the drain connection for many MOS transistors, no more than one of which can be on at any one time. The large number of inactive connections represents a substantial capacitive load on the bit line, slowing its operation.

A better way

The Fairchild read-only memory uses a two-dimensional decoding scheme that reduces the number of decoding gates and therefore the amount of parasitic capacitance. The schematic shown above depicts part of a 16-word memory with an indeterminate number of bits in each word. A four-bit address can select any of the 16 words. A single bit position common to all 16 words is organized in a 4-by-4 array; two address bits select a row and the other two select a column.

Suppose word 5 is to be read out of the memory. The address 5 in binary form is 0101. The address lines labeled 8 and 2 in the schematic are therefore at a positive potential, and address lines 4 and 1 are negative. The three gates controlled by each of the two positive lines are closed, and the gates with negative levels are open. Because Q_6 and Q_{16} are closed, no current passes through their load resistors and the potential holds gates Q_9, Q_{10}, Q_{19} and Q_{20} open. And because Q_1 and Q_{11} are open,



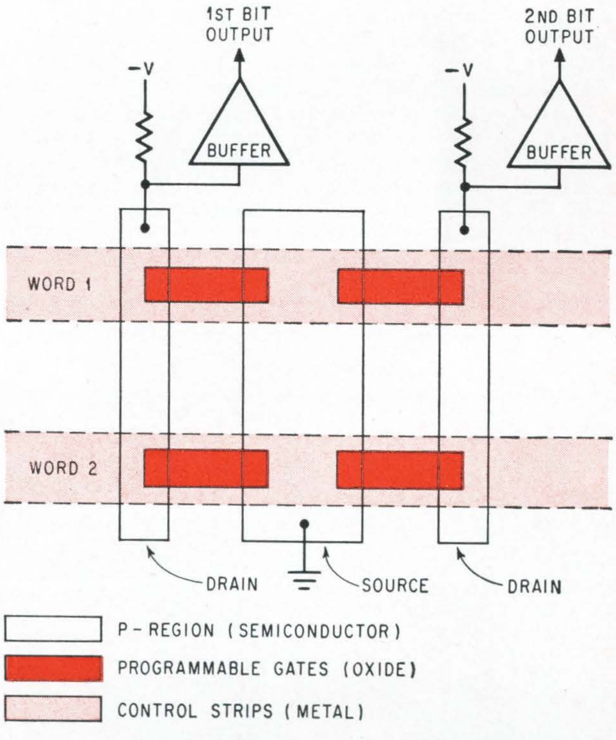
Layout of the 16-word memory in the schematic diagram on the opposite page. The actual 256-word memory being produced is laid out similarly. The output buffer is not shown in this layout.

their load resistors produce a voltage drop that holds gates Q_4, Q_5, Q_{14} and Q_{15} closed.

Because gates Q_4 and Q_8 are both closed, the row line that is their source is negative; transistors Q_{22}, Q_{26}, Q_{30} and Q_{34} are gated on, together with transistors in other bit positions of words 1, 5, 9 and 13 in the memory. Each of the other three row lines is connected to at least one open gate; the load resistor therefore has a voltage drop, the row lines are positive and all transistors controlled by these lines are off.

Similarly only the column line that is the source for transistors Q_{15} and Q_{17} is negative, and Q_{38} is gated on. The other three column lines are positive and Q_{37}, Q_{39} and Q_{40} are off. Gates Q_{37} through Q_{40} have a common load resistor (at the bottom of the schematic), but since only Q_{38} is open, current can be supplied only to transistors Q_{25}, Q_{26}, Q_{27} and Q_{28}. Of these four, Q_{26} is on, corresponding to one bit of word 5 in the memory. Transistors Q_{41}, Q_{42} and Q_{43} buffer the voltage drop across the load resistor. Current passes through Q_{42} from the external circuit—presumably some functional part of a computer or other digital assembly. Current coming from outside represents the reading out of a binary 1 from the memory.

In the same way, suppose word 9 is to be read out. The address is 1001; the row and column decoders work as described previously so that gates Q_4, Q_8, Q_{12} and Q_{20} are closed and the correspond-



Relationship of various layers in the MOS read-only memory. The p-region is deposited first, then the gates and finally the metal control lines. The read-only memory's organization is more sophisticated than this simplified diagram would indicate, but the layers are deposited in the same order.

Logic functions in MOS

Metal oxide semiconductor transistors can be combined into NOR gates from which any logic function can be constructed. A basic two-input NOR gate is at the right; gates with three or more inputs can be put together similarly. The two MOS transistors in the diagram share a common load resistor made from a third MOS transistor with its source connected to the gate.

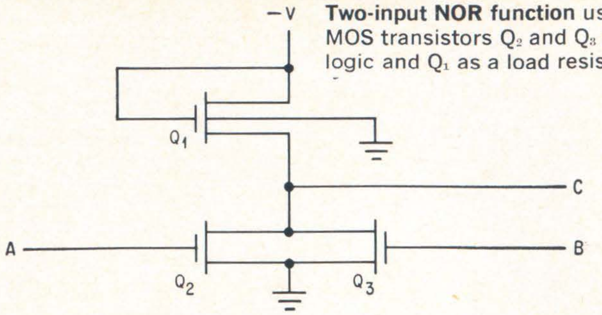
The design of a logic function using MOS transistors is simply topological control of the transistors' transconductance. The drain current is proportional to the transconductance, which in turn is proportional to the device geometry. When a MOS transistor is conducting, its transconductance, together with that of its load resistor, make a voltage divider that determines the output voltage level. When the transistor turns off, the output voltage becomes very nearly the same as the supply voltage.

Simple NOR logic functions can be implemented in MOS devices by connecting the transistors directly, as at the right. The function illustrated is $\overline{AB + C} = D$, read NOT [(A AND B) OR C] equals D. The OR part of the function is represented by the two parallel paths; the AND part by the two transistors in series. The NOT stems from the inverting effect of the transistors. Both parallel paths must have the same total resistance to maintain the proper transconductance ratio between the logic transistors and the load transistor. And this is where a penalty is levied against logic designers using this method.

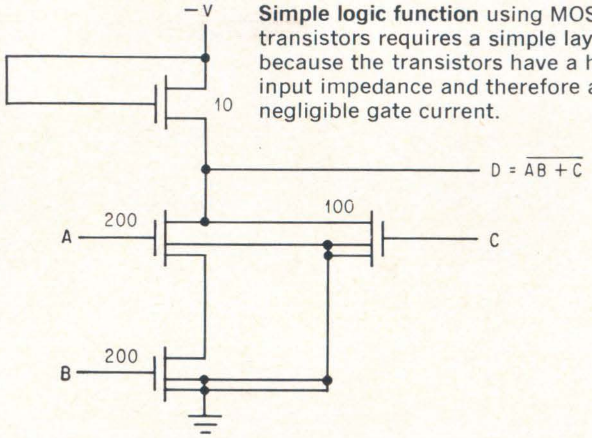
The resistance of each of the series transistors must be half that of the parallel transistor, so that their total resistance is the same. If their resistance is half, then their transconductance is double; therefore the area of the mask is doubled, as in the mask layout at the right. This presents a size penalty and shows that logic functions should be designed with as many parallel paths as possible and with a minimum of series paths to keep the total area of the mask to a minimum. This approach corresponds to using many OR's and very few AND's.

In the read-only memory, a single decoding transistor must be capable of pulling a coordinate line sufficiently positive to cut off the appropriate transistors in the memory array or in the column gates. But since more than one transistor may be turned on, the coordinate lines may have any of several (in the 16-bit schematic, either of two) positive levels capable of ungating a transistor.

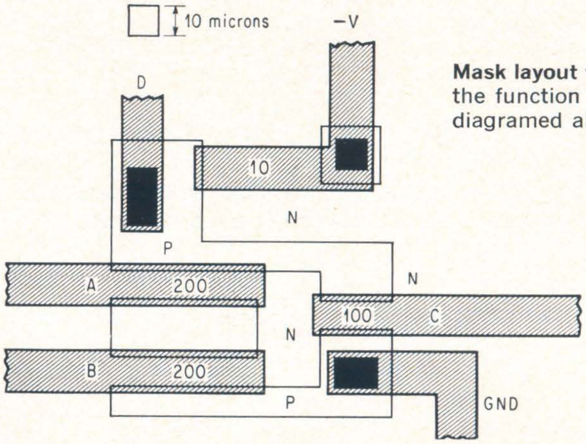
—W.B.R.



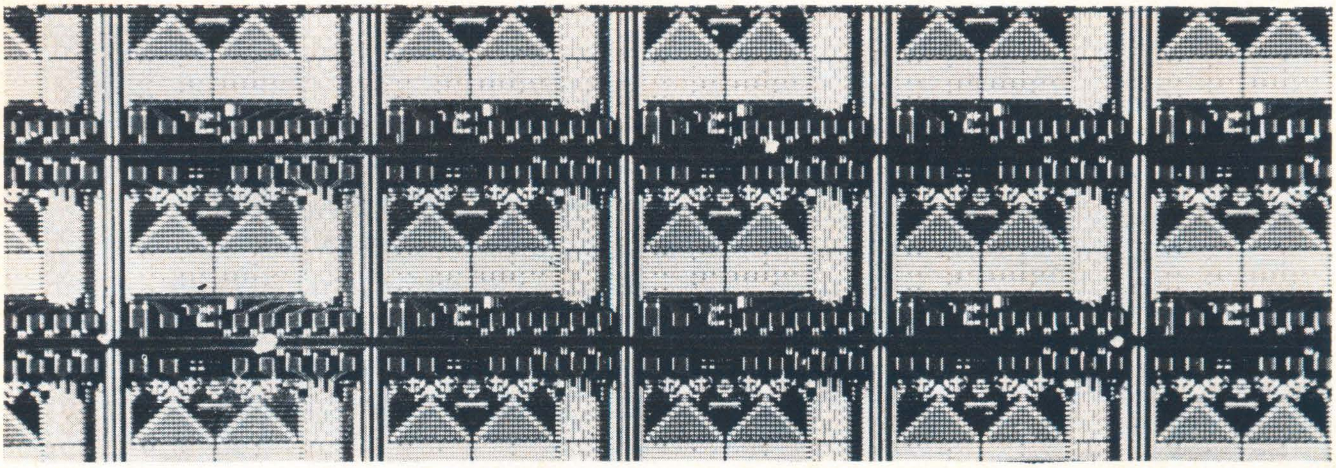
Two-input NOR function uses MOS transistors Q_2 and Q_3 for logic and Q_1 as a load resistor.



Simple logic function using MOS transistors requires a simple layout because the transistors have a high input impedance and therefore a negligible gate current.



Mask layout for the function diagramed above.



Not houses on a hillside, but part of a wafer containing row upon row of memory chips.

ing row and column lines are negative. All other row and column lines are positive. Through Q_{39}, current is supplied to Q_{29}, Q_{30}, Q_{31}, and Q_{32}. Of these, only Q_{30} can accept the current, but it has a thick oxide layer and is not turned on even though its gate is negative. There is no voltage drop across the load resistor. Current passes through Q_{43} to the external circuit, representing the readout of a binary 0 from the memory.

Twice or thrice the root

The two-dimensional decoder approach adds no logic stage delays but results in a much lower parasitic capacitance than the straightforward one-dimensional decoder. Each bit line is the source connection for four transistors at most in the memory array plus four transistors in the column decoding network (Q_{37} through Q_{40} in the schematic), for a total of eight—a 50% reduction from the straightforward design.

Larger arrays would show an even greater contrast between the two approaches. The number of connections to each bit line in the two-dimensional design is twice the square root of the memory size, or 92% less than the number of connections in the one-dimensional design for a 1,024-bit memory.

Three-dimensional stacking, using a decoding network divided into rows, columns and a third set of lines, can reduce the number of connections and decoding gates and the amount of parasitic capacitance by an even larger amount—three times the cube root of the memory size. In large memories, this produces a very great improvement in the speed-power product, a figure of merit for memories. Such stacks are easily implemented in IC's; the arrays don't actually occupy three dimensions in space, but rather involve a third set of decoders that establish a selective ground connection instead of the common ground bus shown in the schematic.

Depositing and etching

In fabricating the read-only memory, long source and drain diffusion strips of p-type material are deposited on the n-type substrate. A thick layer of oxide insulating material is laid on top of the p-type strips. Wherever a gate is to be established, a hole is etched through the oxide clear down to the p-layer and a thin layer of the same oxide is laid in the bottom of the hole, a process called "thinning the oxide." In general, the gates are narrow rectangles whose long dimension is at right angles to the long dimension of the strips of p-material.

The final step is the deposition of metal gate control strips on top of the oxide. However, at certain points these strips must make contact with the p-region as well as with the gates, so before the metal is deposited, more holes are etched through the oxide down to the p-region.

This arrangement of perpendicular strips permits high density of memory cells and retains a simple processing procedure. The actual cell density reaches a million bits per square inch, even when tolerances are kept relatively loose for ease of manufacturing. No current design techniques for devices requiring isolation can approach this extraordinary density.

Simple redesigning

Since each memory requires a new configuration, depending on the data it stores, each memory requires a complete new design. The redesign is reduced to a minimum with a master pattern for the oxide-etching mask. This pattern, if unmodified, would produce a mask that would insert a binary 1 in every bit position in the memory. To insert binary 0's, a small piece of layout tape is placed over the corresponding openings in the pattern. The mask made from the modified pattern is then used with the other masks in a standard process for manufacturing MOS devices.

The read-only memories are easily tested. A copy or test reference of the memory is built of bipolar integrated circuits and a matrix of discrete diodes. Every word in the memory being tested is addressed, and its output compared with that of the corresponding word in the test reference. The comparison is made at high speed and a complete 64-word memory can be tested in a few milliseconds. A batch of identical memories is tested on the wafer before the wafer is diced. The test reference can be modified for different memories by adding or deleting discrete diodes.

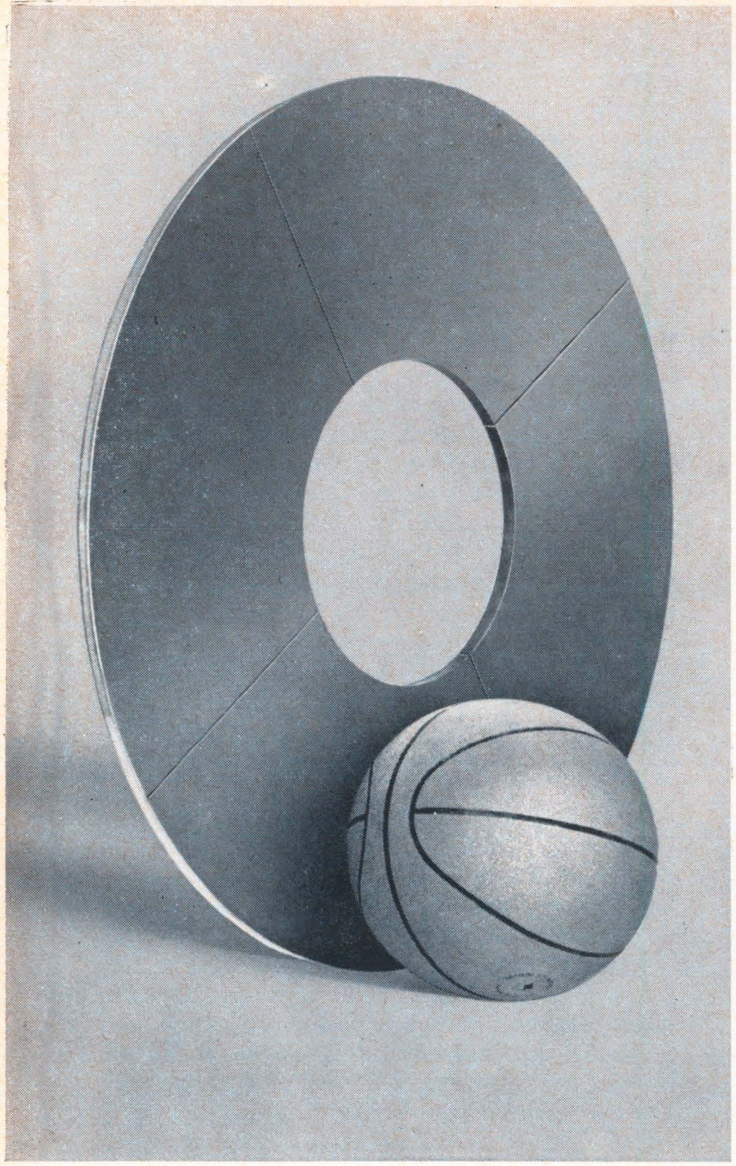
The standard read-only memory now being produced contains 64 words of four bits each. It has p-channel devices in which the electric field created by the gate converts the n-type substrate to p-type. The memory's layout follows that shown for the 16-word example in the diagram on page 95 [a photograph of the complete monolithic memory is on p. 92].

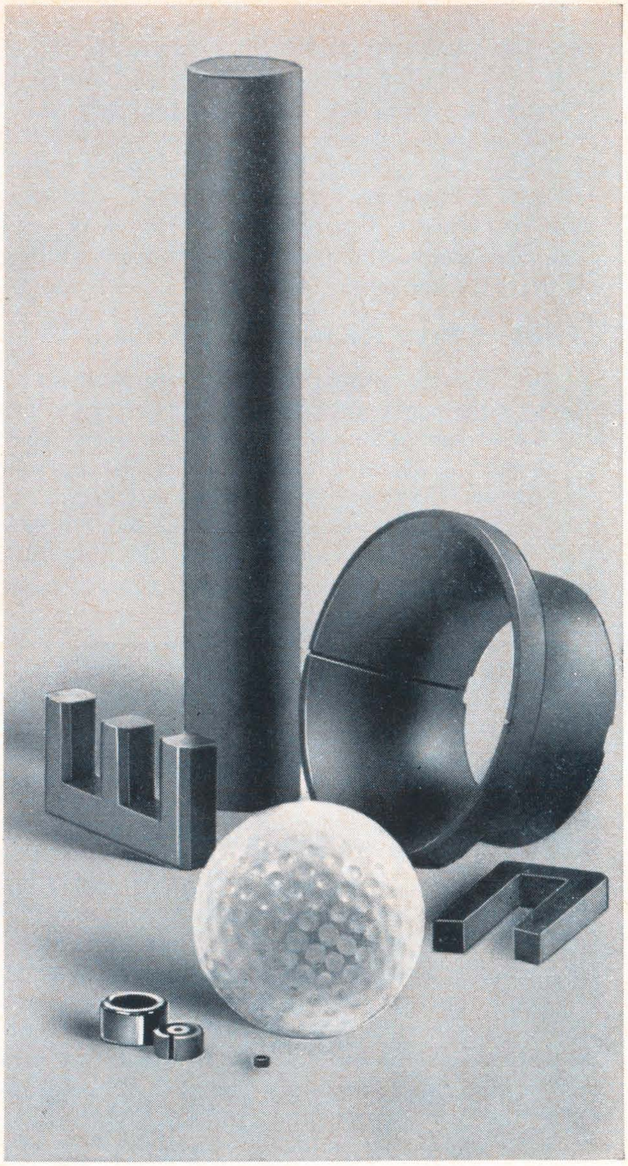
The Fairchild memory has an access time of about a microsecond. Much shorter access times would be attainable in a similar memory built with complementary devices—that is, with p-channel transistors in the memory array and n-channel transistors in the decoder, or vice versa.

New concepts and new approaches to logical organization are needed if the full potential of large-scale integration in MOS technology is to be realized. Circuit design and logic design are no longer important; the function labels in a block diagram have taken their place.

The author

Lee Boysel is in charge of all standard MOS product design at Fairchild Semiconductor. Previously, he designed large MOS arrays for data acquisition at the IBM Corp.





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Japanese technology I

Computers and color: New wave in tv broadcasting

With more than 900 color television stations on the air, the Japanese Broadcasting Co. has its engineers developing automated stations, new color cameras and video recorders

By Charles L. Cohen
Tokyo regional editor, Electronics

Computer-controlled editing system going into operation at the NHK broadcasting studios includes this unique recorder that mixes sound effects from several other recorders.

Most Westerners see only one side of the Japanese consumer electronics industry—the transistor radios, television sets and recorders that pour out of their end of the export pipeline. At the other end, maintaining the momentum of the Japanese consumer electronics industry, millions of dollars are spent each year to improve broadcast technology.

Some of the Japanese broadcast techniques have entered the pipeline, but they have been a trickle compared with the flood of innovations building up in Japan. In television alone, the Japanese have recently improved the methods of converting broadcast signals from one international standard to another, helped make intercontinental satellite relays practical, and reduced the size and improved the sensitivity of color cameras, camera tubes and video recorders. They have successfully automated the editing of video tapes with a computer and are well on their way to computer control of broadcasting networks. New ways of improving the quality of signals received, such as the use of a digital memory to take the jumpiness out of recorded programs, are also being developed.

The examples cited are the work of NHK Technical Research Laboratories, one of the world's largest broadcast technology centers. It was established in 1930 by Nippon Hoso Kyokai (Japan Broadcasting Co.), a nonprofit, public-service corporation that operates more than 1,300 tv and radio stations.

Nearly everyone in Japan is within receiving range of NHK radio and tv stations. For revenue, NHK depends on subscriber fees rather than commercial advertising, and its charter directs it to advance the general welfare and cultural life of the Japanese people. In the technical pursuit of this goal, the corporation supports the work of 400 people at NHK Labs, including about 200 engineers and researchers.

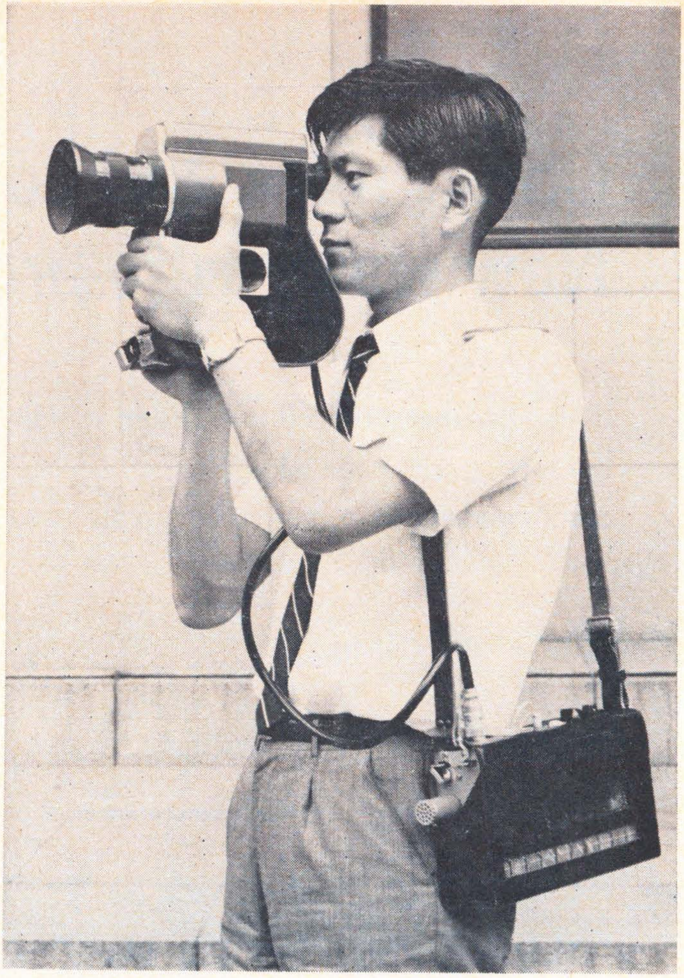
The labs' greatest outpouring of new television equipment was triggered by the Tokyo Olympics of 1964. For that event, NHK developed slow-motion video tape recorders, an antenna that homed in on transmissions from helicopter-borne cameras covering the marathon races, new cameras, new microphones and a satellite relay system.

The Olympics provided a spectacular showcase for Japanese broadcast techniques. And since then, developments in broadcast gear have continued to flow from NHK's labs.

Television research

Last month, NHK and Nippon Columbia Co. announced motion-picture and television cameras that provide color-tv broadcasts from black-and-white images [Electronics, Jan. 23, p. 235]. Black and white reception of color programs was improved by the two-tube color camera described on page 103. That camera, in turn, resulted from improvements in image-orthicon tubes [p. 106].

Research into the causes of hue deviations in prerecorded color programs provided the design basis for a new high-performance video tape recorder [p. 105]. Research is also being done on



Television newsmen don't have to be professional cameramen to operate this new motion-picture camera. A built-in photometer regulates film exposure, automatic controls govern film speed, and sounds are recorded on a magnetic coating on the movie film.

motion picture films, receiving antennas and picture tubes to improve picture quality.

NHK is getting better video-tape recordings from its older VTR's because the labs have devised better recording heads, made of ferrite, and low-noise tape. And it expects error-correction systems to improve both recorders and the quality of received pictures [p. 111].

NHK's network is rapidly expanding—123 tv stations were added, for example, between Aug. 1 and Dec. 1, 1966. This expansion is spurring considerable work on station automation [p. 101] and such improvements in program production techniques as the automatic editing system described on page 114.

To bring in programs from all over the world, the lab work on satellite transmission systems is being reinforced by work on standards-conversion equipment [p. 108.] Basic research on broadcasting from satellites is also under way.

Radio-frequency interference prevents further expansion of NHK's very-high-frequency television network. To supplement the vhf stations, therefore, NHK is constructing unattended translator stations in areas where vhf signal strength is low. These stations pick up the weak signals and rebroadcast them at vhf or at ultra-high frequencies.

NHK Labs is supporting this program with development work on high-reliability translators that can be built as single units and are simple to maintain. It is also trying to devise methods of eliminating radio interference from household appliances; low-noise fluorescent lamps, for example, are being developed.

Among the acoustic devices developed or in trial production are a highly directional capacitor microphone, a doughnut-shaped directional microphone for group discussions, a unidirectional microphone, and an artificial reverberation system that independently varies reverberation time, frequency response and transfer characteristic.

Nippon Hoso Kyokia stations, Dec. 1, 1966

	Total	Color	UHF
General television	473	469	136
Educational television	462	458	134
Radio network 1	170		
Radio network 2	131		
F-m, experimental	87		

NHK is also doing research on broadcast sounds and the human voice; in a related project, voice synthesis is being studied with an analog speech synthesizer.

Japanese technology II

Pulses on a television signal control stations in network

Pairs of frequencies transmitted on tv broadcasts identify programs and switch circuits, enabling a centralized computer to operate remote centers

Centralized control of television broadcast stations can be accomplished by inserting pulses on the tv signal. This technique is being developed so that a computer in Tokyo can operate all the broadcast centers owned by Nippon Hoso Kyoki (NHK)—the Japanese Bradcasting Co. Generating and receiving pulses require very simple circuits.

In NHK's experimental system, control signals identify programs or perform switching operations. The signals are a pair of pulses of different frequencies transmitted in the vertical blanking period during each field in a tv frame. As an example, a frequency pair, such as 1.9 and 2.1 megahertz, would indicate a station break and switch the station to a local announcement stored in a tape recorder. Another pair of frequencies, such as 2.7 and 2.9 Mhz, would switch the station back to the original program.

The technique allows simple filter circuits at the remotely controlled tv station to detect signals. Since the pulse generating circuitry is digital, it is easily interfaced with a computer.

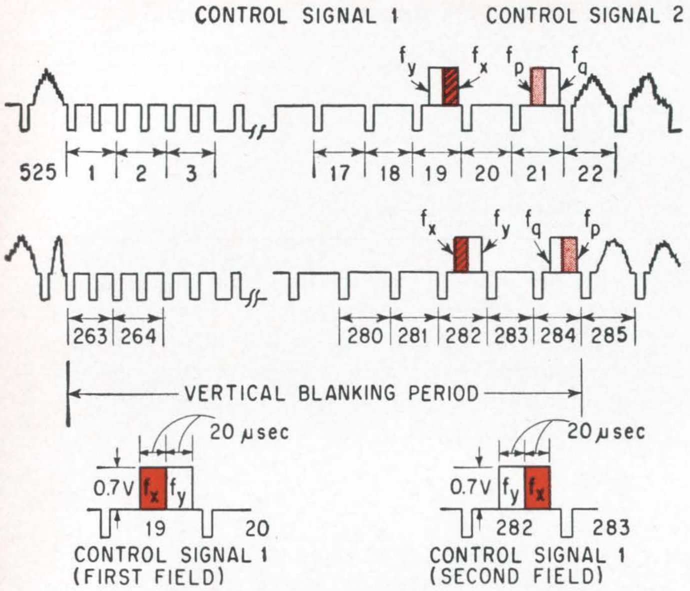
The control signal pulses are transmitted during the 19th and 21st horizontal lines of the first field and 282nd and 284th horizontal lines of the second field. It is easiest to add the control pulses then because there are wide spaces between the horizontal sync pulses that occur in the vertical blanking interval. In addition, adding the pulses during the last few lines in the vertical blanking period prevents interference with the equalizing pulses that separate horizontal and vertical sync pulses.

Signal format

The video waveform diagram on page 102 illustrates how two control signals are transmitted during each field. Signal 1, which is a combination of two frequencies selected from 1.3, 1.5 and 1.7 Mhz, indicates whether the tv program is a special, educational or general broadcast. Signal 2, which performs 15 possible remote switching operations, is a combination of two frequencies selected from 1.9, 2.1, 2.3, 2.5, 2.7 and 2.9 Mhz.

Each control signal consists of a 20-microsecond burst of one frequency—f_x in signal 1—followed by a 20-μsec burst of another frequency (f_y). A similar pattern is transmitted in signal 2, in which the frequencies are designated f_p and f_q. In the first field, signal 1 may consist of f_x followed by f_y; on the next field, the frequencies reverse so that f_y is followed by f_x.

Transmitting two frequencies and reversing them in successive fields, maintains transmission reliability. Frequencies in the tv picture signal will not



Control signals, in color, are added to the two fields that make up a television picture frame. The frequencies of each pair of control signals reverse in successive fields. Control signal 1 identifies the type of tv program while control signal 2 performs a switching operation at the remote stations. The video waveform is shown with the polarity generated at the television studio.

have the same alternating pattern as the control signals and will not trigger the control circuitry. Proper selection of frequencies and transmission time reduces errors caused by crosstalk between the control signals and the picture signals and disturbances along the transmission line.

Generating the pulses

The block diagram on page 103 represents the circuit that generates signal 1 pulses and combines them with signal 2 pulses formed in a separate circuit. A sync separator circuit counts the horizontal sync pulses in the video waveform and triggers the pulse-generating circuit at the beginning of the 19th and 282nd horizontal lines.

If a sync pulse appears on the 19th line it triggers a one-shot which operates a 20-μsec delay. This delayed pulse triggers two one-shots which produce a 20-μsec and 40-μsec pulse. The 40-μsec pulse activates gate 3 during the period that control signal 1 is transmitted.

During the first 20 μsec of the 40-μsec period, the frequency, say f_x, at gate 1 is passed through gate 3 to the output. After 20 μsec, the flip-flop is triggered and reverses polarity allowing frequency f_y to pass through gate 2 and then gate 3. After 40 μsec, gate 3 is disabled and the signals do not pass.

The flip-flop's polarity remains the same until it is triggered by the 20-μsec pulse that occurs during the 282nd line. Consequently, in the next field, frequency f_y will appear at the output first; f_x will appear after the flip-flop is triggered again. Thus the circuit reverses the order of the frequencies in successive fields as desired.

The frequencies to be transmitted are selected by gating signals applied at the frequency selection input of signal 1. These gating signals activate the selection gates connected to the desired crystal-controlled oscillators.

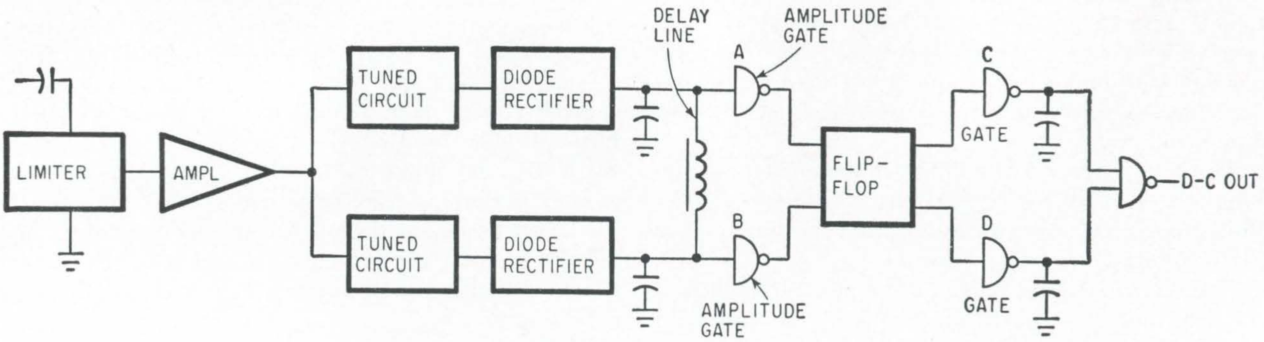
During lines 21 and 284, a similar circuit has generated the control signal 2 pulses. Gate 4 allows these pulses to be interleaved with the control signal 1 pulses and inserted in the video waveform.

Receiving circuits

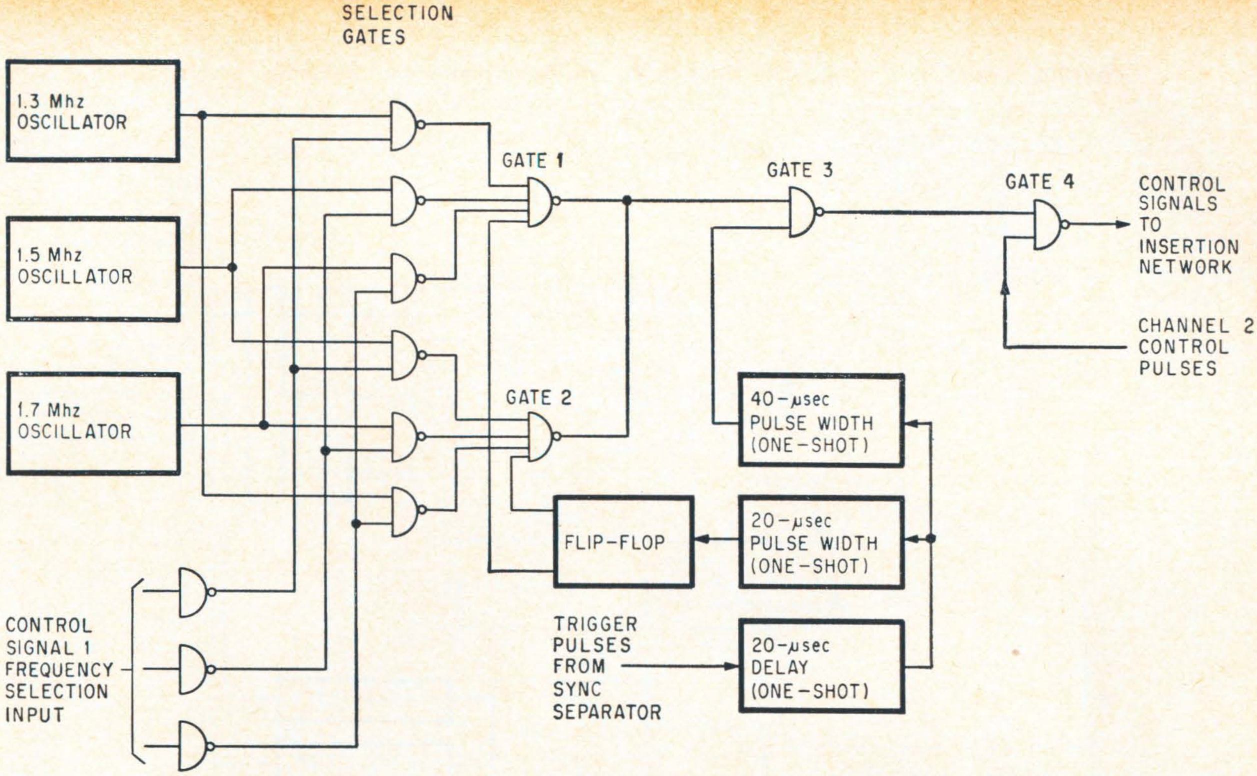
The composite video waveform is transmitted to the tv station where circuits similar to the one in the block diagram shown below detect the control signals. The signal is first limited and then amplified. Tuned circuits separate the control signal frequencies, which are then rectified to produce a simple pulse.

The circuit will produce an output only if the amplitude of the input to gates A or B is the sum of the pulses derived from the two frequencies. Since the pulses are separated in time, a 20-μsec delay line is included to perform the summing.

Assume that the upper circuit is tuned to f_x and the lower circuit is tuned to f_y. If the f_x pulse appears first, it is delayed by 20 μsec in the delay line and arrives at amplitude gate B in time to add to the f_y pulse. The summed pulse triggers gate B, which triggers the flip-flop. Then gate D is triggered, transferring charge on the lower capacitor. In the next field, the signals are reversed and the upper capacitor is charged. After several fields are



Receiving circuit at station separates the two control pulses in tuned circuits, rectifies them and delays the first pulse so two pulses combine to trigger one of the amplitude gates. Capacitors near the output are charged during alternate fields and will trigger the output after a few frames.



Pulse generator and selection network at the transmitter select two of the three frequencies available for control signal 1. A similar circuit performs the same function for control signal 2. Both sets of signals are then combined at the output. The trigger pulses actuate delay circuits and a flip-flop which gate the proper frequencies and reverse the frequencies in each field. Gate 3 is activated only during the 40-microsecond period in which the pulses are transmitted.

received, the charge on the capacitors is sufficient to trigger the final AND gate. A steady output which activates switching circuits will appear as long as the control signals are transmitted.

With different circuitry the frequency pairs could generate digital information. For instance, if f_x precedes f_y the pulse would designate a binary 1; if f_y precedes f_x the pulse would designate a binary 0. Therefore, since there are 60 fields every second, this transmission scheme could add one or more 60 bit-per-second data channels to the picture signal by time division multiplex.

Japanese technology III

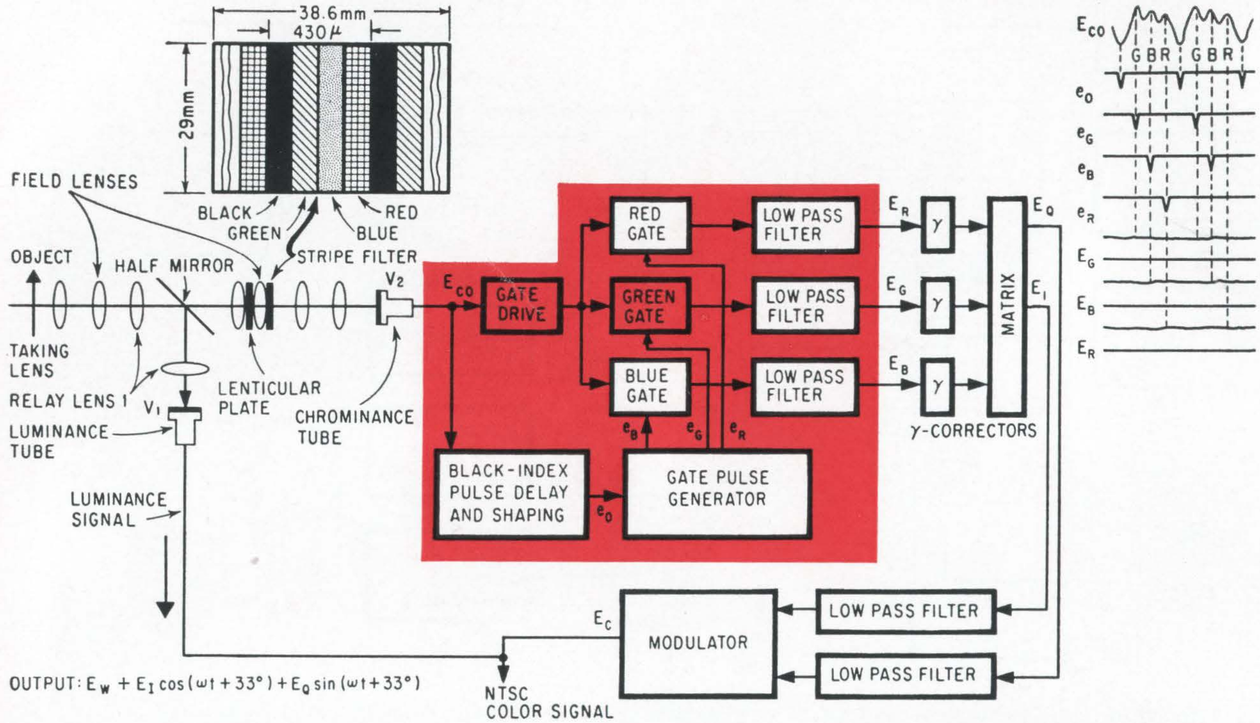
Tv cameras are slimmed down to follow action on sports field

Japanese use only two image orthicons in a lightweight color camera designed for covering outdoor events. One tube handles luminance, the other takes care of three colors

Like overweight ballplayers in spring training, Japanese television cameras are being slimmed down to move faster and react quicker to action on the playing field.

For coverage of outdoor events, NHK Technical Research Laboratories has developed separate-luminance color tv cameras containing only two image-orthicon pickup tubes instead of the usual three or four. The new units weigh 50 to 150 pounds less than conventional studio cameras, and even sharper weight reductions have been achieved in monochrome types.

The newest of these color cameras, a model NHK calls Type II, made its debut last fall at a



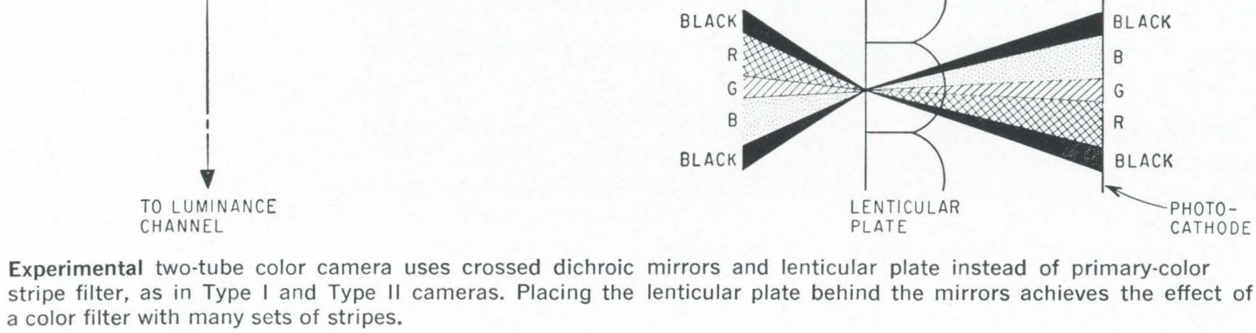
Input signal to two-tube color camera splits into luminance and chrominance signals. Chrominance tube scans signal passing through primary-color stripe filter, then feeds it into dot sequential-to-simultaneous converter. Stripe filter has about 80 sets of stripes in early Type I design, as many as 100 sets in Type II cameras. Luminance and chrominance channels are combined to form NTSC color signal.

baseball game between a Japanese all-star team and the Los Angeles Dodgers in Tokyo. At 155 pounds, it is half the weight of a studio camera.

In this camera, the red, blue and green chrominance signals are separated by an optical filter composed of color stripes. The signals are then picked up by an image orthicon with a magnesium-oxide target developed by NHK [see article starting on page 106].

Under development is a still newer type of camera, expected to further improve color resolution. NHK may replace the Type II camera's tricolor stripe filter with dichroic mirrors. The optical sensitivity would be higher because the mirrors would selectively reflect unwanted color information, instead of absorbing it with the stripe filter.

Meanwhile, NHK is continuing its research on other types of color cameras, including some with four vidicons and some with three image orthicons. The problem in using vidicons in color channels has been that the persistence characteristics of these tubes and the dark-current effect have de-



Experimental two-tube color camera uses crossed dichroic mirrors and lenticular plate instead of primary-color stripe filter, as in Type I and Type II cameras. Placing the lenticular plate behind the mirrors achieves the effect of a color filter with many sets of stripes.

graded the picture produced.

NHK hopes to improve black-and-white sets' reception of color programs through new three-orthicon color camera designs. In these, as in previous similar cameras, one tube detects red, another blue and the third, green. However, bandwidths of the red and blue channels are restricted with low-pass filters while the high-frequency components of the green signal are amplified. This gives a luminance signal in only the green component. The composite signal is similar to that produced by the separate-luminance cameras, but the resolution isn't affected by a shift in channel registration.

The biggest game

Studies of separate-luminance color cameras were started by NHK in 1961. A four-tube camera was tried first, but the image orthicons available at that time were large and the camera was too unwieldy for sports coverage.

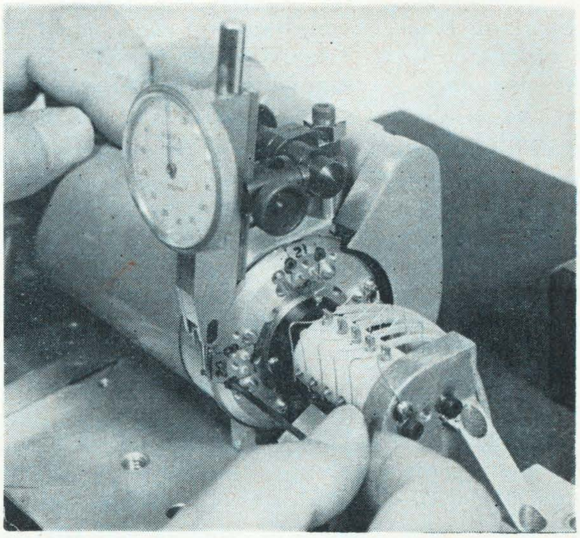
NHK's engineers then developed the predecessor of the Type II separate-luminance camera. The Type I weighs 265 pounds and contains a 4½-inch image orthicon for luminance and a 3-inch image orthicon for chrominance. This camera was completed in time for use at the 1964 Olympic Games in Tokyo, the greatest sports event in Japan's history.

With only two pickup tubes, the Type I's camera-head circuitry is simplified and can be made much smaller. However, the control circuits are more complex because the single chrominance tube makes necessary an initial dot-sequential format of the color information. Conversion to a simultaneous format is then required before the chrominance and luminance channels can be combined for transmission (see diagram at the top of page 104).

Shared scenes

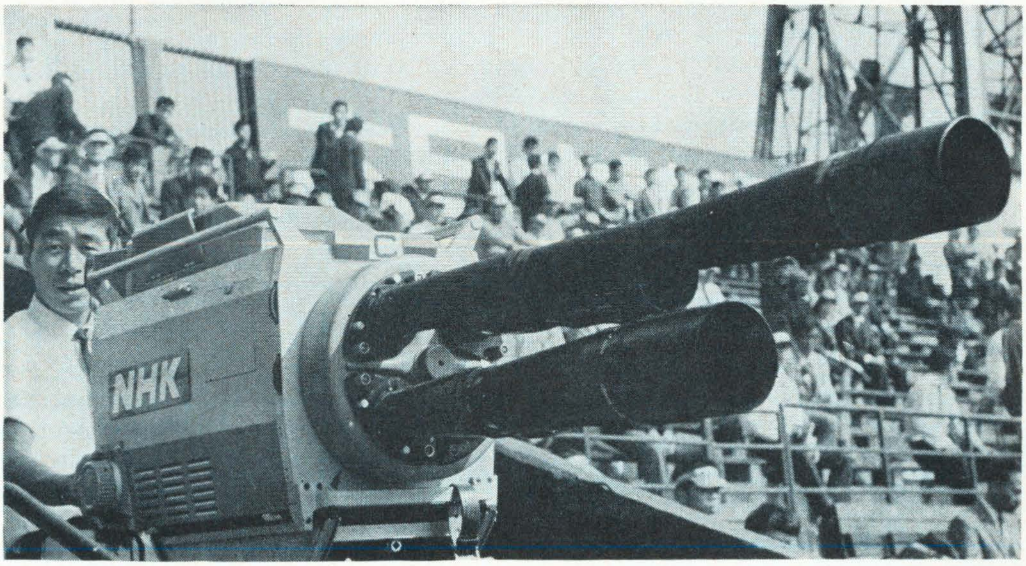
The separate-luminance processing in the Type I camera begins at the input optical system. A half-mirror sends part of the light from the scene through the luminance tube, V_1 (tube type 7295A in the Type I camera and 4415 in the newer model).

The resolution and signal-to-noise ratio of the luminance signal, E_W, which carries most of the black-and-white information, are almost equal to those of a monochrome camera's. The rest of the



At the other end of the color camera

Compact video tape recorders for studios are also being developed at NHK for preparation of news programs in color. One prototype machine, built in 1966, can record for 90 minutes on a 26.7-centimeter reel of tape. Four tracks are recorded on special, low-noise tape, at half the normal tape speed. NHK's engineers designed a new, smaller head mechanism (shown above) with improved sensitivity and resolution. Signal-to-noise ratio is 50 decibels, moiré less than −36 db and phase discrepancies less than 3°, compared with 41 db, −25 db and less than 10° in a conventional studio color recorder, NHK reports.



Lightweight and easy to handle, Type II separate luminance color camera is shown in use at baseball game in Japan.

light passes through the filter, which is composed of bands of black, green, blue and red (shown on the cover).

As this filter is scanned by the chrominance tube, V_2, a dot-sequential signal, E_{CO}, of black index pulses and color pulses is formed (V_2 is tube type M7057 in both camera models). The index pulses are taken out, delayed and shaped to form the gate pulses, e_G, e_B and e_R for the three colors.

After the dot-sequential color signals are gated, the multiplex chrominance signal, E_C, is obtained in a manner similar to that of conventional cameras. Chrominance or saturation correction isn't normally required as it is in other color cameras because saturation is usually within 10% of that of the actual scene. After chrominance and luminance signals are combined, the output signal is compatible with the National Television System Committee (NTSC) standards used in the United States and Japan.

Pros and cons

Spurious color signals can be produced by this technique if the bandwidth of the optical system is more than half the sampling frequency. To limit the optical resolution (the effect is that of reducing bandwidth), a lenticular lens plate is inserted in front of one of the field lenses, as indicated in the diagram.

Sampling frequency depends upon the number of sets of black and colored stripes in the filter. In the Type I camera, 80 sets are used. However, Type II cameras are being field-tested with 90 to 100 sets of stripes to determine whether the increase provides a worthwhile improvement in the resolution of color pictures. Because the color filters absorb light, the optical efficiency of the chrominance channel is reduced. Consequently, the optical transmission and reflectance losses must be minimized.

On the other hand, the separate luminance technique improves color shading, white balance and registration. During black-and-white reception, resolution and signal-to-noise ratio are superior to those of conventional cameras.

The characteristics of the luminance and chrominance tubes need not be uniform. However, to insure accurate gating the resolution of the chrominance tube must be high in the dark regions and the horizontal deflection system must be linear.

Japanese technology IV

Smaller camera tubes feature better targets and cathodes

Composite targets made of magnesium and aluminum oxides plus photocathodes of multiple alkalis improve performance of both 2- and 3-inch television camera tubes

Television cameramen in the field require strong backs or muscular assistants to lug their weighty equipment. The burdens of Japanese cameramen have been lightened, however, as a result of the painstaking work on image-orthicon target and photo cathode materials that has been under way since 1960 at the NHK Technical Research Laboratories.

This effort led recently to the development of a 2-inch image orthicon that can do the job of a standard 3-inch orthicon, even though it has less than half the active area. It owes its higher sensitivity and stability to a new type of target, made of magnesium oxide reinforced with aluminum oxide, and a multialkali photocathode.

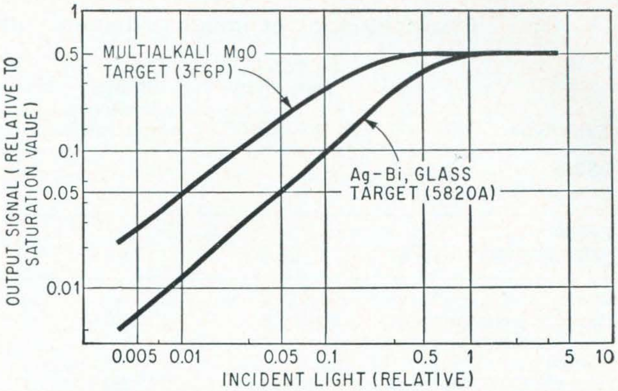
Tube designers at the NHK labs took a 2F3M, and built a new mobile monochrome camera around it. With its transistor circuit control unit and a power supply, the camera weighs only 88 pounds. With a tripod and lens, the head—the business end of the camera—weighs barely 50 pounds. In contrast, a standard 3-inch camera head weighs more than 130 pounds and the system weight runs close to 350 pounds.

The camera gets to work faster, too. It requires only two minutes of warmup time, instead of the 30 minutes required by older models. Resolution is equal to that of a 3-inch camera, 650 lines. Signal-to-noise ratio is now 32 decibels, compared with a 3-inch camera's normal 33 db. Power consumption has been cut in half, to about 300 volt-amperes.

The designers came up with an additional advantage—the camera requires adjustment only once every 10 days. This is due partly to the voltage and current stability of the image orthicon and partly to a low-drift amplifier.

Even smaller monochrome cameras have been built, including one which weighs less than 10 pounds, but the tube is a ½-inch vidicon and the resolution only 300 lines.

Tube improvements—especially the magnesium-oxide target—are also largely responsible for the success of the lightweight color camera described in the article on page 103. Even when the scene illumination is dim, the chrominance tube in that camera can still detect the colors when an image orthicon with a multialkali photocathode is used. NHK has also been using such tubes experimentally in camera relays for the broadcasting of plays from dimly lighted stages.



Sensitivity at low light levels of 3-inch, 3F6P image orthicon with multialkali photocathode and improved magnesium oxide target is much greater than sensitivity of conventional 5820A tube. Target spacing for both tubes is 55 microns; photocathode sensitivity for the 3F6P is 123 microamps per lumen, about twice as high as for the 5820A.

New target

In most image orthicons, a glass target and collector mesh behind the photocathode stores the photoelectrons when the cathode is illuminated by a scene. When the target is scanned by an electron beam, the return beam is amplitude-modulated by the pattern stored on the target.

Despite the use of special glasses, target characteristics change with prolonged use. Inverted afterimages, lower sensitivity and poorer picture tones shorten the useful life of the tube. Low surface resistance makes it impossible to get high resolution when illumination is low. Also, the operating temperature range is small.

Targets made of magnesium oxide don't have these problems. The conduction mechanism is electronic, instead of ionic as it is in glass, so that deterioration is small. The advantages were recognized in 1959, when the General Electric Co. announced development of a magnesium-oxide target for its GL-7629 image orthicon.

Unfortunately, the magnesium-oxide film has to be very thin, which makes the target structure extremely fragile. Only a small amount of tension can be applied to hold the target in position. If it is put close to the mesh, the target may vibrate and create microphonic noise. To prevent this, the target must be about 300 microns away. The wider spacing lowers the signal-to-noise ratio so much that the tubes are generally useless for broadcast applications. However, the ratio of the GL-8092A has been raised to 37:1.

NHK lab workers figured that they could solve the microphonic and spacing problems by reinforcing the target. Eventually, the idea led to the development of targets made of a composite film of evaporated magnesium and aluminum oxides. Such targets can be placed as close to the mesh as 50 microns. Virtually no microphonic noise results and tubes made with these targets have signal-to-noise ratios from 40:1 to 50:1.

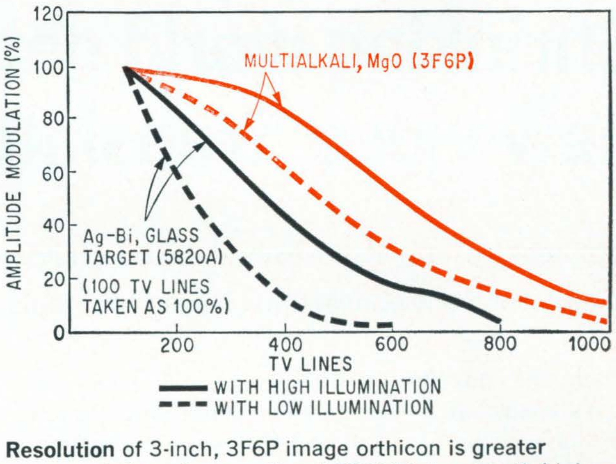
Target surface resistivity is stable and high—above 10^{13} ohms over a temperature range of 20° to 70°C. In contrast, the resistivity of glass targets drops from about 10^{12} to 10^{10} ohms over this range. Resistivity is changed little when the thickness of the composite target is varied between 500 and 3,000 angstroms.

One problem remained—the inverted afterimage. To offset this, NHK deposits thin films of silver and then cesium on the target. Unfortunately, the exact mechanism is not completely understood but the afterimage is reduced.

Multialkali photocathodes

To increase the sensitivity of their image orthicons, NHK engineers also began working with photocathodes made of multiple alkalis. Such surfaces have sensitivities two or three times higher than those of conventional surfaces made with silver and bismuth.

For example, the average photoelectric sensitivity of a silver-bismuth, or S-10, surface is about 50 microamps per lumen. With a multiple-alkali, or S-20, surface, NHK has obtained sensitivities up to 160 microamps per lumen. By using different processing methods, other experimenters have obtained sensitivities as high as 250 microamps per lumen in phototubes. However, the value must be lower in image orthicons because the picture quality de-



Resolution of 3-inch, 3F6P image orthicon is greater than resolution of conventional 5820A tube at both high and low light levels. Low light level is taken as 1/16 of the maximum value of illumination shown in the sensitivity curves.

Characteristics of image orthicons with improved magnesium oxide targets

Tube type	Total sensitivity or f-value*	Photo-sensitivity (μamps/lumen)	S/N ratio	Amplitude response-% (400 lines)	Signal current (μamps)	Target spacing (microns)
2S3M (2-inch; S-10 surface)	13.5	56	50:1	50	14	30
2F3M (2-inch; S-10 surface)	13.5	50	43:1	55	11	35
2F5P (2-inch; S-20 surface)	21.1	150	40:1	70	10	50
5820A (3 inch; S-10 surface)	12.1	50	45:1	55	10	55

* Taken for object of 60% light reflectance, illuminated by 200 lux at kneepoint of tube's operating point.

teriorates when the sensitivity is increased.

The S-20 photocathode consists of sodium, potassium and antimony with a minute quantity of cesium which is believed to attach itself to the surface. First, antimony is evaporated on the inner side of the face plate. Then the vapors of the alkaline metals are absorbed and activated. This produces a semitransparent photoelectric surface with long life, high resolution and high sensitivity.

Targets plus photocathodes

Maximum sensitivity for NHK's image orthicons built with S-20 photocathodes and composite magnesium oxide targets occurs at about 4,500 angstroms. Response tapers off at the wavelength limits of 3,500 and 8,000 angstroms. Dark current is more than an order of magnitude less than that of an S-10 surface.

The great difference in sensitivity at low light levels between an improved and a conventional image orthicon is immediately apparent from a plot of their light-transfer characteristics, top, page 107. Both curves are for three-inch tubes. One, a 3F6P, has a composite magnesium oxide target and a multialkali photocathode. The other, a 5820A, has a conventional glass target and a silver-bismuth photocathode. The tubes also have different electron-multiplier gains. Thus, the curves are drawn for the saturation values of each tube's output.

There is also a difference in the resolution characteristics between the two tubes. The resolution of the 3F6P is much higher than the glass-target tube for both high and low light levels, in the graph, page 107. This is true regardless of the tv scanning rates.

NHK has also substituted the composite magnesium oxide target for the glass target in 2-inch image orthicons. Even though these tubes have conventional silver-bismuth photocathodes, they have almost the same characteristics, summarized in the table above as a standard 3-inch 5820A glass-target tube.

However, NHK is pushing ahead with efforts to combine both the composite magnesium oxide target and the S-20 multialkali photocathode in a 2-inch tube.

Japanese technology V

Shrinking world gets new video 'translator'

Japanese system achieves high picture fidelity by electronically converting relayed tv signals

When the novelty of intercontinental television relays wears off, better ways of converting signals will have to be found to quiet viewers' complaints about poor picture quality.

A German television signal, for instance, conforms to the European broadcast standard of 625 lines per frame and 50 fields per second. Before this picture can be received on Japanese or U.S. tv sets, the signal must be converted to the 525 lines and 60 fields per second standard for black-and-white picture transmission used in those nations.

The conventional way to convert relayed signals involves simply aiming a tv camera at an image storage tube, but a completely electronic system is being developed in Japan to provide greater picture fidelity.

In the case of relayed European-standard signals, NHK Technical Research Laboratories plans to make the conversion by chopping out 100 lines and reassembling the remainder field by field so that there are 10 more fields per second. The degradation effects that arise during this process are to be smoothed out electronically. A breadboard model of the converter has been used to prove the feasibility of this approach, and a prototype unit is now being built.

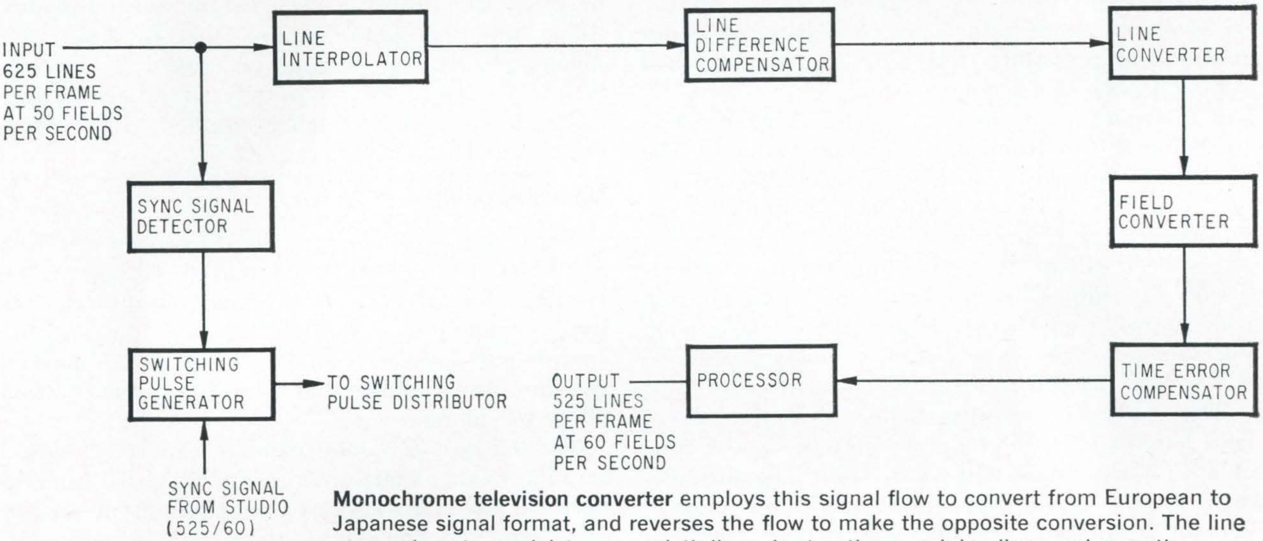
Current conversion methods are electro-optical, with the notable exception of an electronic system developed by the British Broadcasting Corp. to convert 625-line European-standard broadcasts to the 405-line British standard. The inevitable combination of optical and electronic nonlinearities in the usual conversion methods leads to serious degradation of picture quality, especially around the edges of the rescanned pictures.

In conventional conversion, relayed picture images are first reproduced on a storage cathode-ray tube and then scanned by a tv camera. Tonal degradation occurs as it does in a photograph of a photograph. Also, geometric distortions result from nonlinearities in the image and in the camera tubes, their optical parts and their circuitry. In addition, the camera generally scans a slightly decayed image on the storage tube.

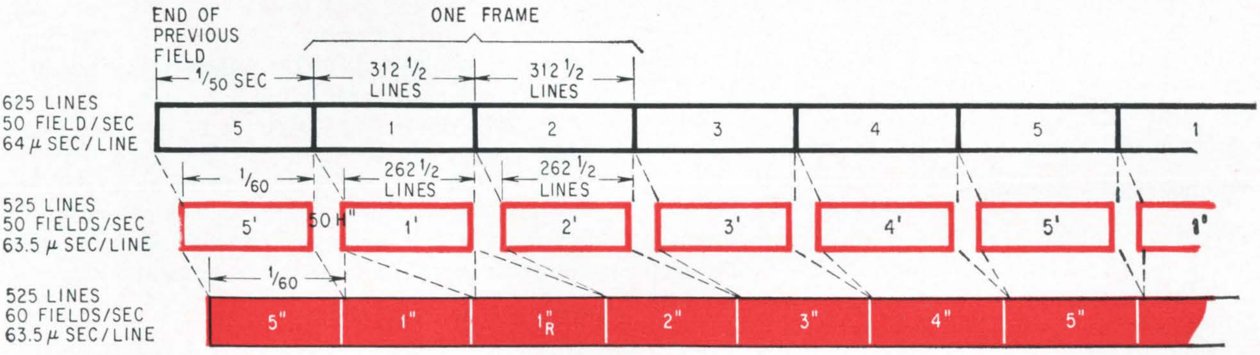
This optical degradation is avoided and the electrical nonlinearities are kept to a minimum when coordinated electronic procedures are used to convert the signal, as in the NHK system.

Magnetic delay line

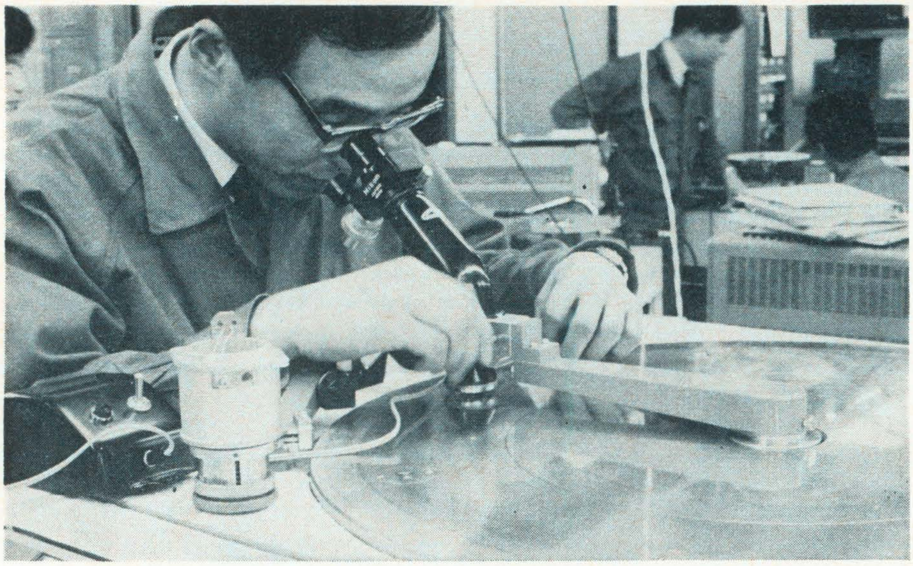
The deletion of excessive lines is accompanied in this system by the closing up of the resulting gaps and by the repetition of some fields to give the appearance of a continuous display. These operations require the use of three types of delay lines: magnetic disk for delays lasting up to an entire tv field; ultrasonic fused-quartz delays for holding a line; and distributed-constant, electrical lines for the short delays needed for fine compensa-



Monochrome television converter employs this signal flow to convert from European to Japanese signal format, and reverses the flow to make the opposite conversion. The line conversion stages delete every sixth line, shorten the remaining lines and smooth out the line-to-line transition. In the field converter, the lines are reassembled as fields and every fifth field is repeated, giving a total of 60 fields a second. The remaining stages adjust the time base and prepare the signal for broadcasting.



Line length and number of lines and fields of a European tv signal are made to conform to the Japanese and American standard in a three-step process, top to bottom. First, 100 lines are taken out of the signal and, second, the remaining lines are shortened and reassembled, producing fields separated by a time equal to one-sixth of a field (50 H"). To make the fields contiguous, field 1' is then reproduced directly as field 1" and duplicated as $1''_R$ in the third step. Room is made for field $1''_R$ by delaying fields 2 through 5 in a magnetic recorder.



Scientist inspects read heads on stationary brass plate which forms part of the magnetic recorder delay line. A disk of magnetic tape material is supported at the center of the plate and rotates past the heads.

tion of line lengths.

The magnetic-disk delay is actually a magnetic recorder designed especially for the conversion system. Unlike an electrical or ultrasonic delay line, it doesn't progressively degrade signal quality as delay times increase. Thus, it solves the major problem of providing delays up to a full tv field lasting 1/60th of a second.

The recording element is a disk, 53 centimeters in diameter, cut from magnetic-tape material. The center of the disk is supported mechanically and centrifugal force supports the rest as the disk revolves. One recording head and six reading heads are spaced along the recording track, which is about 49 centimeters in diameter. The recording track moves past the heads at a rate of 60 meters per second; each space between heads represents a delay of 1/300th of a second.

The conversion requires delays of increments of field lengths with the longest delay being the time of a Japanese black-and-white field. The arrangement allows the same recorder to be used for conversion from the European standard to the Japanese standard and vice-versa.

An erase head blanks out the disk after the signals are read. The magnetic disk rotates over a stationary brass plate which contains the heads. The recording and reading heads have an extremely long life because a layer of air 80-microns thick keeps the contact force between them and the disk negligible. The erase head doesn't make contact with the disk.

Monochrome conversion

To convert from the European to the Japanese standard, the number of lines must be reduced and the number of fields increased. The NHK system eliminates every sixth line until the line count is reduced from 312½ in each field of the European frame to 262½. However, overly long lines and 50 one-line gaps in each field would result if this were all that were done. So the lines are slightly shortened and pushed together. One in every five fields is then repeated to fill the gaps. Lines as well as fields are processed in groups of five.

A problem here is that a person viewing the converted signal might detect sharp tonal gradations or geometric distortions caused by the omissions. As an initial precaution against this, the line interpolator (in the top diagram on page 109) forms a weighed sum of the amplitude of adjacent lines in the input signal, which is applied to the processed signal.

Line shrinking

To shorten the lines from the European duration of 64 microseconds to the Japanese 63.5 μsec, the last 0.5 μsec of each line in each group of five lines is lopped off in the line compensator, and the sixth line is dropped. Usually, line ends are masked by the tv-set cabinet, so the shortening doesn't affect the picture seen.

The 0.5-μsec gaps between lines must be closed up in a manner that provides the 63.5-μsec interval between the horizontal synchronization pulses. In effect, the last line in the group is held stationary while the first four lines are shoved forward in time by delaying them 2, 1.5, 1 and 0.5 microseconds respectively with a group of electrical delay lines in the line converter. This results in a 66.5-μsec gap between groups, because a 64-μsec line has been eliminated while each of the intervening five lines have been shortened by 0.5 μsec.

In a field, these gaps add up to 50 delay units of 66.5 μsec each. In each field, the gaps between the five-line groups are closed up by delays in the line converter. In this case, the delays are multiples of 66.5 μsec and the delay components are ultrasonic delay lines made of quartz crystal.

Slipping in the fields

With this step, each field has the 525 number of lines but there is a gap of approximately 3.33 milliseconds between fields, as in the lower diagram on page 109. The gaps, which each represent one-sixth of a field's duration, are then eliminated by inserting additional fields.

This operation is performed in the field converter with the magnetic recorder delay. Field 1′ is reproduced directly as 1″ while all five fields in the original group are stored on the recorder disk. Field 1′ is also read by the fifth reading head on the recorder, delaying it 5/300 second (5 x 3.33 milliseconds). This repeats field 1′ as field $1''_R$. Fields 2′ through 5′ are delayed 4/300, 3/300, 2/300 and 1/300 second respectively, making room for $1''_R$ and closing up the gaps. Ten fields are inserted, bringing the total to the desired 60.

Smoothing the output

Before a converted signal is broadcast, timing discrepancies are smoothed out by passing it through a time-error compensator—a lumped-parameter, electrical delay line with voltage-controlled capacitor diodes as shunts.

The interpolation at the beginning of the conversion process is done by forming a composite signal representing two adjacent lines. The first line of each pair is delayed so that the amplitude of the two can be added, and the composite signal is then divided, producing an interpolated line signal. The process causes a slight defocusing of the line, but the distortion is far less than that caused by scan conversion.

To convert from the Japanese standard to the European, the procedure is essentially reversed. In fact, with appropriate adjustments in the conversion process, similar techniques can be used with the NHK system to convert any signal format to a broadcast format, and vice-versa.

Further modifications—subcarrier-frequency conversion and subcarrier-phase compensation for line-to-line color interpolation—are needed to convert color signals.

Japanese technology VI

Digital memory calms jittery tv pictures

Video tape recorders can share this time-base correction system, which delays line elements to reestablish standard synchronization

Prerecorded television programs get the jitters if the video tape recorders are not superb. Variations in synchronization and other signal distortions can make the received picture jumpy. Because superlative VTR's are expensive, NHK Technical Research Laboratories is developing a capacitor memory system that will correct the signal time-base and permit broadcast studios to use simpler recorders.

The company's prototype memory divides each horizontal line of the playback signal into discrete digital signals and stores them as voltages for as long as 6.4 microseconds. When the line elements are reassembled by sequential readout, discrepancies of up to about 10% in the time base have been corrected. Plans call for a memory with some 650 capacitors—sufficient to handle worst-case errors in time base. It could store each tv line element for more than 50 microseconds before reassembling the line.

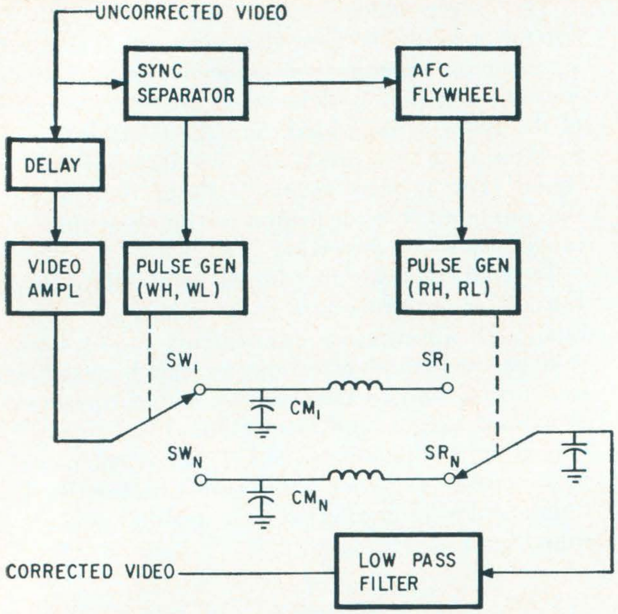
The correction process involves a form of position modulation. Inputs to the memory are timed by the horizontal sync signals in the jittery playback signal. The reassembly is controlled by the average timing between sync signals, obtained in a "flywheel" circuit similar to the automatic frequency control circuit of a television receiver. However, a standard sync-signal generator may replace the flywheel.

Programing aid

Complex and carefully built tape drive mechanisms currently represent about one-third the cost of transverse-scan VTR's, while time-base correction circuits account for about 10%. Built-in capacitor memories would cost more than present correction circuits, but researchers think they will permit simplification of drive mechanisms and thus produce a net saving.

The savings would be bigger if several recorders without correction circuits could share an external memory. A broadcast station might thus have a single memory system handle correction for the different recorders used for a program, commercials, station breaks and preparation of the next program.

Portable VTR's—such as the helical-scan types employed by tv newsmen—don't generally contain correction circuits; they could also share an external



Uncorrected video line signals are stored sequentially in memory capacitors CM_{1-N} by the reading switches at the left. The digital pulse train is read out through the output capacitor and converted back into a corrected analog video signal by the filter.

correction facility.

The new system will also solve some nagging problems with helical-scan VTR's. For instance, it's risky now to record a program on one VTR and play it back on another because recording and drive components rarely match perfectly. Playback synchronization, therefore, would facilitate the exchange of tapes and simplify editing and dubbing.

Trick effects that now require the mixing of live tv camera outputs or special movie films could be produced by merging the playbacks of several VTR's. Called intersynchronization, this process requires a common sync signal to prevent transient changes in sync as the signals of different VTR's are switched into and out of the broadcast signal. With a standard sync-signal generator, the capacitor memory can do the job.

Video flywheel

In the NHK system, each unstabilized video line is processed in 0.08-microsecond elements. The analog video signal is delayed about half the memory delay to allow timing corrections in both directions and amplified to provide a low-impedance drive for charging the capacitors.

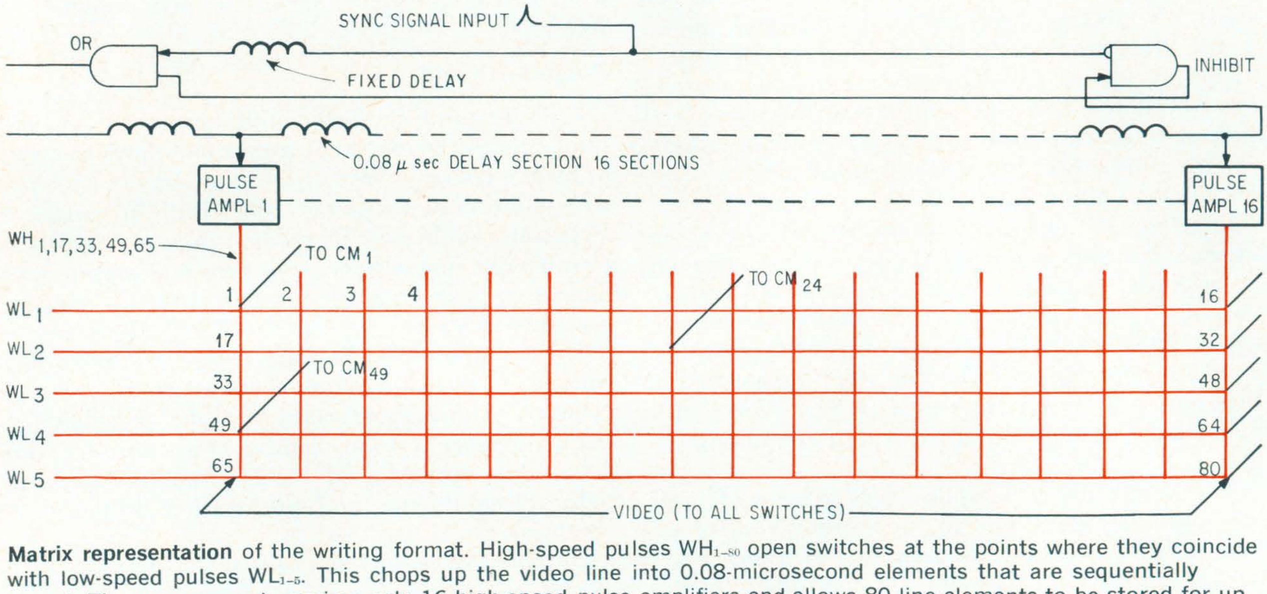
Meanwhile, the incoming sync signal is converted to a sharp pulse repeating at 0.08-μsec intervals in order to sequentially open the switches, SW, at the writing side of the memory. A new processing cycle is started when the following line's sync signal arrives at the writing pulse generator.

A weighted average of the sync-signal frequency for all the incoming lines is obtained in the flywheel circuit. This data provides the corrected time base for operation of the reading switches, SR. As these switches open, the charges in each capacitor are transferred in sequence to the common output capacitance. The voltage level of the charge transferred from each memory capacitor represents the amplitude of that line segment. To convert the output from a digital pulse train to an analog video line, the pulses are passed through a low-pass filter.

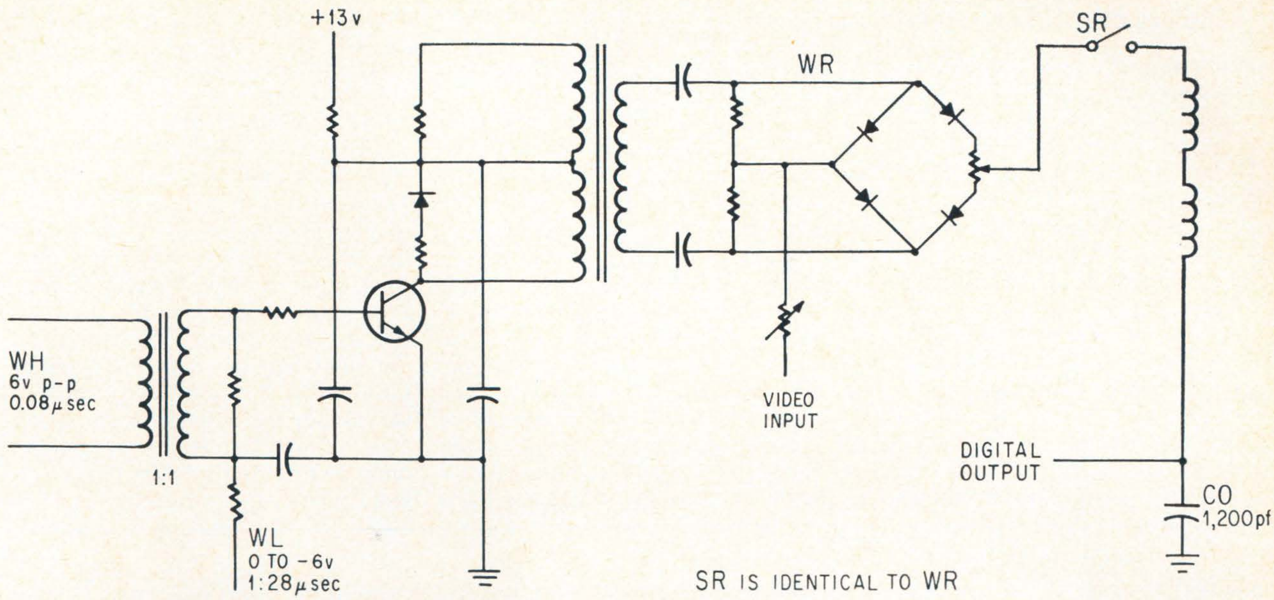
If the recorder is in good running order, the average time base will be as correct as the standard sync-to-sync pulse frequency.

Switching matrix

The 80 writing switches are operated by a combination of high-speed pulses, WH, that are 0.08 μsec wide, and low-speed pulses, WL, 1.28-μ*sec* long—enough to gate 16 WH's and have a center-to-center spacing of 6.4 μsec. Similar pulses are formed for the reading switches, SR.



Matrix representation of the writing format. High-speed pulses WH_{1-80} open switches at the points where they coincide with low-speed pulses WL_{1-5}. This chops up the video line into 0.08-microsecond elements that are sequentially stored. The arrangement requires only 16 high-speed pulse amplifiers and allows 80 line elements to be stored for up to 6.4 microseconds.



Diode-bridge switching circuits are conditioned by low-speed pulses WL and triggered by high-speed pulses WH. Writing switch SW stores a line element as a charge on memory capacitor CM. This charge is resonantly transferred to output capacitance CO when reading switch SR opens.

Gating reduces the number of high-speed pulse amplifiers required on each side of the memory from 80 to 16 and cuts down on system complexity, noise and cost. Each pulse amplifier has a duty cycle of 1 in 16, while the low-speed pulse generators have a duty cycle of 1 in 5 and the switches and storage circuits have a cycle of 1 in 80.

The switching system can be visualized as an X-Y-Z matrix [diagram lower left]. Low-speed pulses enter on the X axis, high-speed pulses on the Y axis and the video signal on the Z axis as a common input to all X-Y crosspoints. Each point in the matrix opens sequentially as coincidences between WL and WH work their way through the matrix in groups of 16.

For example, when WL_1 and WH_1 coincide at the upper left corner of the matrix, the first segment of the video line is free to enter CM_1. After five circulations of the sync pulse through the delay line—taking 6.4 μsec—WL_5 and WH_{80} will coincide at the lower right and enable the 80th line element to charge CM_{80}. A typical line requires about eight such cycles.

To prevent overflow, the charge on CM_1 must be read out when CM_{80} is charged. This clears CM_1 for the 81st line element.

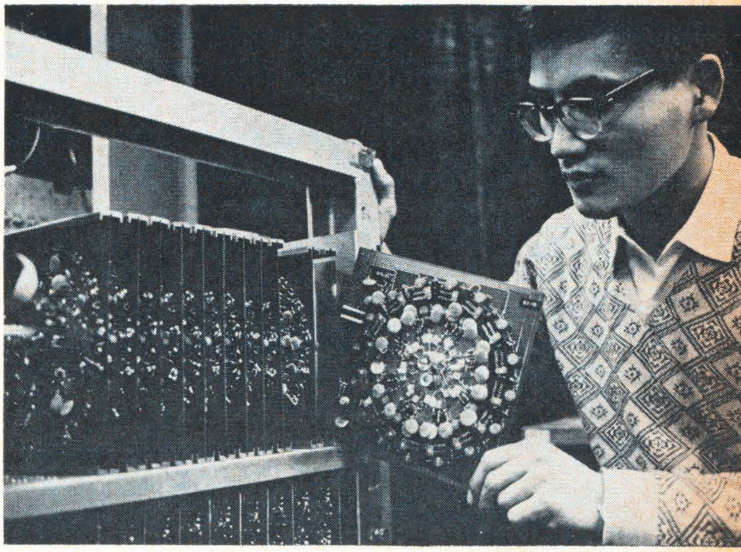
Pulse generation

The first sync pulse enters OR and INHIBIT gates, goes through the line and opens the INHIBIT gate. It circulates until a second sync pulse arrives and closes the INHIBIT gate. The circulation then resumes for the second line. Thus, the actual sync separation of the jittery signal is retained at the writing side of the memory.

Standard television timing requires a sync period of 63.5 μsec, or about 40 circulations through the delay line, and since the maximum delay between operating SW and SR is 6.4 μsec, sync errors of only about one-eighth of a line can be corrected. This is better, though, than the correction achieved by conventional VTR time-base correctors. Also, the capacitor memory responds more quickly to abrupt changes in timing than the servo-controlled delay lines in VTR's.

In a test in which an uncorrected recording was played through the capacitor memory, close analysis of the output signal showed only a slight amount of noise caused by imbalance of the diode bridges employed as switches. The switches are similar to those sometimes used as balanced modulators in telephone circuits; the potentiometers compensate for variations in diode characteristics.

A high-speed pulse and a low-speed pulse are



Capacitor memory's storage circuits are rack mounted in groups of 16.

Delays correct color, too

Minor variations in recording machines add another problem in color television. The hues in the picture lines may be off even if the same machine is used for both recording and playback, as temperature variations can affect the alignment of the reading heads and the length of the tape between color bursts.

The main problem is stabilizing the phase of the color signal, line by line. NHK does this by delaying the line for 1 H, a full period, so the line can be corrected as a unit. Conventional compensators correct the line as it passes through, so the color hues in each line may still be wrong at the right-hand side of the screen and there may be vertical deviations in color.

To the conventional compensation technique—known as zero-order, hold-type compensation—NHK adds linear interpolation compensation. The residual timing error in the zero-order compensation is detected as an error voltage, and a proportional sawtooth voltage is then used to control an electrically variable delay line that cancels it out. The system determines the amount of error by comparing the color-burst signals near the start of each line with the previous signal. Burst signal variations as great as ±4.5 degrees converge to ±0.5.

The one-line delay also gives the system time to avoid correction errors that might occur when the recorder is switching from 16-line channel to another. The switching in the NHK system is synchronized to the last color-burst signal in the channel being switched off. That burst is then considered the first burst in the new channel and the line is corrected according to the time between that burst and the next burst in the new channel. Otherwise, the system might mistake a switching transient for a burst and put out a badly distorted line.

needed to open a switch; WH or RH pulses cannot raise the transistor base voltage above zero. A WL or RL pulse removes the large reverse bias on the transistor so a WH or RH pulse can trigger the switch for 0.08 μsec when it arrives. Ten gating circuits on each side of the memory provide the two-phase gating pulses, which are actually two overlapping pulses.

The chassis isn't used as ground in the NHK system. Instead, to reduce switching noise, pulse transformers couple the pulse-generator circuit boards and video transformers couple the video signals. Discharging the storage capacitors resonantly avoids the need for buffer amplifiers for each memory element.

Gating the video signal itself would simplify the circuitry involved, but the signal would be noisier because it would pass through two switches instead of one. However, this alternative is economically attractive for use in large memories.

Bandwidth of the prototype is theoretically half the sampling frequency of 12.5 megahertz. The best response, however, is achieved in a bandwidth comparable to that of the original video signal, or about 4.5 Mhz. With the filter down 3 decibels at 4.0 Mhz, peak-to-peak switching noise is —50 db steady state and —34 db for transients. The video signal attenuation is only 0.5 db at 2 Mhz and —3 db at 4 Mhz.

Except for the transformers, the switching circuitry could be integrated, but IC's with balanced diode bridges aren't yet available. Built of IC's, the memory would probably cost about as much as conventional VTR correction circuitry.

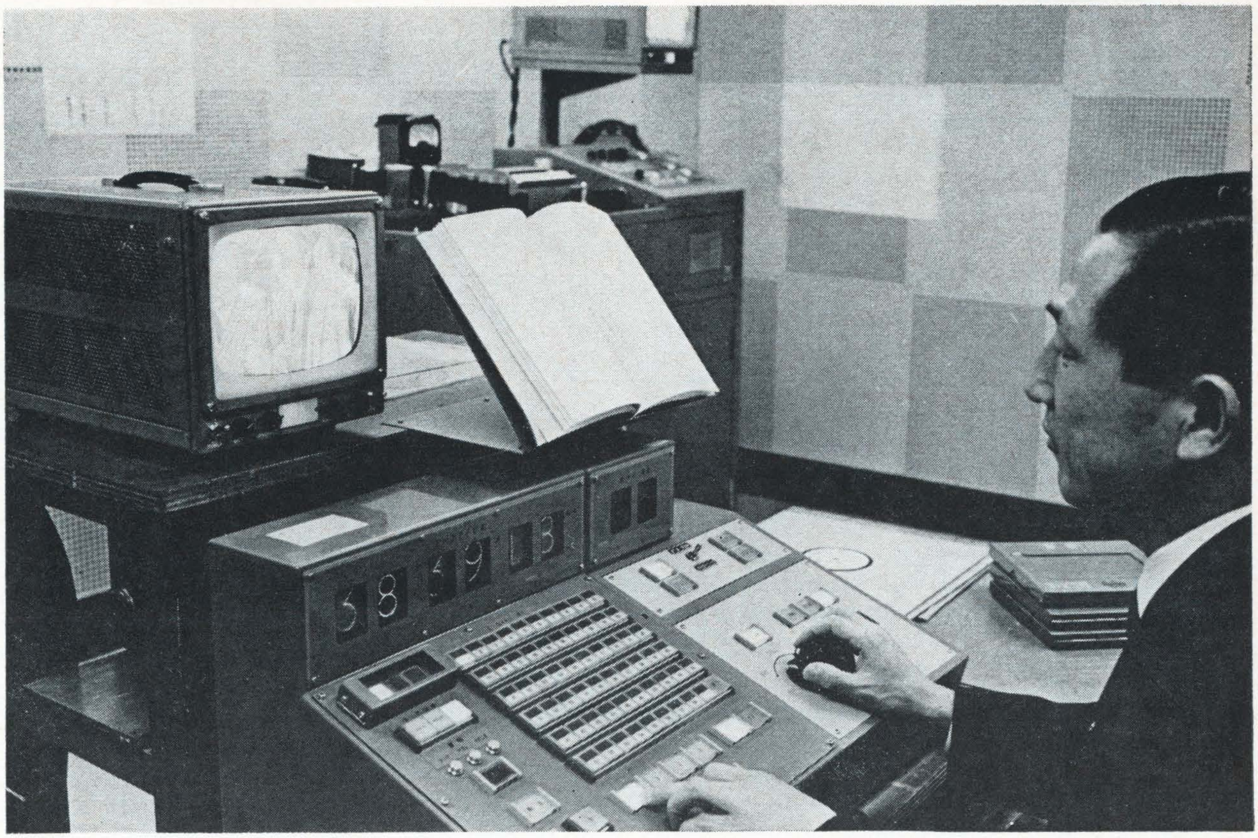
Japanese technology VII

Computer lets tv editors cut out splicing process

Machine follows editing directions in assembling frames of video tape in desired order and adding special sound effects

A leading candidate for the title of world's most sophisticated tv cue card is a process-control system being built for the NHK Broadcasting Center in Tokyo. In automating the process of preparing video tapes, it is expected to afford great cost savings on tapes and tape-editing and audio-dubbing time.

The system will include a computer and a memory of 200,000 bits, enough to store "splicing" information for 20 one-hour programs. Instead of physically splicing tapes—a process that causes noise transients and wastes tape—the system reproduces video and audio information from other tapes. The signals to be magnetically dubbed onto the master program tape are selected by coded minute, second and frame addresses on the original



Television program director, at editing console, views monitor and selects scenes by push-button input to a process-control computer.

recording and a duplicate for the editor.

NHK Technical Research Laboratories has designed the system to ease the editor's job and permit magnetic tape to handle special visual effects in the manner of movie film.

The pilot model allows a tape editor to work without a technician at his elbow and reduces editing time by 35%, according to NHK Labs. It also cuts by 25% the time usually spent recording with expensive four-head, transverse-scan video tape recorders (VTR's), since the video editing is done with an inexpensive helical-scan recorder. NHK estimates that the time-saving properties of the system could reduce costs at a major tv station by as much as $100,000 a year.

The pilot model has a memory capacity of 60,000 bits, enough to assemble nine one-hour programs, with each program drawing on as many as seven different tapes. The computer used is an HOC-300 process-control model made by Hokushin Electric Works Ltd.

Process flow

In the NHK system, the output of the tv camera is simultaneously recorded on four-head and helical-scan VTR's, while the address generator adds coded minute, second and frame address pulses during vertical retrace intervals in the video signal. Using only the helical-scan copy, the editor selects scenes, including stills and slow-motion pictures, slowing or stopping the VTR as he watches his monitor.

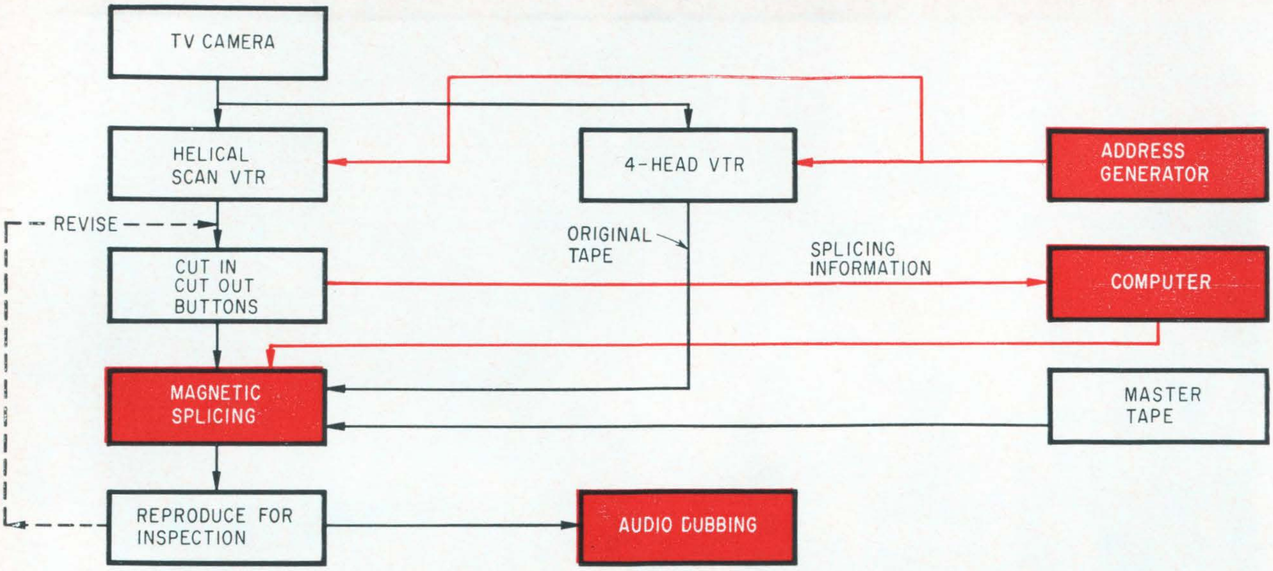
As he pushes "cut-in" and "cut-out" buttons in choosing scenes, the address codes on the tape are sent to the computer, which stores them in its drum memory in the order directed by the editor. There is one drawback here—the editor can't immediately see the over-all result of his editing on the monitor as he can when splicing. However, a poll of NHK editors indicated they felt that viewing the completed tape within a few hours was satisfactory.

The tape recorded on one four-head VTR is played on that machine, while a master tape is recorded on a second four-head VTR. The computer uses the stored address information to select the portions to be recorded on the master tape in the order chosen by the editor.

Audio dubbing

Sound effects are added by a multiaudio VTR. This helical-scan machine, specially built for dubbing by the Victor Co. of Japan, has a 1-inch video track and three ¼-inch sound tracks. The edited video and audio tapes go on the video track and one sound track. Then music and other sound effects are mixed with the original audio on the second audio track at addresses the editor selects. The fourth track remains free for other purposes.

A second HOC-300 computer controls the sound-effect players with scoring information recorded on

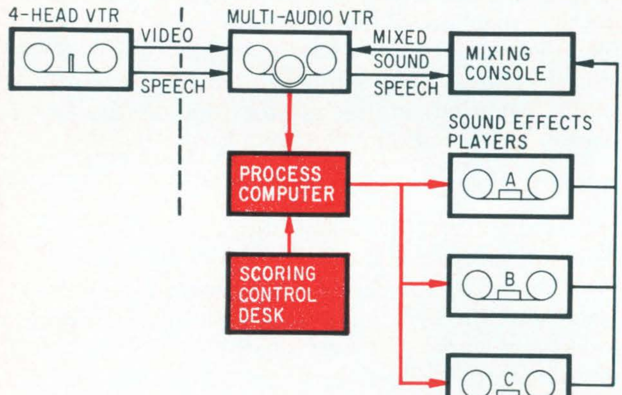


Flow of video editing process. Physical splicing is eliminated as selected scenes from original recording are reproduced on master tape. Color indicates digitally controlled operations.

a drum. This method eliminates manual operation of the players and, therefore, the problems of synchronizing manual operations with the original tape.

When the editor is satisfied with the mixed sound track, it is produced on the master tape with an automatic phase control servo synchronizing the two tapes.

The NHK system thus permits the editor to start and stop his sound track, make revisions and accurately adjust sound-effect start points by changing the address information in the computer memory. The system would replace the current process of reproducing the original four-head tape and dubbing the original tape on a second four-head VTR. Neither tape can be stopped in this older method because the two recorders can't be started up in phase.



Scoring information is fed to computer, which cues in sound-effect tape players. Player output is mixed with original recording's audio and can be revised by changing the digital control information.

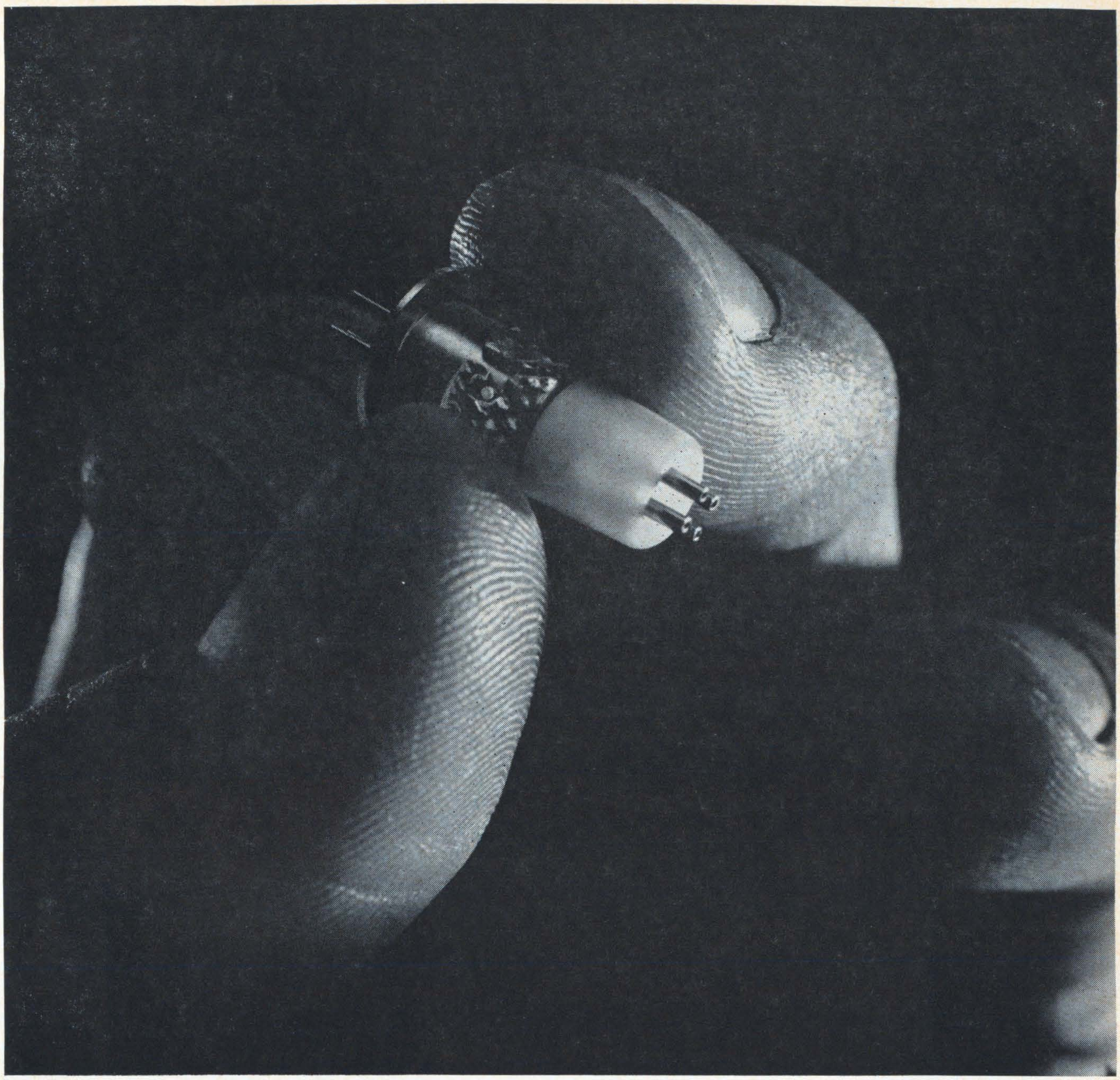
Dubbing movie film

Many of the programs processed at NHK's studio are foreign movie films with Japanese-language tracks dubbed in. A recording technique developed by the company to guide Japanese actors in their dubbing achieves nearly perfect synchronization of the dubbed voices with the lip movements of the performers in the films.

The technique can hold lip-sync variations to one-fifth of a second and allows the actors to deliver their lines with more feeling. The older method of having the actors provide their own cues by watching and listening to the original film didn't permit them to concentrate on acting and was tiring. At the end of a long dubbing session, lip movements were often out of sync by as much as a second.

With the NHK recording technique, the original sound track is first reproduced as an amplitude-modulated waveform on scratch-recording film. As the film is projected on a screen, this waveform flows across the screen under the picture. The heights of the signal components tell the actors where they must provide emphasis in their speeches, and the length of the speeches between breaths is indicated below the waveforms as horizontal lines, with a different track for each actor. Vertical lines give each actor advance warning of upcoming speeches. Programing instructions can also be scratched on the recording.

An editor prepares the cues after the speech waveform is recorded, and the scratch recording and the original sound track are played synchronously. Each time a character in the film pauses for breath or starts talking, the editor has only to push a button representing that character's horizontal-line track. Besides improving acting quality and voice synchronization, the system has reduced dubbing time by 10% to 20%.



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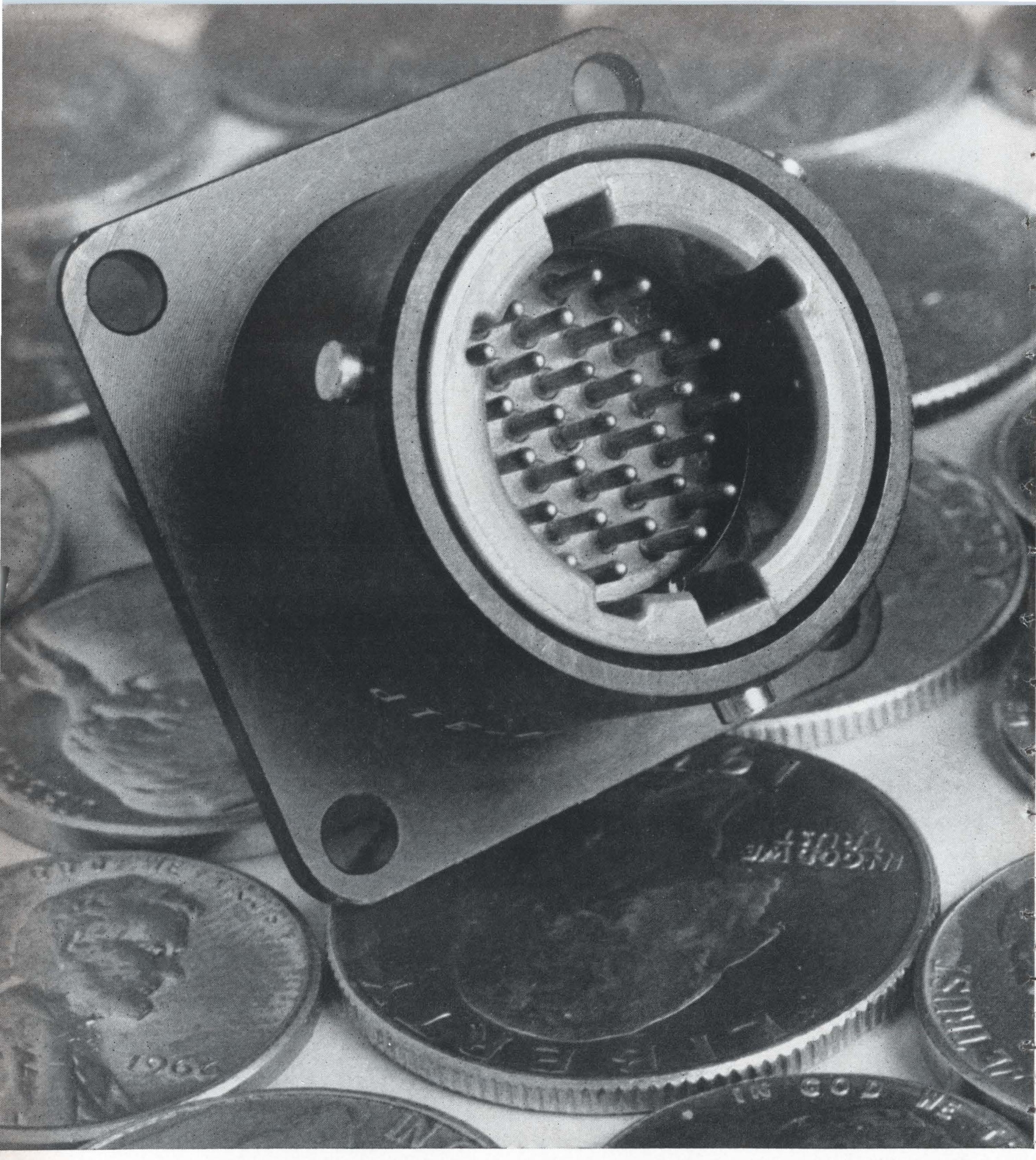

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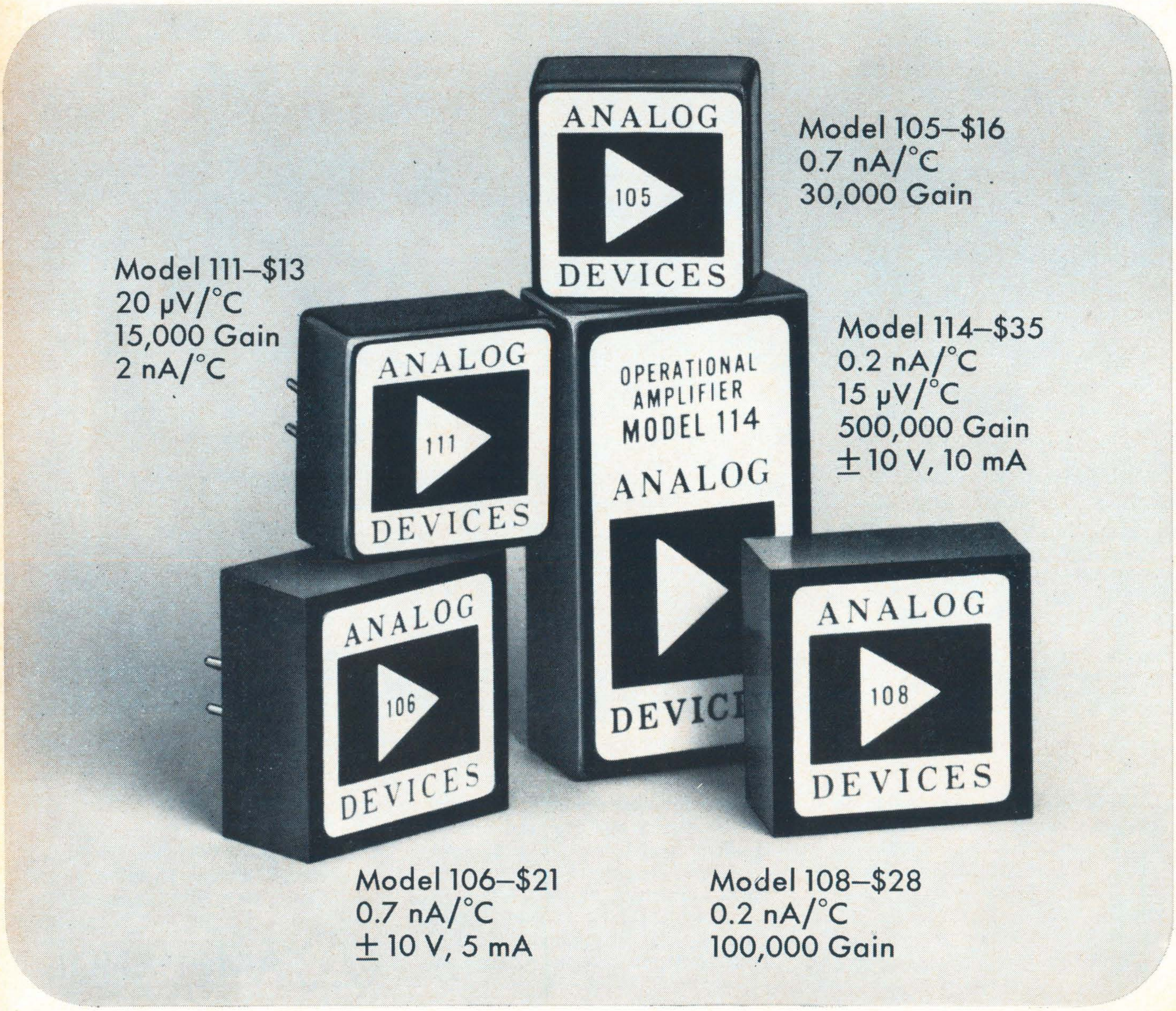

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Parameter	Model 111	Model 105	Model 106	Model 108	Model 114
Open-Loop Gain—min.	15,000	30,000	250,000	100,000	500,000
Rated Output—min.	10 V, 2.5 mA	10 V, 2.5 mA	10 V, 5 mA	10 V, 2.5 mA	10 V, 10 mA
Bias Current—max.	200 nA	50 nA	50 nA	2 nA	2 nA
vs. temp.—max.	2 nA/°C	0.7 nA/°C	0.7 nA/°C	0.2 nA/°C	0.2 nA/°C
Offset Current—max.	20 nA	5 nA	5 nA	2 nA	2 nA
vs. temp.—max.	1 nA/°C	0.2 nA/°C	0.2 nA/°C	0.05 nA/°C	0.05 nA/°C
Input Impedance					
differential	200 kΩ	1 mΩ	1 mΩ	4 mΩ	4 mΩ
common mode	50 mΩ	100 mΩ	100 mΩ	500 mΩ	500 mΩ
Bandwith	1.5 mHz	2 mHz	2 mHz	0.5 mHz	0.5 mHz
Voltage Drift—max.					
Model A	20 µV/°C	20 µV/°C	20 µV/°C	20 µV/°C	20 µV/°C
Model B	—	10 µV/°C	10 µV/°C	10 µV/°C	10 µV/°C
Model C	—	5 µV/°C	5 µV/°C	5 µV/°C	5 µV/°C
		A B C	A B C	A B C	A B C
Price (1–9)	$13	$16 $21 $26	$21 $26 $31	$28 $33 $38	$35 $40 $45

Price Performance Breakthrough — Analog Devices has introduced a step-function improvement in price-performance ratio for low-cost op amps . . . not just a token advance over present-day standards.

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Versus ICs — The new price-performance standards set by Analog Devices economy line clearly resolves the controversy between discrete-component and integrated-circuit operational amplifiers (except where size is the critical factor). Today, and for the foreseeable future, ICs just can't match the current-drift, gain, and input impedance values achieved by these new amplifiers. Model 111, at $9.75 in 1,000-lots, shows that they can't compare in price for a given performance, either.

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	ADO-21	**ADO-23**	**ADO-25**	**ADO-20**	**ADO-22**	**ADO-24**
Open Loop Gain	50,000	50,000	50,000	50,000	50,000	50,000
Gain-Bandwidth Product	10 Mhz	10 Mhz	10 Mhz	10 Mhz	10 Mhz	10 Mhz
Slewing Rate	15 V/μsec	15 V/μsec	15 V/μsec	15 V/μsec	15 V/μsec	15 V/μsec
Offset Current	10 pA	10 pA	10 pA	10 pA	10 pA	10 pA
Input Impedance (Diff.)	$10^{12}\Omega$	$10^{12}\Omega$	$10^{12}\Omega$	$10^{12}\Omega$	$10^{12}\Omega$	$10^{12}\Omega$
Drift vs. Temperature	50 μV/°C	25 μV/°C	10 μV/°C	50 μV/°C	25 μV/°C	10 μV/°C
Drift vs. Time	25 μV/8 hr	10 μV/8 hr	10 μV/8 hr	25 μV/8 hr	10 μV/8 hr	10 μV/8 hr
Price (1-9)	$65.00	$75.00	$85.00	$85.00	$95.00	$105.00

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Probing the News

Meetings

Solid fare at Solid-State Conference

Computer-aided design moves into the spotlight
with large-scale integration and microwave IC's

Computer-aided design will get billing for the first time at the International Solid-State Circuits Conference opening Feb. 15 in Philadelphia. CAD will share the spotlight at the meeting with large-scale integration and microwave integrated circuits.

Although fewer than 10% of the design engineers in the U.S. are currently availing themselves of CAD and only $10 million to $20 million a year is being spent on computerized design programs, these figures represent a spurt from earlier levels and the outlook is for an even sharper increase in the application of the technique.

In one of the papers to be presented at the conference, William W. Happ of the National Aeronautics and Space Administration's research center in Cambridge, Mass., will concentrate on the programs currently available, the standards for such programs and the means by which a computer can be used to achieve LSI.

Graphic displays. Two other papers will deal with specific linear and digital circuit analysis, while another will deal exclusively with graphic displays to permit visual circuit design and analysis. In the latter paper, a low-cost computer console capable of presenting a wide range of graphic displays will be described. The session's final presentation will cover graphics tied to ECAP—Electronic Circuit Analysis Program. After this paper, a 10-minute film on relevant ECAP techniques will be shown.

At an informal evening session on Thursday, Feb. 16, five panel members will discuss such aspects of CAD as active circuit design and active network synthesis. Also, a specific multistage circuit design will be considered from the standpoint of worst-case analysis, pile-up of tolerances and performance characteristics at ambient extremes.

H.H. Ghosh of the International Business Machines Corp. will discuss computer-aided design of specific devices and the use of computers in determining the net results of variations in the diffusion profile. Ghosh believes that as far as IC's are concerned, the best design must consider the effects of loading on other circuits within the cell. Also, since in many cases the performance of the cell can be tested, it's necessary to know the sensitivity of the whole device to a particular component. If, with the aid of a computer, such sensitivity can then be related to some basic process parameters and mask geometry, fabrication time and the cost of making IC's can be cut.

I. Dovetailing techniques

The hand-in-glove nature of LSI and CAD will be underscored on Thursday in a paper presented by C. Hugh Mays of the Fairchild Camera & Instrument Corp.'s Semiconductor division. Mays contends that the only way to achieve the large number of designs predicted for large-scale arrays is to use computers for design work as well as bookkeeping chores.

Topic of discussion. Using computers to design circuits and interconnect large-scale arrays.

He suggests that device manufacturers make a limited number of arrays, processing them up to, but not including, metalizing. The yield for each type of array would have to be high since the CAD technique proposed by Mays would produce just one set of metalization patterns per array type instead of the unique patterns necessary in the discretionary wiring technique [Electronics, Sept. 19, 1966, p. 110].

To use the proposed CAD system, the customer would be expected to supply both logic and test specifications. The CAD program would then be used to confirm that the specs were legitimate and that the logic could indeed perform such specific functions as addition.

Layout. When the design was debugged with the help of the computer program, the physical laying out of the array could begin. The computer would automatically assign logic to specific locations on a standard array and the "handiwork" of the computer could be viewed on a cathode-ray tube. The designer could then alter the assignments made by the computer if he wished by using a light pen and input console.

An informal session on Wednesday evening will take up the problems and potential of LSI in peripheral equipment for time-sharing. The discussion will probably center on LSI in small, low-speed terminal devices that provide access

. . . Why integrate? A basic question in microwaves where performance outweighs size reductions . . .

to large time-shared central processors, like keyboard-printer units at airline ticket windows.

II. Microwave

Frank Brand of the Army Electronics Command, Fort Monmouth, N.J., will moderate an informal Thursday evening session on the special problems of microwave IC's. Brand hopes the panel will address itself to the case for and against integration and the question of hybrid versus monolithic approaches.

Brand believes the only sound basis for integration is performance. While significant gains in weight and size can be achieved by integration, he says, such accomplishments are generally made only at some sacrifice in performance. What, Brand asks, are the design advantages in terms of noise, gain and bandwidth? He concedes that it's possible to get greater complexity within certain weight and size limitations through integration, but asserts that much still has to be done before it can be achieved without sacrificing performance.

So far, in Brand's opinion, the hybrid approach to integration holds the edge over the monolithic as regards microwave applications. He contends that the performance of some monolithic IC's, while surprisingly good, isn't yet up to that of conventional circuits in comparable applications, and cites monolithic balanced mixers in which the noise level is usually 2 to 3 decibels higher than that produced in conventional models; hybrid integrated devices yield noise about 1 db higher than conventional versions.

Cut-and-try. The program chairman, E.D. Maynard Jr. of the avionics laboratory at Wright-Patterson Air Force Base, says the papers at the formal Thursday conference session point to greater acceptance of IC's in microwave applications. He agrees generally with Brand's opinions, but sees some other problems involved in the use of microwave IC's. He notes, for example, a need for power sources that can be integrated, and he holds that Gunn oscillators and avalanche diodes are steps in the right direction.

Maynard also feels that better synthesis procedures are needed in designing circuits with a microstrip line. Although the broad techniques of microstrip are pretty well known, an exact synthesis procedure isn't available. Because microstrip line is moderately dispersive, it doesn't lend itself to exact analysis and design is thus still a cut-and-try procedure.

Connectors are also a problem, according to Maynard. The difficulty in getting in and out of a package efficiently varies with the complexity of the system, unless a high degree of integration exists.

Mixed approach. Maynard feels there is no real competition between hybrid and monolithic devices in microwave applications. He says there will probably always be a mix because of the different technologies involved.

Maynard believes CAD can be a very valuable tool in designing microwave IC's, and that it will eventually be possible to have an on-line setup in which the circuit-design engineer will punch his requirements into a computer that will then list the necessary components, lay out the circuit, analyze the breadboard and compare the working model with experimental versions to make modifications. He warns, however, that a precondition for such an operation is an understanding of microstrip synthesis problems.

Systems applications of solid-state microwave technology will be discussed by speakers at a Wednesday session. New devices, the methods of incorporating them in circuits and their implications for future large-scale microwave arrays will be covered.

New bulk effect. M.R. Barber of the Bell Telephone Laboratories will deliver a paper on microwave oscillators, including both junction and bulk-effect devices. The presentation will cover methods of increasing tuning ranges, reducing noise and operating efficiently at high power, and will also include circuits employing the newly developed limited space-charge accumulation (LSA) bulk-effect device, which can produce relatively high-power oscillations in the millimeter wavelength. [For more on this device, see page 127].

Another informal Thursday evening session will deal with circuits that can modulate microwave carriers with digital information. One of the circuits to be discussed is a sensitive voltage-tuned 1.3-gigahertz oscillator requiring a driving voltage of 25 millivolt. This device can be phase-modulated with a 360-megabit-per-second signal. The panel will also consider factors limiting the speed of solid-state components and circuits.

A formal session Friday on microwave circuits will be one of three dealing with circuit characteristics in systems applications. One paper will cover the computer program used by Texas Instruments Incorporated to optimize ultrahigh-frequency and microwave circuits, a program that predicted the gain of an S-band amplifier to .5 db over a 500-megahertz bandwidth—no mean task.

III. Never the twain

An argument that began during a session of last year's conference is likely to be joined again this year. At issue is the proper design of varactor multipliers, still apparently a burning question eight years after the development of these devices.

Robert D. Hall of Hewlett-Packard Associates, chairman of the Wednesday session on microwave generation, leads the group, identified with the West Coast, that takes a time-domain approach to the varactor-multiplier design, while Robert Rafuse of the Massachusetts Institute of Technology is the consensus leader of the Eastern faction, which favors frequency-domain techniques.

It's difficult to form an equation for resistance, inductance and capacitance in a varactor circuit, since all three variables shift with voltage. If the circuit is linearized, its value as a multiplier is sacrificed. The time-domain solution has been to construct an equivalent circuit using Fourier analysis as guidance for the design.

Serendipity. Early in the 1960's, Hewlett-Packard began work on a step-recovery diode in which a vari-

able capacitor was to be controlled by voltage. The goal was to generate fast pulses, but it was learned that under certain circumstances the pulses could excite resonant tank circuits and produce a useful continuous-wave output at a frequency different from the input. "We thereby backed into the frequency multiplier business," Hall explains.

This "West Coast" approach led to attempts to simplify the circuits in order to minimize the choices of resistance, capacitance and inductance. But the "Eastern" Fourier path led to the development of idler circuits, which resonate at some frequency that is neither that of the input nor that of the output. In other words, "idler" represents the mathematical Fourier component of a current at a particular frequency.

Hall and his supporters profess to be baffled by the idler circuit. "Is the current real?" they ask, "and if so, where does it go? Is the circuit real, and if not, where is the current?"

In any case, the argument is due for a rerun at Philadelphia, as MIT's D.H. Steinbrecher will present a paper on efficiency limits for tuned harmonic multipliers with punch-through varactors. This paper will also cover idlers at all intermediate harmonics of the drive frequency. A contrary approach will be presented by M.E. Hines and J. DeKonig of Microwave Associates Inc. in a paper on high-ratio moderate-power harmonic generation with snap varactors. Theoretical and experimental efforts to come up with simple multipliers without idler resonances will be discussed.

Hall observes that CAD hasn't yet made much of a dent in the frequency-multiplier field. Although programs have been written, he says, they haven't proved very useful to the hardware designer. Steinbrecher, however, will touch on a computer-aided theoretical analysis.

IV. Unglamorous problem

A familiar refrain in the semiconductor business—the assertion that the package has become as important as the chip itself—will occupy the attention of a Wednesday evening panel on microwave power generation. Inner electrode capacitance becomes a problem in a three-lead package, explains Irving H. Solt, manager of microwave products for Fairchild Semiconductor, who will lead the informal discussion. Fairchild has gone to a coaxial package with leads in a row, while TI has developed a package with flat leads in a radial "T"; some other companies lean toward stripline techniques.

"This problem has been somewhat neglected because it's unglamorous," says Solt. "But if you have a problem with chip design, you can get a half dozen Ph.D.'s to jump at it."

The panel will also discuss the performance of transistors, Gunn-effect devices and avalanche devices at frequencies above 1 Ghz. Solt notes that transistors are approaching a finite limit of about 10 Ghz. Fairchild is marketing a low-noise local oscillator that is tunable between 5 and 6 Ghz, and fundamental oscillators with 10% bandwidths are available from 1 to 2.3 Ghz. As for power, TRW Inc. claims 5 watts at 1 Ghz from a single transistor, and Fairchild has put four transistors in parallel to get better than 5 watts at over 1.5 Ghz. For pulsed power, Gunn-effect devices look promising; one of the panelists, Daniel Dow, is from Varian Associates, which has reported pulses of 380 watts at 1.1 Ghz.

V. Thinking small

Since IC makers rarely think big, designers of solid-state image displays are experiencing difficulty in integrating the circuitry that addresses displays. While address circuitry can be assembled behind the display panel, designers would prefer to integrate it. Integrated circuit chips as large as a display panel aren't practicable, so the search is on for a way to spread the devices. One obvious approach would be to scatter chips across a large substrate, but the technique has yet to be proved practicable.

These and other considerations may key the discussions at an informal Wednesday evening panel session on solid-state image sensing and display. The moderator, Bernard J. Lechner of the Radio Corp. of America, points to a more pressing trouble spot. While designers of digital IC's have been concentrating on low voltage devices for computers, displays require relatively high voltages, usually 40 to 100 volts.

The integration of image sensors is further along than integration of displays. As sensors can be very small, they are easier to fabricate as IC's. Two panelists, Paul K. Weimer of RCA Laboratories and William F. List of the Westinghouse Electric Corp., are on teams that have already completed experimental models under government contracts. The RCA sensor is made by depositing thin-film photoconductors; the thin-film transistors of the addressing and control circuitry are deposited around the periphery of the sensor. Westinghouse has been diffusing its elements into semiconductor crystals. Both of these devices perform somewhat like television camera tubes, though with a much lower resolution.

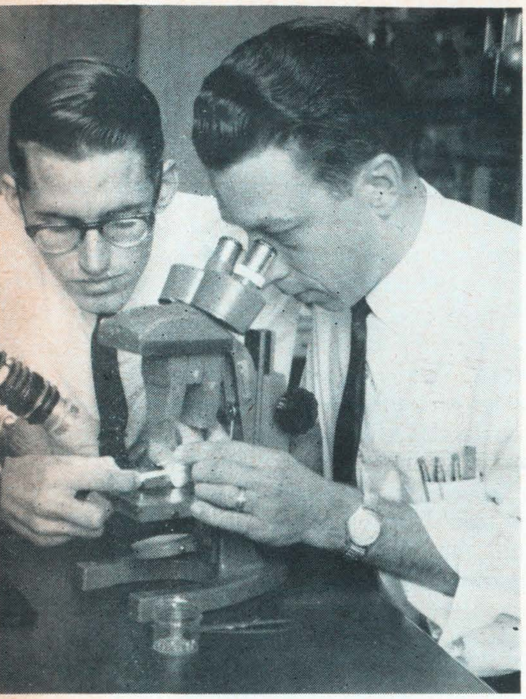
Suppressing space charge improves Gunn effect

By Leonard Weller

Communications editor

While working with a computer model of a Gunn-effect device, John Copeland, Bell Telephone Laboratories engineer, found that the computer predicted higher outputs than expected under special conditions in the gallium arsenide crystal and in the external circuit.

Copeland investigated and soon identified a significant mode of oscillation in the bulk gallium arsenide. Diodes operating in this mode



LSA mode. John Copeland, left, and Robert Spiwak, Bell Laboratories engineers, load a bulk n-GaAs diode into a 90-gigahertz oscillator circuit. Copeland will discuss the device, which operates in the LSA mode, at the Solid-State Conference.

promise peak pulse powers now achieved only with klystrons. They can operate at high frequencies, in the millimeter wavelength and possibly into the far infrared, at low power.

Copeland's new mode of diode oscillation—called limited space-charge accumulation (LSA)—suppresses the accumulation of electrons that usually form in Gunn-effect diodes. In the Gunn-effect diode, a space charge travels through the semiconductor material. As it reaches a contact, another forms at the opposite contact. The time it takes for the space charge to travel through the material determines the operating frequency. Thus, the frequency of a Gunn-effect diode depends on its thickness.

Suppressing the space charge results in a diode whose frequency is independent of transit time. The frequency is determined by an external resonant circuit, usually a cavity.

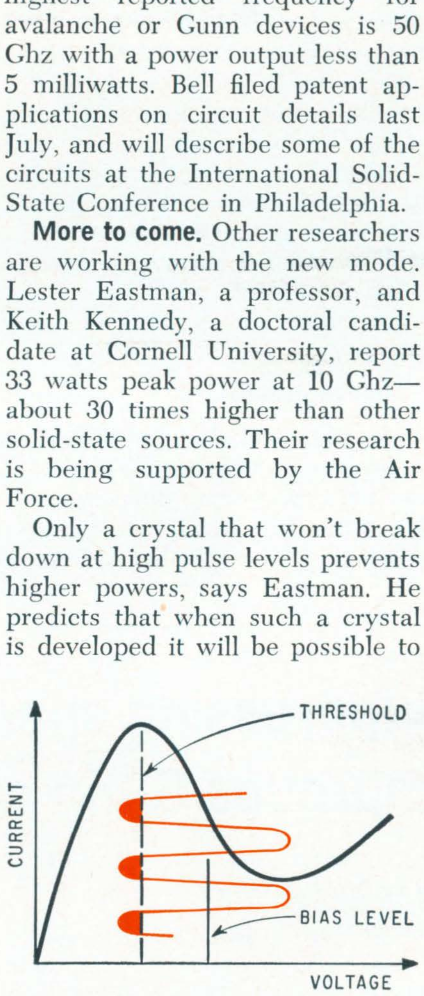
With the frequency independent of the GaAs's thickness, the new devices can be 100 to 1,000 times thicker. For instance, at 10 gigahertz, instead of being 10 microns thick, the device could be 1,000 microns thick. A proportionally higher voltage can be placed across the thicker section of material. Since power is proportional to the square of the voltage, powers can be 10^4 to 10^6 times greater at any frequency.

Higher powers. Copeland recently reported testing LSA diodes at frequencies from 1 to 88 gigahertz. Pulse powers range from 90 watts at the lower frequency to half a watt at the higher frequency, equalling or exceeding the outputs and efficiencies of earlier solid-state sources in most cases. Varian Associates of Palo Alto, Calif. has operated a Gunn-effect device at 380 watts peak at 1.1 Ghz.

Bell Labs, a subsidiary of the American Telephone and Telegraph Co., also has operated LSA devices in a continuous wave at frequencies from 50 to 88 Ghz with a power output of 20 milliwatts. The highest reported frequency for avalanche or Gunn devices is 50 Ghz with a power output less than 5 milliwatts. Bell filed patent applications on circuit details last July, and will describe some of the circuits at the International Solid-State Conference in Philadelphia.

More to come. Other researchers are working with the new mode. Lester Eastman, a professor, and Keith Kennedy, a doctoral candidate at Cornell University, report 33 watts peak power at 10 Ghz—about 30 times higher than other solid-state sources. Their research is being supported by the Air Force.

Only a crystal that won't break down at high pulse levels prevents higher powers, says Eastman. He predicts that when such a crystal is developed it will be possible to produce 400,000 watts pulse power at 10 Ghz with pulses of a half to 1 microsecond duration. Eastman feels the breakthrough could come within the next four years. Eastman and Kennedy are investigating pulse applications for possible use in radars at frequencies below 10 Ghz Varian is also investigating the LSA mode for a possible Air Force application.



Current-voltage curve, in black, for LSA diode exhibits uniform negative conductance—indicated by the portion of the curve directed downward to the right. Oscillations, in color, below the threshold level suppress space charge that forms in Gunn-effect devices.

How it works. For the LSA mode to form, the ratio of the GaAs's doping level, n, to the frequency of oscillation, f, must lie within the limits

$$2 \times 10^5 \geq \frac{n}{f} \gg 10^4 \text{ sec/cm}^3$$

where n is the number of charge carriers per cubic centimeter. The values of n/f are functions of relaxation times which fix the rate at which the space charge builds up or dies out. A second condition for LSA operation is that the external resonant circuit must present a high impedance to the crystal so that oscillations with large amplitudes occur. Also the d-c voltage applied to the diode must produce an electric field within the GaAs that is triple or quadruple the threshold field, which is 3,700 volts per centimeter. The threshold field is the level at which a heavily doped diode would break into conventional Gunn oscillations.

The LSA diode's current-voltage curve provides a simplified explanation for the n/f restriction and the suppression of the space charge. The solid vertical line in the diagram is at the external voltage which biases the GaAs to 3 or 4 times above the threshold field. Oscillations occur in the LSA diode's negative resistance region represented by the portion of the curve sloping down towards the right. When the oscillations are large, a portion of the cycle swings into the positive resistance region to the left of the threshold level, and suppresses the space charge. If the frequency increases the oscillation will dip into the positive region more frequently. Therefore the doping level, n, can be higher as the frequency goes up because the space charge will have even less time to accumulate. However n must be low enough at all times to prevent a significant charge accumulation.

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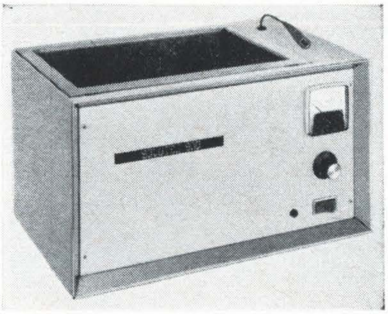

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Federal budget

Escalating the economy

Fiscal 1968 budget has new look and more money for military, space and civilian electronics

Candor, caution and compromise in varying proportions characterize the U.S. budget for the fiscal year beginning July 1, 1967. Vietnam costs have been realistically underwritten for the first time since the war began. But such sizable projects as Nike X, the supersonic transport and Project Rover, all of vital interest to the electronics industry, still await a decision. Offsetting these uncertainties is the fact that the nation's space effort has been upgraded while more politically palatable Great Society programs are slated for only modest budget boosts.

President Johnson's record request is, however, somewhat ambivalent since he has resurrected the national income accounts budget. The NIA, hitherto the preserve of professional economists, presents a complete picture of the Government's financial activities, taking into account all Federal operations, including trust funds such as those for highways and Social Security. The more familiar but less comprehensive administrative budget is the one for which Congress votes appropriations, while the cash budget keeps track of income and outgo.

Estimated NIA expenditures during fiscal 1968 total $169.2 billion, with an anticipated deficit of $2.1 billion. Outlays are up $15.6 billion and receipts $17.3 billion from the prior fiscal year. The administrative budget of $135 billion would yield an $8.1 billion deficit. Administration critics point to the $6 billion disparity between the two deficit figures, but supporters of the President maintain that NIA is being stressed only because policymakers would like to see it achieve greater currency among legislators considering spending and taxation proposals.

Electronics companies will be able to take advantage of a number of new opportunities in the military, space and civilian sectors. Poseidon, the Voyager spacecraft and an Apollo applications program are among the new projects to be funded in a big way during fiscal 1968. The commitment to civilian space spending is especially good news since the groundwork has been laid for average annual outlays of $5 billion through fiscal 1970. More than half of these monies are earmarked for electronics. Not all the returns are happy, however. The Federal Aviation Agency's wings were clipped, and several programs FAA officials considered crucial will have to go by the boards.

Finally, electronics concerns can hopefully eye history's largest contingency fund—the $2.2 billion set aside for the deployment of Nike X, intensified development of a nuclear rocket and construction of a prototype SST. Previously used for relief purposes in times of natural disaster, contingency monies have become an economic and political tool.

Probing the budget

Military electronics

Billions for defense

The war in Vietnam chews up a lot of aircraft. Expenditures for replacements as well as tremendous amounts of other equipment are the major reason why the defense budget continues to climb in fiscal 1968. The President is asking for $75.27 billion. In fiscal 1967, the original defense request was $61.42 billion but a $12.3 billion supplemental for Vietnam had to be tacked on. The electronics industry's share of fiscal 1968 outlays for hardware and equipment is $5.937 billion, according to data compiled by the Electronics Industries Association.

There are no big surprises in the defense budget. As expected, a large—$1.115 billion—outlay has been ticketed for Poseidon. Nike X stays in the budget although as a development program rather than a production item. There will be $5.8 billion for defense research and development programs. Total expenditures for the diversified general-purpose forces used to counter nonnuclear threats faced by the U.S. will come to $34.4 billion.

More for planes. To replace the aircraft shot down or worn out in combat there is a 1968 budget request for $9.111 billion; the 1967 Southeast Asia supplemental for this purpose amounted to $3.715 billion. For this money, the armed forces are getting 2,441 new helicopters and 2,542 fixed-wing aircraft. Among the bigger buys are the Army's UH-1B/D Iroquois transport helicopter and the AH-1G HueyCobra chopper that will go to Vietnam this spring with five

Defense budget by mission
(Billions of dollars)

	Fiscal 1967*	1968
Strategic forces	7.1	8.1
General-purpose forces	34.3	34.4
Specialized activities	4.9	5.3
Airlift and sealift forces	1.5	1.6
Reserve and guard forces	2.6	2.8
Research and development	5.4	5.8
Logistics	6.3	6.0
Personnel support	8.2	8.9
Administration	3.0	3.1
Military assistance program	.9	.6
Total obligational authority	74.2	76.6

*Includes $12.3 billion Vietnam supplemental.

weapons systems aboard [Electronics, Jan. 23, p. 137].

Also on the Army's shopping list are more OV-1C Mohawk fixed-wing reconnaissance planes. This is good news for the electronics industry, since they are equipped with side-looking radar, infrared sensors and cameras. Funds are also being requested for long lead time components for the AH-56A, the advanced aerial fire support system.

Two new Navy helicopters will be bought. One, the CH-46, is a high-speed, carrier-based, assault transport. The D model of this chopper will be equipped with IHAS, an integrated helicopter avionics system built by Teledyne Inc. The IHAS has a multifunction computer, doppler navigator and other navigation components. More CH-53A Sea Stallions, the Marine Corps' heavy assault helicopter, will also be bought. In addition to IHAS, the Sea Stallion will be equipped with terrain-clearance and avoidance radar.

Beginning in 1968, all new P-3 Orions—the long-range antisubmarine patrol aircraft—will carry the wholly integrated A-New avionics system [Electronics, Dec. 12, 1966, p. 184].

In the attack category, the Navy will buy far more planes than it had planned to a year ago. It wants $419 million worth of A-6A Intruders—$151 million in the 1967 supplemental and $268 million in fiscal 1968. The Intruder is the fleet's only fully all-weather aircraft; it can bomb its target guided by radar alone. In addition, an integrated display system enables the crew to see targets or the aircraft's environment.

The Navy is asking $615 million for more F-4 mach-2 fighters. They will be outfitted with a doppler fire-control system that provides improved air-to-air capability because of its ability to detect low-flying targets. The Air Force will ask $904 million for F-4's and $201 million for the reconnaissance version, the RF-4C. Called the "horizontal missile," this plane carries an infrared sensor, side-looking and forward-looking radar as well as several electronically controlled cameras.

Air Force outlays for tactical, air-control and reconnaissance aircraft will total $2.076 billion in fiscal 1968. Almost half these funds are ticketed for the F-111A.

Airlift. The gigantic long-range C-5A transport aircraft which comes under a separate budget category designated Airlift and Sealift, will require $423 million in fiscal 1968. Total cost of the program, which includes research, development and facilities construction, is estimated at $3.4 billion.

I. Tactical missiles

Scores of missiles that have a better-than-40% electronics content are expended every day in Vietnam. Among them are wire-guided M-22's fired from helicopters and Sparrow and Sidewinder air-to-air missiles used by fighter planes. As a result, the supplemental Southeast Asia budget calls for $107.3 million for tactical missiles for Vietnam. The asking price in fiscal 1968 is $1.357 billion, $187 million more than the request for fiscal 1967, and almost matching the $1.429 billion asked for ballistic missiles.

Army missile procurement, including spares, will total $561 million in 1967 and $769 million in 1968. The 1968 program covers ground support for the Pershing surface-to-surface missile, more Lance missiles, initial procurement of the wire-guided TOW, a large quantity of the infrared-guided, tank-mounted Shillelagh missiles, more heat-seeking Redeyes for defense against low-flying planes and Chaparrals to be used against high-performance planes.

In 1968, the Army plans to start a new development program to ensure that the Nike-Hercules surface-to-air missile will continue to operate effectively during the 1970's. This project, along with the Hawk improvement program, will provide a hedge against possible slippage in the development of the SAM-D, which will eventually replace both the Hercules and the Hawk.

Navy missiles. The Navy wants $351.8 million for tactical missiles in 1968, plus $48.7 million in the 1967 supplemental. The 1967 total comes to $251.7 million. The Marine Corps, usually supplied by the Navy, has its own bid in for $23 million worth of tactical missiles in 1968 and a request for $2.1 million in the 1967 supplemental.

For surface-to-air missile ships, beginning in 1968, the Navy will buy only the new Standard missile. The Navy is requesting $52 million for both the medium- and extended-range versions. Procurement of the surface-to-surface Talos will be completed.

Two air-to-air missiles will be bought—the Sidewinder and the Sparrow 3. Pilot production of the Phoenix missile for the F-111B will also get under way.

For antisubmarine warfare, the Navy will continue to buy the Asroc rocket-torpedo, the Subroc torpedo-rocket-torpedo, the MK-46 wire-guided torpedo, the tv-guided Walleye glide bomb and the air-to-surface ARM-1, antiradiation missile.

The Air Force needs $45 million for Vietnam in the 1967 supplemental, making a total of $396.5 million for the year; the 1968 request amounts to $347.2 million.

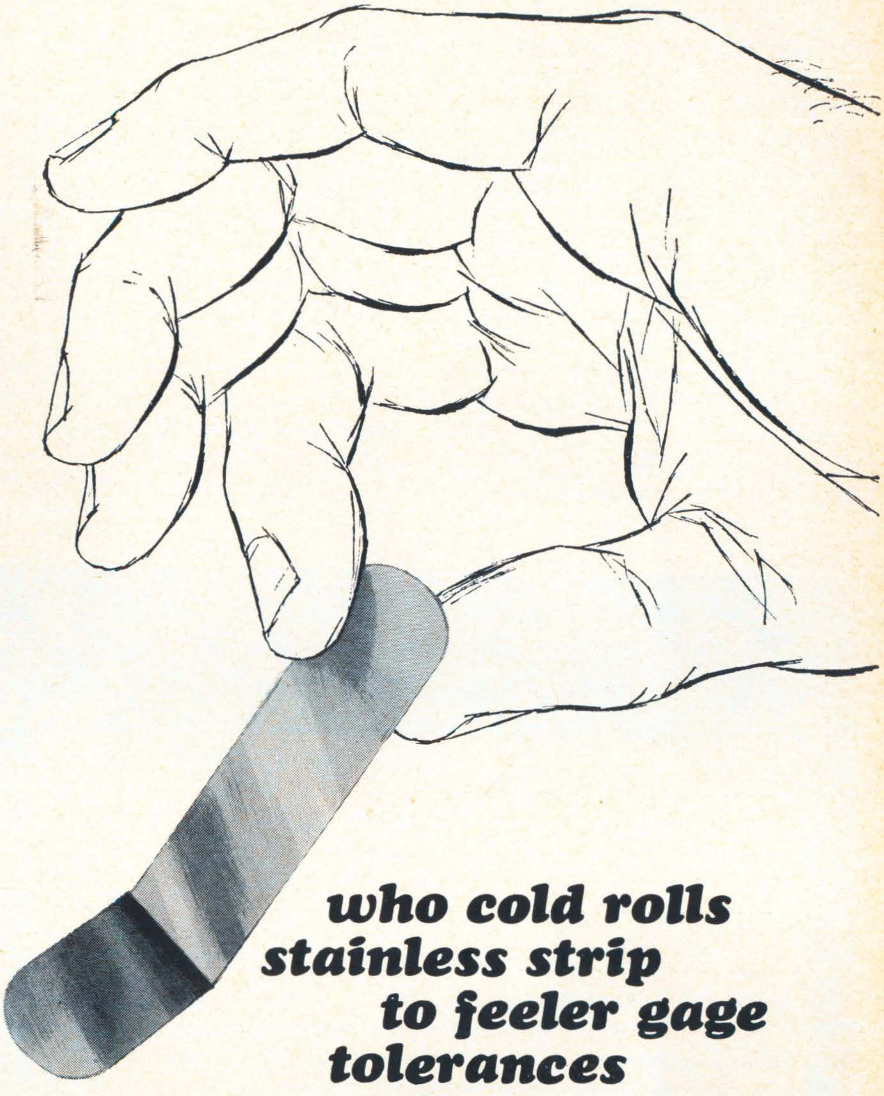
The Air Force will also buy Walleye bombs and Sparrow air-to-air missiles. It will continue to buy the Shrike to home in on enemy radar until ARM-1 becomes available late in fiscal 1968.

II. Shipbuilding

Budget plans for general-purpose naval forces include construction of 27 ships and conversion of 17 more at a cost of $1.9 billion. Funds are allocated for the procurement of long lead time items for a third nuclear-powered attack carrier. Naval vessels, on an over-all basis, have a 22% electronics composition. Certain specialized craft, of course, have a higher proportion.

Three ballistic-missile submarines and a submarine tender are involved in construction and conversion projects as are 20 antisubmarine-warfare ships to increase the long-range detection and weapons capability of the ASW fleet and to replace older ships. New construction covers three nuclear-powered attack subs and 10 destroyer escorts. The escort vessels will be equipped with the new and highly effective AN/SQA-26 sonar and the Asroc rocket-torpedo. Seven destroyers will be converted and will have Asrocs, improved communications, a new variable-depth sonar, better electronic countermeasures capability, the improved SQS-23 sonar and a modern ASW combat information center. Total cost is $14 million a ship.

A nuclear frigate authorized by Congress for 1967—over Administration objections—will be built in 1968, as will two new guided-mis-



sile destroyers with the new and highly capable Tartar missile system. Another frigate will be modernized to increase antiaircraft capabilities.

The 1968 program also provides for development of a new concept for future destroyer construction which is of interest to the electronics industry. By emphasizing the use of standard and interchangeable major components, new ships can be adapted more readily to improved antiair and ASW systems.

Other equipment. For communications and electronics, the Army's revised program for fiscal 1967 provides $617 million; for 1968 the request comes to $550 million. The Marine Corps will spend $107 million for comparable equipment in 1967, including such items as radars and the Marine Tactical Data System. The 1968 request is for $145 million. The price tag on new communications and electronic equipment for the Navy's ships and shore-based facilities is expected to be $340.2 million in 1968.

III. Deterrence

Reports that the Soviet Union is deploying an antiballistic-missile defense system have loosened Defense Department purse strings for strategic forces. The equipment portion of this budget is heavy on electronics. Long lead time items for the new Poseidon missile will be bought and Polaris submarines will be converted to carry the bigger missile.

In 1968, Poseidon outlays will total $1.115 billion. Missiles and equipment will cost $303 million; submarine conversion, $326 million; construction, $23 million; and research, development, test and evaluation, $463 million. In addition, the Navy wants $187.2 million for Polaris missiles and support equipment.

Development of the improved capability missile (ICM), an advanced intercontinental weapons system still under the aegis of the Defense Department, will continue; $19 million is earmarked for this project in the 1968 budget.

Department of Defense: Where procurement dollars go
(Millions of dollars)

Fiscal	1967*	1968	1968**	1968**
Aircraft	10,350	9,111	25%	2,277
Missiles	2,199	2,786	42	1,701
Ships	2,041	1,946	22	428
Combat vehicles	527	430	6	25
Electronics and communications	1,502	1,444	90	1,299
Other procurement	7,765	8,296	2.5	207
Total obligational authority	24,384	24,013	24	5,937

*Includes $12.3 billion Vietnam supplemental.
**Percentage and spending for electronics equipment based on data compiled by the Electronic Industries Association.

Up to the minute. The Air Force is requesting $379.3 million for an intensive upgrading of the Minuteman missile force in 1968. The proportion of Minuteman III's will be increased and they will be equipped with an improved third stage so they can carry bigger payloads and more penetration aids. Total cost of this program is estimated at $400 million. Operational Minuteman II's will be reequipped with an advanced reentry vehicle, and they will get new penetration-aid packages as will operational Minuteman III's. The cost of this program is $315 million; $100 million was provided for in the 1967 budget and $125 million in 1968, leaving $90 million to come later.

A bomber version of the protean F-111—the FB-111—equipped with the air-to-ground SRAM missille will be bought by the Air Force; $502 million is being requested for it. The advanced manned strategic aircraft program will be kept alive with $26 million to continue work on the avionics and engine.

For continental defense, now a part of the strategic forces category, the Defense Department will continue "intensive development" of Nike X. It hopes, however, to forgo having to produce and deploy an antimissile system if diplomats can talk the Soviet Union out of building theirs. In case these negotiations fail, $375 million will be set aside to start production of an operational system for installation around Minuteman sites. Meanwhile, $431.4 million is being requested for ongoing research, development, test and evaluation.

For early warning, projects continue on backscatter over-the-horizon radar to detect intercontinental missiles. SAGE and Spacetrack radars will be modified for sea-launched missiles and the Air Force will continue to modify Thor missiles to provide a defense against hostile satellites.

Keeping track. Defense officials say the development of an advanced interceptor depends on whether electronics companies can come up with an airborne radar system that will reject ground clutter and reflection well enough to detect and track low-flying enemy planes. If such equipment can be developed, it would be installed aboard an airborne warning and control system (Awacs) aircraft which, upon detecting enemy attackers, would be able to guide interceptors to the hostile craft.

Specialized activities. A new category in the 1968 budget—specialized activities—will cover programs using electronics gear heavily, such as communications, command and control, global weather prediction, air-traffic control, nuclear weapons activities, oceanography and air rescue and recovery.

Operation and updating of the National Military Command System (NMCS) falls into this classification. The system is the key element of the worldwide military command control setup that would

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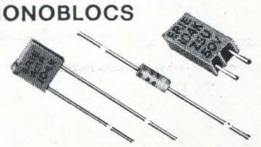

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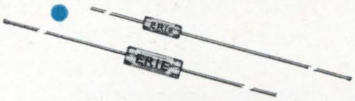

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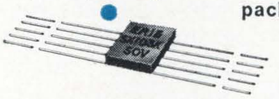

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The 1968 budget has money to expand the automatic voice and data switching terminals in the Defense Communication System so that larger areas of the globe can be covered. In addition, the secure network that permits military authorities to carry on classified conversations will be expanded.

Spending for military air-traffic control includes the operation of facilities not now provided by the Federal Aviation Agency. They include a worldwide complex of military control towers, radar-approach-control centers, instrument landing systems and air-ground communications systems. Among the projects planned for 1968 is replacement of the very-high-frequency and ultrahigh-frequency air-ground-air communications systems to meet the stringent requirement of 50-kilohertz spacing between channels set in the International Civil Aviation Organization agreement. Money is also provided for beacons in military planes.

IV. Research and development

Initial work on concepts of systems not yet approved for operational use will amount to $5.8 billion in fiscal 1968, $400 million more than in 1967. Increases are largely for such critical strategic systems as the manned orbiting laboratory and ballistic missile defense, and weapons systems necessary for ASW, tactical operations, electronic warfare, and command and control.

The Army, with $216 million, will work on small, rugged, field-operated digital data-processing gear; communications equipment with greater traffic-handling and improved antijamming capabilities; devices for rapid, positive and automatic recognition and identification among friendly surface units; new sensors for airborne and ground surveillance and target acquisition; night-vision devices and improved solid-state, thermionic and frequency-control components.

The Navy wants $272 million for sea-based countermeasures to protect ships against mines, torpedoes, air-to-surface missiles and nuclear attack; better shipboard radar; and sonar with improved capabilities for target acquisition, surveillance

Where defense research dollars go
(Millions of dollars)

	Fiscal 1967*	1968
Military sciences	616	615
Aircraft	1,171	1,145
Missiles	2,414	2,499
Astronautics	954	1,119
Ships	285	299
Ordnance and vehicles	354	313
Other equipment	968	988
Management and support	395	412
Emergency fund	18	125
Total obligational authority	**7,177**	**7,523**
Estimated dollars for electronics**	2,296	2,407

*Includes $12.3 billion Vietnam supplemental.
**Based on EIA data.

and navigation. Seabased electronic systems that are less affected by variations in temperature, humidity and shock are also a major concern.

The Air Force will spend $285 million investigating new mission techniques; and $160 million for communications, electronics and avionics.

The main portion of the Advanced Research Projects Agency's budgeted $215 million is for Project Defender, which will consider advanced defensive systems against ballistic missiles. This work will influence the design of penetration aids for Minuteman and Poseidon. Defender also includes work on over-the-horizon radar.

In advanced development a total of $1.25 billion is being requested to work on experimental hardware to facilitate make-or-break decisions. Several triservice projects involving a large amount of electronics are at this stage.

Engineering development. Projects being engineered for service use but not yet approved for production and deployment also represent a big effort. Nike X is typical of this category. Another Army project is a shoulder-fired missile called the medium antitank weapon; it is wire-guided and uses an infrared sighting device.

The Navy is developing the Condor air-to-surface missile, an advanced Sparrow, and is trying to improve the "Terrible T's"—Tartar, Terrier and Talos. Funds are requested for work on the VFAX, a multimission tactical fighter. Some $76 million is earmarked for undersea warfare. Included are: a new ASW aircraft (VSX) with sensors and integrated avionics; the Mk-48 torpedo; a directional sonobuoy capable of giving the bearing of a target directly to an ASW aircraft; a shipboard periscope detection radar; antennas integrated into a submarine's superstructure; and a carrier-based airborne tactical control system.

The Air Force is working on a new ICBM, an advanced ballistic missile reentry system, an improved tactical fighter, a fire-control and folding-fin missile system for a new interceptor and a system to enable aircraft to navigate to specific locations in bad weather and at night without external ground assistance and make drops.

Space electronics

Space stays

NASA research and development (Millions of dollars)	Fiscal 1967	1968
Manned space flight, total	3,024.00	3,069.20
Gemini	21.60	—
Apollo	2,916.20	2,606.50
*Apollo applications	80.00	454.70
Advanced mission studies	6.20	8.00
Space science and applications, total	607.10	694.60
Physics and astronomy	129.80	147.50
Lunar planetary exploration	169.40	142.00
*Voyager	10.45	71.50
Sustaining university program	31.00	20.00
Launch-vehicle development	31.20	—
Launch-vehicle procurement	122.40	165.10
Bioscience	41.55	44.30
Space applications	71.30	104.20
Advanced research and technology, total	268.15	318.00
Basic research	21.46	23.50
Space-vehicle systems	33.94	37.00
Electronics systems	33.60	40.20
Human-factor systems	16.17	21.00
Space power and electric propulsion systems	40.44	45.00
Nuclear rockets	53.00	46.50
Chemical propulsion	33.64	38.00
Aeronautics	35.90	66.80
Tracking and acquisition	270.85	297.70
Technology utilization	5.00	5.00
Total obligational authority	4,175.10	4,384.50

*New line items

Despite the belt-tightening effects of the Vietnam conflict, the National Aeronautics and Space Administration has gotten the go-ahead to ask Congress for $5.1 billion in fiscal 1968 obligational authority, enough to start work on the Voyager unmanned planetary exploration program and the Apollo applications program.

Although chances are slim that this budget will get through Congress without some cuts, the fiscal 1968 request marks the first time that NASA has gained full White House approval of a post-Apollo program. It also apparently assures that civilian space spending will continue at a pace of around $5 billion annually through fiscal 1970.

Electronics share. All this is good news to the electronics industry. Not only do most estimates accord half of the current NASA budget to electronics, but the flow of space funds to electronics companies is expected to increase over the next three years even if over-all outlays remain stable. Space agency chief James E. Webb predicts that "by 1970, 60% of all our funds will go into electronics."

Including $60 million of untapped fiscal 1967 funds, NASA will have $4.39 billion to spend on research and development in fiscal 1968, up from $4.18 billion in the current year.

The Apollo applications program, which becomes a line item in the NASA budget for the first time, is ticketed for $454.7 million, up from this year's $80 million.

This money will be used to continue production of Saturn IB, Saturn V and Apollo hardware to accommodate about eight major Saturn launches per year after the objectives of the Apollo lunar landing program have been met. Next year's Apollo applications budget includes $263.7 million for space vehicles, enough for four Saturn IB's and two Apollo command and service modules, plus long-lead items for five more Saturn rockets and three Apollo spacecraft.

NASA has slated $140.7 million

ahead

for Apollo applications experiments in fiscal 1968. This outlay includes money for the Apollo telescope mount and for the Saturn IV B-stage workshop—a 10,000-cubic-foot laboratory in space.

Voyager. The other new line item in the NASA budget is the Voyager. The funding for this program, slated to climb to $71.5 million from the $10.5 million of fiscal 1967, will keep the project on its current schedule, which aims at a first launch in 1973 to Mars. The cost of the first two Voyager shots—two spacecraft to Mars in 1973 on a single Saturn V, and two more spacecraft in a single launch in 1975—is expected to total slightly more than $2 billion.

To bridge the gap between the 1969 Mariner-Mars mission and the 1973 Voyager shot, NASA will launch two new Mariner-type spacecraft to Mars in 1971. Mariner funding will roughly double in fiscal 1968, rising to $68.9 million from $35.2 million a year earlier, largely because of these added shots.

Next year's budget also includes $2.3 million to start work on a voice broadcast satellite. This craft, scheduled for a 1971 launch, will use large oriented solar-cell arrays and components to relay broadcasts directly to home radios.

Another project being started in fiscal 1968—this one with a $2 million funding—is the Sunblazer, a program to launch a 40-pound satellite with the five-stage Scout vehicle now being developed. After about 18 months aloft, the satellite is to transmit 75- and 225-megahertz signals through the sun's corona at a distance of about 150 million miles.

An advanced Applications Technology Satellite will be added to the present five-shot ATS program, with launches planned for 1970 and 1971. The over-all program's fiscal 1968 funding will rise to $35.5 million from $28.5 million this year.

Picking up the pieces. The flop of the first 3,600-pound telescope-carrying Orbiting Astronomical Observatory last April led to a major investigation of the program and to criticism of the design of several of the craft's electronic subsystems. It also presented NASA with the choice of either scrubbing the program or spending a considerable amount of money to make the necessary design changes.

Citing "the tremendous interest among scientists in astronomy," NASA finally decided to go ahead with the project. The fiscal 1968 outlay for OAO will jump to $40.6 million from this year's $27.7 million, while the agency's over-all physics and astronomy spending will climb to $147.5 million from $129.8 million.

Lunar and planetary exploration funds are being slashed from $169.4 million to $142 million, with outlays for Surveyor falling from $84.5 million to $42.2 million and Lunar Orbiter expenditures dropping from $28.8 million to $10 million.

Space applications spending will spurt from $71.3 million to $104.2 million, with weather satellite work accounting for most of the increase. A 1968 launching of RCA's Tiros-M boosts over-all Tiros spending for fiscal 1968 to $7.5 million from $3.1 million.

GE's Nimbus weather satellite is budgeted for $34.5 million in fiscal 1968, up from $23.4 million this year. Launches are scheduled for 1968 and 1970, with the number of experiments aboard to increase from three to as many as 11.

The Geodetic satellite program is slated for $4.7 million of funding, more than triple the $1.6 million of this year. Single launches are scheduled for 1968, 1969 and 1970. The three satellites will be similar to the Geos I, but will include reflectors to test laser techniques.

Aeronautics revisited. The budget for advanced research and technology will be increased by $50 million to a level of $318 million, a boost reflecting a doubling of funds for aircraft research and development to $66.8 million. Apparently reacting to charges that it has neglected this side of its duties in recent years, NASA has earmarked at least $150 million for aeronautics in its 1968 budget.

Spending on electronics-systems research will rise by $7 million in fiscal 1968 to $40.2 million, including $1 million for flight projects. In an attempt to solve some of the problems plaguing spacecraft, NASA will fund work in two other areas: radio attenuation measurement during reentry and the earth's horizon radiation profile as a function of the season and the latitude.

Funds for research work on power and electronic propulsion systems will be increased by $5 million to a level of $45 million; of the total, $1.1 million will support the space electric rocket test program (SERT), which is back in the budget after a year's absence. Solar-cell work to be funded includes more research on the effects of radiation and on flexible substrates that may allow the deployment of very large solar-cell arrays.

Tracking and data-acquisition outlays are due for a boost as Apollo moves into the busiest part of its flight schedule during fiscal 1968. The authorization in this area calls for $297.7 million, up $27 million from this year. Money for equipment will decline from $59.7 million to $55.1 million.

Defense maneuvers. On the military side, the Defense Department wants $1.998 billion for space programs in fiscal 1968, $328 million more than in 1967. For the Manned Orbiting Laboratory, the biggest military space project, design work is almost done and hardware fabrication is near.

The Pentagon has budgeted $83 million for communications satellites in 1968 and plans to spread the money among Air Force, Army and Navy projects.

The Navy wants to spend $18 million to improve the satellite navigation systems used by subs.

Five nondefense agencies have requested $199.7 million for space programs in fiscal 1968. The Atomic Energy Commission's $152 million space budget includes programs to develop nuclear-propulsion and nuclear-power sources, and the Commerce Department plans to spend $40.1 million on space efforts to collect data on the geophysical environment. Also, the National Science Foundation is seeking $2.4 million for astronomical studies with rockets and satellites, while the Interior and Agriculture Departments have requested $5 million to support research on possible studies of the earth's resources from space.

Civilian electronics

...and butter

Civilian agencies of the Government have asked for funds to provide something for every element of the population in fiscal 1968. Requests range from aid for the poor to surveys of the ocean floor for oil companies. Electronics firms will be called upon to supply increasing amounts of equipment as new programs and services call for hardware and established activities are updated. There will, for example, be new opportunities for electronics concerns in oceanology, and the next national census will be processed on a new large-scale computer.

I. Education aids

Several agencies will seek electronic aids for education. The National Science Foundation has requested $13 million for efforts to make the computer a teaching tool, and will spend another $11 million to help support computer centers at colleges and universities. The Office of Education may boost its expenditures for electronic data processing gear as much as fivefold from fiscal 1967. Its program for Educational Resources Information Centers (ERIC) will receive an initial $3 million in fiscal 1968. This project will establish and support perhaps a dozen centers devoted to linking new teaching concepts to computers.

The Department of Health, Education and Welfare has budgeted $20 million for the development of educational television. In addition, HEW will spend $14.5 million on equipment to help improve undergraduate instruction, with $1.5 million of this going for television gear.

The National Institutes of Health has earmarked $10.8 million for special research projects involving computer systems. A $12.6 million rise from fiscal 1967 in the NIH budget for general research and services reflects, among other things, an expanding use of computers. Other funds will back such projects as the further automation of medical laboratories and the improvement of electronic pacemaker hearts.

The Environmental Services Administration (ESSA) of the Commerce Department will have more to spend on satellite operations and research and development but less for new facilities and equipment. Covered in the agency's $29.8 million R&D budget are wider hydrographic and oceanographic services and expanded weather forecasting, telecommunications and space operations. Most of ESSA's $32 million space outlay will go for satellites and launchers, but data acquisition, processing and analysis will also account for a considerable share. ESSA will buy new radar and communications equipment for its hurricane and tornado warning system and automated equipment for flood forecasting.

The deep. The Johnson Administration last year gave a boost to oceanographic sciences and technology when it formed the National Council on Marine Resources and Engineering Development. Funds for marine technology in fiscal 1968 will climb 15% from a year earlier, with 11 agencies getting a slice of the total $462 million outlay.

One question still to be answered is exactly how information on the oceans will be collected. In its first major report, due this month, the new council—dubbed "the wet NASA"—will make strong recommendations concerning the relative merits of ships, satellites and buoys as data collectors. Whatever the eventual decisions here, the electronics industry will find a sizable market.

Grab-bag. Funds for water pollution control are set at $101 million and for air pollution control at $64 million, both almost double the fiscal 1967 levels. Electronics firms should get a good portion of these outlays to provide such gear as pollution monitors sensors and related hardware.

The Atomic Energy Commission's physical research budget includes $10 million for the preliminary design of a $240-million 200-billion-electronvolt accelerator near Chicago, and $4 million for the design of a $24-million omitron particle accelerator at the Lawrence Radiation Laboratory, Berkeley, Calif.

The fiscal 1968 budget of the National Highway Safety Bureau of the Department of Transportation has been more than tripled from a year before to $32.5 million. The bureau's research work on traffic-control and highway-safety programs will involve the acquisition of electronic surveillance, control and warning equipment, as will the R&D efforts of the Bureau of Public Roads, which are funded at $11.5 million.

II. Computer binge

Requests for new computers and related equipment appear in many agency budgets. The Post Office has earmarked $6 million for data processing gear and $62.6 million for automated mail-processing equipment for 17 major postal facilities.

Helping spark a buying splurge is the contention of the General Services Administration that the Government is better off purchasing computers outright than leasing them. The GSA wants to spend $10 million to buy up 14 systems now leased by the Government—about 1% of the total—claiming that the savings realized by this move over the next three to four years will more than cover the purchase price.

The Internal Revenue Service has requested $127.4 million for automatic data processing, while the National Bureau of Standards plans to increase its efforts to assist other agencies in their data processing operations.

Of the $19 million budgeted for the Justice Department's Office of Law Enforcement, all but $6 million is earmarked for projects involving surveillance devices and new equipment to record statements made by suspects and witnesses.

Civilian aviation

FAA is grounded

Not only are there no new programs in the Federal Aviation Agency's fiscal 1968 budget, but research and development funds have been pared by $1 million from a year before. This reduction, coming atop a $10 million slash in fiscal 1967, is causing concern over the future of the agency's long-range programs. Furthermore, the new budget contains no provision for additional money to build a prototype of the supersonic transport (SST).

The FAA, which becomes the Federal Aviation Administration in the new Department of Transportation, is down for $894.7 million in total obligational authority in fiscal 1968, off from fiscal 1967's $1.07 billion, which included $244.7 million for SST development. Electronics gear accounts for more than 10% of the latest FAA budget.

I. Postponed projects

But with budgeted R&D funds about 20% below the level FFA officials wanted, the agency will have to postpone plans to find a replacement for its present short-range, very-high-frequency navigation-aid system along with a study of a global network of very-low-frequency navigation aids—either ground-based or satellite borne.

A reduction from fiscal 1967 in funds available for new hardware will delay the introduction of bad-weather landing equipment at major air terminals. Twenty-three airports are to get these instrument landing systems with money appropriated for fiscal 1967, but FAA planners had hoped to extend this capability to more terminals with fiscal 1968 funds.

Mum on SST. Agency spokesmen aren't saying a word about the SST effort. "There is nobody more ignorant than I about civilian supersonic aircraft development," said David D. Thomas, deputy administrator, when questioned about the program's future. The FAA has $88.3 million in unexpended fiscal 1967 funds to continue work on the SST, and some observers think there might be $400 million in fiscal 1968 contingency money set aside for the plane. This would be in addition to the $200 million appropriated in fiscal 1967 for construction of a prototype, an outlay that could be tapped to continue development projects.

In his budget message, President Johnson said: "The allowance for contingencies is adequate to cover the possible costs of this [SST] effort, should an affirmative decision be made to proceed."

Of the FAA funds earmarked for electronics, the biggest single slice —$26.3 million—would go to automatic air-route traffic-control centers at Jacksonville, Fla., and one unspecified site. With 50 to 70 airports as candidates for such installations, the agency is hoping for supplemental funds after the Jacksonville facility begins operations this spring.

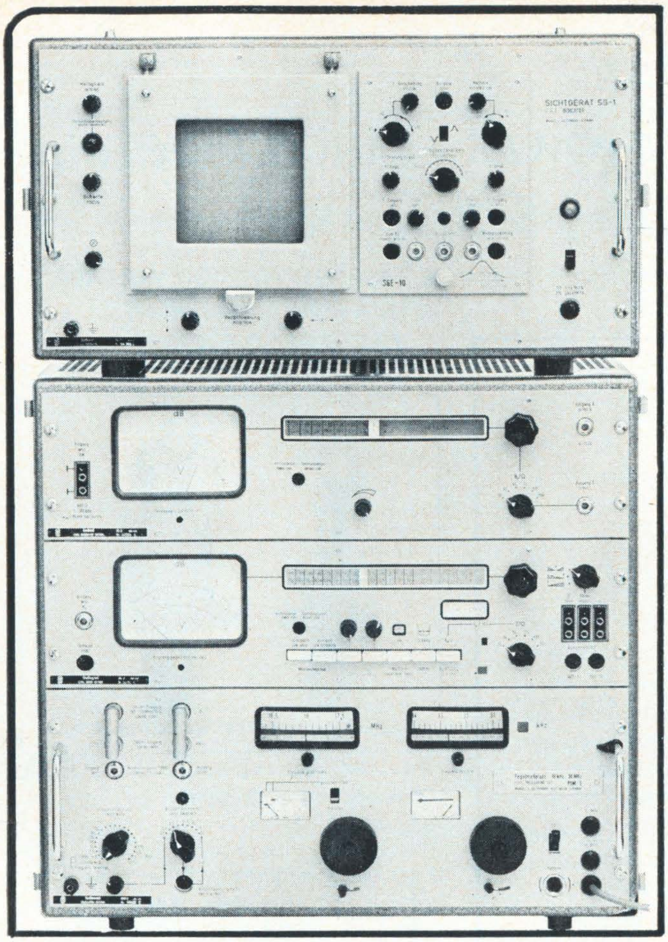
Metroplex. The automation effort is part of the National Airspace Stage-A program—a refinement of enroute air-traffic control centers with digitized, computer-controlled equipment and alphanumeric displays. The terminal counterparts of this system are Metroplex air-traffic control complexes, for which the FAA has asked $8.5 million for fiscal 1968. These funds will go to automate terminal operations in the Chicago area. Another $3.3 million is to be spent during fiscal 1968 for research on Metroplex software.

II. Navigation facilities

Air navigation facilities are slated to cost the FAA $10.7 million in fiscal 1968, down slightly from the fiscal 1967 figure of $11.8 million. Vortac installations—radio systems equipped with tactical air navigation gear—will account for the biggest portion of navigation-equipment purchases, $5.3 million, while outlays for instrument-landing systems will total $3.2 million.

The squeeze on research funds that has forced the postponement of work on new navigation-aid systems will also slow efforts in the field of air-derived separation assurance, the broad name applied within the agency to four approaches to the problem of aerial collisions. The fiscal 1968 research program is essentially limited to $500,000 to be spent in-house entirely for work on the highly sophisticated "black box" collision-avoidance system.

About $200,000 is budgeted for fiscal 1968 research into clear air turbulence (CAT), up slightly from the $163,000 of fiscal 1967.



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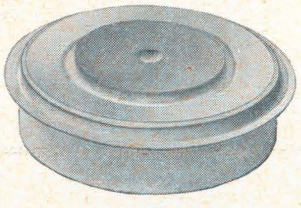

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A typical current capability increase of about 60% stems from PRESS PAK's externally applied pressure contact package. The new package allows double-sided cooling of the SCR, drastically reducing thermal resistance. Result: you get more average amps per total dollar.

Right now PRESS PAK SCR's are available rated up to 1300 volts, 110 or 240 amps *average* (equivalent to 172 amps and 377 amps RMS *respectively* on stud-mounted types). Soon, other kinds of semiconductor devices, as well as other SCR's will also be available in the PRESS PAK.

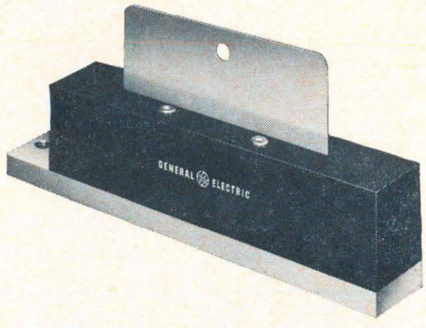
Try PRESS PAK SCR's for heavy industrial, motor drive, electro-plating, and other high line voltage applications.

■ NOW AVAILABLE FOR HIGHER POWER AT HIGHER FREQUENCIES: G-E POWER SCR'S

For computer power supplies, G-E C14040 power SCR's give you high frequency switching at current levels up to 80 amps peak at 25 kHz, or 310 amps peak at 5 kHz.

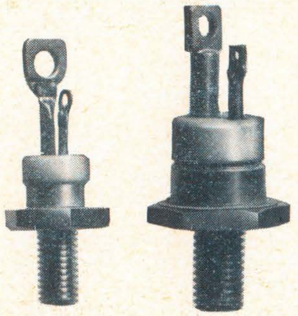
Unique matching capability allows common anode and common cathode terminations, making G-E power thyristors convenient and economical performers as inverters, choppers, cycloconverters, and regulated power supplies.

G-E C14040 line SCR's are also ideal for ultrasonic generators, high frequency lighting, sonar transmitters, induction heaters, and radio transmitters.



G-E C14040 power SCR for high power/high frequency applications

■ PRESENTING: HIGH VOLTAGE IN A MEDIUM CURRENT PACKAGE—G-E C137 AND C145 SCR'S



Actual size G-E C137 and C145 SCR's

Get 1200 volt capability for 480-volt a-c operation of industrial equipments.

G.E.'s C137 SCR is a compact 35 amp device with a di/dt rating of 150 amps/μsec. when switching from 1200 volts or 300 amps/μsec. when switching from 600 volts. And the 100 volts/μsec. minimum dv/dt rating eliminates the need for many protective components . . . reduces the cost of your circuits.

For high current transformer primary phase control, the 55 amp C145 puts the squeeze on cost and size, but delivers 1200-volt capability. Maximum di/dt rating is 100 amps/μsec., when switching from 1200 volts or 200 amps/μsec. when switching from 600 volts. The minimum dv/dt rating is a money-saving 200 volts/μsec.

Typical C137 or C145 SCR applications include motor speed control, power supply regulation, pulse modulation, a-c static switching, and transformer primary phase control applications.

For further information on these and other items in G.E.'s leadership line of SCR's and rectifiers see your G-E engineer/salesman or distributor and get the full story of G.E.'s total electronic capability.

Or write to Section 220-43. General Electric Company, Schenectady, N.Y. In Canada: Canadian G.E., 189 Dufferin St., Toronto, Ont. Export: Electronic Components Sales I.G.E. Export Division, 159 Madison Ave., New York, N.Y.

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• But what really is the right amount for trouble-free, tight-knot lacing?

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• GUDEBROD TAPE cuts harness costs!

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Give the sample any comparative test you want. Let your harness crew try it. Send it to your lab. It's exactly what you'll get when you order Gudebrod tape—everytime.

You are often required to lace with tape that meets MIL-T Specs—with a specified range of wax content. But that's no assurance that you are using a tape that ties tight, holds tight, that probably won't be rejected—unless, of course, you have Gudebrod Gudelace. Like all Gudebrod Lacing Tapes it's manufactured under strict quality control including the wax coating. Every yard of Gudelace is impregnated exactly the same, exactly right. You can count on that—and on speedier, easier, better harnessing. That's where you save real money. Want to know more? Get in touch with Gudebrod.

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The first hand tool engineered for wire harnessing. Handle holds bobbins, feeds tape as needed, grips tape for knotting. Speeds, eases harnessing. Pays for itself in time saving.

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Circle 147 on reader service card

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Infinite resolution. Excellent high frequency performance characteristics. No catastrophic failures.

These four new additions to the extensive CTS trimmer line have many applications in High Performance Industrial and Military fields: computers, instruments, medical electronics, communications equipment, electronic machine controls, aerospace electronics, microwave transmission, etc.

Series 330

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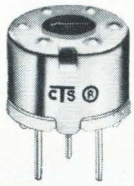
Series 330P



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Priced lower than comparable wirewound trimmers.

- Proven Reliable CTS Carbon-Ceramic Resistance Element
- Far Exceeds Environmental Performance Spec of MIL-R-94B, Char. Y
- ± 8% Humidity Stability
- 100 Ohms to 2.5 Megohms
- 3/8 Watt @ 70°C Derated to Zero Load @ 150°C
- Grounded Construction Available on Model 330

Series 330 Has Solder Terminals. Series 330P Has Pin Terminals on .100″ Grid Configuration and Standoffs to Insulate Metal Cover From P. C. Board.

Write for Data Sheet 2330A

Series 630

$1.50

Series 630P

$1.60

in production quantities
Priced lower than comparable wirewound trimmers.

- Famous CTS CERMET Resistance Element
- Extreme Stability Under Severe Environmental Conditions
- ± 4% Humidity Stability
- 20 Ohms to 2.5 Megohms
- 1/2 Watt @ 85°C Derated to Zero Load @ 150°C
- Low Noise—Long Life
- Extreme Overload Capacity
- Grounded Construction Available on Model 630

Series 630 Has Solder Terminals. Series 630P Has Pin Terminals on .100″ Grid Configuration and Standoffs to Insulate Metal Cover From P. C. Board.

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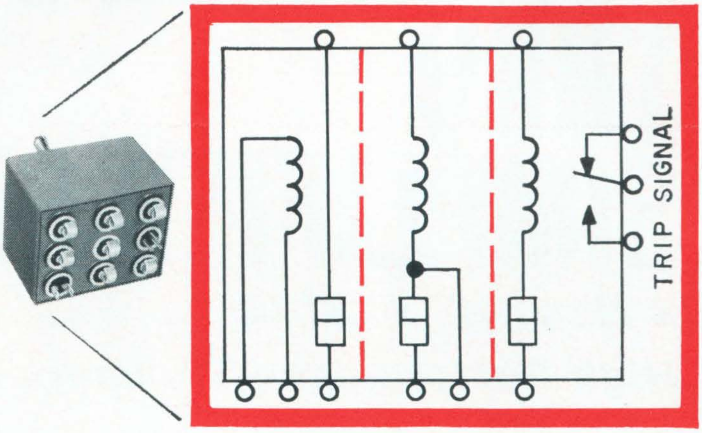
CIRCUIT CONTROL AND PROTECTION BY AIRPAX

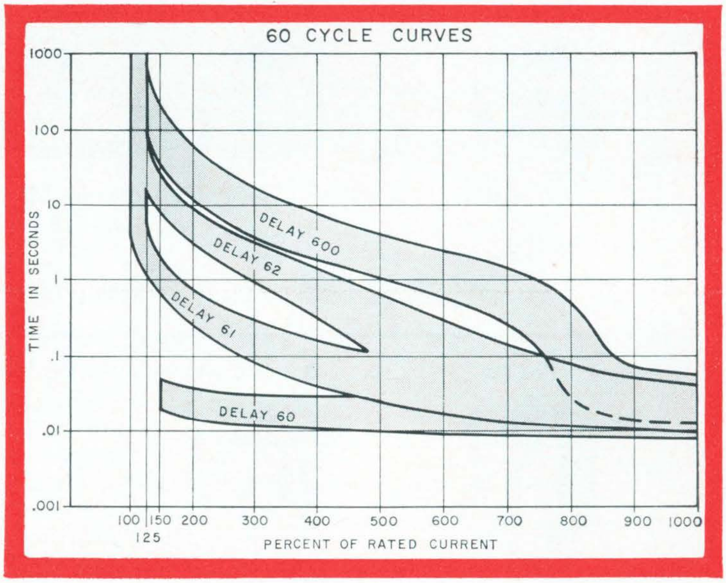
style AP

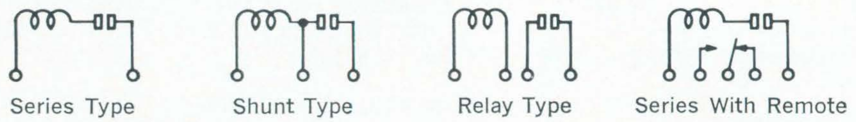
Style AP is all magnetic trip, hermetically sealed, meets MIL-C-39019, available 1, 2 or 3 pole, 10 ma to 20 amperes AC or DC, interrupts 1000 ampere fault at 240 volts AC.



style 50-APL

Style 50-APL is entirely magnetic trip (no heating elements), available 1, 2, 3, 4 and up to 10 poles, 10 ma to 50 amperes AC or DC, will open a 5000 ampere fault at 240 volts AC.





Completely magnetic circuit breakers depend on current only trip. Any coil or combination within listed ranges can be supplied for immediate delivery.

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Kit, plus scissors, builds multilayer wiring

Interconnecting matrix for dual in-line integrated circuits is prepared by snipping tabs from standardized wiring layers

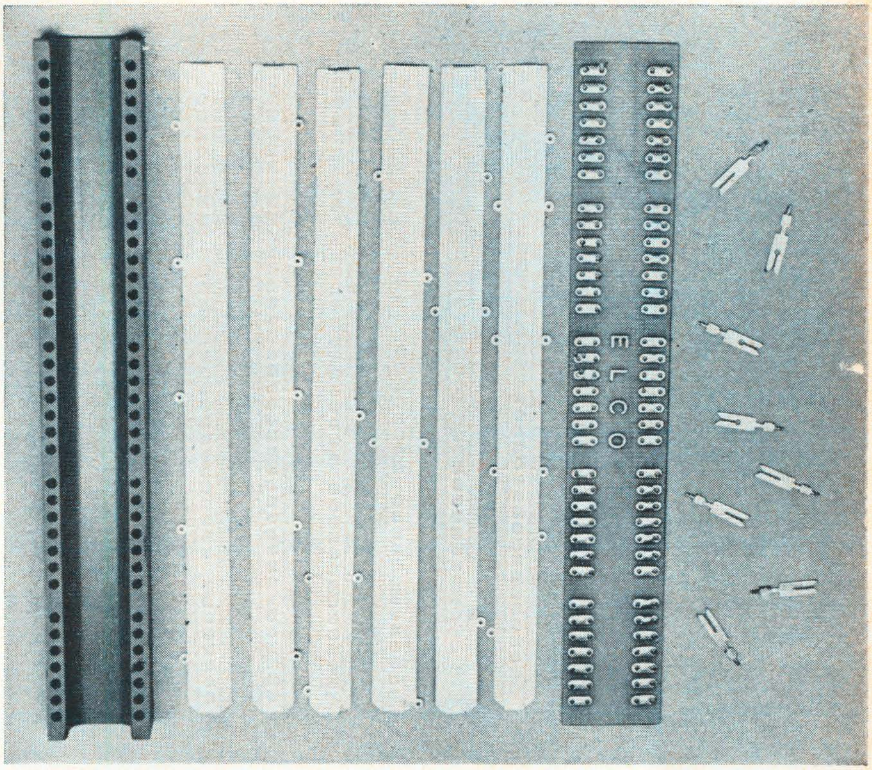
A "do-it-yourself" kit for tightly assembling dual in-line integrated circuits will be introduced in a few months. Described by the developer, the Elco Corp. of Willow Grove, Pa., as the only such interwiring package that permits the customer to do his own potting, the product is a module with a multilayer interconnecting matrix for breadboarding and limited production runs.

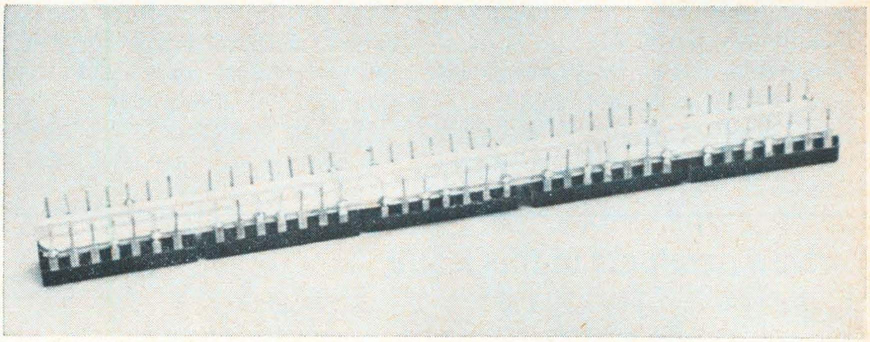
Application techniques will be outlined by John M. Martinell, an Elco project engineer, next week at the Society of Automotive Engineers' electronic packaging conference in New York (Feb. 14 to 16).

The package, designated the DIP Omni-Comb, is similar in concept to the original Omni-Comb for flat packs [Electronics, Aug. 9, 1965, p. 142], but different in configuration. The new module's four basic parts, in the upper picture, are, from left to right: the header, molded from a thermosetting plastic; tin-plated copper interconnection layers, or combs, each consisting of a double bus strip with protruding tabs; a glass-epoxy terminal board; and nickel-silver contacts for making connections to the outside world.

The first step in interconnecting as many as five IC's is to make a logic diagram showing which tabs are needed. Unnecessary tabs are then sheared from the carriers—for prototypes, a manicure scissors will do. (In the picture, the carriers are shown ready for assembly, with Mylar tape laid between them for insulation and some tabs shorn.)

The carrier layers (usually six or fewer) are set between the leads of IC's lined up Indian file on their backs, and the tabs are slid over the leads. After this unit is dip-soldered to interconnect the IC's, the leads are poked through the





two center rows of holes in the terminal board. To make handling easier, the leads can be bent 90° so they will rest on the oval pads.

The contacts must be positioned in the plastic header in those cavities designated on a lead-organization diagram. After insertion, the contacts' "tails" are rotated about 20° to lock each contact to the header, and the two subassemblies are brought together by inserting the IC's into the header. After another solder bath the assembly is complete.

Two special tools are needed: a twist tool to lock contacts into the header and bus-cutting pliers to horizontally segment a bus.

Elco hasn't yet released prices

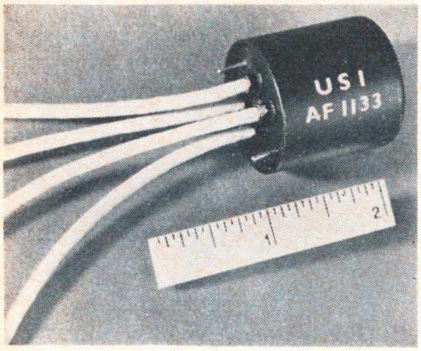
Specifications

Module length	4.1 in.
Module width	0.625 in.
Module height	0.382 in.
Capacity	5, 14-lead dual-in-line IC's

but original Omni-Combs for flatpacks were available in a $195 introductory kit containing hand tools and enough equipment to make several test devices for evaluation purposes.

Elco Corp., Willow Grove, Pa. 19090
Circle **349** on reader service card

Coaxial transfer relay has 80-db isolation



A coaxial transfer relay with a rated life of 10 million cycles and an 80-decibel isolation at 50 megahertz has been developed by United Standard Industries Inc. Its long life and high isolation characteristics are due to reeds instead of the conventional electromechanical armature and coil.

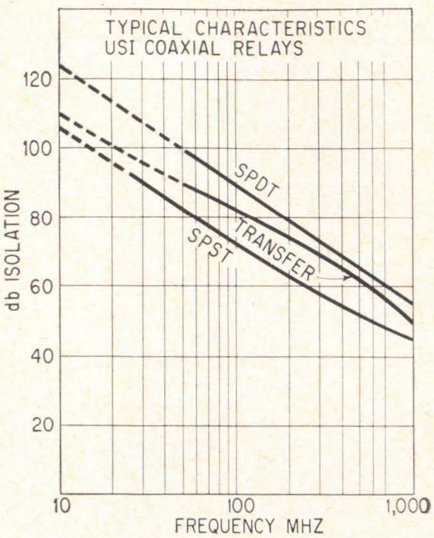
Much smaller than a conventional electromechanical relay, about one-fifth the volume, the relay consumes little power—only 500 milliwatts at 26 volts d-c. A power level of several watts is usually needed to actuate conventional relays. The relay passes 100 watts (cold switching) and makes and breaks 3 watts of radio-frequency power in a 50-ohm system.

The primary applications are in areas where high isolation and small size are paramount, such as the insertion or removal of crystal filters in communications equipment by switching, and of high-gain preamplifiers in antenna systems. Other applications include data processing systems, logic circuits, antenna switching gear, programers, timers and frequency counters.

The transfer relay, model AF-1133, is a double-pole-double-throw; model AF1134 is a single-pole-double-throw.

The company is also offering three single-pole-single-throw coaxial relays: model AF1167-1, which has a high isolation of 120 db at 1 Mhz and 45 db at 1,000 Mhz; model AF1167-2, a high reliability relay with a mean-time-to-first-error rating of 125 million operations at 100 milliamps and 12 volts d-c; model AF1167-3, which has an insertion loss of less than 0.05 db to 400 Mhz. The spst prices start at $28.50 for 1 to 9 units, going down for $14.75 for quantities of 400 to 999.

Typical isolation characteristics for the various coaxial relays are shown in the chart.



Small quantities of all five relays are available from stock.

Specifications

Model AF 1133 transfer relay

Isolation	
at 50 Mhz	80 db
at 1,000 Mhz	40 db
Insertion loss	
at 200 Mhz	0.25 db
at 1,000 Mhz	0.6 db
Vswr	
at 200 Mhz	1.15
at 1,000 Mhz	1.3
Impedance	50 ohms
Operating time	2 msec with contact bounce
Actuating voltage	26 v d-c, usual
Actuating power	500 mw
Size	1⅛ in. long, 1-1/16 in. diam.
Price	
1-9	$100 each
400-999	$52 each

United Standard Industries, Inc., 30 North LaSalle St., Chicago, Ill. 60602
Circle **[350]**

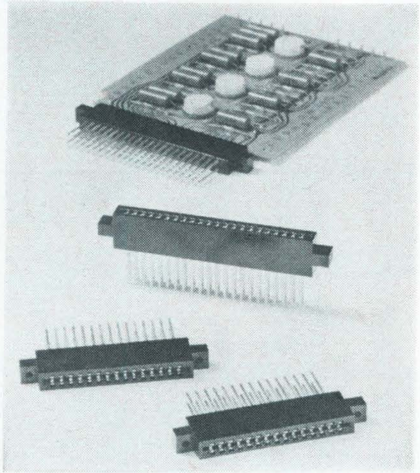
New products in this issue

Happiness is an Acopian power supply . . . because it's shipped in only 3 days.

Whether your application is op amps, ICs, logic circuits, relays, lamps or electronic measuring equipment, look to Acopian to meet your needs for AC to DC plug-in power supplies. Acopian's new catalog lists over 62,000 different supplies . . . all available for shipment within 3 days. Get your 16 pages of happiness by writing or calling Acopian Corp., Easton, Pennsylvania (215) 258-5441.

Circle 153 on reader service card

Contact buttons wear well



Card connectors with precious metal contact tips are being made available off-the-shelf by Amphenol Corp. The tips, which insure long contact life, were made available in the past only to large-volume users willing to pay the extra production costs, according to Paul Hoppe Jr., the product manager.

Amphenol plans to price the new standard line about the same as conventional connectors with plated contacts—40 to 50 cents for a typical 22-contact connector. However, with the new tips the minimum number of mating cycles is raised to 500. Plating, usually 40 millionths of an inch of gold, can take only a minimum of 200 mating cycles before wearing away. The tips are more durable because they are buttons of wrought precious metal alloys that are 0.007- to 0.010-inch thick. They are welded to the contact member at the wear point.

Hoppe says a tipped contact has never failed in field use. Moreover, after a few mating cycles have "broken in" the mating surfaces, contact resistance remains stable throughout the 500-cycle minimum. Carefully used, the contacts will last many more cycles, he adds. With mass production, the improvement costs about the same as plating, because precious metal is used only at the point of wear.

The connectors are designed for use in data processing and other digital systems. The connector pins can be soldered to an interconnection board. Or, either Wire-Wrap or Termi-Point back panel wiring can be used, because all four corners of the pins are beveled. Another design feature is a small retaining wall molded into the space behind each contact member. This prevents the contacts from being pushed forward by a probe or improper insertion and avoids electrical shorts due to misalignment of contacts.

Contact members are phosphor bronze, preloaded for constant contact pressure. The dielectric is phenolic, or diallyl phthalate is available at extra cost. Although the connectors are designed for industrial use, Amphenol has a performance specification that follows the military standard testing procedures. There is no military specification for this type of connector.

Connectors with 15 or 22 contacts on 0.156-inch centers are now in production. By April, Amphenol will be producing a complete line of single or double-sided connectors, including: 15, 18, 22, 30, 36 and 43 contacts spaced 0.100, 0.125 and 0.156 inch; 18 or 28 contacts spaced 0.150 inch; and 22 or 36 contacts spaced 0.200 and 0.250 inch.

Typical electrical ratings, for contacts spaced 0.100 inch are: current, 5 amperes; contact resistance, 6 milliohms maximum; voltage, 300 volts rms at sea level; and breakdown, 1,800 volts rms minimum.

Amphenol PMT Products, Amphenol Corp., 2863 South 25th Ave., Broadview, Ill. 60653 **[351]**

Insulating wafers for TO-3 transistors

A dielectric coating that is thermally conductive provides an excellent temperature path between the case and heat sink. The coating is applied to new insulating wafers for TO-3 transistors. According to the manufacturer, aluminum type

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offers more profit potential for electronics firms

Before you select your next plant location, investigate SOLVENT IOWA, where there is no state debt and where tax rates are equitable. State revenue is spent in a business-like way . . . on projects that foster present growth and provide for future progress. Iowa's workers, both men and women, are easily trainable. Many were educated by leading space-age scientists in state universities and private colleges. Others are trained through an area system of vocational schools and community colleges. It's a profitable climate, geared to the nation's sophisticated industries. Let us provide you, in confidence, with detailed information on the other site selection factors which SOLVENT IOWA can offer you . . . for greater profit.

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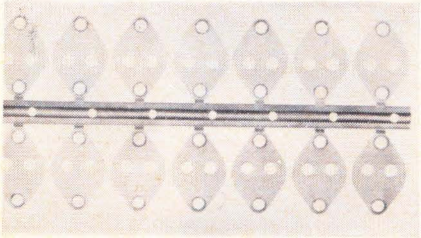
Circle 155 on reader service card

New Components



170 wafers provide the following features not available with other types of electrical insulators for TO-3 mountings:

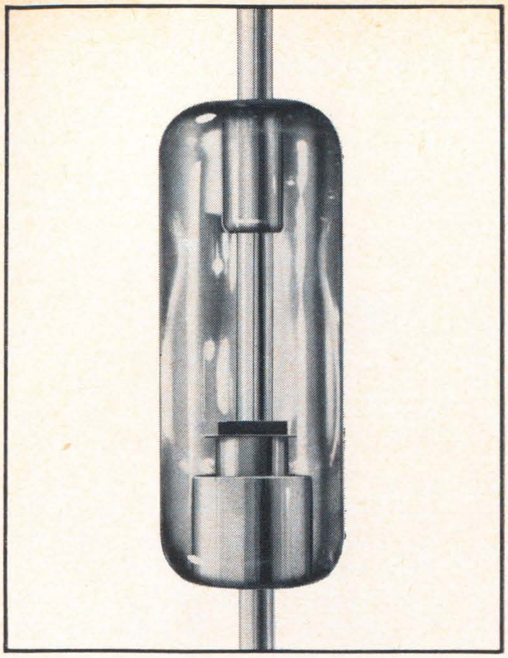
- An eyelet boss on each of two screw holes provides positive location of the wafer. It also permits uniform clearance between the screws and the wafers.
- Burrs on chassis or heat sink holes do not impair the insulating ability of the wafer since dielectric coating is on the transistor side.
- All edges, both perimeter and holes, have burr-free coined chamfers.
- Dielectric coating is applied to the 0.003-in. precision aluminum substrate of Delta Coate 151H on the transistor side only, including edges and hole inside diameters. This provides dielectric strengths of 3,600 v breakthrough and 1,000 v arcing around the edges. Resistance is only 0.20°C/watt. Breakthrough dielectric strength is not affected by water.
- Wafers are shipped on a two-sided carrier that holds 20 on each side. The carrier aids in counting, inspecting and shipping. Each wafer is scored for fast, easy breakoff from the carrier. The breakoff tab is tipped upwards 0.040 in. above the chassis or sink when mounted.

Price is 4.9 cents per wafer in quantities.

Wakefield Engineering Inc., Wakefield, Mass., 01880. [352]

Comb-actuated relays need little space

General-purpose, comb-actuated relays—with plug-in, solder, or printed circuit terminals—can be used in computer systems, control and alarm systems, business machines and data processing equip-



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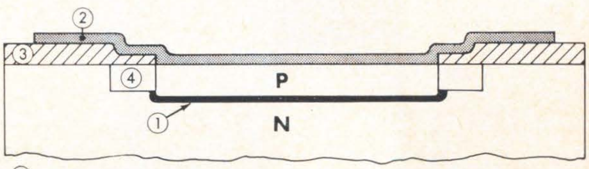
MAKE A "RamRod" ZENER DIODE!

Improving an already "topnotch" device usually isn't easy. However, our engineers have come up with several state-of-the-art innovations that will even *further* enhance the unequalled quality and long-term reliability of Motorola 250- and 400 mW glass zener diodes. We call it the RamRod*

First, they obsoleted the traditional "whisker" contact. This questionably reliable element has given way to thermally efficient, gold-plated dumet leads that give you:

- straight-through lead alignment that prevents "S-bend" mismatches and shorts to substrate
- increased power dissipation through direct, lead-to-die, soldered contact
- continuous device operation when subjected to shock or vibration
- closely matched thermal expansion coefficients that allow the device to easily handle −65°C to +175°C Mil thermal cycling

Voltage "drift" and progressive device degradation have been virtually designed out of Motorola units, too. Metal overlays completely protect the silicon oxide-passivated junction surfaces. This prevents the movement of ionic contamination on the oxide . . . ensures excellent reverse current stability



1. Active breakdown region (heavy line) buried in substrate, not exposed to surface
2. Metal-over-oxide assures maximum device stability before and after breakdown
3. Passivation layer ensures bulk breakdown at reference voltages, minimizes leakage
4. "Depthless" junction eliminates conventional junction "pop-out" and thermal shock/fracture problems

before breakdown . . . keeps the units at consistent, uniform voltage levels.

Our engineers also conducted reliability tests on the RamRod. As of this publication, large samples of these new units have withstood 7,500 hours of over-stressed 500 mW testing (over ½-million device-hours) without a failure!

Then there's price. Even with all the improvements, there's *no increase in price.*

All-in-all we're sure you'll want to specify RamRod devices on your next zener diode order.

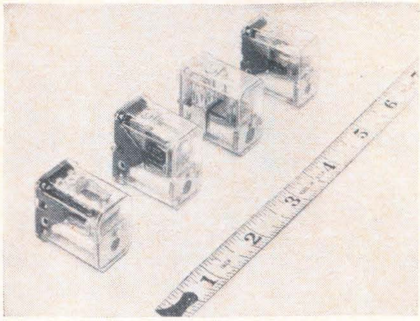
Now at your franchised Motorola distributor . . . technical data: Box 955, Phoenix, Arizona 85001.

– where the priceless ingredient is care!

MOTOROLA Semiconductors

*Trademark of Motorola Inc.

New Components



ment. They are designed for transistorized systems where space requirements and operational longevity are of prime importance.

All series AZ-420 relays occupy less than 1 cu in. of space. When installed with the company's right-angle socket, the over-all height is only ¾ in.

Other features include a life expectancy of up to 100 million operations, and a balanced spring-held armature enables the unit to operate in many positions.

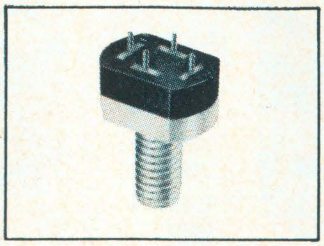
Contacts can carry loads up to 5 amps, as well as low-level signals. Hermetically sealed and high-voltage models with contact ratings of 2 amps at 110 v d-c and 1 amp at 250 v a-c are available.
American Zettler Inc., 697 Randolph Ave., Costa Mesa, Calif., 92626. **[353]**

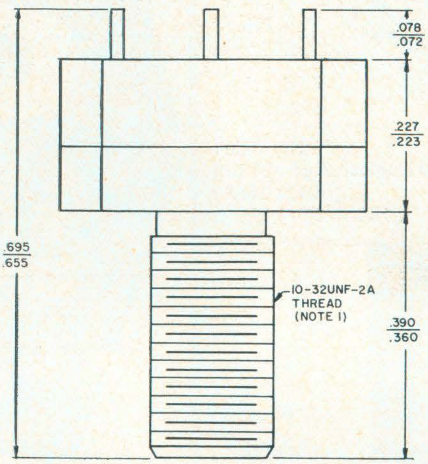
Optoelectronic devices serve as controls

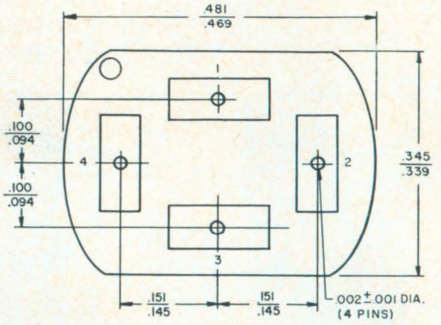
Automatic gain control is provided by three cadmium sulfide optoelectronic devices packaged in crystal cans. These Raysistors, designated the CK2051, CK2052 and CK2053, are claimed to offer improved performance for agc application because of improved linearity, inherent stability of the CdS cells, no loss in switch on time and slower switch off time.

The Raysistor is a four-terminal device in which a controlled light acts on a photoresistive element. No electrical or mechanical signal path exists between the control and the signal circuits. Input and output are completely isolated.
Raytheon Co., Components division, Spring St., Lexington, Mass., 02173. **[354]**

Plastic makes (almost) perfect







DIMENSIONS IN INCHES

A broadband radio-frequency transistor with lead inductances so low they can't be accurately measured is now being offered as a developmental type by the semiconductor division of the Radio Corp. of America. The emitter lead inductance is approximately 0.1 nanohenry; the base lead inductance is about 0.2 nh.

Much of the credit for the achievement can be attributed to the plastic case of the TA2909 which electrically isolates the electrodes from the stud. Since there is no need for a header, the path into the chip is shorter than with a metal can. A comparable developmental model, TA2675, has identical outputs but is hermetically sealed in a TO-60 can and consequently has higher inductance: 0.2 nh for the emitter lead and 3.0 nh for the base lead.

In addition, the configuration of the plastic case permits circuit flexibility, since the four short pins on top permit wiring the device to strip lines or to printed-circuit boards.

Designed for class B and class C r-f amplifiers in military and industrial communications equipment, the transistor will cover the spectrum from 225 to 500 megahertz. At 225 Mhz, typical output is 22 watts; at 400 Mhz it is 15 watts.

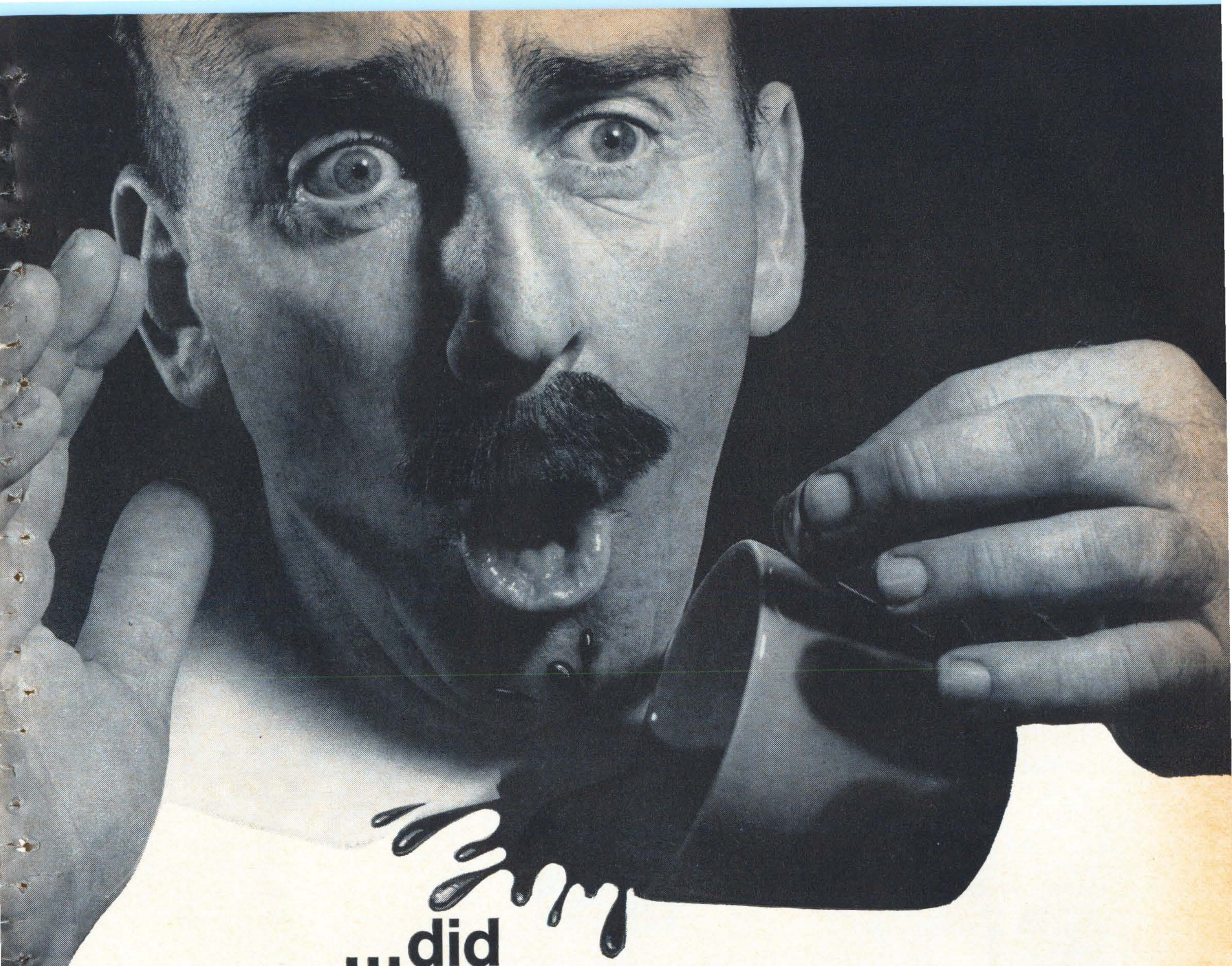
The transistor is an epitaxial silicon n-p-n device made with an overlay structure. More than 400 tiny emitter sites are connected in parallel and covered with a layer of aluminum that conducts current to the lead. The structure gives a high periphery-to-area ratio that increases current-handling ability while at the same time decreasing both input and output capacitances.

As developmental models, both the plastic and metal versions cost $66. Commercial models should be available soon.

Specifications

Frequency range	225 to 500 Mhz
R-f output, 28 v	
at 225 Mhz	22 w typical
at 400 Mhz	15 w typical
Collector-to-emitter voltage	
V_{BE}=1.5 v	65 v
External base-to-emitter resistance of 30 ohms	40 v
Emitter-to-base voltage	4 v
Collector current	4.5 amps
Transistor dissipation up to 25° C	36 w
Gain-bandwidth product	600 Mhz typical
Temperature range	—65 to 200°C

Radio Corp. of America, Semiconductor division, Somerville, N.J. **[361]**



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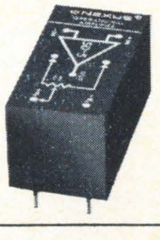
This new unit is ideal for commercial and industrial OEM applications where dependable performance is required and price is an important factor. It is now available for 2-week delivery from stock in reasonable quantities.

The SQ-5 is also available, with the same electrical specifications, at a price of $10.50*. Write Nexus Research Laboratory, Inc. for complete information.

TYPICAL PERFORMANCE

Supply voltage	±15 volts
Output	±10V @ 2.2 mA
Open loop gain @ dc	10,000
$\Delta E_{OS}/\Delta T$ (−5°C to 70°C)	30μV/°C
Input offset current (either input)	200nA
Frequency limit for full output	20kHz
Unity gain crossover frequency	1.5MHz



*In quantities of 10-99 – Prices F.O.B. Canton, Massachusetts. Prices slightly higher outside North America. **IEEE BOOTH 4D25/4D27**

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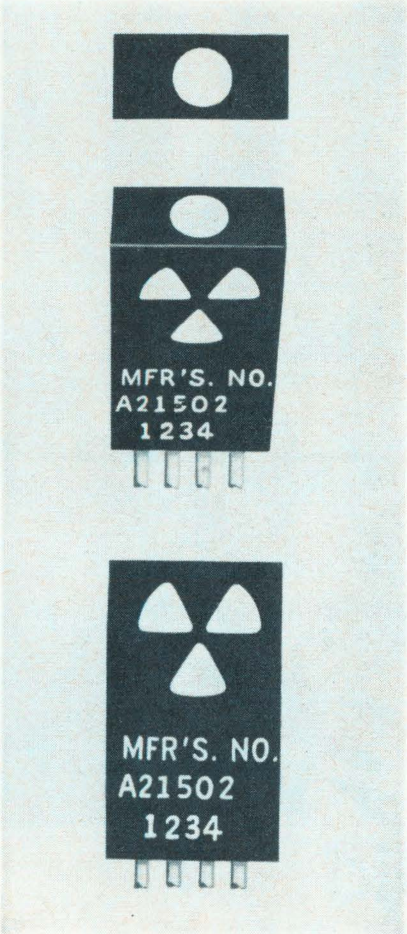
Circle 161 on reader service card

Putting the BITE on faults



To circumvent the shortage of maintenance technicians the Defense Department has ordered the installation of fault indicating devices on most avionic equipment —down to the module level. Eventually the Defense Department plans to include indicators in almost all their gear. These indicators are termed BITE—for built-in test equipment.

Many commercial companies are faced with similar manpower problems, and now BITE indicators have been made available to them. The A.W. Haydon Co. recently introduced microminiaturized fault indicators for nonmilitary use.

A latching feature is unique to the Haydon indicators. A fault is indicated visually by a change from black to white in a window on the module. When the change occurs, it remains fixed until the indicator has been reset by a pulse of the opposite polarity, even if power is removed from the system being monitored.

If, for example, line transients in a computer were a problem, the fault indicators could be designed into the circuit to sense abnormalities within a particular circuit card. A periodic check of the printed-circuit cards would show whether a transient had occurred and which cards were affected. Those cards on which the fault indicators switched to white could be removed and replaced with fresh cards. The damaged cards would be sent to a central facility for checkout and repair. An obvious advantage of this troubleshooting technique is that no special skills are required and special electronic test equipment is unnecessary.

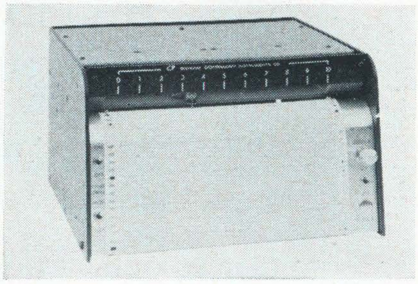
The indicators respond to a pulse input with a duration as short as 15 milliseconds. When the unit senses a pulse, it transfers from one static state to the other. No power is drawn by the device during a static state, only during the transfer time—a matter of milliseconds. The Haydon indicators operate over a 17 to 29 volt d-c range and can be supplied with arc-suppression diodes. Variations include units utilizing a 4-volt fault signal, round packages, pop-up indicators and units with special interface circuitry. Indicator size is 0.7 x 0.2 x 0.4 inch.

A.W. Haydon Co., 232 North Elm St., Waterbury, Conn. **[371]**

Strip chart recorder uses MOS-FET chopper

The R series strip chart recorder, available in single- and dual-channel models with one or two chart speeds, features flip-out chart loading, solid state electronics including metal-oxide-silicon field effect transistor chopper, and disposable ink cartridges.

High-performance features include an accuracy of 0.3% of full scale, 500,000 ohms input resist-



ance, 0.5 second full scale pen speed and adjustable damping. Quality construction features include fully enclosed motors and slidewires, sturdy aluminum outer structure and provisions for an optional built-in disk integrator.

Dohrmann Instruments Co., CP Recorder division, 1062 Linda Vista Ave., Mountain View, Calif., 94040. **[372]**

Test oscillator boasts amplitude stability

Covering the spectrum from 10 hz to 10 Mhz in six continuously variable ranges, the solid state model 651B test oscillator is designed for fast, accurate measurements of tv amplifiers, audio amplifiers, filter networks, tuned circuits, and telephone and telegraphic carrier equipment. A dual amplitude control—coarse and fine—makes amplitude adjustments easy and precise.

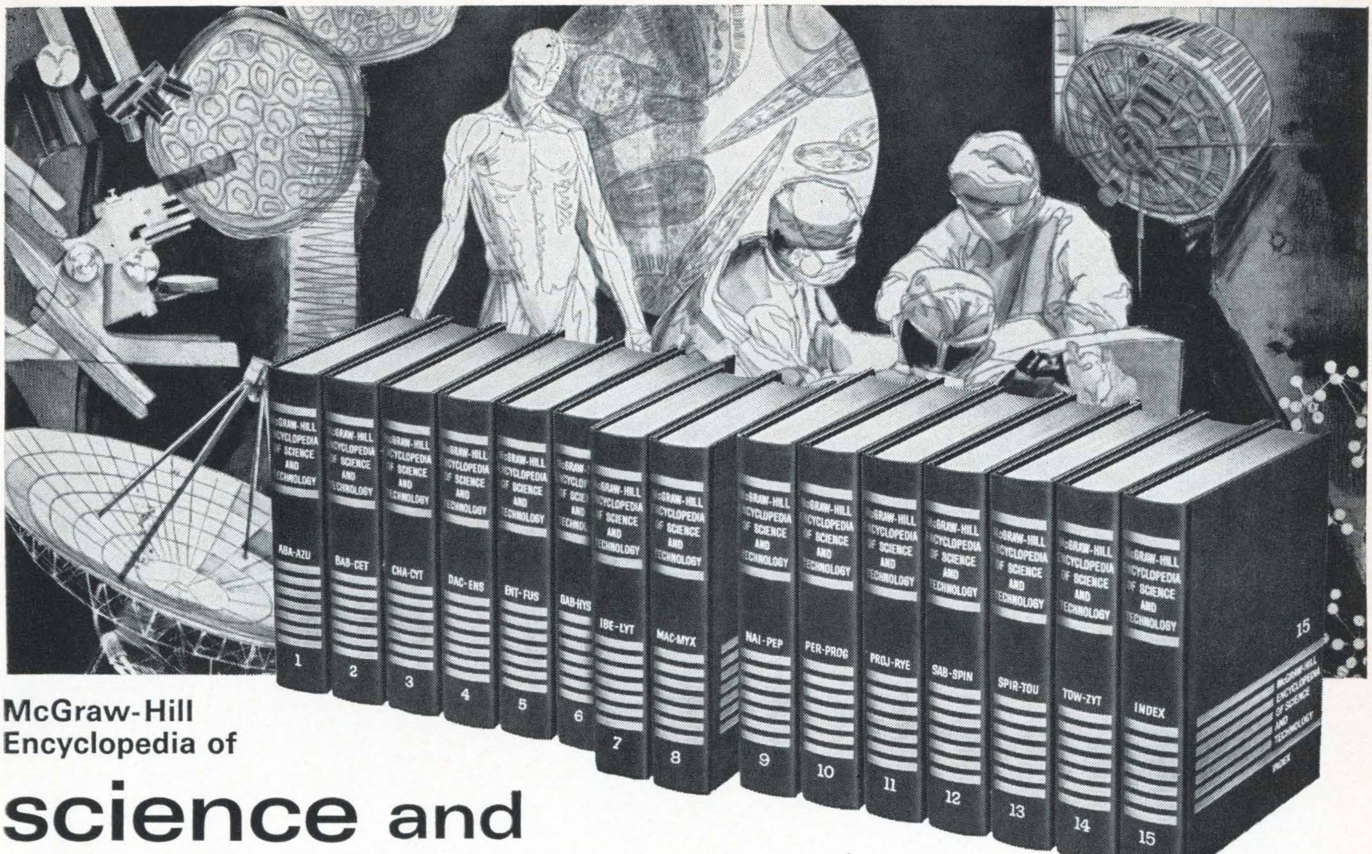
Short term frequency stability in normal laboratory environments is typically ±0.02%/22 hours, even at the least stable frequencies. Similarly, typical amplitude stability is ±0.1%/17 hours.

Frequency response is flat within ±2% from 100 hz to 1 Mhz. The dial is accurate within ±2% from 100 hz to 1 Mhz. Available output is 200 mw into 50 ohms, 16 mw into 600 ohms, or 6.32 v open circuit. Either output is controlled by a 90-db attenuator in 10-db steps (±1%).

Model 651B is housed in a rack-convertible module measuring 5¼ in. in height. The unit is 16¾ in. wide, 13¼ in. deep, and weighs 17 lbs.

Price for the basic model is $590; delivery, 6 to 8 weeks.

Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif., 94304. **[373]**



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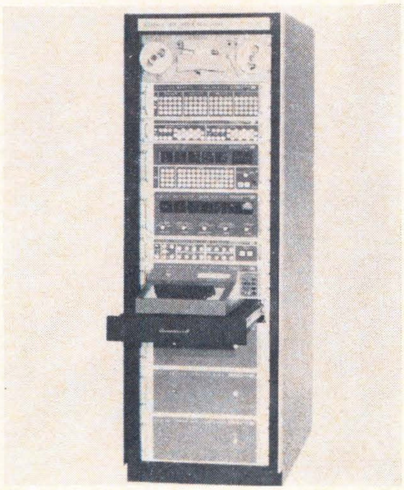
Automatic data system tests multilead units



Incoming inspection, engineering, production and quality control areas are expected to benefit from a fully automatic system that tests many types of multilead devices, including integrated circuits, circuit boards and modules. With the Auto Data 9400 system, programing of stimuli, measurement, comparison and switching functions is accomplished with a high-speed tape reader that uses inexpensive, versatile paper tape.

Four constant voltage supplies and four constant current ranges that can be programed are incorporated in the system for d-c stimuli. Other features of the Auto Data 9400 include programed high speed d-c dual limit go/no-go comparisons, and five-digit d-c, a-c and resistance measurements with data logging and sorting outputs.

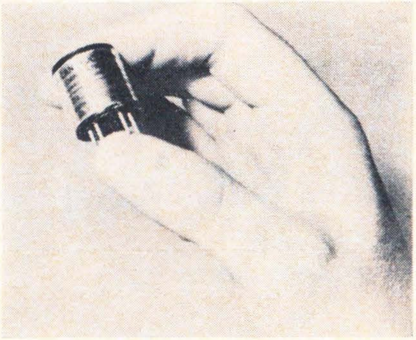
A data switch, that can be programed and which provides 512 individual memory switching points, permits switching for the various stimuli and multilead connections for the device being tested. The data switch may be readily expanded to accommodate changing test requirements.

The complete system is of modular construction, employing highly reliable integrated circuits. A system test panel, which is included as a standard item, will perform preventive maintenance tests in conjunction with check programs.

The basic 9400 system is approximately $40,000. Current delivery is 45 to 60 days after receipt of order.

The 3M Co., 2501 Hudson Road, St. Paul, Minn., 55119. **[381]**

Small audio amplifier features low noise



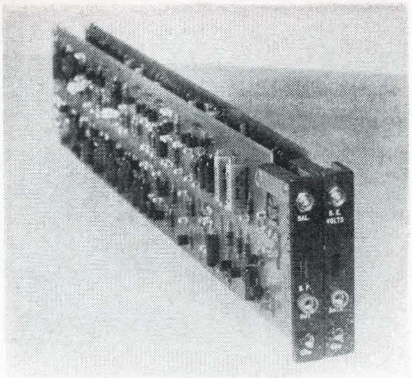
A miniature audio amplifier designated model 614A can be used as a power and line amplifier for tape recording or as a microphone preamplifier, tape playback and magnetic cartridge preamplifier. Extremely low noise and minimum distortion, even in the severest applications, make it also particularly adaptable for use with hydrophones, accelerometers, biomedical sensors and transducers.

The amplifier mounts in any standard nine-pin miniature tube socket, or may be used with a p-c board. It has a flat frequency response from 6 hz to 100 khz ±0.25 db. With a 600-ohm source and 600-ohm load operating at 40 v, the open loop gain tested at 57 db with noise at −130 dbm.

American Nucleonics Corp., 1007 Airway, Glendale, Calif. **[382]**

F-m discriminator has modular construction

All-silicon transistor circuitry and a pulse averaging detector provide a small, high quality telemetry frequency-modulated subcarrier discriminator at moderate cost. The small size of the modules allows the placement of 14 discriminators



in a standard 19-inch rack with a panel height of only 3½ inches. Over 200 discriminators fit a standard 72-in. rack.

A four-pole-pair linear phase-active bandpass filter provides equal rejection for upper and lower adjacent IRIG channels because of arithmetic design. According to company engineers, the limiter provides a dynamic range equal to that of the highest priced discriminators. Using present switching techniques, the limiter is designed for very high speed operation without feedback. This eliminates the tendency for spurious oscillations that is a source of noise in many discriminator designs.

The unit has a standard output current of 50 milliamperes; 100 ma is available. Delivery is within 30 days; cost less than $500.

Defense Electronics Inc., Rockville, Md. [383]

Voltage memory card monitors transients

Model 5221 voltage memory card provides an economical approach to the monitoring of single or repetitive transients in pulse widths from 0 to 100 microseconds. It is used with an external meter and power supplies, and mounts in the user's equipment.

The card converts the peak amplitude of any input signal of 100 μsec or longer duration into a d-c output and holds it indefinitely in an electronic memory until reset or until a higher amplitude input pulse is received. Input impedance is 10,000 ohms minimum, and the input circuit has a 20% over-range capability. Output of the memory card is 0 to 100 μa d-c, full scale,

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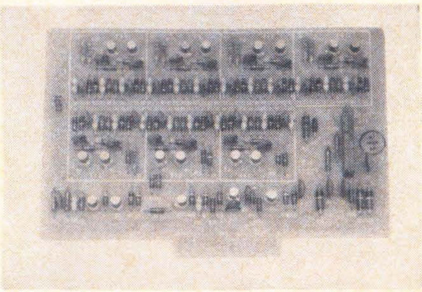
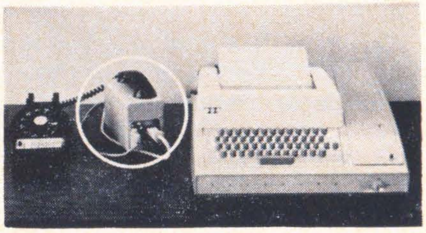


and is internally adjustable to full scale for meters of 500 to 1,000 ohms internal resistance. Accuracy is ±2% of full scale.

Model 5221 is a printed-circuit card 6⅜ in. long x 4⅝ in. high, including connector fingers. It is priced at $150 each in quantities of 1 to 9. Discounts are available on larger quantities.

Micro Instrument Co., 12901 Crenshaw Blvd., Hawthorne, Calif., 90250. [384]

Compact transceiver talks to computers

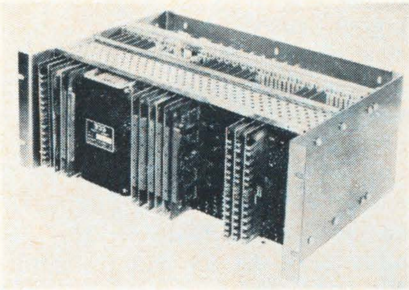


A teletypewriter or similar device may be operated as a portable remote computer terminal using an audio coupler for data transmission, designated the Audio Magnetic Data Receiver. The teletypewriter can communicate with a computer from anywhere an ordinary telephone is available. An interface adaptor connects the transceiver to the teletypewriter. The user dials the number of the computer from the telephone and places the telephone handset on the audio magnetic data transceiver; information can then be transmitted both ways between the terminal device and the computer over standard telephone lines.

The transceiver transmits by coupling acoustically into the telephone's handset. It receives by magnetically coupling the signal (acoustic-receive option is avail-

able). The unit operates either half or full duplex; fits either model 33 or 35 Teletype; and is built with silicon components exclusively for high reliability.
Tymshare, Inc., 745 Distel Drive, Los Altos, Calif., 94022. **[385]**

Core memory system is easily expanded



Latest addition to the manufacturer's family of core memories offers features of both off-the-shelf and custom designed systems. The CE-100 has a 1-microsecond cycle time; it comes in modules of 4,096 four-bit words, and is expandable to 4,096 words of 36 bits in four-bit increments. Expansion is accomplished by the addition of bit-oriented, plug-in logic boards and selection of magnetic modules.

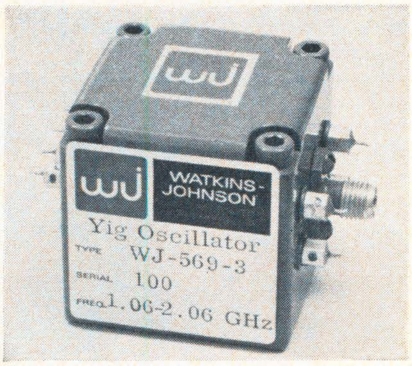
The user may custom design his system by selecting any portion of the prewired 4,096-word by 36-bit capacity. He can change his design after the system is functioning by specifying additional modules or stacks. The result is a semicustom memory produced from standard modules.

The system requires only 7 inches of standard cabinet rack space; the optional power supply requires only another 5¼ in. The CE-100 uses integrated circuits in all but the high-current circuits. Power consumption is 325 watts maximum for the full 4,096-by-36 bit system, and proportionately less for smaller systems.

Typical applications for the new memory include special-purpose computer systems, digital instrumentation and data reduction systems, data buffer systems, stored-program memory systems and a central memory for small electronic data processing computers.
Lockheed Electronics Co., 6201 E. Randolph St., Los Angeles, Calif., 90022. **[386]**

New Microwave

YIG-tuned oscillator covers 1 to 2 Ghz



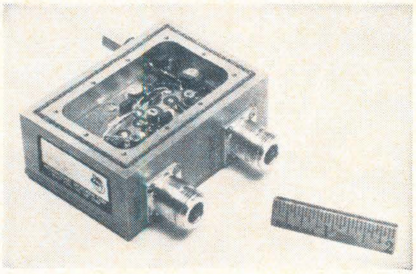
Introduction of a miniature YIG-tuned oscillator represents the first of a new family of lightweight, long-life, solid-state sources. This compact device is voltage tuned over a frequency range of 1 to 3 Ghz with excellent tuning linearity and high temperature stability. The device is a 1-in. cube.

The resonant frequency of the oscillator, WJ-569, is directly proportional to the magnetic field applied to the YIG element. Tuning is accomplished by superimposing the varying field of an electromagnet on the field of a permanent magnet. Also available is a YIG-driver supply that allows a high-impedance, low-voltage source to tune the oscillator.

For applications requiring maximum frequency stability, a small heating element and a thermistor can be mounted inside the assembly close to the YIG resonator. This holds the YIG resonator at a constant temperature even if the ambient temperature varies over a large range.

Watkins-Johnson Co., 3333 Hillview Ave., Stanford Industrial Park, Palo Alto, Calif. **[391]**

Vhf-uhf preamps boast low noise

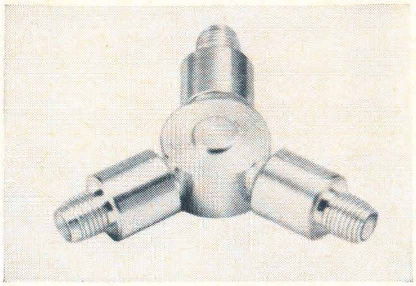


Solid state vhf-uhf preamps cover the band of 200 to 550 Mhz with a noise figure of 2.5 to 3.5 db over the band. They are ruggedly constructed to operate in all types of field environmental conditions. A special case and filters protect against radio interference generated by transmitters and other nearby equipment. The unit was designed to replace parametric amplifiers in tropo scatter systems operating in these bands.

Operating specifications include a gain of 18 db ± 1 db over the band. Input and output impedance is 50 ohms; operating temperature, −30° to +65°C; operating power, —24 v dc at 17 ma. The unit measures 3¼ x 2¼ x 1⅜ in.

International Microwave Corp., River Road, Cos Cob, Conn., 06607. **[392]**

Tiny power dividers cover broad bands



Two lines of resistive and reactive miniature power dividers, covering broad frequency ranges, are priced at only $50.

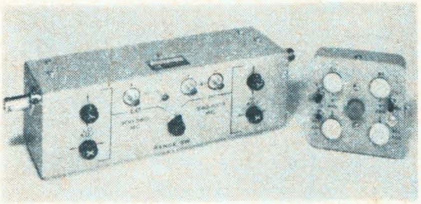
The resistive power dividers, series DA, measure as little as 2 in. in diameter and ½ in. in height and operate over the frequency range from d-c to 12.4 Ghz. Average power rating is 1 watt; peak power rating is 1 kw, and maximum vswr, 1.50.

Series D2 reactive units offer 10 w average power handling capability in both the 2 to 8 Ghz and 4 to 15 Ghz ranges. Insertion loss is only 0.2 db. Connectors on all power dividers are type MFM.

All units are available from stock.

Microlab/FXR, Ten Microlab Road, Livingston, N.J. [393]

Impedance plotters come in 2 types



Automatic Smith chart impedance plotters are available in both coaxial and waveguide units.

Coaxial models cover a 3 to 1 frequency range with the highest frequency unit operating to 3 Ghz. Waveguide models begin at 350 Mhz and cover the range to 12 Ghz with each unit covering a full waveguide frequency band.

Each impedance plotter kit includes all the cables and accessories necessary to set up an impedance test system.

Texscan Corp., 51 Koweba Lane, Indianapolis, Ind. [394]

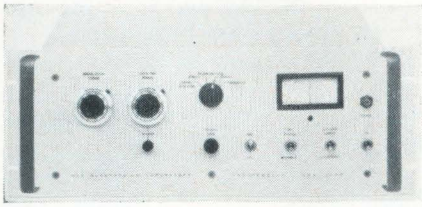
Microwave receivers offer high resolution

Solid state radar receivers, designated series HR400, are suited for extended-range reconnaissance and pinpoint surveillance. The units provide high fidelity reception of pulses as short as 10 nsec and have a linear instantaneous dynamic range of 30 db. Internal pulse reflections are reduced 30 db within 10 nsec, thereby providing accurate cross section and range data on closely spaced targets.

Suitable for systems such as airport taxi-radar, and short range tactical fire control and any radar system requiring close target definition, models are available from L through K band.

Typical of the series is the

New Microwave

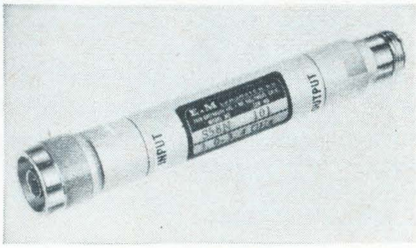


HR400A95, which incorporates the following specifications: r-f tuning range, 8.5 to 9.6 Ghz; noise figure, 9 db; i-f bandwidth, 120 Mhz; i-f center frequency, 160 Mhz; minimum pulse width, 10 nsec; instantaneous dynamic range, 30 db; video output capability, 5 v into 50 ohms.

Prices for this series start at $7,900 with deliveries of 60 days.

RHG Electronics Laboratory, Inc., 94 Milbar Blvd., Farmingdale, N.Y., 11735. **[395]**

Coaxial isolators feature low loss



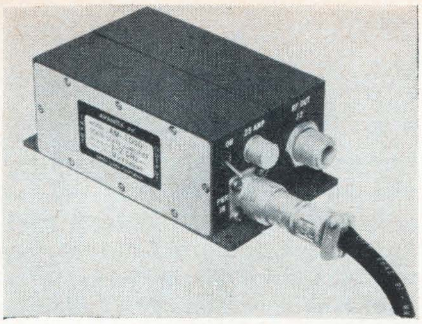
Missile and satellite systems are included among the applications for a series of low-loss, lightweight coaxial isolators. Covering the frequency range of 2 to 3 Ghz, the units offer a 40-to-1 front-to-back ratio in a magnetically shielded package ¾ in. in diameter by 5¼ in. long over-all.

Isolation is 20 db minimum; insertion loss, 0.5 db maximum; vswr, 1.20 maximum; temperature range 0° to +50°C; weight, 6 oz.

E&M Laboratories, 7419 Greenbush Ave., North Hollywood, Calif. **[396]**

Microwave preamp replaces heavy twt's

An integrated power supply and transistorized microwave amplifier enables systems designers to re-



place heavy traveling-wave tubes with a solid state microwave preamp weighing only 2 pounds. Conventional twt units currently weigh 15 to 20 pounds and occupy about ½ cu ft.

Advantages of the integral module over twt units are a 10 to 1 reduction in weight and power drain; infinite shelf life; 206,000-hr mean-time-between-failures rating; 4 to 1 size reduction and flatter passband gain.

Frequency response of the module is 1 to 2 Ghz; noise figure, 6-db maximum; gain, 25-db minimum; power output, −6-dbm minimum; gain flatness, ±1 db.

Units will meet full military specifications for shock, vibration, radio frequency interference and humidity.

Price is approximately $2,500 depending on options. Units are available within 30 days.

Avantek Inc., 3001 Copper Road, Santa Clara, Calif. **[397]**

Vhf diode limiters handle high power

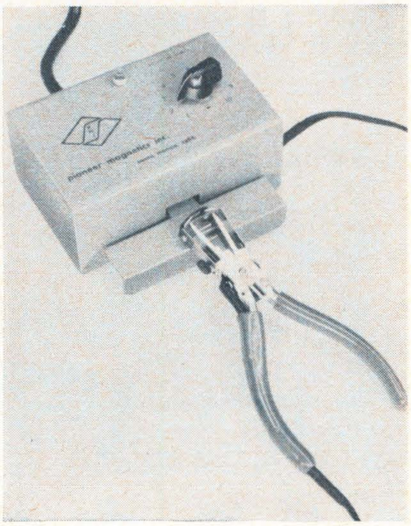
Coaxial diode limiters can handle 5 kilowatts average or 1 megawatt peak in the 20 to 200 Mhz range. The limiters provide complete receiver protection over any 20% bandwidth in this frequency range. Spike leakage has been totally eliminated and recovery time is less than 1 μsec. Insertion loss is 1 db nominal. If damaged, the diodes in the unit are easily replaced.

Suited for high power, tracking radars, the diode limiters are compact in length and provide a pressure seal at the input flange which can be specified as either 3⅛ or 1⅝ EIA. The output connector is type N; however, other connectors may be specified.

Microwave Associates, Inc., Burlington, Mass. **[398]**

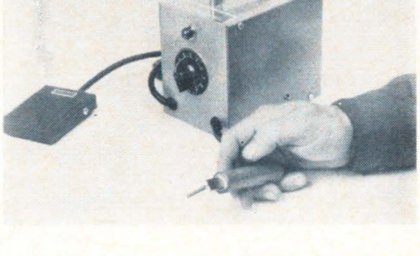
New Production Equipment

Thermal wire stripper offers no-nick action



A thermal wire stripper using higher temperature alloy heater elements and special friction gripper pads is designed for stripping wire having DuPont H-Film (Kapton) insulation. The PM1056H features a no-nicking patented action that allows the operator to sever and remove the insulation slug from the wire in one combined operation. It utilizes non-slip, cushion-grip plastisol handles and a Teflon covered guide-guard that provides maximum protection against scratching of the stripped bare wire as it is withdrawn from the stripper.
Pioneer Magnetics, Inc., 1745 Berkeley St., Santa Monica, Calif., 90404. **[399]**

Silver-soldering tool makes strong joints



A solder tool can silver-solder small parts and wire as fine as 0.3 mil. It is used almost exactly as the conventional miniature iron for low melting solder. The tip of the tool is heated directly by current passing through it; but the current does not pass through the parts to be joined as in resistance soldering. The tip's temperature is precisely controlled—from room temperature to bright red heat—by a continuously variable power supply.

Only a few seconds are required to complete the operation: silver solder paste is placed on the parts and the soldering tip is placed on the point.

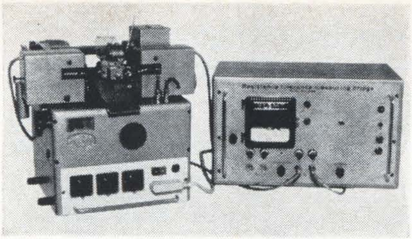
The tool is designed for use where an open torch cannot be applied on small gauge wire and miniaturized parts. It is intended for soldering wire from larger than No. 26 Awg to extremely fine wires as small as 0.0003 in. Precise temperature control of the tip permits joining wires whose melting point is close to that of the silver solder used.

Typical shear strength of a silver solder joint is 40,000 psi. One advantage of the hard soldering technique is that it anneals copper wire joints and makes them less subject to breakage. Other advantages include the ability to work in normally inaccessible locations and to direct heat in exactly the desired spot.

The tool's handle is 3½ in. long and holds the metal heating element which is 1 in. long. The active portion of the chisel-pointed tip is approximately $\frac{1}{16}$ x $1\frac{1}{16}$ in. The power supply is in a 4 x 5 x 6 in. baked enamel steel box. A foot switch activates the continuously variable power supply from a 115-volt a-c source. Power dissipation of the complete handle assembly is a maximum of 50 watts. A pilot light indicates when power is applied to the tip. Weight is 8 lbs.
Western Electronic Products Co., 107 Los Molinos, San Clemente, Calif., 92672. **[400]**

Helixing machine cuts any resistor

An automatic helixing machine is designed to cut a helical, strip or



slot path on all types of resistors with an accuracy of ±0.25%. It handles resistors with or without leads and over a very wide resistance range.

The machine, model WS62-A65, will cut a desired path in the resistor until a predetermined resistance value is reached. Operation is completely automatic and controlled by a resistance bridge. The bridge is a null-seeking automatic balancing type, combining the advantages and reliability of null-type bridges with direct-reading circuitry.

Problems associated with resistor feeding, pick-up and holding have been eliminated by a new feeding-assembly design, according to the manufacturer. Also, the retraction time of the grinding disk has been shortened, thereby increasing the output and reducing the mechanical inertia to the lowest possible level, the company says.

Ball bearing and needle bearings are in all rotating parts. Individual controls are provided for all variable functions.

B. Freudenberg, Inc., 50 Rockefeller Plaza, N.Y., N.Y. **[401]**

Accurate machine winds flyback transformers

A flyback transformer winder multiple winds perfectly symmetrical layers of tertiary coils repetitively. An automatic two-speed cycle winds the wire rapidly through each layer and then automatically decelerates so that the operator may insert paper accurately between each layer.

Coil length ranges from 0 in. to 3 in. Maximum coil outside diameter is 5 in. Loading distance for multiple windings is adjustable between 24 in. and 39 in. Wire sizes wound are 20 to 41 Awg. Output end of the spindle is a ⅞ in., flatted shaft. A spindle locking fea-

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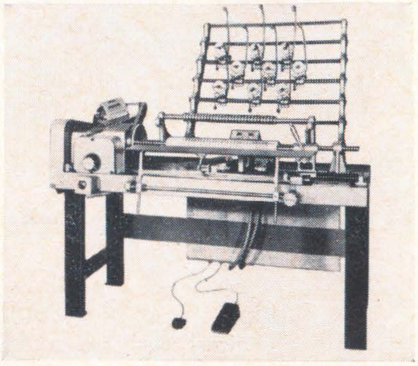


ture prevents wire slack and also provides immediate emergency stopping.

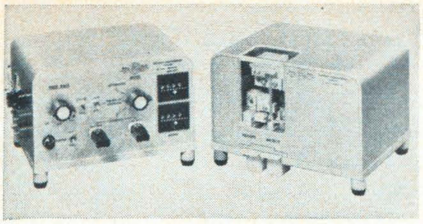
One winding set-up is furnished with 32-pitch, $\frac{5}{16}$-in. face, ½-in. bore, 20° pressure angle gears. Winding speed is 10 to 800 rpm and winding range 10 to 200 turns per layer. Changing traverse gears and cams requires only about 5 minutes. The operator can manually return the wire guide assembly repetitively to the starting point for each new stick. The machine is furnished with a low horsepower, d-c shunt wound motor with self-contained d-c source, instant resetting predetermining counter, magnetic brake, positive locking tailstock and one-way clutch for assuring positive drive and return of winding arm to starting position.

Price range of the model 116-AM is $4,000 to $4,500 depending on requirements. A tilting table or a fixed shelf for precut paper are available at slight extra cost. Delivery is 5 to 6 weeks.

George Stevens Manufacturing Co., 6001 N. Keystone Ave., Chicago, Ill., 60646. [402]

Semiautomatic device scans cores rapidly

Incoming inspection and quality assurance testing of ferrite memory cores as small as 12 mils can be done with a semiautomatic core handler. Model CH-25 scans large numbers of cores at a speed of 100 per minute and sorts the cores into either accept or reject categories. Electro-mechanical counters on an associated control unit tally the totals of accepted and rejected cores.



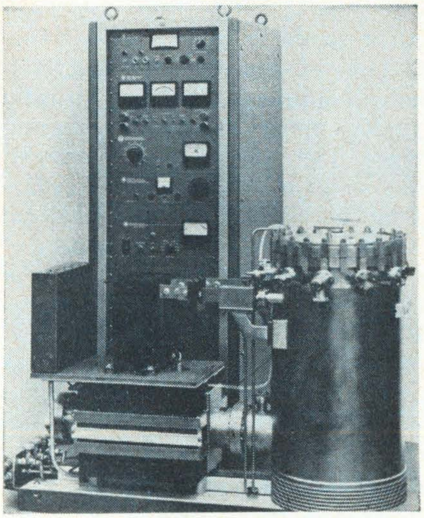
The device is also useful for analyzing core performance. It can be operated under remote control at temperatures up to 85°C so that core behavior can be observed under a wide range of temperature conditions.

The CH-25 accepts up to six individually isolated current driver inputs. High frequency wiring techniques and inductance compensating circuitry permit driving the cores with fast rise time (20 nsec) current pulses with minimum pulse waveform distortion. Uncancelled noise output is reduced to negligible levels of less than 1 mv.

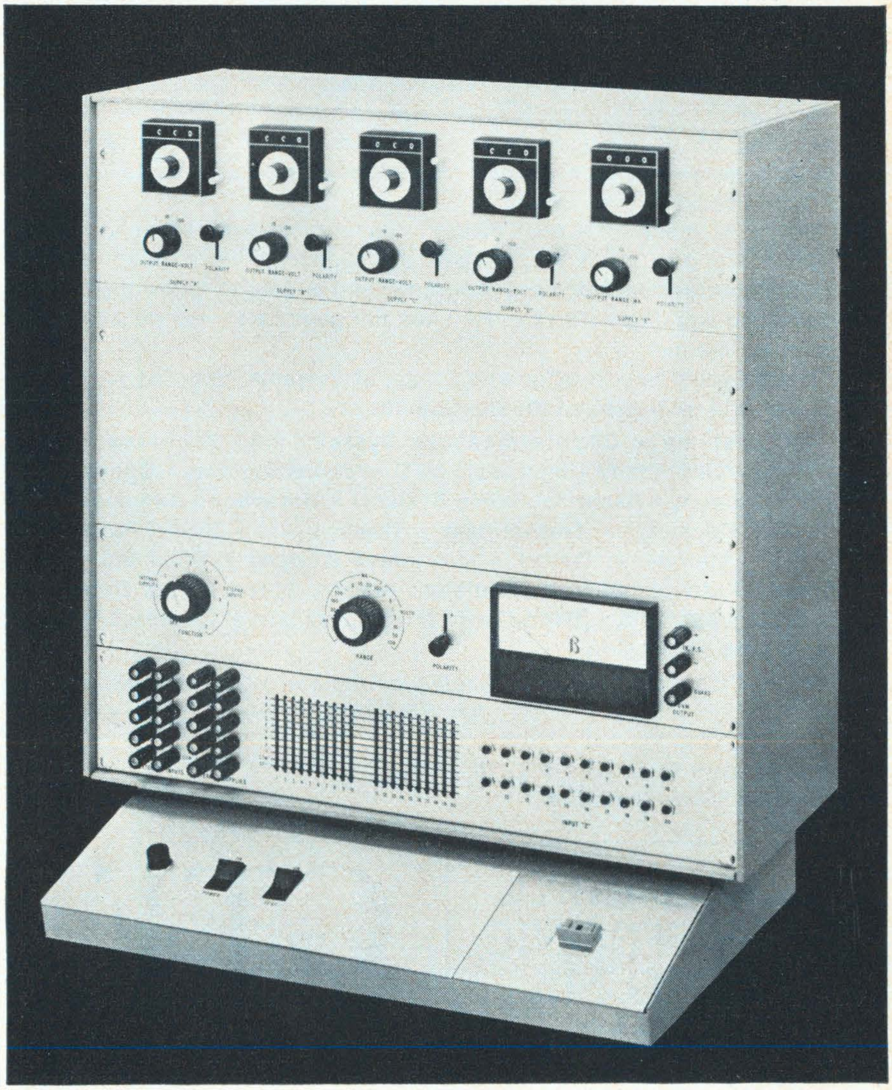
Input power to the CH-25 is 115 v a-c, 60 hz, at 0.25 amp. Dimensions of the body are 5½ x 7¾ x 6 in., and the control unit measures 5½ x 7¾ x 7 in.

Computer Test Corp., Computer Drive, Cherry Hill, N.J., 08034. **[403]**

Vacuum furnace gives rapid recycling



Vacuum brazing, degassing tests and long-term space simulation studies can be carried out with a new vacuum furnace that combines high stability with precise control. The furnace is also suited for annealing and heat-treating of refractory metals and alloys. It can



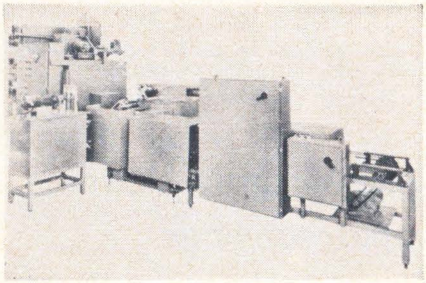
Production Equipment

be used for hydrogen brazing when operated with a tungsten or molybdenum hot zone. Tantalum and columbium hot zones are also available. The furnace's contamination-free pumps make it ideal for clean-room work.

The VF-200 furnace provides a large work space—20 in. inside diameter by 36 in. high. It can be rapidly recycled to $5x10^{-9}$ torr at greater than 1,250°C and achieves a base pressure below $1x10^{-10}$ torr within 24 hours. Precise temperature control is obtained by a thermal watt converter.

Varian Associates, Vacuum division, 611 Hansen Way, Palo Alto, Calif. 94303 **[404]**

Epoxy spray system coats armatures



An intricate system of several machines—electrically and mechanically interlocked—automatically applies epoxy insulation to armatures. The system eliminates end fiber, end tube and slot linear assemblies, saving time and labor.

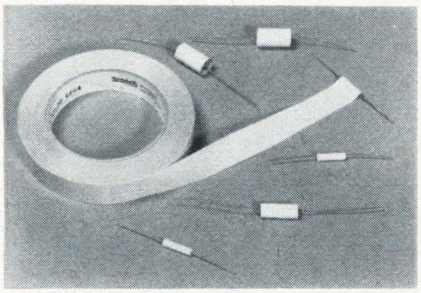
The only manual operation occurs when the operator places the armatures in a holder on the pre-heat oven conveyor chain. The rest of the operation, from the pre-heat oven through the spray coating and post-cure stages to the discharge conveyor is entirely automatic. Rate of production is up to 600 per hour of coated parts, depending upon the size of the armature.

Included in the automatic spray-coating system are a resin-feed system, an automatic resin-recovery unit and two automatic transfer devices.

Possis Machine Corp., 825 Rhode Island Ave. South, Minneapolis, Minn., 55426. **[405]**

New Materials

Polyester film tape for capacitor wrapping



Bondable backing and a thermosetting, pressure sensitive adhesive make this polyester film electrical tape suitable for wrapping capacitors and small diameter coils. The 2-mil-thick film provides sufficient body and the bondable backing resists the tendency to lift when the tape is applied to small-diameter objects.

A special 4X type adhesive is used which is highly resistant to solvents and oil in both the cured or uncured state.

Number X-1209 tape allows the customer to apply identification markings in the plant with a pressure sensitive tape printing machine. Rolls may be printed, re-rolled and dispensed later with standard equipment without transfering the ink to the adhesive. Resin adhesion to the bondable backing is as high as 45 oz/in. No paper release liner is required.

Other properties for X-1209 tape include a tensile strength of 50 lbs/in.; electrical strength of 6,500 v, and an insulation resistance of 1 x 10^6 megohms. The electrolytic corrosion factor is 1.0 and adhesion to steel is 60 oz/in.

The tape is available in widths from ½ in. to 1 in. Price for 1-in.-wide rolls ranges from \$8.56 to \$5.56, depending on quantity.

3M Company, 2501 Hudson Road, St. Paul, Minn., 55119. **[406]**

Polyurethane coating boasts low viscosity

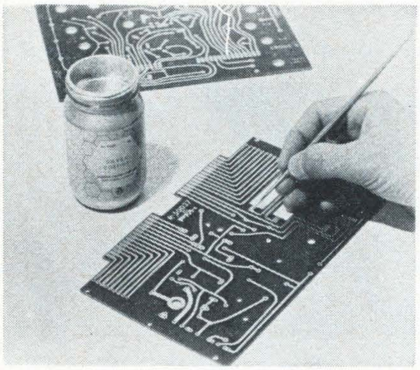
An electrical insulating polyurethane coating that conforms to Kennedy Space Center specification 0001 is designed for p-c boards and electrical assemblies. The coating is transparent and contains a fluorescent pigment for detecting uncoated parts under ultraviolet light.

Low viscosity, averaging 20 centipoises, supplies good wetting and penetration for sealing, and provides protection against stringent environmental conditions. Electrical characteristics include a dielectric strength of 2,000 volts per mil and a dielectric constant of 2.6.

HumiSeal type 2A56-LU is a two-part system. Working pot-life is as long as 4 hours; curing time is overnight at room temperature. It can be brushed, dipped or sprayed with conventional equipment.

Columbia Technical Corp., 24-30 Brooklyn-Queens Expressway, West, Woodside, N.Y., 11377. **[407]**

Conductive coating is easily applied



An electrically conductive coating made up of very fine silver particles dispersed in an air-drying resin is easy to apply to a variety of surfaces. The silver conductive coating, known as Dispersion FH-1629, provides excellent electrical conductivity with a volume resistivity of 0.01 ohm-cm. It adheres readily to a variety of surfaces including those of many metal, plastic, glass, ceramic, paper and rubber materials. The coating exhibits good environmental protection and is heat resistant to temperatures up to 250°F.

Designed for applications where

Circle 179 on reader service card→

a high degree of conductivity is required, Dispersion FH-1629 can be applied readily to flat or complex-shaped surfaces or components. Areas of typical application include electroplating, electroforming, sensing inks, electrostatic screening, potentiometer tracks, capacitors, electrodes, Mylar tape, static charge bleed and prototype printed circuits.

The new coating can be applied by conventional spray, brush, dip or roller coating techniques. After application, the coating dries into a hard film which is ready for use in 20 seconds.

Acheson Colloids Co., Port Huron, Mich., 48061. **[408]**

Centrifugal casting concentrates pigments

Epoxy tubing is now being centrifugally cast to concentrate the dense fillers and pigments in the outside wall area. This process produces a glassy-smooth, voidless inner wall surface for superior component encapsulation and positive bonding of the end seals.

Light foreign materials such as dandruff, hair, flakes and so forth remain on the inner surface and can be easily detected by quality control procedures, says the manufacturer. Electrolytic or moisture leaks by wicking action are eliminated in these nonfibrous tubes. Potting of components in this tubing also eliminates the need for molds and provides the positive insulation of a nontapered cylinder of cured, maximum-density epoxy resin with uniform wall thickness.

The epoxy tubing is suited for such applications as cable splices, capacitors, chokes, coil forms, computer building blocks, delay lines, diodes, feed-through, fuses, inductors, multiple-stage plug-in components, photon couplers, potentiometers, rectifiers, relays, resistors, slip rings, solenoids, transformers and transistors.

Resdel Corp., Box 217, Rio Grande, N.J. 08242. **[409]**

Fluorocarbon tubing shrinks with heating

A high temperature, heat-shrinkable Insultite fluorocarbon tubing, FEP, operates continuously up to 400°F and will shrink at temperatures in excess of 350°F.

Applications include wire and cable harnessing, and the insulation and protection of connectors, splices, electromechanical connections and motor leads. It can also quickly encapsulate solid state and other electronic components.

The manufacturer says the Insultite will form a quick, permanent insulating bond and will function ideally as an insulator or as an encapsulation for components that are subject to shock, strain, and vibration.

It is available in sizes Awg 24 to 1 in. expanded inside diameter. Delivery is three to four weeks.

Electronized Chemicals Corp., Box 57, Burlington, Mass. **[410]**

Low density, foamable polyethylene compound

Marlex TR-610 is a low density, foamable polyethylene compound designed for wire and cable coating and insulation. The material will produce small, uniform cell-size foam under proper processing conditions, according to the manufacturer.

Foamed wire coatings of Marlex TR-610 have been produced in thicknesses ranging from 12 mils to ¼ inch.

Phillips Petroleum Co., Chemical Dept., Bartlesville, Okla. **[411]**

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New Books

Unhandy handbook

Amplifier Handbook
Edited by Richard F. Shea
McGraw-Hill Book Co., 1,512 pp., $37.50

Although massive, this compilation is not worth the equally massive price of $37.50. The dust jacket promises "a tremendous fund of basic information [about] amplifiers," but the book is more a survey of amplifier technology than a handbook.

The major problems are the poor choice of material and the scarcity of charts, graphs and tables that are standard inclusions in a handbook. There are some tables, but most give only specialized material that few designers need. There is no appendix, hence, no tables of such handy information as mathematical constants and transfer functions of active and passive networks.

The index, however, is well-organized and sufficiently detailed. This is fortunate since the fundamentals of a particular topic tend to be scattered throughout the book, not grouped in one easily accessible section.

Furthermore the book is outdated. There is far too much emphasis on vacuum tubes at the expense of transistors. It is surprising to find 102 pages on electron tubes, while the chapter on transistors is a scant 26 pages and just brushes the surface of useful information. In contrast, ceramic filters are allocated 70 pages—rather wide coverage for such a specialized area.

The book is organized into three major sections: fundamentals of network theory, devices and circuits. The first section comprises seven chapters which are distillations of network theory from several books on the subject. There is too much detail about specialized fields that are not applicable to the rest of the book. Conversely, there is not enough detail about other areas which are covered in later sections.

Much more space is devoted to vacuum-tube than to semiconductor feedback theory. The significant feed-forward technique developed by H.S. Black is not mentioned. Stabilizing networks are not covered in sufficient detail to aid the designer. A chart summarizing the feedback characteristics of various configurations would have been an appropriate addition.

Operational amplifiers are slighted, and many design features and applications of these versatile performers are omitted. Audio amplifiers, however, receive a disproportionate amount of space. The schematics of Williamson amplifiers may be of historical interest, but their inclusion in a designer's handbook is questionable since these designs are no longer used. The many schematics and block diagrams of stereo, high-fidelity vacuum-tube amplifiers are also unnecessary. Even if tubes weren't virtually obsolete in this application, it would be redundant information for the hi-fi designer and of only marginal interest to the designer working in another area.

Martin A. Weiner
Kearfott Systems division
General Precision Inc.
Little Falls, N.J.

Choosing the proper device

The Semiconductor Data Book
Motorola, Inc., Semiconductor Products division
About 1,500 pages, $3.95

For many years, the Radio Corp. of America's manual on receiving tubes could be found on every engineer's desk. A new manual, reminiscent of the RCA classic, may become the new bible of the industry. The massive volume lists semiconductors, not tubes, and is published by Motorola, Inc.

More than 10,500 devices registered with the Electronic Industries Association are listed by EIA number, along with the major operating parameters and the number of the Motorola-made semiconductor which meets the specifications. This list is printed in very small type and takes up 178 pages. Larger type is used for the list of Motorola's semiconductors which are not registered with the EIA.

Data sheets for Motorola's semiconductors (there are 2,800, the company says) occupy 11 sections, with devices grouped by class, such as radio-frequency and field effect transistors and thyristors.

Since the EIA hasn't begun registering integrated circuits yet, Motorola includes data sheets on its own IC's only.

Other sections cover hardware, late additions to the listing and application notes. Several pages are left blank so the user can update his own copy as new products are introduced.

Recently published

Designing Transistor I.F. Amplifiers, W.Th.H. Hetterscheid, Philips Technical Library, Springer-Verlag New York Inc., 330 pp., $11.25

Stage-by-stage design of transistorized intermediate-frequency amplifiers isn't possible, says the author, because internal feedback in each stage affects performance of all the remaining stages. He includes internal feedback among the parameters in a number of design charts from which he develops a practical design procedure.

Noise and its Effect on Communications, Nelson M. Blachman, McGraw-Hill Book Co., 212 pp., $16.50

A presentation of the fundamentals of random processes and their spectra, the effect of a nonlinear transformation (such as demodulation) on a signal and noise, the statistical theory of detection and information theory following lines set by Claude Shannon. Although the noise dealt with is mainly Gaussian, the approach can be extended to apply to other types.

Networks and Systems, Peter H.O.'N. Roe, Addison-Wesley Publishing Co., 336 pp., $12.50

Another in the fast growing number of books on how to analyze networks. This one introduces signal-flow graph techniques and state variable equations to provide a modern technique for analyzing networks from a set of linear differential equations rather than with the old method of converting the network into an analog. Intended for the undergraduate, the book can nevertheless help practicing engineers keep up with modern circuit analysis techniques.

Electronic Drafting and Design, Nicholas M. Raskhodoff, Prentice-Hall, 594 pp., $15.95

Although written for technical institute students, engineers may find this a handy (though expensive) reference for tube and transistor outlines, military reference numbers, graphic symbols, etc.

The Theory and Design of Circular Antenna Arrays, James D. Tillman Jr., The University of Tennessee Engineering Experiment Station, 235 pp., available at no charge; must be requested on company letterhead.

Monograph applying the theory of circular antenna arrays to the design of antennas with circular symmetry. Based on research done by a professor of electrical engineering at the University of Tennessee, Knoxville.

Frequency Independent Antennas, Victor H. Rumsey, Academic Press, 150 pp., $7.50

The man who conceived the theory of frequency independent antennas in 1957 reviews recent theoretical and practical work. Both original writings and reprints from journal articles are included.

Technical Abstracts

Reliable assembly

Microelectronics packaging as applied to microelectronic modular assembly
J.M. Welty
Amelco Semiconductor, Mountain View, Calif.

A modular assembly taking up one-twelfth of a cubic inch replaces about 25 individual packages on a printed circuit board. Reliability is boosted, since 90% of the hermetic feedthrough connections required with conventional packages are avoided.

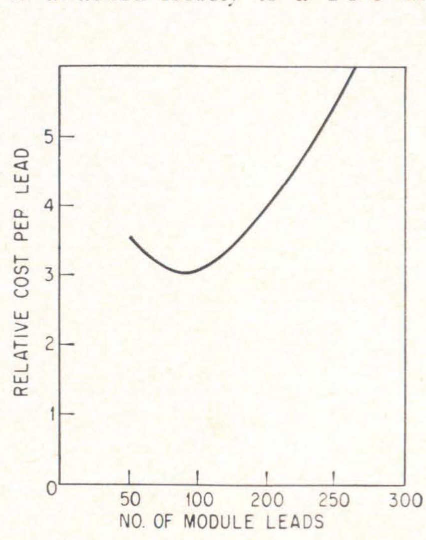
In fabricating the microelectronic modular assembly the starting point is a ceramic substrate molded with a 0.01-inch hole at each terminal. A mixture of pulverized molybdenum and manganese in a cellusolve carrier is used to coat the side of the substrate upon which the circuit will be formed, as well as the inside of the terminal holes. On the terminal side of the substrate a pad pattern is printed by a screening process. The metalization is fired, then gold is plated on the substrate. A photoresist and sulfuric-nitric acid etch are used to define the wanted circuit.

Next, a flange and a frame for the leads are brazed to the substrate. Semiconductor elements are alloyed to the substrate, and gold leads are thermocompression bonded. Up to 32 integrated circuits can be mounted in one package.

An innovation in the technique is this: Before IC's are sent to the module assembly line, they are alloyed to a molybdenum tab which is attached loosely to a TO-5 or TO-8 header. Device leads are brought to the header pin so that the device can be tested. If the IC is okay, the gold leads are snipped and the moly tab pulled loose from the header. The tab is then gold-tin soldered to the etched circuit.

The finished modules are available with 24 leads on one side or 18 leads on opposite sides.

The relative cost of assembling, testing, sealing and marking a module is a function of complexity, as shown in the curve. Complexity is measured by the number of device leads in the package.



The completed package is hermetically sealed using a preform that is shaped to fit the top of the frame and a rectangular metal lid.

Presented at the Microelectronics Lecture Series, Boston Section, IEEE, Nov. 22, 1966. [A similar lecture series is planned for the IEEE Convention in March.]

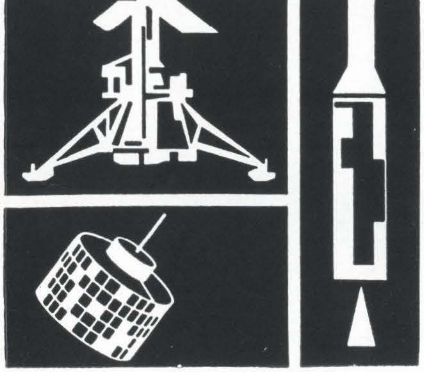
Lower failure rates

Semiconductor reliability design guidelines for characterization and application of signal diodes, transistors and dual transistors
Edwin A. Herr and Albert Fox
General Electric Co., Syracuse, N.Y.

The results of three extensive physics of failure reliability improvement studies on silicon diodes, transistors and dual transistors provide guidelines and design application information for semiconductors. These analyses—identified as component quality assurance programs—enable a designer to choose a circuit's operating conditions to maximize the semiconductor's performance and reliability. Particular attention was given to stress factors which affect reliability, such as junction temperature, voltage, current and environment.

Accelerated step-stress tests determined the threshold of failure and the accelerated stress region for each device. The results were used to set the levels for constant-stress in-time tests run at three or more stress levels for 1,200 to 4,000 hours.

Devices that failed these tests or whose performance was degraded, were subjected to physics of failure analysis. The failure modes and



Technical Abstracts

mechanisms were analyzed to evaluate the device designs and corrective action was taken, based on the findings. Semiconductors were then retested after corrections were made.

The primary objective of the diode program was to reduce the accelerated failure rate over a 1- to 1½-year period by about two orders of magnitude, bringing it to 0.0001%/1,000 hours. The goal with the transistor was to cut the failure rate over the same time period to 0.0004%/1,000 hours, 1/25 of its original value. And with the dual transistor, to 1/80 of its value —to 0.00025%/1,000 hours. These improved failure rates were achieved following a number of corrective actions taken in the design, process, fabrication, material and inspection procedures.

The results of testing the screened devices over these stress ranges indicated a similarities between devices made by the planar epitaxial passivated process. It became apparent that the semiconductor's junction temperature is dominant in determining reliability. Reducing the operating junction temperature from 200° C to 100° C resulted in a marked improvement in the failure rate in all three devices; as much as 25,000/1 in the dual transistor, 44.5/1 in the transistor and 15.8/1 in the diode. Further improvement was made by reducing the operating voltage at the lower operating junction temperatures. These improvements were 110,000/1 and 26.7/1 for the dual transistor and transistor respectively.

Presented at the 1967 Annual Symposium on Reliability, Washington, Jan. 10-12.

Circuit arrays

The impact of large scale integration on packaging and interconnection of digital electronic systems
J.W. Lathrop
Texas Instruments Incorporated, Dallas

Large scale integrated circuits can provide system packaging engineers with a new degree of freedom, if the packaging of the LSI circuits can be adapted to system needs. Packaging guidelines, as

Technical Abstracts

well as the alternative techniques of fabricating the circuits, are now being worked out.

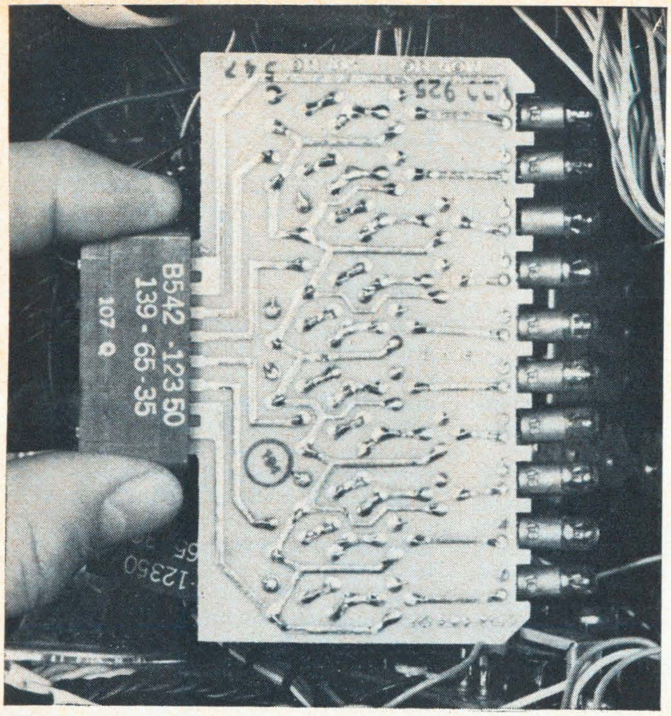
At the chip level, many circuits can be interconnected, so the ratio of system connection volume versus components volume is substantially lower than for conventional IC's. Also, the functional capability of each chip is about ten times as much as regular IC's. Three LSI interconnection methods are: make individual circuits larger and more complex, interconnect many small circuit cells with discretionary wiring, or combine these two approaches. One interconnection layer on the chip can suffice for complex circuits, discretionary wiring requires three layers, and the middle-of-the-road method takes two layers.

One of the first systems applications of discretionary wiring will be the computer of a phased array radar. Average complexity of the IC's may be about 250 cells. A process control computer whose circuitry was partitioned for the use of conventional IC's is a design model. The substitution of LSI circuits is expected to yield much useful information on packaging and interconnection of the new circuits.

Packages of early LSI arrays had 60 vertical pins and a later one has 42 leads on a side. Neither will be the final package form, because more consideration must be given system interconnection needs and such factors as assembly methods, repairability and testing.

At the system level, LSI saves interconnections because common connections to an array require only one lead each. With good design of the internal wiring, the number of signal interconnections increases as the square root of the number of gates, rather than one for one. The ultimate—only one lead each for input and output signals, ground and power—may never become practical. But the trend is toward more and more gates per lead.

Presented at the Microelectronics lecture Series, Boston Section, IEEE, Nov. 22, 1966. [A similar lecture series is planned for the IEEE Convention in March]



EAI®

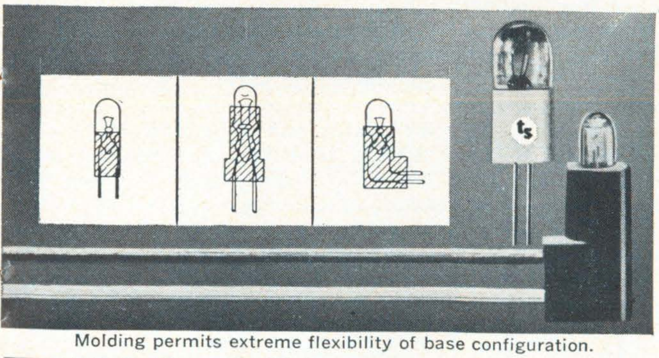
Where Tung-Sol Tu-Pin Subminiature Lamps help hold down Computer Assembly costs

Electronic Associates, Inc., Long Branch, New Jersey, manufacturer of analog, hybrid and digital computers, is a major user of Tung-Sol Tu-Pin molded base lamps. EAI has found that ease of assembly and the negligible reject rate with Tung-Sol lamps contribute substantially to production economy.

Designed especially for computer applications, these self-mounted lamps provide transistor-like installation convenience. Tu-Pin lamps have a molded nylon encapsulation instead of a cemented-on base. No mounting socket is needed. Lamps are soldered directly into the circuit board. Assembly may be done with automated equipment.

Molding provides almost unlimited latitude for base configurations. Bases may be color-coded for accurate identification.

More information about Tu-Pin lamps and other molded base subminiature types will be supplied on request.



Molding permits extreme flexibility of base configuration.

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One Summer Avenue, Newark, N. J. 07104

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WITH EXTRA FUNCTIONS . . .

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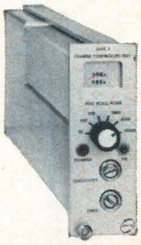

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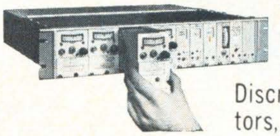

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New Literature

Solid-state servo amplifiers. Melcor Electronics Corp., 1750 New Highway, Farmingdale, L.I., N.Y., 11735. Condensed catalog C1005 covers solid state servo amplifiers for analog computation, control and instrumentation. Circle **420** on reader service card.

Electronic chopper. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif., 91343, has available a two-page bulletin describing its model 150 high-voltage electronic chopper. **[421]**

Programable oscillator. Krohn-Hite Corp. 580 Massachusetts Ave., Cambridge, Mass., 02139. Two-page data sheet, 4030R, describes a programable oscillator that provides automatic selection of frequency and output signal amplitude programed by computers, punched cards, punched or magnetic tape. **[422]**

Core memory stacks. Electronic Memories, 12621 Chadron Ave., Hawthorne, Calif. High-drive, fast-switching 30-mil core memory stacks for commercial memory systems are described in an illustrated four-page brochure. **[423]**

Microwave anechoic chambers. Emerson & Cuming Inc., Canton, Mass., 02021. A four-page folder covers some innovations in high performance Eccosorb microwave anechoic chambers. **[424]**

Optics catalog. Spectra-Physics, 1255 Terra Bella Ave., Mountain View, Calif., 94040, has published an 18-page catalog on optical components for commercial gas lasers. **[425]**

Stripline connectors. Elpac Microwave, a division of Elpac Inc., 3800 Campus Drive, Newport Beach, Calif., 92660. A two-page data sheet describes the OM series miniature stripline connectors for 0.141-in. semirigid cable. **[426]**

Magnetic-memory systems. Ferroxcube Corp. of America, Saugerties, N.Y., offers a brochure on the FX-18 family of 0.5 million-bit, full-control, true random access memories, with an access time of less than 4 μsec. **[427]**

Double-density connector. ITT Cannon Electric, a division of ITT Corp., 3208 Humboldt St., Los Angeles, Calif., 90031, has available catalog 2D-1 on the double-intensity D connector, which provides twice the contact density in conventional shell sizes. **[428]**

Computer linkage equipment, Redcor Corp., 7800 Deering Ave., Canoga Park, Calif. A four-page technical note covers the application of hybrid analog-to-digital and digital-to-analog equipment for analog and digital computer linkage. **[429]**

Capacitors. MH&W International Corp., 301 Sylvan Ave., Englewood Cliffs, N.J., 07632, has available catalog E901 illustrating and describing a broad line of capacitors manufactured by Nippon Communication Industrial Co. of Japan. **[430]**

Power supplies. Nytron Inc., 795 San Antonio Road, Palo Alto, Calif., 94303, offers a catalog containing technical data and descriptive text on such products as a military and industrial silicon power module, aerospace type d-c/d-c converters, twt power supplies and high-voltage modules. **[431]**

Subminiature switches. Rowan Controller Co., Oceanport, N.J., 07757, has published a bulletin on its line of PS subminiature switches that feature low bounce, low resistance, minimum voltage drop, long life and ultrahigh-density pack. **[432]**

D-c microvolt/picoammeter. Boonton Electronics Corp., Route 287 Parsippany, N.J., 07054. A four-page technical bulletin provides a functional description, circuit analysis and detailed specifications of the model 95A d-c microvolt/picoammeter. **[433]**

Synchros and resolvers. Kearfott Products division, General Precision Inc., 1150 McBride Ave., Little Falls, N.J., 07424, has issued a catalog describing a wide variety of synchros and resolvers. **[434]**

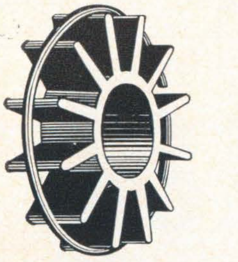
Screen-process printed circuits. Colonial Process Supply Co., 180 E. Union Ave., East Rutherford, N.J., 07073, has available a brochure describing five resists for screen-process circuit board printing. **[435]**

Ion pumps. Ultek Corp., P.O. Box 10920, Palo Alto, Calif. Bulletin B-1400 provides the reader with a thorough insight into the operation of a line of differential sputter ion pumps. **[436]**

Ultrasonic assembly. Branson Instruments Inc., Miry Brook Road, Danbury, Conn., 06810, has released a six-page illustrated brochure, bulletin S-888, describing the latest developments in ultrasonic plastics-assembly equipment and methods. **[437]**

R-f chokes and coils. J.W. Miller Co., 5917 S. Main St., Los Angeles, Calif., 90003. A six-page guide to better coil selection contains a 10-point check list of primary considerations in selecting inductors. **[438]**

Logic modules. Farmer Electric Products Co., Tech Circle, Natick, Mass., 07160. Bulletin A-131 describes type TR logic modules and their use with various resistive transducers, including photocells, photo transistors and limit switches. **[439]**



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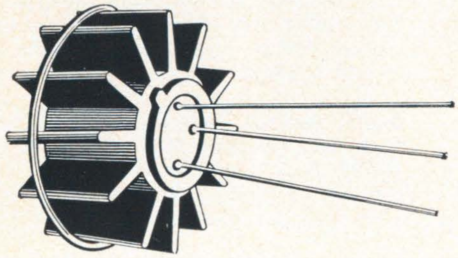

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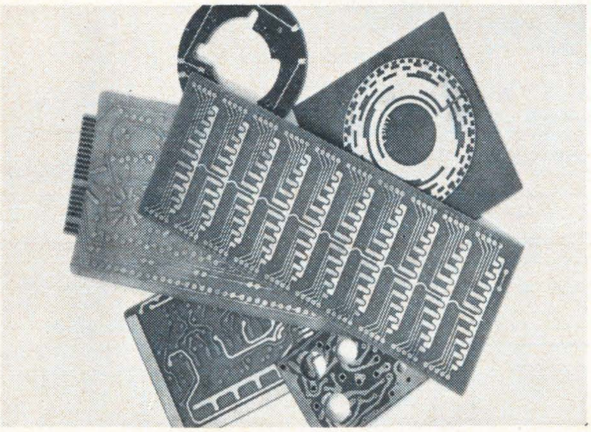

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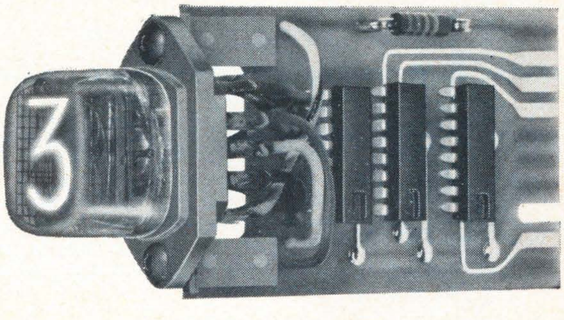

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New Literature

Low-resistance connectors. Deutsch Co., Municipal Airport, Banning, Calif. A six-page, two-color brochure covers the HP series of low-resistance, hermetically sealed electrical connectors. **[440]**

Power Supplies. Sorensen Operation, Raytheon Co., Richards Ave., Norwalk, Conn., 06856. A 12-page short-form catalog presents what the company calls the industry's most complete line of power supplies. **[441]**

Relay catalog. Magnecraft Electric Co., 5575 N. Lynch Ave., Chicago, Ill., 60630, offers its designers' handbook and catalog of reed and mercury wetted contact relays. A glossary of terms is included. **[442]**

Digital readout systems. Farrand Controls Inc., 99 Wall St., Valhalla, N.Y., 10595. A six-page illustrated folder describes an easily installed, numerical control digital readout system. **[443]**

Rfi filters. Cornell-Dubilier Electronics, 50 Paris St., Newark, N.J., 07101. A 16-page catalog is offered to help the design engineer select the proper filter to eliminate unwanted signals. **[444]**

Stripline couplers. Electronic Standards Corp. of America, 1426 W. Front St., Plainfield, N.J., 07063, has prepared the "Stripline Coupler Design Chart" to aid microwave engineers in rapid design of stripline couplers. Along with the chart, the company will enclose a reference sheet on its stripline launchers. **[445]**

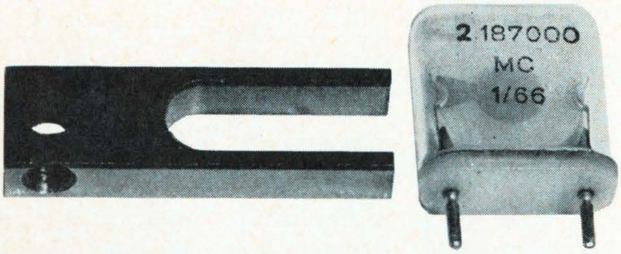
Wire and cable clips. Electrovert, Inc., Components Equipment division, 86 Hartford Ave., Mount Vernon, N.Y., 10553. Bulletin 1000 describes adjustable P-clips that are furnished in nine sizes to fit all wire and cable bundle diameters from 1/8 in. through 2 in. **[446]**

Silicon power supplies. Deltron, Inc., Wissahickon Ave., North Wales, Pa., 19454. Bulletin 107B announces increased ratings and new accessories for the company's silicon, high-precision system power supplies. **[477]**

Component insertion equipment. The Barth Corp., 12650 Brookpart Road, Cleveland, Ohio, 44130. A four-page brochure features the C-100 Versamatic component insertion equipment used for semiautomatic circuit assembly. **[448]**

Programers. Barber-Colman Co., Rockford, Ill., 61101. Bulletin 1214 DB 2-2 describes the Chronotrol automatic program control unit, discussing the many basic models of the instrument that are available for process and laboratory control applications. **[449]**

Crystals or tuning-forks?



Assuming equal accuracies, which would be best for your oscillator application?

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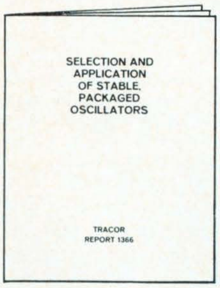

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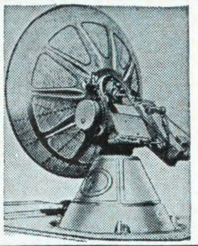

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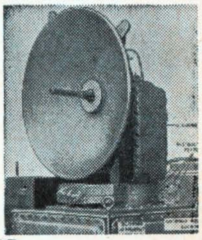

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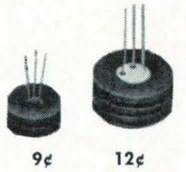

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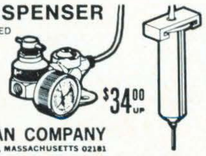

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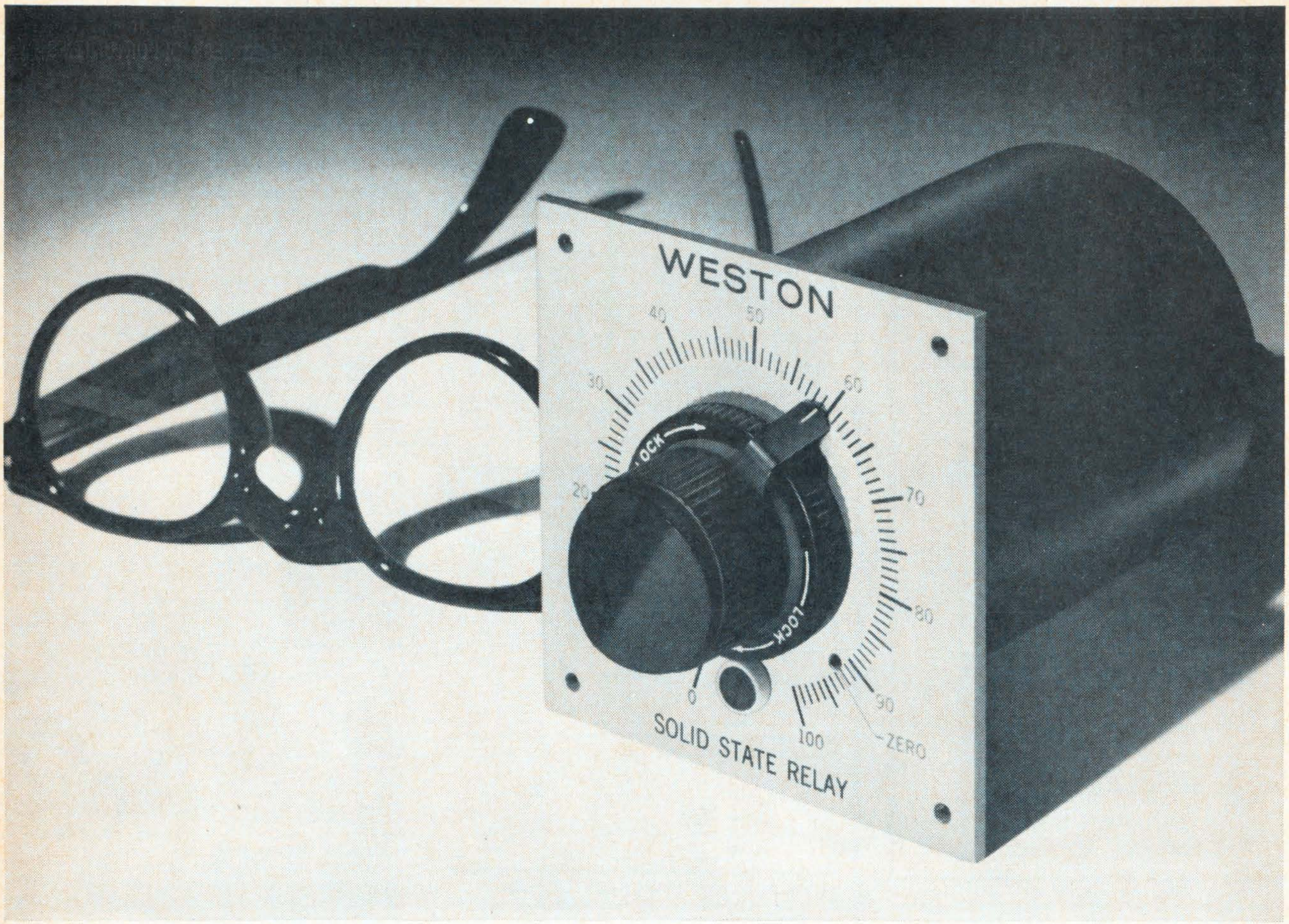

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Newsletter from Abroad

February 6, 1967

Germans seek slash in 'offset' spending

Kurt Georg Kiesinger's coalition government, beset by financial problems, will soon make a strong bid to slash the amount of money it is obliged to spend on U.S. and British military hardware.

Bonn reportedly will ask a 50% cutback in arms purchases made to offset the foreign exchange losses incurred by the U.S. and Britain in maintaining troops in West Germany. Under a treaty expiring June 30, Germany must buy $700 million of military equipment from the U.S. yearly; a similar pact with Britain calls for a $215 million annual arms outlay.

At an upcoming round of talks—probably this month—**Bonn will also press for the inclusion of nonmilitary gear in its "offset" purchases.** The U.S. so far has insisted on selling the Germans only military hardware, but Washington may soften its stand now that Bonn has run into budget problems and U.S.-West German defense ties are under fire from German "Gaullists."

Whatever Bonn wangles from its allies in new offset arrangements, **the result will be lost business for U.S. electronics firms. Although German defense officials don't specify a figure, they say a "considerable" part of the offset spending has gone for electronics.** The impact on U.S. companies won't be immediate, however. Bonn is in arrears on its offset buying and will have to order about $1 billion of U.S. military equipment by mid-year to catch up.

Swedes may drop Viggen interceptor, use U.S. missiles

Sweden's projected slowdown in military spending may be a boon to U.S. missile makers. The cutback may force the Swedish air force to drop plans for an interceptor version of the Viggen supersonic all-purpose aircraft. If that happens, **the Swedes very likely will turn to U.S. missiles for air defense.**

On the heels of a hold-the-line budget for the upcoming fiscal year [Electronics, Jan. 23, p. 228], the government has directed the defense staff to revise its hardware plans for the coming three years. The government plans to go ahead with fighter and reconnaissance versions of the Viggen, but has suggested substituting missiles for the interceptor version. As originally conceived, the Viggen project would cost about $2 billion.

GE, two Japanese firms slate joint computer marketing

The General Electric Co., which has run into difficulties around the world with its 600-series computers, has moved to bolster its position in the Japanese market.

The company expects to work out final details this month for a joint venture with Tokyo Shibaura Electric Co. (Toshiba) and the Mitsubishi Electric Corp. **to sell business machines based on GE designs but manufactured by the two Japanese concerns.** Apparently because Japan's powerful Ministry of International Trade and Industry wanted it that way, Toshiba will own 34% of the joint venture, with the balance split equally between GE and Mitsubishi. **The trio plans to apply for MITI approval by April and set up the new company by the end of the year.**

The joint venture will lease business computers through the government-financed Japan Electronic Computer Co. For other than business computers, both Toshiba and Mitsubishi will continue to operate independently. Toshiba's line includes both house- and GE-designed models; Mitsubishi produces computers under license from the Westinghouse Electric Corp.

... and Sony plans to team with IBM on tape recorders

The Sony Corp. has applied to the Japanese government for permission to join the International Business Machines Corp. in developing video tape recorders and related hardware. Although neither company has released details on the upcoming collaboration, **IBM apparently wants Sony video-recorder know-how for teaching machines with cathode-ray-tube displays linked to a computer.** The recorders could be used off-line to drive crt displays or on-line to cut down computer memory requirements.

Franco-German communications satellite likely

The de Gaulle government apparently has dropped its ambitious goal of a small—but all-French—communications satellite in favor of a joint project with West Germany.

France's science minister, Alain Peyrefitte, last week hinted that **Paris has scrapped its original plan to build a 400-pound satellite with 144 telephone channels** [Electronics, April 4, 1966, p. 235]. The French now have in mind a 440-pound version with 1,000 phone channels plus broadcast channels. Neither the French nor the West German government has talked publicly about negotiations on a satellite, but **Peyrefitte intimated that the satellite would be a joint effort and would be in a stationary orbit by 1971.** The launch vehicle would come from the European Launcher Development Organization.

Philips' way is clear in bid to buy Pye

Philips Gloeilampenfabrieken NV now has a clear field in its bid to add Pye of Cambridge Ltd. to its worldwide network of subsidiaries.

Its competitor, Thorn Electrical Industries Ltd., has dropped out of contention, and Pye's directors have recommended that shareholders accept Philips' offer of $84 million for the company, up 50% from the initial bid [Electronics, Dec. 26, 1966, p. 166]. The last step in Philips' takeover—stockholder approval—is now a formality. The Dutch company got the go-ahead from the British Treasury and the Minister of Technology before it made its formal offer to buy Pye shares.

Pye will operate as an independent company within the Philips group **but the parent company plans to fit Pye into its over-all British setup.** Some of Pye's radio and tv production presumably will be taken over by Philips Electrical Ltd., while Mullard Ltd. figures to become Pye's major picture-tube and semiconductor supplier. Philips also plans to mesh the M.E.L. Equipment Co., its British telecommunications subsidiary, into Pye's telecommunications operations.

Russians may buy VOR sets from West

Western aviation experts in Moscow think the Russians will have to buy very-high-frequency omnidirectional range receivers abroad before starting regular flights between Moscow and New York this spring. During the negotiations covering the flights—expected to begin in May—the Russians agreed to install VOR displays in the cockpits of all planes using New York's Kennedy International Airport. **The Russians say they have already installed displays in most of their long-range aircraft.**

Electronics Abroad

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West Germany

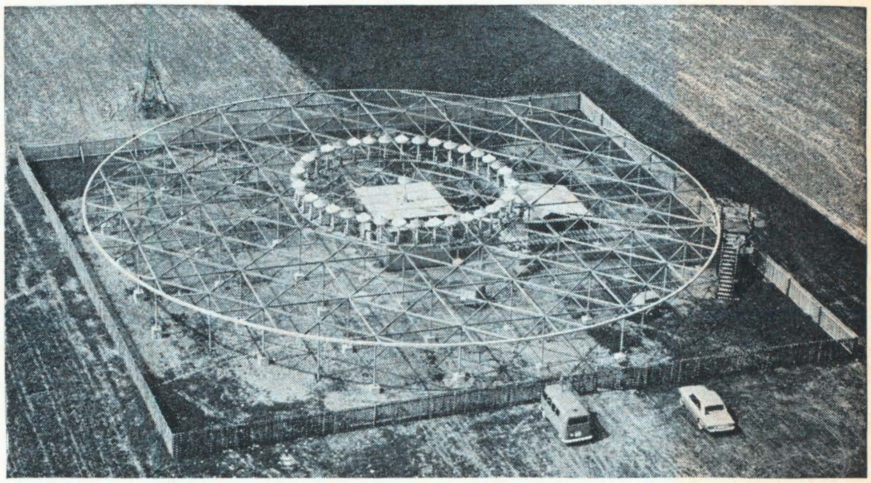
Mountain range

In mountainous country, conventional very-high-frequency omnidirectional range systems fare poorly since reflections of the rotating signal lead to spurious bearing indications. A way out is a doppler VOR technique with the azimuth-dependent signal switched rapidly round a ring of antennas, usually by a fast-turning mechanical commutator that requires frequent maintenance and replacement.

An electronic antenna switching technique that overcomes these shortcomings is now being used in an experimental doppler VOR operating near Ruedesheim. Standard Elektrik Lorenz AG, a West German subsidiary of the International Telephone and Telegraph Corp., designed and built the facility. The company has a second system undergoing tests at Salzburg, Austria. Although both are spotted at difficult sites, they are accurate to within 0.5°, the norm for commercial VOR systems.

Merry-go-round. The electronically switched array resembles a big carrousel. It consists of 40 mushroom-like antennas, 39 of them spotted uniformly around a 44-foot diameter circle with the 40th antenna at the center. As radio-frequency energy is switched around the ring, it moves alternatively toward and away from an aircraft homing on the range and the azimuth-dependent signal thus appears to be frequency-modulated because of the doppler effect.

Basic to the antenna switching system are an electronic driver unit and transistor-diode switches that can handle r-f power. Control pulses about 0.85-milliseconds long, generated in the driver unit, open the switches in a preset sequence.



Antenna carrousel for doppler VOR system at Ruedesheim, Germany, projects above mesh-covered support frame 130 feet in diameter. Azimuth-variable signal is switched around antenna ring electronically.

The pulse spacing and diode connections are arranged so that the transmitter output is switched from one antenna to another that is almost diametrically opposite. This arrangement keeps energy interaction low between antennas switching on and off. The diode switching circuits have attenuation of 70 decibels in the nonconducting state and 0.4 db in the conducting state.

Sidebands. The 200-watt transmitter output switched around the antenna ring consists of a pair of alternating sidebands spaced at plus and minus 9,960 hertz from the carrier. The carrier, which varies between 112 and 118 megahertz, is amplitude-modulated by a 30-hertz sinewave signal from the driver unit and broadcast continuously from the center antenna as a reference signal.

To improve the simulated antenna rotation, both sidebands are amplitude-modulated by a 1,170-hertz cosine signal. This gives the effect of 30-hertz frequency-modulation on the subcarriers as they are switched around the 39-antenna ring. In the aircraft VOR receiver, the phase difference between the a-m reference signal and the f-m signal gives the aircraft's bearing from the center antenna.

Radiating elements in the antennas are horizontally polarized Alford loops with omnidirectional characteristics. To reduce antenna costs, Standard Elektrik is currently developing printed-circuit versions of the loops.

Astronomical antenna

It's the beginning of the end for the backseat in radio astronomy that West Germany long has occupied. Before the month is out, the Max Planck Institute for Radio Astronomy, backed financially by the Volkswagen Foundation, plans to let contracts for a $5.5 million fully steerable radio telescope that will be the world's largest and probably the most accurate when it goes into service some 30 months from now.

The West German telescope will have an antenna diameter of 328 feet and thus outclass considerably the renowned Jodrell Bank facility, which measures in at 250 feet. And the upcoming German dish will even outspan the 300-foot antenna of the U.S. National Radio Astronomy Observatory at Green

Bank, W. Va., which can move about one axis only.

However, the West German telescope may not hold its first-place rank for long. A group of U.S. research institutions known as the Cambridge Radio Observatory Committee (Camroc) has design studies under way for a 400-foot antenna. But the Camroc project trails Planck's by at least a year.

Precise. Basically, the German radio telescope will consist of a shallow circular dish with an aluminum-clad inner circle about 262 feet in diameter surrounded by a 33-foot-wide outer rim of wire mesh. The aluminum clad inner circle will handle signals of wavelengths down to 3 cm—or a frequency of 10 gigahertz. To handle frequencies in this range, the antenna must be built to tolerances between 2 and 3 millimeters.

The wire-mesh section is designed for signals down to 8 cm wavelength. For 3-cm operation, the maximum antenna gain will be about 42 million and the main lobe about 85 seconds of arc wide. Largely because of cost considerations, the big dish will have no radome.

Contending. Kingpin item in the $5.5 million German project is the massive antenna, whose moving parts will weigh about 2,200 tons. Seemingly having an edge for the antenna contract is Fried. Krupp Maschinenfabrik. Maschinenfabrik Augsberg-Nurenberg also is in the running.

German electronics companies will share about $750,000 in receiver and antenna control contracts with U.S. and possibly British companies. Siemens AG, West Germany's largest electrical-electronics firm, has been tapped to build a 100-channel spectrometer for 20-cm signal reception. Airborne Instruments Laboratories, a subsidiary of Cutler-Hammer Inc., has already delivered 10-cm receivers for the project. Still to be selected are suppliers for the telescope's 6-cm and 3-cm receivers. All receivers have helium-cooled parametric amplifiers.

The telescope will be positioned to an accuracy of 10 seconds by a control system built around an analog computer. Siemens, Britain's Ferranti Ltd., and the Control Data Corp. are contending for the control-system contract.

France

Patient telemetry

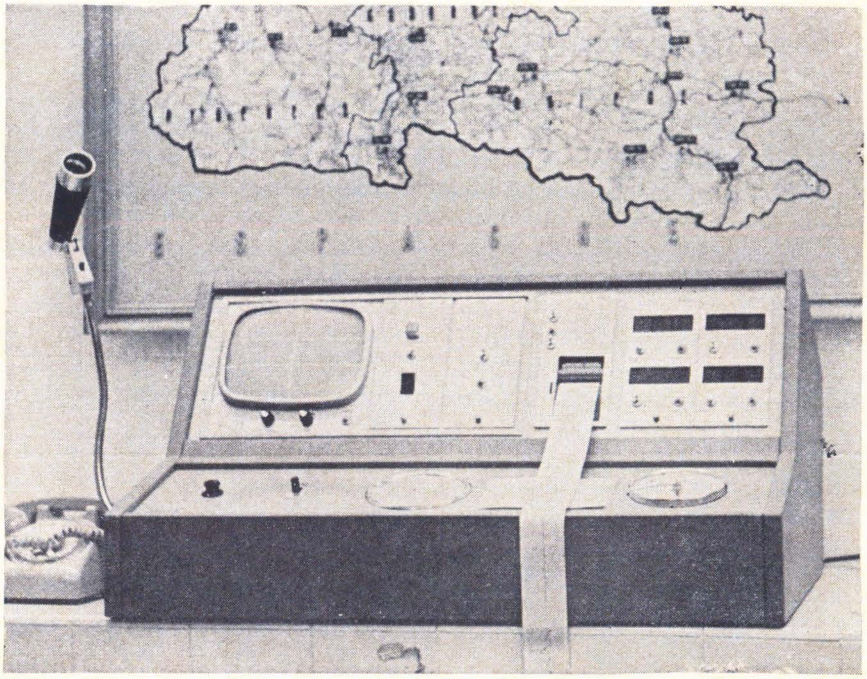
For want of a doctor in the ambulance, many a badly injured accident victim dies before he can receive intensive care in a hospital. With a doctor in every ambulance out of the question, Electronique Marcel Dassault has come up with a next-best solution—ambulance equipment that monitors a patient and feeds the data over a microwave link to a hospital where a doctor can look it over and radio instructions for treatment to the ambulance attendant.

Coded. Dassault's system can keep a hospital in touch with up to eight ambulances as far away as 40 miles. From the radioed-in data, the hospital's receiving unit develops both a temporary display and a permanent record of the patient's electrocardiogram, blood pressure and breathing rate.

The electrocardiogram shows up on an oscilloscope and also is recorded on a chart. Blood pressure and breathing rates are displayed on digital readouts and stored on punched tape. When more than one emergency case is on the way to the hospital, the doctor in charge can shift from ambulance to ambulance at will; each ambulance's data transmission starts with an identifying code.

Uncomplicated. The monitoring equipment in the vehicle makes the attendant's chore simple. He attaches a pair of electrodes to the patient to pick up the electrocardiogram signal and puts a mask fitted with a thermistance sensor over his mouth and nose to get the breathing-rate input. For blood pressure, the attendant fits the patient with either an arm band or a finger cuff. Blinking lights on the vehicle unit show when the sensors are properly placed and working.

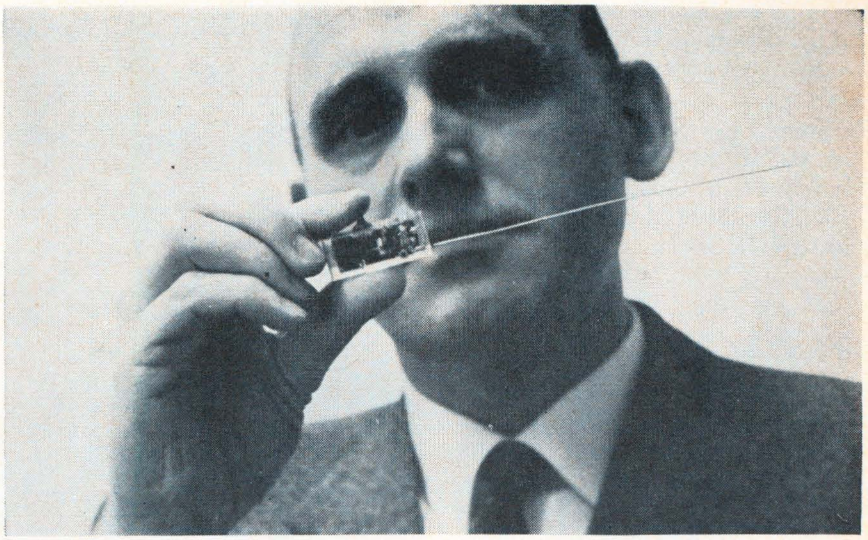
Inputs from the three sensors are amplified and shaped, then fed to an encoder for transmission by phase-modulation over a normal radiotelephone channel. In Toulouse, where first installations of the equipment have been made in an ambulance and a fire-depart-



Doctor at hospital can keep close watch on condition of patient in ambulance and radio instructions to attendant through Dassault remote-monitoring equipment.

ment rescue wagon, the system operates on the 85.5-megahertz police and fire band.

Both the rescue wagon and the ambulance have the basic monitoring equipment that can be handled by any ambulance attendant. The ambulance has, in addition, on-vehicle readouts that an intern, nurse, or specially trained attendant could use. They include an oscilloscope cardiogram display and drum meters that show blood pressure, heart beat and breathing rate. An electronic heart-stimulator rounds out the ambulance equipment.



Calling all cars. Swedish police are testing a tiny prototype transmitter that officers could use to call for help. Svenska Radio AB developed the transmitter, which has thin-film circuitry.

Sweden

Thumb-size transmitter

The machine-gun slaying of two policemen and a night watchman in suburban Stockholm last month may well spur production of a thumb-size transmitter developed in Sweden.

The shooting occurred within 500 yards of a police station but wasn't discovered until some hours later. Police feel that if their slain comrades had been in radio contact with the station or a patrol car, the killers—still at large—would have been caught quickly.

As a result, the Swedish Police Agency is now testing two prototype transmitters developed by Svenska Radio AB, a subsidiary of the L.M. Ericsson Telephone Co. Built around a hybrid thin film circuit, the devices are about 1½ inches long and ½-inch square, small enough for an individual policeman to carry easily. The transmitters' oscillator circuits use a tunnel diode and are crystal controlled to meet Swedish requirements for mobile transmitters in the 68—78, 155—174 and 300—450 megahertz bands.

Two versions. One of the prototypes has a 20-milliwatt output, the other 100 mw. The range of the 100-mw version at 150 mhz comes to about 1½ miles in open country and 500 yards in built-up city areas.

Besides police applications, Svenska Radio expects its thin-film transmitters to be used in hospitals to link ambulant patients to central surveillance units, and in industry to feed data from remote production facilities into central control computers.

For Svenska Radio, the thumb-size transmitter marks just the beginning of thin-film technology in civilian electronics. The company already has a thin-film transceiver in development and it plans to incorporate thin-film circuits into about 80% of its portable-radio line before long.

Great Britain

Seaworthy

British engineers have been quick to try out the second batch of eight communications satellites put into orbit late last month as part of the United States Interim Defense Communications Satellite Project.

A team from the Admiralty Surface Weapons Establishment has been bouncing signals back and forth between the satellite string and a shipboard terminal that it has under construction. The terminal is an experimental model intended to provide the Royal Navy with experience in operating this sort of equipment and British engineers with the experience of building it. The team leader, Granville Harries, says the tests were satisfactory.

Home grown. The British model uses mainly native equipment in a design that largely resembles the terminals built for the U.S. Navy by the Hughes Aircraft Co. [Electronics, Sept. 5, 1966, p. 31]. The method, Harries says, was to draw on American experience, build in features that would suit British use, and thus come up with something largely home grown.

There are two big differences between the British and U.S. designs. The British have gone for a power output of 20 kilowatts as against the 5 kw of the Hughes unit. Harries explains that he wanted to be sure he had enough power to get into the satellites. Secondly, the parametric amplifiers of the British receiver are helium-cooled while the Hughes design uses thermoelectric cooling. These differences contribute to a greater total weight of around 22,400 lb for the British terminal. U.S. Navy ships will mount their terminals on a mast, British ships on a gun mount. This, Harries says, will facilitate installation in a variety of ships. Both designs use a 6-ft. diameter antenna.

The British unit, being built on the Isle of Wight by the space division of Plessey Radar Ltd., uses a parametric amplifier and cooling system designed by Mullard Ltd., a subsidiary of Philips Gloeilampenfabrieken of the Netherlands. Ferranti Ltd. designed the platform stabilization gyro system. Ultimately the terminal will go to sea for trials in H.M.S. Wakeful, a 2,200-ton frigate.

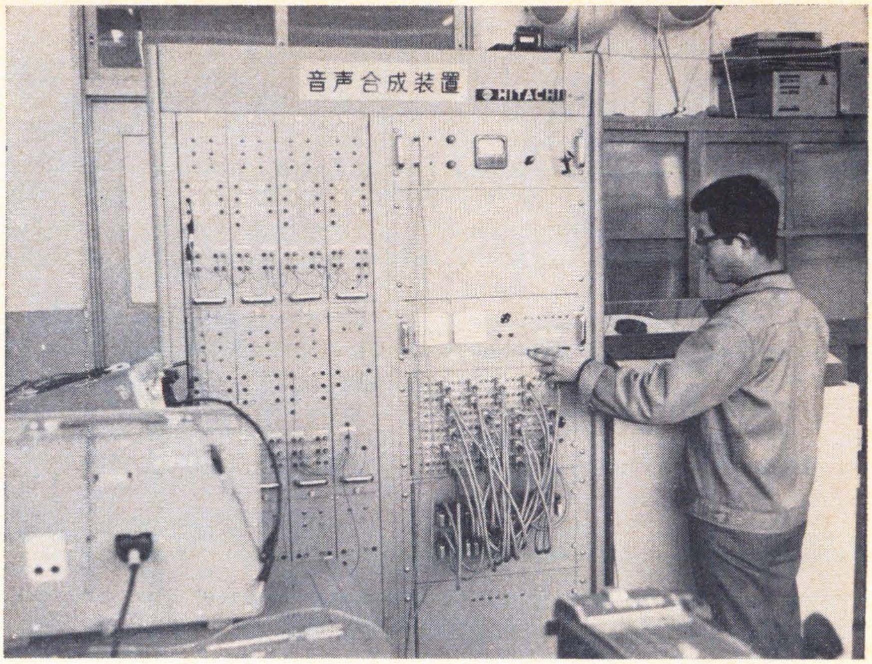
Dintensity

There's no particular problem in pinning down the decibel level of an irritating noise be it a clacking typewriter in the adjoining office, the din of a neighbor's late-night party or a daytime earsore like a jackhammer. Gauging a noise's annoyance level, however, poses a tricky problem, but Wolfgang Hawel of the Max Planck Institute in Dortmund thinks he can develop an electronic instrument that will solve it.

Hawel outlined his scheme in London late last month at a conference on acoustic noise control. Along with the sound level proper, Hawel says there are at least four other factors that must be taken into account to determine how much a noise will annoy someone. One is the state of the listener, whether he's in generally good humor or bad when his tympanum is jostled. A second is the situation he's in when the noise is heard—working, relaxing, sleeping.

The third of Hawel's factors is the listener's activity—dancing, puzzling out a difficult problem, reading and the like. Then there's the quality of the sound, which might be a ticking clock in a quiet room or roaring automobile traffic during rush hour.

Hawel has found there's an interdependence between these four factors and the actual decibel level of the sound itself. By feeding the parameters into matrix networks working in tandem with a sound-level meter, he figures, a measure can be had of a sound's annoyance for the circumstances in which it's heard. Hawel already has simulated annoyance measurements on a computer as a first step toward designing a manageable instrument.



Talking machine. Analog computer electronically duplicates changes that occur in human vocal tract when a person speaks. Controlled by a digital computer, the analog speech synthesizer already has been programed to speak Japanese and will be able to spout some English as well by mid-1968.

Japan

Robot raconteur

Researchers at the Japanese government's Electrotechnical Laboratory on the outskirts of Tokyo have apparently come up with the latest word in talking machines.

In the field of voice synthesizers, anyone with a machine that can produce intelligible speech is up with the leaders. The ETL group, headed by Ei'Ichi Matsui, already has a computer-controlled synthesizer that can speak Japanese with about the facility of a first-grader and can even tell a fairy tale. Now Matsui's group has begun to teach the machine English and expects to have a bilingual synthesizer by mid-1968. As with other efforts to develop synthesizers, the ultimate goal is a machine that can vocally read out data stored in computers.

Analog. ETL's voice synthesizer is built around a numerically controlled computer that functions as a dynamic analog of the human vocal tract. The computer, developed jointly with Hitachi Ltd., uses 71 operational amplifiers plus 22 multipliers to duplicate electronically the changes in volume and shape that occur in the human vocal tract when a person speaks. To produce sounds, driving waveforms—a sawtooth wave for vowels and white noise for consonants—are fed into the varying transmission line set up by the analog computer.

The multipliers are photoconductors whose resistance is controlled by flashing neon lamps. The lamps, in turn, are turned on and off by switches actuated by a digital computer; the control interval is 5 milliseconds. Because the multipliers are essentially resistors, their frequency response is excellent. To hold down the effect of phase shift in the operational amplifiers, the bandwidth of the amplifiers is limited to 2,500 hertz, although they have a frequency response up to 200 kilohertz.

Tape talk. The multipliers and driving waveforms are controlled by a tape prepared on a IBM 7090 computer using a Fortran program. Since the tapes have to be prepared in real-time, they cost about $14 for each minute of talk and make for expensive speech. Matsui is convinced, however, that tape costs will decrease as synthesizer hardware and programing techniques are improved.

Matsui's group is currently putting special emphasis on programing its existing machine for English, but at the same time it is going ahead with hardware improvements. ETL and Hitachi plan to have an integrated-circuit version of the analog computer ready by March 1968. Only a fourth the size of the present machine, the IC model will have operational amplifiers with improved frequency response so that sounds with frequencies higher than 2.5 khz can be synthesized. Also, it will be based on second-order approximations of the differential equations established to match vocal-tract changes. The improved approximations will cut down the computer capacity needed for speech synthesis.

Soviet Union

Playback pathology

American doctors haven't taken to electronic stethoscopes. They usually cost $100 or more, whereas an old-fashioned stethoscope can be had for $7.50 or less. What's more, doctors get used to sorting out significant sounds with the old stethoscopes during their medical schooling and generally don't feel it's worth the trouble to retrain themselves on an instrument that "plays" differently.

The electronic stethoscope may one day catch on with Russian medical men, however. A research group in Leningrad has designed one that not only amplifies and filters respiratory-tract sounds but also records the sound patterns on photographic paper. Because of the recording feature, the Leningrad group calls the instrument a stethophonograph.

Basically, the instrument consists of a sensitive microphone, an amplification system and filters that separate out five frequency ranges carrying particular diagnostic information. From the recorded readings, the Leningrad researchers claim, the condition of the respiratory tract can be determined.

Learning to interpret the stethophonograph's pneumograms obviously requires special training, and at first glance this would point to a lackluster future for the instrument. But the Leningrad group reportedly plans to sidestep such drudgery for physicians by developing a computer to process pneumograms automatically for fast and easy diagnoses.

Around the world

Spain. The largest Iberian electronics producer has been caught up in the struggle of Spanish workers councils to gain control of the government-run labor unions. Standard Electrica, a subsidiary of the International Telephone and Telegraph Corp., has been ordered by the Ministry of Labor to negotiate a new wage contract and reemploy 2,400 workers laid off because of cutbacks in government orders for telephone equipment. The order was the upshot of a demonstration inspired by the workers councils and the subsequent arrest of six labor leaders. In ordering the jailed leaders' release and the renegotiation, the Madrid tribunal for the first time in 30 years failed to rule a labor demonstration illegal, pointing to sweeping changes in the government's labor policy.

Saudi Arabia. The French Ministry of Posts and Telecommunications has won a contract from the Saudi government for feasibility studies of satellite-communications ground stations in Arabia. The French also will do the preliminary study for a project that would link Saudi towns in a communications network.

Sweden. SAAB Aktiebolag has added to its arsenal of electronic battlefield training aids [Electronics, Dec. 12, 1966, p. 257]. In addition to its radio-controlled infantry targets, SAAB now has a laser mounted in a tank cannon for target practice against other tanks and a radio-controlled automobile that pulls tank targets.

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February 6, 1967

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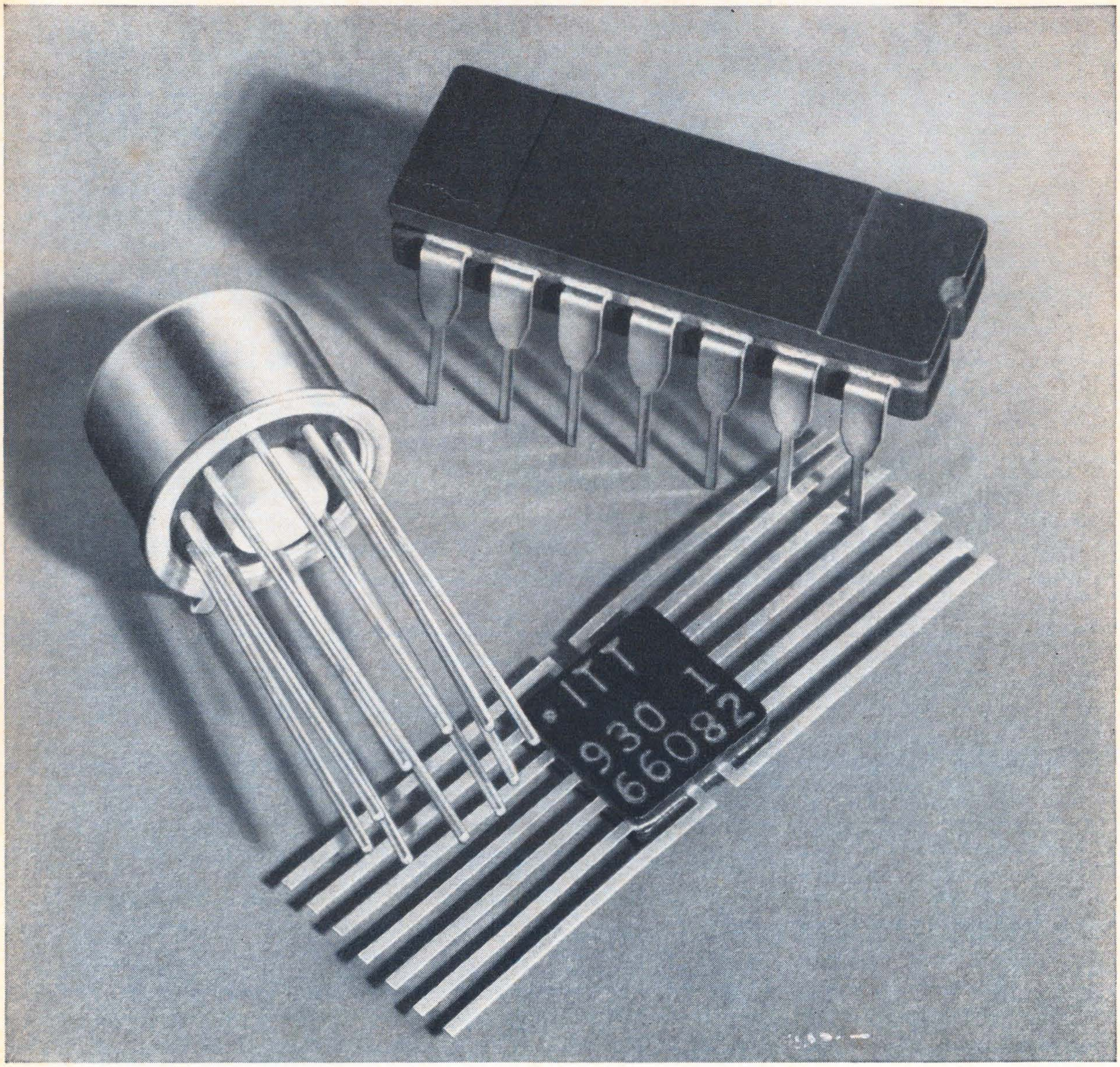

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